CENTURY CLASS TRUCKS WORKSHOP MANUAL

Models: Argosy® COE
C112 Conventional
C120 Conventional
Coronado™

STI-342, S22 (6/04P)

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Supplement 22

Century Class Trucks Workshop Manual **June 2004**

Enclosed are new and revised pages for your *Century Class Trucks Workshop Manual.*

Major changes are as follows:

Group 00	Section 00.00 "Component Manufacturers and Addresses" is removed.
Group 15	Section 15.04 "Starter, Mitsubishi" is new.
Group 32	Section 32.04 "Freightliner AirLiner Suspension" has added torque values for 3/4-inch U-bolts.
Group 54	Section 54.02 "Batteries, Maintenance-Free" has added battery test procedures for Midtronics 740.
Group 60	Section 60.01 "Cab Rear Air Suspension" has added Subject 150 that was new in Supplement 12 but never published at that time.
	Section 60.07 "Cab Structure Repair, Century Class Conventional" has revised figures in specifications.
Group 83	Section 83.00 "Refrigerant Compressor, Climate Control" has revised refrigerant oil specifications.
Group 88	Section 88.00 "Hood" has added information on Century Class vehicles built from September 2000.

File Supplement 22 as follows:

Group or Section	Remove	Insert
Validity List	all pages	all pages
Preface	Title Page	Title Page
00	Group Index	Group Index
00.00	400	—
00.01	050	050
15	Group Index	Group Index
15.04	—	Contents–400
31.01	100	100
32.04	400	400
54.02	140	140
60.01	—	150
60.07	400	400
83.00	100	100
	400	400
83.06	300	300
88.00	100–120	100–120
	140	140
Index	all pages	all pages

Century Class Trucks Workshop Manual
Validity List

Section	Subject	Current Date
Title Page	—	June 2004
Foreword	—	—
Introduction	—	April 2003

Section Number	Subject Number	Current Date
00 Group Index	—	June 2004
00.01	Contents	January 1996
00.01	050	June 2004
00.02	Contents	January 1996
00.02	050	January 1996
00.03	Contents	June 2002
00.03	050	June 2000
00.03	100	June 2002
00.04	Contents	June 2000
00.04	050	June 2000
00.04	060	June 2000
00.05	Contents	January 1996
00.05	050	January 1996
00.05	100	January 1996
00.05	400	January 1996
00.06	Contents	June 2000
00.06	050	June 2000

Section Number	Subject Number	Current Date
01 Group Index	—	June 2001
01.00	Contents	October 1996
01.00	050	October 1996
01.00	100	January 1996
01.00	105	January 1996
01.00	110	January 1996
01.00	120	October 1998
01.00	400	January 1996
01.01	Contents	October 1996
01.01	050	October 1996
01.01	100	January 1996
01.01	105	October 1999
01.01	110	January 1996
01.01	115	October 1998
01.01	400	January 1996
01.02	Contents	June 2001
01.02	050	October 1996
01.02	100	June 2001
01.02	110	June 2001
01.02	120	June 2001
01.02	130	June 2001
01.02	140	June 2001
01.02	150	June 2001
01.02	400	June 2001
01.03	Contents	January 1996
01.03	050	January 1996
01.03	100	January 1996
01.03	110	January 1996
01.03	120	January 1996
01.03	130	January 1996
01.03	400	January 1996
01.04	Contents	January 1996
01.04	050	January 1996
01.04	100	January 1996
01.04	300	October 1996
01.04	400	January 1996
01.05	Contents	January 1996
01.05	050	January 1996
01.05	100	January 1996
01.05	110	January 1996
01.05	120	January 1996
01.06	Contents	January 1996
01.06	050	January 1996
01.06	100	January 1996
01.06	110	January 1996
01.06	120	January 1996
01.06	130	January 1996
01.06	140	January 1996
01.06	150	January 1996
01.06	160	January 1999
01.06	170	January 1996
01.07	Contents	January 1996
01.07	050	January 1996
01.07	100	January 1996
01.07	110	January 1996
01.07	120	January 1996
01.07	130	January 1996
01.07	140	January 1996
01.07	150	January 1996
01.07	160	January 1996

Century Class Trucks Workshop Manual
Validity List

Section Number	Subject Number	Current Date
01.07	170	January 1996
01.07	180	January 1996
01.07	190	January 1996
01.08	Contents	January 1996
01.08	050	January 1996
01.08	100	January 1996
01.08	110	January 1996
01.08	120	January 1996
01.08	130	January 1996
01.08	140	January 1996
01.08	150	January 1996
01.08	160	January 1996
01.09	Contents	January 1996
01.09	050	January 1996
01.09	100	January 1996
01.09	110	January 1996
01.09	120	January 1996
01.09	130	January 1996
01.09	140	January 1996
01.09	150	January 1996
01.09	160	January 1996
01.09	170	January 1996
01.10	Contents	January 1996
01.10	050	January 1996
01.10	100	January 1996
01.10	110	January 1996
01.10	120	January 1996
01.10	130	January 1996
01.10	140	January 1996
01.10	150	January 1996
01.10	160	January 1996
01.10	170	January 1996
01.10	180	January 1996
01.11	Contents	January 1996
01.11	050	January 1996
01.11	100	January 1996
01.11	110	January 1996
01.11	120	January 1996
01.11	130	January 1996
01.11	140	January 1996
01.11	150	January 1996
01.11	160	January 1996

Section Number	Subject Number	Current Date
01.12	Contents	January 1996
01.12	300	January 1996
01.13	Contents	June 2001
01.13	100	June 2001
01.13	400	June 2001

Section Number	Subject Number	Current Date
09 Group Index	—	January 1996
09.00	Contents	June 2000
09.00	050	October 1998
09.00	100	December 2001
09.00	110	October 1998
09.00	120	June 2000
09.01	Contents	December 2001
09.01	100	October 1998
09.01	110	June 2002
09.01	120	December 2001
09.01	130	June 2002
09.01	140	December 2001
09.02	Contents	September 2000
09.02	050	October 1998
09.02	100	October 1998
09.02	110	September 2000
09.02	120	October 1999
09.02	130	October 1998
09.02	140	October 1998

Section Number	Subject Number	Current Date
13 Group Index	—	June 2001
13.00	Contents	January 1996
13.00	050	January 1996
13.00	100	October 1998
13.00	110	January 1996
13.00	120	January 1996
13.00	130	January 1999
13.00	300	January 1996
13.00	400	January 1999
13.01	Contents	January 1996
13.01	050	January 1996
13.01	100	December 2001
13.01	110	October 1998
13.01	120	January 1996

Century Class Trucks Workshop Manual
Validity List

Section Number	Subject Number	Current Date
13.01	130	December 2001
13.02	Contents	October 1997
13.02	050	October 1997
13.02	100	October 1997
13.02	110	October 1997
13.02	300	October 1997
13.02	400	October 1997
13.03	Contents	June 2001
13.03	050	June 2001
13.03	100	June 2001
13.03	110	June 2001
13.03	300	June 2001

Section Number	Subject Number	Current Date
15 Group Index	—	June 2004
15.00	Contents	January 1996
15.00	050	January 1996
15.00	100	October 1998
15.00	110	January 1996
15.00	300	April 1997
15.00	400	January 1996
15.01	Contents	October 1996
15.01	050	July 1998
15.01	100	October 1996
15.01	110	October 1996
15.01	120	October 1996
15.01	130	October 1996
15.01	140	October 1996
15.01	150	October 1996
15.01	160	October 1996
15.01	300	August 2003
15.01	400	October 1996
15.02	Contents	June 2000
15.02	050	July 1998
15.02	100	June 2000
15.02	110	October 1996
15.02	120	October 1996
15.02	130	October 1996
15.02	140	June 2000
15.02	150	October 1996
15.02	300	August 2003
15.02	400	July 1998

Section Number	Subject Number	Current Date
15.03	Contents	October 1996
15.03	050	October 1996
15.03	100	October 1996
15.03	110	October 1996
15.03	120	October 1996
15.03	130	October 1996
15.03	140	October 1996
15.03	150	October 1996
15.03	300	August 2003
15.03	400	October 1996
15.04	Contents	June 2004
15.04	050	June 2004
15.04	100	June 2004
15.04	300	June 2004
15.04	400	June 2004

Section Number	Subject Number	Current Date
20 Group Index	—	April 2003
20.00	Contents	January 1996
20.00	050	June 2000
20.00	300	January 1996
20.01	Contents	April 2003
20.01	050	January 1996
20.01	100	January 1996
20.01	110	January 1996
20.01	120	October 1998
20.01	130	June 2002
20.01	140	October 1998
20.01	150	January 1996
20.01	160	October 1997
20.01	165	October 1998
20.01	170	October 1998
20.01	180	October 1998
20.01	190	June 2002
20.01	200	October 2002
20.01	300	April 2003
20.01	400	June 2002
20.02	Contents	September 2000
20.02	050	January 1996
20.02	100	January 1996
20.02	110	January 1996
20.02	120	September 2000

Century Class Trucks Workshop Manual
Validity List

Section Number	Subject Number	Current Date
20.02	130	September 2000
20.02	140	September 2000
20.02	150	September 2000
20.02	300	March 1996
20.02	400	September 2000
20.03	Contents	January 1996
20.03	050	January 1996
20.03	100	January 1996
20.03	300	January 1996
20.03	400	January 1996
20.04	Contents	April 2003
20.04	050	April 2003
20.04	100	April 2003
20.04	110	April 2003
20.04	120	April 2003
20.04	300	April 2003
20.04	400	April 2003

Section Number	Subject Number	Current Date
25 Group Index	—	August 2003
25.00	Contents	August 2003
25.00	050	August 2003
25.00	100	August 2003
25.00	110	August 2003
25.00	120	August 2003
25.00	130	August 2003
25.00	300	August 2003
25.00	400	August 2003
25.01	Contents	January 1996
25.01	050	January 1996
25.01	100	June 1996
25.01	110	January 1996
25.01	120	January 1996
25.01	130	January 1996
25.01	300	January 1996
25.01	400	January 1996
25.02	Contents	July 1997
25.02	050	July 1997
25.02	100	October 1998
25.02	110	July 1997
25.02	120	July 1997
25.02	130	July 1997

Section Number	Subject Number	Current Date
25.02	300	July 1997
25.02	400	October 1998
25.03	Contents	October 1998
25.03	050	January 1998
25.03	100	October 1998
25.03	110	January 1998
25.03	120	October 1999
25.03	400	January 1998
25.04	Contents	December 1999
25.04	050	December 1999
25.04	100	December 1999
25.04	110	December 1999
25.04	120	December 1999
25.04	300	December 1999

Section Number	Subject Number	Current Date
26 Group Index	—	December 1999
26.00	Contents	October 1998
26.00	100	January 1996
26.00	110	October 1998
26.01	Contents	December 1999
26.01	050	April 2003
26.01	100	December 1999
26.02	Contents	October 1999
26.02	100	October 1999

Section Number	Subject Number	Current Date
30 Group Index	—	January 1996
30.00	Contents	June 2000
30.00	050	June 2000
30.00	100	January 1997
30.00	110	July 1998
30.00	300	June 2000

Section Number	Subject Number	Current Date
31 Group Index	—	April 2003
31.00	Contents	January 1996
31.00	050	January 1996
31.01	Contents	January 1996
31.01	050	October 1998
31.01	100	June 2004

Century Class Trucks Workshop Manual
Validity List

Section Number	Subject Number	Current Date
31.01	110	October 1997
31.01	120	October 1997
31.01	130	October 1999
31.01	140	January 1996
31.01	150	January 1996
31.01	400	January 1996
31.02	Contents	January 1996
31.02	050	January 1996
31.02	100	January 1996
31.02	300	January 1996
31.03	Contents	October 1998
31.03	050	October 1998
31.03	100	October 1998
31.03	110	October 1998
31.03	120	October 1998
31.04	Contents	October 1998
31.04	050	October 1998
31.04	100	October 1998
31.04	110	October 1998
31.05	Contents	January 1998
31.05	050	January 1998
31.05	100	January 1998
31.05	110	January 1998
31.05	120	January 1998
31.05	130	January 1998
31.05	300	January 1998
31.06	Contents	January 1998
31.06	050	January 1998
31.06	100	January 1998
31.06	110	January 1998
31.07	Contents	April 2003
31.07	050	April 2003
31.07	100	April 2003
31.07	110	April 2003
31.07	300	April 2003
31.08	Contents	January 1996
31.08	050	January 1996
31.08	100	January 1996
31.09	Contents	March 1996
31.09	050	March 1996
31.09	100	March 1996
31.09	110	March 1996

Section Number	Subject Number	Current Date
31.10	Contents	March 1996
31.10	050	March 1996
31.10	100	March 1996
31.10	110	March 1996
31.11	Contents	March 1996
31.11	050	March 1996
31.11	100	March 1996
31.11	110	March 1996
31.12	Contents	June 2002
31.12	100	June 2002
31.12	110	June 2002
31.13	Contents	June 2002
31.13	100	June 2002
31.14	Contents	June 2002
31.14	050	June 2002
31.14	100	June 2002
31.15	Contents	April 2003
31.15	050	April 2003
31.15	100	April 2003
31.15	110	April 2003
31.15	300	April 2003

Section Number	Subject Number	Current Date
32 Group Index	—	October 1999
32.00	Contents	January 1996
32.00	050	January 1996
32.00	100	January 1999
32.00	110	January 1996
32.00	120	January 1996
32.00	300	January 1996
32.00	400	October 1999
32.01	Contents	January 1996
32.01	050	January 1996
32.01	100	January 1996
32.01	300	January 1996
32.02	Contents	January 1996
32.02	050	January 1996
32.02	100	January 1996
32.02	110	June 1996
32.02	120	January 1996
32.02	130	January 1996
32.02	400	October 1999

Century Class Trucks Workshop Manual
Validity List

Section Number	Subject Number	Current Date
32.03	Contents	January 1996
32.03	050	January 1996
32.03	100	January 1996
32.03	110	January 1996
32.03	120	June 1996
32.03	130	January 1996
32.03	140	January 1996
32.03	400	October 1999
32.04	Contents	January 1998
32.04	050	July 1997
32.04	100	January 1996
32.04	110	October 1999
32.04	120	January 1996
32.04	130	June 2001
32.04	140	January 1996
32.04	150	March 1996
32.04	155	July 1997
32.04	160	March 1996
32.04	170	August 2003
32.04	180	March 1996
32.04	190	October 1997
32.04	400	June 2004
32.05	Contents	March 1996
32.05	050	June 1996
32.05	100	March 1996
32.05	110	March 1996
32.05	115	March 1996
32.05	117	March 1996
32.05	120	March 1996
32.05	130	March 1996
32.05	140	March 1996
32.05	300	March 1996
32.05	400	October 1999
32.06	Contents	March 1996
32.06	050	March 1996
32.06	100	July 1999
32.06	110	March 1996
32.06	120	March 1996
32.06	130	March 1996
32.06	140	March 1996
32.06	150	March 1996
32.06	160	March 1996
32.06	400	March 1996
32.07	Contents	March 1996
32.07	050	March 1996
32.07	100	March 1996
32.07	110	March 1996
32.07	120	March 1996
32.07	130	March 1996
32.07	140	March 1996
32.07	150	March 1996
32.07	160	March 1996
32.07	400	March 1996
32.08	Contents	October 1999
32.08	050	October 1999
32.08	100	October 1999
32.08	110	October 1999
32.08	115	October 1999
32.08	120	October 1999
32.08	125	October 1999
32.08	130	October 1999
32.08	135	October 1999
32.08	137	October 1999
32.08	140	October 1999
32.08	145	October 1999
32.08	150	October 1999
32.08	160	October 1999
32.08	165	October 1999
32.08	170	October 1999
32.08	180	October 1999
32.08	300	October 1999
32.08	400	October 1999
32.09	Contents	October 1996
32.09	050	June 1996
32.09	100	June 1996
32.09	110	June 1996
32.09	120	June 1996
32.09	300	October 1996
32.09	400	June 1996
32.10	Contents	June 1996
32.10	050	April 1998
32.10	100	June 1996
32.10	110	April 1998
32.10	120	April 1998

Century Class Trucks Workshop Manual
Validity List

Section Number	Subject Number	Current Date
32.10	130	April 1998
32.10	140	April 1998
32.10	150	June 1996
32.10	160	June 1996
32.10	170	June 1996
32.10	180	April 1998
32.10	190	June 1996
32.10	300	June 1996
32.10	400	June 1996
32.11	Contents	June 1996
32.11	050	June 1996
32.11	100	June 1996
32.11	110	June 1996
32.11	120	June 1996
32.11	130	June 1996
32.11	140	June 1996
32.11	150	June 1996
32.11	160	June 1996
32.11	170	June 1996
32.11	400	June 1996
32.13	Contents	December 2001
32.13	050	October 1999
32.13	100	October 1999
32.13	110	October 1999
32.13	120	December 2001
32.13	130	October 1999
32.13	140	December 2001
32.13	150	December 2001
32.13	400	December 2001

Section Number	Subject Number	Current Date
33 Group Index	—	October 1998
33.00	Contents	October 1998
33.00	050	October 1998
33.00	100	January 1996
33.00	110	January 1996
33.00	120	January 1996
33.00	130	January 1996
33.00	140	January 1996
33.00	150	January 1996
33.00	160	October 1998
33.00	400	June 2001

Section Number	Subject Number	Current Date
33.01	Contents	August 2003
33.01	050	October 1998
33.01	100	October 1998
33.01	105	January 1996
33.01	110	January 1996
33.01	115	January 1996
33.01	120	January 1996
33.01	125	January 1996
33.01	130	January 1996
33.01	135	January 1999
33.01	140	August 2003
33.01	145	August 2003
33.01	150	October 1998
33.01	300	January 1996
33.01	400	June 1996
33.02	Contents	December 2001
33.02	050	January 1996
33.02	100	December 2001
33.02	110	December 2001
33.02	120	December 2001
33.02	130	December 2001
33.02	400	December 2001

Section Number	Subject Number	Current Date
35 Group Index	—	January 1996
35.00	Contents	January 1996
35.00	050	January 1996
35.00	100	June 2001
35.00	110	January 1996
35.00	120	January 1996
35.00	400	June 2001
35.01	Contents	October 1998
35.01	050	October 1998
35.01	100	October 1998
35.01	105	January 1996
35.01	110	January 1996
35.01	115	January 1996
35.01	120	January 1996
35.01	125	January 1996
35.01	130	January 1996
35.01	135	January 1999
35.01	140	January 1996

Century Class Trucks Workshop Manual
Validity List

Section Number	Subject Number	Current Date
35.01	150	October 1998
35.01	300	January 1996
35.01	400	June 2001
35.02	Contents	December 2001
35.02	050	January 1996
35.02	100	December 2001
35.02	110	December 2001
35.02	120	December 2001
35.02	130	December 2001
35.02	400	December 2001

Section Number	Subject Number	Current Date
40 Group Index	—	January 1996
40.00	Contents	June 2001
40.00	050	January 1996
40.00	100	June 2001
40.00	110	June 2001
40.00	120	January 1998
40.00	130	January 1996
40.00	140	January 1996
40.00	150	January 1996
40.00	160	January 1996
40.00	170	January 1996
40.00	180	January 1996
40.00	190	January 1996
40.00	200	January 1996
40.00	210	January 1996
40.00	300	January 1996
40.00	400	June 2001

Section Number	Subject Number	Current Date
41 Group Index	—	January 1996
41.00	Contents	January 1996
41.00	050	October 1999
41.00	100	October 1999
41.00	110	October 1999
41.00	120	October 1999
41.00	130	October 1999
41.00	140	January 1997
41.00	150	October 1999
41.00	300	October 1999
41.00	400	October 1999

Section Number	Subject Number	Current Date
41.01	Contents	January 1996
41.01	050	January 1996
41.01	100	January 1996
41.01	110	January 1996
41.01	400	January 1996

Section Number	Subject Number	Current Date
42 Group Index	—	December 2001
42.00	Contents	January 1996
42.00	050	January 1996
42.00	100	January 1996
42.00	110	January 1996
42.00	120	October 1999
42.00	130	January 1996
42.01	Contents	January 1996
42.01	050	January 1996
42.01	100	January 1996
42.01	110	January 1996
42.01	120	January 1996
42.02	Contents	January 1996
42.02	050	January 1996
42.02	100	January 1996
42.02	110	January 1996
42.02	120	January 1996
42.02	130	January 1996
42.02	300	January 1996
42.03	Contents	January 1996
42.03	050	January 1996
42.03	100	January 1996
42.03	110	January 1996
42.03	120	January 1996
42.04	Contents	October 1998
42.04	050	October 1998
42.04	100	October 1998
42.04	110	October 1998
42.04	120	October 1998
42.04	130	October 1998
42.04	140	October 1998
42.04	150	October 1998
42.04	300	October 1998
42.04	400	October 1998
42.05	Contents	October 1999

Century Class Trucks Workshop Manual
Validity List

Section Number	Subject Number	Current Date
42.05	050	October 1999
42.05	100	October 1999
42.05	110	July 1997
42.05	400	October 1999
42.06	Contents	January 1996
42.06	050	January 1996
42.06	100	January 1996
42.06	110	January 1996
42.06	115	January 1996
42.06	120	January 1996
42.06	400	January 1996
42.07	Contents	January 1996
42.07	050	January 1996
42.07	100	January 1996
42.07	110	January 1996
42.07	120	January 1996
42.07	130	January 1996
42.07	400	January 1996
42.08	Contents	April 1998
42.08	050	July 1998
42.08	100	January 1996
42.08	110	April 1997
42.08	120	June 1996
42.08	130	April 1997
42.08	140	April 1998
42.08	300	April 1998
42.08	400	June 1996
42.09	Contents	January 1996
42.09	050	January 1996
42.09	100	January 1996
42.09	110	January 1996
42.09	120	January 1996
42.10	Contents	January 1996
42.10	050	January 1996
42.10	300	January 1996
42.11	Contents	January 1996
42.11	050	January 1996
42.11	100	January 1996
42.11	110	January 1996
42.11	120	January 1996
42.11	130	January 1996
42.12	Contents	September 2000
42.12	050	September 2000
42.12	100	September 2000
42.12	300	January 1996
42.13	Contents	January 1996
42.13	100	January 1996
42.13	400	January 1996
42.14	Contents	January 1996
42.14	050	January 1996
42.14	100	January 1996
42.14	110	January 1996
42.14	120	January 1996
42.14	125	January 1996
42.14	130	January 1996
42.14	140	January 1996
42.14	400	January 1996
42.15	Contents	January 1996
42.15	050	October 1997
42.15	100	January 1996
42.15	110	January 1996
42.15	120	January 1996
42.16	Contents	January 1996
42.16	050	January 1996
42.16	100	January 1996
42.16	110	January 1996
42.16	120	January 1996
42.16	130	January 1996
42.16	400	January 1996
42.17	Contents	January 1996
42.17	050	January 1996
42.17	100	October 1999
42.17	110	January 1996
42.17	115	January 1996
42.17	120	January 1996
42.17	400	October 1999
42.18	Contents	January 1996
42.18	050	January 1996
42.18	100	January 1996
42.18	110	January 1996
42.18	120	January 1996
42.18	130	January 1996
42.19	Contents	October 1998
42.19	050	October 1998

Century Class Trucks Workshop Manual
Validity List

Section Number	Subject Number	Current Date
42.19	100	October 1998
42.19	110	October 1998
42.19	120	October 1998
42.19	130	October 1998
42.19	400	October 1998
42.20	Contents	January 1996
42.20	050	January 1996
42.20	100	January 1996
42.20	400	January 1996
42.21	Contents	January 1996
42.21	050	January 1996
42.21	100	January 1996
42.21	110	January 1996
42.21	120	January 1996
42.21	130	January 1996
42.22	Contents	January 1996
42.22	050	January 1996
42.22	100	January 1996
42.22	110	January 1996
42.22	120	January 1996
42.22	130	January 1996
42.23	Contents	June 1996
42.23	100	January 1999
42.23	110	January 1999
42.24	Contents	October 1997
42.24	050	October 1997
42.24	100	October 1997
42.24	110	October 1997
42.24	120	October 1997
42.24	130	October 1997
42.24	400	January 1999
42.25	Contents	January 1998
42.25	050	January 1998
42.25	100	January 1998
42.25	110	January 1998
42.25	120	January 1998
42.25	130	January 1998
42.25	140	January 1998
42.25	150	January 1998
42.25	160	January 1998
42.25	170	January 1998
42.25	180	January 1998

Section Number	Subject Number	Current Date
42.25	190	January 1998
42.25	200	January 1998
42.25	210	January 1998
42.25	300	January 1998
42.25	400	January 1998
42.27	Contents	October 1998
42.27	050	October 1998
42.27	100	October 1998
42.27	110	October 1998
42.27	120	October 1998
42.27	130	October 1998
42.27	140	October 1998
42.27	150	October 1998
42.27	160	October 1998
42.27	170	October 1998
42.27	300	October 1998
42.28	Contents	January 1999
42.28	050	January 1999
42.28	100	January 1999
42.28	110	January 1999
42.28	120	January 1999
42.28	130	January 1999
42.28	300	January 1999
42.28	400	January 1999
42.29	Contents	December 1999
42.29	050	December 1999
42.29	100	December 1999
42.29	110	December 1999
42.29	120	December 1999
42.29	300	December 1999
42.29	400	December 1999
42.30	Contents	December 2001
42.30	050	December 2001
42.30	100	December 2001
42.30	110	December 2001

Section Number	Subject Number	Current Date
46 Group Index	—	October 2002
46.00	Contents	October 1999
46.00	050	October 1999
46.00	100	September 2000
46.00	110	January 1996

Century Class Trucks Workshop Manual
Validity List

Section Number	Subject Number	Current Date
46.00	300	January 1996
46.00	400	April 2003
46.01	Contents	October 1999
46.01	050	October 1999
46.01	100	October 1999
46.01	110	April 2003
46.01	120	October 1999
46.01	130	October 1999
46.01	140	October 1999
46.01	300	October 1999
46.01	305	October 1999
46.01	400	April 2003
46.02	Contents	January 1996
46.02	050	January 1996
46.02	100	October 1998
46.02	110	January 1996
46.02	300	January 1996
46.02	400	April 2003
46.03	Contents	June 1996
46.03	050	January 1996
46.03	100	October 1998
46.03	110	January 1996
46.03	120	June 1996
46.04	Contents	December 1999
46.04	050	October 1999
46.04	100	October 1999
46.04	110	October 1999
46.04	120	December 1999
46.04	400	October 1999
46.05	Contents	June 2001
46.05	050	June 2001
46.05	100	Apirl 2003
46.05	110	June 2001
46.05	120	June 2001
46.05	130	June 2001
46.05	140	June 2001
46.05	150	June 2001
46.05	160	June 2001
46.05	170	June 2001
46.05	300	June 2001
46.05	305	June 2001
46.05	400	June 2001

Section Number	Subject Number	Current Date
46.06	Contents	January 1996
46.06	050	October 1999
46.06	100	June 2001
46.06	110	June 2001
46.06	400	June 2001
46.07	Contents	January 1996
46.07	050	October 1999
46.07	100	June 2001
46.07	110	June 2001
46.07	400	June 2001
46.08	Contents	April 1997
46.08	050	April 1997
46.08	100	April 1997
46.08	110	April 1997
46.08	300	April 1997
46.08	400	April 1997
46.09	Contents	June 2002
46.09	050	June 2001
46.09	100	June 2001
46.09	110	June 2001
46.09	120	June 2001
46.09	130	June 2001
46.09	140	June 2002
46.10	Contents	June 2001
46.10	050	June 2001
46.10	100	June 2001
46.10	300	June 2001
46.10	400	April 2003
46.11	Contents	October 2002
46.11	050	October 2002
46.11	100	April 2003
46.11	110	October 2002
46.11	120	October 2002
46.11	130	October 2002
46.11	140	October 2002
46.11	150	October 2002
46.11	160	October 2002
46.11	170	October 2002
46.11	180	October 2002
46.11	190	October 2002
46.11	200	October 2002
46.11	300	October 2002

Century Class Trucks Workshop Manual
Validity List

Section Number	Subject Number	Current Date
46.11	310	October 2002
46.11	400	October 2002
46.12	Contents	June 2002
46.12	050	June 2002
46.12	100	June 2002

Section Number	Subject Number	Current Date
47 Group Index	—	March 1996
47.00	Contents	January 1996
47.00	050	January 1996
47.00	100	January 1996
47.00	110	January 1996
47.00	120	January 1996
47.01	Contents	March 1996
47.01	050	March 1996
47.01	100	March 1996
47.01	110	March 1996
47.01	300	March 1996
47.01	400	March 1996
47.02	Contents	January 1999
47.02	050	January 1999
47.02	100	January 1999
47.02	110	January 1999
47.02	120	January 1999
47.02	130	January 1999
47.02	300	January 1999
47.03	Contents	March 1996
47.03	050	March 1996
47.03	100	March 1996
47.04	Contents	March 1996
47.04	050	March 1996
47.04	100	March 1996
47.05	Contents	March 1996
47.05	050	March 1996
47.05	100	March 1996
47.05	300	March 1996
47.05	400	March 1996

Section Number	Subject Number	Current Date
49 Group Index	—	January 1996
49.00	Contents	June 2002
49.00	050	June 2002
49.00	100	September 2000
49.00	110	June 2002
49.00	120	June 2002
49.00	130	June 2002
49.00	140	June 2002
49.00	150	June 2002
49.00	160	June 2002
49.00	170	June 2002

Section Number	Subject Number	Current Date
54 Group Index	—	June 2001
54.00	Contents	April 1997
54.00	050	April 1997
54.00	100	April 1997
54.00	400	January 1999
54.01	Contents	October 1997
54.01	050	October 1998
54.01	100	June 2002
54.01	110	October 1998
54.01	120	October 1997
54.01	130	April 2003
54.01	300	June 1996
54.01	400	April 1997
54.02	Contents	April 1997
54.02	050	October 1998
54.02	100	January 1996
54.02	110	January 1996
54.02	120	April 1997
54.02	130	April 1997
54.02	140	June 2004
54.02	150	April 1997
54.02	160	October 1998
54.02	300	January 1996
54.02	400	April 1997
54.03	Contents	April 1997
54.03	050	October 1999
54.03	100	October 1999
54.03	110	October 1999
54.03	120	October 1999
54.03	130	April 1997
54.03	140	October 1999
54.03	150	January 1999

Century Class Trucks Workshop Manual
Validity List

Section Number	Subject Number	Current Date
54.03	160	October 1999
54.03	170	October 1997
54.03	180	October 1997
54.03	190	October 1997
54.03	200	October 1997
54.03	210	October 1997
54.03	220	October 1997
54.03	300	October 1997
54.03	400	October 1997
54.04	Contents	October 1998
54.04	050	October 1998
54.04	100	October 1998
54.04	300	October 1999
54.04	400	October 1998
54.05	Contents	January 1996
54.05	050	October 1998
54.05	100	October 1998
54.05	110	October 1998
54.05	300	December 1999
54.05	400	October 1998
54.06	Contents	October 1999
54.06	050	October 1998
54.06	100	October 1998
54.06	110	October 1998
54.06	300	October 1999
54.06	400	April 1997
54.07	Contents	March 1996
54.07	050	January 1996
54.07	100	March 1996
54.07	300	January 1996
54.08	Contents	January 1997
54.08	050	July 1998
54.08	100	January 1997
54.08	110	January 1997
54.08	120	January 1997
54.08	130	January 1997
54.08	300	January 1997
54.08	400	January 1997
54.09	Contents	January 1997
54.09	100	January 1997
54.09	110	January 1997
54.10	Contents	April 1997
54.10	400	July 1998
54.11	Contents	April 1997
54.11	400	July 1998
54.12	Contents	April 1997
54.12	400	July 1998
54.13	Contents	October 1997
54.13	050	October 1997
54.13	100	October 1997
54.13	110	October 1997
54.13	120	October 1997
54.13	130	October 1997
54.13	140	October 1997
54.13	150	October 1997
54.13	160	October 1997
54.13	300	October 1997
54.13	400	October 1997
54.14	Contents	October 1999
54.14	050	January 1999
54.14	100	October 1998
54.14	110	October 1998
54.14	300	October 1999
54.14	400	October 1998
54.15	Contents	April 1998
54.15	050	October 1999
54.15	100	October 1999
54.15	110	October 1999
54.15	120	October 1999
54.15	130	October 1999
54.15	140	October 1999
54.15	150	October 1999
54.15	160	October 1999
54.15	170	October 1999
54.15	180	October 1999
54.15	190	October 1999
54.15	200	October 1999
54.15	300	October 1999
54.15	400	October 1999
54.16	Contents	April 1998
54.16	050	April 1998
54.16	100	April 1998
54.16	110	April 1998
54.16	300	October 1999

Century Class Trucks Workshop Manual
Validity List

Section Number	Subject Number	Current Date
54.16	400	April 1998
54.17	Contents	April 1998
54.17	050	April 1998
54.17	300	April 1998
54.18	Contents	April 1998
54.18	050	April 1998
54.18	100	April 1998
54.18	110	April 1998
54.18	300	April 1998
54.18	400	April 1998
54.19	Contents	October 1999
54.19	050	October 1999
54.19	100	October 1999
54.19	110	April 1998
54.19	120	April 1998
54.19	130	April 1998
54.19	140	April 1998
54.19	150	April 1998
54.19	300	October 1999
54.19	400	October 1999
54.20	Contents	January 1999
54.20	050	January 1999
54.20	100	January 1999
54.20	110	January 1999
54.20	120	January 1999
54.20	400	January 1999
54.22	Contents	October 1999
54.22	050	October 1999
54.22	100	October 1999
54.22	110	October 1999
54.22	120	October 1999
54.22	130	October 1999
54.22	140	October 1999
54.22	150	October 1999
54.22	160	December 1999
54.22	170	October 1999
54.22	180	December 1999
54.22	300	October 1999
54.22	400	October 1999
54.23	Contents	June 2000
54.23	050	June 2000
54.23	100	June 2000
54.23	300	June 2000
54.23	400	June 2000
54.24	Contents	June 2001
54.24	100	June 2001
54.24	400	June 2001
54.24	410	June 2001
54.24	420	June 2001

Section Number	Subject Number	Current Date
60 Group Index	—	June 2002
60.00	Contents	October 1998
60.00	050	January 1997
60.00	100	October 1998
60.00	110	October 1998
60.00	120	October 1998
60.00	130	October 1998
60.00	400	January 1999
60.01	Contents	January 1999
60.01	050	January 1999
60.01	100	August 2003
60.01	110	January 1999
60.01	120	January 1999
60.01	130	January 1999
60.01	140	January 1999
60.01	150	June 2004
60.01	300	January 1999
60.01	400	January 1999
60.02	Contents	January 1999
60.02	050	January 1996
60.02	100	January 1996
60.02	110	January 1999
60.03	Contents	January 1997
60.03	100	April 1997
60.03	110	January 1997
60.04	Contents	October 1996
60.04	050	October 1996
60.04	100	January 1997
60.04	110	October 1996
60.04	120	October 1996
60.05	Contents	January 1999
60.05	100	January 1996
60.05	110	January 1999

Century Class Trucks Workshop Manual
Validity List

Section Number	Subject Number	Current Date
60.06	Contents	October 1999
60.06	050	October 1998
60.06	100	April 1997
60.06	110	October 1996
60.06	120	April 1997
60.06	130	October 1999
60.06	140	October 1999
60.06	150	October 1999
60.06	160	October 1999
60.06	400	January 1996
60.07	Contents	January 1996
60.07	050	January 1996
60.07	100	January 1996
60.07	110	January 1996
60.07	120	October 1997
60.07	130	January 1996
60.07	140	January 1996
60.07	150	January 1996
60.07	160	July 1997
60.07	170	January 1996
60.07	180	January 1996
60.07	400	June 2004
60.08	Contents	October 1998
60.08	100	October 1998
60.08	110	October 1998
60.09	Contents	March 1996
60.09	100	March 1996
60.10	Contents	January 1997
60.10	100	January 1997
60.11	Contents	April 1997
60.11	050	October 1998
60.11	100	April 1997
60.11	110	April 1997
60.11	120	April 1997
60.11	130	April 1997
60.11	400	April 1997
60.12	Contents	October 1996
60.12	100	October 1996
60.13	Contents	October 1998
60.13	100	October 1998
60.13	110	October 1998
60.14	Contents	October 1997

Section Number	Subject Number	Current Date
60.14	100	October 1997
60.15	Contents	October 1998
60.15	050	October 1998
60.15	060	October 1998
60.15	100	October 1998
60.15	110	October 1998
60.15	120	October 1998
60.15	130	October 1998
60.15	140	October 1998
60.15	300	October 1998
60.15	400	October 1998
60.16	Contents	June 2002
60.16	100	October 1998
60.16	110	June 2002
60.17	Contents	January 1999
60.17	050	January 1999
60.17	100	January 1999
60.17	110	January 1999
60.19	Contents	October 1999
60.19	100	October 1999
60.20	Contents	June 2000
60.20	050	October 1998
60.20	100	January 1999
60.20	110	January 1999
60.20	120	January 1999
60.20	130	January 1999
60.20	140	January 1999
60.20	150	January 1999
60.20	160	December 1999
60.20	170	December 1999
60.20	400	June 2000
60.21	Contents	June 2002
60.21	100	June 2002

Section Number	Subject Number	Current Date
72 Group Index	—	January 1996
72.00	Contents	December 1999
72.00	050	July 1998
72.00	100	January 1996
72.00	110	December 1999
72.00	120	December 1999
72.00	140	January 1996

Century Class Trucks Workshop Manual
Validity List

Section Number	Subject Number	Current Date
72.00	145	January 1996
72.00	147	October 1996
72.00	150	January 1996
72.00	160	October 1997
72.00	170	December 1999
72.00	175	October 1999
72.00	180	August 2003
72.00	190	January 1996
72.00	200	October 1999
72.00	400	October 1999

Section Number	Subject Number	Current Date
82 Group Index	—	October 1998
82.00	Contents	January 1996
82.00	050	January 1996
82.00	100	October 1999
82.00	110	October 1997
82.00	120	January 1996
82.00	300	January 1996
82.00	400	October 1997
82.01	Contents	October 1998
82.01	050	October 1998
82.01	100	January 1999
82.01	110	January 1999
82.01	120	October 1998
82.01	400	October 1998

Section Number	Subject Number	Current Date
83 Group Index	—	April 2003
83.00	Contents	January 1996
83.00	050	January 1996
83.00	100	June 2004
83.00	110	January 1996
83.00	120	June 2001
83.00	130	October 1999
83.00	140	June 1996
83.00	150	January 1996
83.00	160	January 1996
83.00	170	January 1996
83.00	400	June 2004
83.01	Contents	January 1996
83.01	050	December 1999
83.01	100	January 1996
83.01	110	January 1996
83.01	120	June 2001
83.01	130	December 1999
83.01	140	January 1996
83.01	150	January 1996
83.01	160	January 1996
83.01	400	June 2001
83.02	Contents	October 2002
83.02	050	October 2002
83.02	100	October 2002
83.02	105	October 2002
83.02	110	October 2002
83.02	120	October 2002
83.02	130	October 2002
83.02	140	October 2002
83.02	150	October 2002
83.02	160	October 2002
83.02	170	October 2002
83.02	180	October 2002
83.02	190	October 2002
83.02	200	October 2002
83.02	210	October 2002
83.02	220	October 2002
83.02	230	October 2002
83.02	240	October 2002
83.02	250	April 2003
83.02	260	October 2002
83.02	270	October 2002
83.02	280	October 2002
83.02	290	October 2002
83.02	300	October 2002
83.02	400	October 2002
83.03	Contents	October 2002
83.03	050	October 2002
83.03	100	October 2002
83.03	110	October 2002
83.03	120	October 2002
83.03	130	October 2002
83.03	140	October 2002
83.03	150	October 2002
83.03	160	October 2002

Century Class Trucks Workshop Manual
Validity List

Section Number	Subject Number	Current Date
83.03	170	October 2002
83.03	300	October 2002
83.03	400	October 2002
83.04	Contents	April 2003
83.04	050	April 2003
83.04	100	June 2002
83.04	110	June 2002
83.04	120	June 2002
83.04	130	August 2003
83.04	140	June 2002
83.04	150	April 2003
83.04	160	June 2002
83.04	170	June 2002
83.04	180	June 2002
83.04	190	June 2002
83.04	200	June 2002
83.04	210	April 2003
83.04	220	April 2003
83.04	230	June 2002
83.04	240	October 2002
83.04	400	April 2003
83.05	Contents	April 2003
83.05	050	June 2002
83.05	100	June 2002
83.05	110	October 2002
83.05	120	October 2002
83.05	130	October 2002
83.05	140	October 2002
83.05	150	June 2002
83.05	160	June 2002
83.05	170	October 2002
83.05	180	June 2002
83.05	400	April 2003
83.06	Contents	April 2003
83.06	300	June 2004

Section Number	Subject Number	Current Date
88 Group Index	—	January 1996
88.00	Contents	June 2002
88.00	050	June 2002
88.00	100	June 2004
88.00	110	June 2004
88.00	120	June 2004
88.00	130	January 1997
88.00	140	June 2004
88.00	150	June 2002
88.00	160	June 2002
88.00	400	April 1997

Section Number	Subject Number	Current Date
90 Group Index	—	June 2001
90.00	Contents	June 2001
90.00	050	June 2001
90.00	100	June 2001
90.00	110	June 2001
90.00	120	June 2001
90.00	130	June 2001
90.00	140	June 2001
90.00	150	June 2001
90.00	300	June 2001
90.00	400	June 2001

Section Number	Subject Number	Current Date
91 Group Index	—	June 2002
91.00	Contents	June 1996
91.00	050	June 1996
91.00	100	June 1996
91.00	110	June 1996
91.00	120	June 1996
91.00	130	June 1996
91.00	140	June 1996
91.00	150	June 1996
91.00	160	June 1996
91.00	400	June 1996
91.01	Contents	October 1997
91.01	050	October 1997
91.01	100	October 1997
91.01	110	October 1997
91.01	120	October 1997
91.01	130	October 1997
91.01	140	October 1997
91.01	150	October 1997
91.01	160	October 1997
91.01	400	October 1997

Century Class Trucks Workshop Manual
Validity List

Section Number	Subject Number	Current Date
91.02	Contents	April 1997
91.02	050	June 1996
91.02	100	June 1996
91.02	110	June 1996
91.02	120	June 1996
91.02	130	June 1996
91.02	140	June 1996
91.02	150	June 1996
91.02	160	June 1996
91.02	170	June 1996
91.02	400	April 1997
91.03	Contents	January 1996
91.03	100	January 1996
91.04	Contents	June 1996
91.04	100	June 1996
91.04	110	June 1996
91.05	Contents	June 2002
91.05	050	June 2001
91.05	100	June 2001
91.05	110	June 2001
91.05	120	June 2001
91.05	130	June 2001
91.05	140	June 2001
91.05	150	June 2001
91.05	160	June 2002
91.05	300	June 2001
91.06	Contents	June 2002
91.06	100	June 2002

Section Number	Subject Number	Current Date
98 Group Index	—	January 1996
98.00	Contents	June 2000
98.00	050	June 2000
98.00	100	June 2000
98.00	110	June 2000
98.00	120	April 2003
98.00	130	June 2000
98.00	400	June 2000

Section	Subject	Current Date
Index	—	June 2004

Group Index, Alphabetical

Section	Section Number
Decking Devices	00.06
List of Abbreviations	00.01
Metric/U.S. Customary Conversion Chart	00.02
Threaded Fasteners	00.05
Vehicle Identification Numbering System	00.04
Vehicle Receipt, Storage, and Pre-Delivery Information	00.03

List of Abbreviations

The following is a list of definitions for abbreviations and symbols used in Freightliner publications.

A ..... amperes
ABS ..... antilock braking system
ABS ..... acrylonitrile-butadiene-styrene
A/C ..... air conditioner
AC ..... alternating current
ACPU ..... air conditioning protection unit
ADLO ..... auto-disengagement lockout
a.m. ..... *ante meridiem* (midnight to noon)
AM ..... amplitude modulation
amp(s) .... ampere(s)
AMU ..... air management unit
ANSI ..... American National Standards Institute
API ..... American Petroleum Institute
ARI ..... Air Conditioning and Refrigeration Institute
ASA ..... American Standards Association
ASF ..... American Steel Foundries
ASR ..... automatic spin regulator
assy. ..... assembly
ASTM ..... American Society for Testing and Materials
ATC ..... automatic temperature control
ATC ..... automatic traction control
ATC ..... automatic transmission control
ATF ..... automatic transmission fluid
attn ..... attention
aux. ..... auxiliary
av ..... *avoirdupois* (British weight system)
AWG ..... American wire gauge
AWS ..... American Welding Society
BAT ..... battery
BBC ..... bumper-to-back-of-cab
BOM ..... bill of material
BTDC ..... before top dead center
Btu(s) ..... British thermal unit(s)
C ..... common (terminal)
CAC ..... charge air cooler
CAN ..... controller area network
CARB ..... California Air Resources Board
CAT ..... Caterpillar
CB ..... circuit breaker
CB ..... citizens' band
CCA ..... cold cranking amperes
CD-ROM .. compact-disc/read-only memory
CDTC ..... constant discharge temperature control
CEL ..... check-engine light
CFC ..... chlorofluorocarbons (refrigerant-12)
cfm ..... cubic feet per minute
CFR ..... Code of Federal Regulations
CLS ..... coolant level sensor
cm ..... centimeters
cm^3 ..... cubic centimeters
CMVSS .... Canadian Motor Vehicle Safety Standard
Co. ..... company
COE ..... cab over engine
Corp. ..... corporation
CPU ..... central processing unit
cSt ..... centistokes (unit of measurement for describing the viscosity of general liquids)
cu ft ..... cubic feet
cu in ..... cubic inches
CUM ..... Cummins
CWS ..... collision warning system
DC ..... direct current
DDA ..... Detroit Diesel Allison
DDC ..... Detroit Diesel Corporation
DDE ..... Detroit Diesel Engines
DDEC ..... Detroit Diesel Electronic (engine) control
DDR ..... diagnostic data reader
DDU ..... driver display unit
DGPS ..... differential global positioning system
dia. ..... diameter
DIP ..... dual inline package (switch)
DLA ..... data link adaptor
DLU ..... data logging unit
DMM ..... digital multimeter
DOT ..... Department of Transportation
DRL ..... daytime running lights
DRM ..... dryer reservoir module
DSM ..... district service manager
DTC ..... discharge temperature control
DVOM ..... digital volt/ohm meter
ea. ..... each
EBS ..... electronic braking system
ECAP ..... electronic control analyzer programmer
ECAS ..... electronically controlled air suspension
ECI ..... electronically controlled injection
ECM ..... electronic control module
ECU ..... electronic control unit
EDM ..... electronic data monitor
EEPROM .. electrically erasable programmable read-only memory
EMI ..... electromagnetic interference
EOA ..... electric over air
EP ..... extreme pressure (describes an antiwear agent added to some lubricants)
EPA ..... Environmental Protection Agency
EPS ..... engine position sensor
etc. ..... *et cetera* (and so forth)
ETEC ..... electronic truck engine control
EUI ..... electronic unit (fuel) injectors
FAS ..... Freightliner air suspension
Fig. ..... figure
fl oz ..... fluid ounces
FLA ..... post-1984 advancements Freightliner COE
FLB ..... enhanced Freightliner FLA COE
FLC ..... steel-cab Freightliner 112 Conventional
FLD ..... post-1984 advancements Freightliner 112/120 aluminum-cab Conventional
FM ..... frequency modulation
FMCSA .... Federal Motor Carrier Safety Administration
FMI ..... failure mode identifier
FMSI ..... Friction Materials Standards Institute
FMVSS .... Federal Motor Vehicle Safety Standard
FRP ..... fiberglass reinforced plastic
FSA ..... field service authorization
ft ..... feet
ft^3 ..... cubic feet
ft^3/min ..... cubic feet per minute
FTL ..... Freightliner
F.U.E.L. .... fuel usage efficiency level
g ..... grams

List of Abbreviations

gal ..... gallons
GAWR ..... gross axle weight rating
GL ..... gear lubricant
GND ..... ground
gpm ..... gallons per minute
GPS ..... global positioning system
GVWR ..... gross vehicle weight rating
HCU ..... hydraulic control unit
HD ..... heavy-duty
HEPA ..... high-efficiency particulate air (filter)
HFC ..... hydrogenated fluorocarbons (refrigerant-134a)
hp ..... horsepower
hp ..... high pressure
HRC ..... Rockwell "C" hardness
hr(s) ..... hour(s)
htr ..... heater
HVAC ..... heating, ventilating and air conditioning
H/W ..... hardware
ICU ..... instrumentation control unit
i.d. ..... inside diameter
ID ..... identification
IFI ..... Industrial Fasteners Institute
IGN ..... ignition
ILO ..... *in lieu of* (in the place of)
in ..... inches
in^3 ..... cubic inches
Inc. ..... incorporated
inH_2O ..... inches of water
inHg ..... inches of mercury
IP ..... instrument panel
ISO ..... International Organization for Standardization
k ..... kilo (1000)
kg ..... kilograms
km ..... kilometers
km/h ..... kilometers per hour
kPa ..... kilo Pascals
kW ..... kilowatts
L ..... liters
lb ..... pounds
lbf·ft ..... pounds force feet
lbf·in ..... pounds force inches
LCD ..... liquid crystal display
LED ..... light-emitting diode
LH ..... left-hand
LH DR ..... left-hand drive
LHK ..... liters per hundred kilometers
LHS ..... low hydrogen steel
LLC ..... limited liability company
L/min ..... liters per minute
LPG ..... liquefied petroleum gas
m ..... meters
max. ..... maximum
MESA ..... Mining Enforcement Safety Act
mfr. ..... manufacturer
mi ..... miles
MID ..... message identifier
MIL ..... military specification
min. ..... minutes
min. ..... minimum
misc. ..... miscellaneous
mL ..... milliliters
mm ..... millimeters
mod. ..... module
mpg ..... miles per gallon
mph ..... miles per hour
MSHA ..... Mining Safety and Health Administration
MVDA ..... Motor Vehicle Dealers Association
n ..... negative (front axle wheel alignment specification)
N/A ..... not applicable
N·cm ..... Newton-centimeters
NC ..... normally closed (terminal or switch)
NHTSA .... National Highway Traffic Safety Administration
NIOSH ..... National Institute for Occupational Safety and Health
NLGI ..... National Lubricating Grease Institute
N·m ..... Newton-meters
NO ..... normally open (terminal or switch)
no. ..... number
NPT ..... national pipe thread
NPTF ..... national pipe thread fitting
NSBU ..... neutral start/backup
NT ..... nylon tube or nylon tubing
OCV ..... open circuit voltage
o.d. ..... outside diameter
O.D. ..... overdrive
OEM ..... original equipment manufacturer
OSHA ..... Occupational Safety and Health Administration
oz ..... ounces
ozf·in ..... ounces force inches
p ..... positive (front axle wheel alignment specification)
parm ..... parameter
PC ..... personal computer
PCB ..... printed circuit board
PDC ..... parts distribution center
PDM ..... power distribution module
PEEC ..... programmable electronic engine control
PID ..... parameter identifier
PLC ..... power line carrier
PLD ..... *Pumpe-Linie-Düse* (pump-line-nozzle)
p.m. ..... *post meridiem* (noon to midnight)
p/n ..... part number
PSA ..... pressure sensitive adhesive
psi ..... pounds per square inch
psia ..... pounds per square inch, atmosphere
psig ..... pounds per square inch, gauge
pt ..... pints
pt ..... points
PTCM ..... pressure time control module
PTO ..... power take-off
pvc ..... polyvinyl chloride
PWM ..... pulse width modulation
qt ..... quarts
qty. ..... quantity
R & O ..... rust inhibitors and oxidants
R–12 ..... refrigerant-12 (CFC)
R–134a .... refrigerant-134a (HFC)
RAM ..... random access memory
recirc ..... recirculation
Ref(s). ..... reference(s)
RFI ..... radio frequency interference
RH ..... right-hand
RH DR ..... right-hand drive
R/I ..... removal and installation
RMA ..... return material authorization
ROM ..... read-only memory
rpm ..... revolutions per minute
R/R ..... removal and replacement
RSG ..... road speed governor
RTV ..... room temperature vulcanizing

List of Abbreviations

RV ..... recreational vehicle
SAE ..... Society of Automotive Engineers
SB ..... service bulletin
SD ..... severe duty
SDU ..... step deployment unit
SEL ..... shutdown engine light
SI ..... service information
SI ..... *Système International*
SID ..... subsystem identifier
SMC ..... sheet molded compound
S/N ..... serial number
SPACE .... seat pretensioner activation for crash survival enhancement
SRT ..... standard repair time
SSD ..... side sensor display
SST ..... stainless steel
std. ..... standard
S/W ..... software
SW ..... switch
TAM ..... thermocouple amplifier module
TBS ..... turbo boost sensor
TCU ..... transmission control unit
TDC ..... top dead center
TDR ..... technician diagnostic routine
temp ..... temperature
TIG ..... tungsten inert gas
TPS ..... thermal protection switch
TPS ..... throttle position sensor
TRS ..... timing reference sensor
TSO ..... truck sales order
U.D. ..... underdrive
UNC ..... unified national coarse
UNF ..... unified national fine
U.S. ..... United States
U.S.A. ..... United States of America
USC ..... United States customary (measures)
V ..... volts
VDC ..... vehicle data computer
Vdc ..... volts, direct current
VIN ..... vehicle identification number
VIP ..... vehicle instrumentation and protection (Kysor)
VOC ..... volatile organic compounds
VOM ..... volt-ohmmeter
VSG ..... variable speed governor
VSS ..... vehicle speed sensor
WB ..... wire braid
WI ..... work instructions
WOT ..... wide open throttle
- ..... minus or negative
+ ..... plus or positive
± ..... plus-or-minus
> ..... greater than
< ..... less than
x ..... by (used in fastener size descriptions)
" ..... inches
° ..... degrees (of an angle)
°C ..... degrees Celsius (centigrade)
°F ..... degrees Fahrenheit
..... number
% ..... percent
& ..... and
© ..... copyright
™ ..... trademark
® ..... registered trademark

Major Component Manufacturers' Addresses

Maintenance and service publications are available by writing or calling the component manufacturers listed below. In some cases, there may be a small charge for the publication. **See Table 1.**

Component	Manufacturer and Address		
Alternator	Delco Remy Service Department P. O. Box 2439 Anderson, IN 46018	Leece-Neville Prestolite Electric Incorporated 400 Main Street Arcade, NY 14009	
Clutch	Dana Corporation Spicer Clutch Division P. O. Box 191 Auburn, IN 46706	Rockwell International Corporation Rockwell Clutch Company 2135 West Maple Road Troy, MI 48084	
Engine	Caterpillar, Incorporated Literature Orders Section 1335 S.W. Washington Peoria, IL 61602	Cummins Engine Company, Inc. Mail Code 41308 Box 3005 Columbus, IN 47202–3005	Detroit Diesel Corporation 13400 Outer Drive, West Detroit, MI 48239–4001
Front Axle and Rear Axle	Eaton Corporation Axle Division Field Service Department 739 East 140th Street Cleveland, OH 44110	Rockwell International Corporation Automotive Operations 2135 West Maple Road Troy, MI 48084	
Starter	Delco Remy Service Department P. O. Box 2439 Anderson, IN 46018		
Steering Gear	R.H. Sheppard Company, Incorporated P. O. Box 877 101 Philadelphia Street Hanover, PA 17331–0877	TRW Ross Gear Division 800 Heath Street Lafayette, IN 47902	
Steering Pump	TRW Commercial Steering Division P. O. Box 60 Lafayette, IN 47902–0060	Vickers Incorporated 1401 Crooks Road Troy, MI 48084	

00.00 Component Manufacturers and Addresses

Major Component Manufacturers' Addresses

Component	Manufacturer and Address		
Suspension	Chalmers Suspensions International P. O. Box 1000 Brampton, Ontario, Canada L6V 2L9		Hendrickson Suspension 800 South Frontage Road Woodridge, IL 60517–4904
	Neway Corporation A Division of Lear Siegler Incorporated P. O. Box 425 Muskegon, MI 49443–0425		Reyco Industries, Incorporated P. O. Box 2268 Springfield, MO 65801–2268
Transmission	Allison Transmission P. O. Box 894 Indianapolis, IN 46206–0894	Eaton Corporation Fuller Transmission Division P. O. Box 4013 Kalamazoo, MI 49003	Rockwell International Corporation Automotive Operations 2135 West Maple Road Troy, MI 48084

Table 1, Major Component Manufacturers' Addresses

Metric/U.S. Customary Conversion Chart

U.S. Customary to Metric			Metric to U.S. Customary		
When You Know	**Multiply By**	**To Get**	**When You Know**	**Multiply By**	**To Get**
Length					
inches (in)	25.4	millimeters (mm)	0.03937		inches (in)
inches (in)	2.54	centimeters (cm)	0.3937		inches (in)
feet (ft)	0.3048	meters (m)	3.281		feet (ft)
yards (yd)	0.9144	meters (m)	1.094		yards (yd)
miles (mi)	1.609	kilometers (km)	0.6215		miles (mi)
Area					
square inches (in^2)	645.16	square millimeters (m^2)	0.00155		square inches (in^2)
square inches (in^2)	6.452	square centimeters (cm^2)	0.15		square inches (in^2)
square feet (ft^2)	0.0929	square meters (m^2)	10.764		square feet (ft^2)
Volume					
cubic inches (in^3)	16387.0	cubic millimeters (mm^3)	0.000061		cubic inches (in^3)
cubic inches (in^3)	16.387	cubic centimeters (cm^3)	0.06102		cubic inches (in^3)
cubic inches (in^3)	0.01639	liters (L)	61.024		cubic inches (in^3)
fluid ounces (fl oz)	29.54	milliliters (mL)	0.03381		fluid ounces (fl oz)
pints (pt)	0.47318	liters (L)	2.1134		pints (pt)
quarts (qt)	0.94635	liters (L)	1.0567		quarts (qt)
gallons (gal)	3.7854	liters (L)	0.2642		gallons (gal)
cubic feet (ft^3)	28.317	liters (L)	0.03531		cubic feet (ft^3)
cubic feet (ft^3)	0.02832	cubic meters (m^3)	35.315		cubic feet (ft^3)
Weight/Force					
ounces (av) (oz)	28.35	grams (g)	0.03527		ounces (av) (oz)
pounds (av) (lb)	0.454	kilograms (kg)	2.205		pounds (av) (lb)
U.S. tons (t)	907.18	kilograms (kg)	0.001102		U.S. tons (t)
U.S. tons (t)	0.90718	metric tons (t)	1.1023		U.S. tons (t)
Torque/Work Force					
inch-pounds (lbf·in)	11.298	Newton-centimeters (N·cm)	0.08851		inch-pounds (lbf·in)
foot-pounds (lbf·ft)	1.3558	Newton-meters (N·m)	0.7376		foot-pounds (lbf·ft)
Pressure/Vacuum					
inches of mercury (inHg)	3.37685	kiloPascals (kPa)	0.29613		inches of mercury (inHg)
pounds per square inch (psi)	6.895	kiloPascals (kPa)	0.14503		pounds per square inch (psi)

Table 1, Miscellaneous Conversions

When You Know	Subtract	Then Divide By	To Get	When You Know	Multiply By	Then Add	To Get
Temperature							
degrees Fahrenheit (°F)	32	1.8	degrees Celsius (°C)	1.8	32	degrees Fahrenheit (°F)	

Table 2, Temperature Conversions

Contents

Subject	Subject Number
General Information	050
Service Operations	
Hoses and Electrical Wiring Routing Standards	100

Vehicle Receipt

Prior to signing for vehicle delivery from a transporter company, the dealer is responsible for checking for transporter-related shortages or damages, and noting these discrepancies on the transporter's delivery receipt.

The dealer is also responsible for ensuring that the vehicle was built according to the Truck Sales Order/ Invoice.

Refer to Section 3 of the Freightliner LLC *Warranty Manual* for details.

Vehicle Storage

There may be times when a vehicle is stored for long periods before customer delivery. To protect all vehicles from deterioration and weather, they must be properly maintained. Adequate protection and storage of new vehicles is the responsibility of the dealer.

Claims arising from loss and damage to improperly stored vehicles will not be reimbursed.

See Section 3 of the Freightliner LLC *Warranty Manual* for instructions on storage of new vehicles.

Pre-Delivery Information

All pre-delivery inspections and services must be performed at an authorized Freightliner LLC facility, assigned to fully qualified service personnel and recorded on the "New Vehicle Pre-Delivery Inspection" form.

Refer to Section 3 of the Freightliner LLC *Warranty Manual* for details.

It is recommended the pre-delivery inspection be performed within 30 days of vehicle receipt.

Hoses and Electrical Wiring Routing Standards

Cooling System

1. Cooling system hoses must clear all moving parts by a minimum of 1/4 inch (6 mm).
2. The 1-inch (25-mm) hose from the surge tank to the engine must be free of sumps and have allowance for engine torque.
3. All hoses from the engine hard pipes must be wrapped in convoluted tubing.
4. Hoses that are protected with convoluted tubing may be secured with tie straps to clear the inner fenders.
5. Cooling system hoses should not be twisted or kinked.
6. Cooling system hoses must be routed at least six inches (152 mm) from a heat source if the heat source does not have a heat shield. If a heat shield is provided, the hose must be routed at least three inches (76 mm) from the heat source.

HVAC System

1. Cushion clamps are required to support all A/C lines. Butterfly or figure-8 clamps (two cushion clamps) may be used to prevent rubbing or chafing.
2. Heater hoses that are protected with convoluted tubing may be fastened with tie straps. If not protected with convoluted tubing, only cushion clamps or butterfly clamps may be used for heater hoses
3. A/C lines cannot be secured to air lines, fuel lines, or electrical wires.
4. HVAC hoses should be protected from damage by routing them away from hazards of heat, wheel splash (water, gravel, ice), human traffic, and moving parts of the vehicle.
5. HVAC hoses should be routed away from sharp points and edges (such as nuts, bolts, brackets, and frame rail edges), moveable parts, and sources of abrasion, cutting, pinching, or crushing.

NOTE: If hoses are covered with convoluted tubing, they may touch any of the above.

6. Hoses that are protected with convoluted tubing may come in contact with the bends on frame rails and filters.
7. HVAC hoses must be routed at least six inches (152 mm) from a heat source if the heat source does not have a heat shield. If a heat shield is provided, the hose must be routed at least three inches (76 mm) from the heat source.
8. All HVAC hoses must be routed so that regularly serviced components, such as fuel filters, fuel/water separators, oil filters, air filters, belts, and fill and drain plugs, are readily accessible for adjustment or replacement without the need to relocate or remove the hoses.
9. All A/C hoses in the engine compartment must have convoluted tubing.
10. If cushion clamps are used over convoluted tubing at existing clamp points, no additional tie straps or tape is needed.
11. When convoluted tubing is installed on the heater hose where it routes past the splash shield on the front right-hand side of the firewall, and if it uses existing clamps, no additional tie straps or tape is needed.

Auxiliary Heater

All auxiliary heater lines are deck-mounted hard piping with rubber hose at both ends. No additional tie straps are required.

Engine Plumbing

1. On vehicles equipped with the Cummins M-11 engine and power steering, no additional tie straps or tape are needed if convoluted tubing is installed on the power steering hose where it routes under the frame rail.
2. The engine oil pressure line should not rub or chafe against the Teflon® discharge line.

Electrical Wiring

1. Wires that are bundled together should be fastened at 8- to 12-inch (203- to 305-mm) intervals. If anchor clamps are more than 12 inches (305

Hoses and Electrical Wiring Routing Standards

mm) apart, a tie strap must be used between the anchor clamps.

2. Bundles of wires that are located in an exposed area, such as under the cab or outside the frame rail, need to be fastened with heavy-duty cable ties.
3. Any wiring that will be exposed to water or heat must be covered with either loom or convoluted tubing. Loom or convoluted tubing need not butt up against Weather Pack® connectors.
4. Any wiring routed across the vehicle, on the engine crossmember, or across the rear of the engine, must be secured with a clamp or tie strap, and covered with either convoluted tubing or a loom.
5. Any wiring that may come into contact with sharp points and edges (such as nuts, bolts, brackets, and frame rail edges), moveable parts, and sources of abrasion, cutting, pinching, or crushing, must be protected by either a loom or convoluted tubing.
6. Unprotected breakouts (individual wires) of up to eight inches (203 mm) are acceptable as long as these wires are routed safely away from sharp points and edges, moveable parts, and sources of abrasion, cutting, pinching, or crushing.
7. Gray, flame-retardant convoluted tubing may be used to protect wiring in the cab or the chassis. Black nylon convoluted tubing may only be used in the chassis.
8. All wiring must be routed so that regularly serviced components, such as fuel filters, fuel/water separators, oil filters, air filters, belts, and fill and drain plugs, are readily accessible for adjustment or replacement without the need to relocate or remove any wiring.
9. In exposed locations, such as the road light harness near the headlights, loose loops of wire must be secured with tie straps.
10. All wiring should be routed a minimum of four inches (102 mm) from the exhaust. In situations where the wiring is less than four inches (102 mm) from the exhaust, a heat shield must be placed between the wiring and the exhaust.

Battery Cables

1. Battery cables must be routed along an unobstructed path from the starter to the battery box. The cables must **not** rub or chafe on brackets, tanks, air lines, or fuel lines.
2. Battery cables and electrical wiring cannot be tied or secured to fuel lines, discharge lines, or air lines.
3. Battery cables must have support brackets no more than 30 inches (762 mm) apart. Tie straps must be within six inches (152 mm) of both sides of the support brackets, and every 12 inches (305 mm) between the brackets.
4. Battery cables must have convoluted tubing from the frame bracket to the batteries, and from the frame bracket to the starter.

Fuel Lines

1. Fuel lines must not be clamped to A/C lines, battery cables, jumper cables, or any other electrical wiring.
2. Stand-off brackets or clamps may be used to prevent fuel lines from rubbing against the frame.
3. Fuel lines must be routed at least six inches (152 mm) from a heat source. If a heat shield is provided, the fuel line must be at least three inches (76 mm) from the heat source.
4. Fuel lines that are parallel may be fastened together. Fuel lines that cross or that rub on metal, plastic, or electrical parts, need to be separated with butterfly clamps.

Chassis Air Lines and Brake Hoses

1. Hoses may come in contact with each other if they are parallel, or if they are bundled together.
2. If the hoses lie on the curve or flat surface of a bracket or crossmember, they do not need convoluted tubing.
3. Brake hoses may be clamped at the top of the axle housing, and touch or lie against the axle housing in its path to the brake chamber as this assembly moves together.

4. Brake hoses must have slack between the last clamping point on the frame rail and the brake chamber to allow for full range of suspension travel.
5. Brake hoses should have butterfly clamps at breakout points.
6. Air lines and brake hoses that are bundled together should be fastened at 8- to 12-inch (203- to 305-mm) intervals. If anchor clamps are more than 12 inches (305 mm) apart, a tie strap must be used between the anchor clamps. Tie straps may be closer than 12 inches (305 mm) apart.
7. Hoses or lines that may come into contact with the sharp edge of a bracket or frame rail are to be protected by convoluted tubing.
8. Air lines and brake hoses that are parallel may be fastened together. Air lines and brake hoses that cross or that rub on metal, plastic, or electrical parts need to be separated with butterfly clamps.
9. Nylon or STX (wire braid) chassis air lines may be fastened together to prevent rubbing, as long as the lines are stationary.

Hoses and Electrical Wiring Routing Standards

Cooling System

1. Cooling system hoses must clear all moving parts by a minimum of 1/4 inch (6 mm).
2. The 1-inch (25-mm) hose from the surge tank to the engine must be free of sumps and have allowance for engine torque.
3. All hoses from the engine hard pipes must be wrapped in convoluted tubing.
4. Hoses that are protected with convoluted tubing may be secured with tie straps to clear the inner fenders.
5. Cooling system hoses should not be twisted or kinked.
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3. Any wiring that will be exposed to water or heat must be covered with either loom or convoluted tubing. Loom or convoluted tubing need not butt up against Weather Pack® connectors.
4. Any wiring routed across the vehicle, on the engine crossmember, or across the rear of the engine, must be secured with a clamp or tie strap, and covered with either convoluted tubing or a loom.
5. Any wiring that may come into contact with sharp points and edges (such as nuts, bolts, brackets, and frame rail edges), moveable parts, and sources of abrasion, cutting, pinching, or crushing, must be protected by either a loom or convoluted tubing.
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7. Hoses or lines that may come into contact with the sharp edge of a bracket or frame rail are to be protected by convoluted tubing.
8. Air lines and brake hoses that are parallel may be fastened together. Air lines and brake hoses that cross or that rub on metal, plastic, or electrical parts need to be separated with butterfly clamps.
9. Nylon or STX (wire braid) chassis air lines may be fastened together to prevent rubbing, as long as the lines are stationary.

Contents

Subject	Subject Number
VIN for Vehicles Built through April 30, 2000	050
VIN for Vehicles Built from May 1, 2000	060

VIN for Vehicles Built through April 30, 2000

IMPORTANT: See **Subject 060** for the vehicle identification numbering system for vehicles built May 1, 2000, or later.

Federal Motor Vehicle Safety Standard 115 specifies that all vehicles sold in the U.S. be assigned a 17-character Vehicle Identification Number (VIN). Using a combination of letters and numerals, the VIN defines the manufacturer, model, and major characteristics of the vehicle. See **Table 1** for the character positions of a typical Freightliner VIN, 1FUYSTEBXVPA99999.

The VIN can be found on the Vehicle Specification Decal (see the driver's manual for decal location) and stamped on the left frame rail over the front axle about 2 inches (50 mm) from the top of the web or on the top flange of the left frame rail at frame station 30.

NOTE: For Freightliner vehicles assembled and sold in Mexico, the VIN appears on a plate or label attached to the driver's door. Also, a data card placed in the glove box shows the Mexican VIN as the "CHASSIS" number. The "CABIN" number is part of the Freightliner VIN, the last six digits of which are the Freightliner serial number.

IMPORTANT: A new VIN-code structure will be used for all vehicles built after April 30, 2000. Character positions 1 through 4 and 9 through 17 are nearly the same in both versions, but positions 5 through 8 have been assigned slightly different parameters. As a result, the build date of a vehicle must be determined before the VIN can be decoded.

For all vehicles, a check digit (9th character) is determined by assignment of weighted values to the other 16 characters. These weighted values are processed through a series of equations designed to check validity of the VIN and to detect VIN alteration.

NOTE: Always specify the VIN when ordering parts.

Seventeen-Character Vehicle Identification Number (VIN)									
Typical VIN	**1 F U**	**Y**	**S**	**T E**	**B**	**X**	**V**	**P**	**A 9 9 9 9 9**
Character Position	**1, 2, 3**	**4**	**5**	**6, 7**	**8**	**9**	**10**	**11**	**12 thru 17**
Decoding Table*	**Table 2**	**Table 3**	**Table 4**	**Table 5**	**Table 6**	**—**	**Table 7**	**Table 8**	**—**
Code Description									
Manufacturer, Make, Vehicle Type									
Chassis, Front Axle Position, Brakes									
Vehicle Model Series, Cab									
Engine Model, Horsepower Range									
Gross Vehicle Weight Rating (GVWR)									
Check Digit									
Vehicle Model Year									
Plant of Manufacture									
Production Number									

* For corresponding decoding information, see the applicable tables in this subject.

Table 1, Seventeen-Character Vehicle Identification Number (VIN)

VIN Positions 1, 2, and 3 (Manufacturer, Make, Vehicle Type)			
Code	**Vehicle Manufacturer**	**Vehicle Make**	**Vehicle Type**
1FU	Freightliner, U.S.A.	Freightliner	Truck-Tractor
1FV	Freightliner, U.S.A.	Freightliner	Incomplete Vehicle
2FU	Freightliner, Canada	Freightliner	Truck-Tractor
2FV	Freightliner, Canada	Freightliner	Incomplete Vehicle

VIN for Vehicles Built through April 30, 2000

VIN Positions 1, 2, and 3 (Manufacturer, Make, Vehicle Type)			
Code	**Vehicle Manufacturer**	**Vehicle Make**	**Vehicle Type**
3FE	M-B, Mexico (before April 1996)	Freightliner	Truck-Tractor
3FF	M-B, Mexico (before April 1996)	Freightliner	Incomplete Vehicle
3AK	M-B, Mexico (after April 1996)	Freightliner	Truck-Tractor
3AL	M-B, Mexico (after April 1996)	Freightliner	Incomplete Vehicle
AFV	M-B, South Africa	Freightliner	Truck
KFB	AIL, Israel	Freightliner	Truck
RSA	NAI, Saudi Arabia	Freightliner	Incomplete Vehicle
RSB	NAI, Saudi Arabia	Freightliner	Truck-Tractor

Table 2, VIN Positions 1, 2, and 3 (Manufacturer, Make, Vehicle Type)

VIN Position 4 (Chassis, Front Axle Position, Brakes)			
Code	**Chassis**	**Front Axle Position**	**Brakes**
A	4 x 2 Truck	Forward	Hydraulic
B	8 x 4 Truck-Tractor	Setback	Air
C	6 x 6 Truck-Tractor	Setback	Air
D	4 x 4 Truck	Setback	Hydraulic
E	4 x 4 Truck	Setback	Air
F	8 x 4 Truck	Forward	Air
G	8 x 4 Truck-Tractor	Forward	Air
H	4 x 2 Truck	Forward	Air
J	10 x 4 Truck	All	Air
K	4 x 2 Truck-Tractor	Forward	Air
L	6 x 2 Truck	Forward	Air
M	6 x 2 Truck-Tractor	Forward	Air
N	6 x 4 Truck	Forward	Air
P	6 x 4 Truck-Tractor	Forward	Air
R	10 x 6 Truck	Forward	Air
S	10 x 6 Truck-Tractor	Forward	Air
T	6 x 6 Truck	Setback	Air
U	8 x 6 Truck	All	Air
V	8 x 6 Truck-Tractor	All	Air
W	4 x 2 Truck-Tractor	Setback	Air
X	6 x 4 Truck	Setback	Air
Y	6 x 4 Truck-Tractor	Setback	Air
Z	6 x 2 Truck	Setback	Air

VIN Position 4 (Chassis, Front Axle Position, Brakes)			
Code	**Chassis**	**Front Axle Position**	**Brakes**
1	4 x 2 Truck*	Forward	Air/Hydraulic
	10 x 6 Truck†	Setback	Air
2	4 x 4 Truck	Setback	Air
3	4 x 2 Truck	Setback	Hydraulic
4	8 x 4 Truck	Setback	Air
5	6 x 2 Truck-Tractor	Setback	Air
6	4 x 2 Truck	Setback	Air
7	Glider	Setback	Air
8	Glider	Forward	Air
9	4 x 2 Truck	Setback	Air/Hydraulic
0	Glider	Setback	Air

* Starting August 1998.
† Through July 1998; included in code R starting August 1998.

Table 3, VIN Position 4 (Chassis, Front Axle Position, Brakes), January 18,1988 through April 30, 2000

VIN Position 5 (Model Series, Cab)	
Code	**Vehicle Model, Cab**
A	FLA High COE
B	FLB High COE
C	120 Conventional XL
D	FLD120 Conventional, Highway
E	FL50 Short Conventional
F	FLD120SD Conventional, Construction

VIN for Vehicles Built through April 30, 2000

VIN Position 5 (Model Series, Cab)	
Code	**Vehicle Model, Cab**
G	FL60 Short Conventional
H	FL70 Short Conventional
J	FL80 Short Conventional
L	112 Conv., Alum. Cab, Hwy., 48RR94MY*
	Argosy High COE
M	120 Conventional, Military
N	Century Class 112 Conventional
P	120 Conv., Alum. Cab, Hwy., 48RR94MY
	Columbia 120 Conventional
R	112 Conventional, Steel Cab, Hwy., RH Drive
S	Century Class 120 Conventional
T	High COE (through 88MY)
	FL112 Conventional
U	120 Conventional XL, 48RR94MY
V	MB60 Short Conventional (to 95MY)
	Legacy FL112 (00MY)

VIN Position 5 (Model Series, Cab)	
Code	**Vehicle Model, Cab**
W	FC80 Freightliner Cargo COE
X	MB70 Short Conventional (to 97MY)
	Legacy FLD120 (00MY)
Y	MB80 Short Conventional (through 98MY)
Z	112 Conventional, Steel Cab, Highway
1	FLC112 Conv., Steel Cab, Constr. (to 98MY)
2	FLC120 Conventional (to 91MY)
	FC60 Freightliner Cargo COE
3	FLD112 Conventional, Alum. Cab, Highway
4	Low COE, Aluminum Cab
5	MB50 Short Conventional
6	FLD112SD Conv., Alum. Cab, Construction
7	FLD120 Conventional, SilverAero (91MY)
	FC70 Freightliner Cargo COE
8	FL106 Short Conventional
9	RIV

* MY = Model Year

Table 4, VIN Position 5 (Model Series, Cab)

VIN Positions 6 and 7 (Engine Manufacturer, Model, Horsepower Range)			
Code	**Engine Manufacturer**	**Engine Model**	**HP Range**
AY	Cummins	NTC / N14	207–251
BD	Mercedes-Benz	MBE4000	353–407
BE	Mercedes-Benz	MBE4000	408–495
BX	Mercedes-Benz	MBE4000	288–352
BY	Cummins	NTC / N14	254–310
CX	Detroit Diesel	S-60, 11.1 L	331–402
CY	Cummins	N14	315–385
DY	Cummins	NTC / N14	389–475
DZ	Cummins	N14	476–580
EB	Caterpillar	C10 / 3176J	225–275
EC	Caterpillar	C10 / 3176J	276–335
ED	Caterpillar	C10 / 3176	336–407
F4	Cummins	B5.9 (propane)	185–224
FA	Cummins	6BT 5.9 (diesel) / ISB	185–224
FB	Cummins	6BT 5.9 (diesel) / ISB	225–275

VIN for Vehicles Built through April 30, 2000

VIN Positions 6 and 7 (Engine Manufacturer, Model, Horsepower Range)			
Code	**Engine Manufacturer**	**Engine Model**	**HP Range**
FF	Cummins	6BT 5.9/ ISB	153–184
FH	Cummins	6BT 5.9–195G (natural gas)	185–224
FV	Cummins	6BT 5.9–195G (natural gas)	126–152
GA	Mercedes-Benz	OM 366LA	185–224
GB	Mercedes-Benz	OM 366LA	225–275
GF	Mercedes-Benz	OM 366LA	153–184
HB	Detroit Diesel	S–50	225–275
HC	Detroit Diesel	S–50	276–335
HD	Detroit Diesel	S–50	336–407
JA	Caterpillar	CFE / 3126 (diesel)	185–224
JB	Caterpillar	CFE / 3126 (diesel)	225–275
JC	Caterpillar	CFE / 3126 (diesel)	276–335
JF	Caterpillar	CFE / 3126 (diesel)	153–184
KY	Cummins	L10	225–275
LA	Cummins	6C 8.3 (diesel) / ISC	185–224
LB	Cummins	6C 8.3 (diesel) / ISC	225–275
LC	Cummins	6C 8.3 (diesel) / ISC	276–335
LD	Cummins	L10	336–407
LE	Cummins	ISC	336–407
LL	Cummins	C 8.3 (natural gas) / ISC	225–276
LY	Cummins	L10	276–330
MC	Cummins	M11 / ISM	276–335
MD	Cummins	M11 / ISM	336–407
ME	Cummins	M11 / ISM	408–495
MW	Cummins	ISM	496–605
NT	Cummins	4B 3.9–130 hp (diesel)	126–152
PY	Detroit Diesel	S-60, 11.1 L	275–330
RY	Caterpillar	3406	270–330
SE	Detroit Diesel	S-60, 12.7 L	408–495
SM	Detroit Diesel	S-60, 12.7 L	276–335
SY	Caterpillar	3406	333–407
SZ	Detroit Diesel	S-60, 12.7 L	496–605
TD	Detroit Diesel	S-55	336–407
TE	Detroit Diesel	S-55	408–495
TJ	Dodge	Magnum V8 (gasoline)	207–253
TR	Dodge	Magnum V10 (gasoline)	270–330

VIN for Vehicles Built through April 30, 2000

VIN Positions 6 and 7 (Engine Manufacturer, Model, Horsepower Range)			
Code	**Engine Manufacturer**	**Engine Model**	**HP Range**
TY	Caterpillar	3408	383–467
UY	Caterpillar	3306	225–275
VY	Caterpillar	3406	225–269
WC	Caterpillar	CFE/3126	276–335
WD	Caterpillar	C12 / 3176L	336–407
WE	Caterpillar	C12 / 3176L	408–495
WY	Caterpillar	3306	276–335
XY	Caterpillar	3406	408–495
XZ	Caterpillar	3406	496–605
YY	Detroit Diesel	S-60, 11.1 L	225–274
ZY	Detroit Diesel	S-60, 12.7 L	333–407
1B	Detroit Diesel	6L–71	225–275
1C	Detroit Diesel	6L–71	276–335
2W	Detroit Diesel	S-60, 14.0L	496–605
3A	Mercedes-Benz	MB904	185–224
4Y	Detroit Diesel	6V–92	239–287
5Y	Detroit Diesel	6V–92	288–352
6A	Mercedes-Benz	MB906	185–224
6B	Mercedes-Benz	MB906	225–275
6C	Mercedes-Benz	MB906	276–335
6Y	Detroit Diesel	8V–92	365–446
7D	Cummins	ISX Signature	336–407
7E	Cummins	ISX Signature	408–495
7W	Cummins	ISX Signature	496–605
8Y	Detroit Diesel	8V–92	302–364
9Y	Detroit Diesel	8V–92	447–522
0Y	No Engine	—	—

Table 5, VIN Positions 6 and 7 (Engine Manufacturer, Model, Horsepower Range)

VIN Position 8 (Gross Vehicle Weight Rating)		
Code	**lb**	**kg**
A	26,001–33,000	11 794–14 968
B	33,001 or over	14 969 or over
C	19,501–26,000	8846–11 793
D	16,001–19,500	7258–8845

VIN for Vehicles Built through April 30, 2000

VIN Position 8 (Gross Vehicle Weight Rating)		
Code	**lb**	**kg**
2	6001–10,000	2722–4536
3	10,001–14,000	4537–6350
4	14,001–16,000	6351–7257
9	N/A: Incomplete Vehicle or Glider	

Table 6, VIN Position 8 (Gross Vehicle Weight Rating)

VIN Position 10 (Vehicle Model Year)	
Code	**Model Year**
J	1988
K	1989
L	1990
M	1991
N	1992
P	1993
R	1994
S	1995
T	1996
V	1997
W	1998
X	1999
Y	2000
1	2001
2	2002

Table 7, VIN Position 10 (Vehicle Model Year)

VIN Position 11 (Plant of Manufacture)	
Code	**Plant of Manufacture**
A	St. Thomas, Ontario
B	Mercedes-Benz, South Africa
C	Gaffney, South Carolina
D	Mercedes-Benz, Mexico, Santiago
F	AIL, Israel
H	Mt. Holly, North Carolina
L	Cleveland, North Carolina
M	Mercedes-Benz, Monterrey
N	Mercedes-Benz, Australia
P	Portland, Oregon

VIN Position 11 (Plant of Manufacture)	
Code	**Plant of Manufacture**
R	American LaFrance, Cleveland, NC
V	Burnaby, British Columbia
W	NAI, Saudi Arabia

Table 8, VIN Position 11 (Plant of Manufacture)

VIN for Vehicles Built from May 1, 2000

IMPORTANT: See **Subject 050** for the vehicle identification numbering system for vehicles built before May 1, 2000.

Federal Motor Vehicle Safety Standard 115 specifies that all vehicles sold in the U.S. be assigned a 17-character Vehicle Identification Number (VIN). Using a combination of letters and numerals, the VIN defines the manufacturer, model, and major characteristics of the vehicle. See **Table 1** for the character positions of a typical Freightliner VIN, 1FUPABAV11PA12345.

The VIN can be found on the Vehicle Specification Decal (see the driver's manual for decal location) and stamped on the left frame rail over the front axle about 2 inches (50 mm) from the top of the web or on the top flange of the left frame rail at frame station 30.

NOTE: For Freightliner vehicles assembled and sold in Mexico, the VIN appears on a plate or label attached to the driver's door. Also, a data card placed in the glove box shows the Mexican VIN as the "CHASSIS" number. The "CABIN" number is part of the Freightliner VIN, the last six digits of which are the Freightliner serial number.

IMPORTANT: A new VIN-code structure will be used for all vehicles built after April 30, 2000. As a result, the build date of a vehicle must be determined before the VIN can be decoded.

Character positions 1 through 4 and 9 through 17 are nearly the same in both versions, but positions 5 through 8 have been assigned slightly different parameters.

Another new feature is that each product line has its own model list; that is, positions 5 and 6 are will be product-specific in the new system. For example, the code AB in positions 5 and 6 for a Freightliner vehicle indicates an FLD112. Code AB in the same position for a Sterling vehicle represents an SC7000 Cargo.

For all vehicles, a check digit (9th character) is determined by assignment of weighted values to the other 16 characters. These weighted values are processed through a series of equations designed to check validity of the VIN and to detect VIN alteration.

NOTE: Always specify the VIN when ordering parts.

Seventeen-Character Vehicle Identification Number (VIN)								
Typical VIN	**1 F U**	**P**	**AB**	**AV**	**1**	**1**	**P**	**A 1 2 3 4 5**
Character Position	1, 2, 3	4	5, 6	7, 8	9	10	11	12–17
Code Description	World Manufacturer Identification	Chassis Configuration	Model, Cab, GVWR	Engine, Brakes	Check Digit Calculation	Model Year	Build Location	Production Serial Number
Decoding Table*	**Table 2**	**Table 3**	**Table 4**	**Table 5**	—	**Table 6**	**Table 7**	—

* For corresponding decoding information, see the applicable tables in this subject.

Table 1, Seventeen-Character Vehicle Identification Number (VIN)

VIN Positions 1, 2, and 3 (World Manufacturer Identification)			
Code	**Vehicle Manufacturer**	**Vehicle Make**	**Vehicle Type**
1FU	Freightliner, U.S.A.	Freightliner	Truck-Tractor
1FV	Freightliner, U.S.A.	Freightliner	Incomplete Vehicle
3AK	M-B, Mexico (after April 1996)	Freightliner	Truck-Tractor
3AL	M-B, Mexico (after April 1996)	Freightliner	Incomplete Vehicle
RSA	NAI, Saudi Arabia	Freightliner	Incomplete Vehicle
RSB	NAI, Saudi Arabia	Freightliner	Truck-Tractor

Table 2, VIN Positions 1, 2, and 3 (World Manufacturer Identification)

VIN for Vehicles Built from May 1, 2000

VIN Position 4 (Chassis Configuration)	
Code	**Chassis**
A	4 x 2 Truck
B	4 x 2 Truck-Tractor
D	4 x 4 Truck
E	4 x 4 Truck-Tractor
F	6 x 2 Truck
G	6 x 2 Truck-Tractor
H	6 x 4 Truck
J	6 x 4 Truck-Tractor
K	6 x 6 Truck
L	6 x 6 Truck-Tractor
M	8 x 4 Truck
N	8 x 4 Truck-Tractor
P	8 x 6 Truck
R	8 x 6 Truck-Tractor
S	10 x 4 Truck
T	10 x 4 Truck-Tractor
U	10 x 6 Truck-Tractor
V	10 x 6 Truck-Tractor
X	Glider

Table 3, VIN Position 4 (Chassis Configuration)

VIN Positions 5 and 6 (Model, Cab, Class/GVWR)			
Code	**Model**	**Cab**	**Class (GVWR)**
AA	FLB Glider	COE	Glider
AB	FLD112	Conventional	Class 7*
AC	FLD112	Conventional	Class 8†
AD	FLD112 Glider	Conventional	Glider
AE	FLD112 SD	Conventional	Class 8
AF	FLD112 SD Glider	Conventional	Glider
AG	FLD120	Conventional	Class 7
AH	FLD120	Conventional	Class 8
AJ	FLD120 Glider	Conventional	Glider
AK	FLD120 SD	Conventional	Class 7
AL	FLD120 SD	Conventional	Class 8
AM	FLD120 SD Glider	Conventional	Glider

VIN Positions 5 and 6 (Model, Cab, Class/GVWR)			
Code	**Model**	**Cab**	**Class (GVWR)**
AN	FLD132 XL Classic	Conventional	Class 7
AP	FLD132 XL Classic	Conventional	Class 8
AR	FLD132 XL Classic Glider	Conventional	Glider
AS	FLD120 Military	Conventional	Class 7
AT	FLD120 Military	Conventional	Class 8
AU	FLD120 Mil Glider	Conventional	Glider
AV	Argosy	COE	Class 7
AW	Argosy	COE	Class 8
AX	Argosy Glider	COE	Glider
AY	C112 (Century Class)	Conventional	Class 7
AZ	C112	Conventional	Class 8
A1	C112 Glider	Conventional	Glider
A2	C120 (Century Class)	Conventional	Class 7
A3	C120	Conventional	Class 8
A4	C120 Glider	Conventional	Glider
A5	Columbia 120	Conventional	Class 7
A6	Columbia 120	Conventional	Class 8
A7	Columbia 120 Glider	Conventional	Glider
A8	ST112 (Century Class)	Conventional	Class 7
A9	ST112	Conventional	Class 8
A0	ST112 Glider	Conventional	Glider
BA	ST120 (Century Class)	Conventional	Class 7
BB	ST120	Conventional	Class 8
BC	ST120 Glider	Conventional	Glider
BD	FLD120 Classic Legacy	Conventional	Class 8
BE	FLS112 Legacy	Conventional	Class 8
BF	FL112	Conventional	Class 7
BG	FL112	Conventional	Class 8
BH	FL112 Glider	Conventional	Glider
BJ	FL50	Conventional	Class 4‡
BK	FL50	Conventional	Class 5§
BL	FL50	Conventional	Class 6¶
BM	FL50	Conventional	Class 7

VIN for Vehicles Built from May 1, 2000

VIN Positions 5 and 6 (Model, Cab, Class/GVWR)			
Code	**Model**	**Cab**	**Class (GVWR)**
BN	FL60	Conventional	Class 5
BP	FL60	Conventional	Class 6
BR	FL60	Conventional	Class 7
BS	FC70	Conventional	Class 6
BT	FC70	Conventional	Class 7
BU	FC70	Conventional	Class 8
BV	FC80	Conventional	Class 6
BW	FC80	Conventional	Class 7
BX	FC80	Conventional	Class 8
BY	FL106	Conventional	Class 6
BZ	FL106	Conventional	Class 7
B1	FL106	Conventional	Class 8
B2	FC70 Cargo	COE	Class 6
B3	FC70 Cargo	COE	Class 7
B4	FC70 Cargo	COE	Class 8
B5	FC80 Cargo	COE	Class 6
B6	FC80 Cargo	COE	Class 7
B7	FC80 Cargo	COE	Class 8
B8	RIV	None	Class 8
B9	Sport Chassis	Conventional	Class 6
B0	Sport Chassis	Conventional	Class 7
CA	FL106 Glider	Conventional	Glider
CB	FL60 Glider	Conventional	Glider
CC	FL70 Glider	Conventional	Glider
CD	FL80 Glider	Conventional	Glider
CE	T-2	COE	Class 7
CF	T-2	COE	Class 8

* Class 7 GVWR is 26,001–33,000 lb.
† Class 8 GVWR is 33,001 lb and over.
‡ Class 4 GVWR is 14,001–16,000 lb.
§ Class 5 GVWR is 16,001–19,500 lb.
¶ Class 6 GVWR is 19,501–26,000 lb.

Table 4, VIN Positions 5 and 6 (Model, Cab, Class/GVWR)

VIN Positions 7 and 8 (Engine, Brakes)					
Code	**Engine**	**Fuel**	**Displacement (L)**	**Configuration**	**Brakes**
AA	Caterpillar 3176	Diesel	10.3	I–6	Air
AB	Caterpillar 3176	Diesel	10.3	I–6	Hydraulic
AC	Caterpillar 3176	Diesel	10.3	I–6	Air/Hydraulic
AD	Caterpillar 3406	Diesel	14.6	I–6	Air
AE	Caterpillar 3406	Diesel	14.6	I–6	Hydraulic
AF	Caterpillar 3406	Diesel	14.6	I–6	Air/Hydraulic
AG	Caterpillar 3406E	Diesel	15.8	I–6	Air
AH	Caterpillar 3406E	Diesel	15.8	I–6	Hydraulic
AJ	Caterpillar 3406E	Diesel	15.8	I–6	Air/Hydraulic
AK	Caterpillar 3126/CFE	Diesel	7.2	I–6	Air
AL	Caterpillar 3126/CFE	Diesel	7.2	I–6	Hydraulic
AM	Caterpillar 3126/CFE	Diesel	7.2	I–6	Air/Hydraulic

VIN for Vehicles Built from May 1, 2000

VIN Positions 7 and 8 (Engine, Brakes)					
Code	**Engine**	**Fuel**	**Displacement (L)**	**Configuration**	**Brakes**
AN	Caterpillar C10	Diesel	10.3	I–6	Air
AP	Caterpillar C10	Diesel	10.3	I–6	Hydraulic
AR	Caterpillar C10	Diesel	10.3	I–6	Air/Hydraulic
AS	Caterpillar C12	Diesel	12.0	I–6	Air
AT	Caterpillar C12	Diesel	12.0	I–6	Hydraulic
AU	Caterpillar C12	Diesel	12.0	I–6	Air/Hydraulic
AV	Caterpillar C15	Diesel	14.6	I–6	Air
AW	Caterpillar C15	Diesel	14.6	I–6	Hydraulic
AX	Caterpillar C15	Diesel	14.6	I–6	Air/Hydraulic
AY	Caterpillar C16	Diesel	15.8	I–6	Air
AZ	Caterpillar C16	Diesel	15.8	I–6	Hydraulic
A1	Caterpillar C16	Diesel	15.8	I–6	Air/Hydraulic
A2	Cummins L10	Diesel	10.8	I–6	Air
A3	Cummins L10	Diesel	10.8	I–6	Hydraulic
A4	Cummins L10	Diesel	10.8	I–6	Air/Hydraulic
A5	Cummins M11	Diesel	10.8	I–6	Air
A6	Cummins M11	Diesel	10.8	I–6	Hydraulic
A7	Cummins M11	Diesel	10.8	I–6	Air/Hydraulic
A8	Cummins ISM	Diesel	10.8	I–6	Air
A9	Cummins ISM	Diesel	10.8	I–6	Hydraulic
A0	Cummins ISM	Diesel	10.8	I–6	Air/Hydraulic
BA	Cummins NTC	Diesel	14.0	I–6	Air
BB	Cummins NTC	Diesel	14.0	I–6	Hydraulic
BC	Cummins NTC	Diesel	14.0	I–6	Air/Hydraulic
BD	Cummins N14	Diesel	14.0	I–6	Air
BE	Cummins N14	Diesel	14.0	I–6	Hydraulic
BF	Cummins N14	Diesel	14.0	I–6	Air/Hydraulic
BG	Cummins ISX/Signature	Diesel	14.9	I–6	Air
BH	Cummins ISX/Signature	Diesel	14.9	I–6	Hydraulic
BJ	Cummins ISX/Signature	Diesel	14.9	I–6	Air/Hydraulic
BK	Cummins C8.3	Diesel	8.3	I–6	Air
BL	Cummins C8.3	Diesel	8.3	I–6	Hydraulic
BM	Cummins C8.3	Diesel	8.3	I–6	Air/Hydraulic

VIN for Vehicles Built from May 1, 2000

VIN Positions 7 and 8 (Engine, Brakes)					
Code	**Engine**	**Fuel**	**Displacement (L)**	**Configuration**	**Brakes**
BN	Cummins B5.9	Diesel	5.9	I–6	Air
BP	Cummins B5.9	Diesel	5.9	I–6	Hydraulic
BR	Cummins B5.9	Diesel	5.9	I–6	Air/Hydraulic
BS	Cummins ISC	Diesel	8.3	I–6	Air
BT	Cummins ISC	Diesel	8.3	I–6	Hydraulic
BU	Cummins ISC	Diesel	8.3	I–6	Air/Hydraulic
BV	Cummins ISB	Diesel	5.9	I–6	Air
BW	Cummins ISB	Diesel	5.9	I–6	Hydraulic
BX	Cummins ISB	Diesel	5.9	I–6	Air/Hydraulic
BY	Cummins B5.9	Propane	5.9	I–6	Air
BZ	Cummins B5.9	Propane	5.9	I–6	Hydraulic
B1	Cummins B5.9	Propane	5.9	I–6	Air/Hydraulic
B2	Cummins B5.9	Natural Gas	5.9	I–6	Air
B3	Cummins B5.9	Natural Gas	5.9	I–6	Hydraulic
B4	Cummins B5.9	Natural Gas	5.9	I–6	Air/Hydraulic
B5	Cummins C8.3	Natural Gas	8.3	I–6	Air
B6	Cummins C8.3	Natural Gas	8.3	I–6	Hydraulic
B7	Cummins C8.3	Natural Gas	8.3	I–6	Air/Hydraulic
B8	Detroit Series 50	Diesel	8.5	I–4	Air
B9	Detroit Series 50	Diesel	8.5	I–4	Hydraulic
B0	Detroit Series 50	Diesel	8.5	I–4	Air/Hydraulic
CA	Detroit Series 55	Diesel	12.0	I–6	Air
CB	Detroit Series 55	Diesel	12.0	I–6	Hydraulic
CC	Detroit Series 55	Diesel	12.0	I–6	Air/Hydraulic
CD	Detroit Series 60	Diesel	11.1	I–6	Air
CE	Detroit Series 60	Diesel	11.1	I–6	Hydraulic
CF	Detroit Series 60	Diesel	11.1	I–6	Air/Hydraulic
CG	Detroit Series 60	Diesel	12.7	I–6	Air
CH	Detroit Series 60	Diesel	12.7	I–6	Hydraulic
CJ	Detroit Series 60	Diesel	12.7	I–6	Air/Hydraulic
CK	Detroit Series 60	Diesel	14.0	I–6	Air
CL	Detroit Series 60	Diesel	14.0	I–6	Hydraulic
CM	Detroit Series 60	Diesel	14.0	I–6	Air/Hydraulic

VIN for Vehicles Built from May 1, 2000

VIN Positions 7 and 8 (Engine, Brakes)					
Code	Engine	Fuel	Displacement (L)	Configuration	Brakes
CN	Mercedes-Benz MBE900	Diesel	4.3	I–4	Air
CP	Mercedes-Benz MBE900	Diesel	4.3	I–4	Hydraulic
CR	Mercedes-Benz MBE900	Diesel	4.3	I–4	Air/Hydraulic
CS	Mercedes-Benz MBE900	Diesel	6.4	I–6	Air
CT	Mercedes-Benz MBE900	Diesel	6.4	I–6	Hydraulic
CU	Mercedes-Benz MBE900	Diesel	6.4	I–6	Air/Hydraulic
CV	Mercedes-Benz MBE4000	Diesel	12.0	I–6	Air
CW	Mercedes-Benz MBE4000	Diesel	12.0	I–6	Hydraulic
CX	Mercedes-Benz MBE4000	Diesel	12.0	I–6	Air/Hydraulic
CY	Cummins ISL	Diesel	8.3	I–6	Air
CZ	Cummins ISL	Diesel	8.3	I–6	Hydraulic
C1	Cummins ISL	Diesel	8.3	I–6	Air/Hydraulic
C2	Cummins B3.9	Diesel	3.9	I–4	Air
C3	Cummins B3.9	Diesel	3.9	I–4	Hydraulic
C4	Cummins B3.9	Diesel	3.9	I–4	Air/Hydraulic
C5	Cummins ISB 3.9	Diesel	3.9	I–4	Air
C6	Cummins ISB 3.9	Diesel	3.9	I–4	Hydraulic
C7	Cummins ISB 3.9	Diesel	3.9	I–4	Air/Hydraulic
00	No Engine	—	—	—	—

Table 5, VIN Positions 7 and 8 (Engine and Brakes)

VIN Position 10 (Model Year)	
Code	Model Year
Y	2000
1	2001
2	2002
3	2003
4	2004
5	2005
6	2006
7	2007

Table 6, VIN Position 10 (Model Year)

VIN Position 11 (Build Location)	
Code	Build Location
D	Mercedes-Benz, Mexico, Santiago
H	Mt. Holly, North Carolina
L	Cleveland, North Carolina
P	Portland, Oregon

Table 7, VIN Position 11 (Build Location)

Contents

Subject	Subject Number
General Information	050
Service Operations	
General Instructions	100
Specifications	400

Threaded Fastener Types

The majority of threaded fasteners used throughout the vehicle have U.S. customary threads (diameter and pitch are measured in inches). **See Fig. 1.** However, the engine and some items attached to the cab use metric fasteners (diameter and pitch are measured in millimeters).

Most threaded fasteners used on the vehicle that are 1/2-inch diameter or larger are plain hex-type fasteners (non-flanged); *all* metric fasteners are non-flanged. Special hardened flatwashers are used under the bolt head, and between the part being attached and the hexnut, to distribute the load, and to prevent localized overstressing of the parts. The washers are cadmium- or zinc-plated, and have a hardness rating of 38 to 45 HRC.

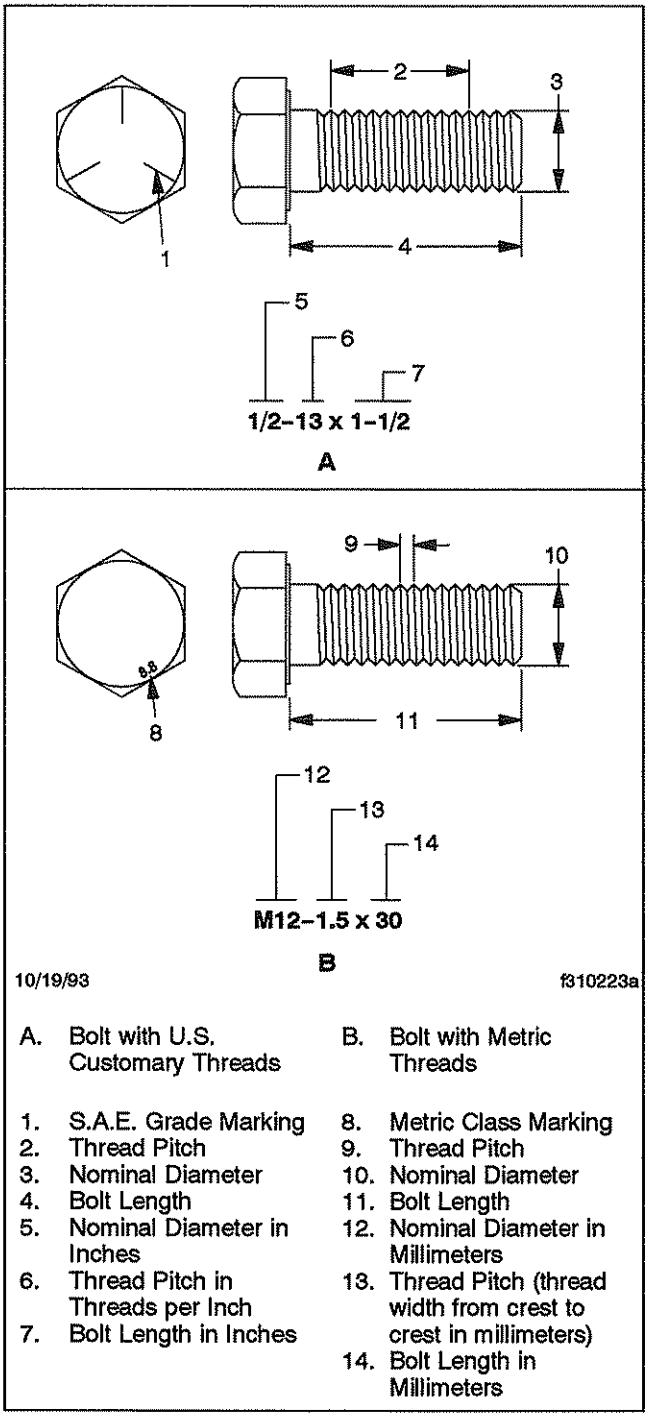
Some fasteners smaller than 1/2-inch diameter are flanged fasteners, which have integral flanges that fit against the parts being fastened. The flanges eliminate the need for washers.

NOTE: The standard fasteners used to assemble the vehicle frame and to attach components to the vehicle frame are threaded lockbolts (Spin Hucks). These fasteners are covered in **Section 31.00.**

Fastener Grades and Classes

Fasteners with U.S. customary threads are divided into grades established by the Society of Automotive Engineers (S.A.E.) or the International Fastener Institute (I.F.I.). The fastener grades indicate the relative strength of the fastener; the higher the number (or letter), the stronger the fastener. Bolt (capscrew) grades can be identified by the number and pattern of radial lines forged on the bolt head. **See Fig. 2.** Hexnut (and locknut) grades can be identified by the number and pattern of lines and dots on various surfaces of the nut. **See Fig. 3.** Nearly all of the bolts used on the vehicle are grades 5, 8, and 8.2. Matching grades of hexnuts are always used: grade 5 or grade B hexnuts are used with grade 5 bolts; grade 8, grade C, or grade G (flanged) hexnuts are used with grade 8 or 8.2 bolts.

Fasteners with metric threads are divided into classes adopted by the American National Standards Institute (ANSI). The higher the class number, the stronger the fastener. Bolt classes can be identified by the numbers forged on the head of the bolt. **See Fig. 4.** Hexnut (and locknut) classes can be identified by the marks or numbers on various surfaces of the nut. **See Fig. 5.**

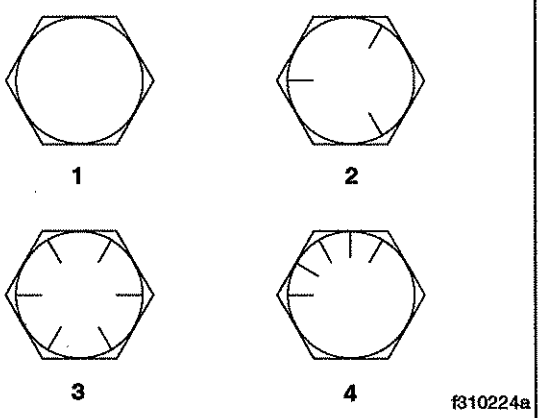


A. Bolt with U.S. Customary Threads
B. Bolt with Metric Threads

1. S.A.E. Grade Marking
2. Thread Pitch
3. Nominal Diameter
4. Bolt Length
5. Nominal Diameter in Inches
6. Thread Pitch in Threads per Inch
7. Bolt Length in Inches
8. Metric Class Marking
9. Thread Pitch
10. Nominal Diameter
11. Bolt Length
12. Nominal Diameter in Millimeters
13. Thread Pitch (thread width from crest to crest in millimeters)
14. Bolt Length in Millimeters

Fig. 1, Fastener Size and Thread Identification

General Information



NOTE: Grade 2 bolts have no grade marking; grade 2 bolts are rarely used by Freightliner.

These grade markings are used on plain hex-type and flanged bolts (capscrews). In addition to the grade markings, the bolt head must also carry the manufacturer's trademark or identification.

1. Grade 2
2. Grade 5
3. Grade 8
4. Grade 8.2

Fig. 2, Bolt Grades

Class 8 hexnuts are always used with class 8.8 bolts; class 10 hexnuts with class 10.9 bolts.

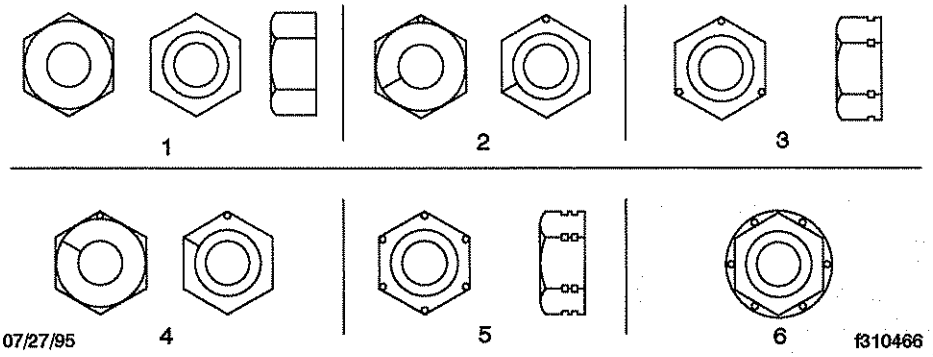
Frame Fasteners

The standard fasteners used to assemble the vehicle frame and to attach most components to the vehicle frame are threaded lockbolts (Spin Hucks). These fasteners are covered in **Section 31.00.**

For some other components attached to the frame, grade 8 and 8.2 phosphate-and oil-coated hexhead bolts and grade C cadmium-plated and wax-coated prevailing torque locknuts are used. The prevailing torque locknuts have distorted sections of threads to provide torque retention. For attachments where clearance is minimal, low-profile hexhead bolts and grade C prevailing torque locknuts are used. **See Fig. 6.**

Tightening Fasteners

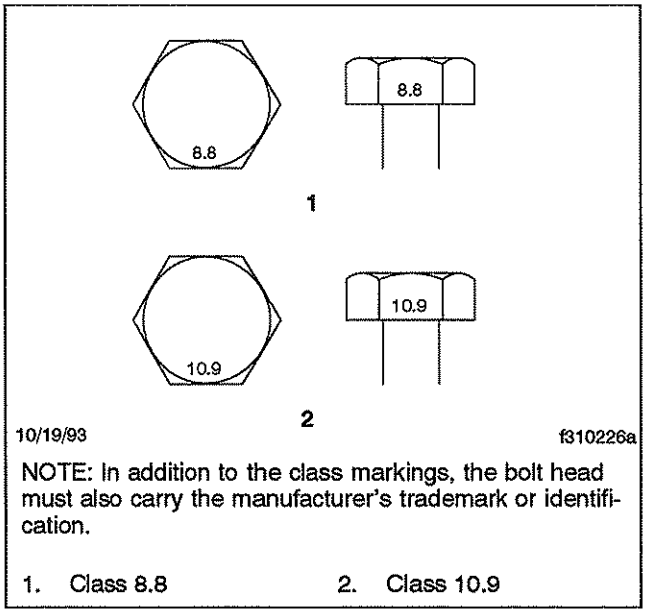
When a capscrew is tightened to its torque value in a threaded hole, or a nut is tightened to its torque value on a bolt, the shank of the capscrew or bolt is



NOTE: Grade 2 (S.A.E.) and grade A (I.F.I.) nuts have no identification marks or notches; they are rarely used by Freightliner. Grade B (I.F.I.) nuts have three identification marks at 120 degrees, or 6 notches. Grade C (I.F.I.) nuts have three identification marks at 60 degrees, or 12 notches. Grade G (I.F.I.) flanged nuts have six identification marks as shown; each identification mark may be a dot, line, pair of dots or lines, or any other symbol at the manufacturer's option.

1. S.A.E. Grade 2 or I.F.I. Grade A Nut (strength compatible with grade 2 bolt.)
2. S.A.E. Grade 5 Nut (strength compatible with grade 5 bolt.)
3. I.F.I. Grade B Nut (strength compatible with grade 5 bolt.)
4. S.A.E. Grade 8 Nut (strength compatible with grade 8 or grade 8.2 bolt.)
5. I.F.I. Grade C Nut (strength compatible with grade 8 or grade 8.2 bolt.)
6. I.F.I. Grade G Nut (flanged locknut; strength compatible with grade 8 or grade 8.2 bolt.)

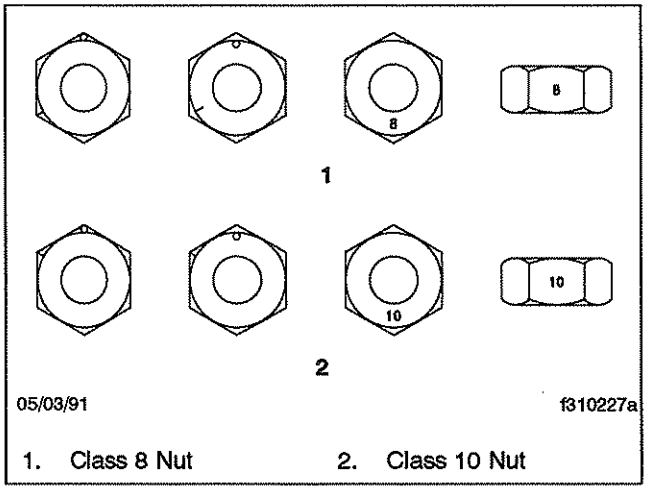
Fig. 3, Nut Grades



NOTE: In addition to the class markings, the bolt head must also carry the manufacturer's trademark or identification.

1. Class 8.8
2. Class 10.9

Fig. 4, Bolt Classes

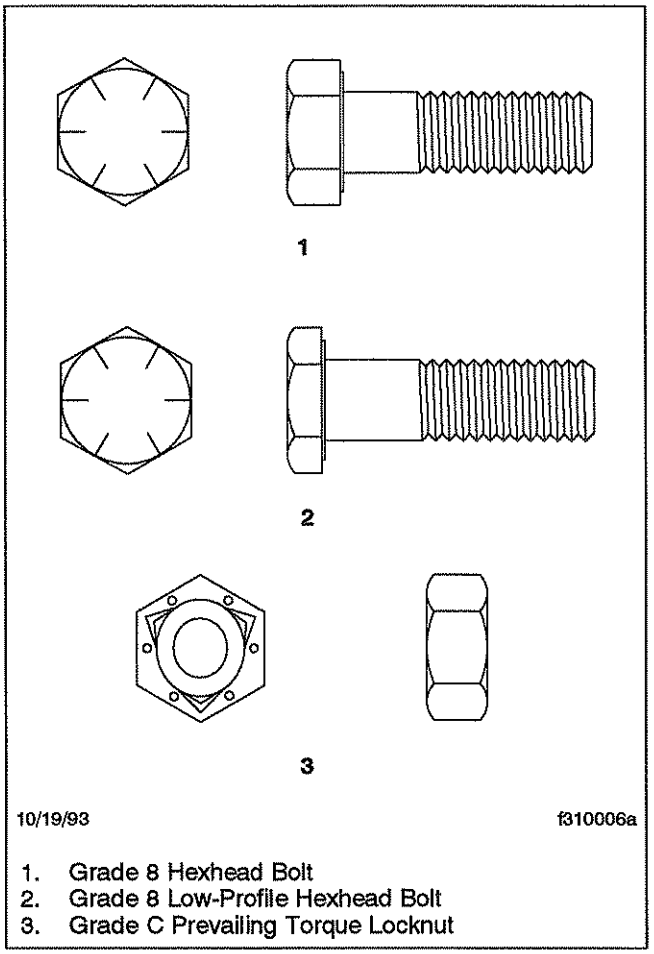


1. Class 8 Nut
2. Class 10 Nut

Fig. 5, Nut Classes

stretched slightly. This stretching (tensioning) results in a preload that reduces fatigue of the fasteners. The torque values given in the tables in **Specifications, 400** have been calculated to provide enough clamping force on the parts being fastened, and the correct tensioning of the bolt to maintain the clamping force.

Use of a torque wrench to tighten fasteners will help prevent overtensioning them. Overtensioning causes permanent stretching of the fasteners, which can result in breakage of the parts or fasteners.



1. Grade 8 Hexhead Bolt
2. Grade 8 Low-Profile Hexhead Bolt
3. Grade C Prevailing Torque Locknut

Fig. 6, Frame Fastener Identification

When torquing a fastener, typically 80 to 90 percent of the turning force is used to overcome friction; only 10 to 20 percent is used to stretch the capscrew or bolt. About 40 to 50 percent of the turning force is needed to overcome the friction between the underside of the capscrew head or nut and the washer. Another 30 to 40 percent is needed to overcome the friction between the threads of the capscrew and the threaded hole, or the friction between the threads of the nut and bolt.

The amount of torque required to tighten a fastener is reduced when the amount of friction is reduced. If a fastener is dry (unlubricated) and plain (unplated), the amount of friction is high. If a fastener is wax-coated or oiled, or has a zinc phosphate coating or cadmium plating, the amount of friction is reduced. Each of these coatings and combinations of coatings has a different effect. Using zinc-plated hardened flatwashers under

the bolt (capscrew) head and nut reduces the amount of friction. Dirt or other foreign material on the threads or clamping surfaces of the fastener or clamped part also changes the amount of friction.

Even though each different condition affects the amount of friction, a different torque value cannot be given for each different condition. To ensure they are always torqued accurately, Freightliner recommends that all fasteners be lubricated with oil (unless specifically instructed to install them dry), then torqued to the values for lubricated- and plated-thread fasteners. When locking compound or anti-seize compound is recommended for a fastener, the compound acts as a lubricant, and oil is not needed.

Fastener Replacement

When replacing fasteners, use only identical bolts, washers, and nuts; they must be the same size, strength, and finish as originally specified. See the Freightliner Service Parts Catalog for fastener specifications.

When replacing graded (or metric class) bolts and capscrews, use only fasteners that have the manufacturer's trademark or identification on the bolt head; do not use substandard bolts. Inferior, counterfeit fasteners are difficult to identify; buy your fasteners from a reputable supplier.

Fastener Selection and Installation

When using nuts with bolts, use a grade (or class) of nut that matches the bolt.

When installing non-flanged fasteners, use hardened steel flatwashers under the bolt (capscrew) head, and under the hexnut or locknut.

For bolts 4 inches (100 mm) or less in length, make sure that at least 1-1/2 threads and no more than 5/8-inch (16-mm) bolt length extends through the nut after it has been tightened. For bolts longer than 4 inches (100 mm), allow a minimum of 1-1/2 threads and a maximum of 3/4-inch (19-mm) bolt length.

Never hammer or screw bolts into place. Align the holes of the parts being attached, so that the nut and bolt surfaces are flush against the washers, and the washers are flush against the parts.

When installing fasteners in aluminum or plastic parts with threaded holes, start the fasteners by hand, to ensure straight starting and to prevent damaged threads.

Do not use lockwashers (split or toothed) next to aluminum surfaces.

When installing studs that do not have an interference fit, install them with thread locking compound, as instructed in this subject.

When installing parts that are mounted on studs, use free-spinning (non-locking) nuts and helical-spring (split) lockwashers or internal-tooth lockwashers. Do not use locknuts, because they tend to loosen the studs during removal. Do not use plain washers (flatwashers).

Do not use lockwashers and flatwashers in combination (against each other); each defeats the other's purpose.

Use stainless steel fasteners against chrome plating, unpainted aluminum, or stainless steel.

Fastener Tightening

Before installing fasteners, clean all fastener (and parts) threads, and all surfaces being clamped.

To ensure they are always torqued accurately, Freightliner recommends that *all* fasteners be lubricated with oil (unless specifically instructed to install them dry), then torqued to the values for lubricated- and plated-thread fasteners. When locking compound or antiseize compound is recommended for a fastener, the compound acts as a lubricant, and oil is not needed.

Bring parts and fasteners into contact, with no gaps between them, before using a torque wrench to tighten fasteners to their final torque values.

Tighten the nut, not the bolt head. This will give a truer torque reading by eliminating bolt body friction.

Always use a torque wrench to tighten fasteners, and use a slow, smooth, even pull on the wrench. Do not overtorque fasteners; overtightening causes permanent stretching of the fasteners, which can result in breakage of the parts or fasteners.

If specific torque values are not given for countersunk bolts, use the torque value for the corresponding size and grade of regular bolt, as given in **Specifications, 400**.

Always follow the torque sequence or torque interval when provided, to ensure that clamping forces are even, and parts and fasteners are not distorted.

Thread Locking Compound Application

When the use of thread locking compound is recommended or desired, for studs, capscrews, and bolts with a thread diameter of 1 inch (25 mm) or less, use Loctite® 271 or Perma-Lok® HM-128.

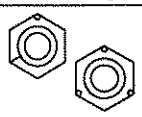
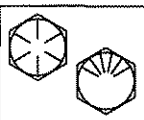
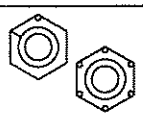
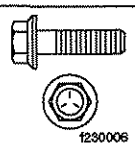
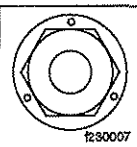
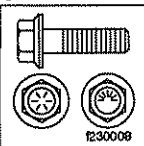
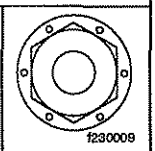
For thread diameters over 1 inch (25 mm), use Loctite 277.

General Instructions

NOTE: Follow the safety precautions given on the locking compound container.

1. Clean the male and female threads of the fasteners, removing all dirt, oil, and other foreign material. If parts are contaminated, use Stoddard solvent for cleaning; then allow the fasteners to air dry for 10 minutes. Be sure solvent is completely gone before applying adhesive.
2. Transfer a small amount of the locking compound from the container to a paper cup or small non-metal dish.
3. Using a plastic brush (a metal brush will contaminate the compound), apply a small amount of compound to the entire circumference of 3 or 4 of the male threads that will be covered by the nut after it has been tightened. Be sure enough compound is applied to fill the inside of the nut threads, with a slight excess.
4. Install and torque the nut. Readjustment of the nut position is not possible after installation is complete, without destroying the locking effect.

NOTE: To disassemble the fasteners, heat the bond line to 400°F (200°C) before removing the nut. Every time the fasteners are disassembled, replace them. If any parts are damaged by overheating, replace the parts.

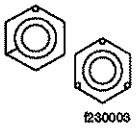
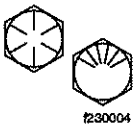
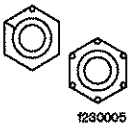
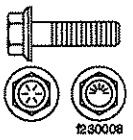
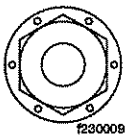
TORQUE VALUES FOR U.S. CUSTOMARY THREAD FASTENERS WITH LUBRICATED* OR PLATED THREADS†								
Thread Diameter–Pitch	Regular Hex				Flanged			
	f230002 Grade 5 Bolt	 f230003 Grade 5 or B Nut	 f230004 Grade 8 or 8.2 Bolt	 f230005 Grade 8 or C Nut	 f230006 Grade 5 Bolt	 f230007 Grade B Nut	 f230008 Grade 8 or 8.2 Bolt	 f230009 Grade G Nut
	Torque: lbf·ft (N·m)		Torque: lbf·ft (N·m)		Torque: lbf·ft (N·m)		Torque: lbf·ft (N·m)	
1/4–20	7 (9)		8 (11)		6 (8)		10 (14)	
1/4–28	8 (11)		9 (12)		7 (9)		12 (16)	
5/16–18	15 (20)		16 (22)		13 (18)		21 (28)	
5/16–24	16 (22)		17 (23)		14 (19)		23 (31)	
3/8–16	26 (35)		28 (38)		23 (31)		37 (50)	
3/8–24	30 (41)		32 (43)		25 (34)		42 (57)	
7/16–14	42 (57)		45 (61)		35 (47)		60 (81)	
7/16–20	47 (64)		50 (68)		40 (54)		66 (89)	
1/2–13	64 (87)		68 (92)		55 (75)		91 (123)	
1/2–20	72 (98)		77 (104)		65 (88)		102 (138)	
9/16–12	92 (125)		98 (133)		80 (108)		130 (176)	
9/16–18	103 (140)		110 (149)		90 (122)		146 (198)	
5/8–11	128 (173)		136 (184)		110 (149)		180 (244)	
5/8–18	145 (197)		154 (209)		130 (176)		204 (277)	
3/4–10	226 (306)		241 (327)		200 (271)		320 (434)	
3/4–16	253 (343)		269 (365)		220 (298)		357 (484)	
7/8–9	365 (495)		388 (526)		320 (434)		515 (698)	
7/8–14	402 (545)		427 (579)		350 (475)		568 (770)	
1–8	—		582 (789)		—		—	
1–12	—		637 (863)		—		—	
1–14	—		652 (884)		—		—	

* Freightliner recommends that all plated and unplated fasteners be coated with oil before installation.

† Use these torque values if either the bolt or nut is lubricated or plated (zinc-phosphate conversion-coated, cadmium-plated, or waxed).

Table 1, Torque Values for U.S. Customary Thread Fasteners with Lubricated or Plated Threads

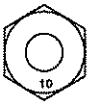
Specifications

TORQUE VALUES FOR U.S. CUSTOMARY THREAD FASTENERS WITH DRY (UNLUBRICATED)* PLAIN (UNPLATED) THREADS†						
Thread Diameter–Pitch	Regular Hex				Flanged	
	f230002 Grade 5 Bolt	 f230003 Grade 5 or B Nut	 f230004 Grade 8 or 8.2 Bolt	 f230005 Grade 8 or C Nut	 f230008 Grade 8 or 8.2 Bolt	 f230009 Grade G Nut
	Torque: lbf·ft (N·m)		Torque: lbf·ft (N·m)		Torque: lbf·ft (N·m)	
1/4–20	8 (11)		10 (14)		—	
1/4–28	9 (12)		12 (16)		—	
5/16–18	15 (20)		22 (30)		22 (30)	
5/16–24	17 (23)		25 (34)		—	
3/8–16	28 (38)		40 (54)		40 (54)	
3/8–24	31 (42)		45 (61)		—	
7/16–14	45 (61)		65 (88)		65 (88)	
7/16–20	50 (68)		70 (95)		—	
1/2–13	70 (95)		95 (129)		95 (129)	
1/2–20	75 (102)		110 (149)		—	
9/16–12	100 (136)		140 (190)		140 (190)	
9/16–18	110 (149)		155 (210)		—	
5/8–11	135 (183)		190 (258)		190 (258)	
5/8–18	155 (210)		215 (292)		—	
3/4–10	240 (325)		340 (461)		340 (461)	
3/4–16	270 (366)		380 (515)		—	
7/8–9	385 (522)		540 (732)		—	
7/8–14	425 (576)		600 (813)		—	
1–8	580 (786)		820 (1112)		—	
1–12	635 (861)		900 (1220)		—	
1–14	650 (881)		915 (1241)		—	

* Threads may have residual oil, but will be dry to the touch.

† Male and female threads (bolt and nut) must both be unlubricated and unplated; if either is plated or lubricated, use Table 1. Freightliner recommends that all plated and unplated fasteners be coated with oil before installation.

Table 2, Torque Values for U.S. Customary Thread Fasteners with Dry (Unlubricated) Plain (Unplated) Threads

TORQUE VALUES FOR METRIC THREAD FASTENERS WITH LUBRICATED* OR PLATED THREADS†				
Thread Diameter–Pitch	f230010 Class 8.8 Bolt	f230011 Class 8 Nut	f230012 Class 10.9 Bolt	 f230013 Class 10 Nut
	Torque: lbf·ft (N·m)		Torque: lbf·ft (N·m)	
M6	5 (7)		7 (9)	
M8	12 (16)		17 (23)	
M8 x 1	13 (18)		18 (24)	
M10	24 (33)		34 (46)	
M10 x 1.25	27 (37)		38 (52)	
M12	42 (57)		60 (81)	
M12 x 1.5	43 (58)		62 (84)	
M14	66 (89)		95 (129)	
M14 x 1.5	72 (98)		103 (140)	
M16	103 (140)		148 (201)	
M16 x 1.5	110 (149)		157 (213)	
M18	147 (199)		203 (275)	
M18 x 1.5	165 (224)		229 (310)	
M20	208 (282)		288 (390)	
M20 x 1.5	231 (313)		320 (434)	
M22	283 (384)		392 (531)	
M22 x 1.5	315 (427)		431 (584)	
M24	360 (488)		498 (675)	
M24 x 2	392 (531)		542 (735)	
M27	527 (715)		729 (988)	
M27 x 2	569 (771)		788 (1068)	
M30	715 (969)		990 (1342)	
M30 x 2	792 (1074)		1096 (1486)	

* Freightliner recommends that all plated and unplated fasteners be coated with oil before installation.
† Use these torque values if either the bolt or nut is lubricated or plated (zinc-phosphate conversion-coated, cadmium-plated, or waxed).

Table 3, Torque Values for Metric Thread Fasteners With Lubricated Or Plated Threads

Decking Devices

⚠ WARNING

The lift brackets are intended only for undecking trucks. Do not use them for vehicle towing or recovery. If used improperly, personal injury or property damage could result.

To avoid damaging vehicles during undecking, follow the instructions below for installing and removing decking devices.

Two lift brackets are required for undecking. Part A21–2611–000 is the left-hand lift bracket and part A21–2611–001 is the right-hand lift bracket. See **Fig. 1**.

Installation

1. Insert the decking device in the tow hook cutout in the front bumper and slide it to the rear until its rear extension/flange rests on top of the front springs. See **Fig. 2**.

⚠ CAUTION

When installing the lifting brackets, be sure that they do not contact or interfere with any air lines. Improper installation could result in component damage.

2. Insert the bolt through the lift bracket to secure it around the tow hook and securely tighten the nut on the bolt.

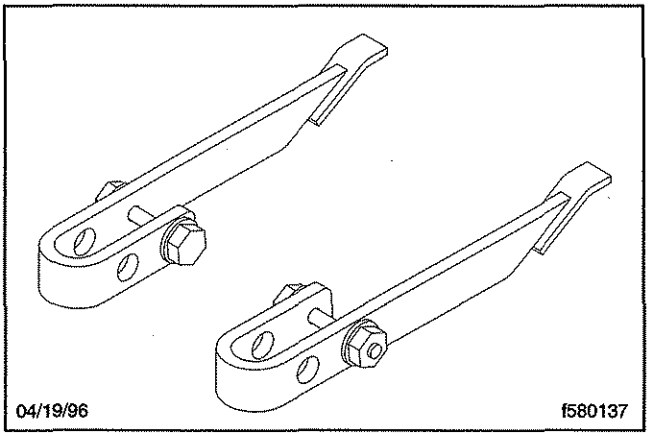
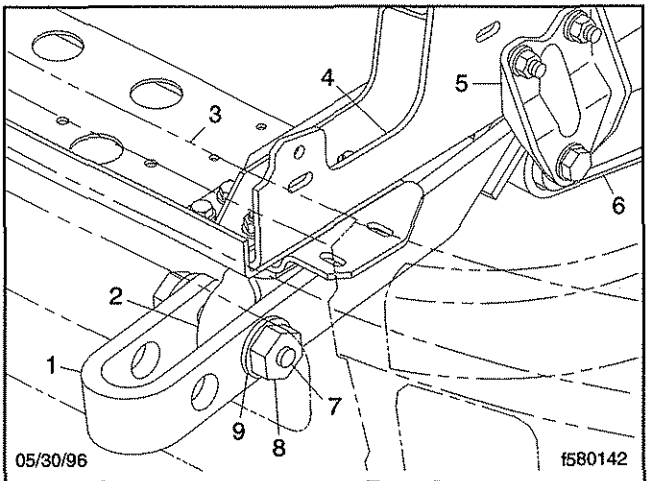


Fig. 1, Lift Brackets

3. The vehicle can now be safely hoisted for undecking. Make sure the undecking area is free of obstacles, has a vertical clearance of at least 14 feet (4.3 m) and a width of at least 12 feet (3.7 m).

Removal

1. Remove the nut and bolt securing lifting bracket to the tow hook.
2. Remove the lifting bracket from the tow hook cutout.



1. Lift Bracket
2. Tow Hook
3. Front Bumper
4. Frame Rail
5. Front Spring Bracket
6. Front Spring
7. Bolt
8. Nut
9. Washer

Fig. 2, Lift Bracket Attachment

Group Index, Alphabetical

Section	Section Number
Bypass Oil Filters	01.05
Caterpillar Engines	01.00
Cummins Engines	01.01
Detroit Diesel Engines	01.02
Engine Brake Troubleshooting	01.12
Engine Mounts	01.03
Ether Start System	01.04
Jacobs Engine Brake, Model 310A	01.06
Jacobs Engine Brake, Model 349A	01.07
Jacobs Engine Brake, Model 404D	01.08
Jacobs Engine Brake, Model 411	01.09
Jacobs Engine Brake, Model 750	01.10
Jacobs Engine Brake, Models 760A and 765	01.11
Mercedes-Benz MBE4000 Engine	01.13

Contents

Subject	Subject Number
Service Operations	
Engine Port Diagrams	050
Pulley and Drive Belt Inspection, Caterpillar Engines	100
Drive Belt Replacement, Caterpillar C-10	105
Drive Belt Replacement, Caterpillar 3406	110
Engine Removal and Installation, Caterpillar 3406	120
Specifications	400

NOTE: For engine service and troubleshooting procedures, refer to the engine manufacturer's service literature.

For engine brake information for the Caterpillar C-10, refer to **Section 01.06**.

For engine brake information for the Caterpillar 3406, refer to **Section 01.07**.

For engine wiring diagrams, refer to the applicable section in **Group 54**.

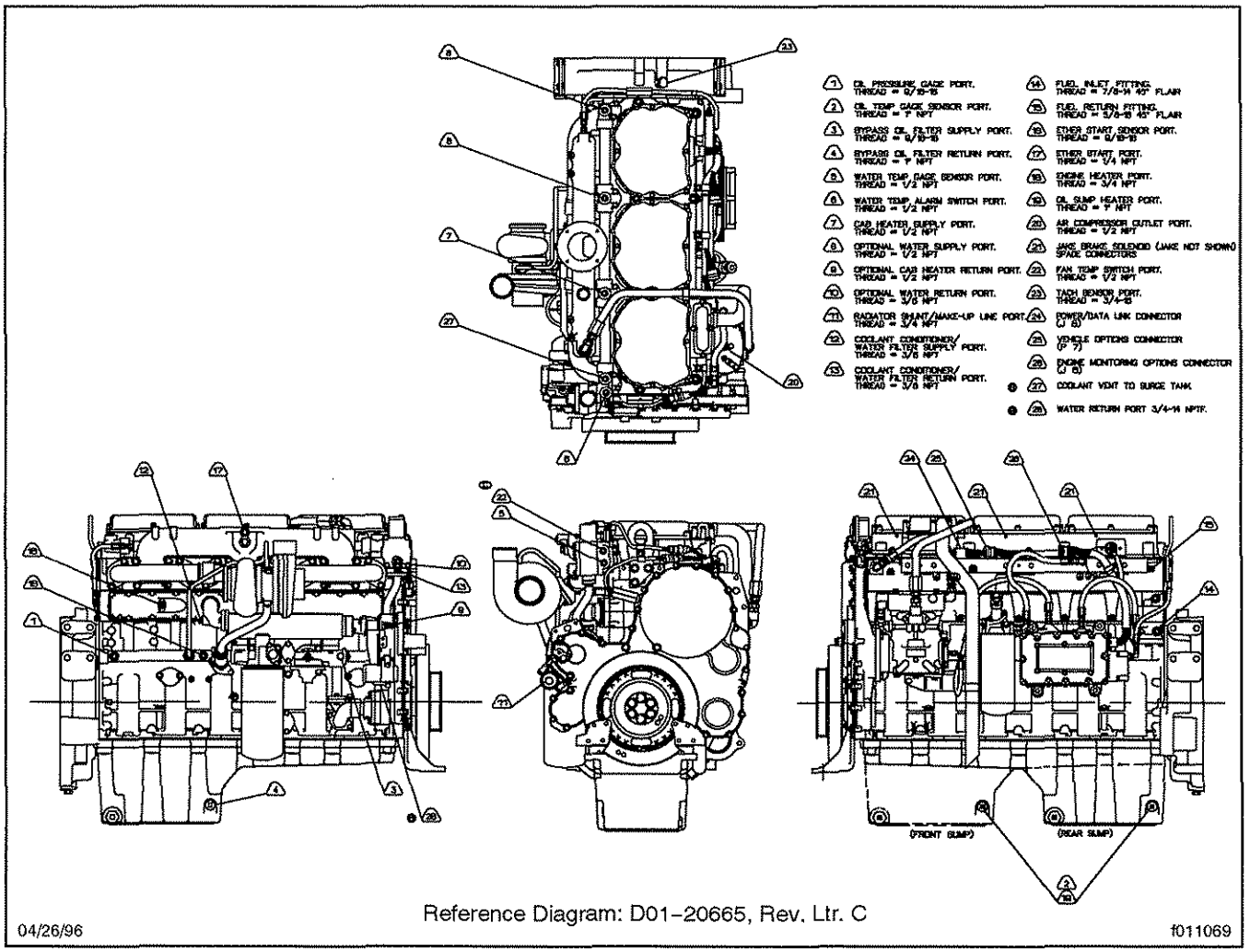
Engine Port Diagrams

Use the following diagrams to identify engine ports:

- For a Caterpillar 3176 Engine, see **Fig. 1**.
- For a Caterpillar 3406 Engine, see **Fig. 2**.

Engine Port Diagrams

- For a Caterpillar C–10 or C–12 Engine, see **Fig. 3**.



Reference Diagram: D01–20665, Rev. Ltr. C

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Fig. 1, Caterpillar 3176 Engine Ports

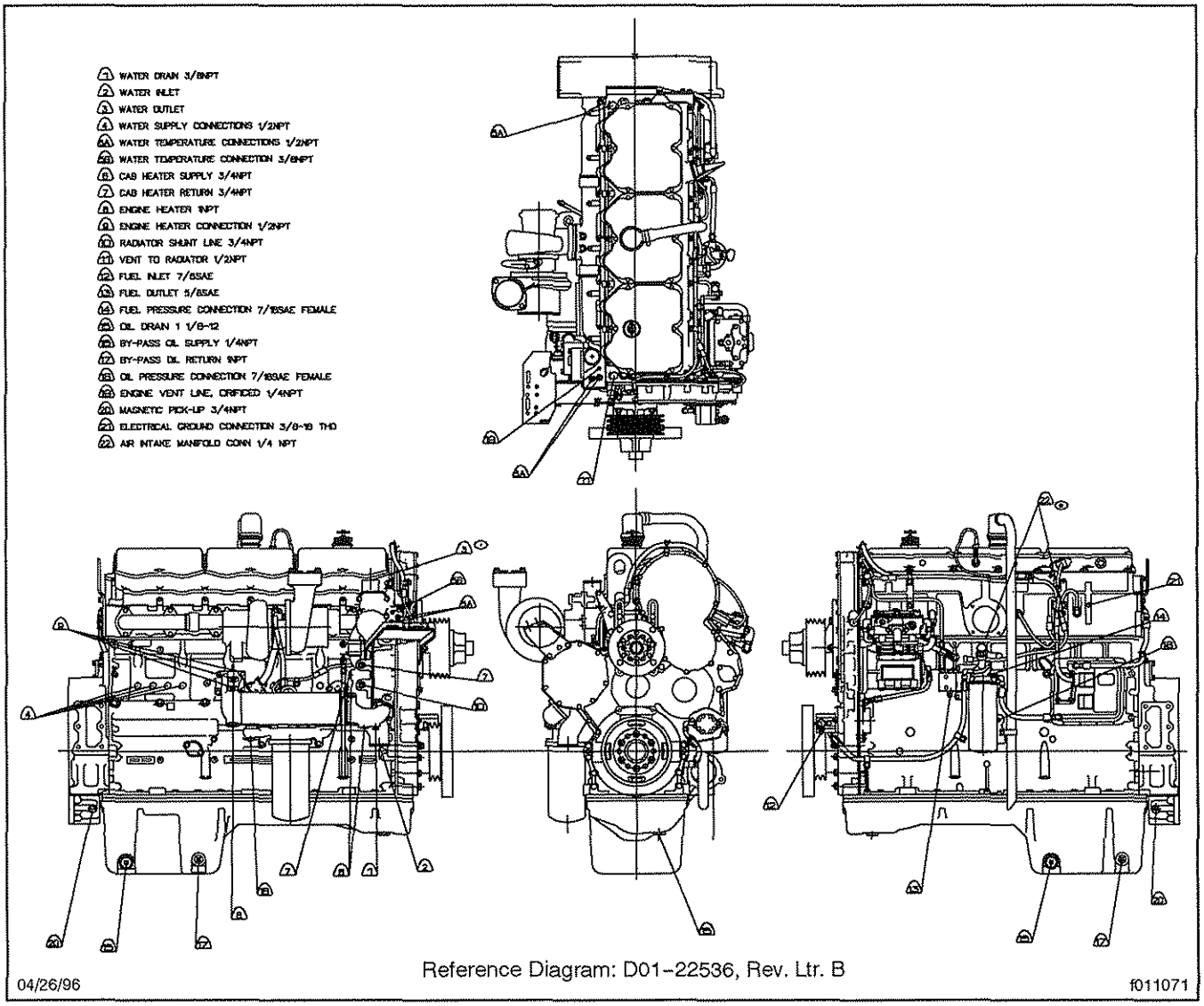


Fig. 2, Caterpillar 3406 Engine Ports

Engine Port Diagrams

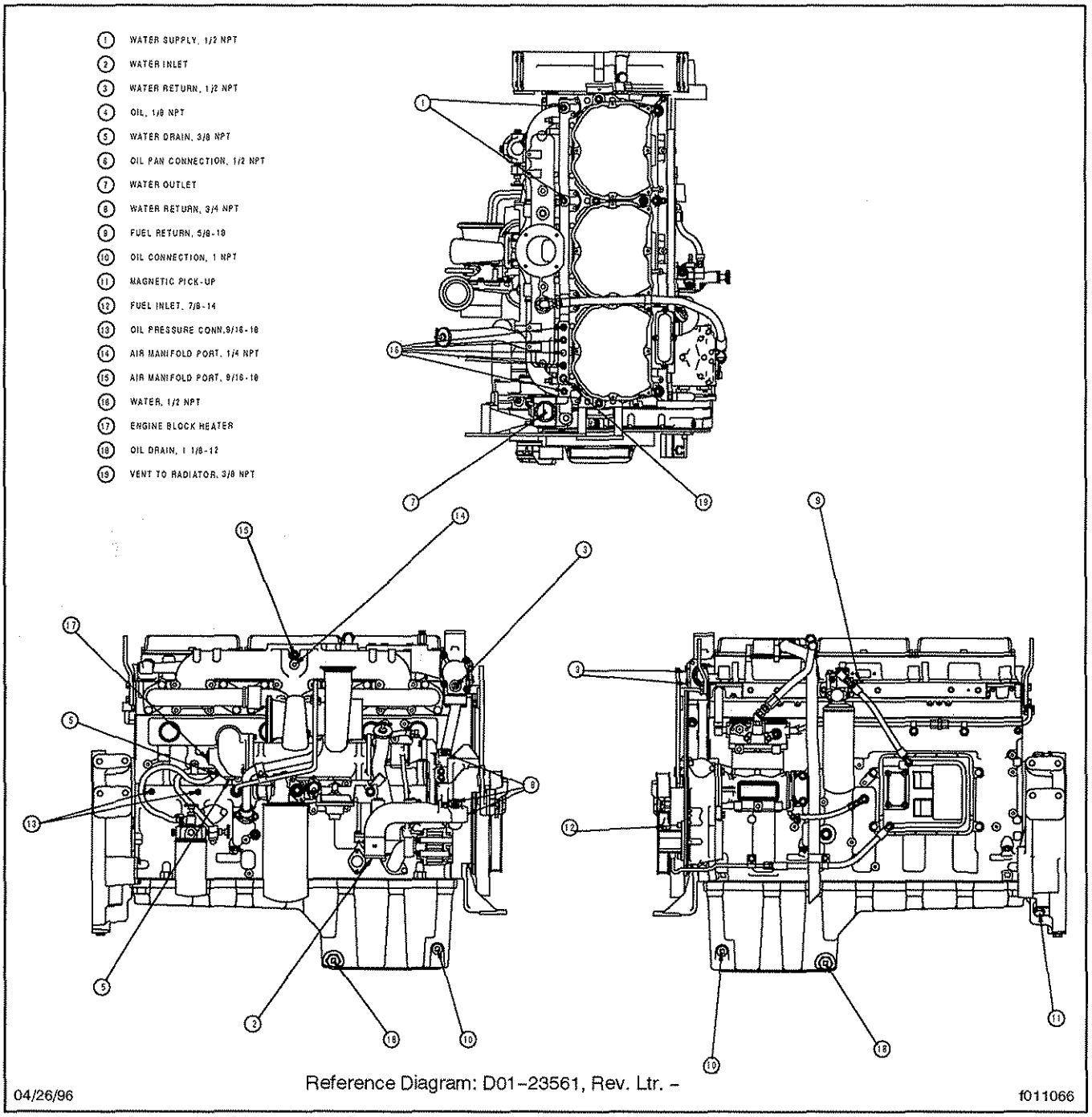


Fig. 3, Caterpillar C-10 and C-12 Engine Ports

Pulley and Drive Belt Inspection, Caterpillar Engines

Inspection

1. Inspect all used drive belts (including those that are being replaced) for the following conditions (**see Fig. 1**):

   NOTE: For an installed belt, gently twist the belt about 90 degrees so you can see the sidewalls and bottom.

   1.1 Inspect for glazing (shiny sidewalls). Glazing is caused by friction created when a loose belt slips in the pulleys. It can also be caused by oil or grease on the pulleys.

   1.2 Inspect for separating layers. Oil, grease, or belt dressings can cause the belt to fall apart in layers. If engine parts are leaking, repair the oil leaks. Do not use belt dressings on any belt.

   1.3 Check for jagged or streaked sidewalls. These are the result of a foreign object (such as sand or small gravel) in the pulley, or a rough pulley wall surface.

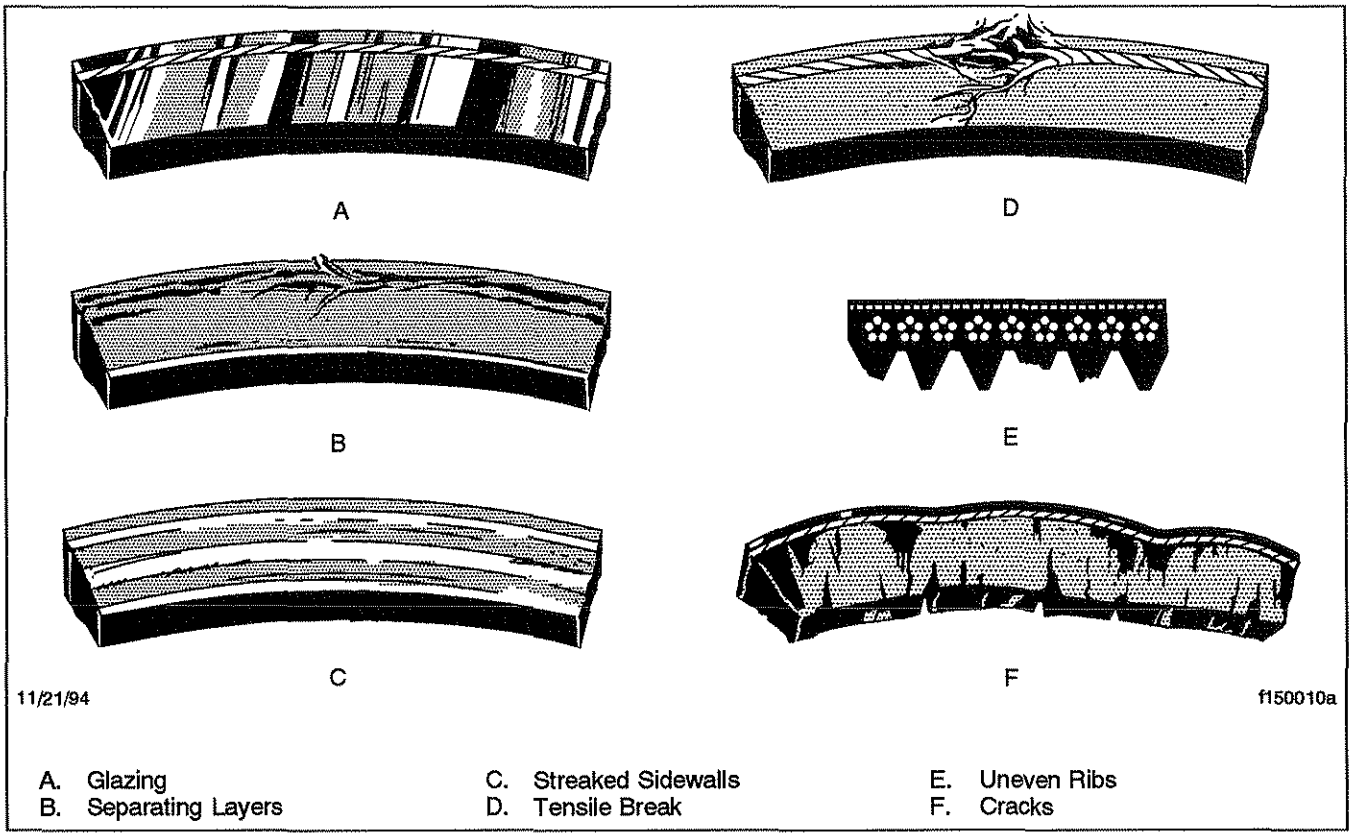
   1.4 Check for tensile breaks (breaks in the cord body). Cuts in a belt are usually caused by large foreign objects in the pulley, or by prying or forcing the belt during installation or removal.

   1.5 On poly-V belts, check for uneven ribs. Foreign objects in the pulley will erode the undercord ribs, causing the belt to lose its gripping power.

   1.6 Inspect for cracks. Small, irregular cracks are usually signs of an old belt.

   Replace the belt if any of the above conditions are found. Replace both belts of a set, at the same time. Matched belts must be from the same manufacturer.

2. Check all pulley bearings for roughness. Replace the bearings if they're rough.



A. Glazing
B. Separating Layers
C. Streaked Sidewalls
D. Tensile Break
E. Uneven Ribs
F. Cracks

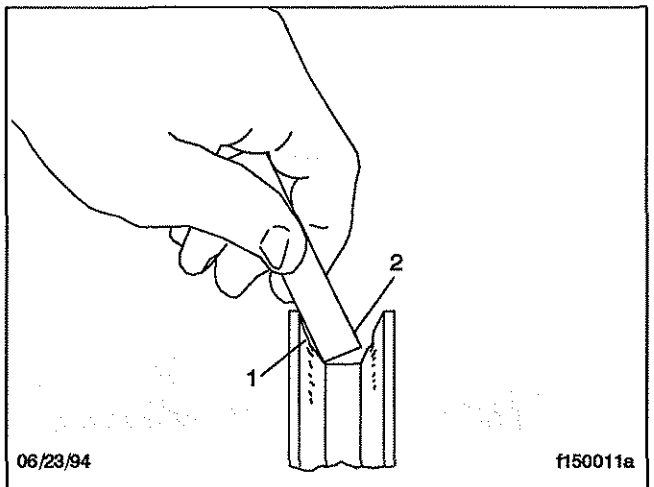
Fig. 1, Drive Belt Problems

Pulley and Drive Belt Inspection, Caterpillar Engines

3. Inspect all pulleys for foreign objects, oil, or grease in the grooves. Use a nonflammable cleaning solvent to remove oils. Use a wire brush to remove rust, and a file to remove burrs.
4. Inspect the pulleys for wear on the inner walls. Hold a small straightedge against the inside of the pulley walls (**Fig. 2**), or use your little finger or fingernail to find grooves in the inner walls. If there are any grooves, replace the pulley.
5. Check alignment of pulleys.Use a thin straightedge that is longer than the longest span between the pulleys. Place the straightedge into the V-grooves of two pulleys at a time. The straightedge should be parallel to the outer edges of the pulleys; if not, the pulleys are misaligned.

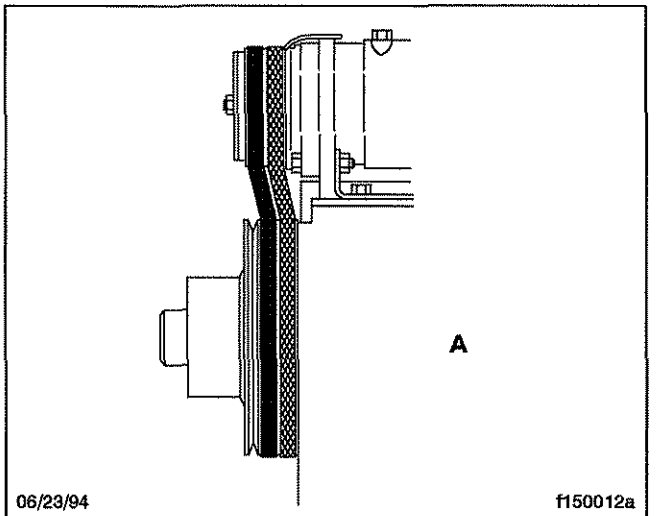
   Pulley misalignment must not be more than 1/16-inch for each foot (1.5 mm for each 30.5 cm) of distance between pulley centers.

   If there is misalignment of the pulleys, adjust the pulleys or brackets if their positions are adjustable. **See Fig. 3.** Replace bent or broken pulleys, pulley brackets, or shafts.
6. Check all drive component mounting parts for loose fasteners, cracks, or other damage. Tighten loose fasteners. Repair or replace cracked or damaged brackets.



1. Groove in Pulley Wall
2. Small Straightedge

Fig. 2, Check for Pulley Wear



A. Side View of Misaligned Pulleys.

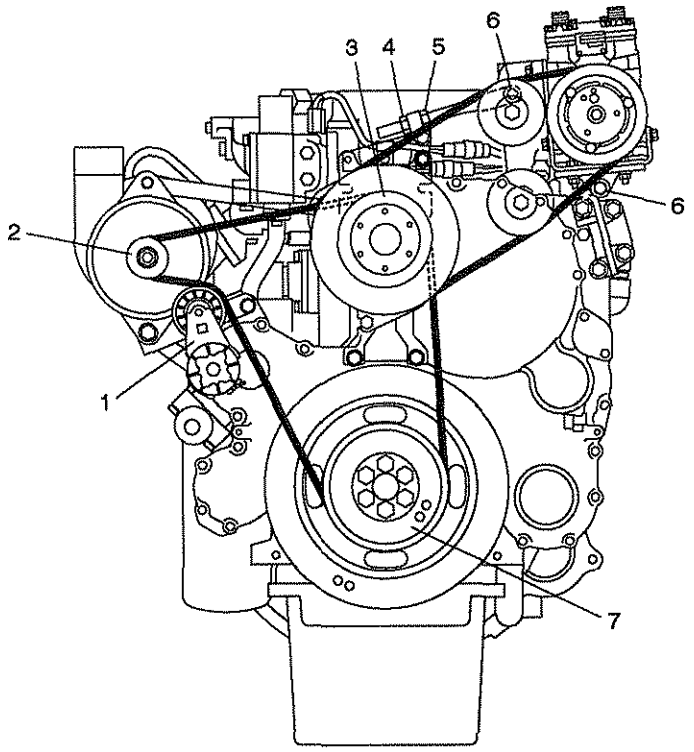
Fig. 3, Check for Misaligned Pulleys

Drive Belt Replacement, Caterpillar C-10

Belt Replacement

FAN AND ALTERNATOR BELT (See Fig. 1)

1. Remove the belt.
   - 1.1 Remove the belt from the refrigerant compressor pulley and let the belt rest on the fan hub. Refer to the refrigerant compressor belt removal procedure in this subject.
   - 1.2 Insert a 1/2-inch breaker bar in the belt tensioner and rotate the tensioner down and off the belt.
   - 1.3 Holding the belt tensioner down, remove the belt from the alternator pulley.
   - 1.4 Slowly release the belt tensioner, and remove the breaker bar.
   - 1.5 Lower the belt, and take it off the vibration damper. Raise the belt, and take it off over the fan. Remove the belt from the engine compartment.
2. Install the belt.
   - 2.1 Inspect the pulleys and used belts (even if installing new belts) as instructed in **Subject 100**.



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1. Belt Tensioner
2. Alternator Pulley
3. Fan Pulley
4. Refrigerant Compressor Jam Nut
5. Refrigerant Compressor Adjusting Nut
6. Refrigerant Compressor Pivot Bolt
7. Vibration Damper

Fig. 1, Drive Belts, Caterpillar C-10 Engine

Drive Belt Replacement, Caterpillar C-10

2.2 If the fan or fan hub was removed to remove the compressor belt, install the fan or fan hub with the compressor belt in the fan pulley groove. Do not attach the compressor belt to the compressor at this time.

2.3 Loop the fan/alternator belt around the fan and align it in the rear channel of the fan pulley.

2.4 Loop the belt down and around the vibration damper pulley.

2.5 Install the refrigerant compressor belt on the compressor. Refer to the refrigerant compressor belt installation instructions in this subject.

2.6 Insert a 1/2-inch breaker bar in the belt tensioner, and rotate the tensioner down while installing the belt on the alternator pulley.

2.7 Slowly release the tensioner assembly onto the belt. The tensioner automatically tightens the belt to the correct tension.

2.8 Remove the breaker bar from the tensioner.

3. Adjust the belt tension.

3.1 The Caterpillar belt tensioner automatically adjusts the fan and alternator belt to the correct tension.

3.2 If the belt slips, repair or replace the tensioner. For instructions, refer to the Caterpillar C-10 Truck Engine Service Manual.

REFRIGERANT COMPRESSOR BELT (See Fig. 1)

1. Remove the belt.

1.1 Loosen the refrigerant compressor jam nut, back off the adjusting nut, and loosen the compressor mounting bolts. Move the compressor towards the fan pulley until the belt can be removed from the compressor.

1.2 Remove the compressor belt from the fan pulley. If necessary, remove the fan from the fan pulley according to the instructions in **Section 20.01**.

2. Install the belt.

2.1 Inspect the pulleys and used belts (even if installing new belts) as instructed in **Subject 100**.

2.2 Install the belt around the fan and the compressor pulleys.

If the fan was removed, install it according to the instructions in **Section 20.01**.

2.3 While keeping the belt seated in the pulley grooves, move the compressor away from the fan pulley to increase belt tension. Use your thumb to apply about 25 lb (11 kg) of force at the center of the longest belt free-span to check the tension. When belt deflection is about 1/2 to 3/4 inch (13 to 19 mm), stop, and adjust the belt tension.

3. Adjust the belt tension.

3.1 Install a belt tension gauge at the center of the belt's longest free-span.

IMPORTANT: Do not overtighten the belts; too much tension shortens belt and bearing life.

3.2 Turn the adjusting nut to adjust the tension to a reading of 100 lb (45 kg).

Tighten the jam nut 155 lbf·ft (210 N·m).

Tighten the compressor pivot bolts 70 lbf·ft (95 N·m).

Check the belt tension and adjust it if needed.

3.3 If any new belts were installed, operate the engine for about 20 minutes, then check the belt tension. All new belts will lose tension after 20 minutes of operation.

If the compressor belt tension is not 100 lb (45 kg), adjust the tension to 100 lb (45 kg).

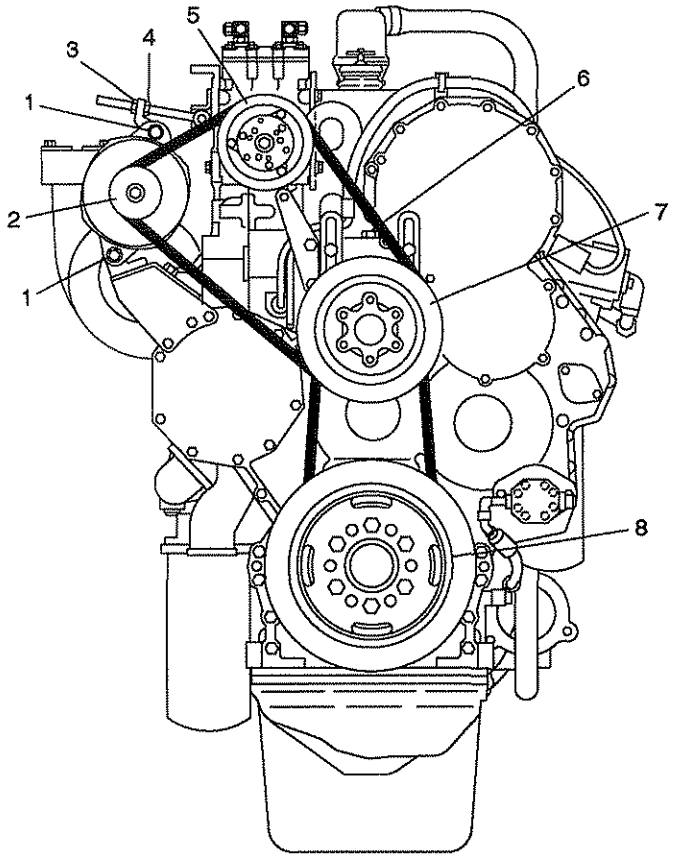
Drive Belt Replacement, Caterpillar 3406

Belt Replacement

ALTERNATOR AND REFRIGERANT COMPRESSOR BELTS (See Fig. 1)

NOTE: Adjust the alternator and refrigerant compressor belt by moving the alternator only. Do not move the refrigerant compressor. The refrigerant compressor is mounted in a slotted bracket and must stay mounted at the bottom of the slots. Do not raise the compressor to tighten the belt.

1. Remove the belt.
   - 1.1 Back off the alternator adjusting nut, then loosen the alternator mounting fasteners enough to allow movement of the alternator.
   - 1.2 Push the loosened alternator toward the fan drive pulley until the distance between them is short enough to allow belt removal without using force.
   - 1.3 Remove the belt by slipping it off of the pulleys and working it over one fan blade at a time.
2. Install the belt.
   - 2.1 If the fan belt was removed, install and adjust it first. For instructions, refer to the fan belt procedure in this subject.



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1. Alternator Mounting Bolt
2. Alternator Pulley
3. Alternator Jam Nut
4. Alternator Adjusting Nut
5. Refrigerant Compressor Pulley
6. Fan Adjusting Bolt
7. Fan Pulley
8. Vibration Damper

Fig. 1, Drive Belts, Caterpillar 3406

Drive Belt Replacement, Caterpillar 3406

2.2 Inspect the pulleys and used alternator belt (even if a new belt is being installed) as instructed in **Subject 100.**

2.3 Make sure the distance between the pulleys is short enough to allow belt installation without using force.

2.4 Install the belt on the pulleys without prying or rolling it into place.

2.5 Back off the jam nut.

2.6 While keeping the belt seated in the pulley grooves, turn the adjusting nut against the adjusting link to increase the belt tension. Use your thumb to apply about 25 lb (11 kg) of force at the center of the belt free-span to check the tension while turning the nut. When belt deflection equals one belt thickness per foot (305 mm) of pulley-center distance, stop, and adjust the belt tension.

3. Adjust the belt tension.

3.1 If not already done, back off the adjusting link jam nut, and loosen the alternator mounting fasteners just enough to allow movement of the alternator.

3.2 Install a belt tension gauge on the belt, at the center of the belt's longest free-span.

IMPORTANT: Do not overtighten the belt; too much tension shortens belt life and bearing life.

3.3 Turn the adjusting nut to adjust the tension to a reading of 100 lb (45 kg).

3.4 Tighten the adjusting rod jam nut 95 lbf·ft (130 N·m).

3.5 Tighten the alternator mounting fasteners 70 lbf·ft (95 N·m).

3.6 Check the belt tension, and adjust it if needed.

3.7 If a new alternator belt was installed, operate the engine for about 20 minutes, then check the belt tension. All new belts will lose tension after 20 minutes of operation.

If the alternator belt tension is not 100 lb (45 kg), adjust the tension to 100 lb (45 kg).

FAN BELTS (See Fig. 1)

1. Remove the belts.

1.1 Remove the alternator belt. For instructions, refer to the alternator belt procedure in this subject.

1.2 Loosen the fan hub mounting bolts.

1.3 Turn the fan hub adjusting bolt until there is minimal distance between the pulley centers.

1.4 Remove the fan belt by slipping it off of the pulleys and working it over one fan blade at a time. Don't roll or pry the belt off; the distance between the pulley centers must be short enough to allow belt removal without using force.

2. Install the belt.

2.1 Inspect the pulleys and used fan belt (even if a new belt is being installed) as instructed in **Subject 100.**

2.2 Make sure the distance between the pulleys is short enough to allow belt installation without using force.

2.3 Work the belt over the fan blades, one blade at a time. Install the belt on the pulleys without prying or rolling it into place.

2.4 While keeping the belt seated in the pulley grooves, turn the fan hub adjusting bolt to increase the belt tension. Use your thumb to apply about 25 lb (11 kg) of force at the center of the belt free-span to check the tension while turning the bolt. When belt deflection equals one belt thickness per foot (305 mm) of pulley-center distance, stop, and adjust the belt tension.

3. Adjust the belt tension.

3.1 If not already done, loosen the fan hub mounting bolts.

3.2 Install a belt tension gauge on the belt, at the center of the belt free-span.

IMPORTANT: Do not overtighten the belt; too much tension shortens belt life and bearing life.

3.3 Turn the fan hub adjusting bolt to increase or decrease the belt tension, but do not adjust the tension to the full value with the fan hub adjusting bolt; tension can increase when the fan hub bracket bolts are tightened. Final tension must be 100 lb (45 kg).

3.4 Tighten the fan hub mounting bolts 70 lbf·ft (95 N·m).

3.5 Loosen the fan hub adjusting bolt one-half turn.

3.6 Check the belt tension, and adjust it if needed.

3.7 Install and adjust the alternator belt.

3.8 If a new belt was installed, operate the engine for about 20 minutes, then check the belt tension. All new belts will lose tension after 20 minutes of operation.

If the fan belt tension is not 100 lb (45 kg), adjust the tension to 100 lb (45 kg).

Engine Removal and Installation, Caterpillar 3406

Removal

1. Apply the parking brakes, chock the tires, and drain the air system.
2. Disconnect the batteries.
3. Remove the hood and the bumper. For instructions, refer to **Group 88** in this manual.
4. Disconnect the transmission from the engine. For instructions, refer to **Group 26** in this manual.
5. Remove the air cleaner housing and the brackets that hold the housing to the bulkhead. This includes removing the heat shield between the cleaner and the turbocharger. For instructions, refer to **Group 09** in this manual.

⚠ WARNING

Drain the coolant only when the coolant and engine are cool. Draining it when these are hot could cause severe personal injury due to scalding.

6. Drain the radiator. For instructions, refer to **Section 20.01**.
7. Move the air conditioning components out of the way without breaking the refrigerant lines.
   - 7.1 Free the refrigerant lines from all routing clamps and stand-off brackets between the compressor and the condenser.
   - 7.2 Free the refrigerant lines from all routing clamps and stand-off brackets between the receiver dryer and the condenser.
   - 7.3 Remove the condensers mounting fasteners, and move the condenser aside.
   - 7.4 Remove the refrigerant compressor and move the compressor aside. For instructions, refer to **Group 83** in this manual.
   - 7.5 Use tie straps to secure the refrigerant compressor and condenser out of the way.
8. Remove the air recirculation shields around the radiator and charge air cooler. For instructions, refer to **Section 20.01** in this manual.
9. Remove the radiator and charge air cooler. For instructions, refer to **Section 20.01** in this manual. Remove the radiator mounting bracket with the radiator.
10. Disconnect or remove the remaining ducts and lines.
    - 10.1 If not already removed, remove the air duct between the turbocharger and the air cleaner.
    - 10.2 Disconnect the vent line from the engine, and move the line aside.
    - 10.3 Disconnect the two air signal lines from the air governor.
    - 10.4 Disconnect the outlet line from the air compressor.
    - 10.5 Disconnect the air line to the fan clutch solenoid, and free the line from routing clamps.
    - 10.6 Disconnect the heater supply and return hoses from the radiator outlet pipe, and free the hoses from the clamps that route them to the bulkhead.
    - 10.7 If applicable, disconnect the ether start fluid line from the engine manifold.
11. Remove the surge tank and mounting bracket from the bulkhead. For instructions, refer to **Section 20.01** in this manual.
12. Remove the windshield wiper pan. For instructions, refer to **Group 60** in this manual.
13. Label and disconnect the wiring.
14. Without draining the power steering fluid, remove the power steering fluid pump from the engine, leaving the fluid plumbing intact. For instructions, refer to **Group 46** in this manual.
15. Under the engine, disconnect or remove the remaining components.
    - 15.1 Remove the section of exhaust ducting that runs between the turbocharger and the muffler.
    - 15.2 Disconnect the fuel return lines. For instructions, refer to **Group 47** in this manual.
    - 15.3 Remove the bolts that hold the engine legs to the rear engine mounts.

Engine Removal and Installation, Caterpillar 3406

⚠ WARNING

The crane and lifting chains used to remove the engine must be capable of safely lifting and supporting two metric tons. Once the engine mounts are disconnected, do not get under the engine until it is securely supported on engine stands. An unsecured engine may fall, causing personal injury or death, and component damage.

16. Remove the engine from the vehicle.

    16.1 Attach the chain to the lifting eyes at the front and the rear of the engine.

    NOTE: If the engine is equipped with an exhaust brake, it may be necessary to remove the front valve cover to provide clearance for the lifting chain.

    16.2 With the two engine lifting eyes connected by chain to the crane, raise the crane enough to tighten the chains, but not enough to lift the front of the vehicle.

    16.3 Remove the nuts from the bolts that fasten the front engine support bracket to the underslung crossmember.

    16.4 Using the crane, lift the engine slightly and remove the upper isolator from the front engine mount.

    16.5 With the front of the engine lifted slightly, remove the front underslung crossmember. For instructions, refer to **Group 31**.

    16.6 Using the crane, lift the engine and pull it forward.

    16.7 Once the engine is clear of the vehicle, place the engine on engine stands.

Installation

⚠ WARNING

The crane and lifting chains used to install the engine must be capable of safely lifting and supporting two metric tons. Once the engine is removed from the engine stands, do not get under the engine until it is securely supported on the engine mounts. An unsecured engine may fall, causing personal injury or death, and component damage.

1. Install the engine in the vehicle.

    1.1 Attach the chain to the lifting eyes at the front and the rear of the engine.

    1.2 With the two engine lifting eyes connected by chain to the crane, lift the engine, and position it in the engine compartment.

    1.3 Connect the engine to the rear engine mounts, and tighten the bolt that runs down through each engine leg, rubber isolators, and engine mount 213 to 269 lbf·ft (289 to 365 N·m).

    1.4 With the front of the engine lifted slightly, install the front underslung crossmember. For instructions, refer to **Group 31**.

    1.5 Assemble the lower isolator under the underslung crossmember and the front engine bracket, and secure the front engine mount with nuts and washers. Tighten the nuts 213 to 269 lbf·ft (289 to 365 N·m).

    1.6 Once the engine is securely installed in the vehicle, remove the lifting chains.

    NOTE: If the valve covers were removed, install them according to the engine manufacturer's service literature.

2. Connect and install components under the engine.

    2.1 Connect the exhaust pipe to the muffler.

    2.2 Connect the two fuel return lines. For instructions, refer to **Group 47** of this manual.

    2.3 Connect the transmission to the engine. For instructions, refer to **Group 26** in this manual.

3. Without breaking the power steering fluid lines, install the power steering pump. For instructions, refer to **Group 46** in this manual.

4. Connect the wiring. For wiring harness information, refer to **Group 54** in this manual.

5. Install the windshield wiper pan. For instructions, refer to **Group 60**.

6. Connect or install the ducts and lines.

6.1 Install the V-band clamp that holds the forward end of the exhaust ducting to the rear of the turbocharger. Tighten the V-band clamp 85 lbf·in (940 N·cm).

6.2 Install the air duct between the turbocharger and the air cleaner.

6.3 Connect the vent line to the engine.

6.4 Connect the two air signal lines to the air governor on top of the compressor.

6.5 Connect the outlet line to the air compressor.

6.6 Connect the air line to the fan clutch solenoid.

6.7 Connect the heater supply and return hoses to the radiator outlet pipe.

6.8 If applicable, connect the ether start line to the engine manifold.

7. Install the radiator, surge tank, fan shroud, and charge air cooler. For instructions, refer to **Section 20.01** in this manual.

8. Install the air recirculation shields around the radiator and charge air cooler. For instructions, refer to **Section 20.01** in this manual.

9. Install the air conditioning components without breaking the refrigerant lines.

9.1 Install the condenser. For instructions, refer to **Group 83** of this manual.

9.2 Install the refrigerant compressor. For instructions, refer to **Group 83** of this manual. For instructions on installing the compressor drive belts, refer to **Section 01.02** in this workshop manual group.

9.3 Route and clamp the refrigerant lines between the compressor and the condenser.

9.4 Route and clamp the refrigerant lines between the receiver-drier and the condenser.

10. Install the air cleaner housing. For instructions, refer to **Group 09** in this manual. Connect the intake air ducting to the air cleaner and the charge air cooler.

11. Install the hood and the bumper. For instructions, refer to **Group 88** in this manual.

12. Fill the radiator.

13. Connect the batteries.

14. Start the engine, and check for leaks. Repair any leaks found.

15. Test drive the vehicle.

Specifications

Engine	Component	Belt Tension, New Belt lbs (kg)	Belt Tension, Used Belt lbs (kg)
3176	Refrigerant Compressor	80 to 100 (36 to 45)	80 to 100 (36 to 45)
3406	Alternator and Refrigerant Compressor	115 to 125 (52 to 57)	80 to 100 (36 to 45)
	Fan	115 to 125 (52 to 57)	80 to 100 (36 to 45)

Table 1, Drive Belt Tensions

Engine	Fastener	Torque lbf·ft (N·m)
3176 and 3406	Rear Engine-to-Mount Bolts	213 to 269 (289 to 365)
	Front Engine-to-Mount Bolts	

Table 2, Fastener Torques

Contents

Subject	Subject Number
Service Operations	
Engine Port Diagrams	050
Pulley and Drive Belt Inspection, Cummins Engines	100
Drive Belt Replacement, Cummins M11	105
Drive Belt Replacement, Cummins N14	110
Engine Removal and Installation, Cummins M11	115
Specifications	400

NOTE: For engine service and troubleshooting procedures, refer to the engine manufacturer's service literature.

For engine brake information for the Cummins M11, refer to **Section 01.09**.

For engine brake information for the Cummins N14, refer to **Section 01.08**.

For engine wiring diagrams, refer to the applicable section in **Group 54**.

Engine Port Diagrams

Use the following diagrams to identify engine ports:

- For a Cummins M11 Engine, see **Fig. 1**.

Engine Port Diagrams

- For a Cummins N14 Engine, see **Fig. 2**.

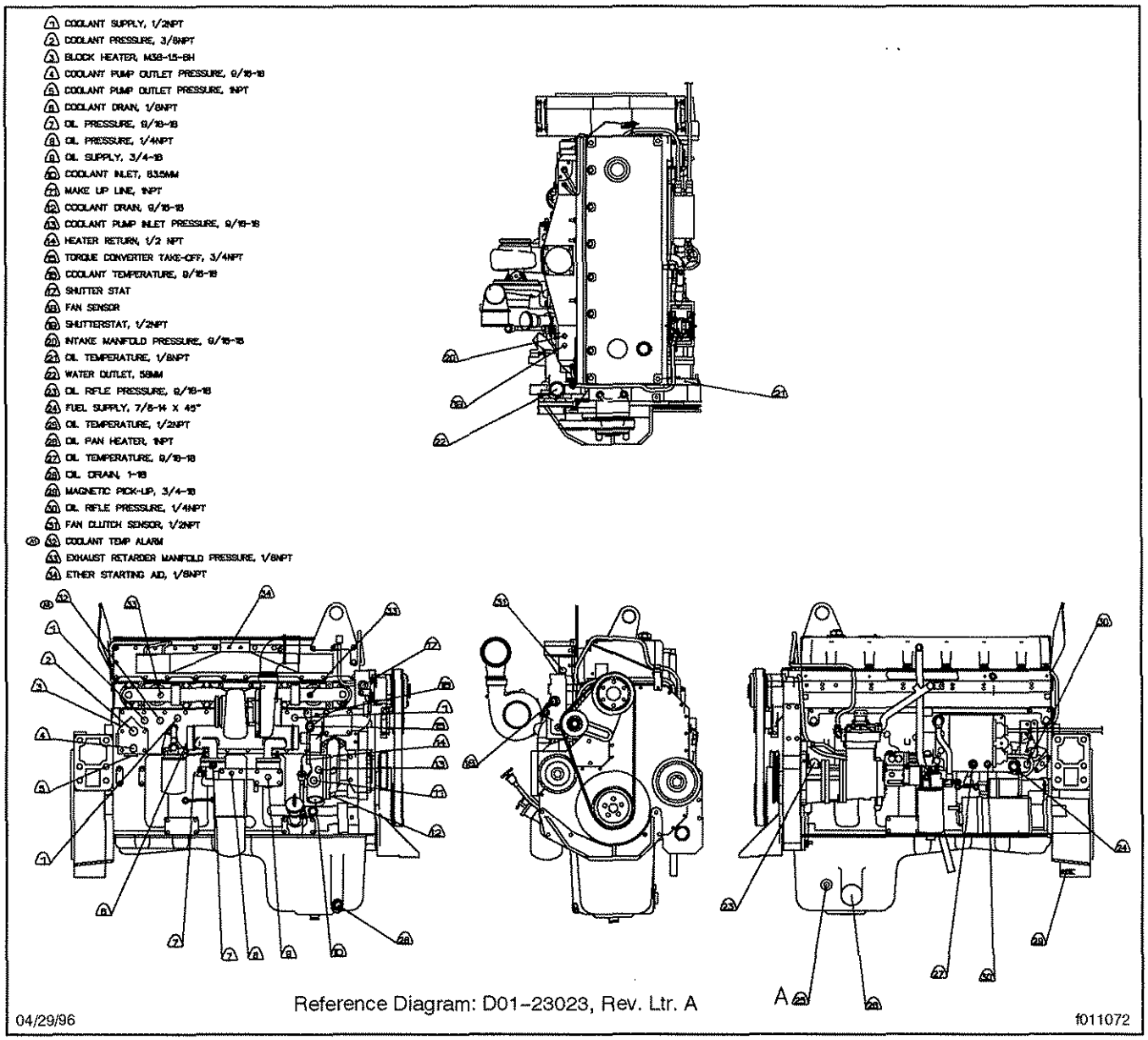


Fig. 1, Cummins M11 Engine Ports

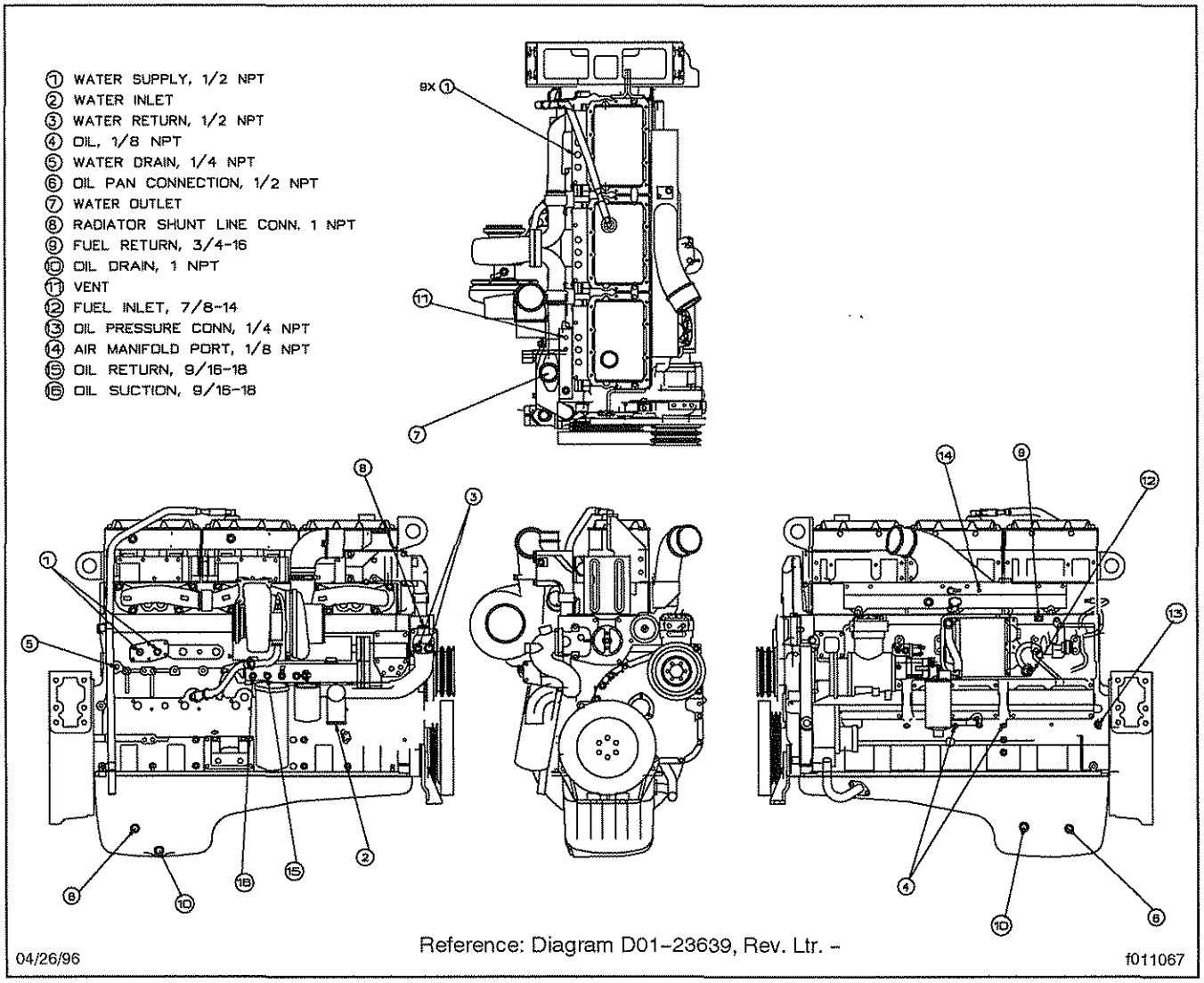


Fig. 2, Cummins N14 Engine Ports

Pulley and Drive Belt Inspection, Cummins Engines

Inspection

1. Inspect all used drive belts (including those that are being replaced) for the following conditions (**see Fig. 1**):

   NOTE: For an installed belt, gently twist the belt about 90 degrees so you can see the sidewalls and bottom.

   1.1 Inspect for glazing (shiny sidewalls). Glazing is caused by friction created when a loose belt slips in the pulleys. It can also be caused by oil or grease on the pulleys.

   1.2 Inspect for separating layers. Oil, grease, or belt dressings can cause the belt to fall apart in layers. If engine parts are leaking, repair the oil leaks. Do not use belt dressings on any belt.

   1.3 Check for jagged or streaked sidewalls. These are the result of a foreign object (such as sand or small gravel) in the pulley, or a rough pulley wall surface.

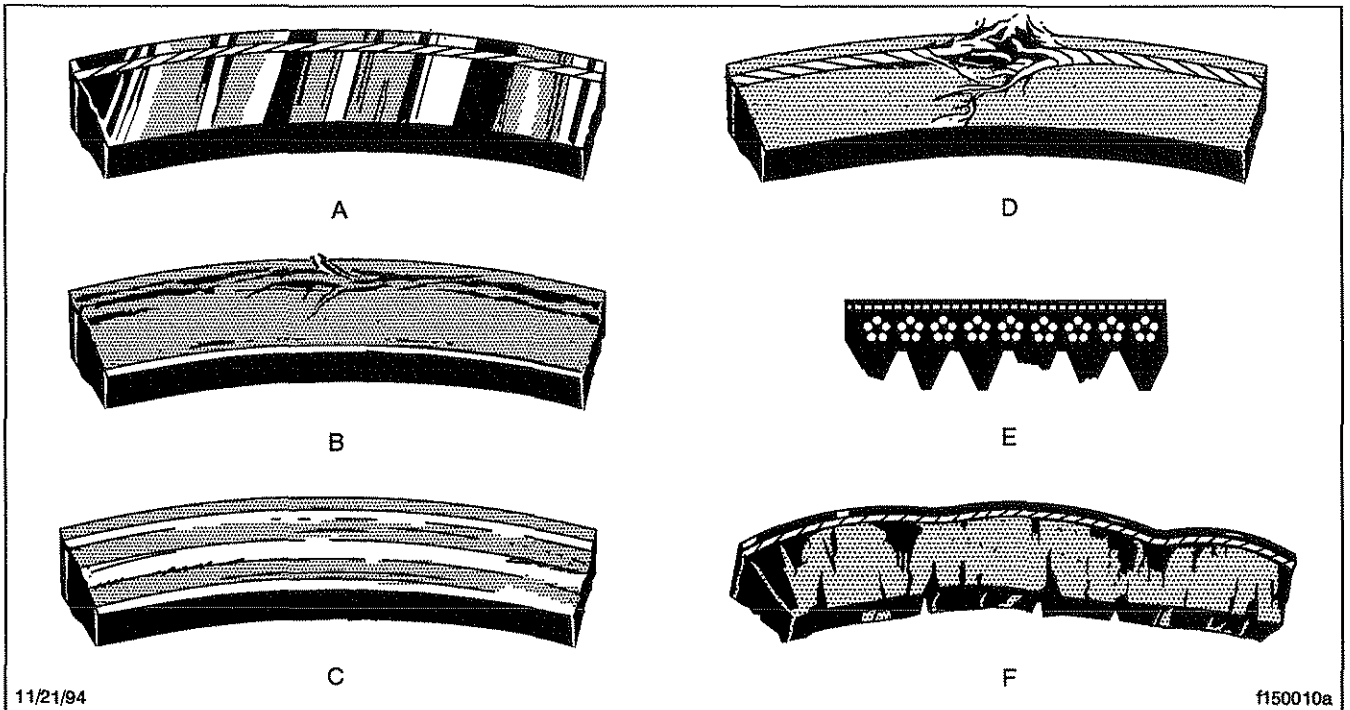
   1.4 Check for tensile breaks (breaks in the cord body). Cuts in a belt are usually caused by large foreign objects in the pulley, or by prying or forcing the belt during installation or removal.

   1.5 On poly-V belts, check for uneven ribs. Foreign objects in the pulley will erode the undercord ribs, causing the belt to lose its gripping power.

   1.6 Inspect for cracks. Small, irregular cracks are usually signs of an old belt.

   Replace the belt if any of the above conditions are found. Replace both belts of a set, at the same time. Matched belts must be from the same manufacturer.

2. Check all pulley bearings for roughness. Replace the bearings if they're rough.



A. Glazing
B. Separating Layers
C. Streaked Sidewalls
D. Tensile Break
E. Uneven Ribs
F. Cracks

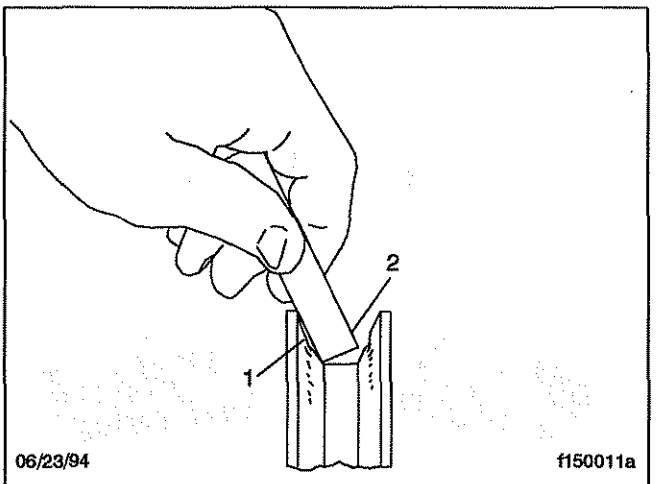
Fig. 1, Drive Belt Problems

Pulley and Drive Belt Inspection, Cummins Engines

3. Inspect all pulleys for foreign objects, oil, or grease in the grooves. Use a nonflammable cleaning solvent to remove oils. Use a wire brush to remove rust, and a file to remove burrs.
4. Inspect the pulleys for wear on the inner walls. Hold a small straightedge against the inside of the pulley walls (**Fig. 2**), or use your little finger or fingernail to find grooves in the inner walls. If there are any grooves, replace the pulley.
5. Check alignment of pulleys.Use a thin straightedge that is longer than the longest span between the pulleys. Place the straightedge into the V-grooves of two pulleys at a time. The straightedge should be parallel to the outer edges of the pulleys; if not, the pulleys are misaligned.

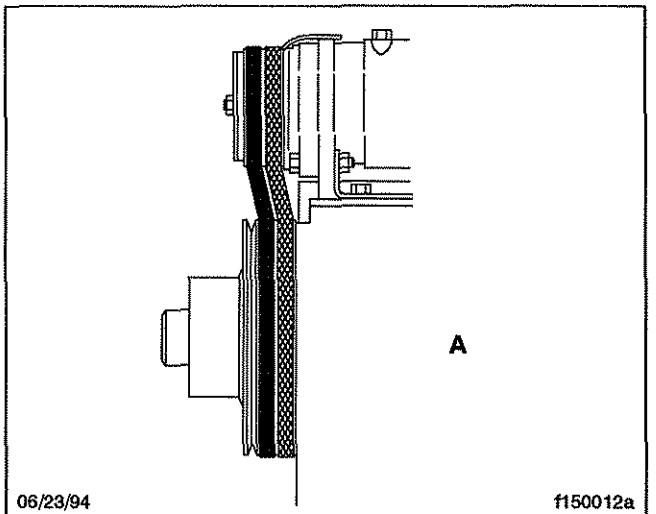
   Pulley misalignment must not be more than 1/16-inch for each foot (1.5 mm for each 30.5 cm) of distance between pulley centers.

   If there is misalignment of the pulleys, adjust the pulleys or brackets if their positions are adjustable. **See Fig. 3**. Replace bent or broken pulleys, pulley brackets, or shafts.
6. Check all drive component mounting parts for loose fasteners, cracks, or other damage. Tighten loose fasteners. Repair or replace cracked or damaged brackets.



1. Groove in Pulley Wall
2. Small Straightedge

Fig. 2, Check for Pulley Wear



A. Side View of Misaligned Pulleys.

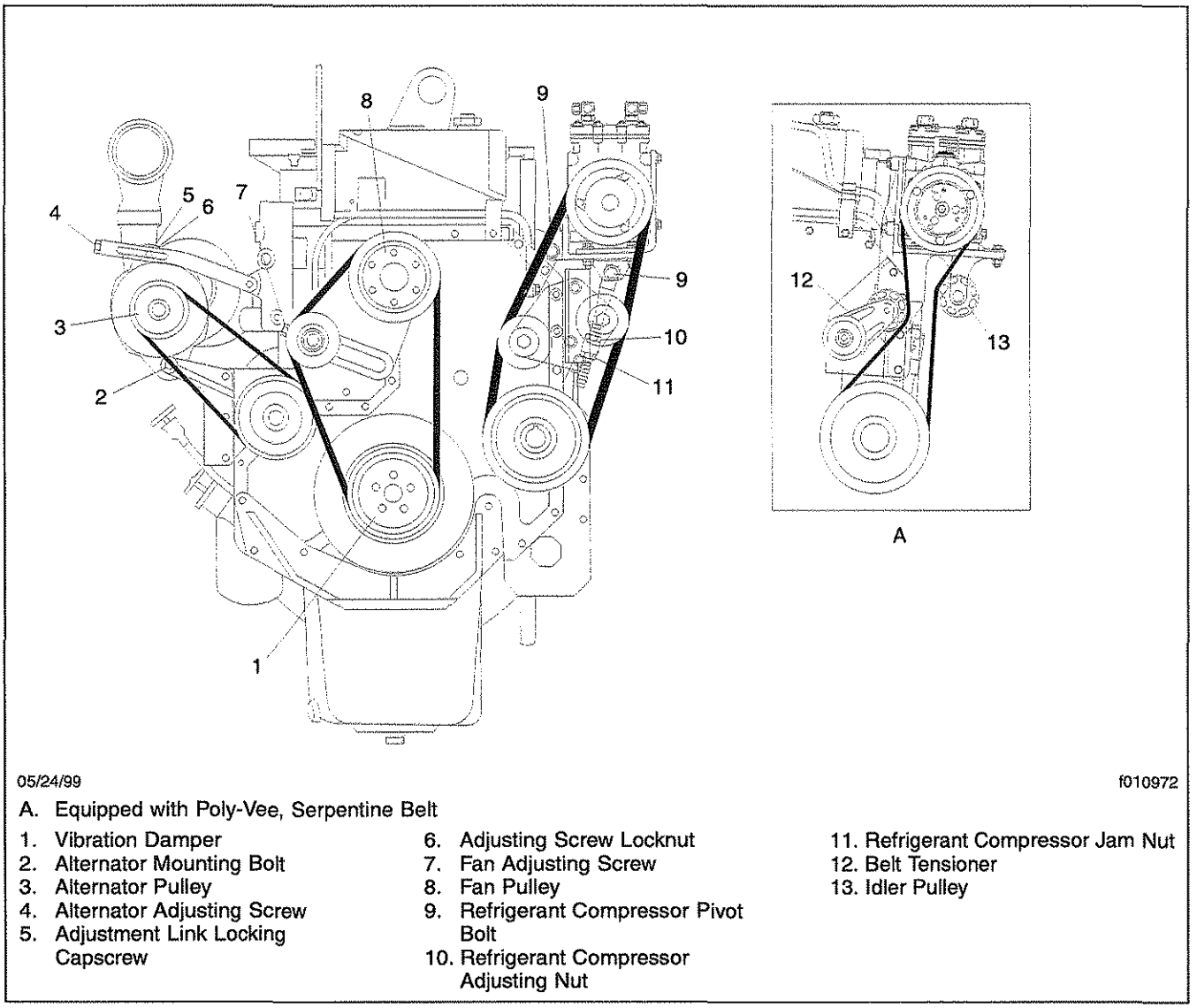
Fig. 3, Check for Misaligned Pulleys

Drive Belt Replacement, Cummins M11

Belt Replacement

ALTERNATOR (See Fig. 1)

1. Remove the belt.
   - 1.1 Loosen the alternator mounting bolt and the adjustment link locking capscrew just enough to allow movement of the alternator.
   - 1.2 Loosen the adjusting screw locknut.
   - 1.3 Turn the alternator adjusting screw, backing off the alternator toward the drive pulley far enough to allow belt removal without using force.
   - 1.4 Remove the belt, without prying or rolling it off of the pulleys.
2. Install the new belt.
   - 2.1 Inspect the pulleys and used alternator belt (even if a new belt is being installed) as instructed in **Subject 100**.



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A. Equipped with Poly-Vee, Serpentine Belt

1. Vibration Damper
2. Alternator Mounting Bolt
3. Alternator Pulley
4. Alternator Adjusting Screw
5. Adjustment Link Locking Capscrew
6. Adjusting Screw Locknut
7. Fan Adjusting Screw
8. Fan Pulley
9. Refrigerant Compressor Pivot Bolt
10. Refrigerant Compressor Adjusting Nut
11. Refrigerant Compressor Jam Nut
12. Belt Tensioner
13. Idler Pulley

Fig. 1, Drive Belts, Cummins M11

Drive Belt Replacement, Cummins M11

2.2 Make sure the distance between the pulleys is short enough to allow belt installation without using force.

2.3 Install the belt on the pulleys without prying or rolling it into place. Be sure the ribs on the belt are seated in the grooves on each pulley.

2.4 While keeping the belt seated in the pulley grooves, turn the adjusting screw clockwise to increase the belt tension. Use your thumb to apply about 25 lbs (11 kg) of force at the center of the belt free-span to check the tension while turning the adjusting screw. When belt deflection equals one belt thickness per foot (305 mm) of pulley-center distance, stop.

3. Adjust the belt.

3.1 If not already done, loosen the adjusting screw locknut, and loosen the alternator mounting bolts, just enough to allow movement of the alternator.

3.2 Install a belt tension gauge at the center of the belt free-span.

3.3 Turn the adjusting screw to adjust the tension to a reading of 100 lbs (45 kg).

IMPORTANT: Do not overtighten the belt; too much tension shortens belt life and bearing life.

3.4 Tighten the adjusting screw locknut 95 lbf·ft (130 N·m).

3.5 Tighten the alternator mounting fastener 70 lbf·ft (95 N·m), the adjusting block nut 35 lbf·ft (50 N·m), and the adjusting link locking capscrew 55 lbf·ft (75 N·m).

3.6 Check the belt tension, and adjust it if needed.

3.7 If a new alternator belt was installed, operate the engine for about 20 minutes, then check the belt tension. All new belts will lose tension after 20 minutes of operation.

3.8 If the alternator belt tension is not 100 lbs (45 kg), adjust the tension to 100 lbs (45 kg).

FAN BELT (See Fig. 1)

1. Remove the belt.

1.1 Loosen the locknut that secures the idler pulley to the fan bracket.

1.2 Turn the fan adjusting screw until there is minimal distance between the pulley centers.

1.3 Remove the fan belt by slipping it off of the pulleys and working it over one fan blade at a time. Don't roll or pry the belt off of the pulleys; the distance between the pulley centers must be short enough to allow belt removal without using force.

2. Install the new belt.

2.1 Inspect the pulleys and used fan belt (even if a new belt is being installed) as instructed in **Subject 100**.

2.2 Make sure the distance between the pulleys is short enough to allow belt installation without using force.

2.3 Work the belt over the fan blades, one blade at a time. Install the belt on the pulleys without prying or rolling it into place. Be sure the ribs on the belt are seated in the grooves on each pulley.

2.4 While keeping the belt seated in the pulley grooves, turn the idler pulley adjustment capscrew to increase the belt tension. Use your thumb to apply about 25 lbs (11 kg) of force at the center of the belt free-span to check the tension while turning the capscrew. When belt deflection equals one belt thickness per foot (305 mm) of pulley-center distance, stop.

3. Adjust the belt.

3.1 If not already done, loosen the locknut that secures the idler pulley to the fan bracket.

3.2 Install a belt tension gauge at the center of the belt's longest free-span.

3.3 Turn the fan adjusting screw to increase or decrease belt tension, but do not adjust the tension to the full value with the idler pulley adjustment capscrew; belt tension can increase when the idler pulley locknut

is tightened. Final tension must be 100 lbs (45 kg).

IMPORTANT: Do not overtighten the belt; too much tension shortens belt life and bearing life.

3.4 Tighten the idler pulley locknut 120 to 140 lbf·ft (165 to 190 N·m).

3.5 Loosen the fan adjusting screw one-half turn, to prevent breakage.

3.6 Check the belt tension, and adjust it if needed.

3.7 If a new fan belt was installed, operate the engine for about 20 minutes, then check the belt tension. All new belts will lose tension after 20 minutes of operation.

3.8 If the fan belt tension is not 100 lbs (45 kg), adjust the tension to 100 lbs (45 kg).

REFRIGERANT COMPRESSOR, EQUIPPED WITH A STANDARD DRIVE BELT **(See Fig. 1)**

1. Remove the belt.

1.1 Back off the adjusting nut. Loosen the pivot bolts just enough to allow movement of the compressor.

1.2 Push the loosened compressor toward the accessory drive pulley until the distance between them is short enough to allow belt removal without using force.

1.3 Remove the belt, without prying or rolling it off of the pulleys.

2. Install the new belt.

2.1 Inspect the pulleys and used refrigerant compressor belt (even if a new belt is being installed) as instructed in **Subject 100**.

2.2 Make sure the distance between the pulleys is short enough to allow belt installation without using force.

2.3 Install the belt on the pulleys without prying or rolling it into place.

2.4 Back off the jam nut.

2.5 While keeping the belt seated in the pulley grooves, turn the adjusting nut to increase belt tension. Use your thumb to apply about 25 lbs (11 kg) of force at the center of the belt free-span to check the tension while turning the nut. When belt deflection equals one belt thickness per foot (305 mm) of pulley-center distance, stop.

3. Adjust the belt.

3.1 If not already done, back off the jam nut, and loosen the mounting bolts just enough to allow movement of the compressor.

3.2 Install a belt tension gauge at the center of the belt free-span.

3.3 Turn the adjusting nut to adjust the tension to a reading of 100 lbs (45 kg).

IMPORTANT: Do not overtighten the belt; too much tension shortens belt life and bearing life.

3.4 Tighten the jam nut 155 lbf·ft (210 N·m).

3.5 Tighten the compressor mounting bolts 30 lbf·ft (40 N·m), and the adjusting link bolt 40 lbf·ft (55 N·m).

3.6 Check the belt tension, and adjust it if needed.

3.7 If a new refrigerant compressor belt was installed, operate the engine for about 20 minutes, then check the belt tension. All new belts will lose tension after 20 minutes of operation.

3.8 If the refrigerant compressor belt tension is not 100 lbs (45 kg), adjust the tension to 100 lbs (45 kg).

REFRIGERANT COMPRESSOR, EQUIPPED WITH A POLY-VEE SERPENTINE BELT **(See Fig. 1)**

1. Remove the belt.

1.1 Insert a breaker bar in the belt tensioner and rotate the tensioner counterclockwise off the belt.

1.2 Remove the belt from the refrigerant compressor pulley and the idler pulley.

1.3 Slowly release the belt tensioner, then remove the breaker bar.

Drive Belt Replacement, Cummins M11

1.4 Remove the belt from the lower pulley.

2. Install the belt.

2.1 Inspect the pulleys and used belt (even if installing a new belt) as instructed in **Subject 100**.

2.2 Loop the belt around the lower pulley and align it in the grooves of the pulley.

2.3 Insert a breaker bar in the belt tensioner, and rotate the tensioner counterclockwise.

2.4 Holding the belt tensioner up, install the belt onto the refrigerant compressor pulley and the idler pulley.

2.5 Slowly release the belt tensioner onto the belt. The tensioner automatically tightens the belt to the correct tension and maintains it.

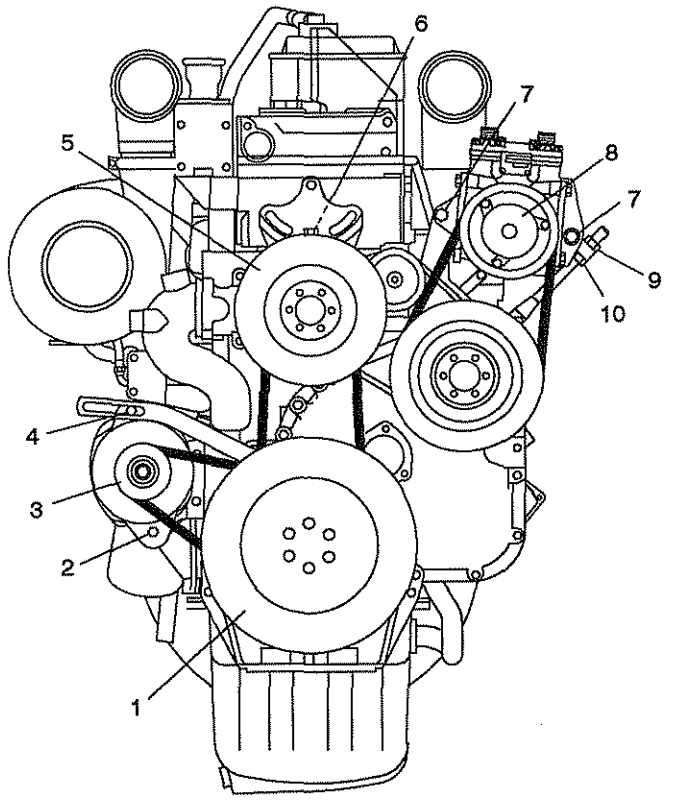
2.6 Remove the breaker bar from the belt tensioner.

3. If the belt slips, replace the belt tensioner. For instructions, refer to the engine manufacturer's service literature.

Belt Replacement

ALTERNATOR BELTS (See Fig. 1)

1. Loosen the alternator adjusting link capscrew and the alternator pivot bolt.
2. Move the alternator toward the drive pulley far enough to remove the drive belt without prying or twisting it.
3. Push in on the alternator, and remove the belt.
4. Install the belt.
   - 4.1 Inspect the pulleys and used alternator belts (even if new belts are being installed) as instructed in **Subject 100.**
   - 4.2 Make sure the distance between the pulleys is short enough to allow belt installation without using force.
   - 4.3 Install the belts on the pulleys without prying or rolling them into place.
5. Adjust the belt tension.
   - 5.1 Install a belt tension gauge at the center of the free-span of one of the belts.



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1. Vibration Damper
2. Alternator Pivot Bolt
3. Alternator Pulley
4. Alternator Adjusting Link Capscrew
5. Fan Pulley
6. Fan Adjusting Screw
7. Refrigerant Compressor Pivot Bolt
8. Refrigerant Compressor Pulley
9. Refrigerant Compressor Jam Nut
10. Refrigerant Compressor Adjusting Nut

Fig. 1, Drive Belts, Cummins N14

Drive Belt Replacement, Cummins N14

IMPORTANT: Do not overtighten the belts; too much tension shortens belt life and bearing life.

5.2 Use a pry bar between the engine and the alternator to tighten the alternator belt.

Adjust the tension to a reading of 100 lbf (45 kg).

5.3 Tighten the adjusting link capscrew 50 lbf·ft (68 N·m).

5.4 Tighten the alternator pivot bolt 70 lbf·ft (95 N·m).

5.5 Check the belt tension, and adjust it if needed.

5.6 If new alternator belts were installed, operate the engine for about 20 minutes, then check the belt tension. All new belts will lose tension after 20 minutes of operation.

If the alternator belt tension is not 100 lbf (45 kg), adjust the tension.

FAN BELTS (See Fig. 1)

1. Remove the belts.

1.1 Loosen the nuts on the bolts that secure the fan hub to the fan bracket.

1.2 Turn the fan adjusting screw until there is minimal distance between the pulley centers.

1.3 Remove both fan belts by slipping them off of the pulleys and working them over one fan blade at a time. Don't roll or pry the belts off of the pulleys; the distance between the pulley centers must be short enough to allow belt removal without using force.

2. Install the belts.

2.1 Inspect the pulleys and used fan belts (even if new belts are being installed) as instructed in **Subject 100**.

2.2 Make sure the distance between the pulleys is short enough to allow belt installation without using force.

2.3 Work the belts over the fan blades, one blade at a time. Install the belts on the pulleys without prying or rolling them into place.

2.4 While keeping the belts seated in the pulley grooves, turn the fan adjusting screw to increase belt tension. Use your thumb to apply about 25 lbf (11 kg) of force at the center of the belt free-span to check the tension while turning the bolt. When belt deflection equals one belt thickness per foot (305 mm) of pulley-center distance, adjust the belt tension.

3. Adjust the belt tension.

3.1 If not already done, loosen the nuts on the bolts that secure the fan hub to the fan hub bracket.

3.2 Install a belt tension gauge at the center of the free-span of one of the belts.

IMPORTANT: Do not overtighten the belts; too much tension shortens belt life and bearing life.

3.3 Turn the fan hub adjusting bolt to increase or decrease belt tension, but do not adjust the tension to the full value with the adjusting bolt; belt tension can increase when the fan hub bracket nuts are tightened.

Final tension must be 100 lbf (45 kg).

3.4 Tighten the fan hub bracket nuts 80 lbf·ft (110 N·m).

3.5 Loosen the fan hub adjusting bolt one-half turn to prevent breakage.

3.6 Check the belt tension, and adjust it if needed.

3.7 Install and adjust the refrigerant compressor belt, if so equipped.

3.8 If any new belts were installed, operate the engine for about 20 minutes, then check the belt tension. All new belts will lose tension after 20 minutes of operation.

3.9 If the fan belt tension is not 100 lbf (45 kg), adjust the tension to 100 lbf (45 kg).

REFRIGERANT COMPRESSOR BELT (See Fig. 1)

1. Remove the belt.

1.1 Loosen the compressor pivot bolts.

1.2 Back off the refrigerant compressor adjusting nut, and lower the compressor in the compressor mounting bracket.

1.3 Remove the belt without prying or rolling it off of the pulleys.

2. Install the belt.

2.1 If the fan belts were removed, install and adjust them first.

2.2 Inspect the pulleys and used refrigerant compressor belt (even if a new belt is being installed) as instructed in **Subject 100.**

2.3 Make sure the distance between the pulleys is short enough to allow belt installation without using force.

2.4 Install the belt on the pulleys without prying or rolling it into place.

2.5 Rotate the compressor pulley away from the drive pulley. Use your thumb to apply about 25 lbf (11 kg) of force at the center of the belt free-span to check the tension while lifting the compressor. When belt deflection equals one belt thickness per foot (305 mm) of pulley-center distance, adjust the belt tension.

3. Adjust the belt tension.

3.1 Install a belt tension gauge at the center of the longest belt free-span.

IMPORTANT: Do not overtighten the belt; too much tension shortens belt life and bearing life.

3.2 Turn the adjusting nut until the belt tension is 100 lbf (45 kg).

3.3 Tighten the compressor mounting capscrews 28 lbf·ft (38 N·m).

3.4 Check the belt tension, and adjust it if needed.

3.5 If a new refrigerant compressor belt was installed, operate the engine for about 20 minutes, then check the belt tension. All new belts will lose tension after 20 minutes of operation.

If the compressor belt tension is not 100 lbf (45 kg), adjust the tension to 100 lbf (45 kg).

Engine Removal and Installation, Cummins M11

Removal

1. Apply the parking brakes, chock the tires, and drain the air system.
2. Disconnect the batteries.
3. Remove the hood and bumper. For instructions, refer to **Group 88** in this manual.
4. Remove the transmission. For instructions, refer to the applicable section in **Group 26** in this manual.
5. Remove the air cleaner housing and the brackets that hold the housing to the bulkhead. This includes removing the heat shield between the cleaner and the turbocharger. For instructions, refer to **Group 09** in this manual.

⚠ WARNING

Drain the coolant only when the coolant and engine are cool. Draining it when these are hot could cause severe personal injury due to scalding.

6. Drain the radiator. For instructions, refer to **Section 20.01**.
7. Move the air conditioning components out of the way without breaking the refrigerant lines.
   - 7.1 Free the refrigerant lines from all routing clamps and stand-off brackets between the compressor and the condenser.
   - 7.2 Free the refrigerant lines from all routing clamps and stand-off brackets between the receiver- drier and the condenser.
   - 7.3 Remove the condenser mounting fasteners, and move the condenser aside.
   - 7.4 Remove the refrigerant compressor and move the compressor aside.
   - 7.5 Use tie straps to secure the refrigerant compressor and condenser out of the way.
8. Remove the air recirculation shields around the radiator and charge air cooler. For instructions, refer to **Section 20.01** in this manual.
9. Remove the radiator and charge air cooler. For instructions, refer to **Section 20.01** in this manual.
10. Disconnect or remove the remaining ducts and lines.
    - 10.1 If not already removed, remove the air duct between the turbocharger and the air cleaner.
    - 10.2 Disconnect the vent line from the engine, and move the line aside.
    - 10.3 Disconnect the two air signal lines from the air governor on top of the compressor.
    - 10.4 Disconnect the outlet line from the air compressor.
    - 10.5 Disconnect the oil line to the gauge.
    - 10.6 Disconnect the air line to the fan clutch solenoid, and free the line from routing clamps.
    - 10.7 Disconnect the heater supply and return hoses from the radiator outlet pipe, and free the hoses from the clamps that route them to the bulkhead.
11. Disconnect the engine harness at the firewall.
12. Disconnect the power and ground connections to the starter.
13. Disconnect the harness from the rear of the engine.
14. Remove the windshield wiper pan. For instructions, refer to **Group 60**.
15. Remove the windshield wiper linkage. For instructions, refer to **Group 82** in this manual.
16. Label and disconnect the wiring.
17. Without breaking the power steering fluid lines, remove the power steering pump, and move it aside. For instructions, refer to **Group 46** in this manual.
18. Under the engine, disconnect or remove the remaining components.
    - 18.1 Remove the flex pipe section of exhaust ducting that attaches to the turbocharger.
    - 18.2 Disconnect the fuel return lines. For instructions, refer to **Group 47** in this manual.

Engine Removal and Installation, Cummins M11

18.3 Remove the bolts that hold the engine legs to the rear engine mounts.

⚠ WARNING

The crane and lifting chains used to remove the engine must be capable of safely lifting and supporting two metric tons. Once the engine mounts are disconnected, do not get under the engine until it is securely supported on engine stands. An unsecured engine may fall, causing personal injury or death, and component damage.

19. Remove the engine from the vehicle.

19.1 Attach the chain to the lifting eyes at the front and the rear of the engine.

19.2 With the two engine lifting points connected by chain to the crane, raise the crane enough to tighten the chains, but not enough to lift the front of the vehicle.

19.3 Remove the nuts from the bolts that fasten the front engine support bracket to the underslung crossmember.

19.4 Using the crane, lift the engine slightly and remove the upper isolator from the front engine mount.

19.5 Remove the front underslung crossmember. For instructions, refer to **Group 31**.

19.6 Using the crane, lift the engine and pull it forward.

19.7 Once the engine is clear of the vehicle, place the engine on engine stands.

Installation

⚠ WARNING

The crane and lifting chains used to install the engine must be capable of safely lifting and supporting two metric tons. Once the engine is removed from the engine stands, do not get under the engine until it is securely supported on the engine mounts. An unsecured engine may fall, causing personal injury or death, and component damage.

1. Install the engine in the vehicle.

1.1 Attach the chain to the lifting eyes at the front and the rear of the engine.

1.2 With the two engine lifting points connected by chain to the crane, lift the engine, and position it in the engine compartment.

1.3 Connect the engine to the rear engine mounts, and tighten the bolt that runs down through each engine leg, rubber isolators, and engine mount 213 to 269 lbf·ft (289 to 365 N·m).

1.4 Install the front underslung crossmember. For instructions, refer to **Group 31**.

1.5 Assemble the lower isolator under the underslung crossmember and the front engine bracket, and secure the front engine mount with nuts and washers. Tighten the nuts 213 to 269 lbf·ft (289 to 365 N·m).

1.6 Once the engine is securely installed in the vehicle, remove the lifting chains and the special lifting bracket.

2. Connect and install components under the engine.

2.1 Connect the exhaust flex pipe to the forward end of the exhaust piping.

2.2 Connect the fuel return lines. For instructions, refer to **Group 47** of this manual.

3. Without breaking the power steering fluid lines, install the power steering pump. For instructions, refer to **Group 46** in this manual.

4. Connect the wiring. For wiring harness information, refer to **Group 54** in this manual.

5. Install the windshield wiper linkage. For instructions, refer to **Group 82** in this manual.

6. Install the windshield wiper pan.

7. Connect or install the ducts and lines.

7.1 Install the V-band clamp that holds the forward end of the flex pipe exhaust ducting to the rear of the turbocharger. Tighten it 85 lbf·in (940 N·cm).

7.2 Install the air duct between the turbocharger and the air cleaner.

7.3 Connect the vent line to the engine.

7.4 Connect the two air signal lines to the air governor on top of the compressor.

7.5 Connect the outlet line to the air compressor.

7.6 Connect the air line to the fan clutch solenoid.

7.7 Connect the oil line to the gauge.

7.8 Connect the heater supply and return hoses to the radiator outlet pipe.

8. Install the radiator, fan shroud, and charge air cooler. For instructions, refer to **Section 20.01** in this manual.

9. Install the air recirculation shields around the radiator and charge air cooler. For instructions, refer to **Section 20.01** in this manual.

10. Install the air conditioning components without breaking the refrigerant lines.

10.1 Install the condenser. For instructions, refer to **Group 83** of this manual.

10.2 Install the refrigerant compressor. For instructions, refer to **Group 83** of this manual. For instructions on installing the compressor drive belts, refer to **Section 01.00** in this manual group.

10.3 Route and clamp the refrigerant lines between the compressor and the condenser.

10.4 Route and clamp the refrigerant lines between the receiver-drier and the condenser.

11. Install the air cleaner housing. For instructions, refer to **Group 09** in this manual. Connect the intake air ducting to the air cleaner and the charge air cooler.

12. Install the transmission. For instructions, refer to the applicable section in **Group 26** in this manual.

13. Install the hood and bumper. For instructions, refer to **Group 88** in this manual.

14. Fill the radiator.

15. Connect the batteries.

16. Start the engine, and check for leaks. Repair any leaks found.

17. Test drive the vehicle.

Specifications

Engine	Component	Belt Tension, New Belt lbs (kg)	Belt Tension, Used Belt lbs (kg)
M11	Alternator	140 to 160 (64 to 73)	90 to 120 (41 to 55)
	Fan	190 to 210 (86 to 95)	155 to 165 (70 to 75)
	Refrigerant Compressor	130 (59)	80 to 100 (36 to 45)
N14	Alternator	140 (63)	60 to 110 (27 to 49)
	Fan	130 to 150 (58 to 68)	80 to 120 (36 to 54)
	Refrigerant Compressor	100 (45)	100 (45)

Table 1, Drive Belt Tensions

Engine	Fastener	Torque lbf·ft (N·m)
M11 and N14	Rear Engine-to-Mount Bolts	213 to 269 (289 to 365)
	Front Engine-to-Mount Bolts	

Table 2, Fastener Torques

Contents

Subject	Subject Number
Engine Port Diagrams	050
Service Operations	
Series 55 Engine Removal and Installation	100
Series 60 Engine Removal and Installation	110
Series 60 Engine Removal and Installation, Argosy COE	120
Pulley and Drive Belt Inspection	130
Series 55 Drive Belt Replacement	140
Series 60 Drive Belts Replacement	150
Specifications	400

NOTE: For engine service and troubleshooting procedures, see the engine manufacturer's service literature.

For engine brake information for the Detroit Diesel Series 60, see **Section 01.11**.

For engine wiring diagrams, see the applicable section in **Group 54**.

Engine Port Diagrams

Use the following diagrams to identify engine ports:

- For a Detroit Diesel Series 55 Engine, see **Fig. 1**.

Engine Port Diagrams

- For a Detroit Diesel Series 60 Engine, see **Fig. 2.**

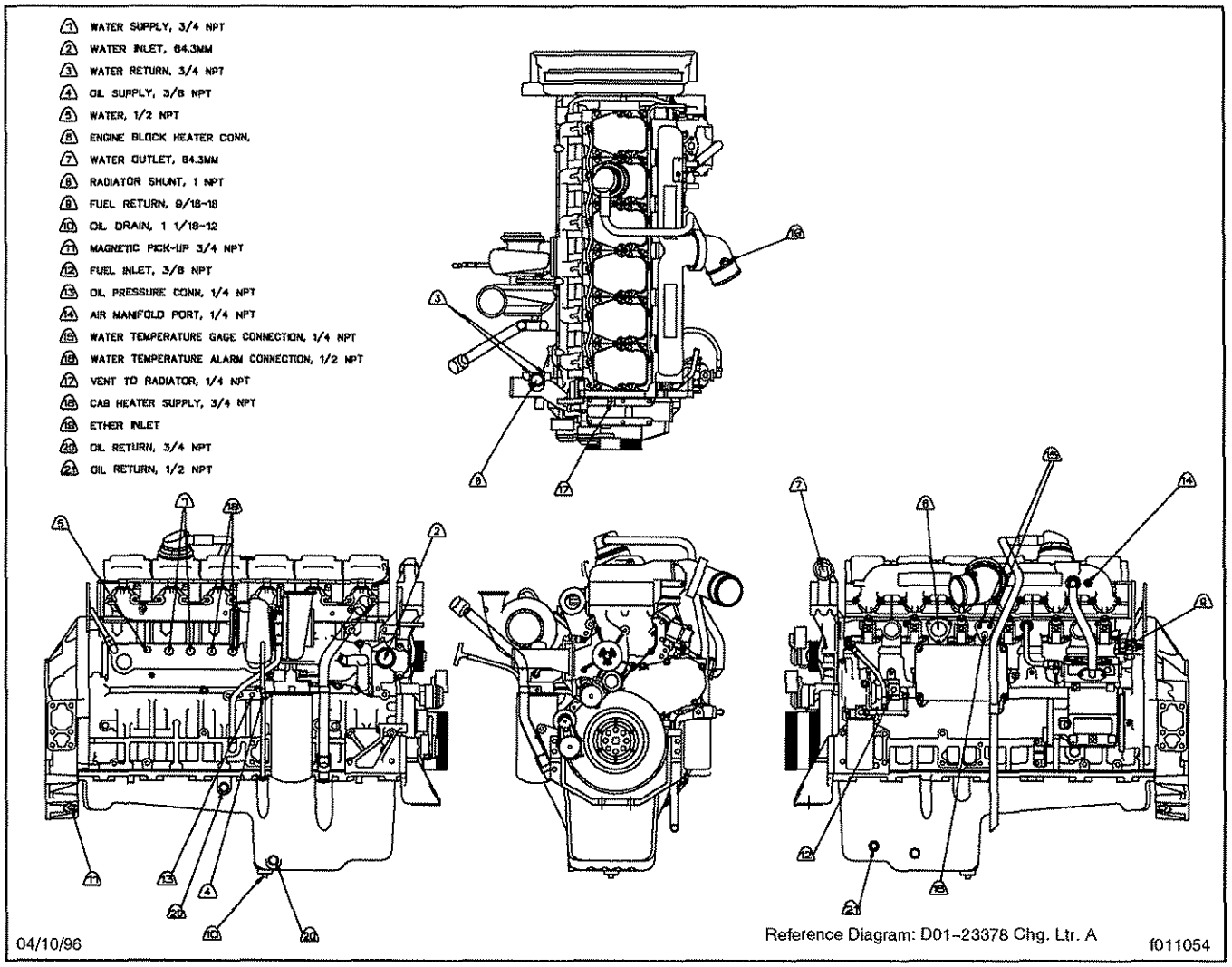


Fig. 1, Detroit Diesel Series 55 Engine Ports

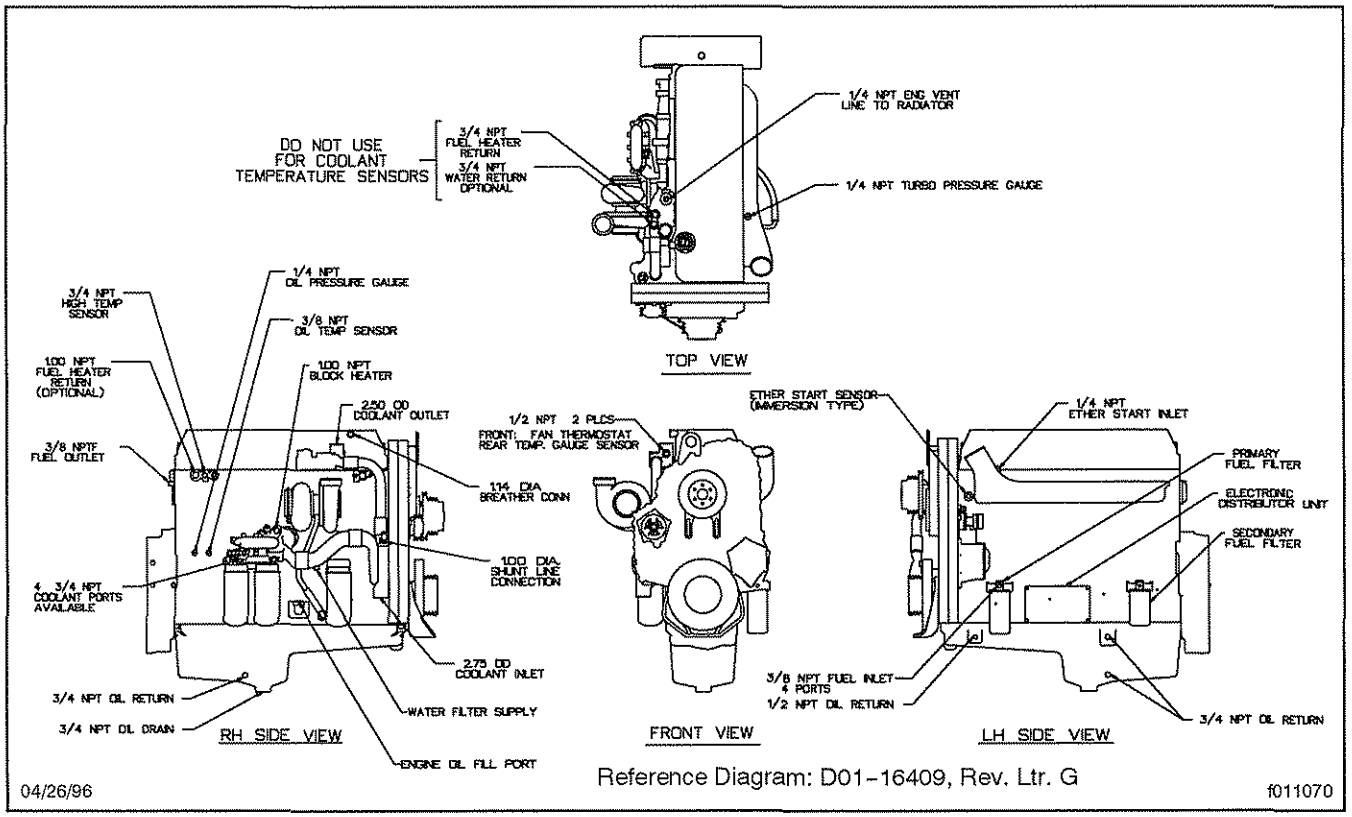


Fig. 2, Detroit Diesel Series 60 Engine Ports

⚠ WARNING

The crane and lifting chains used to remove and install the engine must be capable of safely lifting and supporting two metric tons. Do not get under the engine until it is securely supported on engine stands or the engine mounts. An unsecured engine may fall, causing personal injury or death, and component damage.

Removal

1. Park the vehicle on a level surface and apply the parking brakes. Shut down the engine. Chock the tires.
2. Drain the air system.
3. Disconnect the batteries.
4. Remove the bumper. For instructions, see **Section 31.03** for an aerodynamic bumper or **Section 31.12** for a non-aerodynamic bumper.
5. Remove the hood. For instructions, see **Section 88.00**.
6. Disconnect the transmission from the engine. For instructions, see **Section 26.00**.
7. Remove the air cleaner housing and the brackets that hold the housing to the bulkhead. This includes removing the heat shield between the cleaner and the turbocharger. For instructions, see **Section 09.01**.

⚠ WARNING

Drain the coolant only when the coolant and engine are cool. Draining it when these are hot could cause severe personal injury due to scalding.

8. Drain the radiator. For instructions, see **Section 20.01**.
9. Move the air conditioning components out of the way without breaking the refrigerant lines.
   - 9.1 Free the refrigerant lines from all routing clamps and stand-off brackets between the compressor and the condenser.
   - 9.2 Free the refrigerant lines from all routing clamps and stand-off brackets between the receiver-drier and the condenser.
   - 9.3 Remove the condenser mounting fasteners, and set the condenser aside.
   - 9.4 Remove the refrigerant compressor and set the compressor aside. For instructions, see **Section 83.00** for a Climate Control compressor or **Section 83.01** for a Sanden compressor.
   - 9.5 Use tie straps to secure the refrigerant compressor and condenser out of the way.
10. Remove the air recirculation shields around the radiator and charge air cooler. For instructions, see **Section 20.01**.
11. Remove the radiator and charge air cooler. For instructions, see **Section 20.01**. Remove the radiator mounting bracket with the radiator.
12. Remove the surge tank. For instructions, see **Section 20.01**.
13. Remove the windshield wiper pan.
14. Disconnect or remove the remaining ducts and lines.
    - 14.1 If not already removed, remove the air duct between the turbocharger and the air cleaner.
    - 14.2 Disconnect the vent line from the engine and move the line aside.
    - 14.3 Disconnect the two air signal lines from the air governor.
    - 14.4 At the air dryer, disconnect the outlet line from the air compressor.
    - 14.5 Disconnect the air line to the fan clutch solenoid, and free the line from routing clamps.
    - 14.6 Disconnect the heater supply and return hoses from the radiator outlet pipe, and free the hoses from the clamps that route them to the bulkhead.
15. Label and disconnect the wiring.
16. Disconnect the power steering fluid lines from the power steering fluid pump. Cap the lines.

Series 55 Engine Removal and Installation

For instructions, see **Section 46.00** for a LuK Automotive pump, **Section 46.02** for a TRW pump or **Section 46.08** for a Vickers pump.

17. Under the engine, disconnect or remove the remaining components.
    - 17.1 Remove the section of exhaust ducting that runs between the turbocharger and the muffler.
    - 17.2 Disconnect the fuel return lines. For instructions, see **Section 47.00.**
    - 17.3 Disconnect the starter motor and solenoid power cables.
    - 17.4 Remove the bolts that hold the engine legs to the rear engine mounts.
18. Remove the engine from the vehicle.
    - 18.1 Attach the chain to the lifting eyes at the front and the rear of the engine.
    - 18.2 With the two engine lifting eyes connected by chain to the crane, raise the crane enough to tighten the chains, but not enough to lift the front of the vehicle.
    - 18.3 Remove the nuts from the bolts that fasten the front engine support bracket to the underslung crossmember.
    - 18.4 Using the crane, lift the engine slightly and remove the front underslung crossmember. For instructions, see **Section 31.01.**
    - 18.5 Using the crane, lift the engine and pull it forward.
    - 18.6 Once the engine is clear of the vehicle, place the engine on engine stands.

Installation

1. Install the engine in the vehicle.
    - 1.1 Attach the chain to the lifting eyes at the front and the rear of the engine.
    - 1.2 With the two engine lifting eyes connected by chain to the crane, lift the engine, and position it on the rear engine mounts.
    - 1.3 With the front of the engine lifted slightly, install the front underslung crossmember. For instructions, see **Section 31.01.**
    - 1.4 Connect the engine to the rear engine mounts, and tighten the bolt that runs down through each engine leg, rubber isolators, and engine mount 213 to 269 lbf·ft (289 to 365 N·m).
    - 1.5 Assemble the lower isolator under the underslung crossmember and the front engine support bracket, and secure the front engine mount with nuts and washers. Tighten the nuts 213 to 269 lbf·ft (289 to 365 N·m).
    - 1.6 Once the engine is securely installed in the vehicle, remove the lifting chains.
2. Connect and install components under the engine.
    - 2.1 Connect the power cables to the starter motor and solenoid.
    - 2.2 Connect the exhaust pipe to the muffler.
    - 2.3 Connect the fuel return lines. For instructions, see **Section 47.00.**
    - 2.4 Connect the transmission to the engine. For instructions, see **Section 26.00.**
3. Connect the lines to the power steering fluid pump. For instructions, see **Section 46.00** for a LuK Automotive pump, **Section 46.02** for a TRW pump or **Section 46.08** for a Vickers pump.
4. Connect the wiring. For wiring harness information, see **Section 54.12.**
5. Connect or install the ducts and lines.
    - 5.1 Install the V-band clamp that holds the forward end of the exhaust ducting to the rear of the turbocharger. Tighten it 85 lbf·in (940 N·cm).
    - 5.2 Install the air duct between the turbocharger and the air cleaner.
    - 5.3 Connect the vent line to the engine.
    - 5.4 Connect the two air signal lines to the air governor on top of the compressor.
    - 5.5 Connect the air compressor outlet line to the air dryer.

5.6 Connect the air line to the fan clutch solenoid.

5.7 Connect the heater supply and return hoses to the radiator outlet pipe.

6. Install the radiator, fan shroud, and charge air cooler. For instructions, see **Section 20.01**.

7. Install the air recirculation shields around the radiator and charge air cooler. For instructions, see **Section 20.01**.

8. Install the air conditioning components without breaking the refrigerant lines.

8.1 Install the condenser. For instructions, see **Section 83.02**.

8.2 Install the refrigerant compressor. For instructions, see **Section 83.00** for a Climate Control compressor or **Section 83.01** for a Sanden compressor.

8.3 Install the compressor drive belts. For instructions, see **Subject 140**.

8.4 Route and clamp the refrigerant lines between the compressor and the condenser.

8.5 Route and clamp the refrigerant lines between the receiver-drier and the condenser.

9. Install the surge tank. For instructions, see **Section 20.01**.

10. Install the windshield wiper pan.

11. Install the air cleaner housing. For instructions, see **Section 09.01**. Connect the intake air ducting to the air cleaner and the charge air cooler.

12. Install the hood. For instructions, see **Section 88.00**.

13. Install the bumper. For instructions, see **Section 31.03** for an aerodynamic bumper or **Section 31.12** for a non-aerodynamic bumper.

14. Fill the radiator.

15. Connect the batteries.

16. Start the engine and check for leaks. Repair any leaks found.

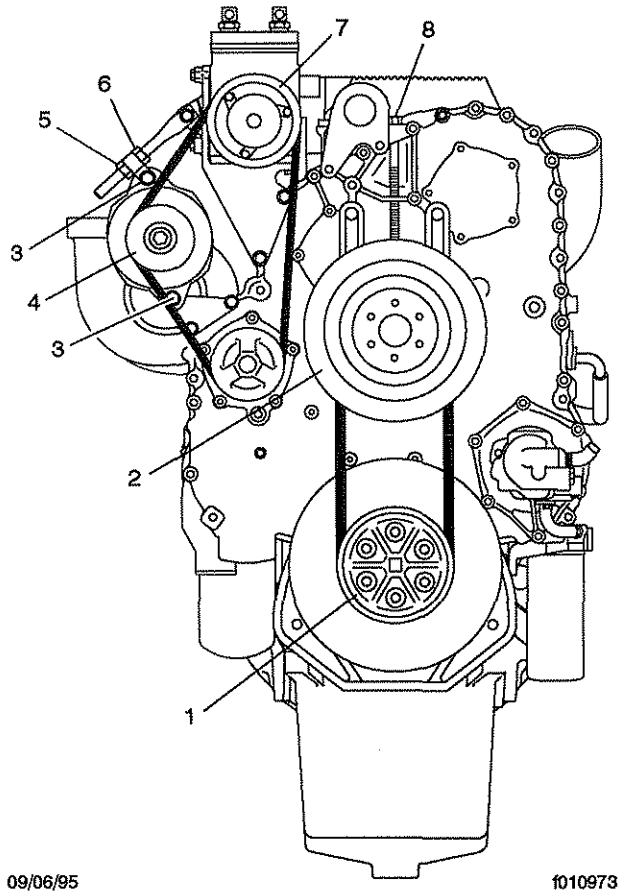
17. Remove the chocks from the tires.

18. Test drive the vehicle.

Belt Replacement

ALTERNATOR BELT AND REFRIGERANT COMPRESSOR (See Fig. 1)

1. Remove the belt.
   - 1.1 Back off the alternator adjusting nut.
   - 1.2 Loosen the alternator pivot bolts.
   - 1.3 Turn the alternator jam nut to rotate the alternator up and toward the engine. Turn the nut until the alternator is close enough to the engine to allow belt removal.
   - 1.4 Remove the belts by slipping them off the pulleys. Don't roll or pry the belts off the pulleys; the distance between the pulley centers must be short enough to allow belt removal without using force.
2. Install the belt.
   - 2.1 Inspect the pulleys and belt (even if installing a new belt) as instructed in **Subject 100.**
   - 2.2 Install the belt on the pulleys without prying or rolling it into place.
   - 2.3 While keeping the belt seated in the pulley grooves, turn the adjusting nut to rotate



1. Vibration Damper
2. Fan Pulley
3. Alternator Pivot Bolt
4. Alternator Pulley
5. Alternator Jam Nut
6. Alternator Adjusting Nut
7. Refrigerant Compressor Pulley
8. Fan Adjusting Rod

Fig. 1, Drive Belts, Detroit Diesel Series 50 and 60

Drive Belt Replacement, Detroit Diesel Series 60

the alternator away from the engine and to increase belt tension.

3. Adjust the belt.

   3.1 Install a belt tension gauge at the center of the belt's longest free-span.

   IMPORTANT: Do not overtighten the belt; too much tension shortens belt and bearing life.

   3.2 Turn the adjusting nut to rotate the alternator out, away from the engine until the belt is tensioned 100 lb (45 kg).

   3.3 Tighten the alternator jam nut 130 lbf·ft (176 N·m).

   3.4 Tighten the alternator pivot bolts 70 lbf·ft (95 N·m).

   3.5 Operate the engine for about 30 minutes (or 15 miles), then check the belt tension. Check again after 8 hours of operation (or 250 miles). Adjust the belt tension as needed.

FAN BELT (See Fig. 1)

1. Remove the belt.

   1.1 Loosen the four mounting capscrews that attach the fan hub to the engine.

   1.2 Loosen the fan adjusting rod to relieve tension from the belts.

   1.3 Remove the belts by slipping them off the pulleys and working them over one fan blade at a time. On some vehicles, it may be necessary to remove the fan. For instructions, refer to **Section 20.01**. Don't roll or pry the belts off the pulleys; the distance between the pulley centers must be short enough to allow belt removal without using force.

2. Install the belt.

   2.1 Inspect the pulleys and used belts (even if installing new belts) as instructed in **Subject 100**.

   2.2 Work the belts over the fan blades, one blade at a time. Install the belts on the pulleys without rolling or prying them into place.

   2.3 While keeping the belts seated in the pulley grooves, turn the adjusting rod to increase belt tension.

3. Adjust the belt.

   3.1 Install a belt tension gauge at the center of the belts' longest free-span.

   IMPORTANT: Do not overtighten the belts; too much tension shortens belt and bearing life.

   3.2 Turn the adjusting rod to increase belt tension to 100 lb (45 kg).

   3.3 Tighten the fan hub mounting capscrews 75 to 83 lbf·ft (100 to 112 N·m).

   3.4 Check the belt tension and adjust it if needed.

   3.5 Operate the engine for about 30 minutes (or 15 miles), then check the belt tension. Check again after 8 hours of operation (or 250 miles). Adjust the belt tension as needed.

Series 60 Engine Removal and Installation

⚠ WARNING

The crane and lifting chains used to remove and install the engine must be capable of safely lifting and supporting two metric tons. Do not get under the engine until it is securely supported on engine stands or the engine mounts. An unsecured engine may fall, causing personal injury or death, and component damage.

Removal

1. Park the vehicle on a level surface and apply the parking brakes. Shut down the engine. Chock the tires.
2. Drain the air system.
3. Disconnect the batteries.
4. Remove the bumper. For instructions, see **Section 31.03** for an aerodynamic bumper or **Section 31.12** for a non-aerodynamic bumper.
5. Remove the hood. For instructions, see **Section 88.00**.
6. Disconnect the transmission from the engine. For instructions, see **Section 26.00**.
7. Remove the air cleaner housing and the brackets that hold the housing to the bulkhead. This includes removing the heat shield between the cleaner and the turbocharger. For instructions, see **Section 09.01**.

⚠ WARNING

Drain the coolant only when the coolant and engine are cool. Draining it when these are hot could cause severe personal injury due to scalding.

8. Drain the radiator. For instructions, see **Section 20.01**.
9. Move the air conditioning components out of the way without breaking the refrigerant lines.
   - 9.1 Free the refrigerant lines from all routing clamps and stand-off brackets between the compressor and the condenser.
   - 9.2 Free the refrigerant lines from all routing clamps and stand-off brackets between the receiver-drier and the condenser.
   - 9.3 Remove the condenser mounting fasteners and set the condenser aside.
   - 9.4 Remove the refrigerant compressor with its mounting bracket and set the compressor aside. Move the heater lines and wiring harness as needed. For instructions, see **Section 83.00** for a Climate Control compressor or **Section 83.01** for a Sanden compressor.
   - 9.5 Use tie straps to secure the refrigerant compressor and condenser out of the way.
10. Remove the air recirculation shields around the radiator and charge air cooler. For instructions, see **Section 20.01**.
11. Remove the radiator and charge air cooler. For instructions, see **Section 20.01**. Remove the radiator mounting bracket with the radiator.
12. Remove the power steering fluid pump, and move the pump out of the way without breaking the lines or draining the fluid. For instructions, see **Section 46.00** for a LuK Automotive pump, **Section 46.02** for a TRW pump or **Section 46.08** for a Vickers pump.
13. Remove the surge tank. For instructions, see **Section 20.01**.
14. Remove the windshield wiper pan.
15. Remove the windshield wiper linkage. For instructions, see **Section 82.00**.
16. Disconnect or remove the remaining ducts and lines.
    - 16.1 If not already removed, remove the air duct between the turbocharger and the air cleaner.
    - 16.2 Disconnect the vent line from the engine and move the line aside.
    - 16.3 Disconnect the two air signal lines from the air governor.
    - 16.4 At the air dryer, disconnect the outlet line from the air compressor.

16.5 Disconnect the air line to the fan clutch solenoid, and free the line from routing clamps.

16.6 Disconnect the heater supply and return hoses from the firewall, and remove the hoses with the radiator outlet pipe.

17. Label and disconnect the wiring.

18. Remove the clutch linkage.

19. Under the engine, disconnect or remove the remaining components.

19.1 Remove the section of exhaust ducting that runs between the turbocharger and the muffler.

19.2 Disconnect the fuel return lines. For instructions, see **Section 47.00.**

19.3 Disconnect the starter motor and solenoid power cables.

19.4 Remove the bolts that hold the engine legs to the rear engine mounts.

20. Remove the engine from the vehicle.

20.1 Attach the chain to the lifting eyes at the front and the rear of the engine.

20.2 With the three engine lifting eyes connected by chain to the crane, raise the crane enough to tighten the chains, but not enough to lift the front of the vehicle.

20.3 Remove the nuts from the bolts that fasten the front engine support bracket to the underslung crossmember.

20.4 Using the crane, lift the engine and pull it forward.

20.5 Once the engine is clear of the vehicle, place the engine on engine stands.

Installation

1. Install the engine in the vehicle.

1.1 Attach the chain to the lifting eyes at the front and the rear of the engine.

1.2 With the three engine lifting eyes connected by chain to the crane, lift the engine, and position it on the rear engine mounts.

1.3 Connect the engine to the rear engine mounts, and tighten the bolt that runs down through each engine leg, rubber isolators, and engine mount 213 to 269 lbf·ft (289 to 365 N·m).

1.4 Assemble the lower isolator under the underslung crossmember and the front engine support bracket, and secure the front engine mount with nuts and washers. Tighten the nuts 213 to 269 lbf·ft (289 to 365 N·m).

1.5 Once the engine is securely installed in the vehicle, remove the lifting chains.

2. Connect and install components under the engine.

2.1 Connect the power cables to the starter motor and solenoid.

2.2 Connect the exhaust pipe to the muffler.

2.3 Connect the fuel return lines. For instructions, see **Section 47.00.**

2.4 Connect the transmission to the engine. For instructions, see **Section 26.00.**

3. Install the power steering fluid pump. For instructions, see **Section 46.00** for a LuK Automotive pump, **Section 46.02** for a TRW pump or **Section 46.08** for a Vickers pump.

4. Install the clutch linkage. For instructions, see **Section 25.03.**

5. Connect the wiring. For wiring harness information, see **Section 54.12.**

6. Connect or install the ducts and lines.

6.1 Install the V-band clamp that holds the forward end of the exhaust ducting to the rear of the turbocharger. Tighten it 85 lbf·in (940 N·cm).

6.2 Install the air duct between the turbocharger and the air cleaner.

6.3 Connect the vent line to the engine.

6.4 Connect the two air signal lines to the air governor on top of the compressor.

6.5 Connect the air compressor outlet line to the air dryer.

6.6 Connect the air line to the fan clutch solenoid.

6.7 Install the heater supply and return hoses and the radiator outlet pipe.

7. Install the radiator, fan shroud, and charge air cooler. For instructions, see **Section 20.01**.
8. Install the air recirculation shields around the radiator and charge air cooler. For instructions, see **Section 20.01**.
9. Install the air conditioning components without breaking the refrigerant lines.

9.1 Install the condenser. For instructions, see **Section 83.02**.

9.2 Install the refrigerant compressor. For instructions, see **Section 83.00** for a Climate Control compressor or **Section 83.01** for a Sanden compressor.

9.3 Install the compressor drive belts. For instructions, see **Subject 150**.

9.4 Route and clamp the refrigerant lines between the compressor and the condenser.

9.5 Route and clamp the refrigerant lines between the receiver dryer and the condenser.

10. Install the windshield wiper pan.
11. Install the wiper linkage. For instructions, see **Section 82.00**.
12. Install the surge tank. For instructions, see **Section 20.01**.
13. Install the air cleaner housing. For instructions, see **Section 09.01**. Connect the intake air ducting to the air cleaner and the charge air cooler.
14. Install the hood. For instructions, see **Section 88.00**.
15. Install the bumper. For instructions, see **Section 31.03** for an aerodynamic bumper or **Section 31.12** for a non-aerodynamic bumper.
16. Fill the radiator.
17. Connect the batteries.
18. Start the engine and check for leaks. Repair any leaks found.
19. Remove the chocks from the tires.
20. Test drive the vehicle.

Series 60 Engine Removal and Installation, Argosy COE

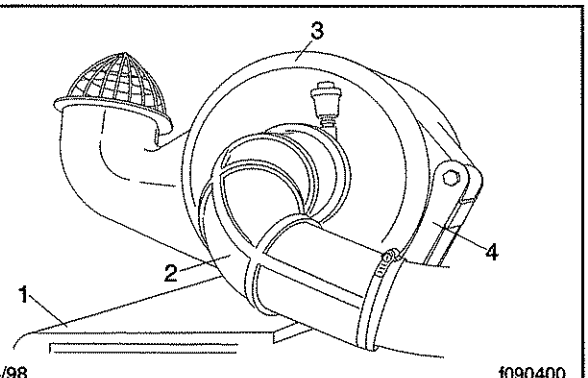
Removal

1. Park the vehicle on a level surface and apply the parking brakes. Shut down the engine. Chock the rear tires.

⚠ WARNING

Before tilting the cab, read the instructions and the Danger and Warning notices in Section 60.15. Failure to follow these instructions could cause the cab to hit or crush a person, possibly resulting in serious injury or death.

2. Tilt the cab.
3. Remove the air cleaner and the air cleaner mounting bracket. See **Fig. 1**.
4. Remove the air duct between the turbocharger and the air cleaner.
5. Disconnect the batteries and remove the battery box assembly. For instructions, see **Section 54.02**.
6. Mark and disconnect all electrical leads, including the main wiring harness to the ECU, and the transmission wiring.
7. On vehicles with automatic transmissions, disconnect the transmission drain plug and the ATF cooler lines.
   - 7.1 Remove the transmission drain plug and drain the automatic transmission fluid (ATF). Install the drain plug and tighten 15 to 20 lbf·ft (20 to 27 N·m).



1. Battery Box
2. Air Cleaner Ducting
3. Air Cleaner
4. Mounting Bracket

Fig. 1, Air Cleaner Assembly

   - 7.2 Disconnect the ATF cooler lines and fittings from the transmission, and drain the remaining transmission fluid. Plug the lines and cap the fittings.
8. Disconnect the starter cables and the solenoid power cables.
9. Disconnect the alternator wiring.
10. Remove the sway bar from the cab air suspension assembly. For instructions, see **Section 60.01**.
11. Disconnect the wiring from the magnetic switch mounted on the overslung crossmember. For instructions, see **Section 54.04**.
12. Remove the bolts securing the overslung crossmember to the frame rail, and remove the crossmember.
13. Disconnect the clutch linkage from the transmission.
14. Remove the bolts attaching the shift cables to the transmission. Remove the shift cables from the shift linkage.
15. Remove the charge air cooler ducting. Cover the air intake manifold and turbocharger manifold with a cloth and clamp securely. See **Fig. 2**.
16. Disconnect the fuel lines, and remove them from the transmission mounting clamp. Plug the lines and cap the fittings.
17. Remove the section of exhaust flex pipe that runs between the turbocharger and the muffler.
18. Adjust the belt tensioner and remove the belt from the alternator and the air compressor.
19. Label and disconnect the two air signal lines from the air governor.
20. Remove the air line at the air compressor and remove the air compressor. For instructions, see **Section 13.00** for a Bendix compressor or **Section 13.02** for a Midland compressor.

⚠ WARNING

Drain the coolant only when the coolant and engine are cool. Draining it when these are hot could cause severe personal injury due to scalding.

Series 60 Engine Removal and Installation, Argosy COE

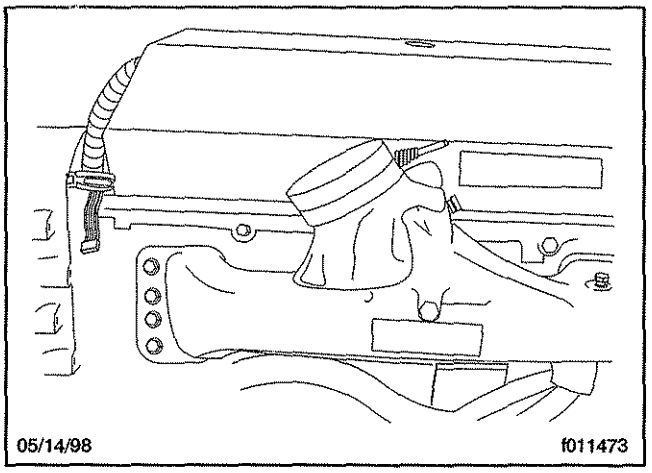


Fig. 2, Air Intake Manifold (covered)

21. Drain the radiator and remove all radiator lines. Plug the lines and cap the fittings.
22. Remove the driveline from the transmission output yoke. For instructions, see **Section 26.00**. Secure the driveline to the frame rail with a chain or other suitable support.
23. Remove the engine oil dipstick and the fill tubes.
24. Remove the capscrews that hold the fan to the fan clutch, and remove the fan. Secure the fan in the shroud.
25. Label and disconnect the water heater sensor plug on the oil filter cooler. Disconnect the heater lines at the valves.
26. Move the air conditioning components out of the way without damaging the refrigerant lines.
    - 26.1 Free the refrigerant lines from all routing clamps and stand-off brackets between the compressor and the condenser.
    - 26.2 Free the refrigerant lines from all routing clamps and stand-off brackets between the receiver-drier and the condenser.
    - 26.3 Move the refrigerant lines and harness wiring as necessary.
27. Remove the four bolts attaching the power steering pump to the front of the engine, and remove the pump.
28. Remove the bolts that secure the muffler support brace to the muffler. Pull the brace up and away from the path of the engine.
29. Remove the air service from the fan clutch.
30. Remove the brace that secures the radiator to the frame rail.

⚠ DANGER

The crane and lifting chains used to remove the engine must be capable of safely lifting and supporting two metric tons. Once the engine mounts are disconnected, do not get under the engine until it is securely supported on engine stands. An unsecured engine may fall, causing personal injury or death, and component damage.

31. Remove the engine from the vehicle.
    - 31.1 Attach a low-profile lifting device to an A-frame. Move the A-frame into place over the engine.

      Attach the lifting device to the front and rear lifting eyes of the engine. See **Fig. 3**.
    - 31.2 Remove the transmission support bolts, and the engine mount bolts, lower bearing washers, and locknuts. See **Fig. 4**.
    - 31.3 Remove the right transmission mount assembly.
    - 31.4 Remove the engine from the vehicle, and set the engine and transmission on an engine stand or other suitable support. Remove the lifting device.

Installation

1. Check all of the front and rear engine support parts for damage or extreme wear. Replace the parts as needed.

   Install the isolators in the engine front crossmember. Coat the rubber mounts with soapy water, and install them in the rear engine mounts.

Series 60 Engine Removal and Installation, Argosy COE

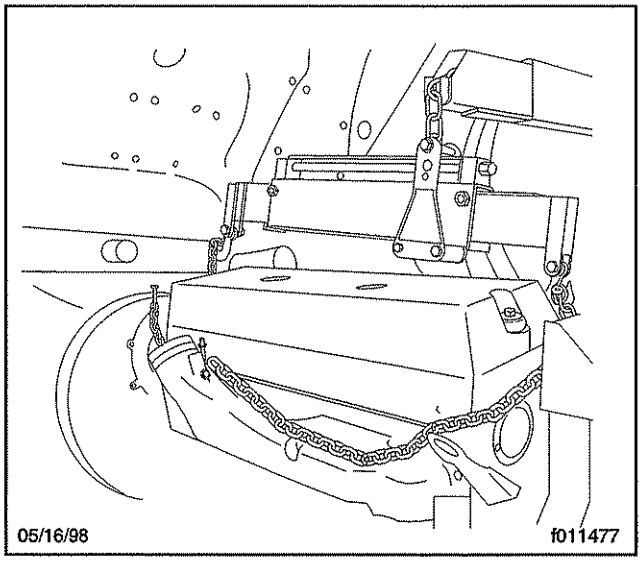


Fig. 3, Engine Lifting Device

⚠ CAUTION

Do not lubricate the components with oil, grease, or silicone lubricants, which can soften the rubber and damage the mounts.

2. Install the right transmission mount assembly. Attach the four bolts to the frame rail and tighten them 136 lbf·ft (184 N·m).
3. Install the engine in the vehicle.

   NOTE: Make sure that all wires are clear before lowering the engine into the vehicle.

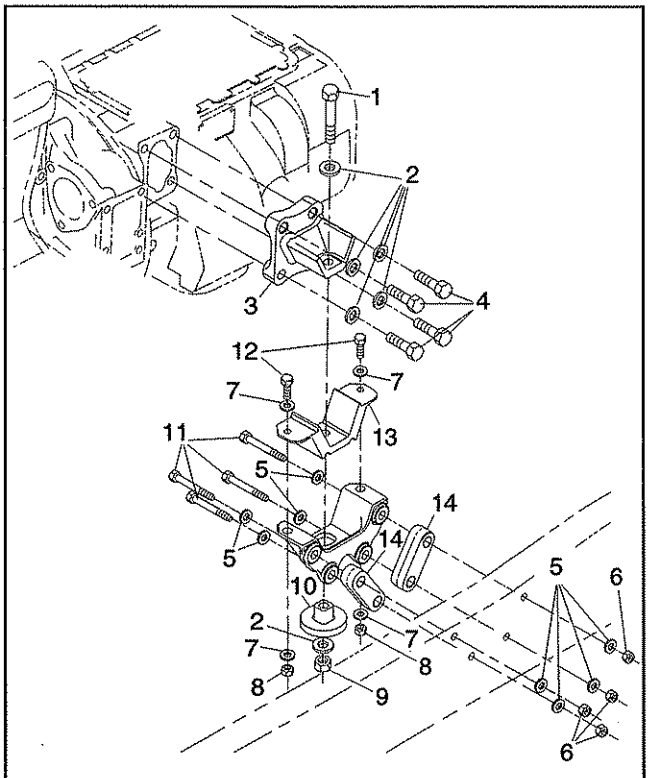
   3.1 Attach the lifting device to the engine lifting eyes. Attach the A-frame or overhead crane to the lifting device.

   3.2 Lift the engine and transmission high enough to clear the chassis. Lower the engine and transmission into position on the front and rear engine support mounts.

   3.3 Install the transmission support bolts, bearing washers, and locknuts. Tighten the bolts 280 to 380 lbf·ft (380 to 515 N·m).

   3.4 Position the isolators on the front engine support bolts. Install the bolts and tighten them 140 to 160 lbf·ft (190 to 217 N·m).

   3.5 Remove the lifting device.



1. Bolt, 3/4–10 x 4.5, Grade 8
2. Hardened Washer, 0.81 x 1.47 x .177
3. Engine Support Bracket
4. Capscrew, 3/4–10 x 3, Grade 8
5. Hardened Washer, 0.69 x 1.31 x .177
6. Nut, 5/8–11
7. Bearing Washer, 1/2 x 1.06 x .14
8. Hexnut, 1/2–13
9. Hexnut, 3/4–10
10. Upper Isolator, Engine Support
11. Bolt, 5/8–11 x 4, Grade 8
12. Bolt, 1/2–13 x 1.25
13. Lower Isolator, Engine Support
14. Spacer, Engine Support

Fig. 4, Series 60 Engine, Argosy COE Rear Mounting Configuration

4. Position the air compressor on the engine. Tighten the capscrews 20 to 25 lbf·ft (27 to 34 N·m). Replace the belt on the alternator and air compressor.
5. Connect the alternator wiring.
6. Connect the driveline to the transmission output yoke. For instructions, see **Section 26.00.**

Series 60 Engine Removal and Installation, Argosy COE

7. On vehicles with automatic transmissions, attach the ATF cooler lines. Tighten the fittings 40 to 50 lbf·ft (54 to 68 N·m).
8. Connect the transmission and engine harness wiring, as previously marked.
9. Connect the starter cables and the solenoid power cables.
10. Connect the vent line to the engine, the two air signal lines to the air governor, and the air line to the fan clutch solenoid.
11. Install the power steering pump.
12. Connect the water heater lines. Secure the valve clamp to the engine and tighten the locknuts.
13. Connect the engine oil dipstick and the fill tubes. Replace the clamps and tighten the locknuts securely.
14. Replace the section of exhaust flex pipe that runs between the turbocharger and the muffler.
15. Attach all radiator hoses and clamps to the engine. Tighten the clamps securely, but do not overtighten.
16. Position the fan on the fan clutch, and install the five capscrews. Tighten 15 lbf·ft (20 N·m).
17. Attach the charge air cooler ducting, and tighten the clamps.
18. Attach the primary and secondary fuel filters to the engine. Tighten the bolts 43 to 54 lbf·ft (58 to 73 N·m). Connect the fuel filter lines.
19. Install and securely tighten the oil filters on the oil filter cooler.
20. Position the overslung crossmember on the frame rails. Tighten the bolts 190 lbf·ft (258 N·m).
21. Connect the magnetic switch wiring. For instructions, see **Section 54.04.**
22. Position the sway bar on the cab air suspension assembly and the overslung crossmember and tighten the bolts. For instructions, see **Section 60.01.**
23. Connect the clutch linkage to the transmission.
24. Connect the shift cables to the transmission shift linkage.
25. Replace the battery box assembly on the frame rail and connect the batteries. For instructions, see **Section 54.02.**
26. Position the air cleaner mounting bracket on the overslung crossmember and tighten the bolts 40 lbf·ft (54 N·m). Position the air cleaner on the mounting bracket and tighten the bolts 40 lbf·ft (54 N·m).
27. Attach the air duct between the turbocharger and the air cleaner, and tighten the clamps.
28. Attach the support brace that runs between the muffler and the driver's side frame rail. Tighten the muffler brace bolts 50 to 60 lbf·ft (68 to 81 N·m).
29. Fill the cooling system with coolant.

⚠ DANGER

Before returning the cab to the normal operating position, read the instructions and Danger and Warning notices in Section 60.15. Failure to follow these instructions could cause the cab to hit or crush a person, possibly resulting in serious injury or death.

30. Return the cab to the operating position.
31. Remove the chocks from the tires.

Engine Removal and Installation, Detroit Diesel Series 60

Removal

1. Apply the parking brakes, chock the tires, and drain the air system.
2. Disconnect the batteries.
3. Remove the hood and the bumper. For instructions, refer to **Group 88** in this manual.
4. Disconnect the transmission from the engine. For instructions, refer to **Group 26** in this manual.
5. Remove the air cleaner housing and the brackets that hold the housing to the bulkhead. This includes removing the heat shield between the cleaner and the turbocharger. For instructions, refer to **Group 09** in this manual.

⚠ WARNING

Drain the coolant only when the coolant and engine are cool. Draining it when these are hot could cause severe personal injury due to scalding.

6. Drain the radiator. For instructions, refer to **Section 20.01**.
7. Move the air conditioning components out of the way without breaking the refrigerant lines.
   - 7.1 Free the refrigerant lines from all routing clamps and stand-off brackets between the compressor and the condenser.
   - 7.2 Free the refrigerant lines from all routing clamps and stand-off brackets between the receiver-drier and the condenser.
   - 7.3 Remove the condenser mounting fasteners, and move the condenser aside.
   - 7.4 Remove the refrigerant compressor with its mounting bracket and move the compressor aside. Move the heater lines and wiring harness as needed. For instructions, refer to **Group 83** in this manual.
   - 7.5 Use tie straps to secure the refrigerant compressor and condenser out of the way.
8. Remove the air recirculation shields around the radiator and charge air cooler. For instructions, refer to **Section 20.01** in this manual.
9. Remove the radiator and charge air cooler. For instructions, refer to **Section 20.01** in this manual. Remove the radiator mounting bracket with the radiator.
10. Remove the power steering fluid pump, and move the pump out of the way without breaking the lines or draining the fluid. For instructions, refer to **Group 46**.
11. Remove the surge tank. For instructions, refer to **Section 20.01** in this manual.
12. Remove the windshield wiper pan. For instructions, refer to **Group 60** in this manual.
13. Remove the windshield wiper linkage. For instructions, refer to **Group 82**.
14. Disconnect or remove the remaining ducts and lines.
    - 14.1 If not already removed, remove the air duct between the turbocharger and the air cleaner.
    - 14.2 Disconnect the vent line from the engine, and move the line aside.
    - 14.3 Disconnect the two air signal lines from the air governor.
    - 14.4 At the air dryer, disconnect the outlet line from the air compressor.
    - 14.5 Disconnect the air line to the fan clutch solenoid, and free the line from routing clamps.
    - 14.6 Disconnect the heater supply and return hoses from the firewall, and remove the hoses with the radiator outlet pipe.
15. Label and disconnect the wiring.
16. Remove the clutch linkage.
17. Under the engine, disconnect or remove the remaining components.
    - 17.1 Remove the section of exhaust ducting that runs between the turbocharger and the muffler.
    - 17.2 Disconnect the fuel return lines. For instructions, refer to **Group 47** in this manual.

Engine Removal and Installation, Detroit Diesel Series 60

17.3 Disconnect the starter motor and solenoid power cables.

17.4 Remove the bolts that hold the engine legs to the rear engine mounts.

⚠ WARNING

The crane and lifting chains used to remove the engine must be capable of safely lifting and supporting two metric tons. Once the engine mounts are disconnected, do not get under the engine until it is securely supported on engine stands. An unsecured engine may fall, causing personal injury or death, and component damage.

18. Remove the engine from the vehicle.

18.1 Attach the chain to the lifting eyes at the front and the rear of the engine.

18.2 With the three engine lifting eyes connected by chain to the crane, raise the crane enough to tighten the chains, but not enough to lift the front of the vehicle.

18.3 Remove the nuts from the bolts that fasten the front engine support bracket to the underslung crossmember.

18.4 Using the crane, lift the engine and pull it forward.

18.5 Once the engine is clear of the vehicle, place the engine on engine stands.

Installation

⚠ WARNING

The crane and lifting chains used to install the engine must be capable of safely lifting and supporting two metric tons. Once the engine is removed from the engine stands, do not get under the engine until it is securely supported on the engine mounts. An unsecured engine may fall, causing personal injury or death, and component damage.

1. Install the engine in the vehicle.

1.1 Attach the chain to the lifting eyes at the front and the rear of the engine.

1.2 With the three engine lifting eyes connected by chain to the crane, lift the engine, and position it on the rear engine mounts.

1.3 Connect the engine to the rear engine mounts, and tighten the bolt that runs down through each engine leg, rubber isolators, and engine mount 213 to 269 lbf·ft (289 to 365 N·m).

1.4 Assemble the lower isolator under the underslung crossmember and the front engine support bracket, and secure the front engine mount with nuts and washers. Tighten the nuts 213 to 269 lbf·ft (289 to 365 N·m).

1.5 Once the engine is securely installed in the vehicle, remove the lifting chains.

2. Connect and install components under the engine.

2.1 Connect the power cables to the starter motor and solenoid.

2.2 Connect the exhaust pipe to the muffler.

2.3 Connect the fuel return lines. For instructions, refer to **Group 47** of this manual.

2.4 Connect the transmission to the engine. For instructions, refer to **Group 26** in this manual.

3. Install the power steering fluid pump. For instructions, refer to **Group 46** in this manual.

4. Install the clutch linkage. For instructions, refer to **Group 25** in this manual.

5. Connect the wiring. For wiring harness information, refer to **Group 54** in this manual.

6. Connect or install the ducts and lines.

6.1 Install the V-band clamp that holds the forward end of the exhaust ducting to the rear of the turbocharger. Tighten it 85 lbf·in (940 N·cm).

6.2 Install the air duct between the turbocharger and the air cleaner.

6.3 Connect the vent line to the engine.

6.4 Connect the two air signal lines to the air governor on top of the compressor.

6.5 Connect the air compressor outlet line to the air dryer.

6.6 Connect the air line to the fan clutch solenoid.

6.7 Install the heater supply and return hoses and the radiator outlet pipe.

7. Install the radiator, fan shroud, and charge air cooler. For instructions, refer to **Group 20** in this manual.
8. Install the air recirculation shields around the radiator and charge air cooler. For instructions, refer to **Group 20** in this manual.
9. Install the air conditioning components without breaking the refrigerant lines.

9.1 Install the condenser. For instructions, refer to **Group 83** of this manual.

9.2 Install the refrigerant compressor. For instructions, refer to **Group 83** of this manual. For instructions on installing the compressor drive belts, refer to **Section 01.02** in this workshop manual group.

9.3 Route and clamp the refrigerant lines between the compressor and the condenser.

9.4 Route and clamp the refrigerant lines between the receiver dryer and the condenser.

10. Install the windshield wiper pan. For instructions, refer to **Group 60**.
11. Install the wiper linkage. For instructions, refer to **Group 82** in this manual.
12. Install the surge tank. For instructions, refer to **Section 20.01** in this manual.
13. Install the air cleaner housing. For instructions, refer to **Group 09** in this manual. Connect the intake air ducting to the air cleaner and the charge air cooler.
14. Install the hood and the bumper. For instructions, refer to **Group 88** in this manual.
15. Fill the radiator.
16. Connect the batteries.
17. Start the engine, and check for leaks. Repair any leaks found.
18. Test drive the vehicle.

Inspection

1. Park the vehicle on a level surface and apply the parking brakes. Shut down the engine. Chock the tires.
2. Inspect all used drive belts (including those that are being replaced) for the following conditions (see **Fig. 1**):

   NOTE: For an installed belt, gently twist the belt about 90 degrees so you can see the sidewalls and bottom.

   2.1 Inspect for glazing (shiny sidewalls). Glazing is caused by friction created when a loose belt slips in the pulleys. It can also be caused by oil or grease on the pulleys.

   2.2 Inspect for separating layers. Oil, grease, or belt dressings can cause the belt to fall apart in layers. If engine parts are leaking, repair the oil leaks. Do not use belt dressings on any belt.

   2.3 Check for jagged or streaked sidewalls. These are the result of a foreign object (such as sand or small gravel) in the pulley, or a rough pulley wall surface.

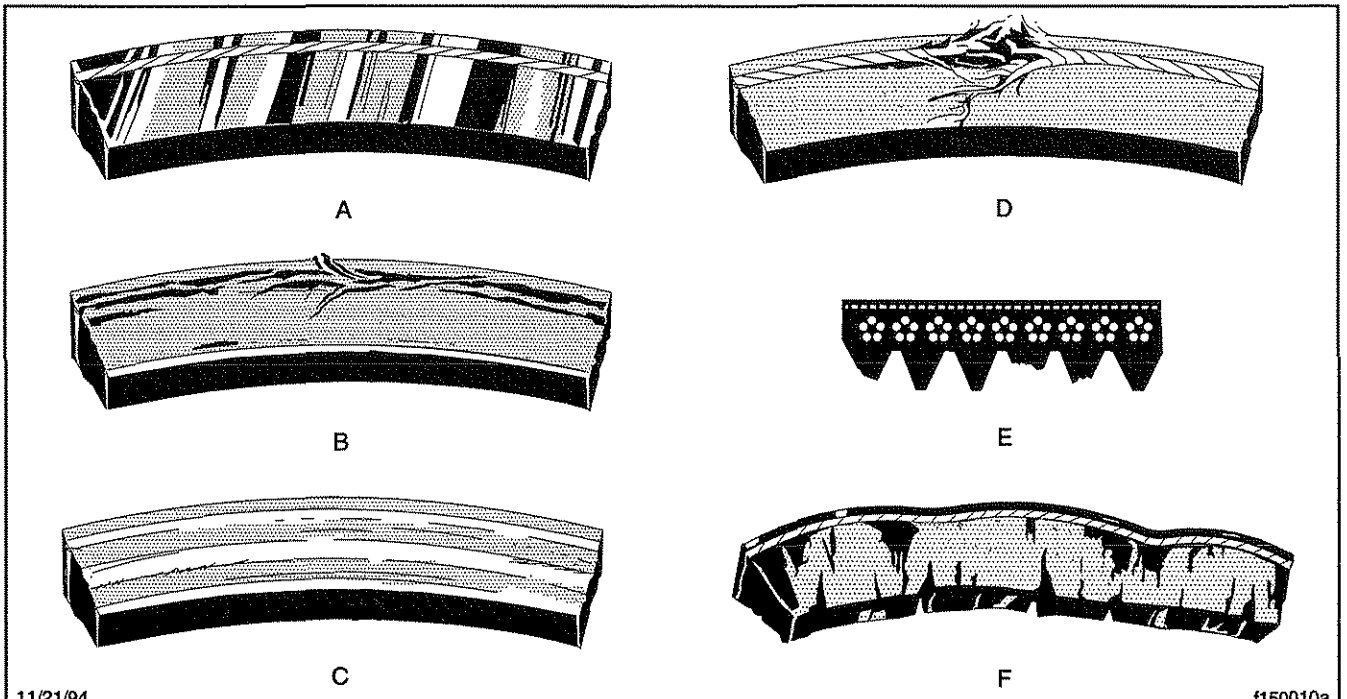
   2.4 Check for tensile breaks (breaks in the cord body). Cuts in a belt are usually caused by large foreign objects in the pulley, or by prying or forcing the belt during installation or removal.

   2.5 On poly-V belts, check for uneven ribs. Foreign objects in the pulley will erode the undercord ribs, causing the belt to lose its gripping power.

   2.6 Inspect for cracks. Small, irregular cracks are usually signs of an old belt.

   Replace the belt if any of the above conditions are found. Replace both belts of a set, at the same time. Matched belts must be from the same manufacturer.

3. Check all pulley bearings for roughness. Replace the bearings if they are rough.



A. Glazing
B. Separating Layers
C. Streaked Sidewalls
D. Tensile Break
E. Uneven Ribs
F. Cracks

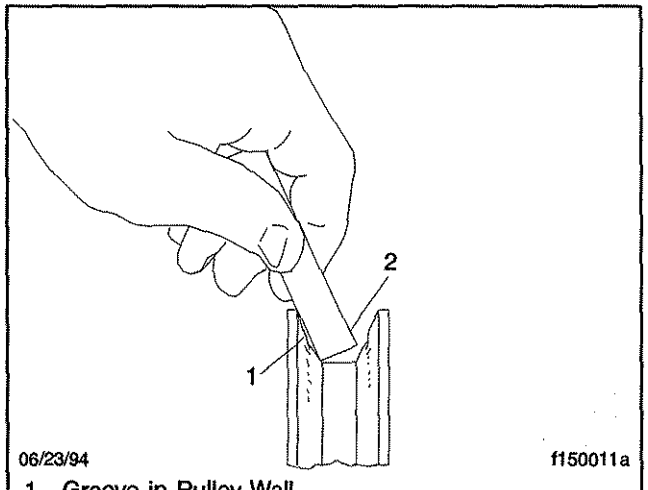
Fig. 1, Drive Belt Problems

Pulley and Drive Belt Inspection

4. Inspect all pulleys for foreign objects, oil, or grease in the grooves. Use a nonflammable cleaning solvent to remove oils. Use a wire brush to remove rust, and a file to remove burrs.
5. Inspect the pulleys for wear on the inner walls. Hold a small straightedge against the inside of the pulley walls, or use your little finger or fingernail to find grooves in the inner walls. If there are any grooves, replace the pulley. See **Fig. 2.**
6. Check alignment of pulleys.Use a thin straightedge that is longer than the longest span between the pulleys. Place the straightedge into the V-grooves of two pulleys at a time. The straightedge should be parallel to the outer edges of the pulleys. If it is not parallel, the pulleys are misaligned.

   Pulley misalignment must not be more than 1/16-inch for each foot (1.5-mm for each 30.5 cm) of distance between pulley centers.

   If there is misalignment of the pulleys, adjust the pulleys or brackets if their positions are adjustable. See **Fig. 3.** Replace bent or broken pulleys, pulley brackets, or shafts.
7. Check all drive component mounting parts for loose fasteners, cracks, or other damage. Tighten loose fasteners. Repair or replace cracked or damaged brackets.
8. Remove the chocks from the tires.



1. Groove in Pulley Wall
2. Small Straightedge

Fig. 2, Check for Pulley Wear

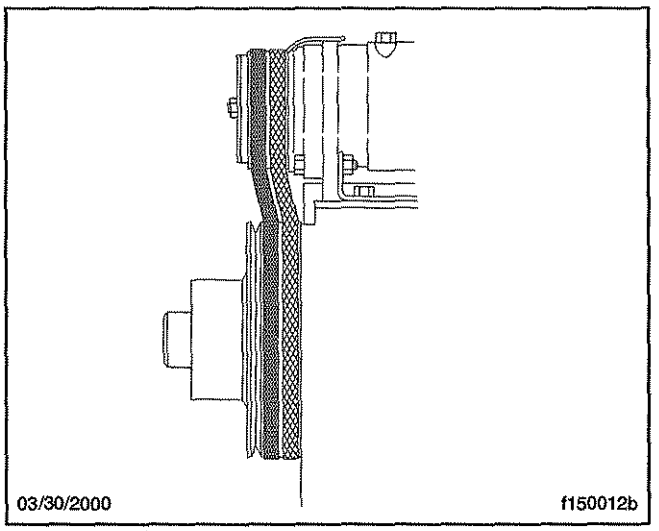
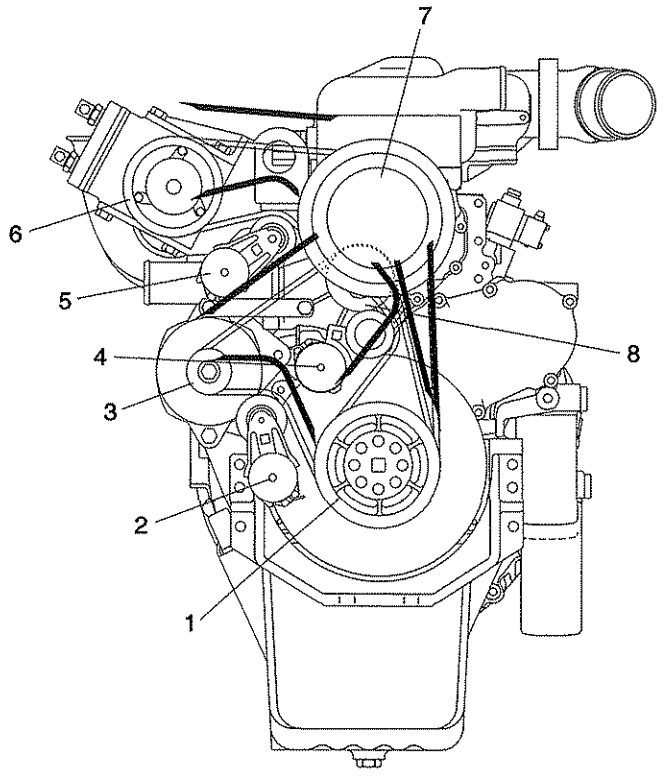


Fig. 3, Side View of Misaligned Pulleys

Belt Replacement

Fan Belt (See Fig. 1)

1. Park the vehicle on a level surface and apply the parking brakes. Shut down the engine. Chock the tires.
2. Remove the belt.
   - 2.1 Insert a breaker bar in the belt tensioner and rotate the tensioner counterclockwise off the belt.
   - 2.2 Holding the belt tensioner up, remove the belt from the vibration damper.
   - 2.3 Slowly release the belt tensioner and remove the breaker bar.
   - 2.4 Raise the belt and take it off over the fan. Remove the belt from the engine compartment.
3. Install the belt.
   - 3.1 Inspect the pulleys and used belts (even if installing new belts) as instructed in **Subject 130.**
   - 3.2 Loop the belt around the fan and align it in the fan pulley.
   - 3.3 Insert a breaker bar in the belt tensioner and rotate the tensioner up while installing the belt around the vibration damper pulley.
   - 3.4 Slowly release the tensioner assembly onto the belt. The tensioner automatically tightens the belt to the correct tension.



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1. Vibration Damper
2. Alternator Belt Tensioner
3. Alternator Pulley
4. Fan Belt Tensioner
5. Refrigerant Compressor Belt Tensioner
6. Refrigerant Compressor Pulley
7. Fan Pulley
8. Water Pump Pulley

Fig. 1, Series 55 Drive Belts

Series 55 Drive Belt Replacement

3.5 Remove the breaker bar from the tensioner.

4. Adjust the belt tension.

4.1 The Detroit Diesel belt tensioner automatically adjusts the belt to the correct tension.

4.2 If the belt slips, repair or replace the tensioner. For instructions, see the engine manufacturer's service literature.

5. Remove the chocks from the tires.

Refrigerant Compressor Belt (See Fig. 1)

NOTE: To remove the refrigerant compressor belt, you must first remove the fan belt.

1. Park the vehicle on a level surface and apply the parking brakes. Shut down the engine. Chock the tires.
2. Remove the belt.

2.1 Insert a breaker bar in the belt tensioner and rotate the tensioner clockwise off the belt.

2.2 Holding the belt tensioner down, remove the belt from the refrigerant compressor.

2.3 Slowly release the belt tensioner and remove the breaker bar.

2.4 Lower the belt and take it off over the fan. Remove the belt from the engine compartment.

3. Install the belt.

3.1 Inspect the pulleys and used belts (even if installing new belts) as instructed in **Subject 130.**

3.2 Loop the refrigerant compressor belt around the fan and align it in the fan pulley.

3.3 Insert a breaker bar in the belt tensioner and rotate the tensioner clockwise while installing the belt on the refrigerant compressor pulley.

3.4 Slowly release the tensioner assembly onto the belt. The tensioner automatically tightens the belt to the correct tension.

3.5 Remove the breaker bar from the tensioner.

4. Adjust the belt tension.

4.1 The Detroit Diesel belt tensioner automatically adjusts the belt to the correct tension.

4.2 If the belt slips, repair or replace the tensioner. For instructions, see the engine manufacturer's service literature.

5. Remove the chocks from the tires.

Alternator/Water Pump Belt (See Fig. 1)

NOTE: To remove the alternator belt, you must first remove the fan and refrigerant compressor belts.

1. Park the vehicle on a level surface and apply the parking brakes. Shut down the engine. Chock the tires.
2. Remove the belt.

2.1 Insert a breaker bar in the alternator belt tensioner and rotate the tensioner counterclockwise off the belt.

2.2 Holding the belt tensioner down, remove the belt from the alternator pulley.

2.3 Slowly release the belt tensioner and remove the breaker bar.

2.4 Lower the belt, and take it off the vibration damper. Raise the belt and take it off over the fan. Remove the belt from the engine compartment.

3. Install the belt.

3.1 Inspect the pulleys and used belts (even if installing new belts) as instructed in **Subject 130.**

3.2 Loop the belt around the fan and align it in the grooves of the water pump pulley.

3.3 Loop the belt down and around the vibration damper pulley.

3.4 Insert a breaker bar in the belt tensioner and rotate the tensioner down while installing the belt on the alternator pulley.

3.5 Slowly release the tensioner assembly onto the belt. The tensioner automatically tightens the belt to the correct tension.

3.6 Remove the breaker bar from the tensioner.

4. Adjust the belt tension.

4.1 The Detroit Diesel belt tensioner automatically adjusts the belt to the correct tension.

4.2 If the belt slips, repair or replace the tensioner. For instructions, see the engine manufacturer's service literature.

5. Remove the chocks from the tires.

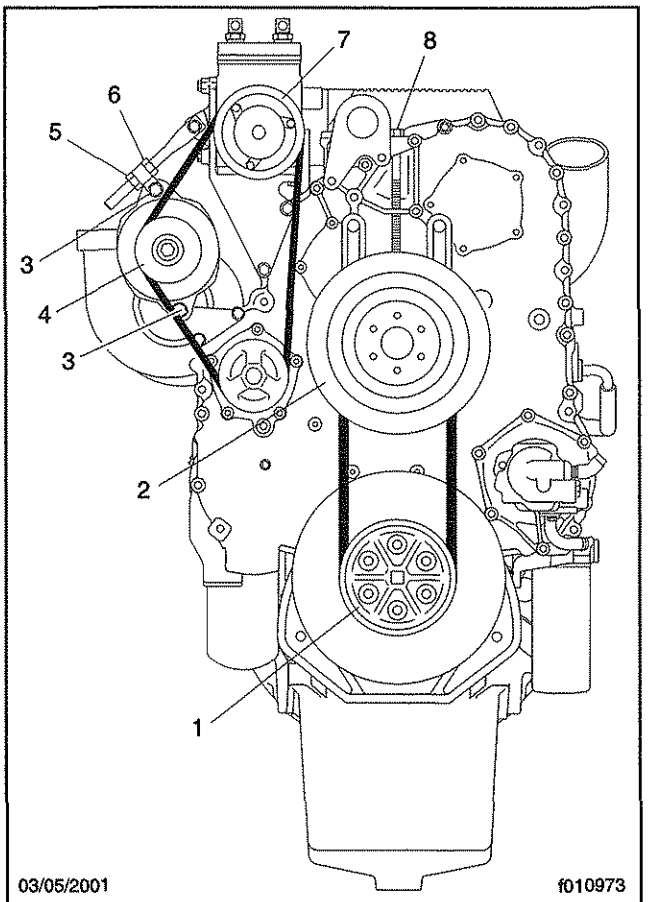
NOTE: On a joined belt, the Krikit gauge will have a low accuracy of approximately +/– 30 percent. The Kent-Moore gauge is inherently a more accurate device. The belt tension gauge must grip the full width of the belt to get an accurate reading. If the gauge grips only one of the two V's in a Powerband belt, it will not give an accurate reading. The actual tension in the belt will likely be greater than the tension indicated by the gauge. In this case, the Kent-Moore gauge will be no more accurate than the Krikit gauge.

Belt Replacement Without an Automatic Belt Tensioner

Alternator and Refrigerant Compressor Belt

1. Park the vehicle on a level surface and apply the parking brakes. Shut down the engine. Chock the tires.
2. Remove the belt. See **Fig. 1**.
   - 2.1 Back off the alternator adjusting nut.
   - 2.2 Loosen the alternator pivot bolts.
   - 2.3 Turn the alternator jam nut to rotate the alternator up and toward the engine. Turn the nut until the alternator is close enough to the engine to allow belt removal.
   - 2.4 Remove the belt by slipping it off the pulleys. Do not roll or pry the belt off the pulleys. The distance between the pulley centers must be short enough to allow belt removal without using force.
3. Install the belt.
   - 3.1 Inspect the pulleys and the belt (even if installing a new belt) as instructed in **Subject 130.**
   - 3.2 Install the belt on the pulleys without prying or rolling it into place.
   - 3.3 While keeping the belt seated in the pulley grooves, turn the adjusting nut to rotate the alternator away from the engine and to increase belt tension.
4. Adjust the belt.
   - 4.1 Install a belt tension gauge at the center of the belt's longest free-span.

   IMPORTANT: Do not overtighten the belt. Too much tension shortens belt and bearing life.
   - 4.2 Turn the adjusting nut to rotate the alternator out, away from the engine until the belt is tensioned 100 lbf (445 N) per belt, 200 lbf (890 N) if using a joined belt.
   - 4.3 Tighten the alternator jam nut 130 lbf·ft (176 N·m).



1. Vibration Damper
2. Fan Pulley
3. Alternator Pivot Bolt
4. Alternator Pulley
5. Alternator Jam Nut
6. Alternator Adjusting Nut
7. Refrigerant Compressor Pulley
8. Fan Adjusting Rod

Fig. 1, Series 60 Drive Belts Without an Automatic Belt Tensioner

Series 60 Drive Belts Replacement

4.4 Tighten the alternator pivot bolts 70 lbf·ft (95 N·m).

4.5 Remove the chocks from the tires.

4.6 Operate the engine for about 30 minutes or 15 miles (24 km) and recheck the belt tension. Re-tension to a minimum of 75 lbf (334 N) per belt, 150 lbf (668 N) if using a joined belt. Check again after 8 hours of operation or 250 miles (400 km). Adjust the belt tension as needed.

Fan Belt

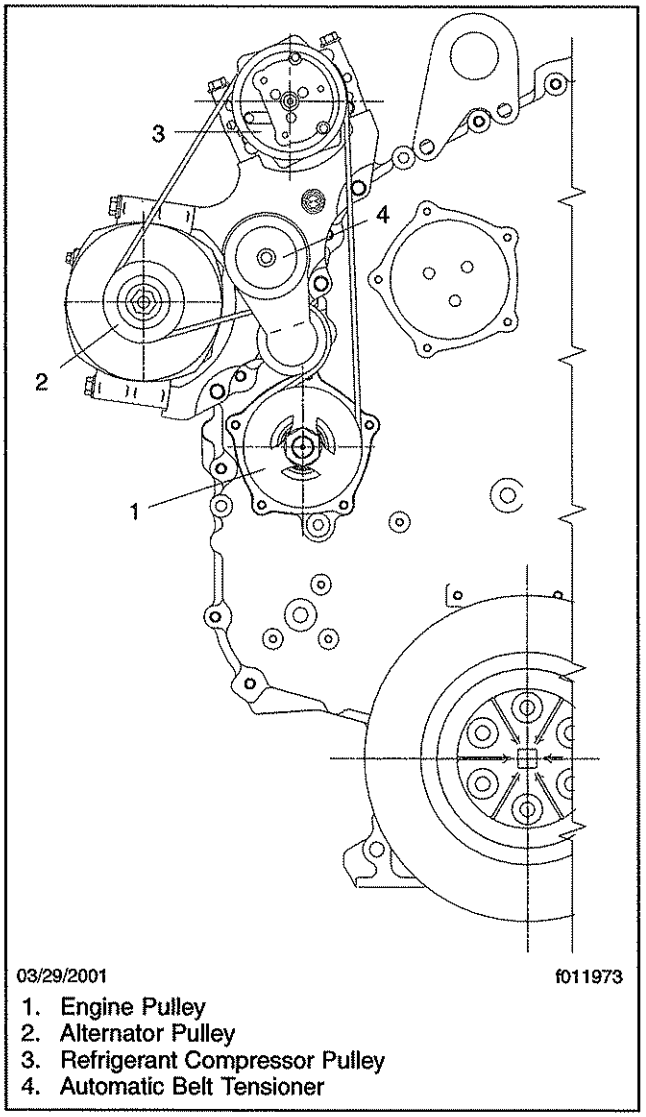
1. Park the vehicle on a level surface and apply the parking brakes. Shut down the engine. Chock the tires.
2. Remove the belt. See **Fig. 1**.
   - 2.1 Loosen the four mounting capscrews that attach the fan hub to the engine.
   - 2.2 Loosen the fan adjusting rod to relieve tension from the belt.
   - 2.3 Remove the belt by slipping it off the pulleys and working it over one fan blade at a time. On some vehicles, it may be necessary to remove the fan. For instructions, see **Section 20.01**. Do not roll or pry the belt off the pulleys. The distance between the pulley centers must be short enough to allow belt removal without using force.
3. Install the belt.
   - 3.1 Inspect the pulleys and the belt (even if installing a new belt) as instructed in **Subject 130**.
   - 3.2 Work the belt over the fan blades, one blade at a time. Install the belt on the pulleys without rolling or prying it into place.
   - 3.3 While keeping the belt seated in the pulley grooves, turn the adjusting rod to increase belt tension.
4. Adjust the belt.
   - 4.1 Install a belt tension gauge at the center of the belt's longest free-span.

   IMPORTANT: Do not overtighten the belt. Too much tension shortens belt and bearing life.
   - 4.2 Turn the adjusting rod to increase belt tension to 100 lbf (445 N) per belt.
   - 4.3 Tighten the fan hub mounting capscrews 75 to 83 lbf·ft (100 to 112 N·m).
   - 4.4 Check the belt tension and adjust it if needed.
   - 4.5 Remove the chocks from the tires.
   - 4.6 Operate the engine for about 30 minutes or 15 miles (24 km) and recheck the belt tension. Re-tension to a minimum of 75 lbf (334 N). Check again after 8 hours of operation or 250 miles (400 km). Adjust the belt tension as needed.

Belt Replacement With an Automatic Belt Tensioner

Alternator and Refrigerant Compressor Belt

1. Park the vehicle on a level surface and apply the parking brakes. Shut down the engine. Chock the tires.
2. Remove the belt. See **Fig. 2**.
   - 2.1 Insert a 1/2-inch breaker bar in the belt tensioner and rotate the tensioner away from the accessory drive belt.
   - 2.2 Holding the belt tensioner down, remove the belt from the alternator pulley.
   - 2.3 Remove the belt from the refrigerant compressor pulley and the engine pulley.
   - 2.4 Slowly release the belt tensioner and remove the breaker bar.
3. Install the belt.
   - 3.1 Inspect the pulleys and the belt (even if installing a new belt) as instructed in **Subject 130**.
   - 3.2 Install the belt onto the engine pulley and the refrigerant compressor pulley.
   - 3.3 Insert a 1/2-inch breaker bar into the belt tensioner and rotate it out while installing the belt onto the alternator pulley.



1. Engine Pulley
2. Alternator Pulley
3. Refrigerant Compressor Pulley
4. Automatic Belt Tensioner

Fig. 2, Alternator and Refrigerant Compressor Belts With an Automatic Belt Tensioner

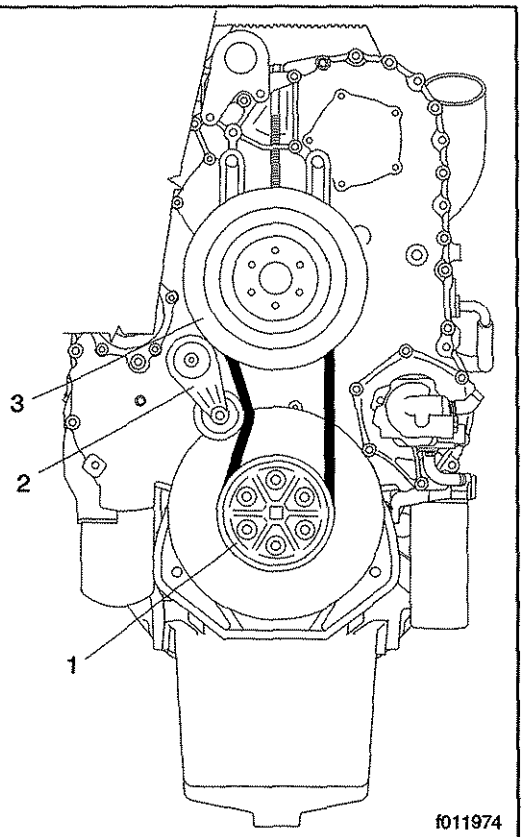
3.4 Slowly release the belt tensioner and remove the breaker bar. The belt tensioner will automatically apply the correct tension on the belt.

4. Remove the chocks from the tires.

Fan Belt

1. Park the vehicle on a level surface and apply the parking brakes. Shut down the engine. Chock the tires.
2. Remove the belt. See **Fig. 3.**
   - 2.1 Insert a 1/2-inch breaker bar in the belt tensioner and rotate the tensioner away from the fan drive belt.
   - 2.2 Holding the belt tensioner down, remove the belt from the fan pulley and the engine pulley.
   - 2.3 Slowly release the belt tensioner and remove the breaker bar.
3. Install the belt.
   - 3.1 Inspect the pulleys and the belt (even if installing a new belt) as instructed in **Subject 130.**
   - 3.2 Install the belt onto the fan pulley.
   - 3.3 Insert a 1/2-inch breaker bar into the belt tensioner and rotate it out while installing the belt onto the engine pulley.
   - 3.4 Slowly release the belt tensioner and remove the breaker bar. The belt tensioner will automatically apply the correct tension on the belt.
4. Remove the chocks from the tires.

Series 60 Drive Belts Replacement



1. Vibration Damper
2. Automatic Belt Tensioner
3. Fan Pulley

Fig. 3, Fan Belt With an Automatic Belt Tensioner

Drive Belt Tensions		
Engine	**Component**	**Belt Tension: lbf (N)**
Series 60	Alternator and Refrigerant Compressor	60–80 (267–356)
	Fan	

Table 1, Drive Belt Tensions

Fastener Torques		
Engine	**Fastener**	**Torque: lbf·ft (N·m)**
Series 55 and 60	Rear Engine-to-Mount Bolts	213–269 (289–365)
	Front Engine-to-Mount Bolts	

Table 2, Fastener Torques

Specifications

Engine	Component	Belt Tension, New Belt lbs (kg)	Belt Tension, Used Belt lbs (kg)
Series 60	Alternator and Refrigerant Compressor	60 to 80 (27 to 36)	60 to 80 (27 to 36)
	Fan	60 to 80 (27 to 36)	60 to 80 (27 to 36)

Table 1, Drive Belt Torques

Engine	Fastener	Torque lbf·ft (N·m)
Series 55 and 60	Rear Engine-to-Mount Bolts	213 to 269 (289 to 365)
	Front Engine-to-Mount Bolts	

Table 2, Fastener Torques

Engine Mounts

01.03

Contents

Subject	Subject Number
General Description	050
Service Operations	
Rear Engine Mount Replacement	100
Front Engine Mount Replacement	110
Rear Engine Mount Isolator Replacement	120
Front Engine Mount Isolator Replacement	130
Specifications	400

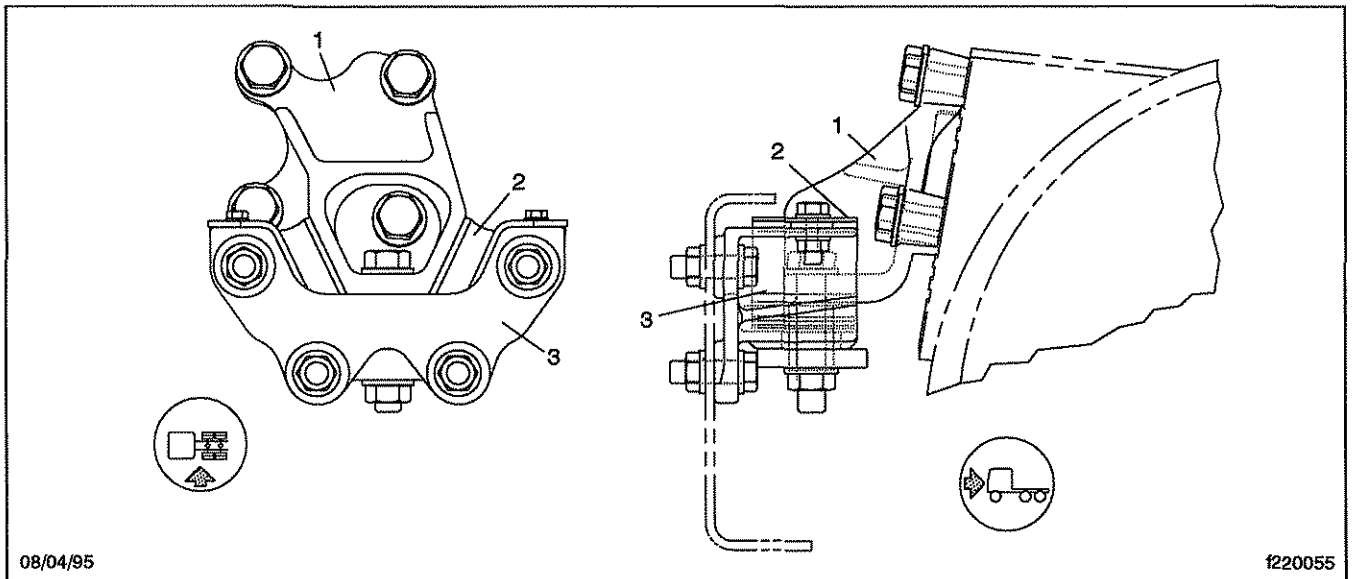
General Description

Three mounts support the engine and transmission, holding a total of almost 816 kg (1800 lb). Two of the engine mounts support the rear of the engine and transmission assembly. The third supports the front of the assembly.

Each of the rear engine mounts (**Fig. 1**) is bolted to the inside of the frame rail near the flywheel housing. These mounts support legs which are bolted to the flywheel housing. The V-shaped rear engine leg sets into a V-shaped rear engine mount. **See Fig. 2** and **Fig. 3**.

The front engine mount is an underslung crossmember under the front of the engine. It supports a bracket (**Fig. 4**) which is bolted to the engine at each side of the vibration damper pulley.

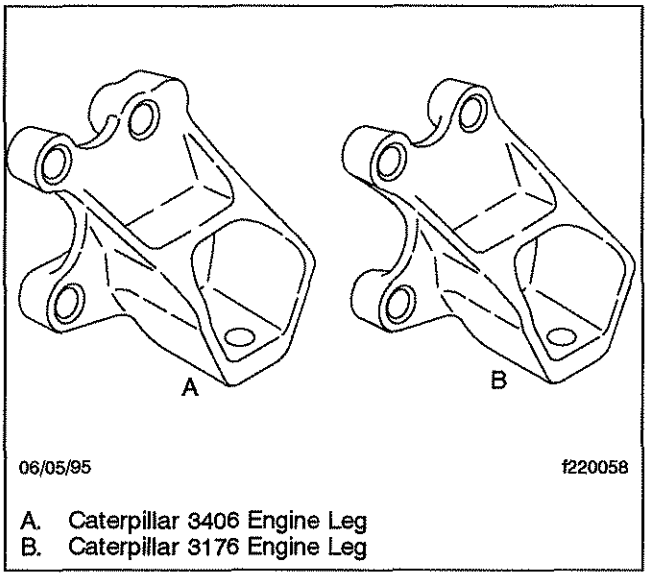
To isolate the engine and transmission from road shock, and to isolate the vehicle frame from engine vibration, the engine mounts are sandwiched between rubber isolator cushions (sometimes called restriction pads). Steel snubbers protect the cushions from wearing on the engine support brackets, and bolts run through the mount, cushions, and snubbers to hold the assembly together and hold the engine on the mount.



1. Engine Leg (bolted to the engine)
2. Rubber Isolator
3. Engine Mount (bolted to the frame rail)

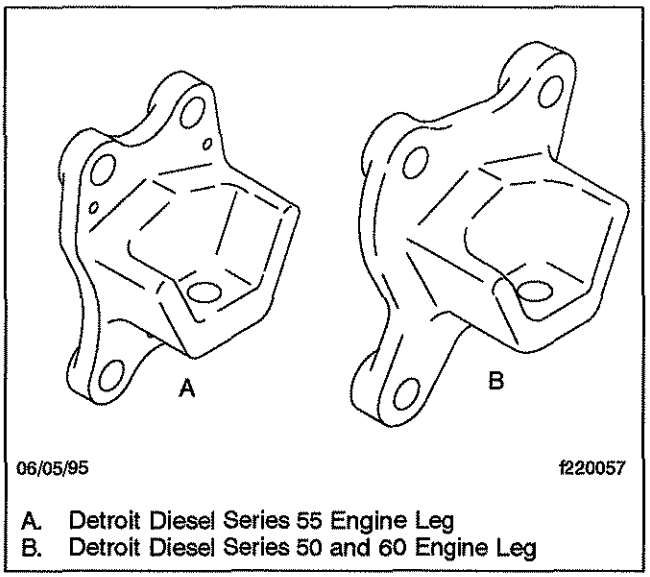
Fig. 1, Rear Engine Mount, Cummins M11 Engine

General Description



A. Caterpillar 3406 Engine Leg
B. Caterpillar 3176 Engine Leg

Fig. 2, Engine Legs, Caterpillar



A. Detroit Diesel Series 55 Engine Leg
B. Detroit Diesel Series 50 and 60 Engine Leg

Fig. 3, Engine Legs, Detroit Diesel

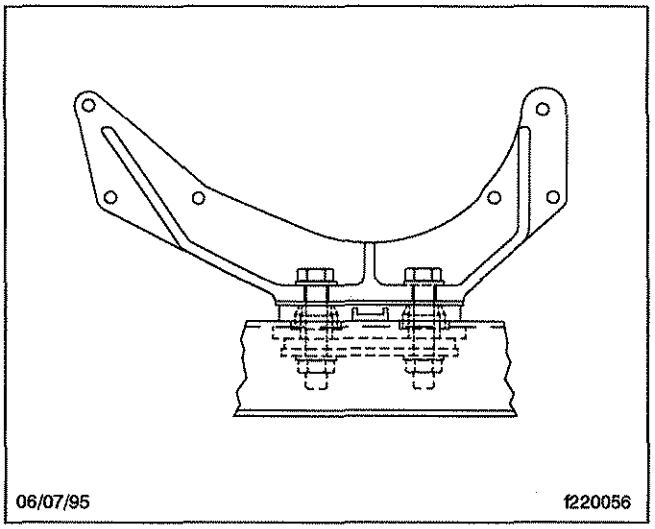


Fig. 4, Front Engine Support Bracket, Cummins M11 Engine

Rear Engine Mount Replacement

Replacement (See Fig. 1)

1. Apply the parking brakes, chock the tires, and (if applicable) drain the air brake system.

WARNING: The jack used to lift the engine must be capable of safely lifting and supporting two metric tons. Once the engine mount is disconnected, do not get under the engine until it is securely supported on engine stands. An unsecured engine may fall, causing personal injury or death, and component damage.

2. Disconnect the engine from the right rear engine mount.

   2.1 Place a jack under the rear of the engine, and raise the jack until it's braced against the engine.

   NOTE: To remove the bolt that connects the engine leg and the engine mount, you may have to disconnect and move the exhaust ducting. To do this, refer to the instructions in **Section 49.00**.

   2.2 Remove the bolt from the right rear engine mount. Save the fasteners, rubber isolator cushions, and snubbers.

   2.3 Lift the engine slightly to take its weight off the right rear engine mount. Place engine stands under the engine to keep it off the engine mount.

3. Remove the bolts which secure the mount to the frame rail. Remove the mount from the frame rail.

   If necessary, remove the four bolts which secure the right engine support bracket to the flywheel housing, and remove the bracket from the engine.

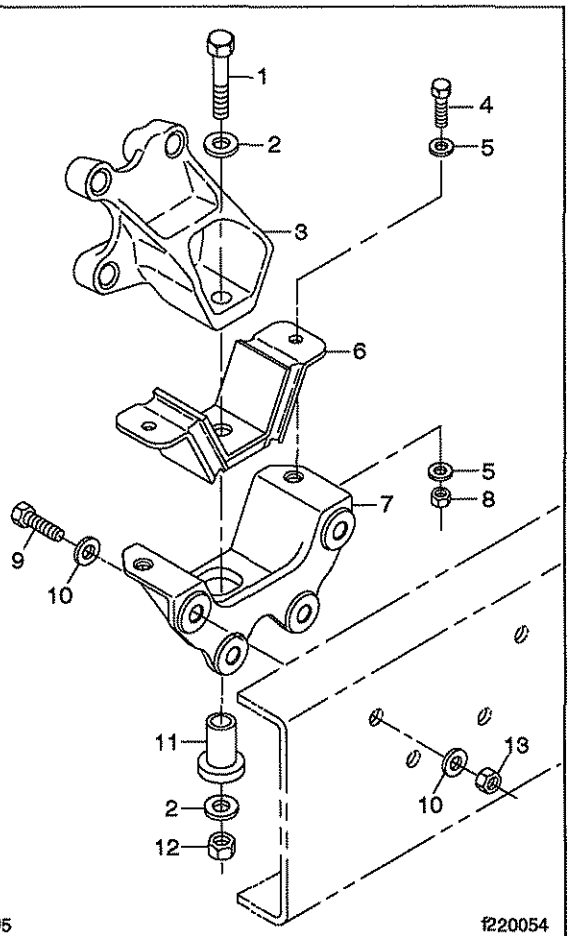
4. Place a new engine mount against the inside of the frame rail, and secure it with bolts, washers, and nuts. Tighten the nuts 120 to 152 lbf·ft (163 to 206 N·m).

5. If removed, install the engine support bracket on the right side of the flywheel housing. Apply thread lock compound to the bracket mounting bolts, and tighten them as follows:

   For aluminum flywheel housings: tighten the nuts 180 to 220 lbf·ft (244 to 298 N·m).

   For iron flywheel housings: tighten the nuts 213 to 269 lbf·ft (289 to 365 N·m).

6. Inspect the engine mount rubber isolators for wear or damage and replace them if necessary.



1. Capscrew, 3/4-10 x 4.5 Inch, Grade 8
2. Washer
3. Engine Leg
4. Capscrew, 5/16-18 x 1 Inch, Grade 8
5. Washer
6. Upper Isolator
7. Rear Engine Mount
8. Nut, 5/16-18
9. Capscrew, 5/8-11 x 2.5 Inch, Grade 8
10. Washer
11. Lower Isolator
12. Nut, 3/4-10
13. Nut, 5/8-11

Fig. 1, Rear Engine Mount Assembly for Cummins M11 Engines

Rear Engine Mount Replacement

CAUTION: Do not lubricate the components with oil, grease, or silicone lubricants; they will deteriorate the rubber isolators.

7. Install the upper isolator in the engine mount. In order for the isolator holes to align with the holes in the engine mount, the painted side of the isolator must be towards the engine. Fasten the isolator to the mount, and tighten the capscrews 14 to 18 lbf·ft (19 to 24 N·m).

WARNING: The jack used to lower the engine must be capable of safely lifting and supporting two metric tons. Once the engine is removed from the engine stands, do not get under the engine until it is securely installed on the engine mount. An unsecured engine may fall, causing personal injury or death, and component damage.

8. Secure the engine to the engine mounts.

   8.1 If not in place, set a jack under the rear of the engine and raise the jack until it is braced against the engine.

   8.2 Lift the engine slightly to remove the engine stands. Remove the stands, and carefully lower the engine onto the engine mount.

   8.3 Holding the lower isolator and snubber in place, install the bolt in the right rear engine mount, and secure it with the nut and hardened washer. Tighten the nut 213 to 269 lbf·ft (289 to 365 N·m).

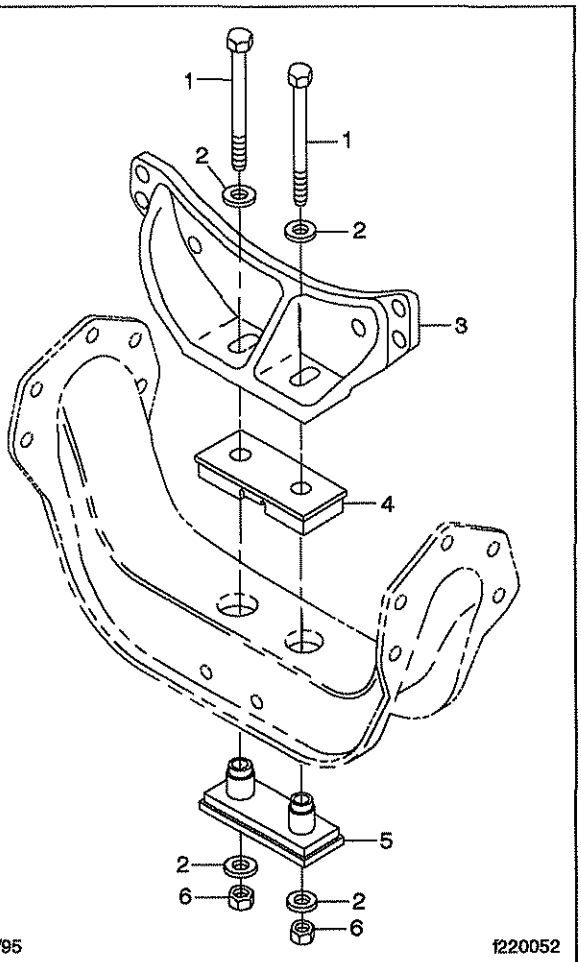
9. Repeat this procedure for the other rear engine mount.

10. Remove the jack from under the engine, and remove the chocks from the tires.

Replacement (See Fig. 1)

1. Apply the parking brakes, chock the tires, and (if applicable) drain the air brake system.

WARNING: The lifting device and chain used to lift the engine must be capable of safely lifting and supporting two metric tons. Once the engine mount is disconnected, do not get under the engine until it is securely supported on engine stands. An unsecured engine may fall, causing personal injury or death, and component damage.



1. Capscrew, 3/4-10 x 4 Inch, Grade 8
2. Washer
3. Front Engine Support Bracket
4. Upper Isolator
5. Lower Isolator
6. Nut, 3/4-10

Fig. 1, Front Engine Mount Assembly, Cummins M11 Engine

2. Disconnect the engine from the front engine mount.

   2.1 Attach a chain to the front engine lifting hook(s), and position a lifting device to lift the engine. Attach the chain to the lifting device, and raise the chain to remove any slack.

   2.2 Remove the bolt(s) from the front engine mount. Save the fasteners, rubber isolator cushions, and snubber(s).

   NOTE: In order to raise the front of the engine, you may have to loosen the bolts that run through the rear engine mounts.

   2.3 Lift the engine slightly to take its weight off the front engine mount. Place engine stands under the engine to keep it off the engine mount.

3. If you're replacing the front engine support bracket, refer to the engine manufacturer's service literature.

4. Inspect the engine mount rubber isolators for wear or damage and replace them if necessary.

CAUTION: Do not lubricate the components with oil, grease, or silicone lubricants; they will deteriorate the rubber isolators.

5. Install the upper isolator(s) in the engine mount. If applicable, place the snubber(s) on the isolator(s).

WARNING: The lifting device and chain used to lower the engine must be capable of safely lifting and supporting two metric tons. Once the engine is removed from the engine stands, do not get under the engine until it is securely installed on the engine mount. An unsecured engine may fall, causing personal injury or death, and component damage.

6. Secure the engine to the front engine mount.

   6.1 Attach a chain to the front engine lifting hook(s). Attach the chain to a lifting device, and raise the chain to remove any slack.

Front Engine Mount Replacement

6.2 Lift the engine slightly to remove the engine stands. Remove the stands, and carefully lower the engine onto the engine mount.

6.3 Holding the lower isolator in place, install the bolts in the front engine mount and secure them with the nuts and washers. Tighten the nuts 213 to 269 lbf·ft (289 to 365 N·m).

NOTE: If you loosened the bolts that run through the rear engine mounts, tighten those bolts 213 to 269 lbf·ft (289 to 365 N·m).

6.4 Remove the lifting chain from the engine lifting hooks.

7. Remove the chocks from the tires.

Rear Engine Mount Isolator Replacement

Replacement (See Fig. 1)

1. Apply the parking brakes, chock the tires, and (if applicable) drain the air brake system.

WARNING: The jack used to lift the engine must be capable of safely lifting and supporting two metric tons. Once the engine mount is disconnected, do not get under the engine until it is securely supported on engine stands. An unsecured engine may fall, causing personal injury or death, and component damage.

2. Disconnect the engine from the right rear engine mount.

   2.1 Place a jack under the rear of the engine, and raise the jack until it's braced against the engine.

   NOTE: To remove the bolt that connects the engine leg and the engine mount, you may have to disconnect and move the exhaust ducting. To do this, refer to the instructions in **Section 49.00**.

   2.2 Remove the bolt from the right rear engine mount. Save the fasteners.

   2.3 Use the jack to raise the engine slightly, and secure it with jack stands.

   2.4 Remove the two capscrews that hold the ends of the isolator to the engine mount.

   2.5 Remove the engine mount from the frame rail. For instructions, refer to **Subject 100**. Remove and discard the isolator.

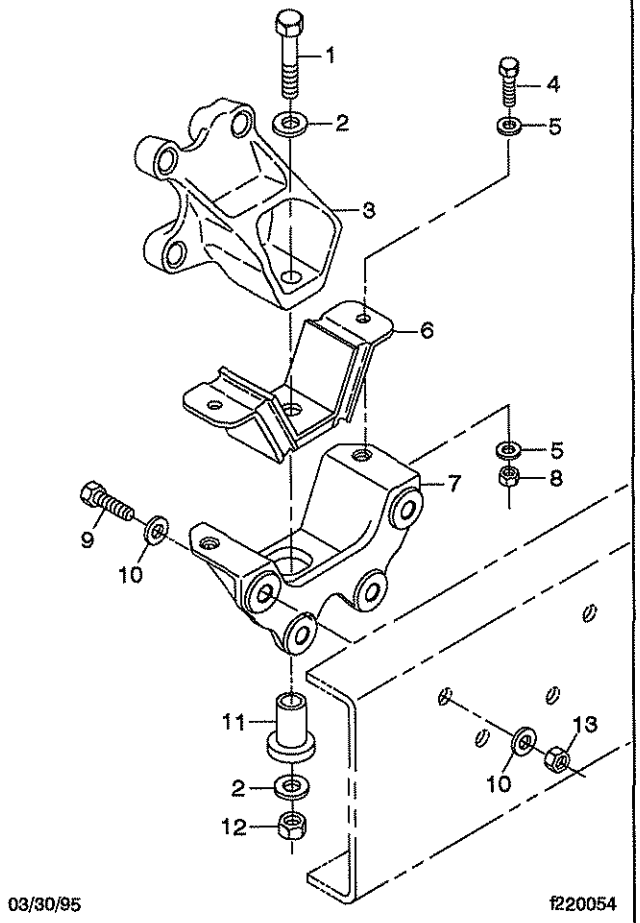
3. Inspect the new engine mount rubber isolators for wear or damage and replace them if necessary.

CAUTION: Do not lubricate the new components with oil, grease, or silicone lubricants; they will deteriorate the rubber isolators.

4. Install the new isolator in the engine mount, and install the engine mount on the frame rail. In order for the isolator holes to align with the holes in the engine mount, the painted side of the isolator must be towards the engine. For instructions, refer to **Subject 100**.

   Secure the isolator to the mount with two capscrews and locknuts, tighten the locknuts 14 to 18 lbf·ft (19 to 24 N·m).

WARNING: The jack used to lower the engine must be capable of safely lifting and supporting two metric tons. Once the engine is removed from the engine stands, do not get under the engine



1. Capscrew, 3/4-10 x 4.5 Inch, Grade 8
2. Washer
3. Engine Leg
4. Capscrew, 5/16-18 x 1 Inch, Grade 8
5. Washer
6. Upper Isolator
7. Rear Engine Mount
8. Nut, 5/16-18
9. Capscrew, 5/8-11 x 2.5 Inch, Grade 8
10. Washer
11. Lower Isolator
12. Nut, 3/4-10
13. Nut, 5/8-11

Fig. 1, Rear Engine Mount Assembly, Cummins M11 Engines

Rear Engine Mount Isolator Replacement

until it is securely installed on the engine mount. An unsecured engine may fall, causing personal injury or death, and component damage.

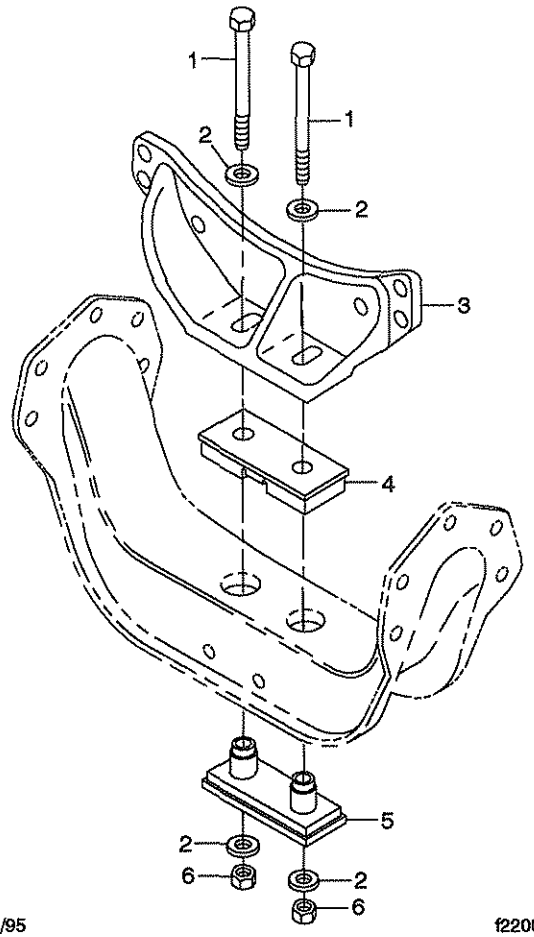
5. Secure the engine to the engine mount.
   - 5.1 If not in place, set a jack under the rear of the engine and raise the jack until it is braced against the engine.
   - 5.2 Lift the engine slightly to remove the engine stands. Remove the stands, and carefully lower the engine onto the engine mount.
   - 5.3 Install the bolt in the right rear engine mount, and secure it with the nut and hardened washer. Tighten the nut 213 to 269 lbf·ft (289 to 365 N·m).
6. Repeat this procedure for the other rear engine mount.
7. Remove the jack from under the engine, and remove the chocks from the tires.

Front Engine Mount Isolator Replacement

Replacement (See Fig. 1)

1. Apply the parking brakes, chock the tires, and drain the air brake system.

WARNING: The lifting device and chain used to lift the engine must be capable of safely lifting and supporting two metric tons. Once the engine mount is disconnected, do not get under the engine until it is securely supported on engine stands. An unsecured engine may fall, causing personal injury or death, and component damage.



1. Capscrew, 3/4-10 x 4 Inch, Grade 8
2. Washer
3. Front Engine Support Bracket
4. Upper Isolator
5. Lower Isolator
6. Nut, 3/4-10

Fig. 1, Front Engine Mount Assembly, Cummins M11 Engine

2. Disconnect the engine from the front engine mount.

   2.1 Attach a chain to the front engine lifting hook(s), and position a lifting device to lift the engine. Attach the chain to the lifting device, and raise the chain to remove any slack.

   2.2 Remove the bolt(s) from the front engine mount. Save the fasteners, tube(s), and snubber(s). Discard the rubber isolator cushions.

   NOTE: In order to raise the front of the engine, you may have to loosen the bolts that run through the rear engine mounts.

   2.3 Lift the engine slightly to take its weight off the front engine mount. Place engine stands under the engine to keep it off the engine mount.

3. Inspect the new front engine mount rubber isolators for wear or damage and replace them if necessary.

CAUTION: Do not lubricate the new components with oil, grease, or silicone lubricants; they will deteriorate the rubber isolators.

4. Install the upper isolator(s) in the engine mount.

WARNING: The lifting device and chain used to lower the engine must be capable of safely lifting and supporting two metric tons. Once the engine is removed from the engine stands, do not get under the engine until it is securely installed on the engine mount. An unsecured engine may fall, causing personal injury or death, and component damage.

5. Secure the engine to the front engine mount.

   5.1 Attach a chain to the front engine lifting hook(s). Attach the chain to a lifting device, and raise the chain to remove any slack.

   5.2 Lift the engine slightly to remove the engine stands. Remove the stands, and carefully lower the engine onto the engine mount.

Front Engine Mount Isolator Replacement

5.3 Holding the lower isolator in place, install the bolts in the front engine mount and secure them with the nuts and washers. Tighten the nuts 213 to 269 lbf·ft (289 to 365 N·m).

NOTE: If you loosened the bolts that run through the rear engine mounts, tighten those bolts 213 to 269 lbf·ft (289 to 365 N·m).

5.4 Remove the lifting chain from the engine lifting hook(s).

6. Remove the chocks from the tires.

Specifications

Description	Capscrew Size	Grade	Torque lbf·ft (N·m)
Engine Mount-to-Framerail Capscrew	5/8-11 x 2.5 Inch	Grade 8	120 - 152 (163 - 206)
Engine Leg-to-Flywheel Housing Capscrew	3/4-10x2.75 Inch	Grade 8	*Aluminum flywheel housings:* 180 - 220 (244 - 298) *Iron flywheel housings:* 213 - 269 (289 - 365)
Isolator Capscrew	5/16-18 x 1 Inch	Grade 8	14 - 18 (19 - 24)
Engine Leg-to-Engine Mount Capscrew	3/4-10 x 4.5 Inch	Grade 8	213 - 269 (289 - 365)
Front Engine Bracket-to-Front Engine Mount Capscrew	3/4-10 x 4 Inch	Grade 8	213 - 269 (289 - 365)

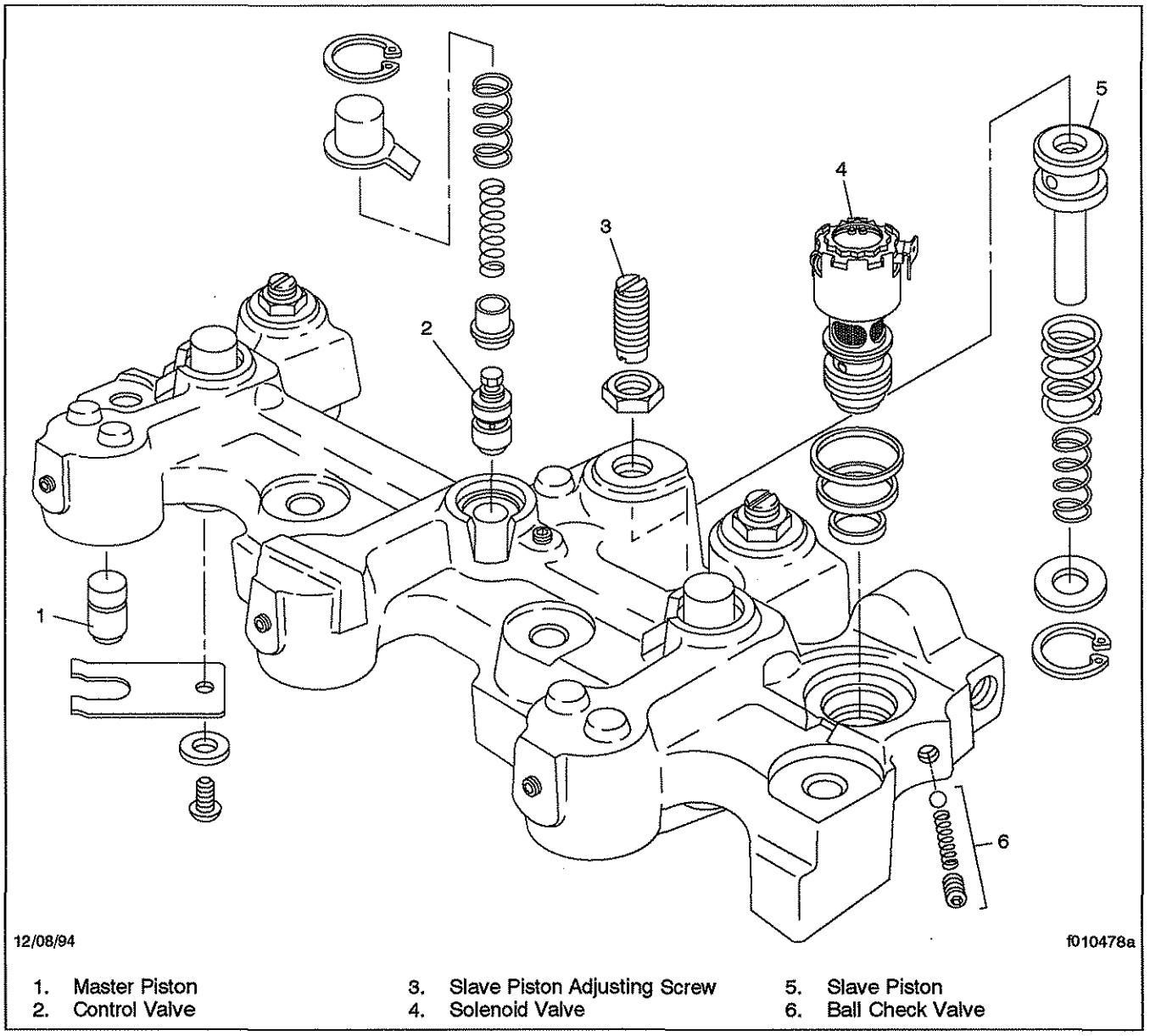
Table 1, Engine Mount Torques

Contents

Subject	Subject Number
General Information	050
Service Operations	
Ball Check Valve Removal, Inspection, and Installation	100
Control Valve Removal, Inspection, and Installation	110
Engine Brake Housing Removal and Installation	120
Master Piston Removal, Inspection, and Installation	130
Slave Piston Removal, Inspection, and Installation	140
Slave Piston Adjusting Screw Removal, Inspection, and Installation	150
Solenoid Valve Removal, Inspection, and Installation	160

For troubleshooting procedures, refer to **Section 01.12** in this manual.

General Information (See Fig. 1)



1. Master Piston
2. Control Valve
3. Slave Piston Adjusting Screw
4. Solenoid Valve
5. Slave Piston
6. Ball Check Valve

Fig. 1, Engine Brake Components

Jacobs engine brake housings are installed on the engine rocker housings. Model 404D (used on Cummins L10 engines) has two engine brake housings that operate three cylinders each. Each engine brake housing has a solenoid valve, control valve, ball check valve, master piston, and slave piston.

Engine brake controls consist of: two dash-mounted toggle switches, a clutch switch mounted under the dash, and the throttle switch. The switches are wired in series so that all of the switches must be closed to operate the engine brake. The engine brake is activated when one or both of the dash switches is on (up), and the clutch and throttle pedals are released.

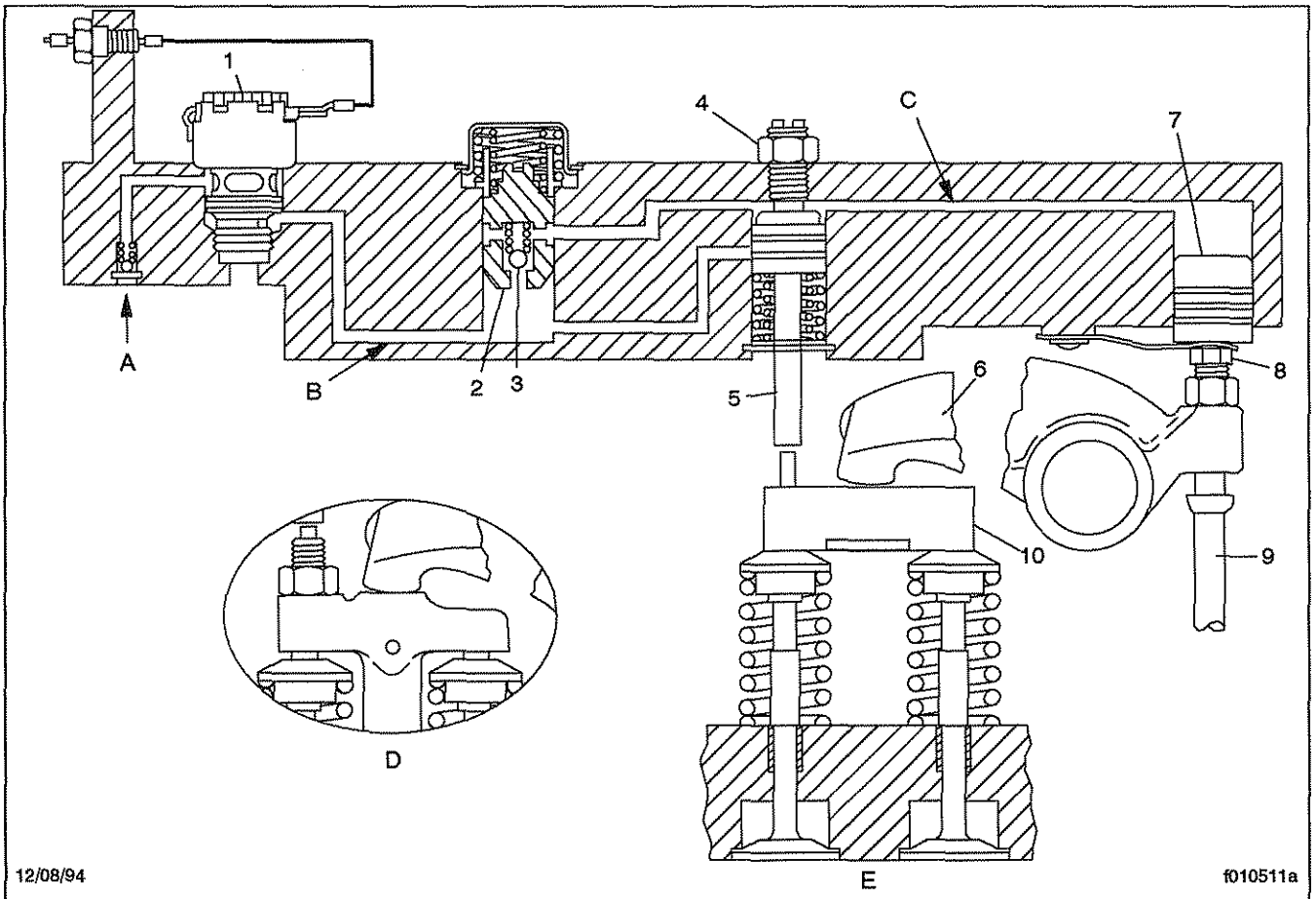
General Information

The dash switches enable the driver to operate the engine brake partially or fully.

Model 404D engine brakes can be operated at one-half or full capacity (three or six cylinders).

When activated, the engine brake converts a power-producing diesel engine to a power-absorbing air compressor. This is accomplished by motion transfer through a master-slave piston arrangement which opens the engine cylinder exhaust valves near the top of the normal compression stroke, releasing the compressed cylinder charge to exhaust. The blowdown of compressed air to atmospheric pressure prevents the return of energy to the engine piston on the expansion (power) stroke. This results in a net energy loss because the work done in compressing the cylinder charge is not returned during the expansion process. Exhaust blowdown occurs as follows (**see Fig. 2**):

1. Activating the engine brake energizes the solenoid valve, allowing engine oil to flow under pressure through the control valve to both the master piston and the slave piston.
2. Oil pressure causes the master piston to move down, coming to rest on the injector rocker lever adjusting screw.
3. The injector rocker lever adjusting screw begins upward travel (as in the normal injection cycle) forcing the master piston upward and creating a high-pressure oil flow to the slave piston. The ball check valve in the control valve holds the high-pressure oil in the master-slave piston system.
4. When the engine piston is near top dead center, the slave piston moves down under the influence of the high-pressure oil flow. This momentarily opens one of the exhaust valves, releasing compressed cylinder air to the exhaust manifold.
5. Compressed air is released to the atmosphere, completing a compression braking cycle.



A. Oil In
B. Low Pressure Oil
C. High Pressure Oil
D. Guided Crosshead
E. Exhaust Valves

1. Solenoid Valve
2. Control Valve
3. Ball Check Valve
4. Adjusting Screw
5. Slave Piston
6. Exhaust Rocker Lever
7. Master Piston
8. Injector Rocker Lever Adjusting Screw
9. Injector Pushrod
10. Guideless Crosshead

Fig. 2

Ball Check Valve Removal, Inspection, and Installation

Removal (See Fig. 1)

1. Remove the engine brake housing from the vehicle. For instructions, refer to **Subject 120**.
2. Remove the hex socket pipe plug. **See Fig. 2.** Be careful during final turns to avoid loss of the spring and ball. Remove the spring and ball.

Inspection

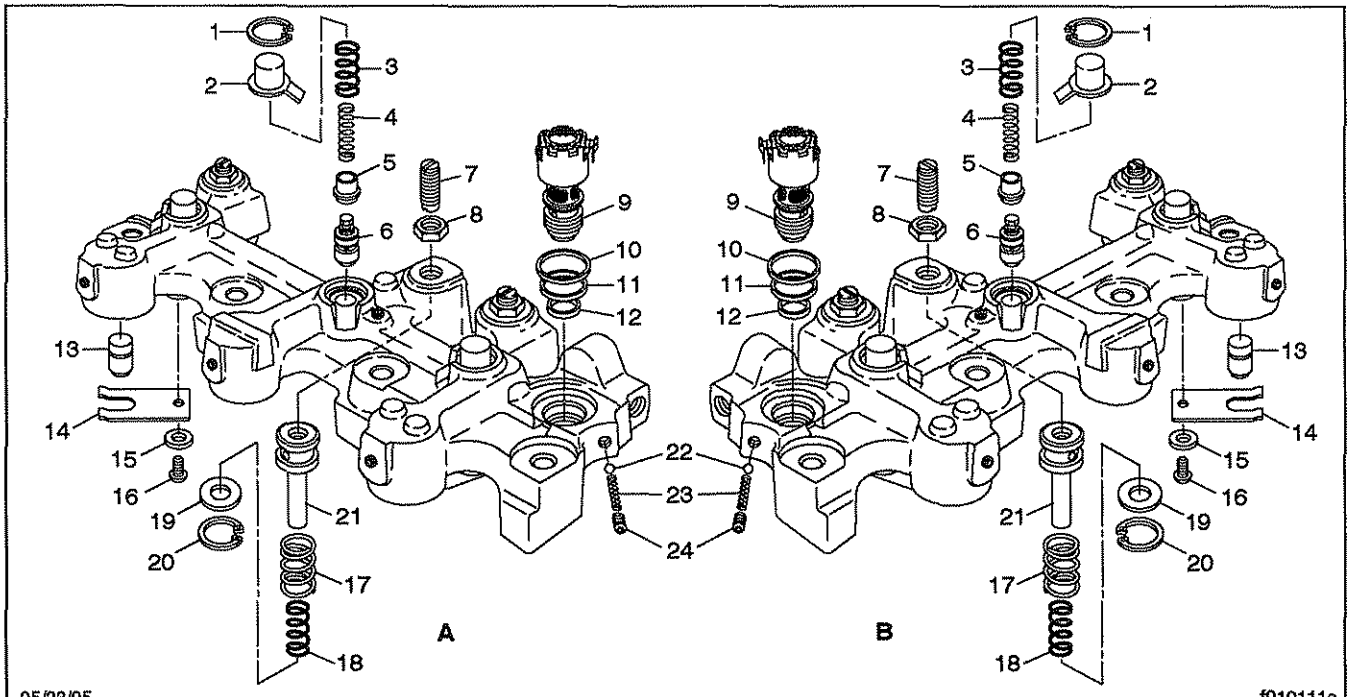
Inspect the parts for wear, then clean them in an approved cleaning solvent, or replace them if necessary.

Installation

1. Assemble the ball check valve by first inserting the ball, then the spring, and then tighten the plug. **See Fig. 3.**

CAUTION: Make certain the parts are installed in the order shown in **Fig. 3.** Improper installation may result in engine damage.

2. Install the engine brake housing using the instructions in **Subject 120**.



A. Front Housing

B. Rear Housing

1. Retaining Ring
2. Control Valve Cover
3. Outer Control Valve Spring
4. Inner Control Valve Spring
5. Control Valve Collar
6. Control Valve
7. Slave Piston Adjusting Screw
8. Locknut
9. Soleneoid Valve
10. Upper Seal Ring
11. Center Seal Ring
12. Lower Seal Ring
13. Master Piston
14. Flat Spring
15. Washer
16. Button Head Screw
17. Outer Spring
18. Inner Spring
19. Spring Retainer
20. Retaining Ring
21. Slave Piston
22. Ball
23. Ball Check Spring
24. Pipe Plug

Fig. 1

Ball Check Valve Removal, Inspection, and Installation

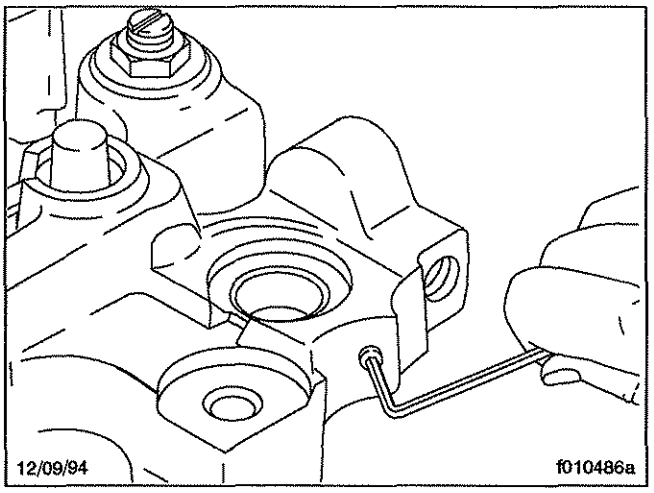


Fig. 2, Remove the Pipe Plug

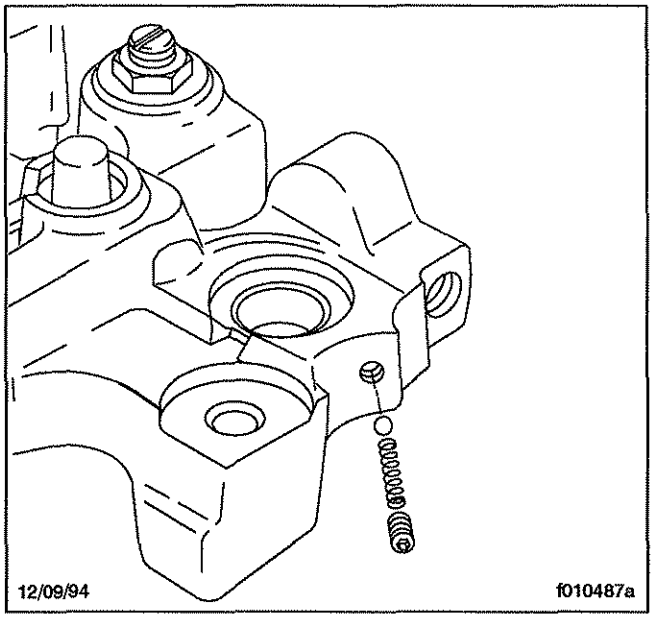


Fig. 3, Assemble the Valve

Control Valve Removal, Inspection, and Installation

Removal (See Fig. 1)

1. Wipe the engine brake housing area clean. Remove the rocker-housing-cover capscrews and the rocker housing cover. For instructions, refer to **Subject 120**.
2. Apply pressure on the control valve cover, and remove the retaining ring, using retaining ring pliers. **See Fig. 2.**

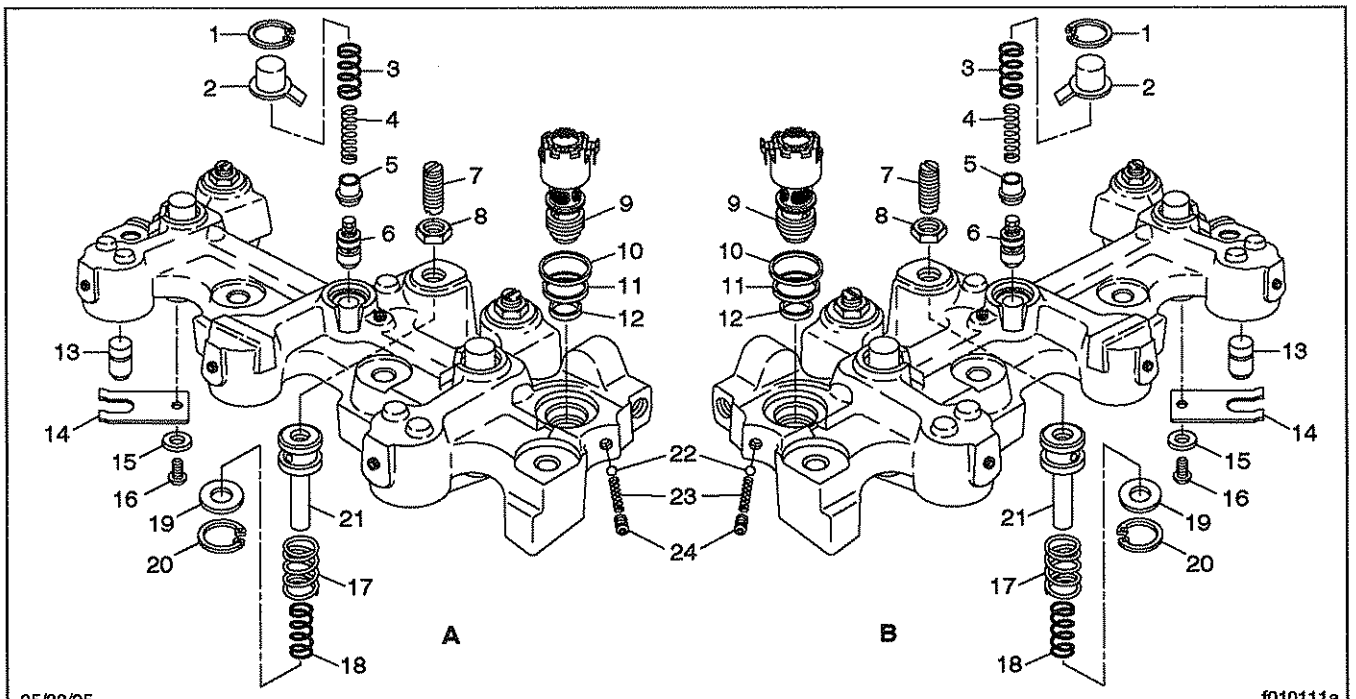
WARNING: The control valve covers are under load from the control valve springs. Remove them carefully to avoid personal injury.

3. Carefully remove both control valve springs and the collar. **See Fig. 3.**
4. Using needle nose pliers or your fingertips, carefully pull the control valve straight up and out of its bore. **See Fig. 4.**

Inspection

If binding occurs during removal, inspect the control valve parts for damage or wear, and replace them if necessary.

If there is no damage, clean the parts in a cleaning solvent.



A. Front Housing

B. Rear Housing

1. Retaining Ring
2. Control Valve Cover
3. Outer Control Valve Spring
4. Inner Control Valve Spring
5. Control Valve Collar
6. Control Valve
7. Slave Piston Adjusting Screw
8. Locknut
9. Soleneoid Valve
10. Upper Seal Ring
11. Center Seal Ring
12. Lower Seal Ring
13. Master Piston
14. Flat Spring
15. Washer
16. Button Head Screw
17. Outer Spring
18. Inner Spring
19. Spring Retainer
20. Retaining Ring
21. Slave Piston
22. Ball
23. Ball Check Spring
24. Pipe Plug

Fig. 1

Control Valve Removal, Inspection, and Installation

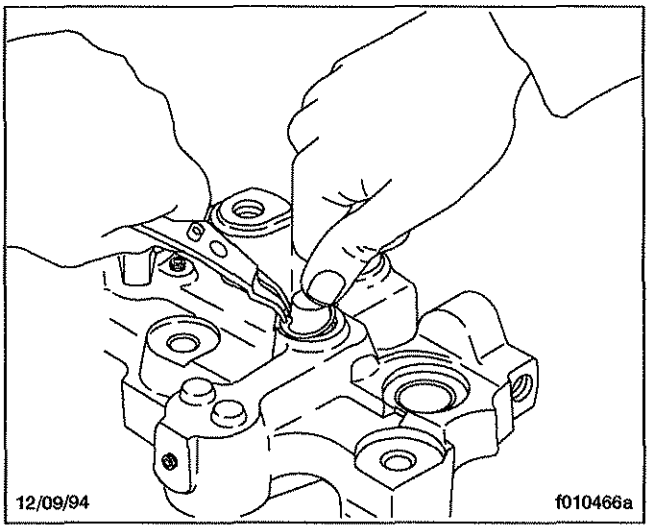


Fig. 2, Remove the Retaining Ring

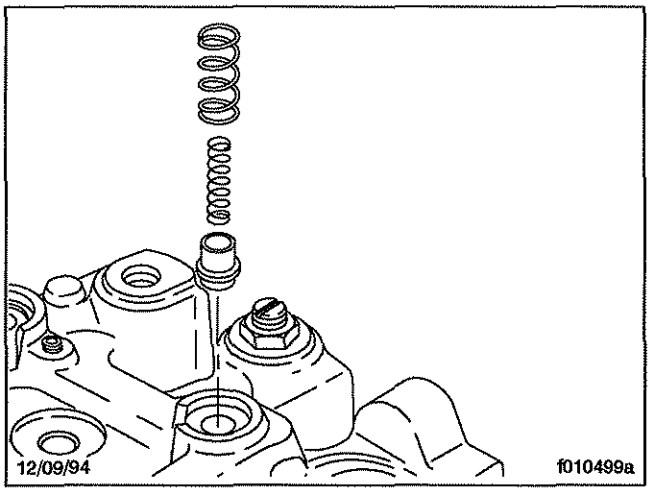


Fig. 3, Remove the Springs and Collar

Installation

CAUTION: Make sure the control valve collar is installed with the longer sleeve area up. **See Fig. 5.** If the collar is installed upside down, engine damage may result.

1. Install the control valve, collar, and springs. Make sure the retaining ring ears are positioned opposite the oil drain slot in the housing.
2. Install the rocker housing cover on the spacer. For instructions, refer to **Subject 120.**

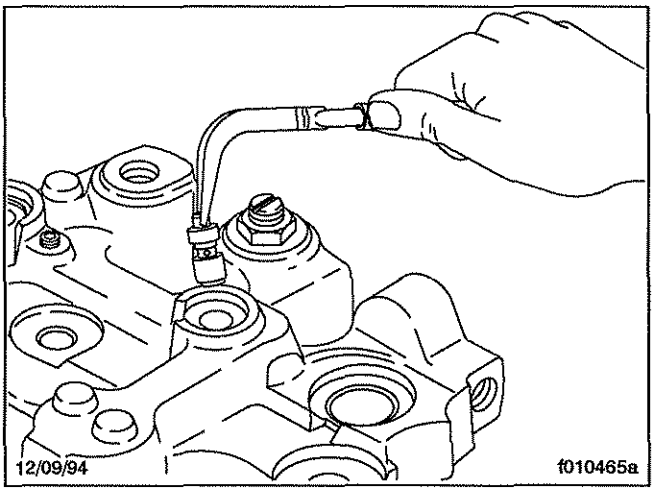
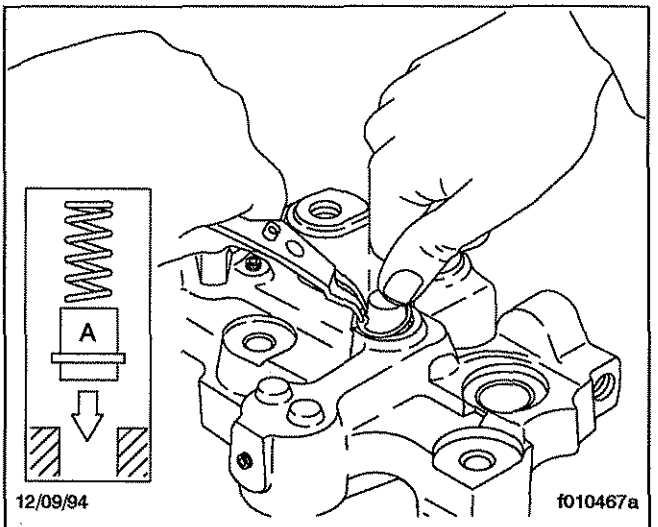


Fig. 4, Remove the Control Valve

3. Return the hood to the operating position.



A. Install the collar with the longer sleeve area up.

Fig. 5, Check the Control Valve Collar

Engine Brake Housing Removal and Installation

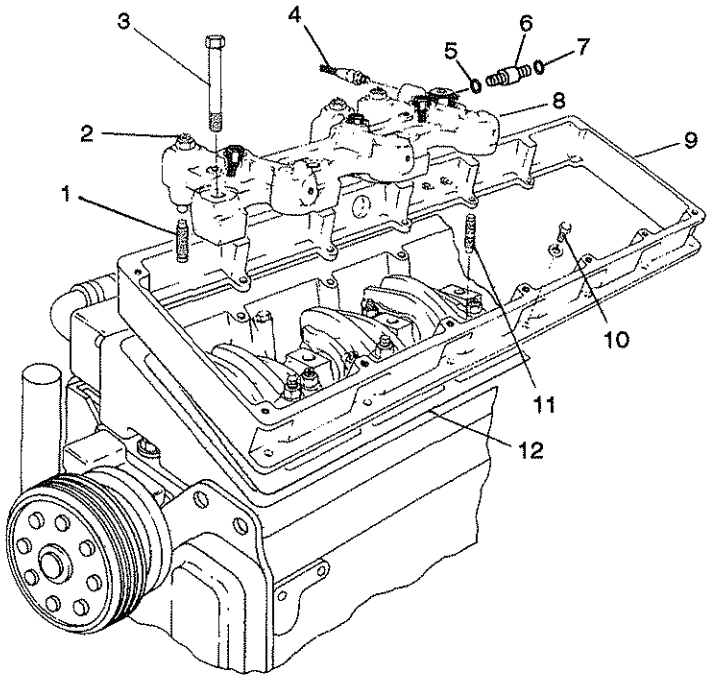
Removal (See Fig. 1)

WARNING: To avoid personal injury, never remove any engine brake component with the engine running.

1. Park the vehicle, apply the parking brakes, shut down the engine, and chock the tires.
2. Disconnect the batteries.
3. Wipe clean the engine brake housing area. Remove the rocker housing cover capscrews, and remove the cover and gasket from the spacer.
4. Disconnect the solenoid electrical harness from the terminal leadout in the spacer. **See Fig. 2.**
5. Remove the steel plates, O-ring, and gasket from the spacer. **See Fig. 3.** Disconnect the oil hose from the front brake housing, and remove it through the hole in the spacer. **See Fig. 4.**
6. Remove the engine brake housing holddown capscrews. **See Fig. 5.**
7. Remove the engine brake housing from the rocker-shaft supports.

Installation

1. If the oil connector was previously removed from the front housing, then install the connector and O-ring into the front housing as far as it will go **(Fig. 6)**.
2. Back out the slave-piston adjusting screws until the slave pistons are fully retracted (screws are loose). **See Fig. 7.**



05/24/95 f010097b

1. Crosshead Adjusting Screw
2. Slave Piston Adjusting Screw
3. Capscrew
4. Oil Supply Hose
5. O-Ring
6. Oil Connector
7. O-Ring
8. Housing
9. Spacer
10. Capscrew
11. Injector Adjusting Screw
12. Spacer Gasket

Fig. 1, Brake Housing Components

Engine Brake Housing Removal and Installation

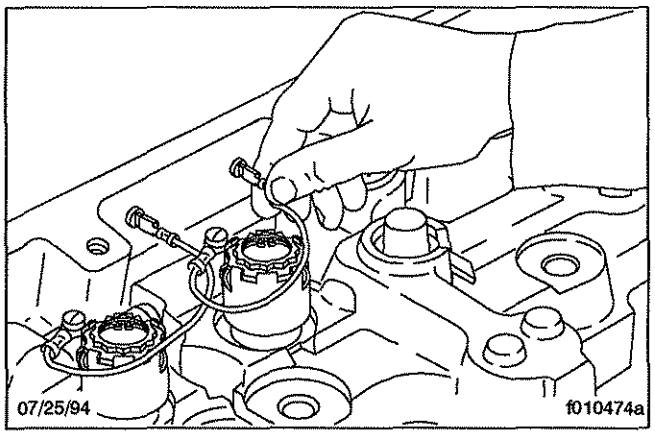


Fig. 2, Disconnect the Solenoid Harness

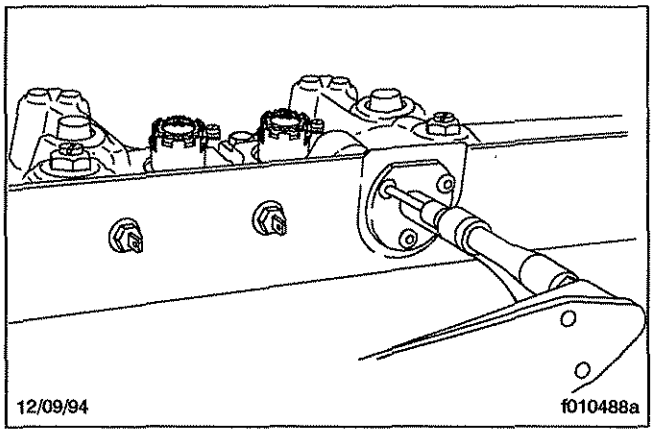


Fig. 3, Remove the Steel Plates, O-Ring, and Spacer

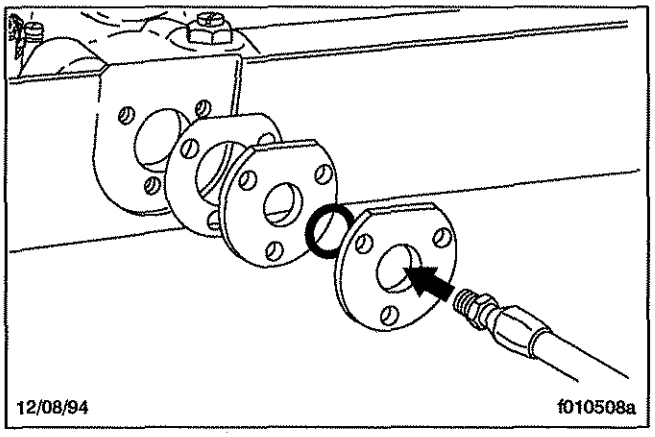


Fig. 4, Remove the Oil Hose

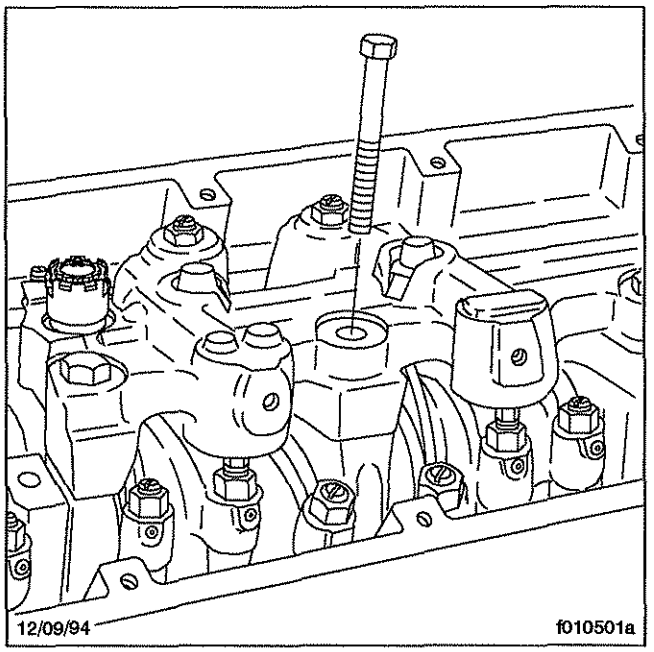


Fig. 5, Remove the Hold-Down Capscrews

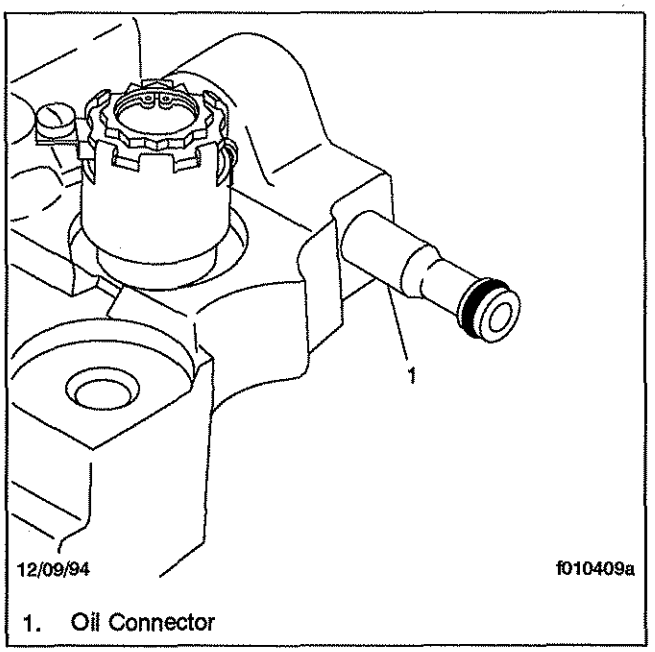


Fig. 6, Install the Oil Connector

3. Place the rear brake housing on the rockershaft supports over cylinders 4, 5, and 6. Loosely install four Jacobs holddown capscrews. **See**

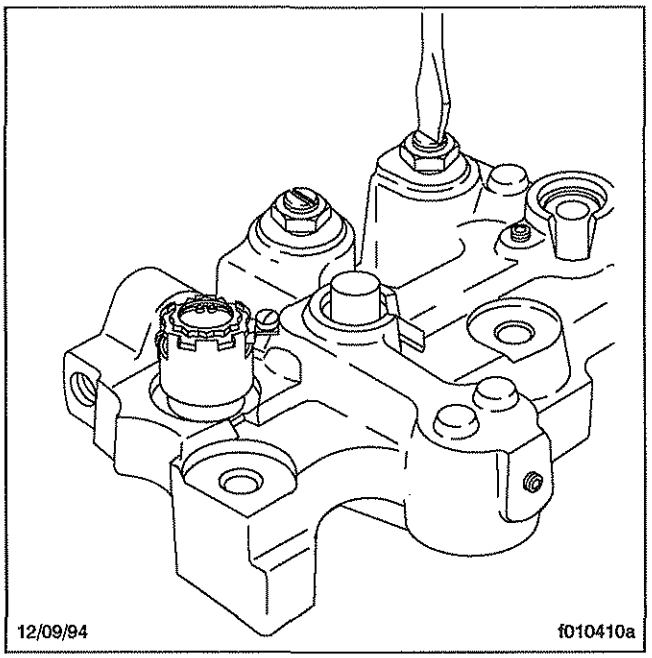


Fig. 7, Retract the Slave Pistons

Fig. 5. Lubricate the threads and underside of the capscrew heads.

NOTE: No washers are used with the capscrews.

4. Place the front brake housing on the rocker-shaft supports over cylinders 1, 2, and 3. Carefully insert the oil connector into the rear housing.

   Loosely install four Jacobs hold-down capscrews. **See Fig. 8.** Lubricate the threads and underside of the capscrew heads. Make sure that the oil connector is centered between the housings. **See Fig. 9.**

NOTE: No washers are used with the capscrews.

5. Slide the number 5 support as far forward as possible. **See Fig. 10.**

6. Align the rear brake housing so that the slave pistons are over the Jacobs actuating pins in the exhaust crossheads on all three cylinders (4, 5, and 6). **See Fig. 11.** Swing each crosshead through its free side play.

7. All three Jacobs actuating pins should remain completely under the slave pistons. **See Fig. 12.** If necessary, tap the housing gently with a soft mallet to obtain proper alignment. Be sure the number 5 support remains in the most forward position. **See Fig. 5** for the next several steps.

8. Tighten the number 5 rocker-lever support hold-down capscrew 60 lbf·in (680 N·cm).

9. Put a 0.022-inch (0.56-mm) feeler-gauge between the number 5 support and the rocker lever on the number 4 cylinder. Set the side clearance. **See Fig. 13.**

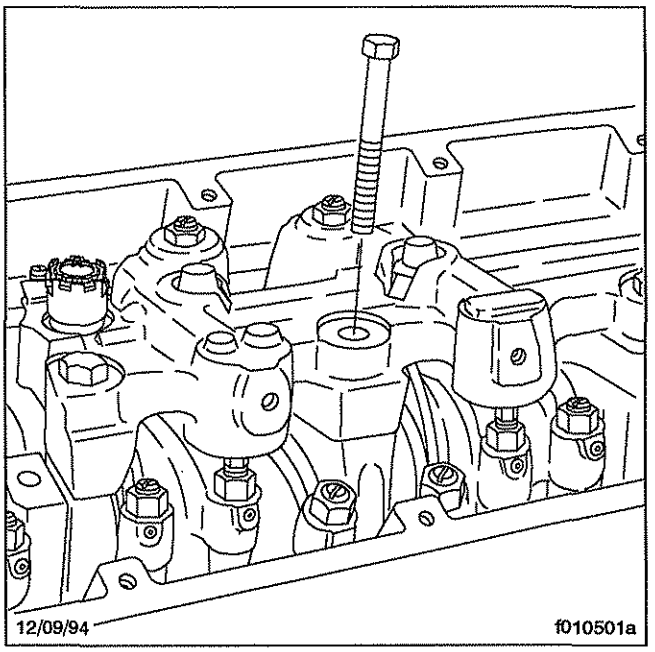


Fig. 8, Install the Hold-Down Capscrews

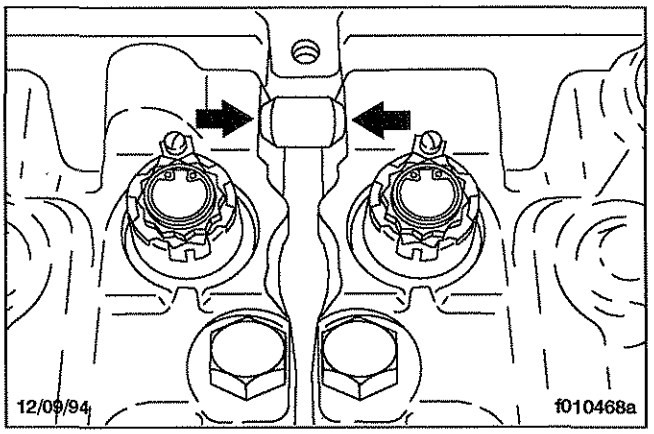
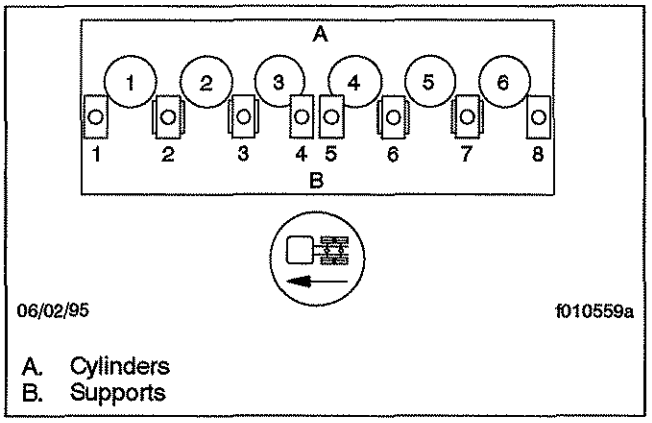


Fig. 9, Center the Oil Connector

Engine Brake Housing Removal and Installation



A. Cylinders
B. Supports

Fig. 10, Rocker-Lever Supports

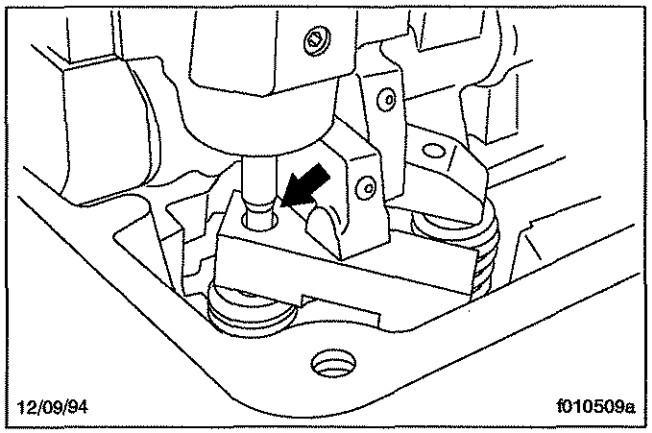


Fig. 11, Align the Brake Housing

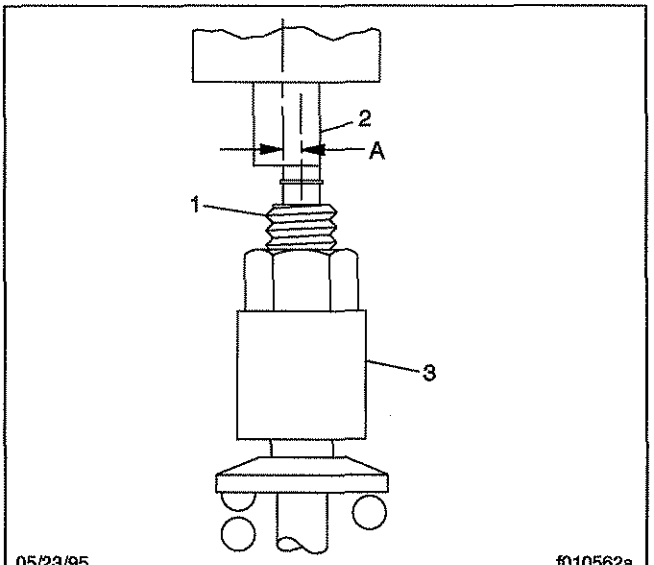
With the feeler gauge in position, slide the number 6 support as far forward as possible. Tighten the capscrew 60 lbf·in (680 N·cm).

10. Put the feeler gauge between the number 6 support and the rocker lever on the number 5 cylinder. Set the side clearance.

    With the feeler gauge in position, slide the number 7 support as far forward as possible. Tighten the capscrew 60 lbf·in (680 N·cm).

11. Put the feeler gauge between the number 7 support and the rocker lever on the number 6 cylinder. Set the side clearance.

    With the feeler gauge in position, slide the number 8 support as far forward as possible. Tighten the capscrew 60 lbf·in (680 N·cm).



A. Actuating pin in the most extreme position acceptable

1. Crosshead Adjusting Screw
2. Slave Piston Stem
3. Crosshead

Fig. 12, Check Slave Piston Alignment

12. Check the rear brake housing slave piston-to-exhaust crosshead actuating pin alignment.

13. Slide the number 4 support as far back as possible.

14. Check the front brake housing alignment as previously outlined for the rear brake housing. After the brake housing is properly aligned, tighten the

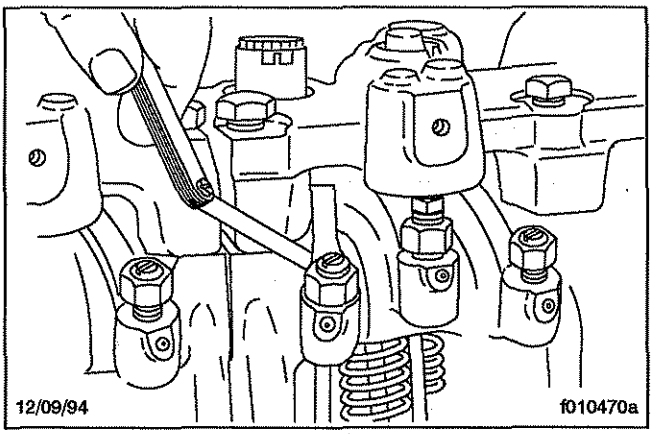


Fig. 13, Set the Side Clearance

number 4 support hold-down capscrew 60 lbf·in (680 N·cm).

15. Put the feeler gauge between the number 4 support and the rocker lever on the number 3 cylinder. Set the side clearance.

    With the feeler gauge in position, slide the number 3 support as far back as possible. Tighten the capscrew 60 lbf·in (680 N·cm).

16. Put the feeler gauge between the number 3 support and the rocker lever on the number 2 cylinder. Set the side clearance.

    With the feeler gauge in position, slide the number 2 support as far back as possible. Tighten the capscrew 60 lbf·in (680 N·cm).

17. Put the feeler gauge between the number 2 support and the rocker lever on the number 1 cylinder. Set the side clearance.

    With the feeler gauge in position, slide the number 1 support as far back as possible. Tighten the capscrew 60 lbf·in (680 N·cm).

18. Check that all side clearances are within 0.020 to 0.025 inch (0.51 to 0.64 mm).

19. Check the alignment of the front brake housing slave pistons to the crosshead actuating pins.

20. Tighten the hold-down capscrews on each housing. **See Fig. 14.** First, tighten the two middle capscrews (**Fig. 15**) 45 lbf·ft (61 N·m); tighten the two outside capscrews (**Fig. 15**) the same amount. Second, using the same sequence, tighten the capscrews 75 lbf·ft (102 N·m). Finally, tighten the middle capscrews, then the outside capscrews 95 lbf·ft (129 N·m).

21. Adjust the injectors first, then the valves, using Cummins' L10 engine troubleshooting and repair manual. Note that the valves to be adjusted are not on the same cylinder as the injector being set. Follow the Cummins 10 Liter sequence chart. The Cummins dial indicator extension can be positioned so that the indicator extension can reach any injector. **See Fig. 16.** Use the long stem extension, Cummins PN 3376749. Make sure the extension is clear of all engine and engine brake components (moves freely).

22. If installing a new engine brake housing, or if the slave piston was removed, adjust the slave piston using the instructions in **Subject 140.** If the previously removed engine brake is being installed and the slave piston was not removed, proceed to the next step.

23. Slide a new Jacobs oil-hose gasket over the male end of the Jacobs oil-hose assembly. **See Fig. 4.**

24. Insert the male end of the oil-hose assembly through the hole in the Jacobs spacer and install it in the front brake housing. **See Fig. 4.**

WARNING: Keep the oil hose clear of all hot engine components and free from rubbing on the engine or chassis. A ruptured hose will spray hot oil and

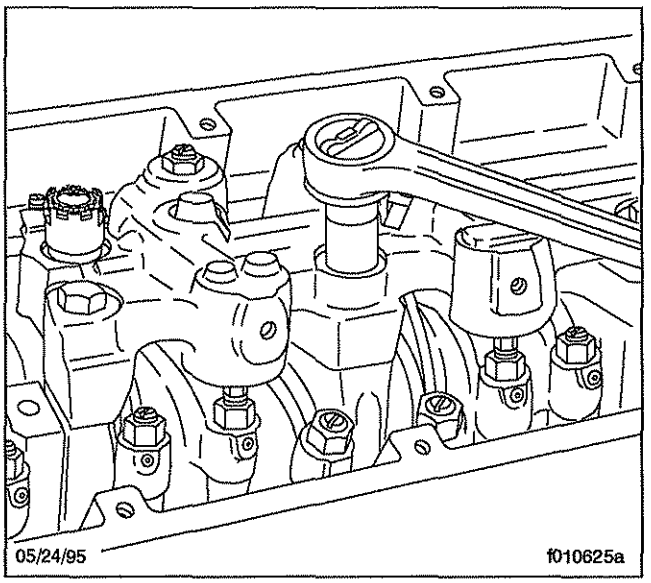


Fig. 14, Tighten the Hold-Down Capscrews

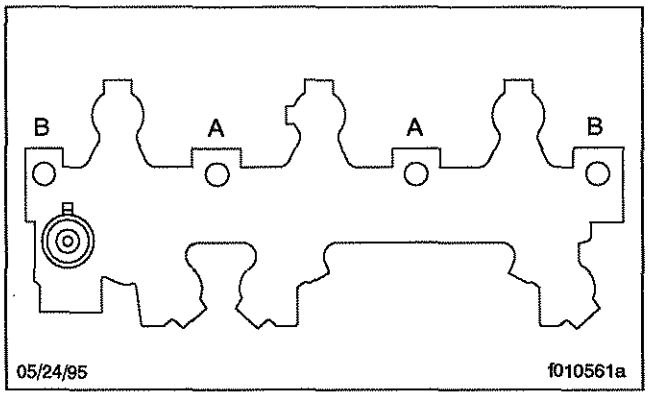


Fig. 15, Tightening Sequence

Engine Brake Housing Removal and Installation

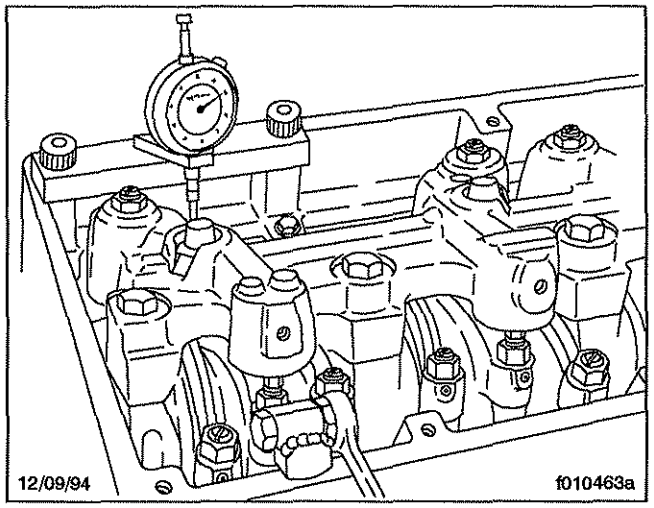


Fig. 16, Adjust the Injectors

could cause heavy smoke or fire upon hitting hot engine components.

25. Slide the gasket, O-ring, and steel plates up to the spacer. Secure them in place with button-head screws. Tighten the screws 10 lbf·ft (14 N·m). Be careful to draw the plate up to the gasket evenly. **See Fig. 3.**

26. Connect the solenoid harness from each solenoid valve to the closest terminal leadout in the spacer. **See Fig. 2.**

WARNING: When the engine is running with the valve covers removed, there is significant oil splash in the engine brake area. Wear eye protection; do not expose your face over the engine area. Take precautions to prevent oil leakage down on the engine. Splashing oil can cause personal injury.

27. To bleed the brake units and check their operation, start the engine and allow it to run 5 to 10 minutes.

    Accelerate the engine to approximately 1800 rpm. Release the throttle, then manually depress each solenoid armature. **See Fig. 17.** This procedure should be done five or six times to permit engine oil to completely fill the brake housing passages.

28. With the engine shut down, check the electrical system by turning the ignition switch on. With the dash switch labeled "RR CYLS" in the up position, the rear brake housing solenoid valve should activate. With the dash switch labeled "FWD CYLS" in the up position, the front brake housing solenoid valve should activate.

29. Install the rocker housing cover (**Fig. 18**).

    29.1 Remove the old cover gasket.

    29.2 Apply a 1/16-inch (2 mm) bead of Cummins black RTV sealant or an equivalent, to the gasket sealing surface on the cover.

    29.3 Set the new gasket on the cover, then place the cover on the spacer.

    29.4 Install the capscrews and hold-downs.

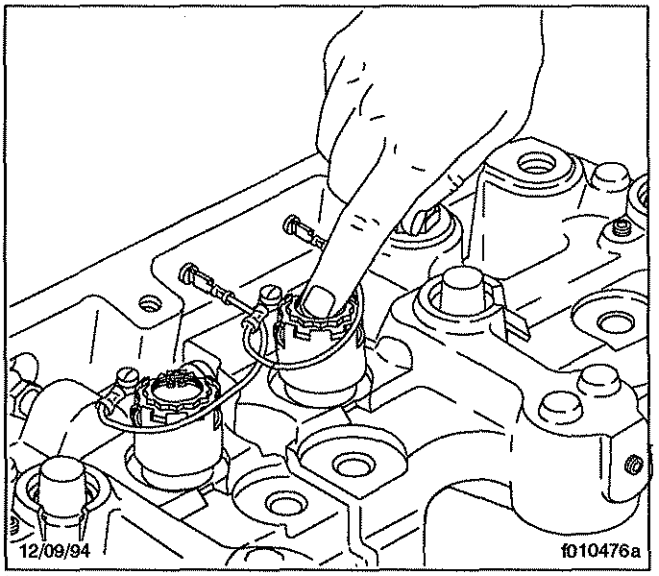


Fig. 17, Check Brake Operation

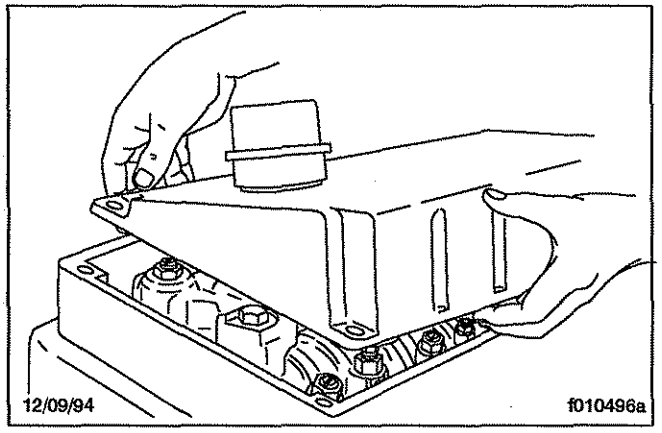


Fig. 18, Install the Rocker Housing Cover

29.5 Using the sequence in **Fig. 19**, in 45 lbf·in (500 N·cm) increments on each pass, tighten the rocker-housing-cover capscrews 130 lbf·in (1460 N·cm).

30. Close the hood, and remove the chocks from the tires.

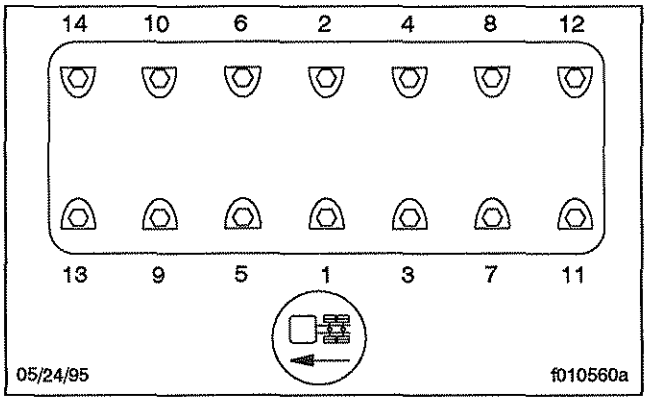
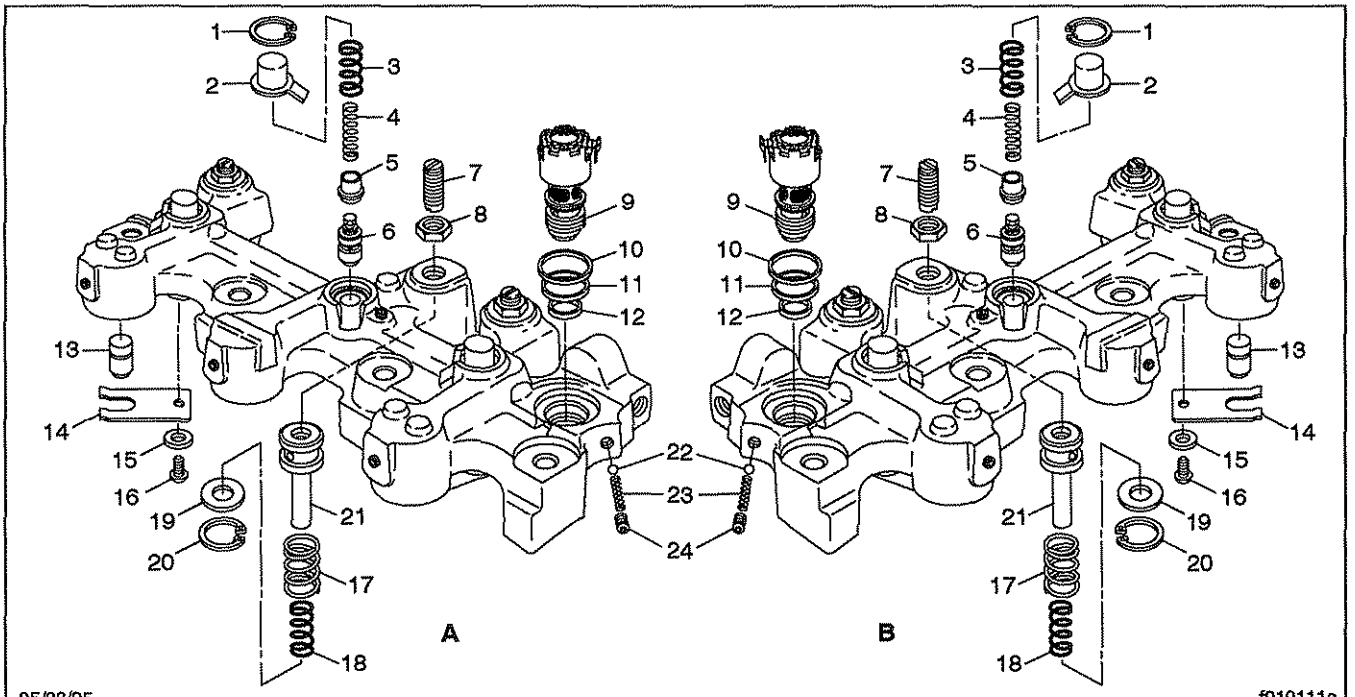


Fig. 19, Tightening Sequence

Removal (See Fig. 1)



A. Front Housing

B. Rear Housing

1. Retaining Ring
2. Control Valve Cover
3. Outer Control Valve Spring
4. Inner Control Valve Spring
5. Control Valve Collar
6. Control Valve
7. Slave Piston Adjusting Screw
8. Locknut
9. Solenoid Valve
10. Upper Seal Ring
11. Center Seal Ring
12. Lower Seal Ring
13. Master Piston
14. Spring
15. Washer
16. Button Head Screw
17. Outer Spring
18. Inner Spring
19. Spring Retainer
20. Retaining Ring
21. Slave Piston
22. Ball
23. Ball Check Spring
24. Pipe Plug

Fig. 1

1. Remove the engine brake housing from the vehicle. For instructions, refer to **Subject 120.**
2. Remove the screw, washer, and master piston spring from the bottom of the housing. **See Fig. 2.**
3. Remove the master piston from its bore; needle-nose pliers are usually needed to initially pull the piston up.

Inspection

If binding occurs during removal, check for burrs, or contaminants in the lube oil. If the piston is damaged, replace it. If the piston is not damaged, clean it in an approved cleaning solvent.

Installation

1. Install the piston, spring, washer, and screw. Make sure that when tightening the button head screw, the two tabs of the spring do not interfere

Master Piston Removal, Inspection, and Installation

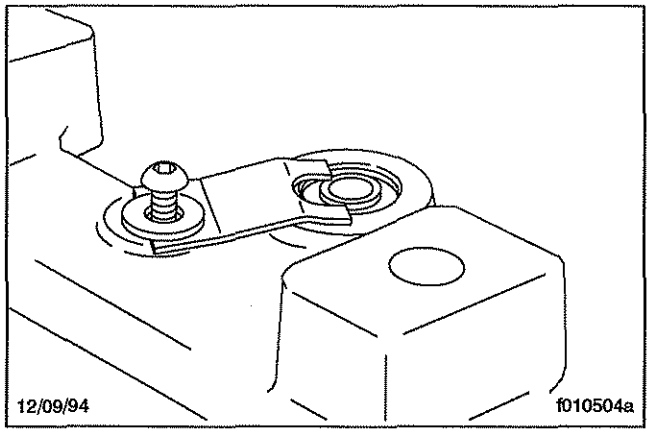


Fig. 2, Remove the Piston Spring

with the sides of the center raised portion of the master piston. **See Fig. 3.**

2. Install the engine brake housing using the instructions in **Subject 120.**

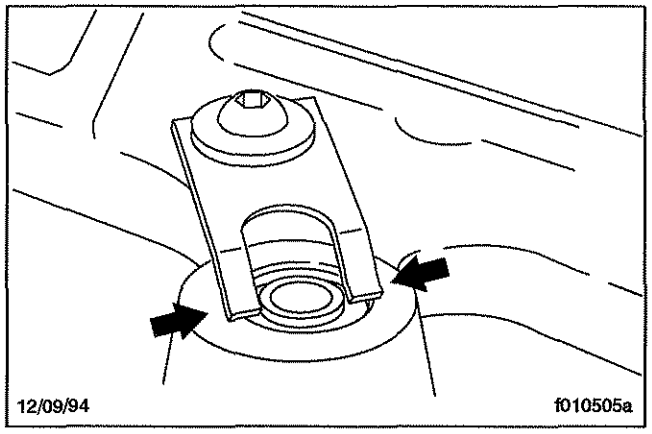


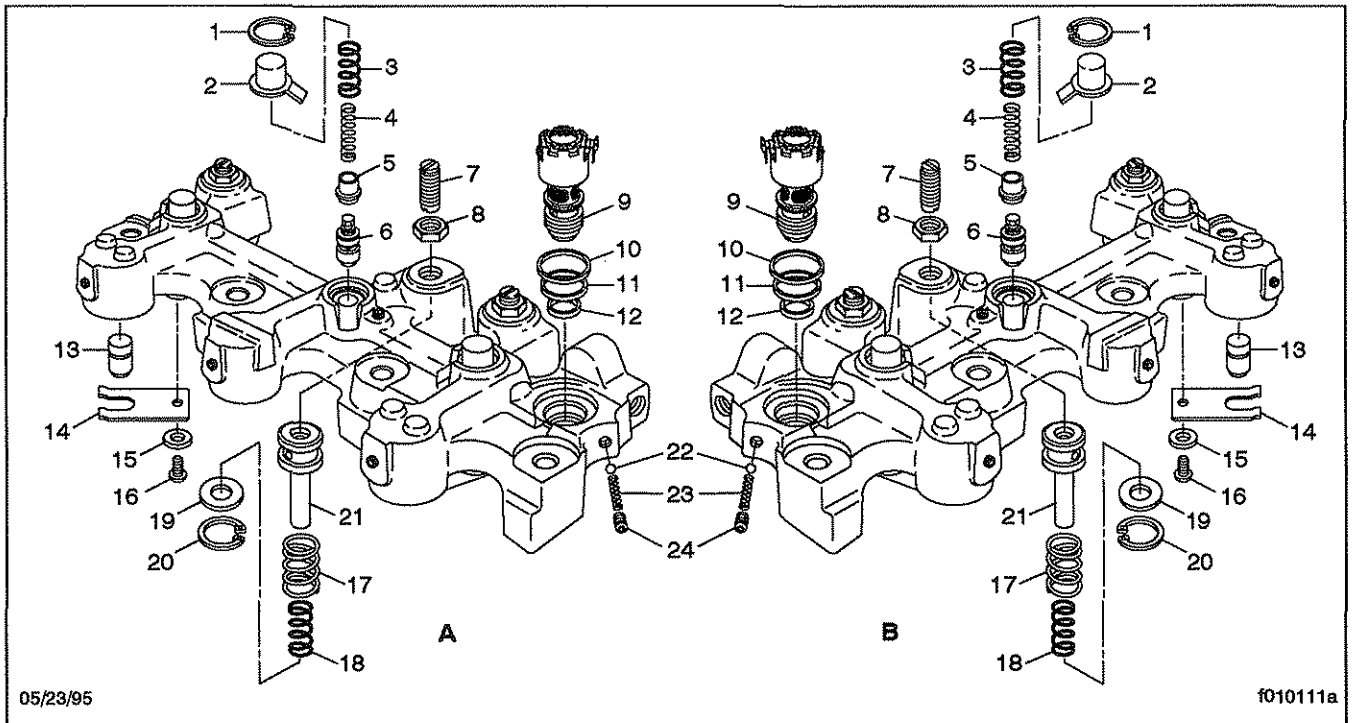
Fig. 3, Check the Spring Tabs

Removal (See Fig. 1)

WARNING: The slave piston is retained by springs that are under heavy compression. If the following instructions are not followed and proper tools are not used, the springs could be discharged with enough force to cause personal injury. Wear safety glasses.

Use the single-valve slave-piston clamp fixture, PN 012359 to remove the slave piston.

1. Remove the engine brake housing from the vehicle using the instructions in **Subject 120.**
2. Remove the locknut on the slave piston adjusting screw. **See Fig. 2.** Back out the adjusting screw until the slave piston is fully retracted (screw is loose).
3. Place the hole in the clamp fixture over the slave piston adjusting screw. **See Fig. 3.** While holding the fixture in position, screw the holder down over the slave piston until the washer is depressed about 0.04 inch (1 mm), so that the retaining ring is loose in the groove. Remove the retaining ring. **See Fig. 4.** Back out the holder and remove the fixture.
4. Remove all slave piston components. **See Fig. 5.**



A. Front Housing

B. Rear Housing

1. Retaining Ring
2. Control Valve Cover
3. Outer Control Valve Spring
4. Inner Control Valve Spring
5. Control Valve Collar
6. Control Valve
7. Slave Piston Adjusting Screw
8. Locknut
9. Solenoid Valve
10. Upper Seal Ring
11. Center Seal Ring
12. Lower Seal Ring
13. Master Piston
14. Flat Spring
15. Washer
16. Button Head Screw
17. Outer Spring
18. Inner Spring
19. Spring Retainer
20. Retaining Ring
21. Slave Piston
22. Ball
23. Ball Check Spring
24. Pipe Plug

Fig. 1

Slave Piston Removal, Inspection, and Installation

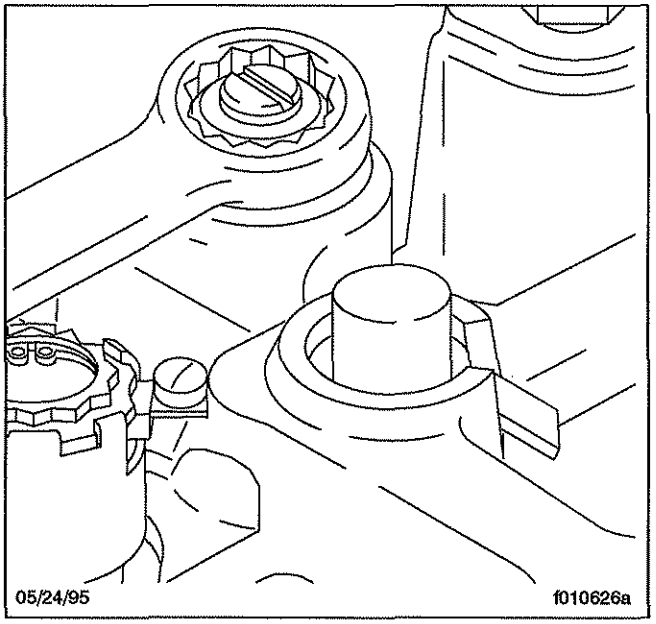


Fig. 2, Remove the Locknut

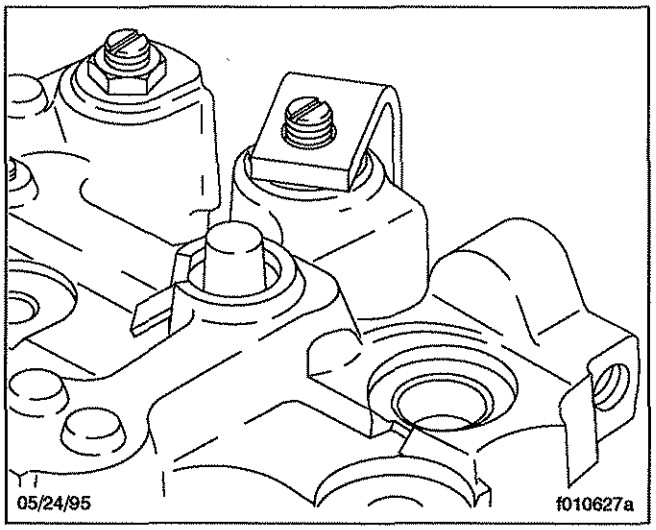


Fig. 3, Place the Clamp

Inspection

Check for binding or burrs during removal. Clean the components in an approved cleaning solvent, or replace them if they are damaged. Make sure all components are assembled in the proper order.

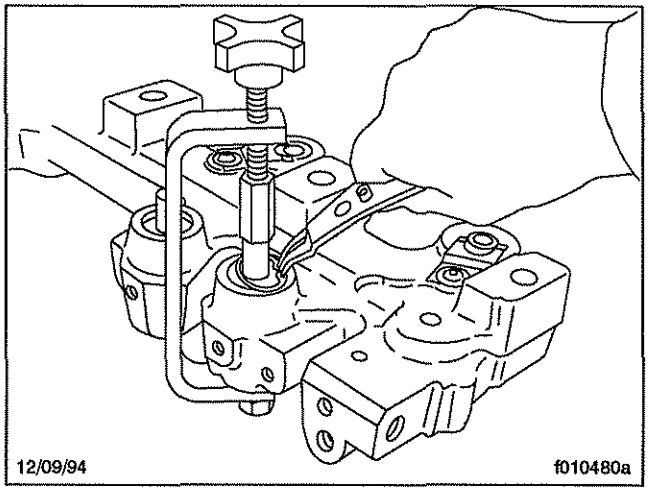


Fig. 4, Remove the Retaining Ring

Installation

1. Use the clamp fixture to install the piston and springs. Make sure the retaining ring is placed on the washer before screwing the clamp holder down over the slave piston. **See Fig. 6.**
2. Push the slave piston and springs down until the washer is about 0.04 inch (1 mm) below the retaining ring groove. Install the retaining ring. Make sure the retaining ring is fully seated in the groove. Remove the clamp fixture.
3. Remove, inspect, and install the slave piston adjusting screw using the instructions in **Subject 150.**

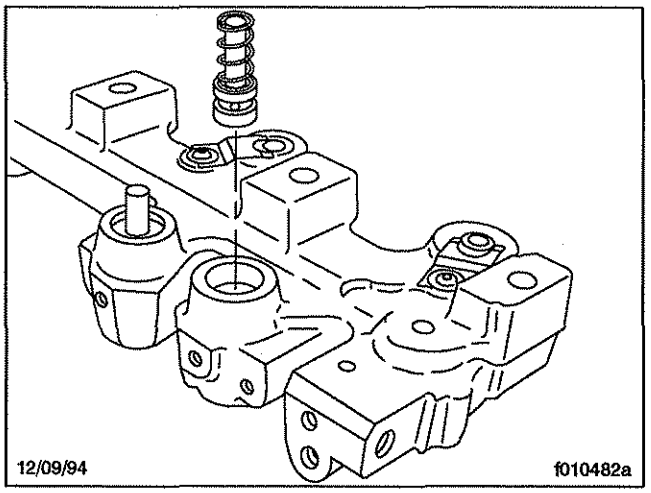


Fig. 5, Remove the Slave Piston

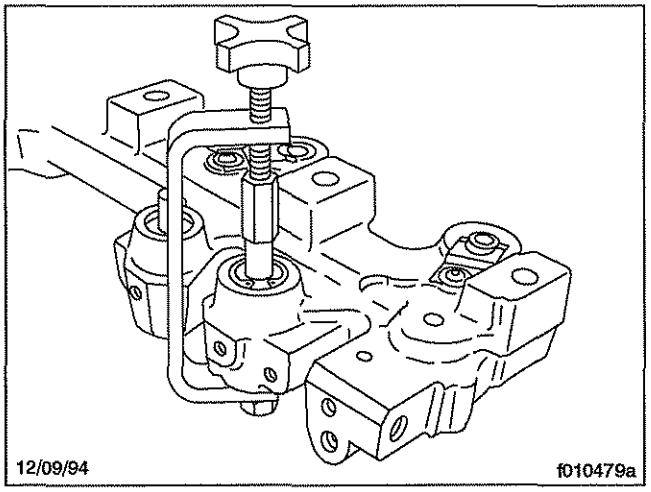


Fig. 6, Install the Piston With a Clamp

4. Install the engine brake housing on the vehicle using the instructions under **Subject 120**.

Adjustment

When adjusting an engine overhead, the most efficient time to adjust the slave piston lash is after setting the exhaust valves on each cylinder.

IMPORTANT: Slave piston adjustment must be made with the engine stopped and cold. The exhaust valves on the cylinder to be adjusted must be closed.

CAUTION: To ensure maximum engine brake efficiency, and to prevent engine damage by piston-to-valve contact, follow the instructions carefully.

Adjust the slave piston lash.

1. Insert a 0.015-inch Jacobs feeler gauge between the slave piston and the actuating pin in the crosshead. Turn the adjusting screw until you feel a light drag on the feeler gauge. **See Fig. 7.**

2. Hold the screw in position with a wrench. Using a crowfoot wrench (**Fig. 8**), tighten the locknut 22 lbf·ft (30 N·m).

CAUTION: Pay special attention to this adjustment. After the slave-piston adjusting-screw locknut is properly tightened, check the clearance with the Jacobs feeler gauge. Over-tightening Jacobs screws could cause engine damage.

3. Adjust all six slave pistons using this procedure.

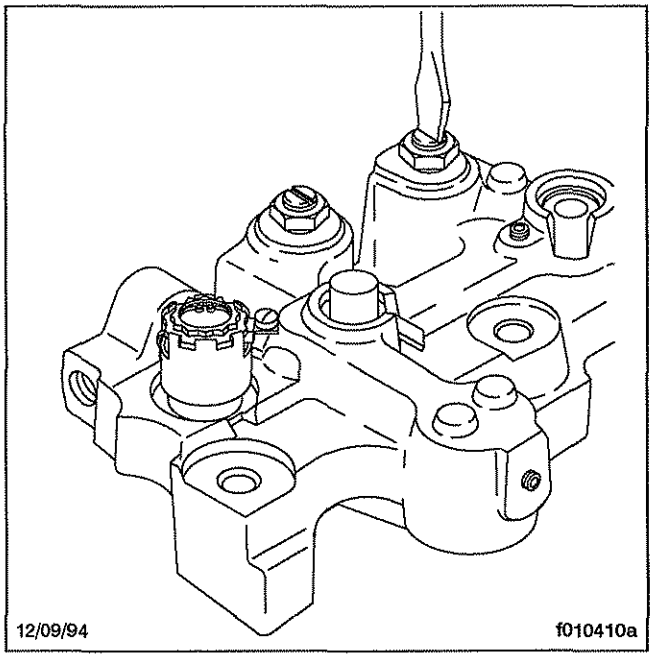


Fig. 7, Turn the Adjusting Screw

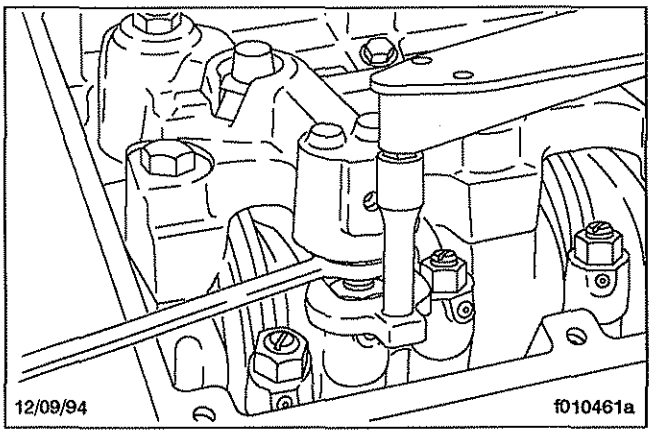


Fig. 8, Tighten the Locknut

Slave Piston Adjusting Screw Removal, Inspection, and Installation

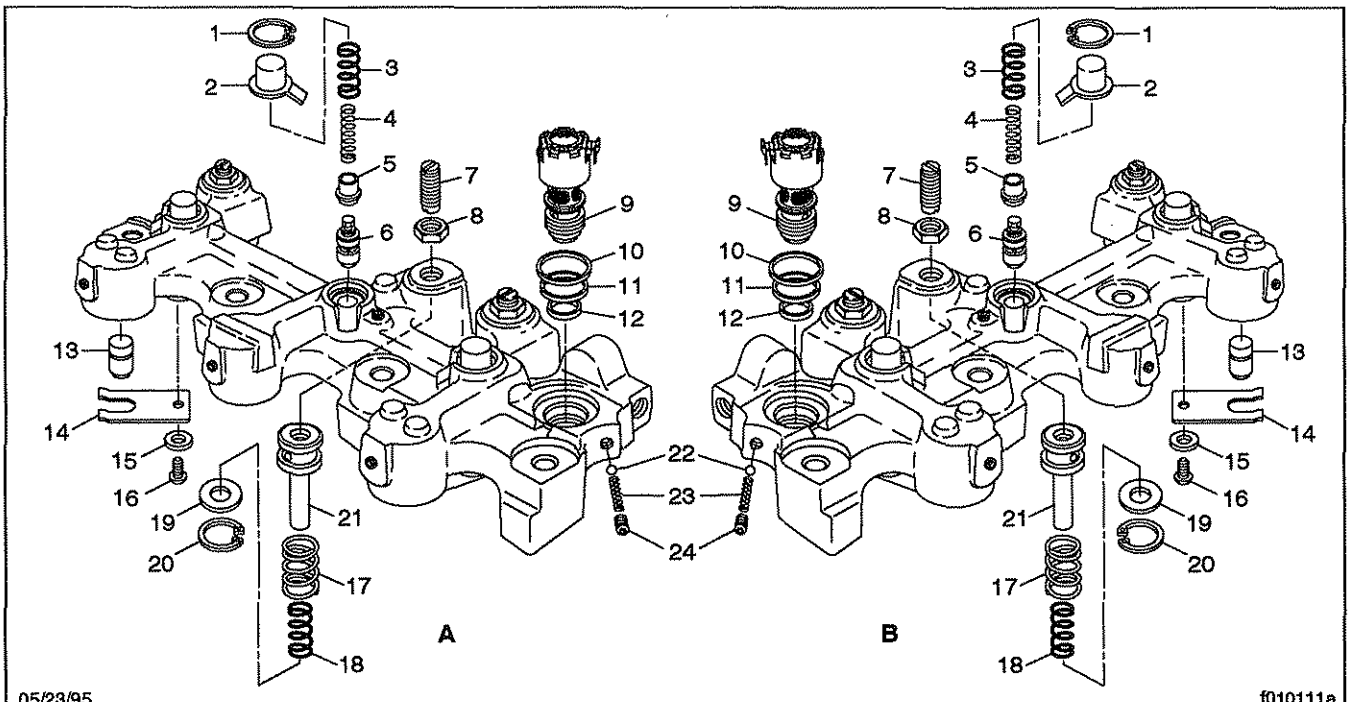
Removal (See Fig. 1)

1. Wipe the engine brake housing area clean. Remove the rocker housing cover capscrews and the rocker housing cover. For instructions, refer to **Subject 120.**
2. Loosen the slave piston adjusting screw locknut, and remove the adjusting screw from the housing. **See Fig. 2.**

Inspection

1. Inspect the slave piston adjusting screw. The plunger should have light spring pressure apparent when depressed, and should move freely. **See Fig. 3.** Make sure the retaining ring is fully engaged in its groove.
2. If the screw is damaged, replace it. If the screw is not damaged, clean it in an approved cleaning solvent.

CAUTION: Don't attempt to adjust or tamper with the adjusting screw. This could result in engine damage.



A. Front Housing

B. Rear Housing

1. Retaining Ring
2. Control Valve Cover
3. Outer Control Valve Spring
4. Inner Control Valve Spring
5. Control Valve Collar
6. Control Valve
7. Slave Piston Adjusting Screw
8. Locknut
9. Solenoid Valve
10. Upper Seal Ring
11. Center Seal Ring
12. Lower Seal Ring
13. Master Piston
14. Flat Spring
15. Washer
16. Button Head Screw
17. Outer Spring
18. Inner Spring
19. Spring Retainer
20. Retaining Ring
21. Slave Piston
22. Ball
23. Ball Check Spring
24. Pipe Plug

Fig. 1

Slave Piston Adjusting Screw Removal, Inspection, and Installation

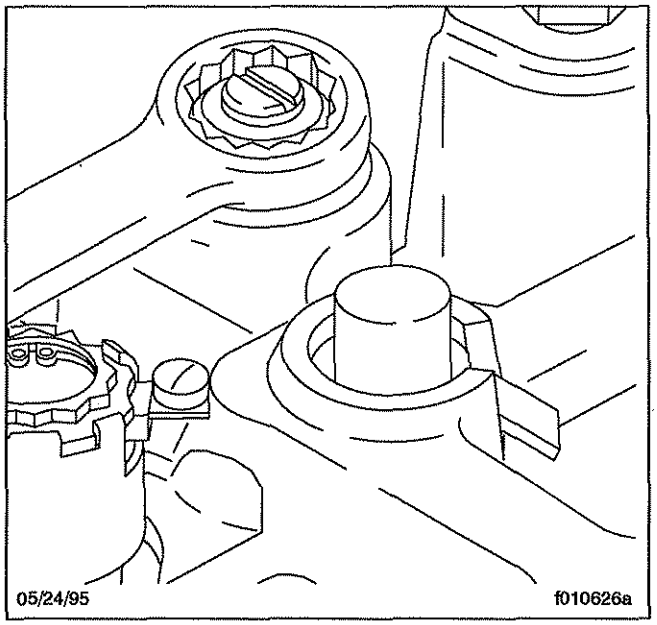


Fig. 2, Loosen the Locknut

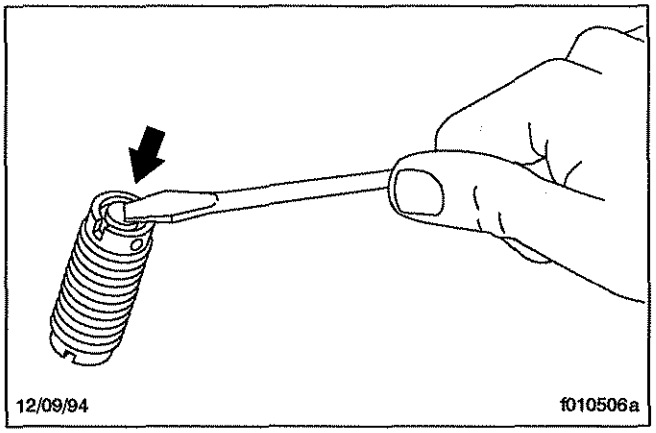


Fig. 3, Check the Adjusting Screw

Installation

1. Install the adjusting screw and attach the locknut. **See Fig. 2.**
2. If the engine brake housing has been removed from the engine, install the engine brake housing, and adjust the slave piston using the instructions **Subject 140.**

   If the engine brake housing was not removed from the engine, adjust the slave piston using the instructions **Subject 140.** Install the rocker housing cover. For instructions, refer to **Subject 120.**

Solenoid Valve Removal, Inspection, and Installation

Removal (See Fig. 1)

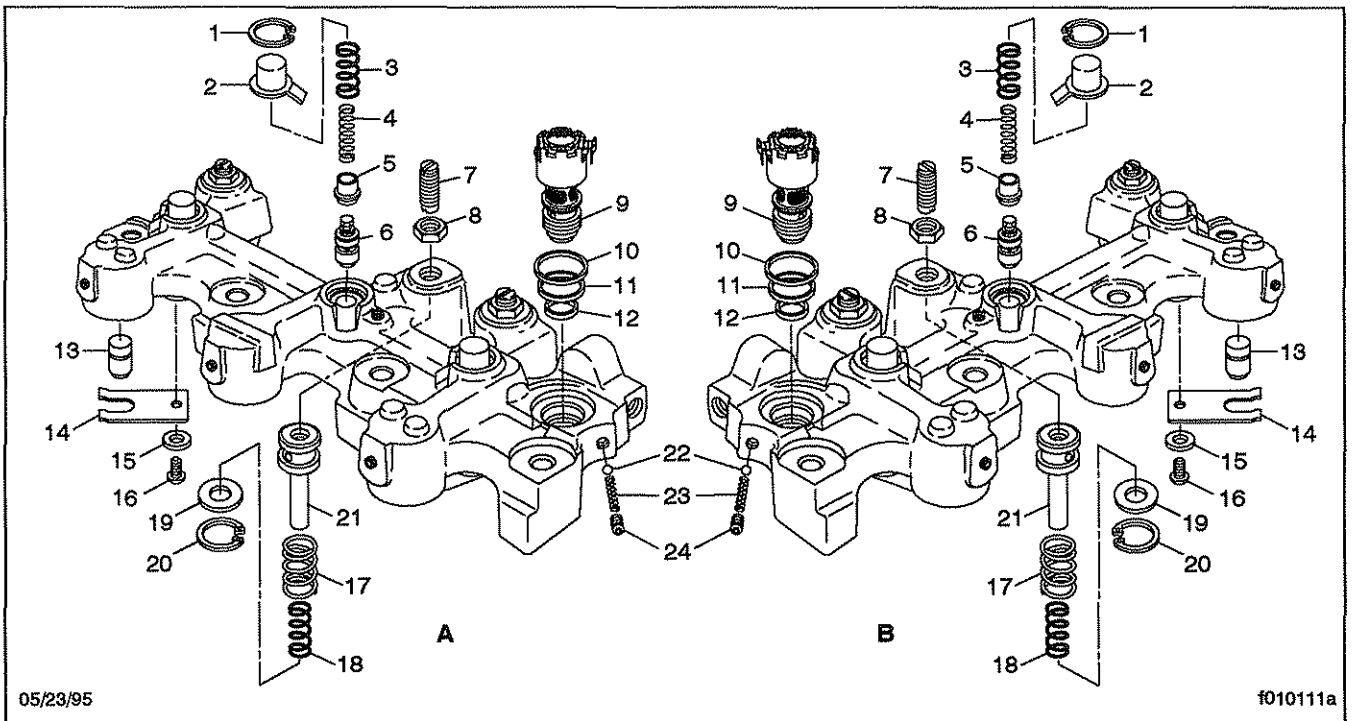
1. Wipe the engine brake housing area clean. Remove the rocker housing cover capscrews and the rocker housing cover. For instructions, refer to **Subject 120**.
2. Disconnect the solenoid harness from the solenoid. Using a 7/8-inch socket and extension, remove the solenoid valve. **See Fig. 2.**

Inspection

Inspect the oil filter screen and solenoid valve. **See Fig. 3.** If the screen or solenoid valve is damaged, replace it. If it is not damaged, clean it in an approved cleaning solvent.

Installation

1. Install the solenoid using new seal rings. First, seat the lower seal ring on the bottom surface of the housing bore. Place the upper and center seal rings on the solenoid, and lubricate them with engine oil. **See Fig. 3** for seal locations.



A. Front Housing

B. Rear Housing

1. Retaining Ring
2. Control Valve Cover
3. Outer Control Valve Spring
4. Inner Control Valve Spring
5. Control Valve Collar
6. Control Valve
7. Slave Piston Adjusting Screw
8. Locknut
9. Solenoid Valve
10. Upper Seal Ring
11. Center Seal Ring
12. Lower Seal Ring
13. Master Piston
14. Flat Spring
15. Washer
16. Button Head Screw
17. Outer Spring
18. Inner Spring
19. Spring Retainer
20. Retaining Ring
21. Slave Piston
22. Ball
23. Ball Check Spring
24. Pipe Plug

Fig. 1

Solenoid Valve Removal, Inspection, and Installation

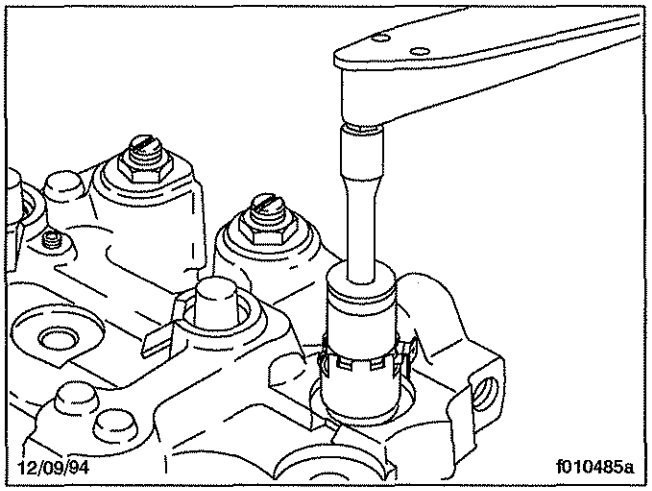
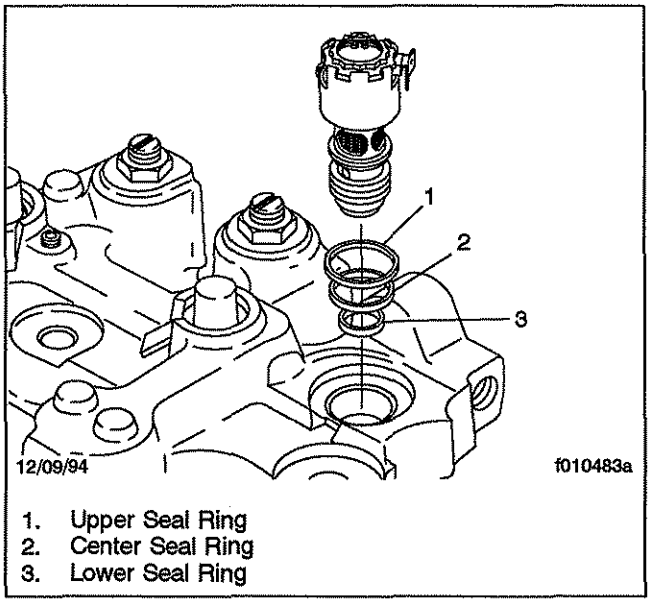


Fig. 2, Remove the Solenoid Valve

When installing the solenoid valve, make sure the seals are seated properly, then gently screw the solenoid into the housing without unseating the seals. **See Fig. 3.** Tighten the solenoid valve 60 lbf·in (680 N·cm).

2. Install the solenoid harness.
3. Install the rocker housing cover on the spacer. For instructions, refer to **Subject 120.**



1. Upper Seal Ring
2. Center Seal Ring
3. Lower Seal Ring

Fig. 3, Install the Solenoid

Contents

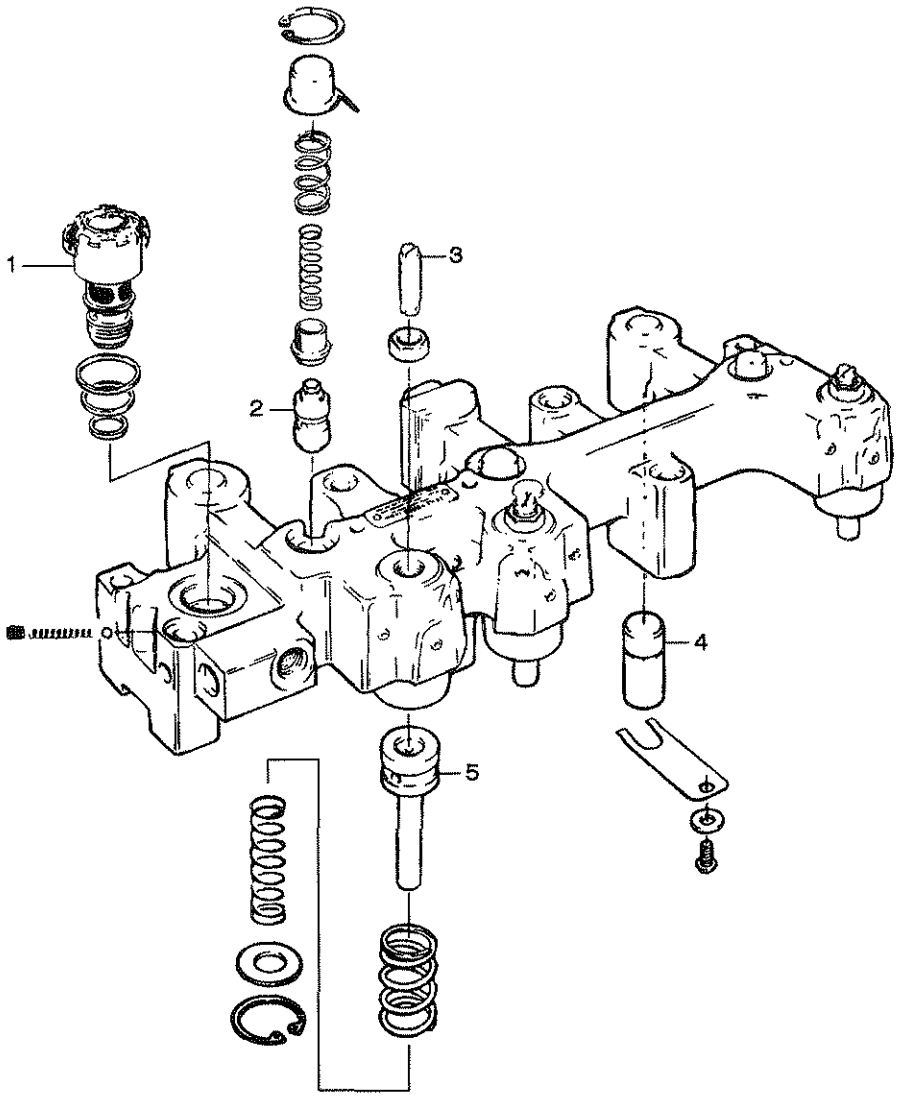
Subject	Subject Number
General Information	050
Service Operations	
Ball Check Valve Removal and Installation	100
Control Valve Removal and Installation	110
Engine Brake Housing Removal and Installation	120
Master Piston Removal, Inspection, and Installation	130
Rocker Cover Removal and Installation	140
Slave Piston Removal, Cleaning, and Installation	150
Slave Piston Adjusting Screw Removal, Inspection, and Installation	160
Solenoid Removal, Cleaning, and Installation	170

For troubleshooting procedures, refer to **Section 01.12** in this manual.

General Information (See Fig. 1)

Jacobs engine brake housings are installed on the engine rocker housings. Model 411 (used on Cummins M11 engines with CELECT) has two engine brake housings that operate three cylinders each. Each engine brake housing has a solenoid valve, control valve, ball check valve, master piston, and slave piston.

Engine brake controls consist of: two dash-mounted toggle switches, a clutch switch mounted under the dash, and the throttle switch. The switches are wired



1. Solenoid Valve
2. Control Valve
3. Slave Piston Adjusting Screw (Reset®)
4. Master Piston
5. Slave Piston

Fig. 1, Engine Brake Components

in series so that all of the switches must be closed to operate the engine brake. The engine brake is activated when one or both of the dash switches is on (up), and the clutch and throttle pedals are released. The dash switches enable the driver to operate the engine brake partially or fully.

Model 411 engine brakes can be operated at one-half or full capacity (three or six cylinders).

When activated, the engine brake converts a power-producing diesel engine to a power absorbing air compressor. This is accomplished by motion transfer through a master-slave piston arrangement which opens the engine cylinder exhaust valves near the top of the normal compression stroke, releasing the compressed cylinder charge to exhaust. The blowdown of compressed air to atmospheric pressure prevents the return of energy to the engine piston on the expansion (power) stroke. This results in a net energy loss because the work done in compressing the cylinder charge is not returned during the expansion process. Exhaust blowdown occurs as follows.

1. Activating the engine brake energizes the solenoid valve, allowing engine oil to flow under pressure through the control valve to both the master piston and the slave piston.
2. Oil pressure causes the master piston to move down, coming to rest on the injector rocker lever adjusting screw.
3. The injector rocker lever adjusting screw begins upward travel (as in the normal injection cycle) forcing the master piston upward and creating a high-pressure oil flow to the slave piston. The ball check valve in the control valve holds the high-pressure oil in the master-slave piston system.
4. When the engine piston is near top dead center, the slave piston moves down under the influence of the high-pressure oil flow. This momentarily opens one of the exhaust valves, releasing compressed cylinder air to the exhaust manifold.
5. Compressed air is released to the atmosphere, completing a compression braking cycle.

Removal (See Fig. 1)

1. Remove the engine brake housing from the vehicle. For instructions, refer to **Subject 120**.
2. Remove the hex socket pipe plug. Be careful during final turns to avoid loss of the spring and ball. Remove the spring and ball.

Installation

1. Inspect the parts for wear, then clean them in an approved cleaning solvent, or replace them if necessary.
2. Assemble the ball check valve by first inserting the ball, then the spring, and then tighten the plug 106 lbf·in (1200 N·cm).

CAUTION: Make certain the parts are installed in the order shown in **Fig. 1**. Improper installation may result in engine damage.

3. Install the engine brake housing using the instructions in **Subject 120**.

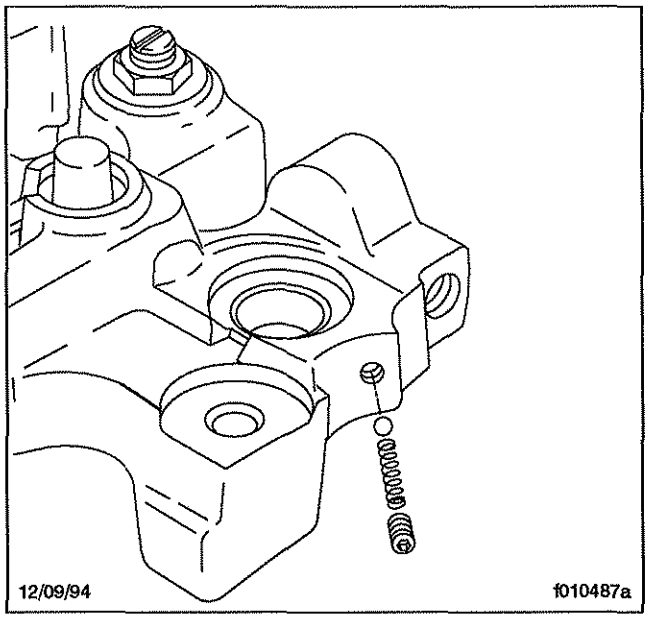


Fig. 1, Ball Check Valve, Exploded

Removal

1. Wipe the engine brake housing area clean. Remove the rocker cover. For instructions, refer to **Subject 120**.

WARNING: Control valve covers are under load from the control valve springs. Remove with care to avoid personal injury.

2. Apply pressure on the control valve cover, and remove the retaining ring, using retaining ring pliers. **See Fig. 1.**
3. Carefully remove the cover until the spring pressure ceases.
4. Carefully remove both control valve springs and the collar. **See Fig. 2.**
5. Using needle nose pliers or your fingertips, carefully pull the control valve straight up and out of its bore. **See Fig. 3.**
6. If binding occurs during removal, inspect the control valve parts for damage or wear, and replace them if necessary.

   If there is no damage, clean the parts in an approved cleaning solvent.

Installation

CAUTION: Make sure the control valve collar is installed with the longer sleeve area up. **See Fig. 4.**

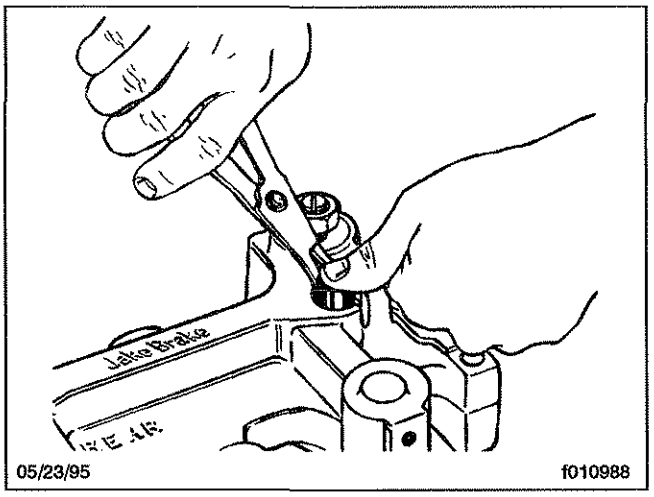


Fig. 1, Remove the Retaining Ring

If the collar is installed upside down, engine damage may result.

1. Install the control valve, collar, and springs. Make sure the retaining ring ears are positioned

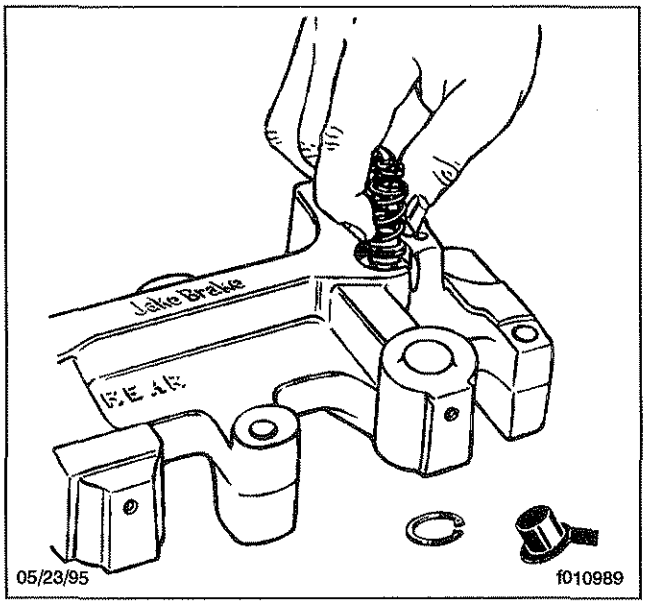


Fig. 2, Remove the Springs and Collar

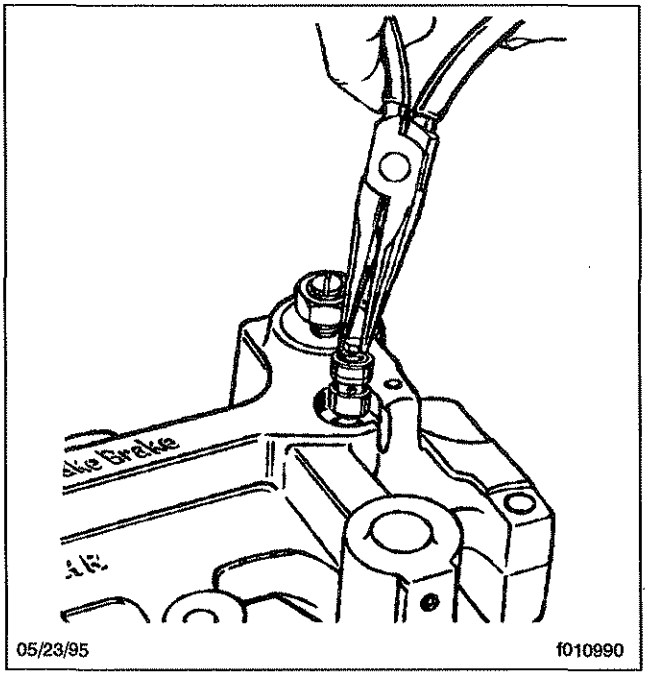
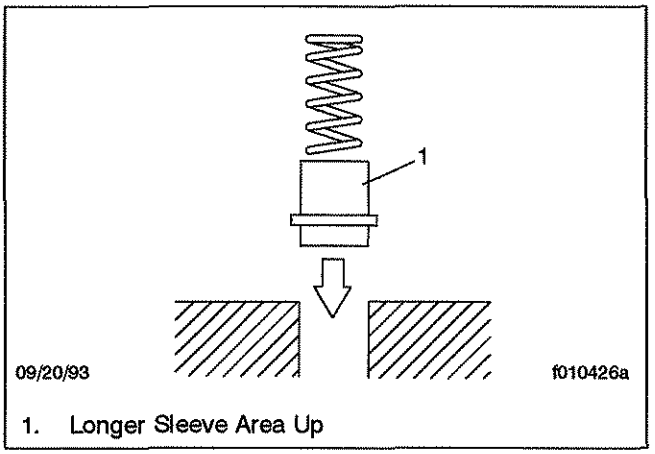


Fig. 3, Remove the Control Valve

Control Valve Removal and Installation

opposite the oil drain slot in the housing. **See Fig. 5.**

2. Install the rocker cover. For instructions, refer to **Subject 120.**



1. Longer Sleeve Area Up

Fig. 4, Check the Control Valve Collar

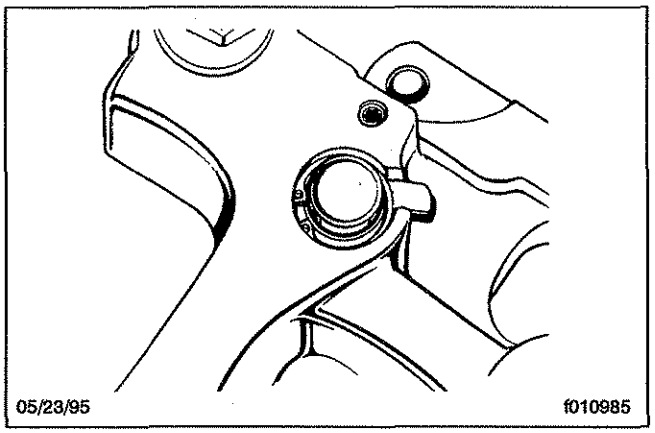


Fig. 5, Check the Retaining Ring Ears

Removal

1. Shut down the engine, and tilt the hood.

WARNING: Never remove any engine brake component with the engine running. Hot oil spray could cause personal injury.

2. Wipe clean the engine brake housing area. Remove the rocker housing cover capscrews, and remove the cover and gasket from the spacer.
3. Disconnect the solenoid electrical harness from the terminal leadout in the spacer.
4. Remove the steel plates, O-ring, and gasket from the spacer. Disconnect the oil hose from the front brake housing, and remove it through the hole in the spacer.
5. Remove the engine brake housing hold-down capscrews.
6. Remove the engine brake housing from the rocker-shaft supports.

Installation

1. If the oil connector was previously removed from the front housing, then install the connector and O-ring into the front housing as far as it will go.
2. Back out the slave-piston adjusting screws until the slave pistons are fully retracted (screws are loose).
3. Place the rear brake housing on the rockershaft supports over cylinders 4, 5, and 6. Loosely install four Jacobs hold-down capscrews. Lubricate the threads and underside of the capscrew heads. Lubricate both ends of the oil supply tube.

NOTE: No washers are used with the capscrews.

4. Place the front brake housing on the rocker-shaft supports over cylinders 1, 2, and 3. Carefully insert the oil connector into the rear housing.
5. Install the capscrews in the sixteen locations and hand tighten them in the sequence shown in **Fig. 1**.

   Then, using the same sequence, tighten the capscrews 60 lbf·ft (81 N·m).

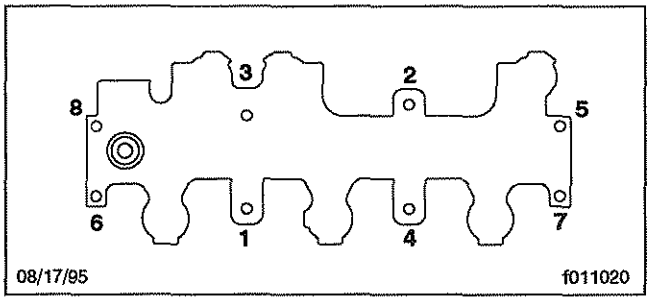


Fig. 1, Capscrew Tightening Sequence

Removal and Inspection

1. Remove the brake housing from the vehicle. For instructions, refer to **Subject 120.**
2. Remove the screw, washer, and master piston spring from the bottom of the housing. **See Fig. 1.**
3. Remove the master piston from its bore; needle-nose pliers are usually needed to initially pull the piston up. **See Fig. 2.**
4. If binding occurs during removal, check for burrs, or contaminants in the lube oil. If the piston is damaged, replace it. If the piston is not damaged, clean it in a cleaning solvent.

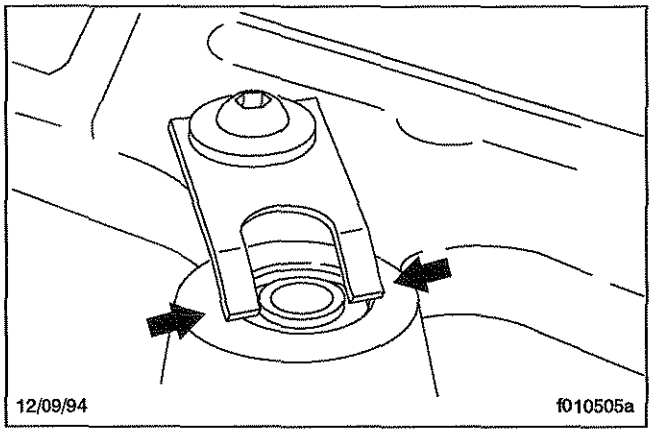


Fig. 1, Remove the Piston Spring

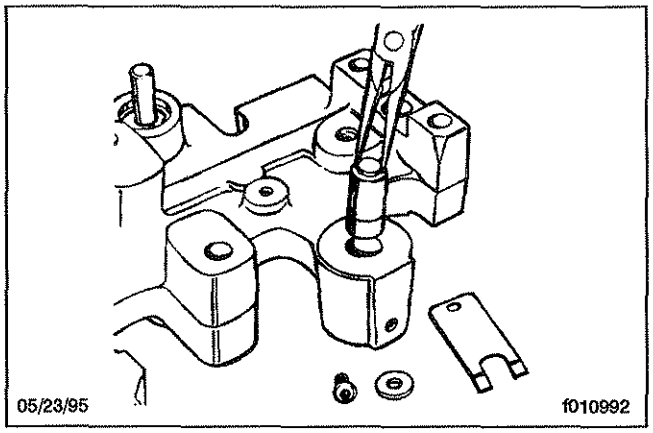


Fig. 2, Remove the Master Piston

Installation

1. Install the piston, spring, washer, and screw. Make sure that when tightening the capscrew, the two tabs of the spring do not interfere with the sides of the center raised portion of the master piston. **See Fig. 1.**
2. Install the engine brake housing using the instructions in **Subject 120.**

Removal

1. Apply the parking brakes, chock the tires, shut down the engine, and tilt the hood.

WARNING: Never remove any engine brake component with the engine running. Hot oil spray could cause personal injury.

2. Wipe the engine brake housing area clean.
3. Remove the bolts that hold each rocker cover, and remove the rocker covers.

Installation

1. Inspect the cover seals, and replace them if they are damaged.
2. Make sure a rocker cover seal is located in the groove of each cover, and install the cover on the spacer.

CAUTION: Be sure to tighten all the rocker cover bolts evenly. Excessive or uneven tightening may cause the rocker cover to crack.

3. Install a flatwasher, a new sleeve, and a new noise isolator on each capscrew, and install the capscrew assemblies in the cover. Tighten the bolts 130 lbf·in (1460 N·cm) in the sequence shown in **Fig. 1.**
4. Remove the chocks from the tires.

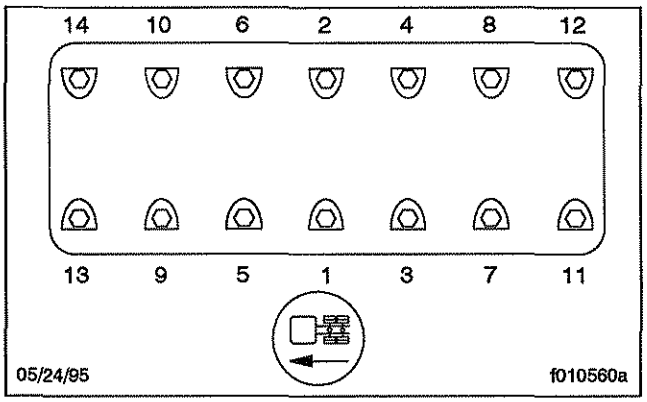


Fig. 1, Bolt Tightening Sequence

Slave Piston Removal, Cleaning, and Installation

Removal

1. Remove the brake housing from the vehicle. For instructions, refer to **Subject 120.**

WARNING: Wear safety glasses, and remove the slave piston carefully. The slave piston is retained by springs that are under heavy compression. If the following instructions are not used and the proper tools are not used, the spring could be discharged with enough force to cause personal injury.

2. Remove the locknut on the slave piston adjusting screw, and back out the adjusting screw until the slave piston is fully retracted (the screw is loose).

3. Use the slave piston clamp fixture to remove the slave piston. **See Fig. 1.** Place the hole in the clamp fixture over the slave piston adjusting screw.

4. While holding the fixture in position, screw the holder down over the slave piston stem until the retainer is contacted. Turn the handle slowly until the retainer is depressed about 1/32 inch (1 mm), relieving pressure against the retaining ring

   Using retaining ring pliers, remove the retaining ring. **See Fig. 2.**

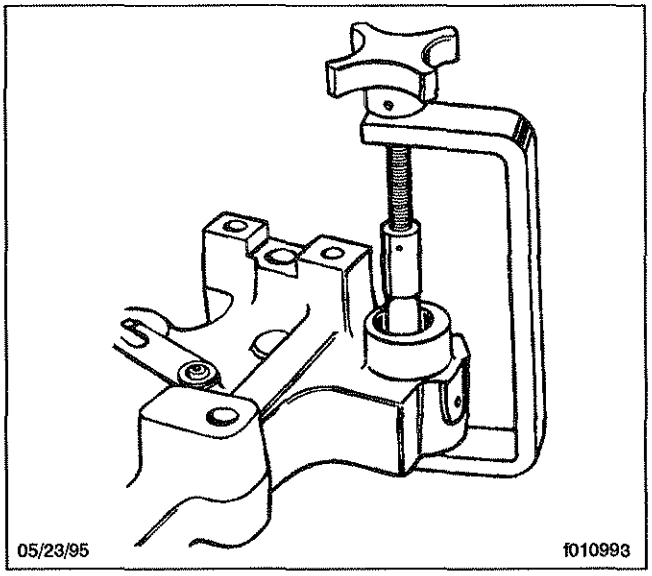


Fig. 1, Using the Clamp Fixture

5. Remove the retainer, spring, and slave piston. Check for nicks or burrs that could cause binding. **See Fig. 3.**

Cleaning

1. Clean the piston in an approved cleaning solvent.
2. Run a small wire through any holes.
3. Replace the piston if the ground surface on the outside diameter is scratched or scored.

Installation

IMPORTANT: Make sure all the components are assembled in the correct order.

1. Install the slave piston into the bore.
2. Install the springs and retainer over the slave piston foot.

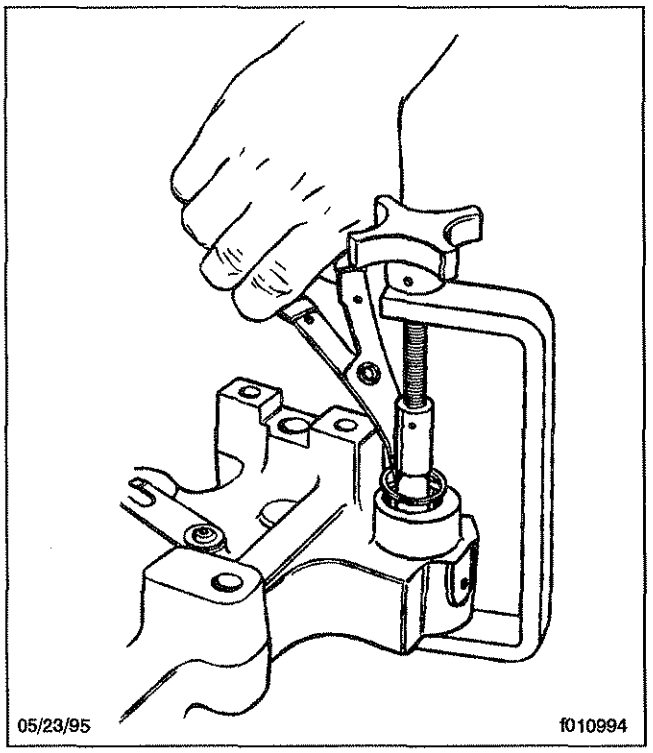


Fig. 2, Removing The Retaining Ring

Slave Piston Removal, Cleaning, and Installation

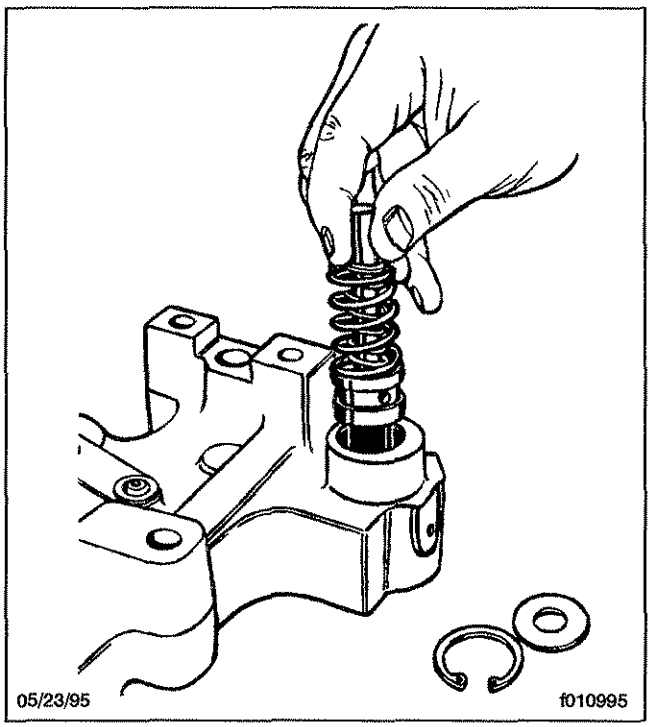


Fig. 3, Remove the Slave Piston

3. Use the clamp fixture to compress the slave piston and springs until the retainer is about 1/32 in (1 mm) below the retaining ring groove.
4. Slide the retaining ring over the threaded rod of the clamp fixture, and install the retaining ring in its groove. Make sure the retaining ring is fully engaged in the groove.

   Remove the clamping fixture slowly to ensure proper seating of the retaining ring.
5. Install the engine brake housing using the instructions in **Subject 120**.

Slave Piston Adjusting Screw Removal, Inspection, and Installation

Removal

1. Remove the rocker cover from the vehicle. For instructions, refer to **Subject 140.**
2. Remove the slave piston adjusting screw locknut, and remove the adjusting screw from the housing. **See Fig. 1.**

Inspection and Installation

1. Clean the adjusting screw in an approved solvent.
2. Inspect the slave piston adjusting screw. **See Fig. 2.** The plunger should protrude from the bottom of the screw, have light spring pressure apparent when depressed, and should move freely. Be sure the retaining ring is fully engaged in its groove. Replace the entire screw assembly if any defect is found.

   Using retaining ring pliers, remove the retaining ring.
3. Install the slave piston adjusting screw, and adjust the slave piston lash to 0.015 inch (0.03 mm).

NOTE: The slave piston lash must be set with the engine stopped and cold. The exhaust valves on the cylinder to be adjusted must be closed.

CAUTION: Do not over tighten the adjusting screw locknut. Over tightening the locknut will cause poor engine brake performance.

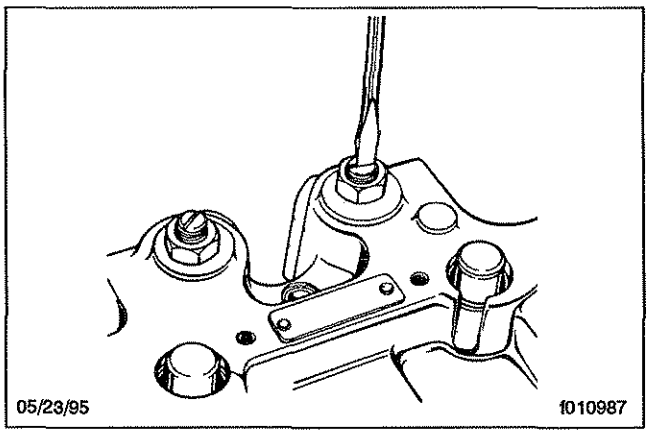


Fig. 1, Remove the Adjusting Screw

After tightening the slave piston adjusting screw locknut, check the clearance with a Jacobs feeler gage. Readjust the piston lash if needed.

4. After the slave piston is adjusted, tighten the adjustment screw locknut 25 lbf·ft (34 N·m).
5. Install the rocker cover using the instructions in **Subject 140.**

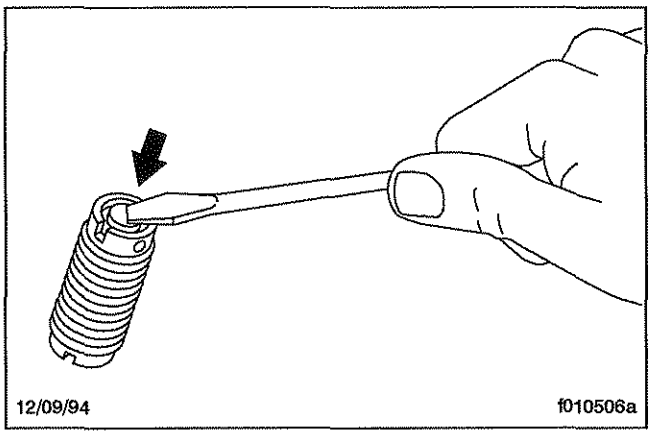


Fig. 2, Inspect the Adjusting Screw

Removal

1. Remove the rocker cover from the vehicle. For instructions, refer to **Subject 140**.
2. Disconnect the solenoid harness.
3. Using a 7/8-inch socket and extension, unscrew the solenoid valve. **See Fig. 1.**

CAUTION: Do not disassemble or tamper with the solenoid valve. Engine damage could result.

4. Remove and discard the three rubber seal rings. **See Fig. 2.**

   If the lower ring stays in the bottom of the housing solenoid bore, remove it with a seal pick.

Cleaning and Installation

1. Wash out the solenoid valve with an approved cleaning solvent. Use a brush to clean the oil screen. Clean and dry the valve with compressed air. Replace the oil screen, if needed.
2. Clean out the solenoid valve bore in the housing. Use clean paper towels. Never use rags, as they may leave lint and residue which can plug the oil passageways.
3. Install the solenoid using new seal rings. Seat the lower seal ring in the base of the solenoid valve bore. Wipe clean lube oil into and around the bore, and place the upper and center seal rings on the solenoid valve body.

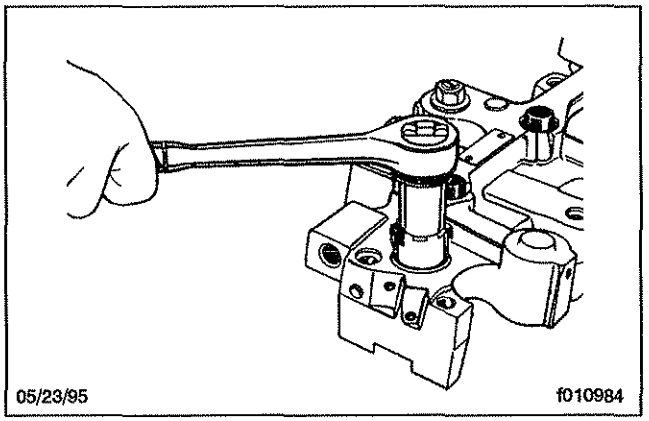
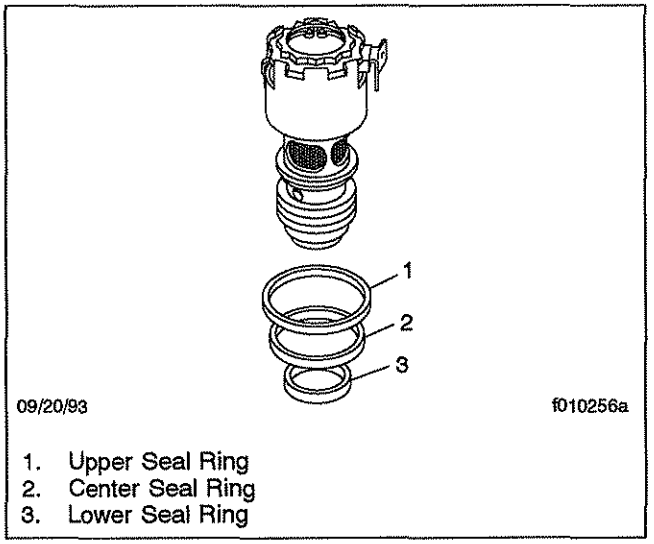


Fig. 1, Unscrew the Solenoid

4. Be sure the seals are seated properly, and carefully screw the solenoid into the housing without unseating the seals. **See Fig. 3.** Tighten the solenoid 10 lbf·ft (7 N·m).
5. Connect the solenoid wiring harness.
6. Install the rocker cover using the instructions in **Subject 140.**



1. Upper Seal Ring
2. Center Seal Ring
3. Lower Seal Ring

Fig. 2, Solenoid Seal Rings

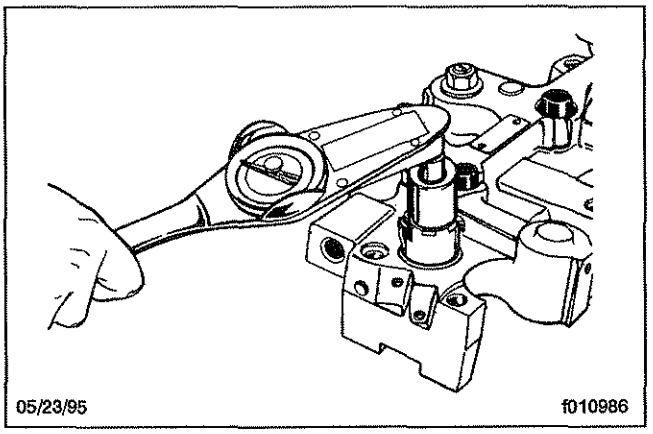


Fig. 3, Installing the Solenoid

Jacobs Engine Brake, Model 750 01.10

Contents

Subject	Subject Number
General Information	050
Service Operations	
Accumulator Removal, Inspection, and Installation	100
Control Valve Removal, Inspection, and Installation	110
Engine Brake Housing Removal and Installation	120
Master Piston Removal, Inspection, and Installation	130
Master Piston Pin and Roller Removal, Cleaning, and Installation	140
Rocker Cover Removal and Installation	150
Slave Piston Adjusting Screw (Reset®) Removal, Inspection, and Installation	160
Slave Piston Removal, Inspection, and Installation	170
Solenoid Valve Removal and Installation	180

For troubleshooting procedures, refer to **Section 01.12** in this manual.

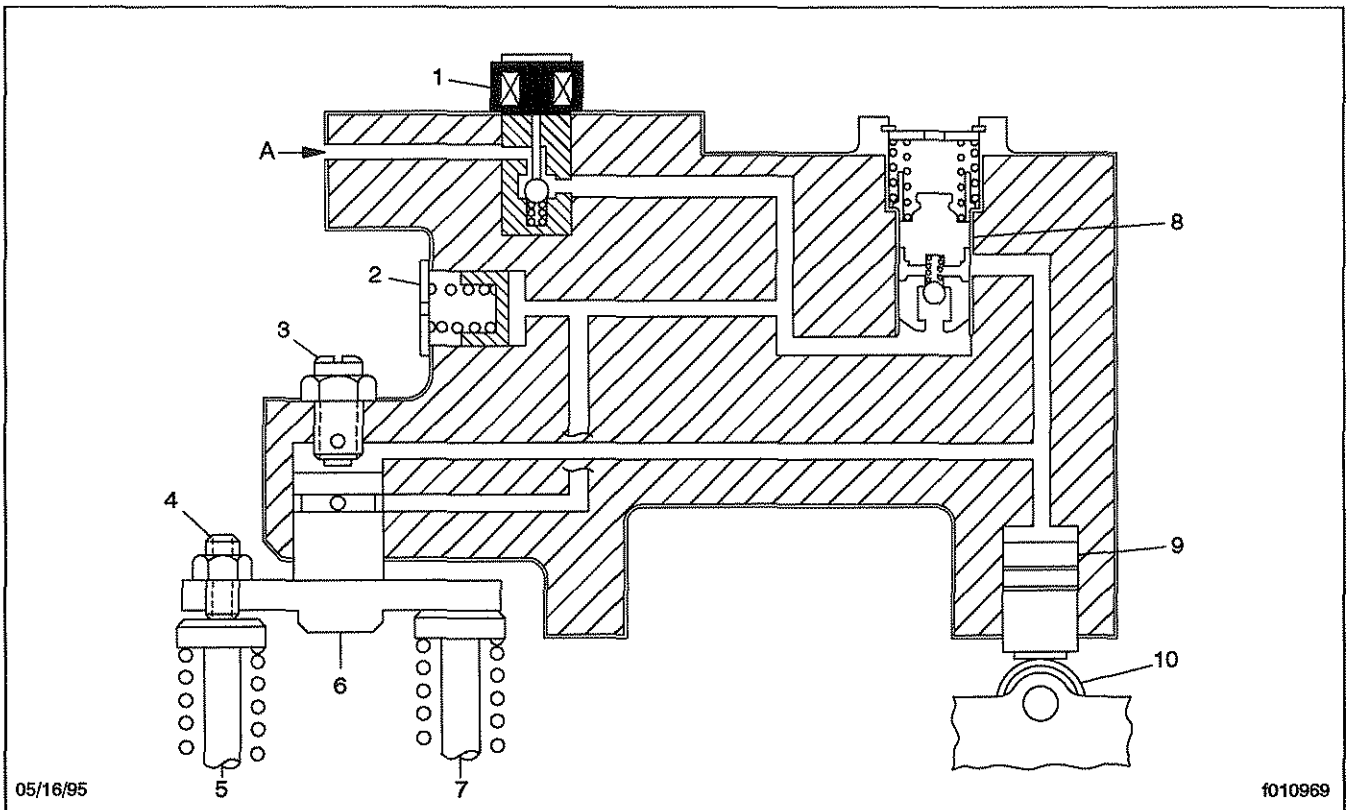
General Information

Jacobs engine brake housings are installed on the engine rocker housings. Model 750 (used on Detroit Diesel Series 50 engines) has two engine brake housings that operate two cylinders each. Each engine brake housing has a solenoid valve, control valves, ball check valves, master pistons, and slave pistons. **See Fig. 1.**

Engine brake controls consist of: dash switches and a clutch switch. The clutch switch is mounted under the dash. The engine brake is activated when the dash switches are on and the clutch and throttle pedals are released. The dash switches enable the driver to operate the engine brake partially or fully.

The Model 750 engine brake can be operated at one-half or full capacity (two or four cylinders).

When activated, the engine brake converts a power-producing diesel engine to a power-absorbing air compressor. This is accomplished by motion transfer through a master-slave piston arrangement which opens the engine cylinder exhaust valves near the top of the normal compression stroke, releasing the compressed cylinder charge to exhaust. The blowdown of compressed air to atmospheric pressure prevents the return of energy to the engine piston on the expansion (power) stroke. This results in a net energy loss because the work done in compressing the cylinder charge is not returned during the expansion process. Exhaust blowdown occurs as follows (**see Fig. 1**):



A. Oil In

1. Solenoid Valve
2. Accumulator
3. Slave Piston Adjusting Screw
4. Leveling Screw
5. Exhaust Valve
6. Slave Piston Assembly
7. Exhaust Valve
8. Control Valve
9. Master Piston
10. Injector Pin and Roller

Fig. 1, Operating Schematic, Model 750 Housing Assembly

General Information

1. Activating the engine brake energizes the solenoid valve, allowing engine oil to flow under pressure through the control valve to both the master piston and the slave piston.
2. Oil pressure causes the master piston to move down, coming to rest on the injector rocker arm roller.
3. The injector rocker arm begins upward travel (as in the normal injection cycle) forcing the master piston upward and creating a high-pressure oil flow to the slave piston. The ball check valve in the control valve holds the high-pressure oil in the master-slave piston system.
4. When the engine piston is near top dead center, the slave piston moves down under the influence of the high-pressure oil flow. This momentarily opens the exhaust valves, releasing compressed cylinder air to the exhaust manifold.
5. At the bottom of its stroke the slave piston separates from the plunger in the slave piston adjusting screw, allowing high-pressure oil to flow into the accumulator. This reduces the pressure in the high-pressure circuit, permitting the slave piston to retract and the exhaust valves to close in preparation for the normal exhaust valve cycle. The oil pressure reserved in the accumulator ensures that the hydraulic circuit is fully charged for the next cycle.
6. Compressed air escapes to the atmosphere completing a compression braking cycle.

Accumulator Removal, Inspection, and Installation

Removal

WARNING: The accumulator spring is under strong compression. Be careful when removing the retaining ring and cover. Wear safety glasses. If the spring is accidentally released, personal injury could result.

1. Remove the engine brake housing from the vehicle. For instructions, refer to **Subject 120.**
2. Push down on the accumulator cover and remove the retaining ring. **See Fig. 1.**
3. Remove the cover and spring. **See Fig. 2.**
4. Using a magnet, remove the piston from the accumulator bore. **See Fig. 3.**

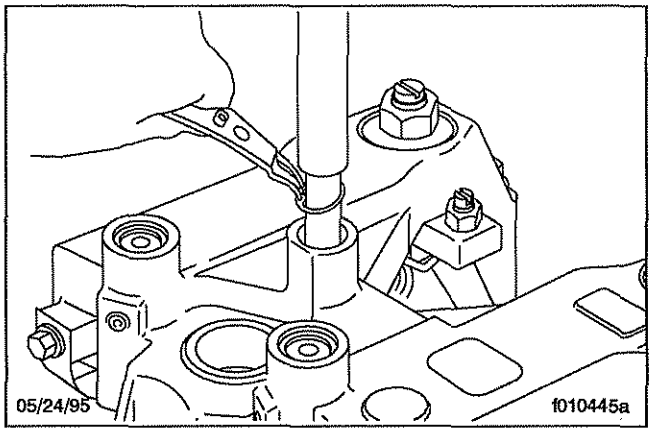


Fig. 1, Remove the Retaining Ring

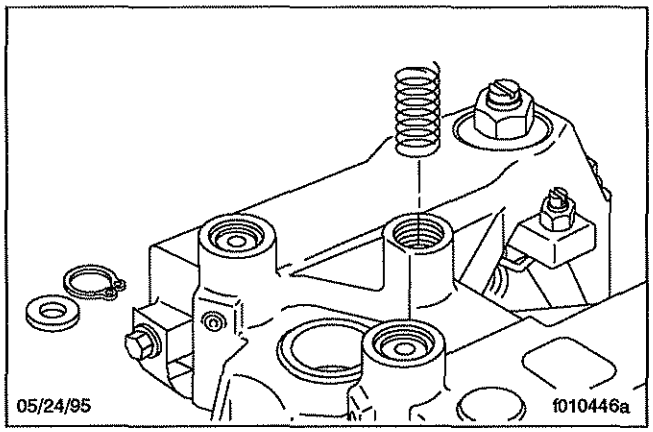


Fig. 2, Remove the Spring

Inspection

Inspect the parts for wear and damage. Replace parts as needed.

Installation

1. Install the piston, spring, cover, and retaining ring.
2. Install the engine brake housing. For instructions, refer to **Subject 120.**

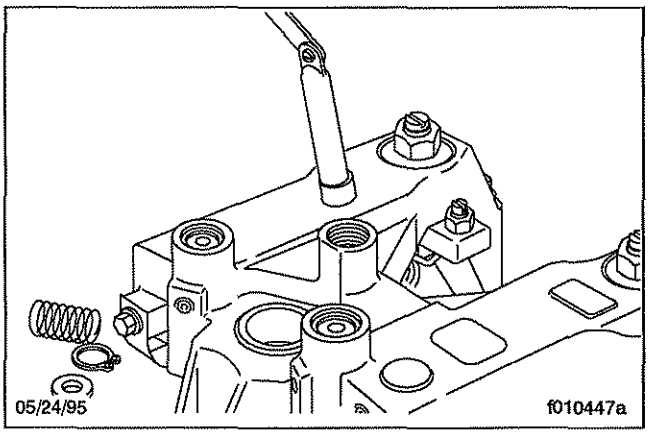


Fig. 3, Remove the Piston

Control Valve Removal, Inspection, and Installation

Removal

1. Wipe the engine brake housing area clean, and remove the rocker cover. For instructions, refer to **Subject 150.**

WARNING: Control valve covers are under load from the control valve springs. Remove the covers with care to avoid personal injury.

2. Press down on the control valve cover to relieve spring pressure. **See Fig. 1.**
3. Remove the retaining ring using retaining ring pliers.
4. Slowly remove the cover until the spring pressure is released; then, remove the two control valve springs and the collar. **See Fig. 2.**
5. Using needle nose pliers, reach into the housing bore and grasp the stem of the control valve. Remove the control valve. **See Fig. 3.**

Inspection

1. Wash the control valves with a cleaning solvent.
2. Push a wire through the hole in the base of the valve to make sure the ball check is free. The ball should lift with light pressure on the wire.

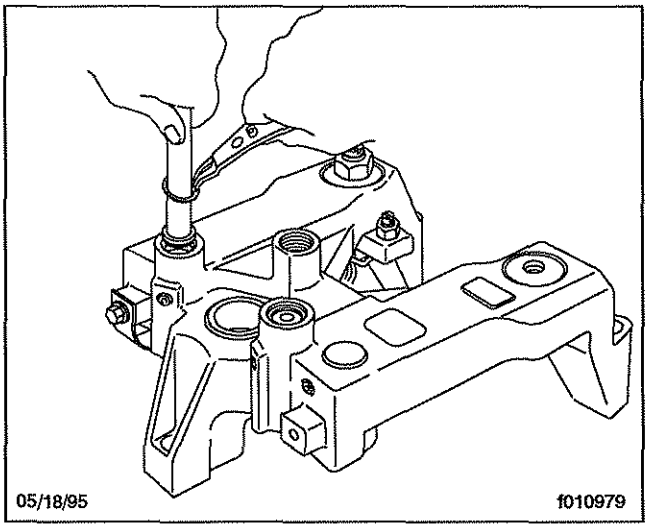


Fig. 1, Press the Control Valve Cover

3. Dry the valve with compressed air and wipe it clean with a paper towel.
4. Using clean paper towels, thoroughly clean the control valve bore in the housing.
5. Dip the control valves in clean lubricating oil. Holding the valve by the stem, let the valve drop into its bore. If it binds or if the ball is stuck in the valve, replace the control valve.

Installation

IMPORTANT: Be sure to coat all parts with clean lubricating oil before installing them.

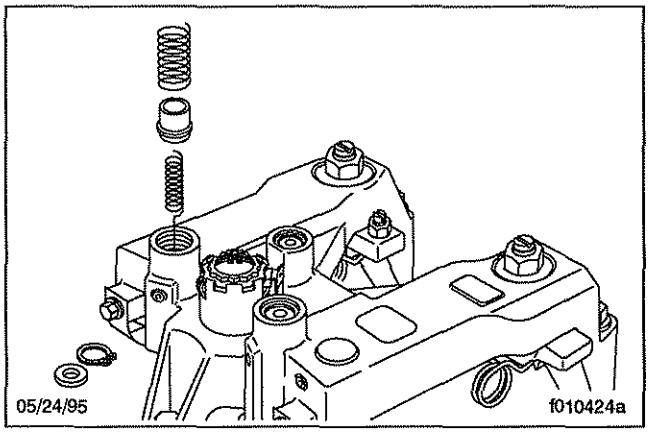


Fig. 2, Remove the Springs and the Collar

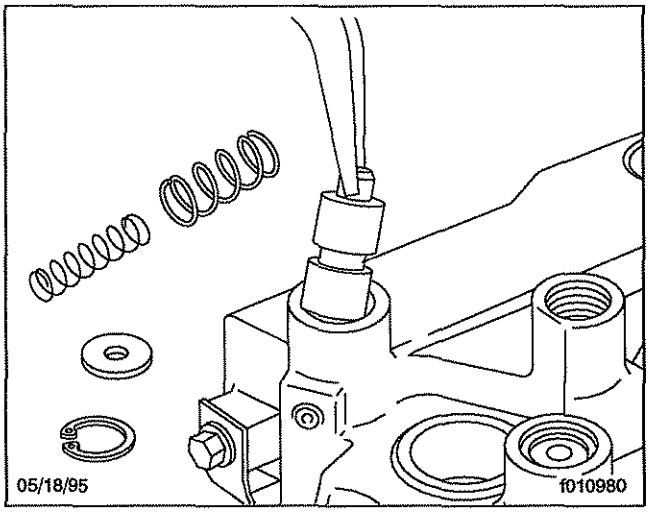


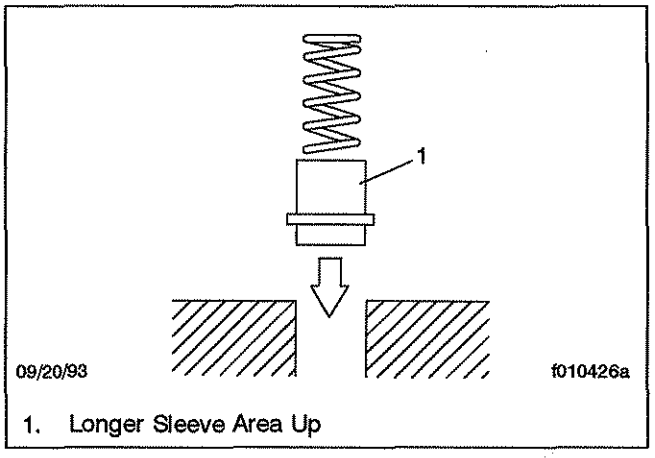
Fig. 3, Remove the Control Valve

Control Valve Removal, Inspection, and Installation

1. Install the control valve reversing the removal procedure.

NOTE: Make sure the control valve collar is installed with the longer sleeve area up. **See Fig. 4.** If the collar is installed upside down, the engine brake cylinder will not operate.

2. Make sure the retaining ring ears are rotated 90 degrees after installation.
3. Install the rocker cover. For instructions, refer to **Subject 150.**



1. Longer Sleeve Area Up

Fig. 4, Check the Valve Collar

Removal

1. Park the vehicle, apply the parking brakes, shut down the engine, and chock the tires.
2. Disconnect the batteries.
3. Tilt the hood.

WARNING: Never remove any engine brake component with the engine running. Hot oil spray may cause personal injury.

4. Remove the rocker cover. For instructions, refer to **Subject 150.**
5. Disconnect the wiring to the engine brake housings.
6. Remove the three bolts that hold each engine brake housing.
7. Remove the engine brake housings.

Installation

1. Place the two engine brake housings over the rocker shafts with the solenoid valves toward the camshaft side of the engine.
2. Move the housings from side to side, then position the housings in the center of the movement range.
3. Tighten the engine brake hold-down bolts.
   - 3.1 Tighten the two bolts on the camshaft side of the engine 40 lbf·ft (55 N·m).
   - 3.2 Tighten the four bolts on the exhaust side of the engine 40 lbf·ft (55 N·m).
   - 3.3 Repeat the previous two steps, but tighten the bolts 100 lbf·ft (135 N·m).
   - 3.4 Check the torque of all the hold-down bolts, and torque to 100 lbf·ft (135 N·m) if needed.
   - 3.5 Reset the engine brake lash. For instructions, refer to **Subject 160.**
   - 3.6 Connect the engine brake wiring.
   - 3.7 Connect the batteries.
   - 3.8 Install the rocker cover. For instructions, refer to **Subject 150.**

Master Piston Removal, Inspection, and Installation

Removal

1. Remove the engine brake housing from the vehicle. For instructions, refer to **Subject 120.**
2. Remove the screw, washer, and master piston spring from the housing. **See Fig. 1.**
3. Using needle nose pliers if necessary, pull out the master piston. **See Fig. 2.**

Inspection

1. Clean the piston in a cleaning solvent.
2. Inspect the piston for excessive wear and for damage. Replace the piston if necessary.

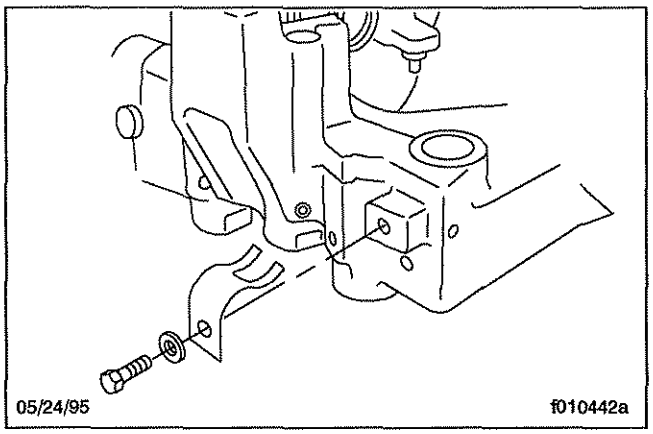


Fig. 1, Remove the Master Piston Spring

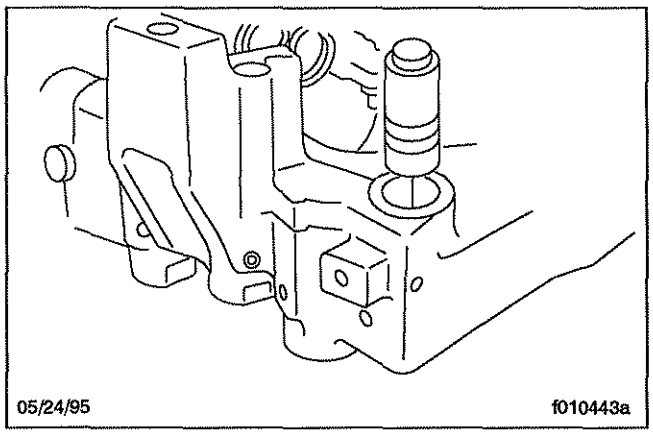


Fig. 2, Remove the Master Piston

Installation

1. Coat the piston with clean lube oil.
2. Install the master piston, spring, washer, and screw in the housing. **See Fig. 3.**

NOTE: Make sure the spring legs are centered around the master piston boss.

3. Tighten the screw 100 lbf·in (1120 N·cm).

IMPORTANT: The spring must hold the master piston completely in the housing. If not, the spring has relaxed and must be replaced.

4. Install the engine brake housing on the vehicle. For instructions, refer to **Subject 120.**

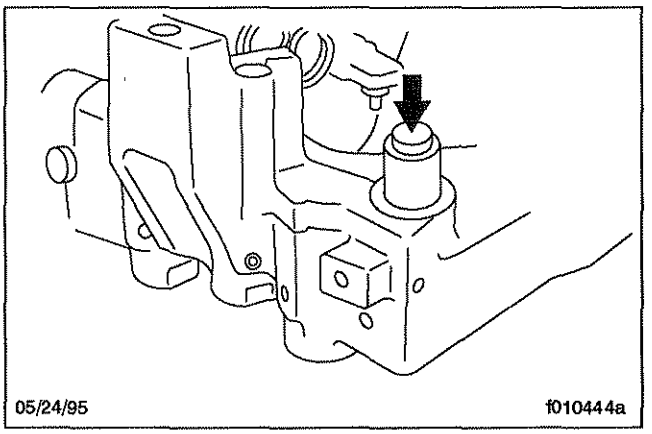


Fig. 3, Install the Master Piston

Master Piston Pin and Roller Removal, Cleaning, and Installation

Removal

The injector rocker arm contains a pin and roller for actuating the engine brake master piston. If excessive wear or damage to the roller is present, the injector rocker arm assembly must be replaced according to the following procedure.

1. Remove the engine brake housing from the vehicle. For instructions, refer to **Subject 120.**
2. Loosen the locknuts on the intake, exhaust, and injector adjusting screws.
3. Remove the bolts, spacers, and nuts from the rocker shafts. **See Fig. 1.**
4. Lift off the rocker arm assembly. **See Fig. 2.**
5. Slide the rockers off the shaft (**Fig. 3**), marking the parts so they can be installed in the same order.

Cleaning

1. Clean the rocker arms and rocker arm shafts in a solvent.
2. Dry the components with compressed air.
3. Inspect the injector rocker arm assemblies, and replace any assembly that has a damaged roller.

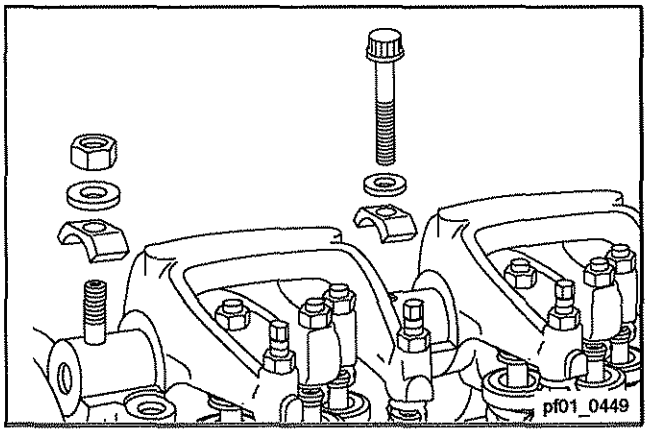


Fig. 1, Remove the Bolts from the Rocker Shaft

Installation

1. Assemble the rockers on the shaft in the order they were removed. **See Fig. 4.**
2. Check the torque on the rocker shaft studs to be sure they were not loosened when the nuts were removed (**Fig. 5**). Tighten the studs 80 lbf·ft (110 N·m).
3. Install the rocker shaft assembly using the bolts, end spacers, and nuts. Using the sequence shown in **Fig. 6**, tighten the bolts and nuts 80 lbf·ft (110 N·m).
4. Install the engine brake housing on the vehicle. For instructions, refer to **Subject 120.**

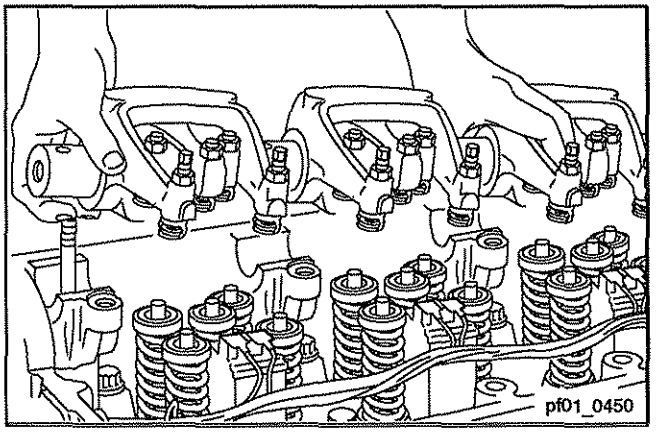


Fig. 2, Remove the Rocker Arm Assembly

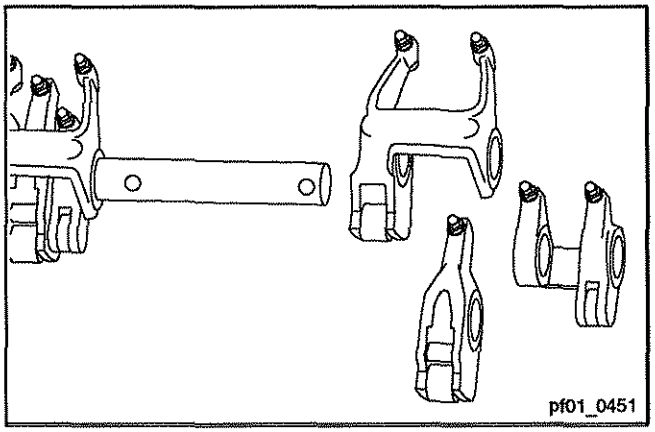


Fig. 3, Remove the Rockers

Master Piston Pin and Roller Removal, Cleaning, and Installation

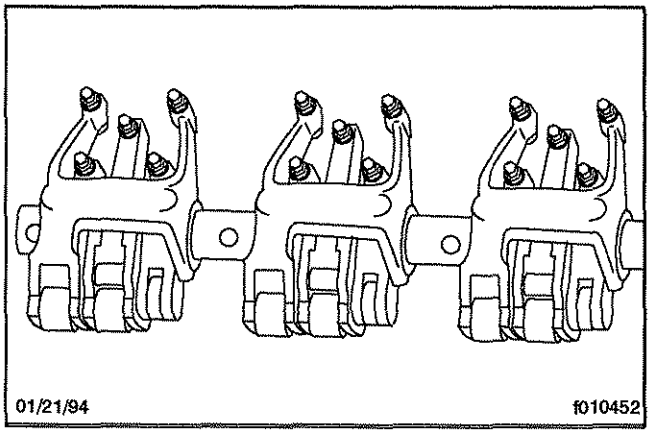


Fig. 4, Assemble the Rockers

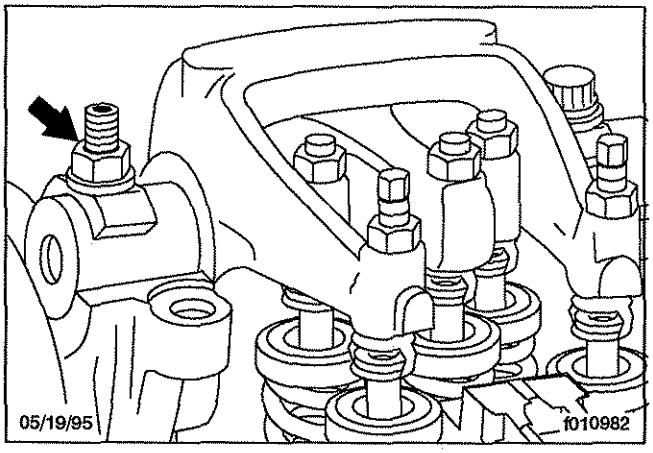


Fig. 5, Rocker Shaft Stud Nut

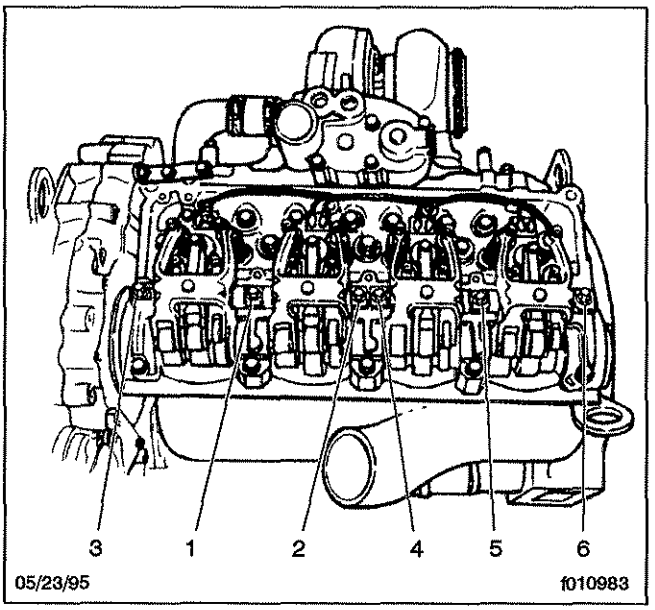


Fig. 6, Rocker Shaft Tightening Sequence

Removal

1. Apply the parking brakes, chock the tires, shut down the engine, and tilt the hood.
2. Disconnect the batteries.

WARNING: Never remove any engine brake component with the engine running. Hot oil spray may cause personal injury.

3. Wipe the engine brake housing area clean.
4. Remove the bolts that hold the rocker cover, and remove the rocker cover. **See Fig. 1.**

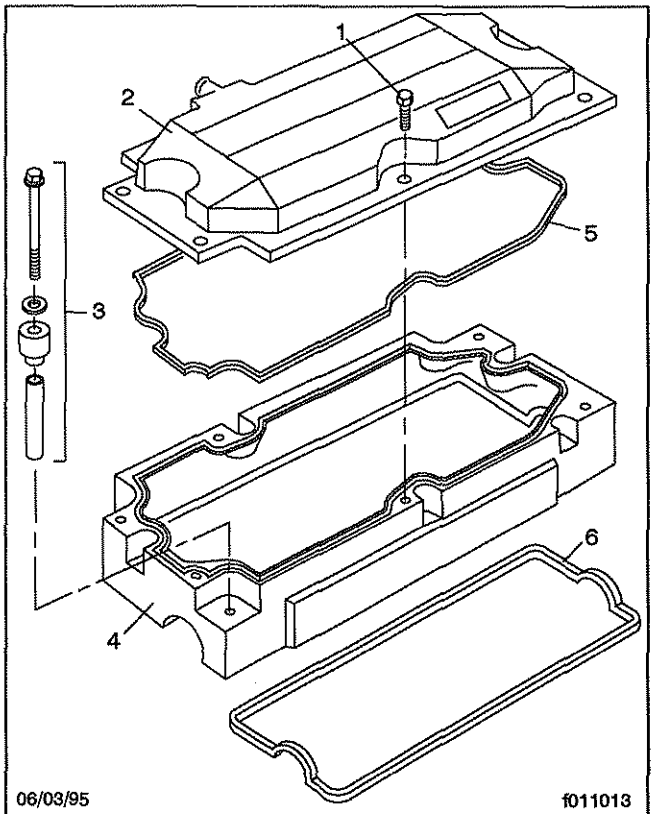
Installation

1. Lubricate the valve cover limiting sleeves with clean silicone spray. Insert the sleeves into the isolators until the end of the sleeve is flush with the isolator. **See Fig. 2.**
2. Install the hold-down bolts, with washers installed, to the limiting sleeves.
3. Install the hold-down bolt assemblies to the rocker cover base, and thread the bolts two to three threads into the cylinder head.

CAUTION: Use care, when tightening the rocker cover base hold-down bolts, that the injector wires do not get caught between the limiting sleeve and the cylinder head.

4. Tighten the eight rocker cover base hold-down bolts 25 lbf·ft (35 N·m) using the tightening sequence shown in **Fig. 3.** Tighten the bolts in two stages, using half-torque value first.
5. Be sure the groove in the top of the rocker cover base and its mating, diamond-shaped seal are clean and dry.
6. Press the diamond-shaped seal into the groove. Use care not to twist the seal. The seal has a definite shape and should be installed exactly as removed from the base.

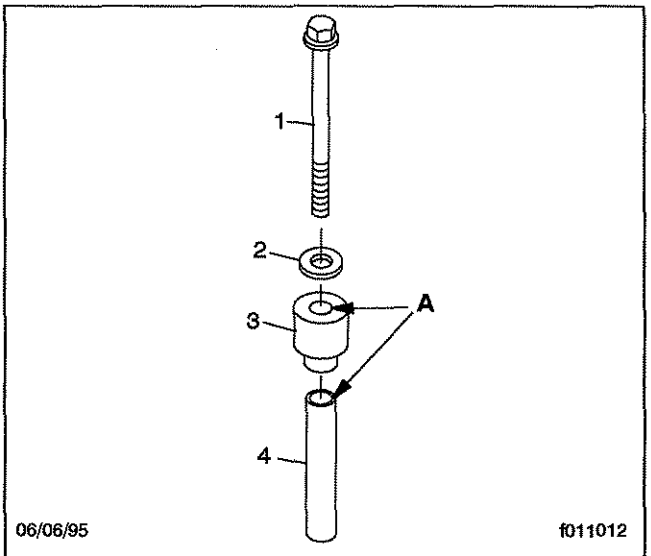
   If the seal cannot be installed into its groove without bunching or looping, the seal is stretched and must be replaced.
7. Install the rocker cover cap to the base. Install the eight screws that attach the cap to the base and tighten the screws 20 lbf·ft (25 N·m) in two stages, using half-torque value first. Use the torque sequence shown in **Fig. 4.**
8. Connect the batteries.
9. Remove the chocks from the tires.



1. Rocker Cover Cap Screw
2. Rocker Cover Cap
3. Hold-Down Bolt Assembly
4. Rocker Cover Base
5. Rocker Cover Cap Gasket
6. Rocker Cover Base Gasket

Fig. 1, Rocker Cover Components

Rocker Cover Removal and Installation



A. Insert the sleeve until the end is flush with the isolator.

1. Bolt
2. Flatwasher
3. Isolator
4. Limiting Sleeve

Fig. 2, Rocker Cover Fasteners

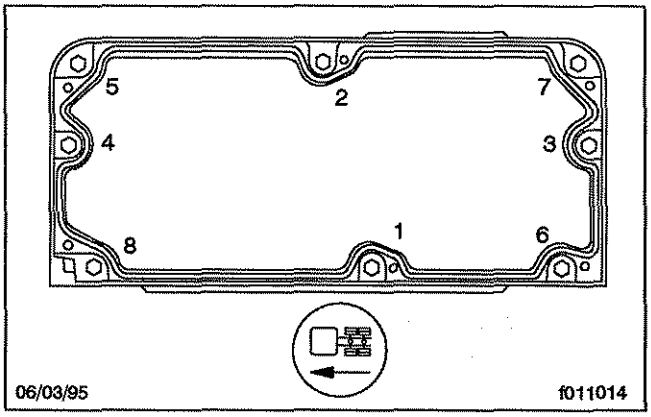


Fig. 3, Bolt Tightening Sequence

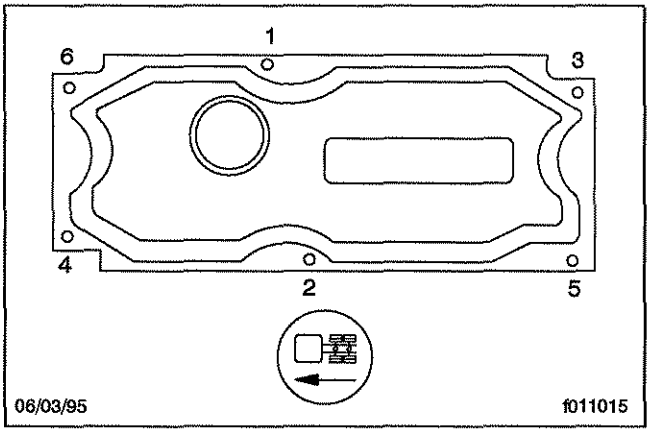


Fig. 4, Cover Screw Tightening Sequence

Slave Piston Adjusting Screw (Reset®) Removal, Inspection, and Installation

Removal

1. Remove the rocker cover. For instructions, refer to **Subject 150.**

CAUTION: Do not adjust or tamper with the adjusting screw assembly. Engine damage could result.

2. Loosen the slave piston adjusting screw locknut, and remove the adjusting screw from the housing. **See Fig. 1.**

Inspection

1. Clean the adjusting screw in cleaning solvent.
2. Inspect the slave piston adjusting screw. The plunger should protrude from the bottom of the screw. There should be light spring pressure when the plunger is depressed, and the plunger should move freely. **See Fig. 2.** Be sure the retaining ring is fully engaged in its groove. If any defect is found, replace the entire screw assembly.

Installation

1. Screw the slave piston adjusting screw into the housing.
2. Tighten the locknut 25 lbf·ft (35 N·m).

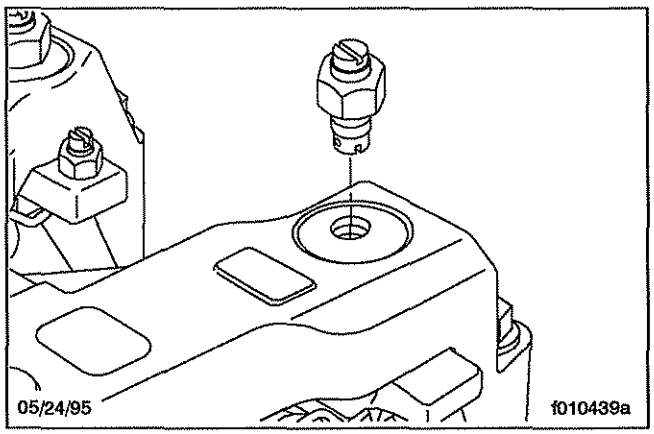


Fig. 1, Remove the Adjusting Screw

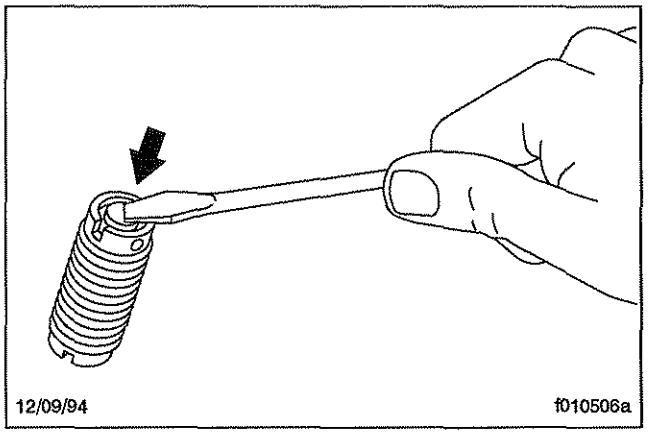


Fig. 2, Check the Plunger

Slave Piston Removal, Inspection, and Installation

Removal

1. Remove the engine brake housing from the vehicle using the instructions in **Subject 120.**
2. Remove the screw and spring that retain the slave piston assembly. **See Fig. 1.**
3. Remove the bridge and the slave piston. **See Fig. 2.**
4. Loosen the leveling screw locknut and remove the leveling screw from the bridge. **See Fig. 3.**

Inspection

1. Inspect all components for excessive wear and for damage.
2. Replace parts as needed.

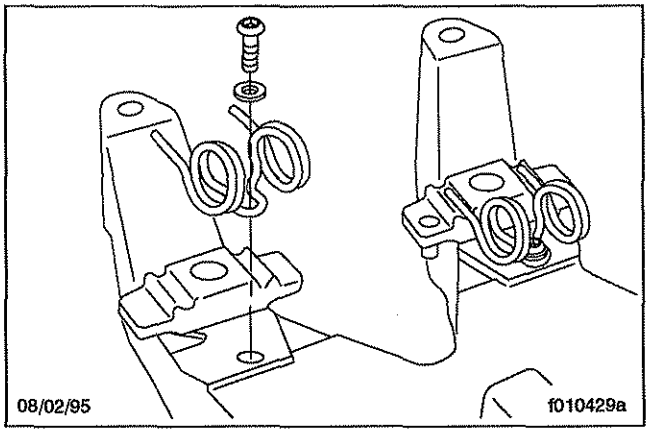


Fig. 1, Remove the Screw and Spring

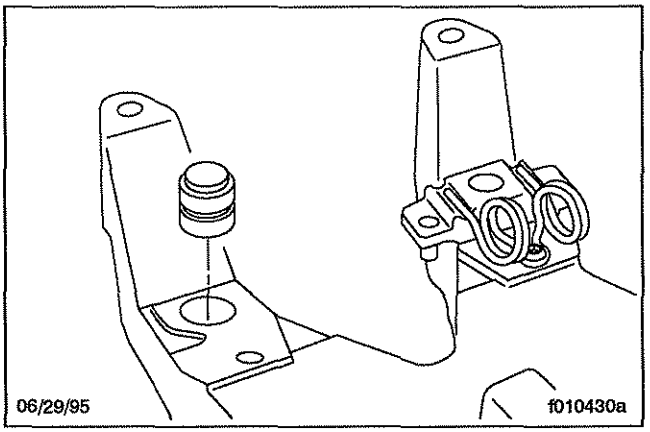


Fig. 2, Remove the Slave Piston

Installation

1. Install the leveling screw in the bridge. **See Fig. 3.** Tighten the locknut 25 lbf·ft (35 N·m).
2. Install the slave piston and the bridge with the leveling screw toward the center of the housing. **See Fig. 4.**
3. Install the slave piston assembly retaining spring with the ends over the bridge. **See Fig. 5.**
4. Install the screw over the center part of the spring. Tighten the screw 15 lbf·ft (20 N·m).
5. Install the engine brake housing on the engine using the instructions in **Subject 120.**

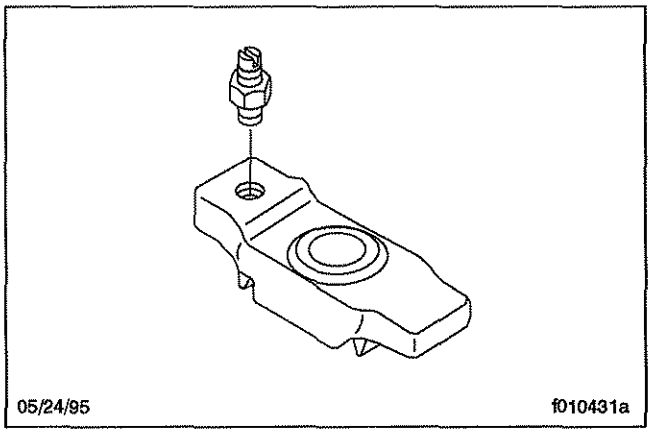


Fig. 3, Remove the Leveling Screw

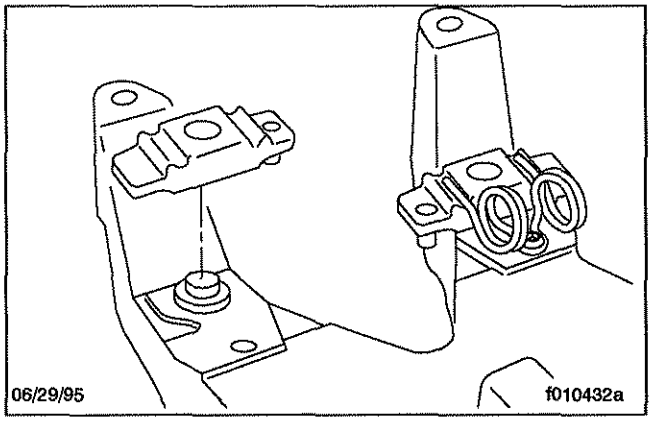


Fig. 4, Install the Slave Piston and Bridge

Slave Piston Removal, Inspection, and Installation

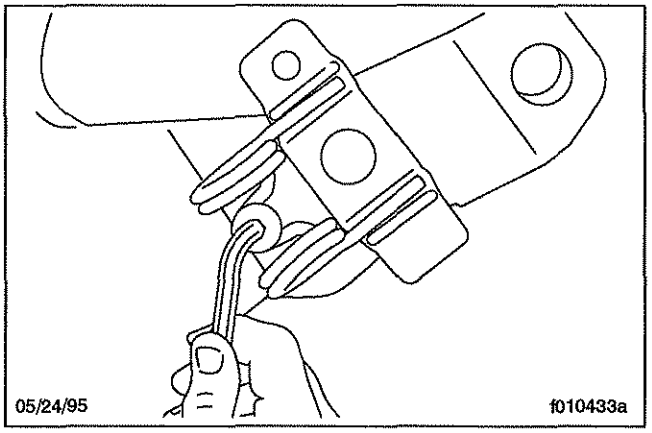


Fig. 5, Install the Retaining Spring

Removal

1. Remove the rocker cover. For instructions, refer to **Subject 150.**
2. Disconnect the solenoid harness.
3. Using a 7/8-inch socket and extension, unscrew the solenoid valve. **See Fig. 1.**

CAUTION: Do not disassemble or tamper with the solenoid valve. Engine damage could result.

4. Remove and discard the three rubber seal rings. **See Fig. 2.** If the lower ring stays in the bottom of the solenoid bore in the housing, remove it with a piece of wire.
5. Wash out the solenoid valve with a cleaning solvent. Use a brush to clean the oil screen.
6. Dry the valve with compressed air.
7. Using clean paper towels, clean out the solenoid valve bore in the housing. Do not use rags, since they can leave lint and residue, which can plug the oil passageways.

Installation

1. Coat a new set of solenoid seal rings with clean lubricating oil. Install the upper and middle seal rings on the solenoid body and the lower seal ring into the bottom of the solenoid bore in the housing. **See Fig. 3.**

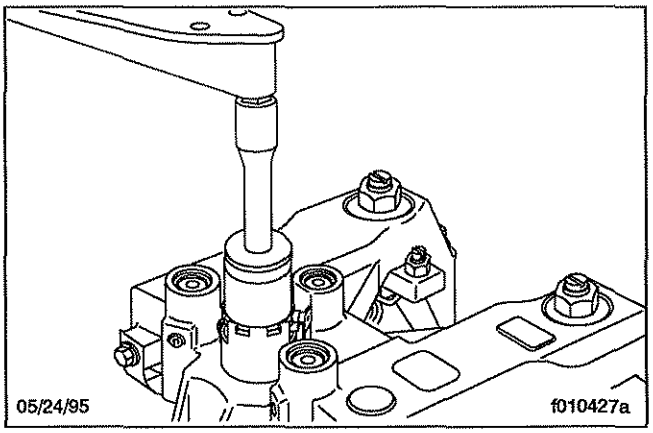
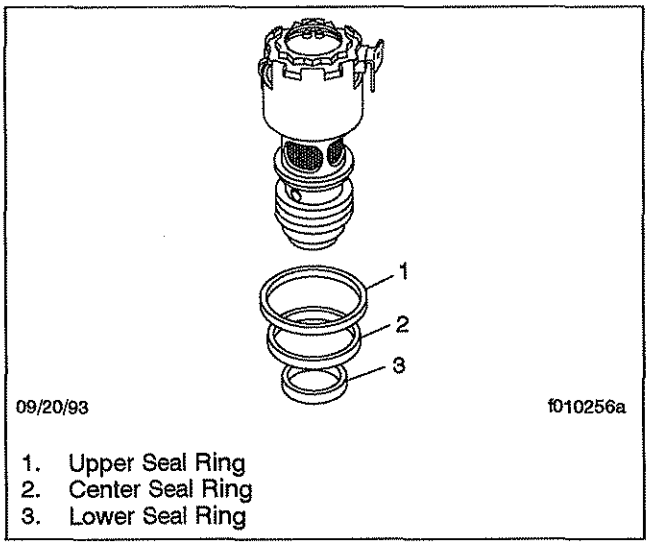


Fig. 1, Unscrew the Solenoid Valve

2. Make sure the seals are seated properly and not twisted. Carefully screw the solenoid into the housing without unseating the seals.
3. Tighten the valve to the torque specification shown on top of the solenoid.
4. Connect the solenoid harness.



1. Upper Seal Ring
2. Center Seal Ring
3. Lower Seal Ring

Fig. 2, Solenoid Seal Rings

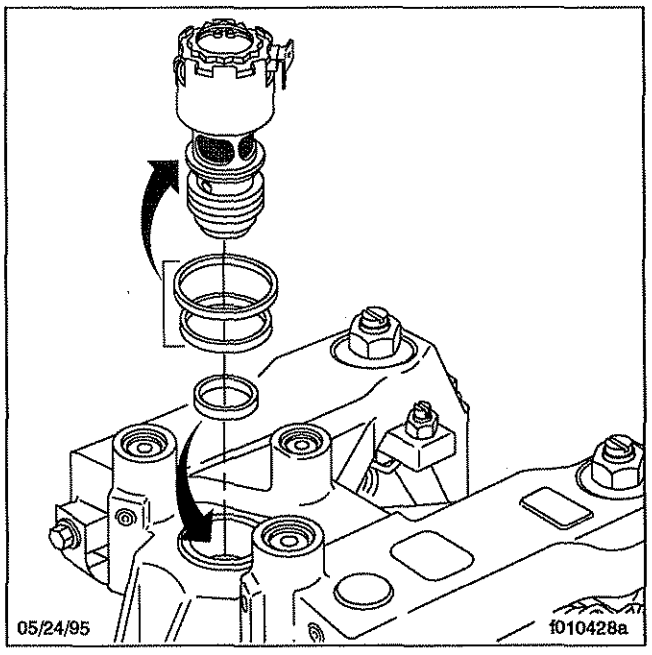


Fig. 3, Install the Seal Rings

Solenoid Valve Removal and Installation

5. Install the rocker cover. For instructions, refer to **Subject 150.**

Contents

Subject	Subject Number
General Information	050
Service Operations	
Accumulator Removal, Inspection, and Installation	100
Solenoid Valve Removal and Installation	110
Control Valve Removal, Inspection, and Installation	120
Engine Brake Housing Removal and Installation	130
Master Piston Removal, Inspection, and Installation	140
Slave Piston Adjusting Screw (Power-Lash®) Removal, Inspection, and Installation	150
Slave Piston Removal, Inspection, Installation, and Adjusting	160

For troubleshooting procedures, refer to **Section 01.12** in this manual.

General Information

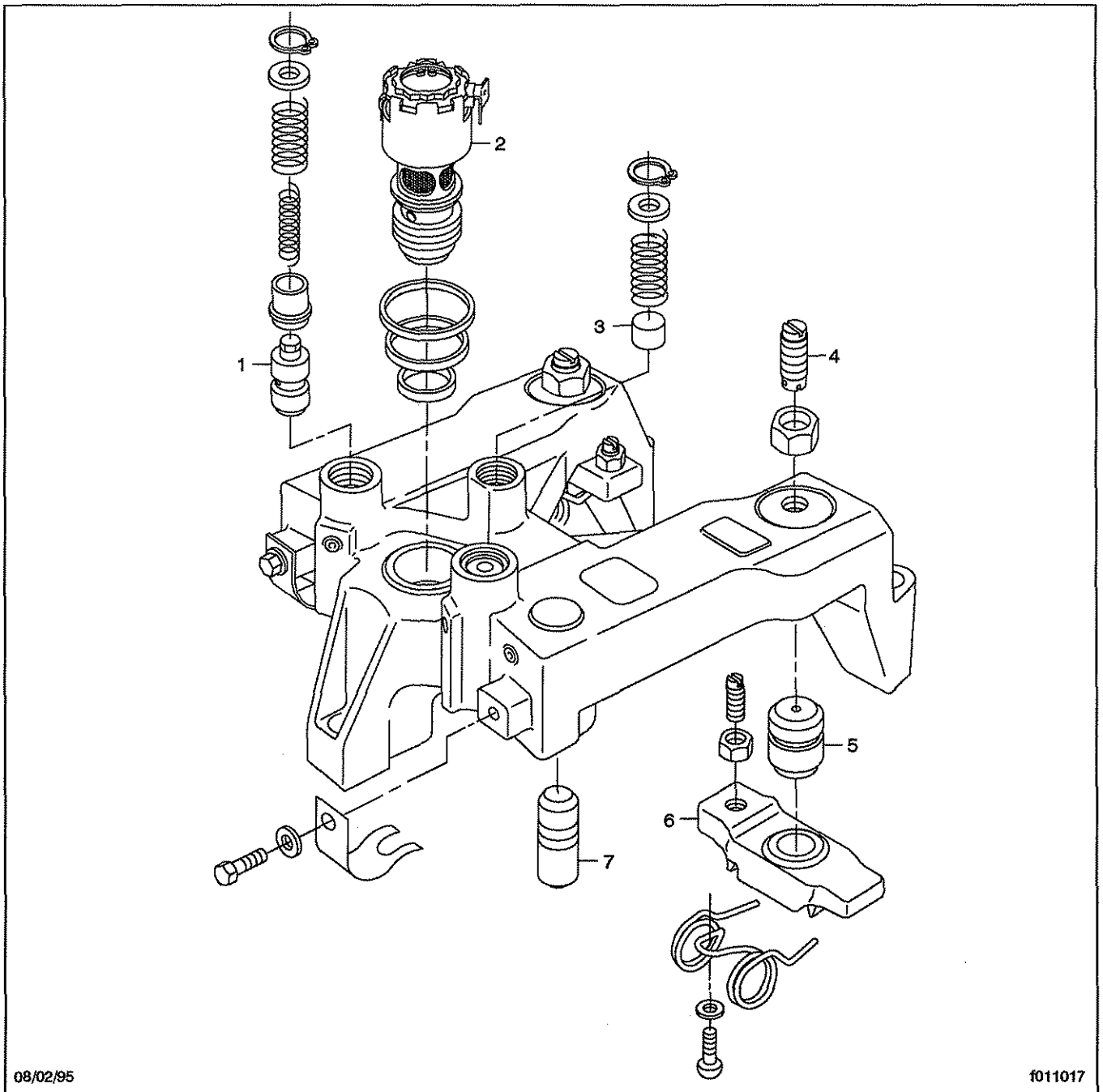
Jacobs engine brake housings are installed on the engine rocker housings. Model 760A (used on Detroit Diesel Series 60 11.1 liter engines) and Model 765 (used on Detroit Diesel Series 60 12.7 liter engines) have three engine brake housings that operate two cylinders each. Each engine brake housing has a solenoid valve, control valves, ball check valves, master pistons, and slave pistons. **See Fig. 1.**

Engine brake controls consist of: dash switches and a clutch switch. The clutch switch is mounted under the dash. The engine brake is activated when the dash switches are on and the clutch and throttle pedals are released. The dash switches enable the driver to operate the engine brake partially or fully.

The engine brake can be operated at one-third, two-thirds, or full capacity (two, four, or six cylinders).

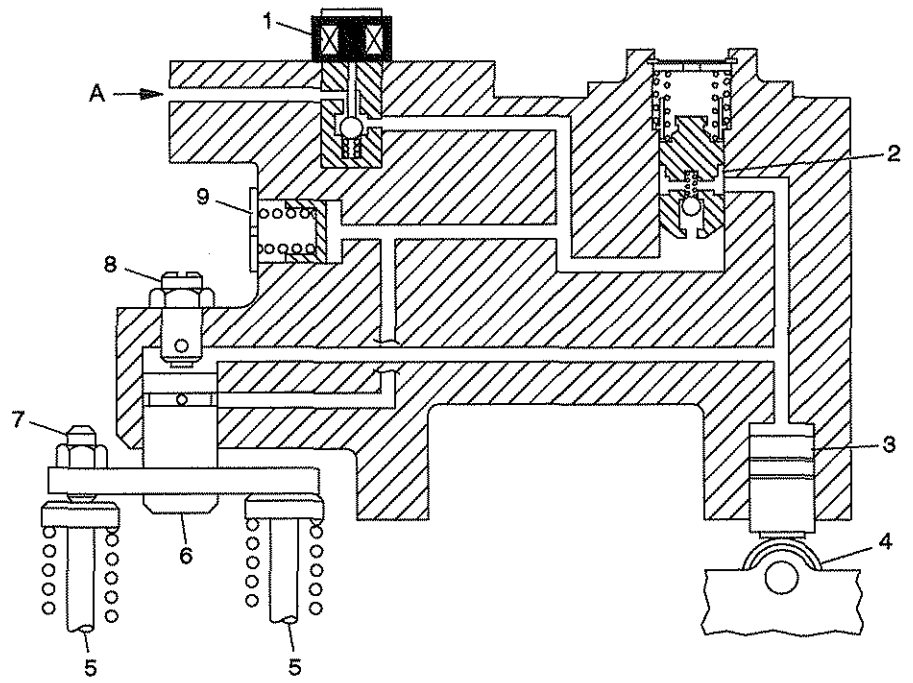
When activated, the engine brake converts a power-producing diesel engine to a power-absorbing air compressor. This is accomplished by motion transfer through a master-slave piston arrangement which opens the engine cylinder exhaust valves near the top of the normal compression stroke, releasing the compressed cylinder charge to exhaust. The blowdown of compressed air to atmospheric pressure prevents the return of energy to the engine piston on the expansion (power) stroke. This results in a net energy loss because the work done in compressing the cylinder charge is not returned during the expansion process. Exhaust blowdown occurs as follows (**see Fig. 2**):

1. Activating the engine brake energizes the solenoid valve, allowing engine oil to flow under pressure through the control valve to both the master piston and the slave piston.
2. Oil pressure causes the master piston to move down, coming to rest on the injector rocker arm roller.
3. The injector rocker arm begins upward travel (as in the normal injection cycle) forcing the master piston upward and creating a high-pressure oil flow to the slave piston. The ball check valve in the control valve holds the high-pressure oil in the master-slave piston system.
4. When the engine piston is near top dead center, the slave piston moves down under the influence of the high-pressure oil flow. This momentarily opens the exhaust valves, releasing compressed cylinder air to the exhaust manifold.
5. At the bottom of its stroke the slave piston separates from the valve in the slave piston reset adjusting screw, allowing high-pressure oil to flow into the accumulator. This reduces the pressure in the high-pressure circuit, permitting the slave piston to retract and the exhaust valves to close in preparation for the normal exhaust valve cycle. The oil pressure reserved in the accumulator ensures that the hydraulic circuit is fully charged for the next cycle.
6. Compressed air escapes to the atmosphere completing a compression braking cycle.



1. Control Valve
2. Solenoid Valve
3. Accumulator Piston
4. Slave Piston Adjusting Screw (Reset)
5. Slave Piston
6. Bridge
7. Master Piston

Fig. 1, Exploded View, Model 760A or 765 Housing Assembly



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A. Oil In

1. Solenoid Valve
2. Control Valve
3. Master Piston
4. Injector Pin and Roller
5. Exhaust Valve
6. Slave Piston Assembly
7. Leveling Screw
8. Slave Piston Adjusting Screw (Reset)
9. Accumulator

Fig. 2

Accumulator Removal, Inspection, and Installation

Removal

WARNING: The accumulator spring is under strong compression. Be careful when removing the retaining ring and cover. Wear safety glasses. If the spring is accidentally released, personal injury could result.

1. Remove the engine brake housing from the vehicle. For instructions, refer to **Subject 130.**
2. Push down on the accumulator cover and remove the retaining ring. **See Fig. 1.**
3. Remove the cover and spring. **See Fig. 2.**
4. Using a magnet, remove the piston from the accumulator bore. **See Fig. 3.**

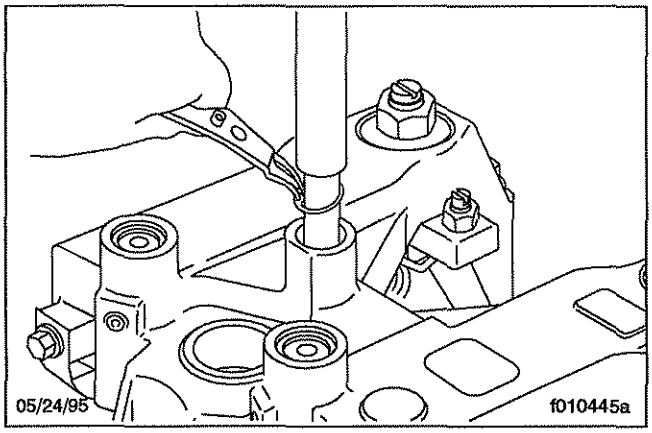


Fig. 1, Remove the Retaining Ring

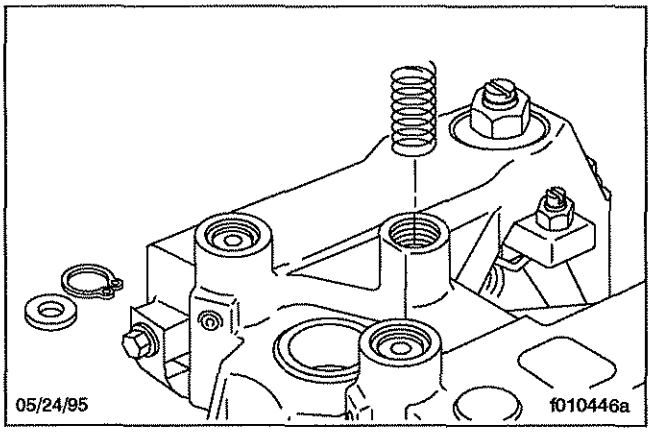


Fig. 2, Remove the Spring

Inspection

Inspect the parts for wear and damage. Replace parts as needed.

Installation

1. Install the piston, spring, cover, and retaining ring.
2. Install the engine brake housing. For instructions, refer to **Subject 130.**

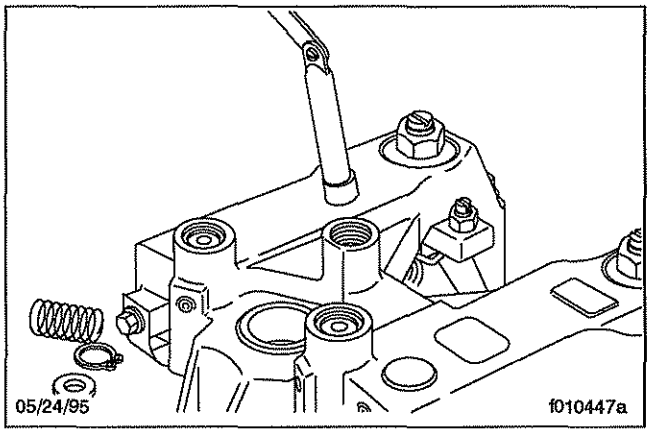


Fig. 3, Remove the Piston

Solenoid Valve Removal and Installation

Removal

1. Park the vehicle, apply the parking brakes, and chock the tires.
2. Disconnect the batteries.
3. Tilt the hood.
4. Wipe the engine brake housing area clean, and remove the valve cover. For instructions, refer to the engine manufacturer's service literature.
5. Disconnect the solenoid harness.
6. Using a 7/8-inch socket and extension, unscrew the solenoid valve. **See Fig. 1.**

CAUTION: Do not disassemble or tamper with the solenoid valve. Engine damage could result.

7. Remove and discard the three rubber seal rings. **See Fig. 2.** If the lower ring stays in the bottom of the solenoid bore in the housing, remove it with a piece of wire.
8. Wash out the solenoid valve with a cleaning solvent that meets OSHA guidlines. Use a brush to clean the oil screen.
9. Dry the valve with compressed air.
10. Using clean paper towels, clean out the solenoid valve bore in the housing. Do not use rags, since they can leave lint and residue, which can plug the oil passageways.

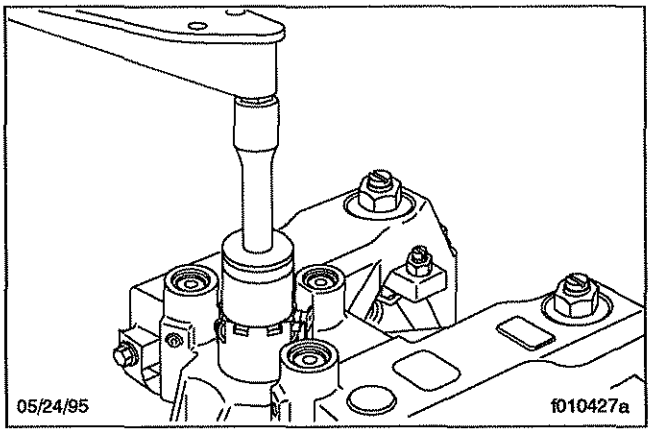
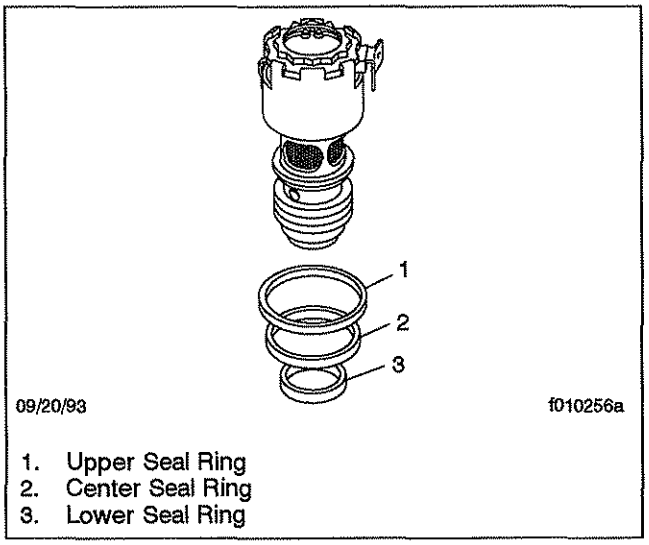


Fig. 1, Unscrew the Solenoid Valve

Installation

1. Coat a new set of solenoid seal rings with clean lubricating oil. Install the upper and middle seal rings on the solenoid body and the lower seal ring into the bottom of the solenoid bore in the housing. **See Fig. 3.**
2. Make sure the seals are seated properly and not twisted. Carefully screw the solenoid into the housing without unseating the seals.
3. Tighten the valve to the torque shown on the top of the solenoid.
4. Connect the solenoid harness.
5. Install the valve cover. For instructions, refer to the engine manufacturer's service literature.
6. Close the hood, connect the batteries, and remove the chocks from the tires.



1. Upper Seal Ring
2. Center Seal Ring
3. Lower Seal Ring

Fig. 2, Solenoid Seal Rings

Solenoid Valve Removal and Installation

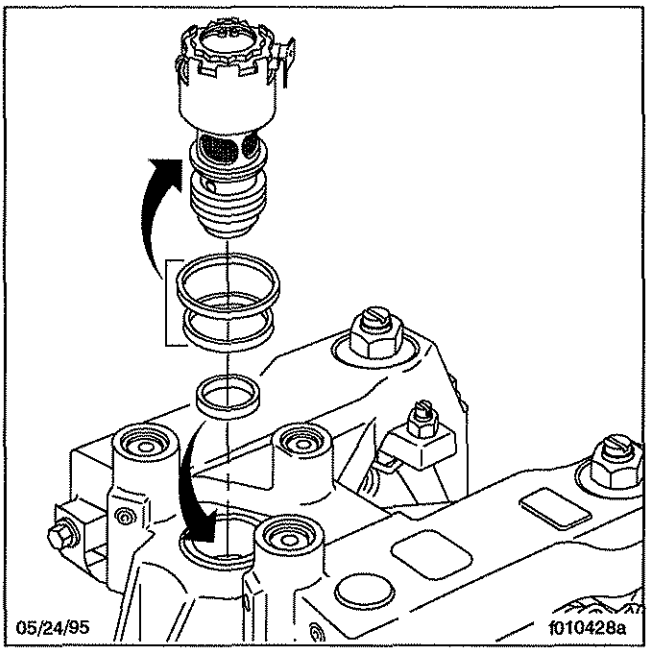


Fig. 3, Install the Seal Rings

Control Valve Removal, Inspection, and Installation

Removal

WARNING: Never remove any engine brake component with the engine running. Hot oil spray may cause personal injury.

1. Park the vehicle, apply the parking brakes, and chock the tires.
2. Disconnect the batteries.
3. Tilt the hood.
4. Wipe the engine brake housing area clean, and remove the valve cover. For instructions, refer to the engine manufacturer's service literature.
5. Press down on the control valve cover to relieve spring pressure. **See Fig. 1.**
6. Remove the retaining ring using retaining ring pliers.
7. Slowly remove the cover until the spring pressure is released; then, remove the two control valve springs and the collar. **See Fig. 2.**
8. Using needle nose pliers, reach into the housing bore and grasp the stem of the control valve. Remove the control valve. **See Fig. 3.**

Inspection

1. Wash the control valves with a cleaning solvent that meets OSHA guidelines.

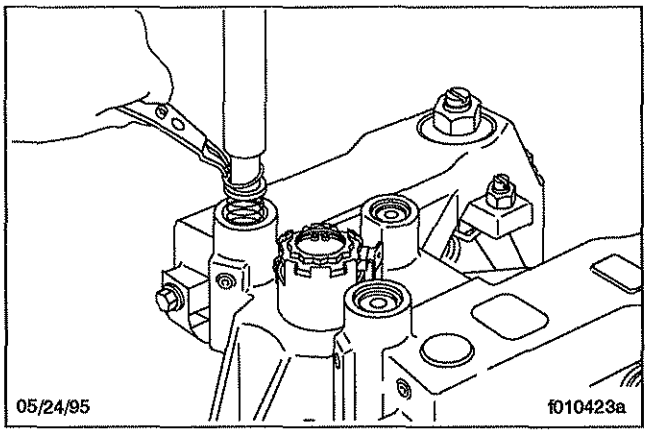


Fig. 1, Press the Control Valve Cover

2. Push a wire through the hole in the base of the valve to make sure the ball check is free. The ball should lift with light pressure on the wire.
3. Dry the valve with compressed air and wipe it clean with a paper towel.
4. Using clean paper towels, thoroughly clean the control valve bore in the housing.
5. Dip the control valves in clean lubricating oil. Holding the valve by the stem, let the valve drop into its bore. If it binds or if the ball is stuck in the valve, replace the control valve.

Installation

IMPORTANT: Be sure to coat all parts with clean lubricating oil before installing them.

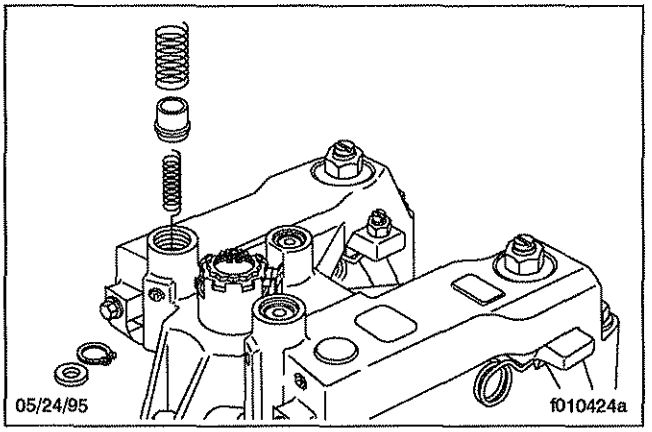


Fig. 2, Remove the Springs and the Collar

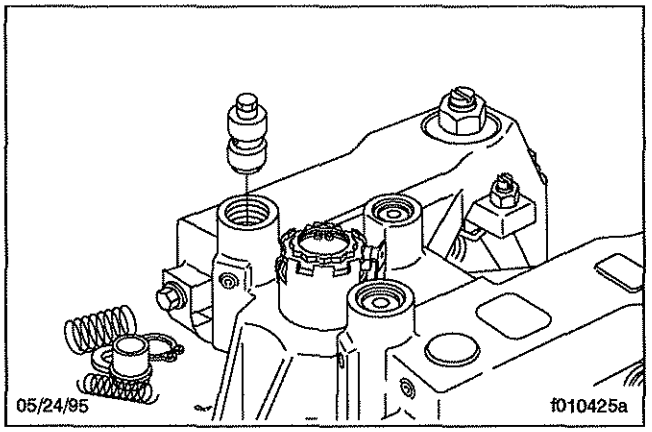


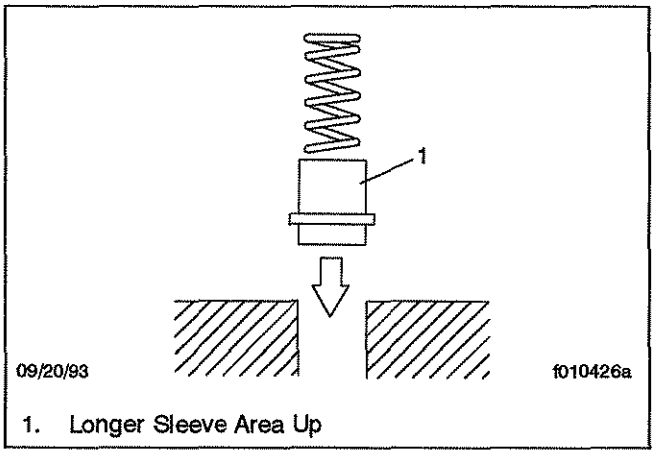
Fig. 3, Remove the Control Valve

Control Valve Removal, Inspection, and Installation

1. Install the control valve reversing the removal procedure.

NOTE: Make sure the control valve collar is installed with the longer sleeve area up. **See Fig. 4.** If the collar is installed upside down, the engine brake cylinder will not operate.

2. Make sure the retaining ring ears are rotated 90 degrees after installation.
3. Install the valve cover. For instructions, refer to the engine manufacturer's service literature.
4. Close the hood, connect the batteries, and remove the chocks from the tires.



1. Longer Sleeve Area Up

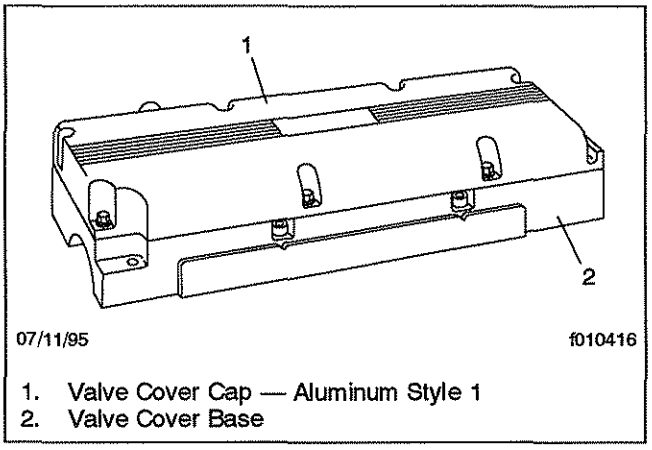
Fig. 4, Check the Valve Collar

Engine Brake Housing Removal and Installation

Removal

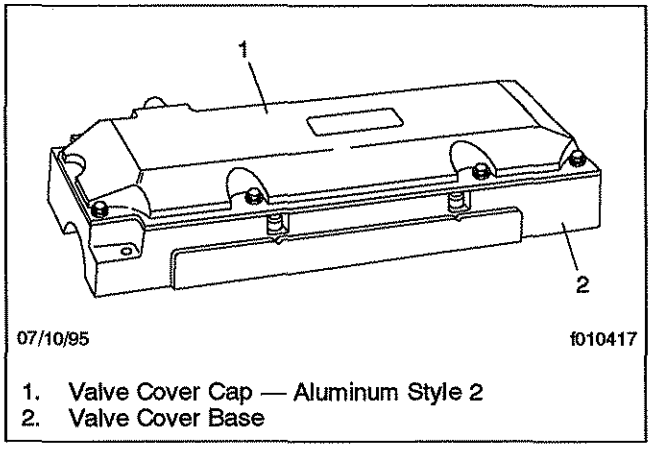
NOTE: The engine brake has been designed to fit on the Series 60 engine with no additional valve cover spacers. On engines equipped with aluminum valve cover caps (**Fig. 1** and **Fig. 2**), it is not necessary to remove the valve cover bases to remove and install the engine brake housings.

1. Park the vehicle, apply the parking brakes, and chock the tires.
2. Tilt the hood.
3. Disconnect the batteries.
4. Remove each valve cover and gasket.



1. Valve Cover Cap — Aluminum Style 1
2. Valve Cover Base

Fig. 1, Valve Cover Cap and Base, Style 1



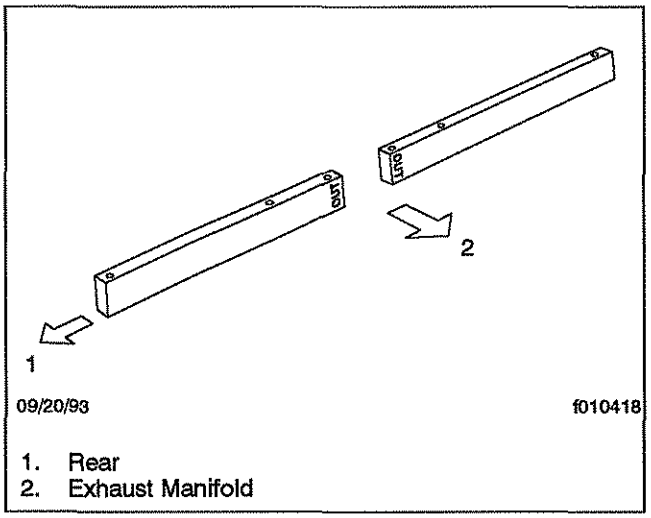
1. Valve Cover Cap — Aluminum Style 2
2. Valve Cover Base

Fig. 2, Valve Cover Cap and Base, Style 2

5. Remove the engine brake housing hold-down capscrews. There is one capscrew per housing on the camshaft side of the engine. There are two capscrews per housing on the exhaust manifold side of the engine.
6. Remove the spacer bar between the exhaust side of each head and each engine brake housing mounting pad.
7. Lift each engine brake housing off the rocker shaft.

Installation

1. Place the spacer bars between the cylinder head and the engine brake mounting pads on the exhaust manifold side of the head. **See Fig. 3** and **Fig. 4.**
2. Place each engine brake housing over the rocker shaft with the solenoid valves toward the camshaft side of the engine. Make sure the housings don't interfere with the wiring harness.
3. Apply "Never Seize" to the threads and underside of the head of the housing hold-down capscrews.
4. Install a 4-3/8 inch (110 mm) long capscrew and its washer into each engine brake housing. **See Fig. 5** and **Fig. 6**. There are three capscrews per housing.



1. Rear
2. Exhaust Manifold

Fig. 3, Spacer Bar Positions

Engine Brake Housing Removal and Installation

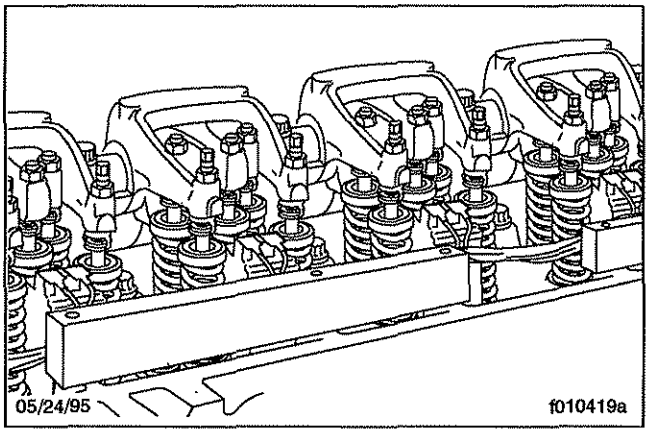


Fig. 4, Spacer Bar Placement

5. Before tightening the engine brake hold-down capscrew, move the housing from side to side, and then locate the housing in the center of the range. **See Fig. 7.**

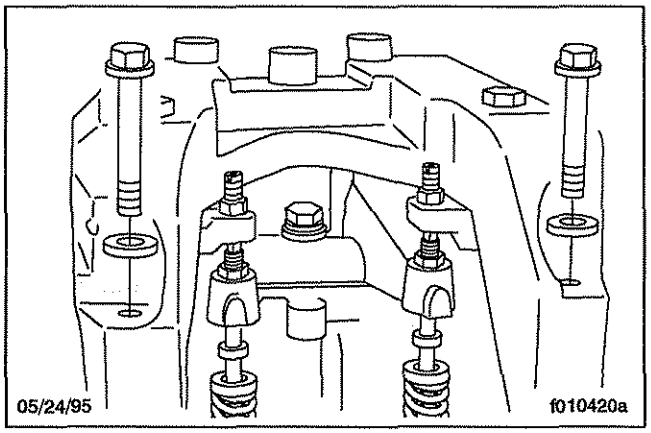


Fig. 5, Capscrews on the Exhaust Manifold Side

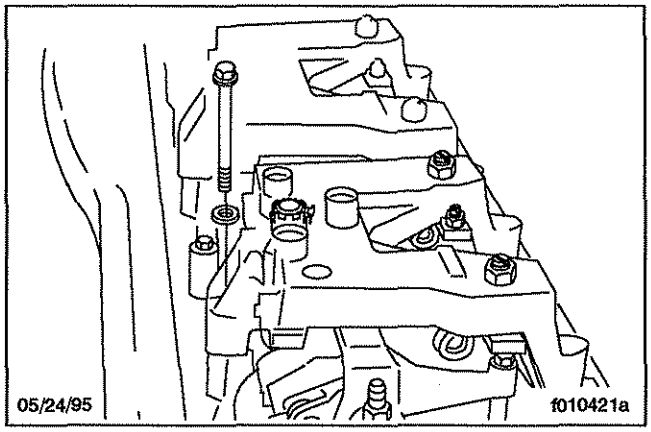


Fig. 6, Capscrew on the Camshaft Side

6. Tighten the engine brake housing hold-down capscrews.
   - 6.1 Tighten the three capscrews on the camshaft side of the engine 40 lbf·ft (55 N·m).
   - 6.2 Tighten the six capscrews on the exhaust manifold side of the engine 40 lbf·ft (55 N·m).
   - 6.3 In the same sequence, tighten all capscrews 100 lbf·ft (135 N·m).
7. Using plastic ties, secure the wiring harnesses to the spacer bars.
8. Adjust the slave piston lash. For instructions, refer to **Subject 150**.
9. Install the valve covers. For instructions, refer to the engine manufacturer's service manual.
10. Close the hood, connect the batteries, and remove the chocks from the tires.

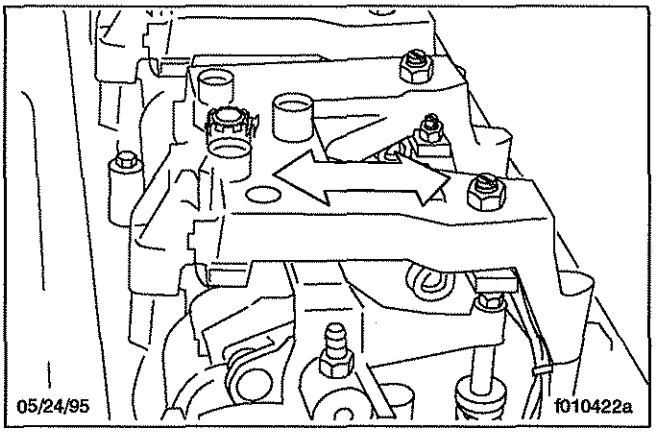


Fig. 7, Center the Housing

Master Piston Removal, Inspection, and Installation

Removal

1. Remove the engine brake housing from the vehicle. For instructions, refer to **Subject 130.**
2. Remove the screw, washer, and master piston spring from the housing. **See Fig. 1.**
3. Using needle nose pliers if necessary, pull out the master piston. **See Fig. 2.**

Inspection

1. Clean the piston in a cleaning solvent.
2. Inspect the piston for excessive wear and for damage. Replace the piston if necessary.

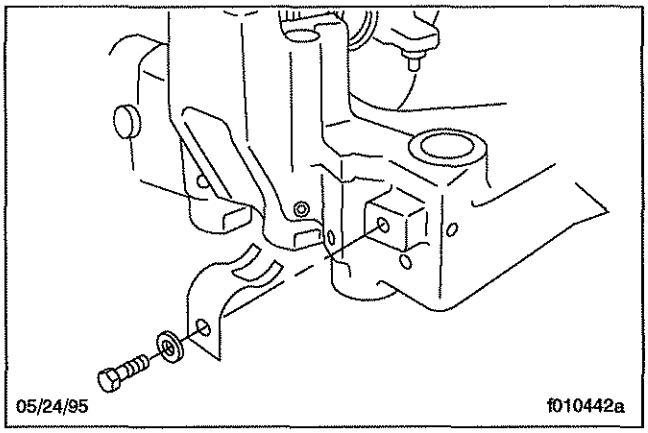


Fig. 1, Remove the Master Piston Spring

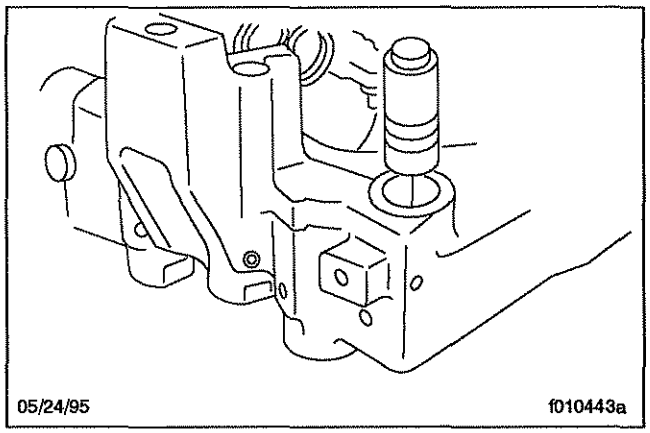


Fig. 2, Remove the Master Piston

Installation

1. Install the master piston, spring, washer, and screw in the housing. **See Fig. 3.**

NOTE: Make sure the spring legs are centered around the master piston boss.

2. Tighten the screw 100 lbf·in (1120 N·cm).
3. Install the engine brake housing on the vehicle. For instructions, refer to **Subject 130.**
4. Reset the engine brake lash. For instructions, refer to **Subject 160.**

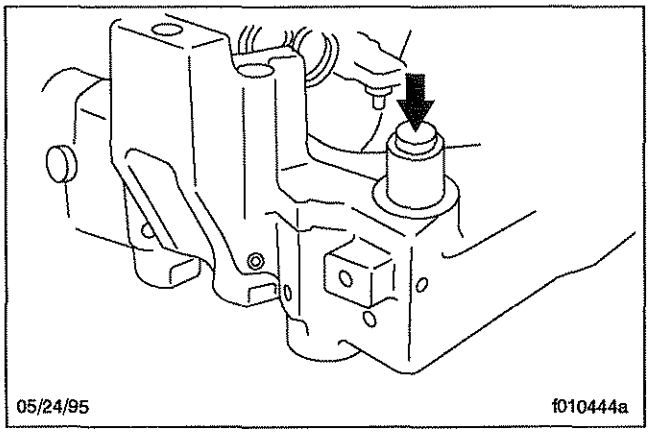


Fig. 3, Install the Master Piston

Slave Piston Adjusting Screw (Power-Lash®) Removal, Inspection, and Installation

Removal

1. Park the vehicle, apply the parking brakes, and chock the tires.
2. Disconnect the batteries.
3. Tilt the hood.
4. Wipe the engine brake housing area clean, and remove the valve cover. For instructions, refer to the engine manufacturer's service literature.
5. Loosen the slave piston adjusting screw locknut and remove the adjusting screw from the housing. **See Fig. 1.**

Inspection

1. Clean the adjusting screw in cleaning solvent.
2. Inspect the slave piston adjusting screw. The plunger should protrude from the bottom of the screw. There should be light spring pressure when the plunger is depressed, and the plunger should move freely. **See Fig. 2.** Be sure the retaining ring is fully engaged in its groove. If any defect is found, replace the entire screw assembly.

CAUTION: Do not disassemble or tamper with the slave piston adjusting screw assembly. Engine damage could result.

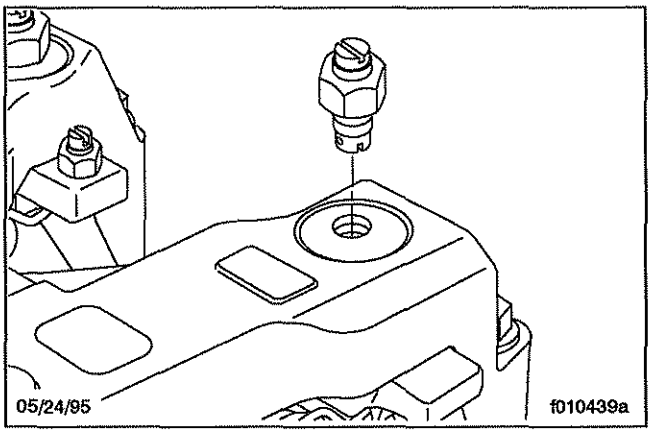


Fig. 1, Remove the Adjusting Screw

Installation

1. Screw the slave piston adjusting screw into the housing.
2. Reset the engine brake lash. For instructions, refer to **Subject 160.**

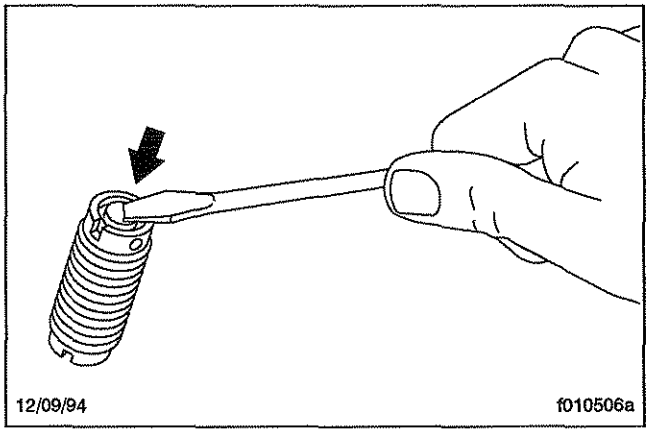


Fig. 2, Check the Plunger

Slave Piston Removal, Inspection, Installation, and Adjusting

Removal

1. Remove the engine brake housing from the vehicle using the instructions in **Subject 130.**
2. Remove the screw and spring that retain the slave piston assembly. **See Fig. 1.**
3. Remove the bridge and the slave piston. **See Fig. 2.**
4. Loosen the leveling screw locknut and remove the leveling screw from the bridge. **See Fig. 3.**

Inspection

1. Inspect all components for excessive wear and for damage.
2. Replace parts as needed.

Installation

1. Install the leveling screw in the bridge. **See Fig. 3.** Tighten the locknut 25 lbf·ft (35 N·m).
2. Install the slave piston and the bridge with the leveling screw toward the center of the housing. **See Fig. 4.**
3. Install the slave piston assembly retaining spring with the ends over the bridge. **See Fig. 5.**
4. Install the screw over the center part of the spring. Tighten the screw 15 lbf·ft (20 N·m).
5. Install the engine brake housing on the engine using the instructions in **Subject 130.**

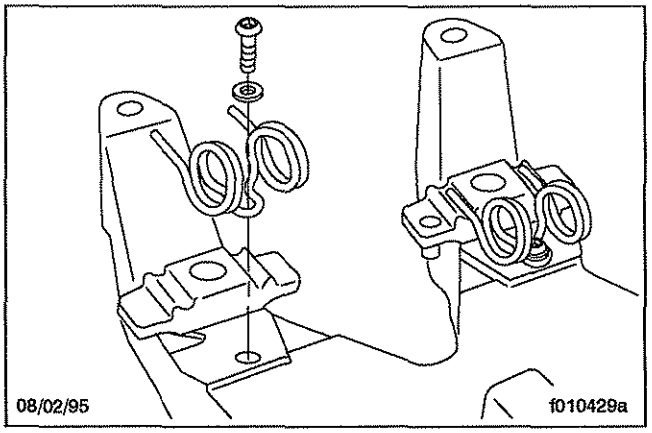


Fig. 1, Remove the Screw and Spring

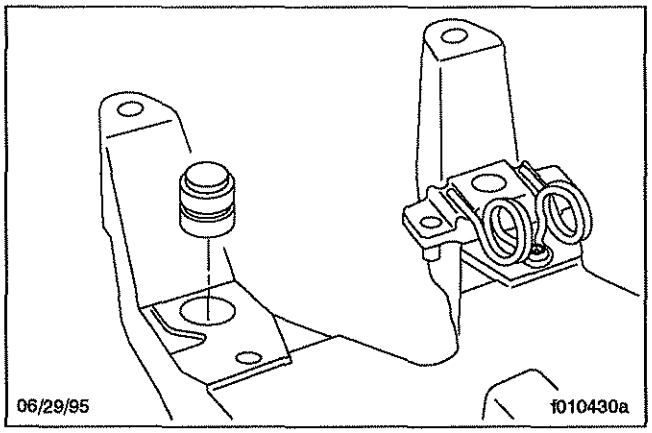


Fig. 2, Remove the Slave Piston

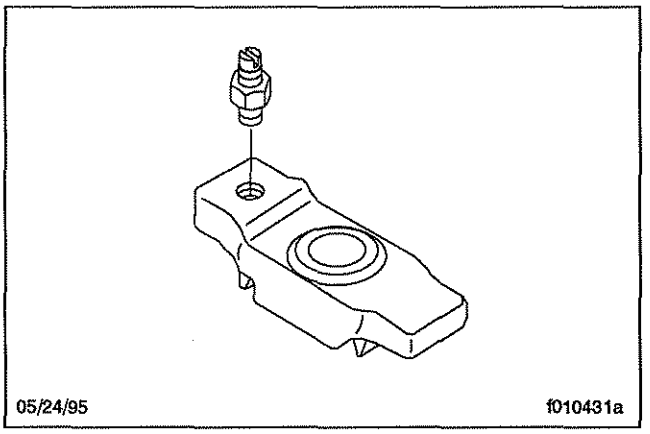


Fig. 3, Remove the Leveling Screw

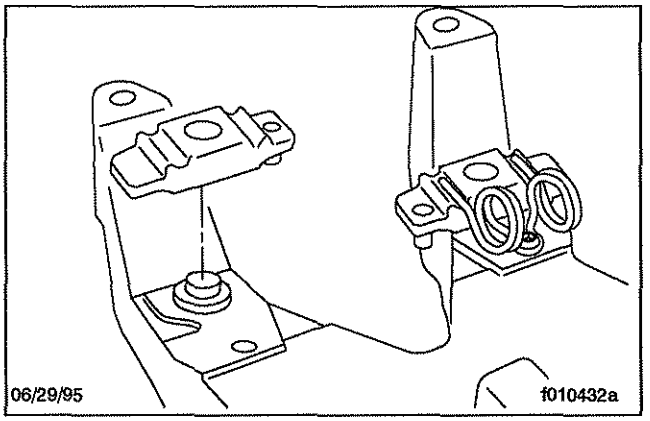


Fig. 4, Install the Slave Piston and Bridge

Slave Piston Removal, Inspection, Installation, and Adjusting

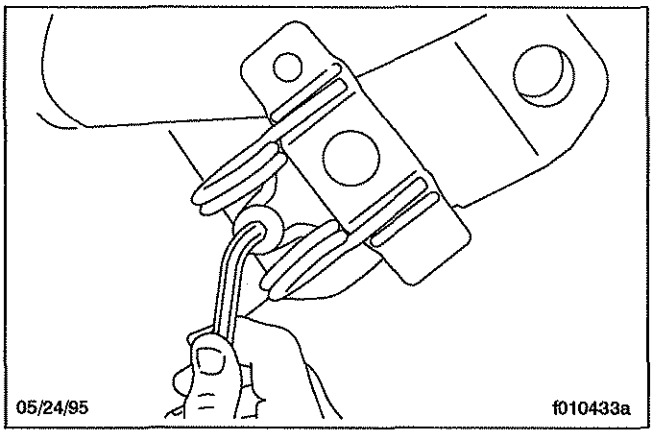


Fig. 5, Install the Retaining Spring

Adjusting

CAUTION: Follow the slave piston adjustment procedure exactly. Failure to use the correct adjustment procedure will result in poor engine brake performance and serious engine damage.

NOTE: Make the following adjustment with the engine stopped and the oil temperature 140°F (60°C) or lower. Rotate the engine until the exhaust valves on the cylinder to be adjusted are closed (rocker arm is loose).

1. Back out the *leveling screw* in the slave piston assembly until the end of the screw is beneath the surface of the bridge in the slave piston assembly. **See Fig. 6.**

NOTE: The leveling screw is the screw located in the bridge member of the slave piston assembly.

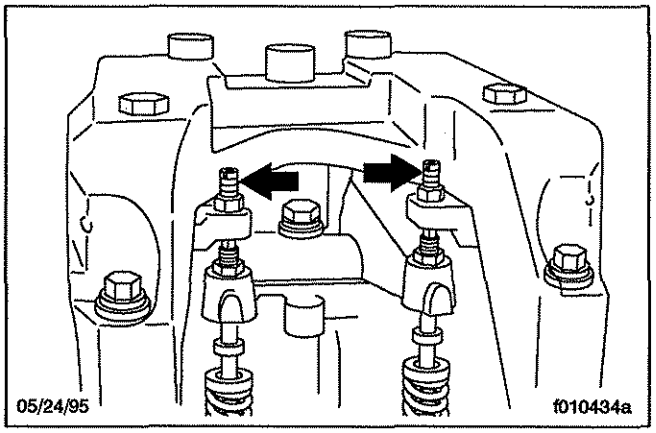


Fig. 6, Back Out the Leveling Screw

2. Place the correct feeler gauge between the solid side of the *bridge* (the side without the leveling screw) and the exhaust rocker arm adjusting screw. **See Fig. 7. See Table 1** for the correct feeler gauge.

Engine Model (Displacement)	Feeler Gauge inches (mm)
12.7 liter	0.026 (0.6)
11.1 liter	

Table 1, Feeler Gauges

NOTE: A "G" in position 5 of the model number indicates a 12.7 liter engine; "W" indicates an 11.1 liter engine. Typical model numbers: 6067GU40 or 6067WU40. The model number is stamped on the engine block beneath the intake manifold. **See Fig. 8.**

3. Turn the slave piston adjusting screw clockwise until a light drag is felt on the feeler gauge.
4. While holding the screw in this position, tighten the locknut 25 lbf·ft (35 N·m). **See Fig. 9.**

IMPORTANT: The slave piston adjusting screws used in the Model 760 Engine Brake are Reset® screws. Do not disassemble these Reset screws in the field.

5. Following the same procedure, set 0.020-inch (0.5-mm) clearance between the slave piston leveling screw and the rocker arm adjusting screw. **See Fig. 10.**
6. While holding the leveling screw in this position, tighten the locknut 35 lbf·ft (47 N·m).

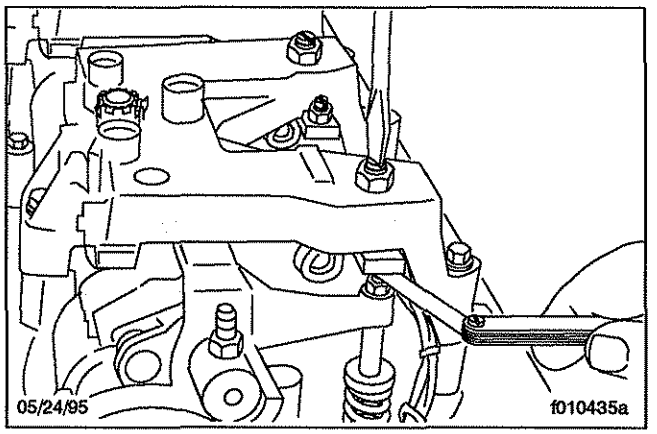
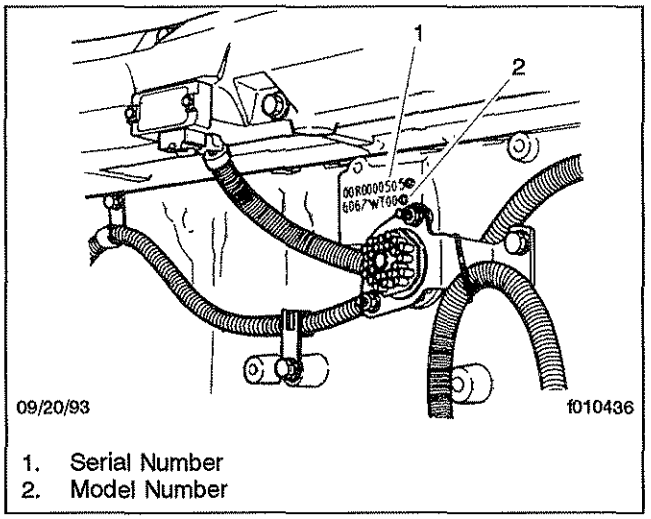


Fig. 7, Check With the Feeler Gauge



1. Serial Number
2. Model Number

Fig. 8, Engine Brake Identification

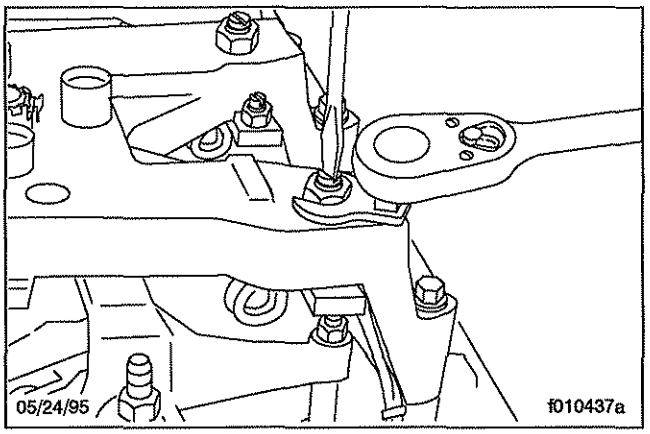


Fig. 9, Tighten the Adjusting Screw Locknut

7. Repeat the steps above for slave pistons of the remaining cylinders. Rotate the engine to close the exhaust valves for the cylinder being adjusted.

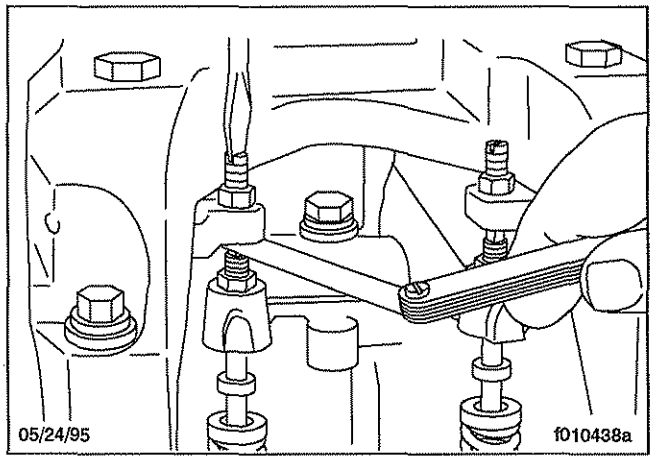


Fig. 10, Check the Clearance

Engine Brake Troubleshooting

01.12

Contents

Subject	Subject Number
Troubleshooting	300

For engine brake service procedures, refer to the **applicable section** for your model of engine brake in this workshop manual group.

Troubleshooting Charts

Problem—Engine Will Not Start

Possible Cause	Remedy
The solenoid valve is stuck in the "on" position.	Make sure the electrical current to the engine brake is off. If the solenoid valve stays "on" (cap down) with the current off, replace the solenoid valve.

Problem—Engine Brake Will Not Function

Possible Cause	Remedy
An electrical lead is open.	Replace any broken wires.
The clutch switch is malfunctioning.	**WARNING: Do not touch the electrical connections when the engine brake system is energized. Touching the connections could possibly cause electrical shock.** Use a volt/ohmmeter to make sure there is electrical current at both terminals of the switch. If voltage will not pass through the switch, replace it.
The engine oil pressure is too low.	Determine the oil pressure at the engine brakes. Refer to the **applicable section** for your engine brake. If the oil pressure is below specifications, repair the engine following the manufacturer's procedures.
The throttle switch is malfunctioning.	Check for correct operation of the throttle.

Problem—Engine Brake Engages With the Switches Off

Possible Cause	Remedy
The solenoid valve center seal ring is damaged.	Remove the solenoid. Replace all the seal rings.
The engine brake is incorrectly wired.	Check the wiring against the Jacobs wiring diagram.

Problem—Engine Brake Weak or Slow to Engage

Possible Cause	Remedy
The lubricating oil is too cold and thick.	Allow the engine to warm up before operating the Jake Brake.
The slave piston is adjusted incorrectly or is binding in its bore.	**WARNING: Slave piston springs are under heavy compression. Remove the slave piston carefully when disassembly is necessary. Use either an arbor press or C-clamp. Failure to follow this procedure could result in personal injury.** Adjust the slave piston.Make sure it responds smoothly to the adjusting screw— loosen the jam nut and screw the adjusting screw through its full range for full slave piston travel. Make sure the piston travels the full range without binding or sticking.
The solenoid lower seal is damaged, allowing oil to escape the housing.	Remove the solenoid valve and replace all the seal rings.
The solenoid screen is clogged, stopping the supply of oil to the engine brake.	Remov the solenoid valve; clean or replace the screen.

01.12 Engine Brake Troubleshooting

Troubleshooting

Possible Cause	Remedy
The master piston is not moving in its bore.	Inspect the master piston and bore for scoring or burrs. If any are present, clean the surface with a crocus cloth. If the burrs cannot be removed, replace the piston or housing. Inspect the lubricating oil for signs of contaminants. If any are present, replace the oil and filters, and correct the cause of the contamination.
The control valves are binding in the housing bores.	Remove each control valve. If the body is scored, replace the valve. Check for contaminants in the lubricating oil. Clean the housing and control valve. If it still binds, replace the housing.
The control valves are malfunctioning.	Remove each control valve. Make sure the check ball is seating in the bore and that it can be moved off the seat. Make sure there is spring pressure against the ball. Flush the valve in diesel fuel. Replace the control valve if needed.
Dash switches, clutch switch, or throttle switch has sluggish operation.	Adjust or replace the switch. Check the throttle or clutch return springs for proper operation.
The electrical insulation of the solenoid valve is breaking down.	**WARNING: Do not touch the electrical connections when the engine brake system is energized. Touching the connections could possibly cause electrical shock.** Make sure the solenoid valve meets electrical specifications. If not, replace the solenoid valve.
The engine brake housing plugs are leaking.	Check the plugs for signs of leaks. If leaks are found, remove the plugs, clean the threads, and install the plugs. Thread locking compound may help. Tighten the plugs 115 lbf·in (1300 N·cm).
The outer control valve spring is broken, or the engine oil pressure is extremely high.	Replace the outer control valve spring. Refer to the engine manufacturer's service manual for causes of high oil pressure.
The upper solenoid seal ring is damaged, causing oil pressure to drop below the minimum required for engine brake operation.	Remove the solenoid. Inspect the seal rings and replace them if needed.
The oil supply seals under or between the housings are damaged, causing oil pressure to drop below the minimum required for engine brake operation.	Remove the housings and replace the seals. Check for cracked or broken oil connectors. Replace the seals.
There is air in the lubricating oil, causing oil pressure to drop below the minimum required for engine brake operation.	Check for aeration of the oil. Turn the engine brake on, then off. Watch the escape oil coming from under the control valve cover. If the oil has bubbles or is foamy, air is present in the system. Aeration can be caused by an over-or underfilled crankcase, by cracks in the oil pickup tube, or by leaks in the oil suction tube or hose. Refer to the engine manufacturer's service manual for corrective measures.
The lubricating oil is being diluted by diesel fuel, causing oil pressure to drop below the minimum required for engine brake operation.	Have the lubricating oil analyzed to determine if fuel is present. Refer to the engine manufacturer's service manual for corrective measures.
The engine oil is low, causing oil pressure to drop below the minimum required for engine brake operation.	Refer to the engine manufacturer's service manual for specifications. Add oil or recalibrate the dipstick as required.
The engine rocker arm bushings are worn, causing oil pressure to drop below the minimum required for engine brake operation.	Replace the bushings. Refer to the engine manufacturer's service manual for instructions.

Possible Cause	Remedy
Oil is leaking around the cylinder heads, causing oil pressure to drop below the minimum required for engine brake operation.	Repair the cause of the leaks. Refer to the engine manufacturer's service manual for instructions.
Restrictions in the oil passage leading to the engine brake are causing oil pressure to drop below the minimum required for engine brake operation.	Inspect all the passageways; remove anything restricting the oil flow.

Problem—Engine Stalls or One or More Cylinders Continue Braking With the Dash Switches Off

Possible Cause	Remedy
The control valve inner spring is broken.	Replace the inner spring.
One or more control valves are stuck in the "on" (up) position.	Check the control valves for binding. Remove and clean or replace them if necessary. Inspect the lubrication oil for contaminants.
The solenoid valve is sticking in the "on" position.	If the solenoid valve cap remains down with no electric current being supplied, replace the solenoid valve.
The center solenoid seal ring is damaged, allowing oil to enter the engine brake with the solenoid valve closed.	Remove the solenoid and replace all the seal rings.
The solenoid valve exhaust is plugged.	Remove any restrictions at the exhaust (bottom) of the solenoid valve.
The dash switch is stuck in the "on" position.	Check for correct switch operation. Replace the switch as needed.

Problem—Engine Misses or Loses Power

Possible Cause	Remedy
The slave piston is adjusted too tight.	Adjust the slave piston. Refer to the **applicable section** for the engine brake model.

Problem— Sudden Drop in Engine Lubrication Oil Pressure

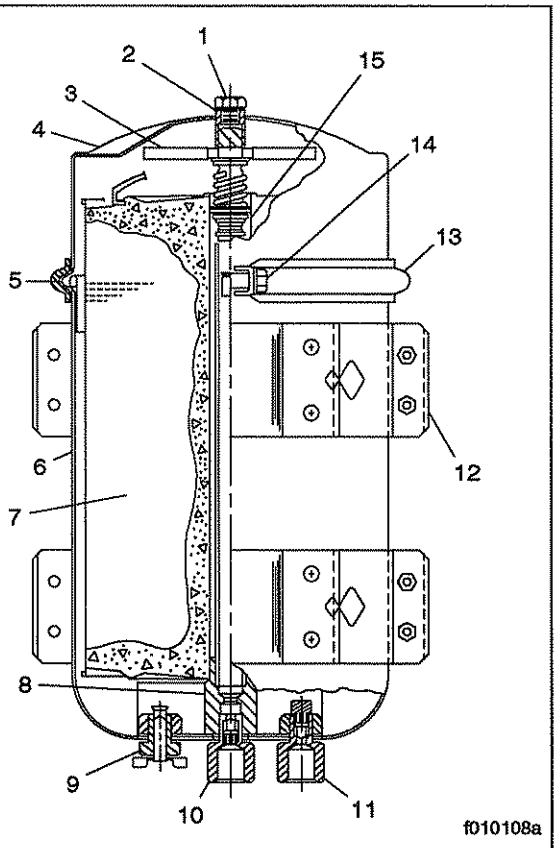
Possible Cause	Remedy
The oil inlet supply seal is missing or damaged.	Replace the seal.
The upper solenoid valve seal is missing or damaged.	Remove the solenoid and replace all the seal rings.
The external oil supply hoses or fittings are cracked and leaking.	Inspect all hoses and fittings for tightness, chafing, or cuts.

Oil Filter Element Replacement, Luber-finer® Model 750–CT

Replacement (See Fig. 1)

IMPORTANT: Do the following procedure at every scheduled engine oil change. Refer to the engine maintenance manual for the quantity of oil that must be added to the lubrication system when replacing the bypass filter.

1. Remove the old filter element.



1. Vent Plug Capscrew
2. Washer
3. T-Handle
4. Cover
5. Cover Gasket
6. Housing
7. Filter Element
8. Outlet Tube
9. Drain Cock
10. Outlet Check Valve Assembly
11. Inlet Check Valve Assembly
12. Mounting Bracket
13. Clamping Ring
14. Clamp-Ring Capscrew
15. Hold-Down Assembly

Fig. 1, Luber-finer Model 750–CT Bypass Oil Filter

1.1 Loosen the vent plug capscrew, then open the drain cock and allow the oil to drain.

1.2 Remove the clamp-ring capscrews. Remove the clamp ring and lift the cover off the filter housing.

1.3 Unscrew the hold-down assembly T-handle and remove the assembly from the housing.

1.4 Remove and discard the oil filter element.

2. Clean the inside of the housing, and the hold-down assembly, with solvent.

3. Assemble the filter.

3.1 Close the drain cock.

3.2 Install a new filter element.

3.3 Check the cover gasket for damage, and replace it if needed.

3.4 Install the hold-down assembly and securely tighten the T-handle.

3.5 Position the cover on the housing. Install the clamp ring and capscrews. Alternately tighten the clamp capscrews to ensure a uniform seal between the cover and gasket.

3.6 Add oil to the crankcase, then start the engine and let it idle until normal operating oil pressure is reached.

3.7 Loosen the vent plug capscrew and bleed any trapped air from the filter housing. Tighten the vent plug capscrew as soon as oil appears at the fitting.

CAUTION: Make sure the engine oil level is correct. Operating the engine with the oil level below the low ("L") mark, or above the high mark, could result in engine damage.

4. Shut down the engine and add oil as needed to bring the oil level up to the high ("H") mark on the dipstick.

Cleaning (See Fig. 1)

IMPORTANT: Do the following procedure at every scheduled engine oil change. Refer to the engine maintenance manual for the quantity of oil that must be added to the lubrication system when replacing the bypass filter.

1. Clean the centrifuge bowl.

   1.1 Shut off the engine, and let the centrifuge turbine assembly come to a complete stop.

   1.2 Loosen the handle on the clamp, disengage the tee bolt and remove the cover, using a coin in the gap to separate the cover from the housing.

   1.3 Partially withdraw the centrifuge turbine assembly from the housing and allow oil to drain from the nozzles before removing the assembly completely.

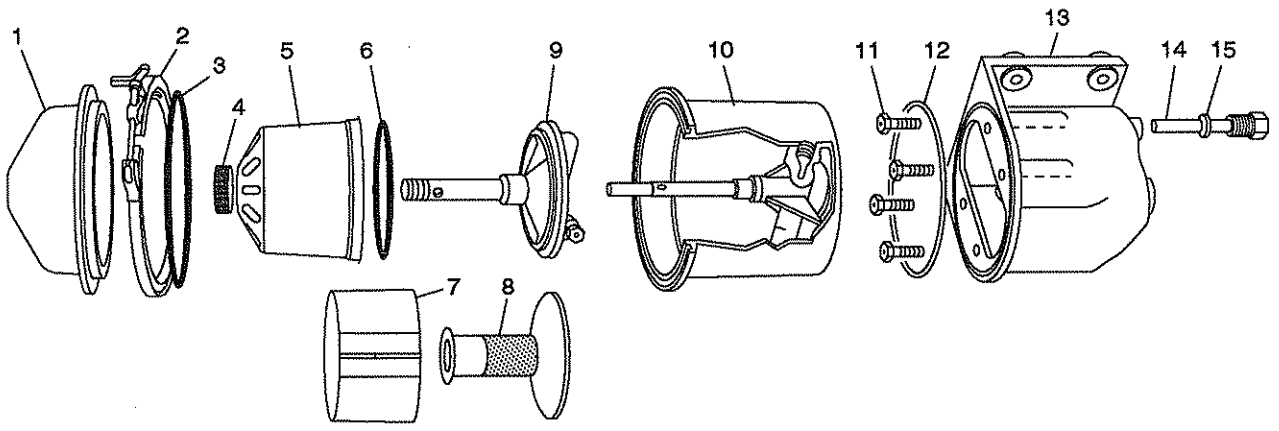
   1.4 Hold the centrifuge turbine assembly in one hand and loosen the knurled nut several turns until the face of the nut projects beyond the bronze bushing face.

   1.5 Carefully separate the centrifuge bowl from the turbine base by striking the face of the nut with the palm of one hand while holding the bowl in the other. *Do not strike the nut or the bushing with or against a hard surface or you will damage them.* Finish removing the nut and then remove the bowl and baffle/screen.

   1.6 Replace the dirty centrifuge bowl with a new one, or carefully remove the cake of dirt from the bowl with a wooden spatula or other non-damaging tool. Wipe out the bowl with solvent

NOTE: To save time cleaning the bowl, an optional die-cut Bristol paper insert is available for lining the bowl so the compressed cake of dirt can be removed quickly.

   1.7 Wash the baffle/screen and turbine base, removing and discarding the black Nitrile bowl seal.



1. Cover
2. Clamp
3. Cover Seal
4. Nut, Centrifuge Bowl
5. Centrifuge Bowl
6. Seal, Centrifuge Bowl
7. Paper Insert
8. Baffle/Screen
9. Centrifuge Turbine
10. Housing Assembly
11. Capscrew, M10x35mm
12. Seal, Control Mechanism
13. Control Mechanism
14. Air Valve Cartridge Assembly
15. Seal, Air Valve Cartridge

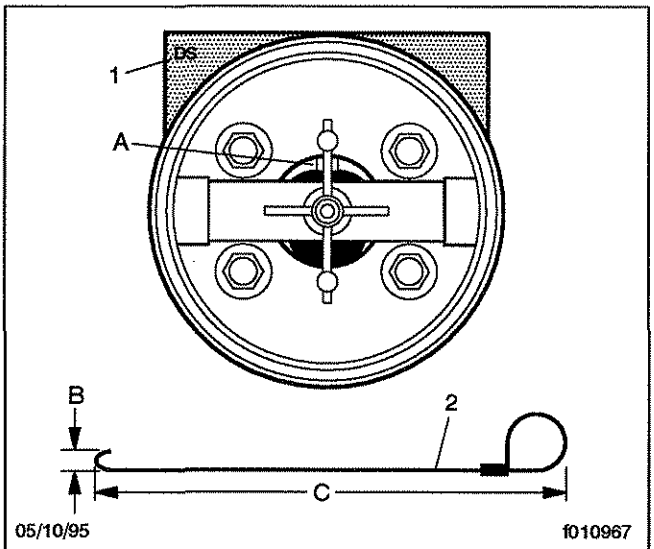
Fig. 1, Spinner II Bypass Oil Filter

Centrifuge Bowl Cleaning, Spinner II

2. Inspect and assemble the centrifuge turbine assembly.
   - 2.1 Inspect the top and bottom bushings of the centrifuge turbine base, and replace the turbine assembly if the bushings show severe wear.
   - 2.2 Place the baffle/screen over the stem of the turbine base and seat the baffle/screen evenly over the shoulder on the base.
   - 2.3 Install the bowl seal in the recess in the outer edge of the turbine base.
   - 2.4 Slide a new centrifuge bowl over the stem and seat it uniformly over the bowl seal.
   - 2.5 Install and tighten the knurled bowl nut securely, *using finger pressure only.*
3. Clean and inspect the oil filter housing.
   - 3.1 Inspect the housing assembly, paying special attention to the journal areas of the spindle.
   - 3.2 Clean and inspect the cover.
   - 3.3 Remove the old cover seal, and clean the groove in the housing and the mating surface of the cover.
   - 3.4 Replace the cover seal with a new black Nitrile seal.
4. Check the air valve control mechanism. **See Fig. 2.**
   - 4.1 Make a hook out of stiff wire, according to the measurements in **Fig. 2.**
   - 4.2 Insert the hook at the spot shown in **Fig. 2**, and hook the float arm.

     Lifting the float should release air into the filter housing.

     Lowering the float should stop the flow of air into the filter housing.
5. Install the centrifuge turbine assembly.
   - 5.1 Install the centrifuge turbine assembly, and make sure it rotates freely.
   - 5.2 Replace the cover, and position the clamp uniformly over the cover and housing flanges.
   - 5.3 Tighten the clamp handle securely *by hand pressure only.*
6. With the engine running, check all the oil filter connections and joints for leaks.



NOTE: This is a view, downward into the housing assembly, with the centrifuge turbine assembly removed.

A. Use the hook at this point to hook the float arm.
B. 3/8 Inch (10 mm)
C. 9 Inches (229 mm)

1. Manufacturer Date Code
2. Hook

Fig. 2, Check The Air Valve

Contents

Subject	Subject Number
General Information	050
Service Operations	
Accumulator Removal, Inspection, and Installation	100
Control Valve Removal, Cleaning, and Installation	110
Engine Brake Bleeding	120
Master Piston Removal, Inspection, and Installation	130
Rocker Cover Removal and Installation	140
Slave Piston Adjusting Screw (Power-Lash™) Removal, Inspection, and Installation	150
Slave Piston Removal and Installation	160
Solenoid Valve Removal, Cleaning, and Installation	170

For troubleshooting procedures, refer to **Section 01.12** in this manual.

General Information (See Fig. 1)

The Jacobs engine brake model 310A is installed on Caterpillar 3176 engines, and slows the vehicle by converting a power-producing diesel engine into a power-consuming air compressor. The brake does this by opening the cylinder exhaust valves near the top of the normal compression stroke, releasing the compressed cylinder charge to exhaust.

The release or "blowdown" of compressed air to atmosphere prevents the return of energy to the engine piston on the expansion stroke. The effect is a net energy loss, because the work done in compressing the cylinder charge is not returned during the expansion process.

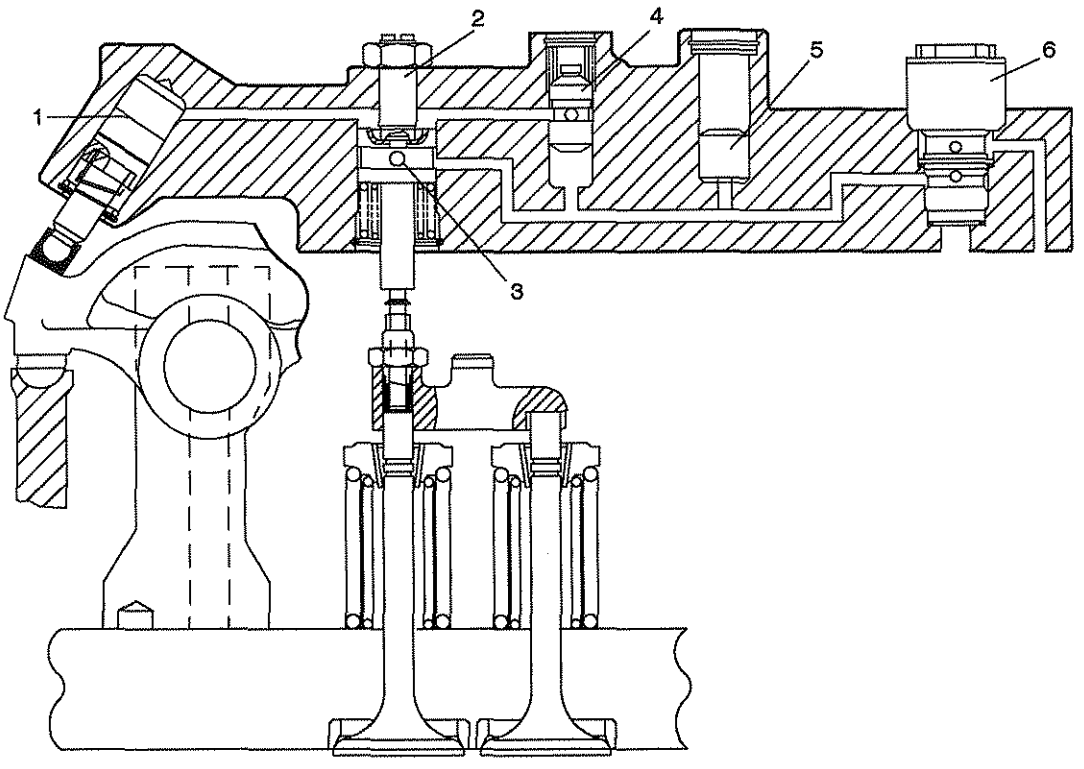
Exhaust blowdown of the braking cylinder is accomplished by using the injector arm motion of that cylinder. **See Fig. 2.**

Energizing the solenoid valve permits engine lube oil to flow under pressure through the control valve to the master piston, slave piston, and accumulator.

Oil pressure makes the master piston move down, coming to rest on the corresponding injector rocker arm.

The injector rocker arm moves (as in a normal injector cycle), forcing the master piston upward and creating a high pressure oil flow to the slave piston of the braking cylinder. The ball check valve in the control valve traps high pressure oil in the master/slave piston system.

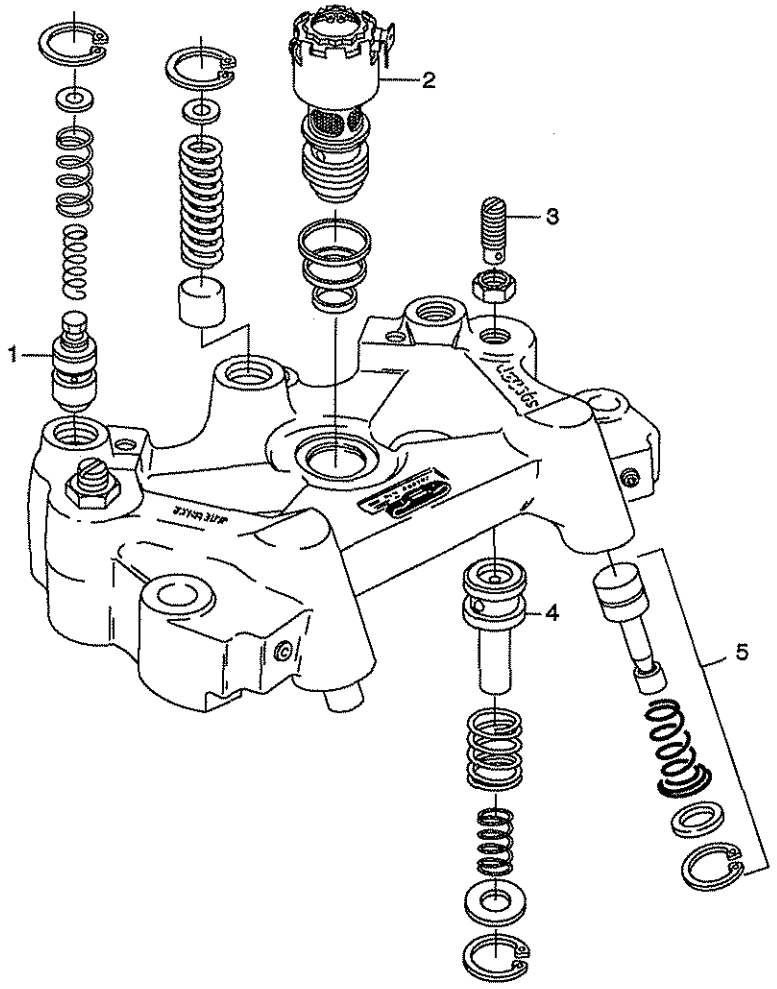
Under the influence of the high pressure oil flow, the slave piston moves down, momentarily opening the



1. Master Piston Assembly
2. Power-Lash™ Slave Piston Adjusting Screw
3. Slave Piston
4. Control Valve
5. Accumulator
6. Solenoid Valve

Fig. 1, Engine Brake, Sectional View

General Information



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1. Control Valve
2. Solenoid Valve
3. Power-Lash Slave Piston Adjusting Screw
4. Slave Piston
5. Master Piston Assembly

Fig. 2, Engine Brake Components

exhaust valves at a pre-determined amount of slave stroke. The Power-Lash™ uncovers a passageway in the slave piston, thus allowing oil to flow back to the undersides of the control valve and accumulator piston, where it is stored for the next cycle. Prior to top dead center position, the exhaust valve is forced open, releasing the compressed cylinder air to the exhaust manifold.

Compressed air escapes into the atmosphere, completing the braking cycle.

Accumulator Removal, Inspection, and Installation

Removal (See Fig. 1)

1. Wipe the engine brake housing area clean. Remove the rocker cover. For instructions, refer to **Subject 140.**

WARNING: The accumulator spring is under strong compression. Use caution when removing the retaining ring and cover. Wear safety glasses. If the spring is accidentally discharged, personal injury may result.

2. Push down on the accumulator cover using the appropriate diameter rod and remove the retaining ring.
3. Relieve pressure on the accumulator cover; remove the cover and the spring.
4. Use a magnet to remove the piston from the accumulator bore.

Inspection

Inspect the parts for wear or damage; replace them if needed.

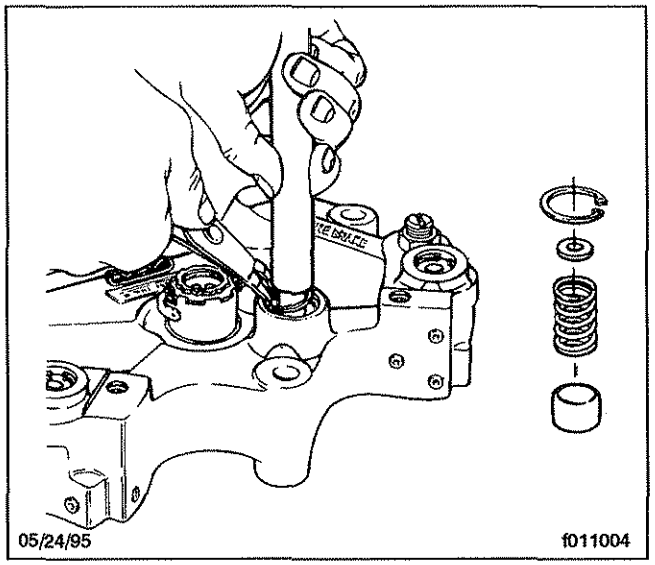


Fig. 1, Accumulator Assembly

Installation

1. Install the piston, then the spring, the cover, and the retaining ring.
2. Install the rocker cover. For instructions, refer to **Subject 140.**

Removal (See Fig. 1)

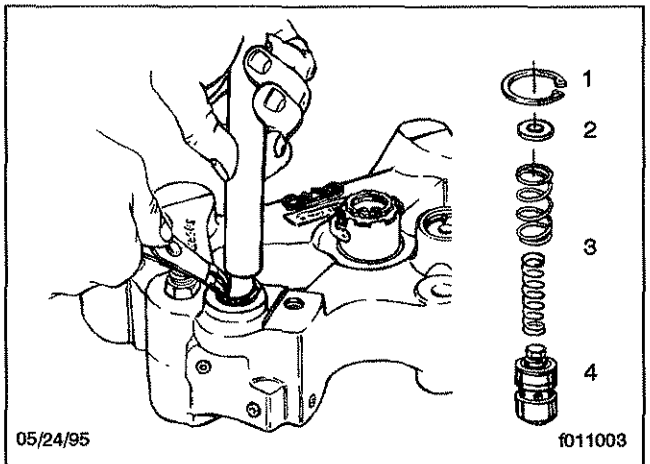
1. Wipe the engine brake housing area clean. Remove the rocker cover. For instructions, refer to **Subject 140.**

WARNING: The control valve covers are under load from the control valve springs. Remove the control valve covers carefully to avoid personal injury. The valve covers could jump out and cause personal injury.

2. Apply pressure on the control valve cover, and remove the retaining ring using retaining ring pliers.
3. Slowly remove the cover until the spring pressure ceases, then remove the two control valve springs.
4. Using needle-nose pliers, reach into the bore and grasp the stem of the control valve. Remove the control valve.

Cleaning

1. Wash the control valves with an approved solvent. Push a wire into the hole in the base of the valve to the distance required to insure that the ball check is free. the ball should lift with light pressure on the wire. If the ball is stuck, replace the control valve. Dry the valve with compressed air and wipe clean with a paper towel.
2. Thoroughly clean the control valve bore in the housing using clean paper towels.



1. Retaining Ring
2. Control Valve Cover
3. Springs
4. Control Valve

Fig. 1, Control Valve Assembly

Installation

1. Install the control valve in the bore, then the springs, the cover, and the retaining ring.
2. Install the rocker cover. For instructions, refer to **Subject 140.**

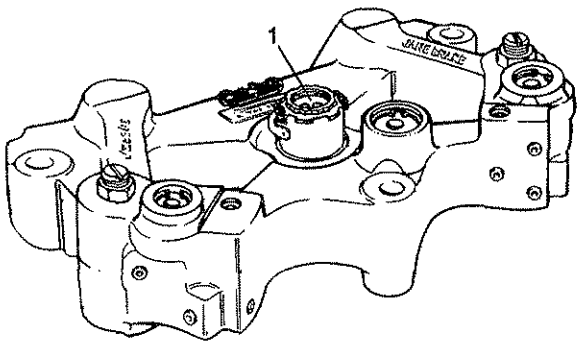
Bleeding (See Fig. 1)

1. Wipe the engine brake housing area clean. Remove the rocker cover. For instructions, refer to **Subject 140**.

WARNING: Wear eye protection, and do not expose your face to the engine area. Take precautions to prevent oil leakage onto the engine. Whenever the engine is running with the valve covers removed, oil splashing in the engine area could cause personal injury.

NOTE: Place a rag over the control valve and the accumulator covers to reduce oil spray.

2. Start the engine, and allow it to run for a few minutes.
3. Press and release the engine brake solenoid disc several times to allow the housing to be filled with oil.
4. Watch the master piston to be sure it is moving down onto the injector rocker arm pad.
5. Watch the slave piston assembly. It should move down to contact the pin in the exhaust valve screw.
6. Check all the housings to be sure they are functioning.
7. Shut down the engine, and clean the gasket surface for the rocker cover.



1. Press here.

Fig. 1, Bleeding the Engine Brake

8. Install the rocker cover. For instructions, refer to **Subject 140**.

Removal and Inspection (See Fig. 1)

1. Wipe the engine brake housing area clean. Remove the rocker cover. For instructions, refer to **Subject 140**.
2. Press down on the master piston retaining washer to relieve the spring force. While holding the washer, use a pair of snap ring pliers to remove the retaining ring from the groove. Carefully release the retainer and remove it along with the old spring.
3. Remove the master piston from the bore. Clean the piston in a solvent, and inspect it for wear. Also inspect the the piston bore for wear.

Installation

1. Install a new master piston return spring by inserting the small end into the bore. The large coil, marked with *white* paint, *should always be facing out.*
2. Place the retaining washer and snap ring over the foot of the master piston and compress them into the bore. Using snap ring pliers, replace the snap ring in the groove to retain the master piston.
3. Ensure the snap ring is properly engaged in the groove by gently grasping the master piston foot and pulling out until the master piston bottoms on the retaining washer. Release the master piston. If the assembly is correct, all parts should return to their original position.

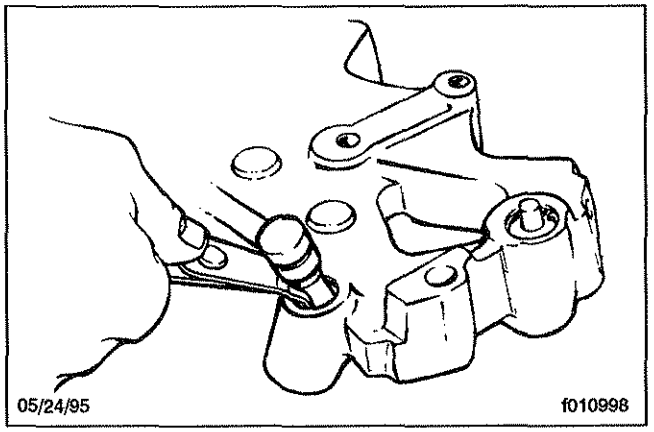


Fig. 1, Removing the Master Piston

NOTE: After the new spring is installed within the retaining washer and snap ring, it is normal to be able to see the spring in the bore around the retaining washer.

4. Repeat this procedure on the five other master pistons.
5. Install the rocker cover. For instructions, refer to **Subject 140**.

Removal (See Fig. 1)

1. Apply the parking brakes, chock the tires, and tilt the hood.
2. Wipe the engine brake housing area clean..
3. Remove the six bolts that hold each rocker cover, and remove the rocker covers.
4. Inspect the cover seals, and replace them if they are damaged.

Installation

CAUTION: Be sure to tighten all the rocker cover bolts evenly. Excessive or uneven tightening may cause the rocker cover to crack.

1. Make sure a seal is located in the groove of each cover, and install the cover on the spacer. Install the six Jacobs' bolts per cover, and tighten the bolts 5 lbf·ft (7 N·m).
2. Remove the chocks from the tires.

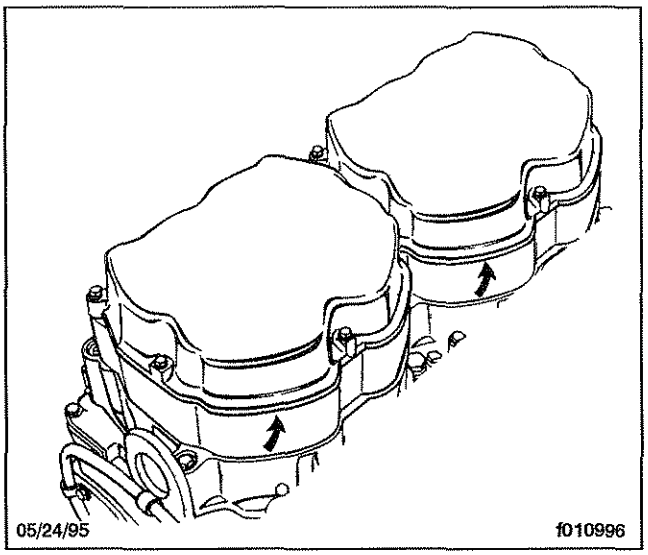


Fig. 1, Rocker Covers

Slave Piston Adjusting Screw (Power-Lash™) Removal, Inspection, and Installation

Removal

1. Wipe the engine brake housing area clean. Remove the rocker cover. For instructions, refer to **Subject 140**.
2. Loosen the slave piston adjusting screw locknut, and remove the adjusting screw from the housing. **See Fig. 1.**

Inspection and Installation

1. Clean the adjusting screw in an approved solvent.

CAUTION: Do not adjust or tamper with the adjusting screw, engine damage could result.

NOTE: The part number for the screw is located at the top of the screw, next to the screwdriver slot. Refer to the manufacturer's parts manual for part number identification.

2. Inspect the slave piston adjusting screw. The plunger should protrude from the bottom of the screw, should have light spring pressure apparent when depressed, and should move freely. **See Fig. 2.** Replace the entire screw assembly if any problem is found.
3. Install the rocker cover. For instructions, refer to **Subject 140**.

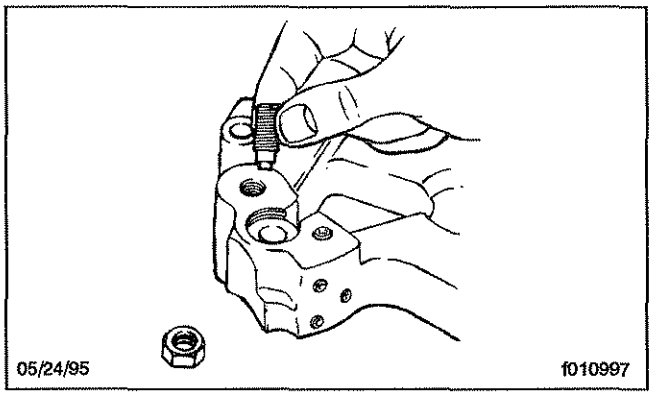


Fig. 1, Remove the Adjusting Screw

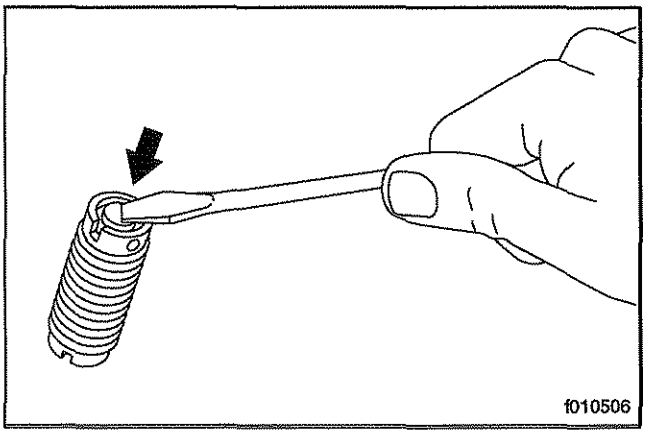


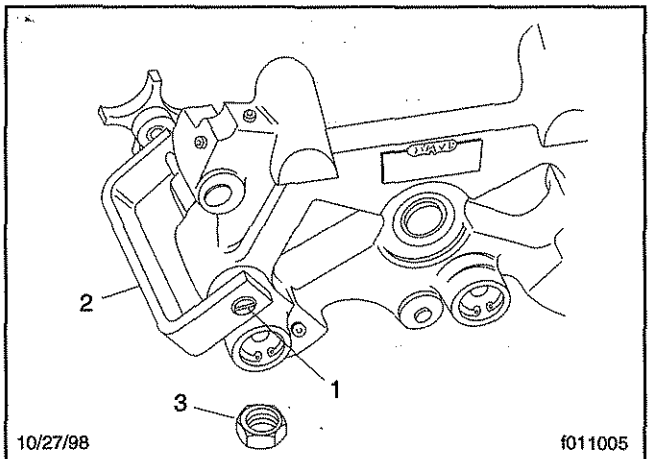
Fig. 2, Check the Adjusting Screw Plunger

Removal (See Fig. 1 and Fig. 2)

1. Wipe the engine brake housing area clean. Remove the rocker cover. For instructions, refer to **Subject 140.**

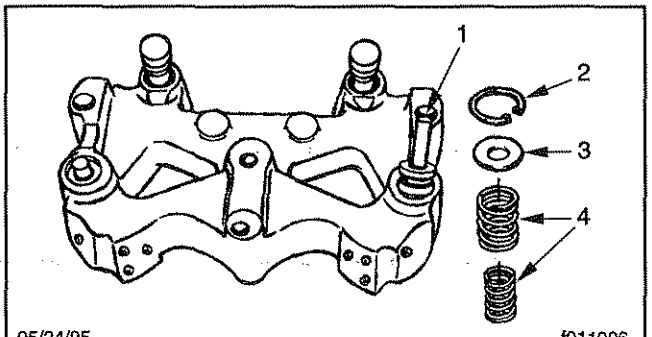
⚠ WARNING

The slave piston is retained by springs that are under heavy compression. Use the following tools and instructions or the springs will be discharged with enough force to cause personal injury.



1. Clamp Fixture Hole
2. Clamp Fixture
3. Adjusting Screw Locknut

Fig. 1, Retract the Slave Piston with a Clamp



1. Slave Piston
2. Retaining Ring
3. Spring Retainer
4. Slave Piston Springs

Fig. 2, Slave Piston Components

2. Remove the locknut on the slave piston adjusting screw. Back out the adjusting screw until the slave piston is fully retracted (the screw is loose).
3. Place the hole in the clamp fixture over the slave piston adjusting screw. **See Fig. 1.**
4. While holding the fixture in position, screw the holder down over the slave piston until the spring retainer is contacted.
5. Turn the handle slowly until the retainer is depressed to about 1/32 inch (1 mm), relieving pressure against the retaining ring.
6. Remove the retaining ring using retaining ring pliers. Back out the holder until the springs are loose. Remove the fixture.
7. Remove all the components, ensuring there is no binding or burrs. Clean in an approved cleaning solvent. Inspect parts and replace as needed.

Installation

1. Use the clamp fixture to install the piston and springs. Be sure the retaining ring is placed on the retainer before screwing the clamp-holder down over the slave piston.
2. Compress the slave piston springs down until the retainer is about 1/32 inch (1 mm) below the retaining ring groove. Install the retaining ring. Be sure the retaining ring is fully seated in the groove.
3. Remove the clamp fixture slowly to ensure correct seating of the retaining ring.
4. Install the rocker cover. For instructions, refer to **Subject 140.**

Removal (See Fig. 1)

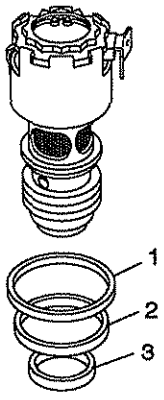
1. Wipe the engine brake housing area clean. Remove the rocker cover. For instructions, refer to **Subject 140.**

CAUTION: Do not disassemble or tamper with the solenoid valve. Engine damage could result. The solenoid valve is not field serviceable.

2. Disconnect the solenoid harness. Using a 7/8-inch socket and an extension, unscrew the solenoid valve.
3. Remove and discard the three rubber seal rings. If the lower ring stays in the bottom of the housing bore, remove it with a pick.

Cleaning and Installation

1. Wash out the solenoid valve with an approved solvent. Use a brush to clean the oil screen. When clean, dry the valve with compressed air.
2. Clean out the solenoid valve bore in the housing. Use clean paper towels. Never use rags as they may leave lint and residue which can plug the oil passageways.
3. Using new solenoid seal rings, coat them with clean lube oil. Install the upper and center seal rings on the solenoid body, and install the lower seal ring into the bottom of the solenoid bore in the housing.
4. Be sure the seals are seated properly and carefully screw the solenoid into the housing without unseating the seals. Tighten the valve 5 lbf·ft (7 N·m). Be careful not to twist the seals while installing the solenoid.
5. Install the rocker cover. For instructions, refer to **Subject 140.**



1. Upper Seal
2. Center Seal
3. Lower Seal

Fig. 1, Solenoid Seals

Contents

Subject	Subject Number
General Information	050
Service Operations	
Check Valve Removal, Inspection, and Installation	100
Control Valve Removal, Cleaning, and Installation	110
Delay Piston Removal, Cleaning, and Installation	120
Engine Brake Bleeding and Operation Check	130
Master Piston Removal, Inspection, and Installation	140
Rocker Cover Removal and Installation	150
Slave Piston Removal, Installation, and Adjustment	160
Solenoid Removal, Cleaning, and Installation	170
Trigger Valve Removal, Inspection, and Installation	180
Engine Brake Housing Removal and Installation	190

For troubleshooting procedures, refer to **Section 01.12** in this manual.

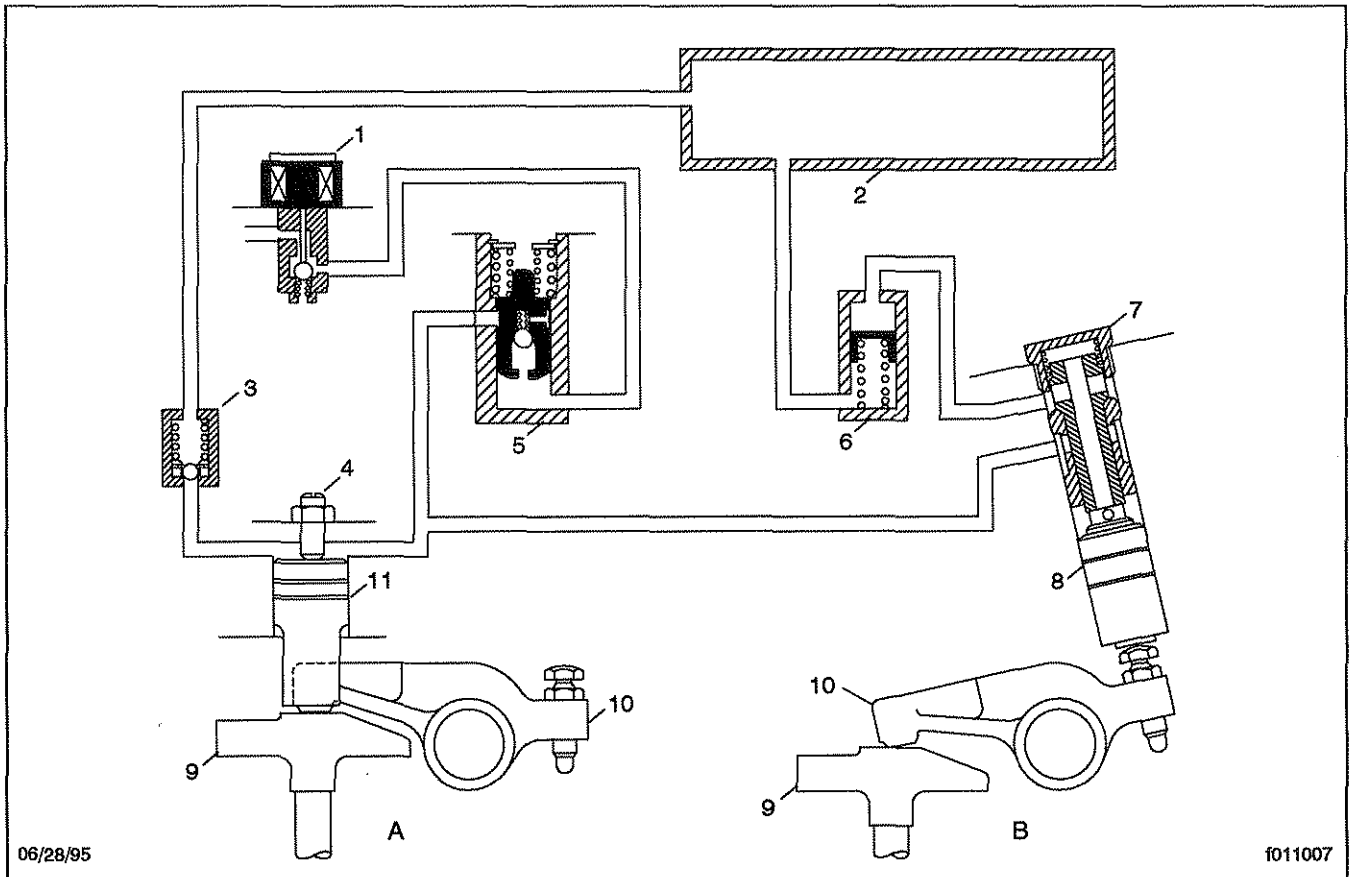
General Information (See Fig. 1)

The Jacobs engine brake model 349A is installed on Caterpillar 3406 engine, and slows the vehicle by converting a power-producing diesel engine into a power-consuming air compressor. The brake does this by opening the cylinder exhaust valves near the top of the normal compression stroke, releasing the compressed cylinder charge to exhaust.

The release or "blowdown" of compressed air to atmosphere prevents the return of energy to the engine piston on the expansion stroke. The effect is a net energy loss, because the work done in compressing the cylinder charge is not returned during the expansion process.

Exhaust blowdown of the braking cylinder is accomplished by using the pushrod motion of an exhaust valve of another cylinder during its normal exhaust cycle. **See Fig. 1.** Cylinder number one exhaust pushrod opens the exhaust valves of cylinder number three in this sequence.

1. Energizing the solenoid valve permits engine lube oil to flow under pressure through the control valve to the master piston and the slave piston.



A. Cylinder Number Three (typical)

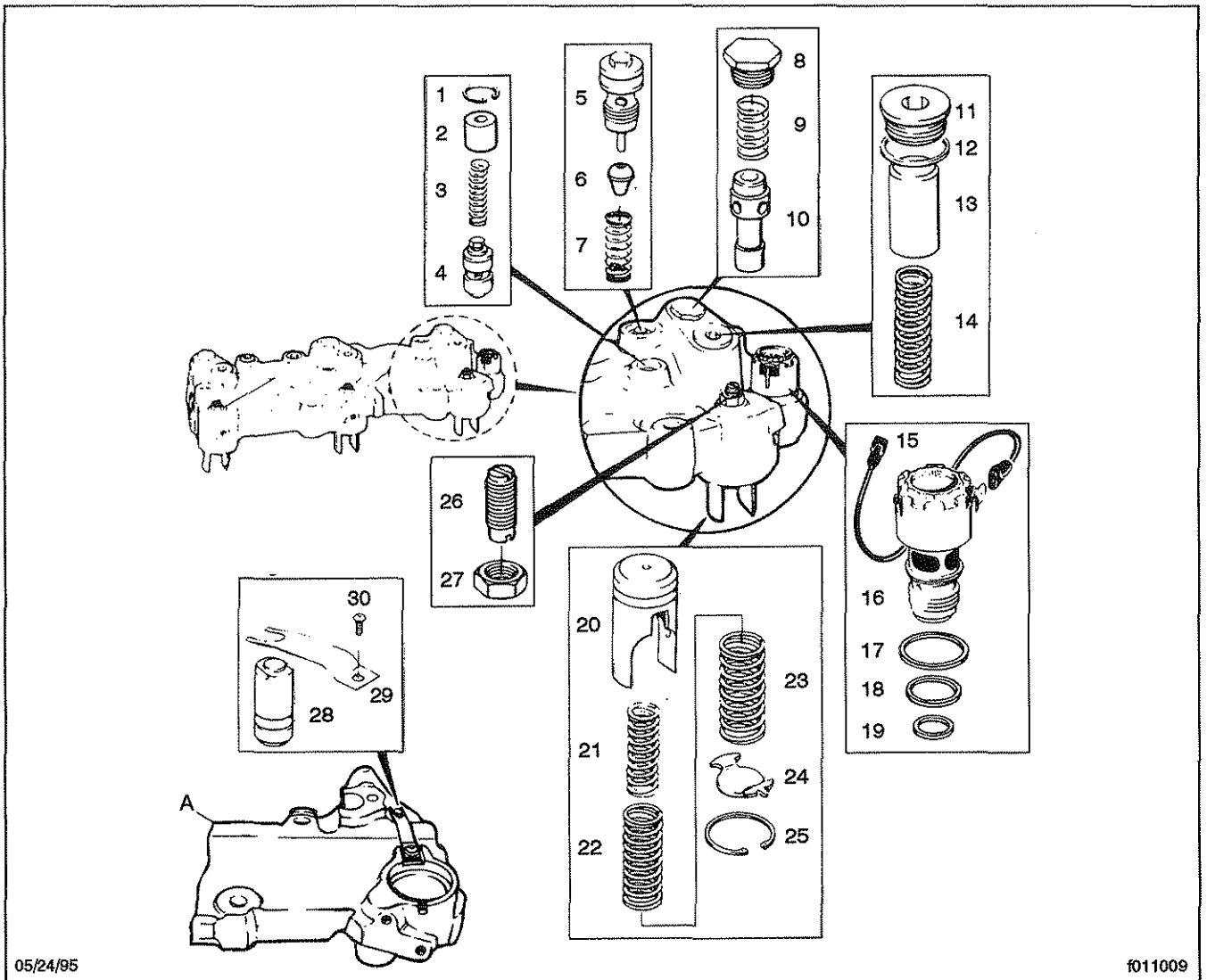
B. Cylinder Number One (typical)

1. Solenoid Valve
2. Plenum
3. Check Valve
4. Slave Piston Adjusting Screw
5. Control Valve
6. Delay Piston
7. Trigger Valve
8. Master Piston
9. Bridge
10. Exhaust Rocker Arm
11. Slave Piston

Fig. 1, Engine Brake Components

2. Oil pressure makes the master piston move down, coming to rest on the corresponding exhaust rocker arm adjusting screw.
3. The exhaust rocker pushrod begins upward travel (as in a normal exhaust cycle) forcing the master piston upward and creating a high pressure oil flow to the delay piston.
4. The delay piston moves and compresses the plenum oil to high pressure. The delay piston and plenum act as a high pressure "spring" to activate the slave piston at the appropriate time.
5. The master piston moves upward, and at the appropriate time, opens the trigger valve.
6. High pressure oil flows from the delay piston through the trigger valve to the slave piston.
7. The slave piston moves down, contacts the exhaust valve bridge, and opens the exhaust valves, releasing compressed air to the exhaust manifold.
8. Compressed air escapes to atmosphere, completing a compression braking cycle.

Removal (See Fig. 1)



A. Bottom of Brake Housing

1. Control Valve Retaining Ring
2. Control Valve Spacer/Cover
3. Control Valve Spring
4. Control Valve
5. Check Valve
6. Check Valve
7. Check Valve Spring
8. Trigger Valve Cap
9. Trigger Valve Spring
10. Trigger Valve
11. Delay Piston Cap
12. Delay Piston Copper Seal (if used)
13. Delay Piston
14. Delay Piston Spring
15. Solenoid Valve Harness
16. Solenoid Valve
17. Upper Seal
18. Center Seal
19. Lower Seal
20. Slave Piston
21. Slave Piston Spring
22. Slave Piston Spring
23. Slave Piston Spring
24. Slave Piston Retainer
25. Slave Piston Retaining Ring
26. Slave Piston Adjusting Screw
27. Slave Piston Adjusting Screw Locknut
28. Master Piston
29. Master Piston Flat Spring
30. Master Piston Buttonhead Screw

Fig. 1, Brake Housing Assembly

Check Valve Removal, Inspection, and Installation

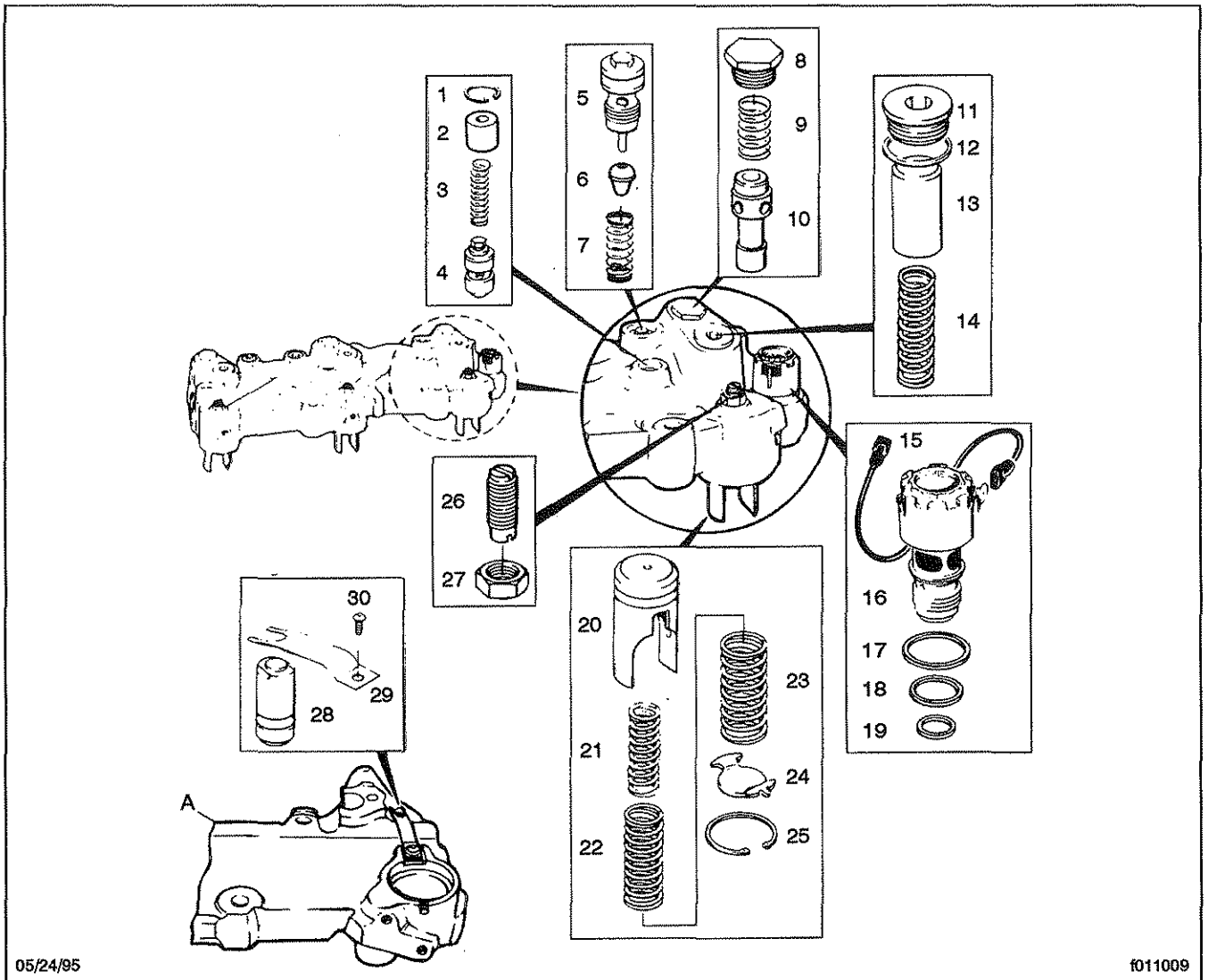
1. Wipe the engine brake housing area clean. Remove the rocker cover. For instructions, refer to **Subject 150.**
2. Remove the check valve and the check valve spring.

Inspection and Installation

NOTE: The check valve assembly contains a three-piece seal. Do not attempt to remove the seal. If the seal is damaged, replace the complete check valve assembly.

1. Install the check valve spring in the bore, then install the check valve.
2. Tighten the check valve 35 lbf·ft (48 N·m).
3. Install the rocker cover. For instructions, refer to **Subject 150.**

Removal (See Fig. 1)



A. Bottom of Brake Housing

1. Control Valve Retaining Ring
2. Control Valve Spacer/Cover
3. Control Valve Spring
4. Control Valve
5. Check Valve
6. Check Valve
7. Check Valve Spring
8. Trigger Valve Cap
9. Trigger Valve Spring
10. Trigger Valve
11. Delay Piston Cap
12. Delay Piston Copper Seal (if used)
13. Delay Piston
14. Delay Piston Spring
15. Solenoid Valve Harness
16. Solenoid Valve
17. Upper Seal
18. Center Seal
19. Lower Seal
20. Slave Piston
21. Slave Piston Spring
22. Slave Piston Spring
23. Slave Piston Spring
24. Slave Piston Retainer
25. Slave Piston Retaining Ring
26. Slave Piston Adjusting Screw
27. Slave Piston Adjusting Screw Locknut
28. Master Piston
29. Master Piston Flat Spring
30. Master Piston Buttonhead Screw

Fig. 1, Brake Housing Assembly

Control Valve Removal, Cleaning, and Installation

1. Wipe the engine brake housing area clean. Remove the rocker cover. For instructions, refer to **Subject 150.**

WARNING: Use caution when removing the control valve spacer/cover. Wear safety glasses. The control valve cover is under load from the control valve spring. If the cover or spring is accidentally discharged, personal injury may result.

2. Press down on the control valve spacer/cover to relieve spring pressure. Then, use retaining ring pliers to remove the retaining ring.
3. Slowly remove the spacer/cover until the spring pressure ceases, then remove the control valve spring.
4. Use needle-nose pliers to remove the control valve.

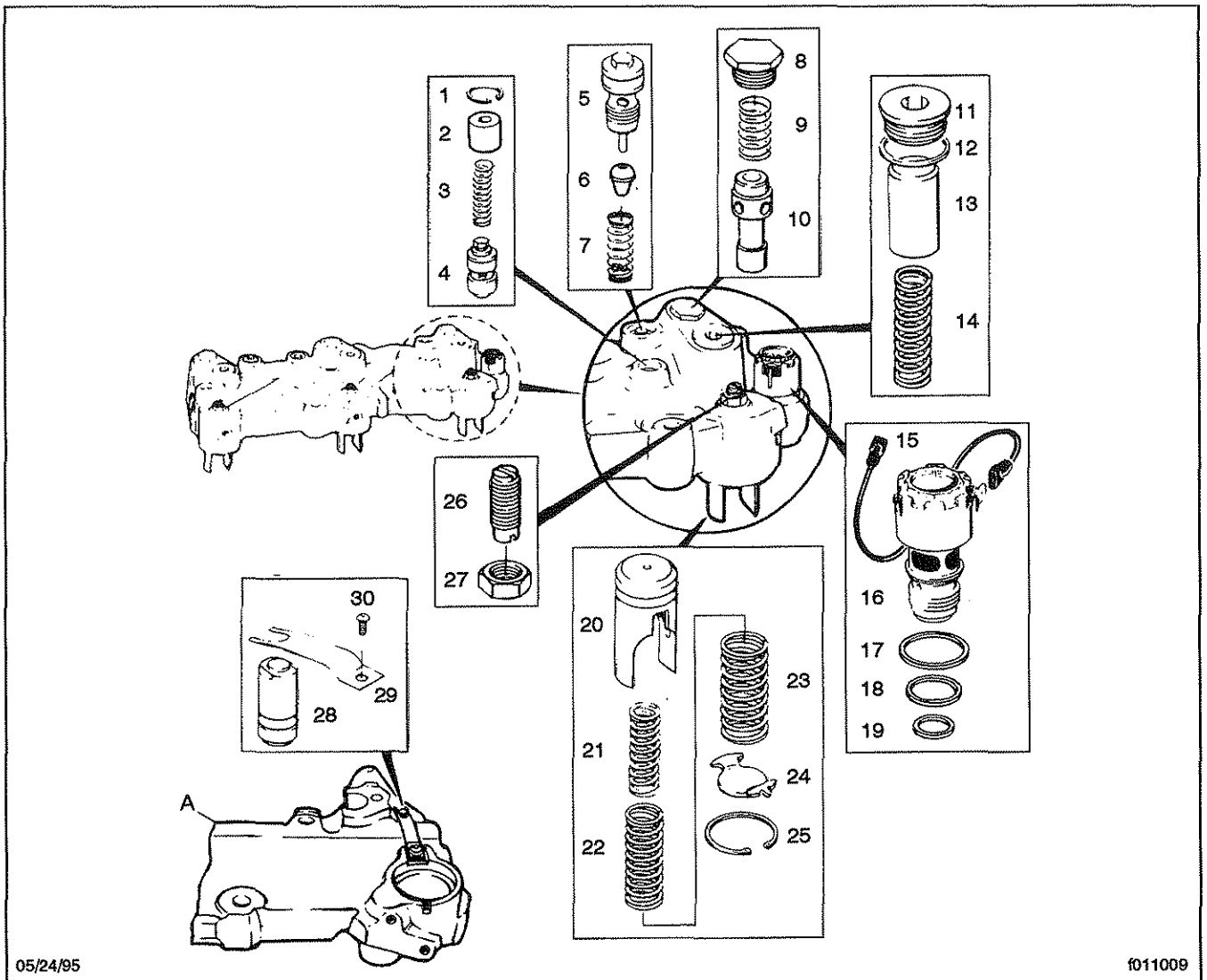
Cleaning and Installation

NOTE: Do not use shop rags to clean the control valve. Shop rags can leave lint which can plug passageways.

1. Clean the control valve bore in the housing, using clean paper towels. Dip the new control valve in clean lube oil and place the valve into its bore.
2. Install the spring, spacer/cover, and retaining ring.
3. Install the rocker cover. For instructions, refer to **Subject 150.**

Delay Piston Removal, Cleaning, and Installation

Removal (See Fig. 1)



A. Bottom of Brake Housing

1. Control Valve Retaining Ring
2. Control Valve Spacer/Cover
3. Control Valve Spring
4. Control Valve
5. Check Valve
6. Check Valve
7. Check Valve Spring
8. Trigger Valve Cap
9. Trigger Valve Spring
10. Trigger Valve
11. Delay Piston Cap
12. Delay Piston Copper Seal (if used)
13. Delay Piston
14. Delay Piston Spring
15. Solenoid Valve Harness
16. Solenoid Valve
17. Upper Seal
18. Center Seal
19. Lower Seal
20. Slave Piston
21. Slave Piston Spring
22. Slave Piston Spring
23. Slave Piston Spring
24. Slave Piston Retainer
25. Slave Piston Retaining Ring
26. Slave Piston Adjusting Screw
27. Slave Piston Adjusting Screw Locknut
28. Master Piston
29. Master Piston Flat Spring
30. Master Piston Buttonhead Screw

Fig. 1, Brake Housing Assembly

Delay Piston Removal, Cleaning, and Installation

1. Wipe the engine brake housing area clean. Remove the rocker cover. For instructions, refer to **Subject 150.**

WARNING: Remove the check valves before removing the delay piston caps. This relieves the pressure in the plenum chamber. Removing the delay piston caps with pressure in the plenum can result in personal injury.

2. Remove the check valves. For instructions, refer to **Subject 100.**
3. Slowly remove the delay piston cap.
4. Use a magnet to remove the delay piston and the delay piston spring.

Cleaning and Installation

1. Inspect the piston. If the piston is scored or damaged in any way, replace it.
2. Install the spring and the delay piston.
3. Clean the oil from the delay piston cap, and apply Loctite 271 (or equivalent) before installing the cap. Tighten the cap 65 lbf·ft (88 N·m).
4. Install the rocker cover. For instructions, refer to **Subject 150.**

Bleeding and Operation Check

1. Wipe the engine brake housing area clean. Remove the rocker cover. For instructions, refer to **Subject 150.**

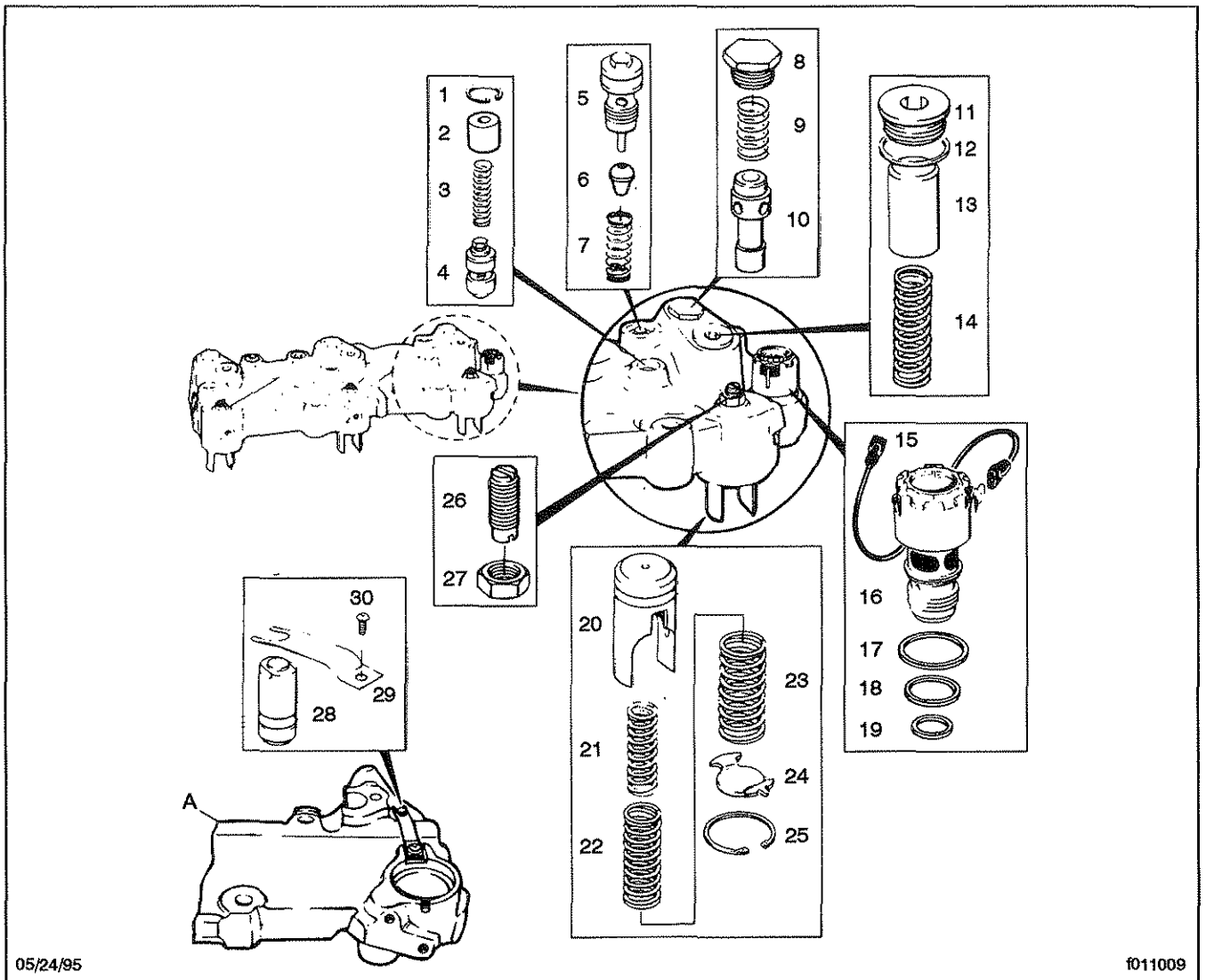
WARNING: Wear eye protection, and do not expose your face to the engine area. Take precautions to prevent oil leakage onto the engine. Whenever the engine is running with the valve covers removed, oil splashing in the engine area could cause personal injury.

2. Start the engine, and allow it to run for five to ten minutes.
3. With the engine at low idle, press and release the engine brake solenoid disc several times until the master pistons move out of the housing and the engine brake begins to operate.

   Oil leaving the control valve covers should be free of air bubbles before replacing the valve covers. This permits oil to fill the brake housing passages and prepares the brake for operation.
4. Inspect the engine brake for oil or fuel leakage or component interference. Correct any problems.
5. Shut down the engine, and clean the gasket surface for the rocker cover.
6. Install the rocker cover. For instructions, refer to **Subject 150**

Master Piston Removal, Inspection, and Installation

Removal (See Fig. 1)



A. Bottom of Brake Housing

1. Control Valve Retaining Ring
2. Control Valve Spacer/Cover
3. Control Valve Spring
4. Control Valve
5. Check Valve
6. Check Valve
7. Check Valve Spring
8. Trigger Valve Cap
9. Trigger Valve Spring
10. Trigger Valve
11. Delay Piston Cap
12. Delay Piston Copper Seal (if used)
13. Delay Piston
14. Delay Piston Spring
15. Solenoid Valve Harness
16. Solenoid Valve
17. Upper Seal
18. Center Seal
19. Lower Seal
20. Slave Piston
21. Slave Piston Spring
22. Slave Piston Spring
23. Slave Piston Spring
24. Slave Piston Retainer
25. Slave Piston Retaining Ring
26. Slave Piston Adjusting Screw
27. Slave Piston Adjusting Screw Locknut
28. Master Piston
29. Master Piston Flat Spring
30. Master Piston Buttonhead Screw

Fig. 1, Brake Housing Assembly

Master Piston Removal, Inspection, and Installation

1. Wipe the engine brake housing area clean. Remove the rocker cover. For instructions, refer to **Subject 150.**
2. Remove the engine brake housing. For instructions, refer to **Subject 190.**
3. Remove the buttonhead screw and the flat spring.
4. Remove the master piston.

Inspection and Installation

1. Inspect all parts for damage and replace as needed.

   If the master piston hard-face surface is scored or damaged, the corresponding rocker arm adjusting screw, master piston assembly, flat spring, and button head screw must *all* be replaced.

NOTE: Do not change the adjustment of the master piston. Final adjustment is done on the engine.

2. Install the master piston.
3. Install a new flat spring and a new buttonhead screw.
4. Tighten the screw 60 lbf·in (680 N·cm).
5. Install the engine brake housing. For instructions, refer to **Subject 190.**
6. Install the rocker cover. For instructions, refer to **Subject 150.**

Rocker Cover Removal and Installation

Removal

1. Apply the parking brakes, shut down the engine, chock the tires, and tilt the hood.

WARNING: To avoid personal injury, never remove any engine brake component with the engine running.

2. Wipe the engine brake housing area clean.
3. Remove the bolts that hold each rocker cover, and remove the rocker covers.
4. Inspect the cover seals, and replace them if they are damaged.
5. If needed, remove the fasteners that hold the engine brake spacer, then remove the engine brake spacer.

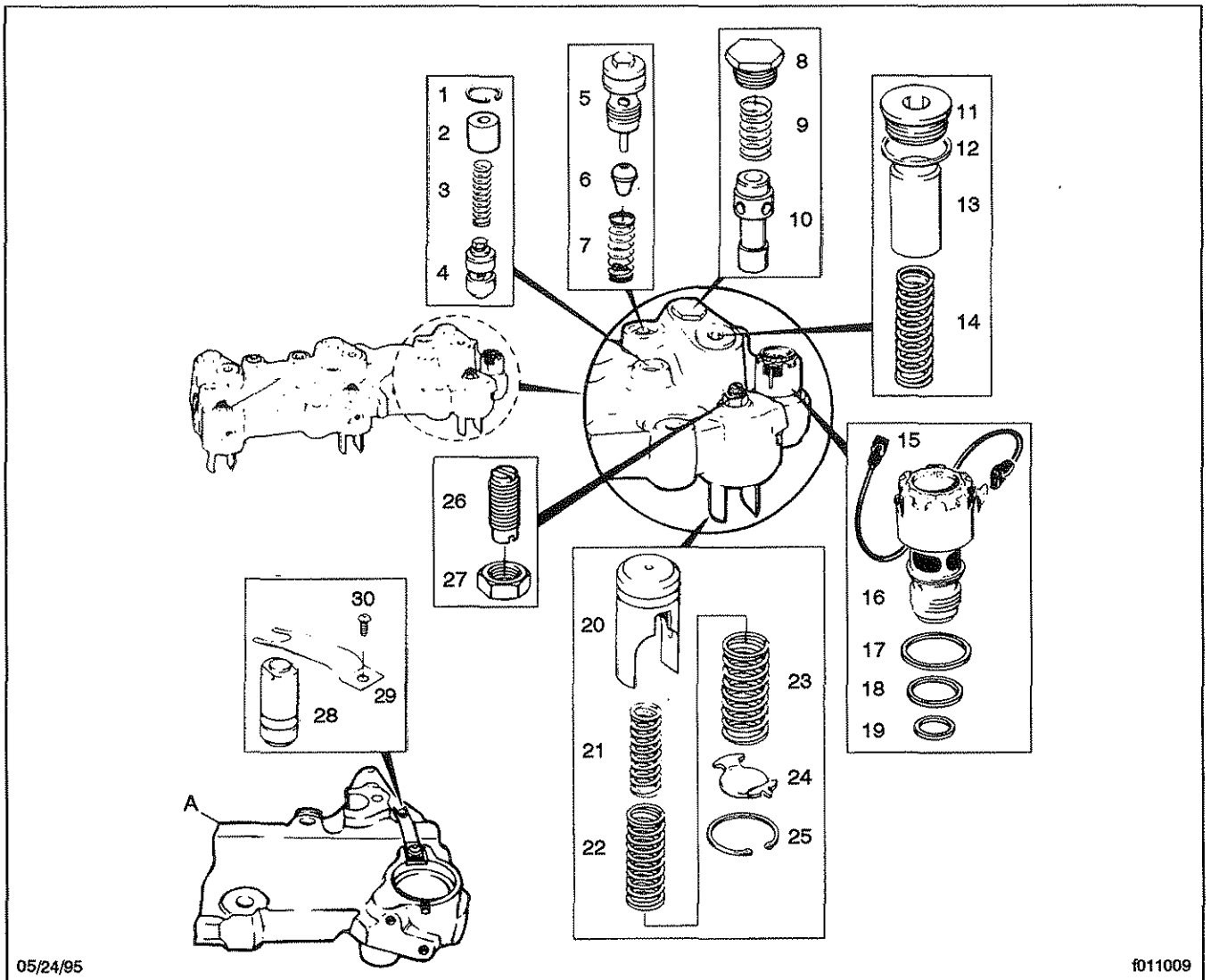
Installation

1. If the engine brake spacer was removed, install it, and tighten the fasteners 10 lbf·ft (14 N·m).

CAUTION: Be sure to tighten all the rocker cover bolts evenly. Excessive or uneven tightening may cause the rocker cover to crack.

2. Make sure a rocker cover seal is located in the groove of each cover, and install the cover on the spacer. Install the six Jacobs bolts per cover, and tighten the bolts 10 lbf·ft (14 N·m).
3. Remove the chocks from the tires.

Removal (See Fig. 1)



A. Bottom of Brake Housing

1. Control Valve Retaining Ring
2. Control Valve Spacer/Cover
3. Control Valve Spring
4. Control Valve
5. Check Valve
6. Check Valve
7. Check Valve Spring
8. Trigger Valve Cap
9. Trigger Valve Spring
10. Trigger Valve
11. Delay Piston Cap
12. Delay Piston Copper Seal (if used)
13. Delay Piston
14. Delay Piston Spring
15. Solenoid Valve Harness
16. Solenoid Valve
17. Upper Seal
18. Center Seal
19. Lower Seal
20. Slave Piston
21. Slave Piston Spring
22. Slave Piston Spring
23. Slave Piston Spring
24. Slave Piston Retainer
25. Slave Piston Retaining Ring
26. Slave Piston Adjusting Screw
27. Slave Piston Adjusting Screw Locknut
28. Master Piston
29. Master Piston Flat Spring
30. Master Piston Buttonhead Screw

Fig. 1, Engine Brake Assembly

Slave Piston Removal, Installation, and Adjustment

1. Wipe the engine brake housing area clean. Remove the rocker cover. For instructions, refer to **Subject 150.**
2. Remove the engine brake housing. For instructions, refer to **Subject 190.**

WARNING: Remove the slave piston carefully. The slave piston is retained by springs that are under heavy compression. If the following instructions are not followed and proper tools are not used, the springs could be discharged with enough force to cause personal injury.

3. Remove the jam nut from the slave piston adjusting screw (Power-Lash®).
4. Back out the adjusting screw until the slave piston is fully retracted (the screw is loose).
5. Install the slave piston removal tool, and turn the handle in to relieve the spring pressure.
6. Using retaining ring pliers, rotate the retaining ring to the slot in the housing and remove the retaining ring.
7. Turn the tool handle out to relieve the spring force, and remove the retainer, the springs, and the slave piston.

Installation and Adjustment

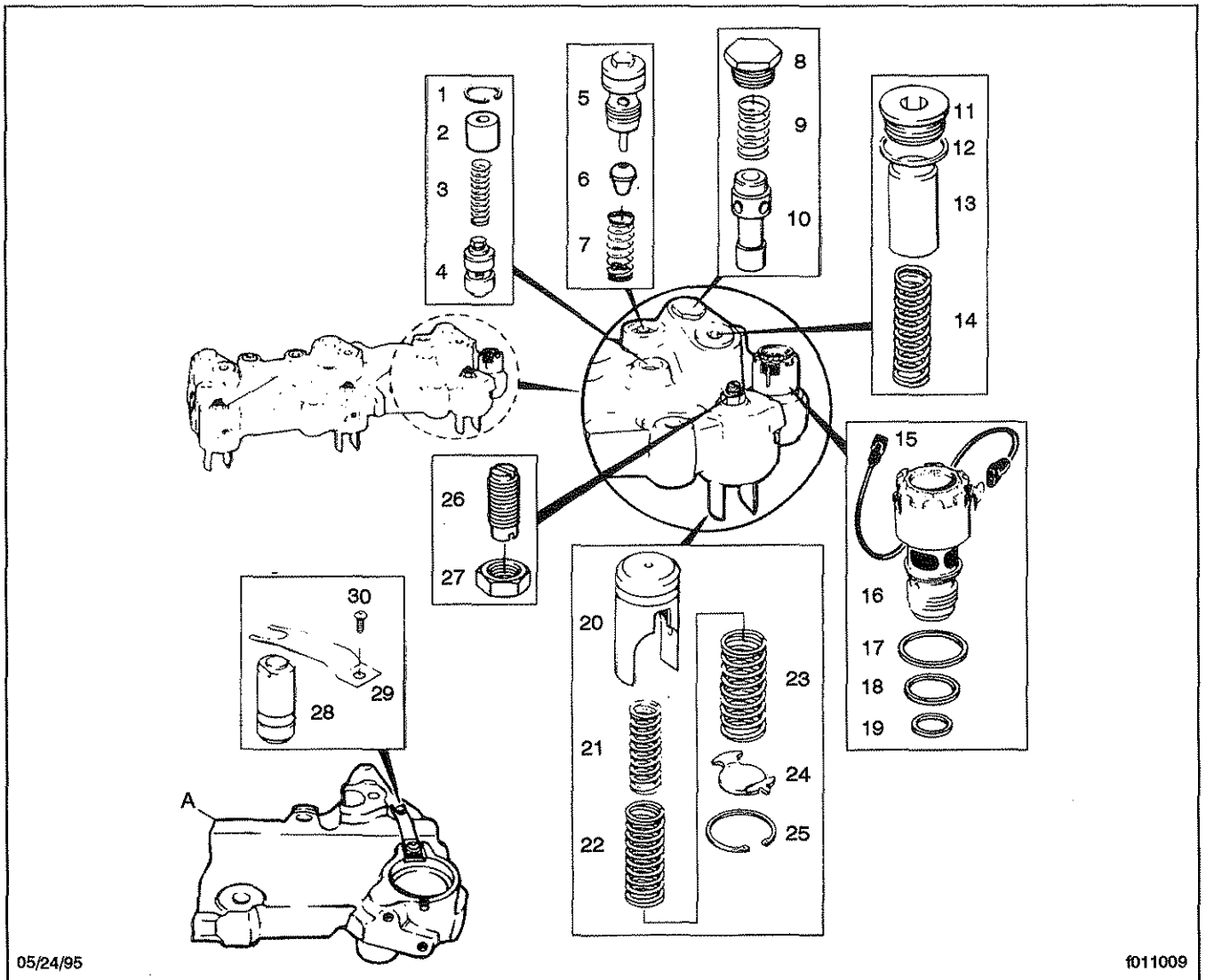
1. Using the slave piston removal tool, install the slave piston, springs, retainer, adjusting screw, and jam nut.
2. Rotate the slave piston retaining ring 90 degrees from the slot in the housing to ensure that it is properly seated.
3. Adjust the slave piston.
   - 3.1 With the exhaust valve on the cylinder closed, insert a Jacobs 0.018-inch feeler gage between the slave piston feet and the exhaust bridge.
   - 3.2 Turn the slave piston adjusting screw assembly in until you feel a slight drag on the feeler gage.
   - 3.3 Hold the slave piston adjusting screw in position and tighten the jam nut 25 lbf·ft (35 N·m).
   - 3.4 Continue the slave piston adjustments following the sequence in **Table 1.**

Engine Position	Slave Piston Cylinder
Cylinder 1 TDC	1, 3, 5
Cylinder 6 TDC	2, 4, 6

Table 1, Slave Piston Adjustment Sequence

4. Install the engine brake housing. For instructions, refer to **Subject 190.**
5. Install the rocker cover. For instructions, refer to **Subject 150.**

Removal (See Fig. 1)



A. Bottom of Brake Housing

1. Control Valve Retaining Ring
2. Control Valve Spacer/Cover
3. Control Valve Spring
4. Control Valve
5. Check Valve
6. Check Valve
7. Check Valve Spring
8. Trigger Valve Cap
9. Trigger Valve Spring
10. Trigger Valve
11. Delay Piston Cap
12. Delay Piston Copper Seal (if used)
13. Delay Piston
14. Delay Piston Spring
15. Solenoid Valve Harness
16. Solenoid Valve
17. Upper Seal
18. Center Seal
19. Lower Seal
20. Slave Piston
21. Slave Piston Spring
22. Slave Piston Spring
23. Slave Piston Spring
24. Slave Piston Retainer
25. Slave Piston Retaining Ring
26. Slave Piston Adjusting Screw
27. Slave Piston Adjusting Screw Locknut
28. Master Piston
29. Master Piston Flat Spring
30. Master Piston Buttonhead Screw

Fig. 1, Brake Housing Assembly

Solenoid Removal, Cleaning, and Installation

1. Wipe the engine brake housing area clean. Remove the rocker cover. For instructions, refer to **Subject 150**.
2. Disconnect the solenoid harness.
3. Using a 7/8-inch socket and extension, remove the solenoid assembly.
4. Remove and discard the three rubber seal rings.

   If the lower seal ring stays in the bottom of the housing solenoid bore, remove it with a pick.

Cleaning and Installation

1. Wash out the solenoid assembly with an approved solvent. Use a brush to clean the oil screen. When clean, dry the valve with compressed air.

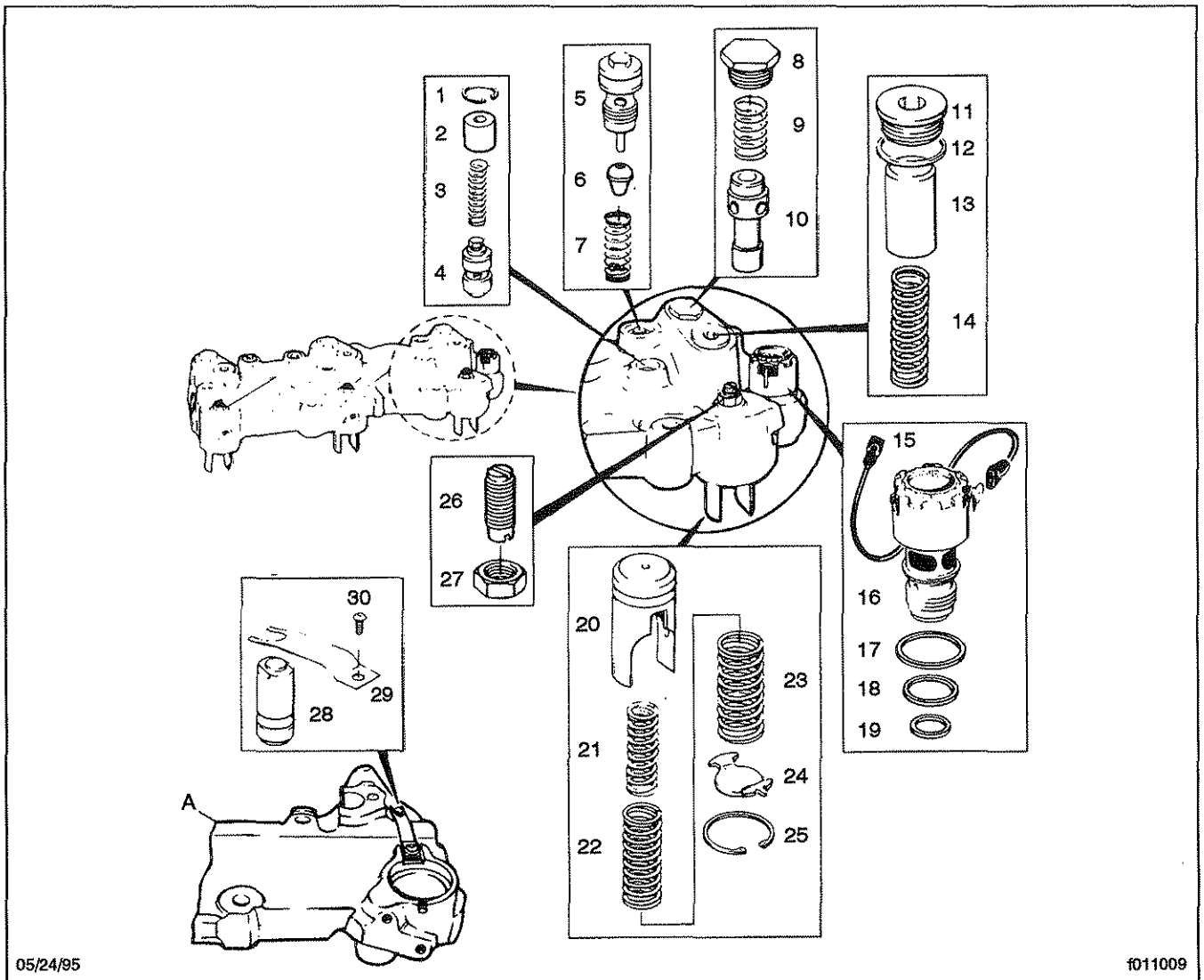
NOTE: Do not use shop rags as they may leave lint or residue which can plug passageways.

2. Use clean paper towels to clean out the solenoid valve bore in the housing.

CAUTION: Do not readjust or tamper with the solenoid valve, engine damage could result.

3. Install the solenoid using new seals rings.
   - 3.1 Seat the lower seal ring in the base of the solenoid valve bore.
   - 3.2 Wipe clean lube oil into and around the bore.
   - 3.3 Place the upper and center seal rings on the solenoid valve body.
   - 3.4 Make sure the seals are seated properly, and carefully screw the solenoid into the housing without unseating the seals.
   - 3.5 Tighten the valve 110 lbf·in (1240 N·cm). Be careful not to twist the seals while installing the solenoid.
4. Install the rocker cover. For instructions, refer to **Subject 150**.

Removal (See Fig. 1)



A. Bottom of Brake Housing

1. Control Valve Retaining Ring
2. Control Valve Spacer/Cover
3. Control Valve Spring
4. Control Valve
5. Check Valve
6. Check Valve
7. Check Valve Spring
8. Trigger Valve Cap
9. Trigger Valve Spring
10. Trigger Valve
11. Delay Piston Cap
12. Delay Piston Copper Seal (if used)
13. Delay Piston
14. Delay Piston Spring
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25. Slave Piston Retaining Ring
26. Slave Piston Adjusting Screw
27. Slave Piston Adjusting Screw Locknut
28. Master Piston
29. Master Piston Flat Spring
30. Master Piston Buttonhead Screw

Fig. 1, Brake Housing Assembly

Trigger Valve Removal, Inspection, and Installation

1. Wipe the engine brake housing area clean. Remove the rocker cover. For instructions, refer to **Subject 150.**
2. Remove the trigger valve cap and spring.
3. Remove the trigger valve.

Inspection and Installation

1. Inspect the trigger valve parts for damage or wear, and replace them as needed.
2. Install the trigger valve, using a new cap and spring.
3. Tighten the cap 35 lbf·ft (48 N·m).
4. Install the rocker cover. For instructions, refer to **Subject 150.**

Engine Brake Housing Removal and Installation

Removal

1. Apply the parking brakes, chock the tires, shut down the engine, and tilt the hood.

WARNING: To avoid personal injury, never remove any engine brake component with the engine running.

2. Wipe the engine brake housing area clean. Remove the rocker cover. For instructions, refer to **Subject 150.**

3. Remove the brake housing.

   3.1 Remove the Jacobs washers and hex-head bolts that run through the housing and support tubes and into the support bases.

   3.2 Remove the two flanged screws and washers at the rocker shaft location.

   3.3 Remove the brake housing. Repeat this step to remove the second brake housing.

Installation

1. Install the brake housing.

   1.1 Make sure there is an O-ring on the oil supply adapter, and place a small amount of grease on the adapter.

   IMPORTANT: The housings are marked front and rear. The front housing must be installed on the front three cylinders, and the rear housing must be installed on the rear three cylinders.

   1.2 Place the housing over the studs, and install the two support tubes between the housing and support bases.

   1.3 Install the Jacobs washers and the hex-head bolts through the housing and support tubes and into the support bases. Hand tighten the bolts.

   1.4 Install the two flanged screws and washers at the rocker shaft location.

   1.5 Tighten the flanged screws at the rocker shaft location 60 lbf·ft (82 N·m).

   1.6 Tighten the next head bolts at the support base locations 60 lbf·ft (82 N·m).

   1.7 Tighten the two flanged screws at the rocker shaft location 120 lbf·ft (163 N·m).

   1.8 Repeat this step to install the second brake housing.

2. Install the rocker cover. For instructions, refer to **Subject 150**

3. Remove the chocks from the tires.

Ether Start System 01.04

Contents

Subject	Subject Number
General Information	050
Service Operations	
Ether Start Fluid Cylinder Replacement	100
Troubleshooting	300
Specifications	400

General Information

During cold weather starts, the KBi starting fluid system injects vaporized ether into the engine manifold to help ignite the diesel fuel in the cylinders. The diesel normally ignites on the compression stroke of each piston, when the compressed air within the cylinder reaches about 725°F (385°C). However, during cold weather starts, the heat of the compressed air dissipates into the surrounding engine block so the diesel may never reach the temperature it needs to ignite. Ether ignites at 360°F (182°C). Therefore, ether vapor injected with the engine intake air ignites at the lower cylinder temperature, and the burning ether ignites the diesel.

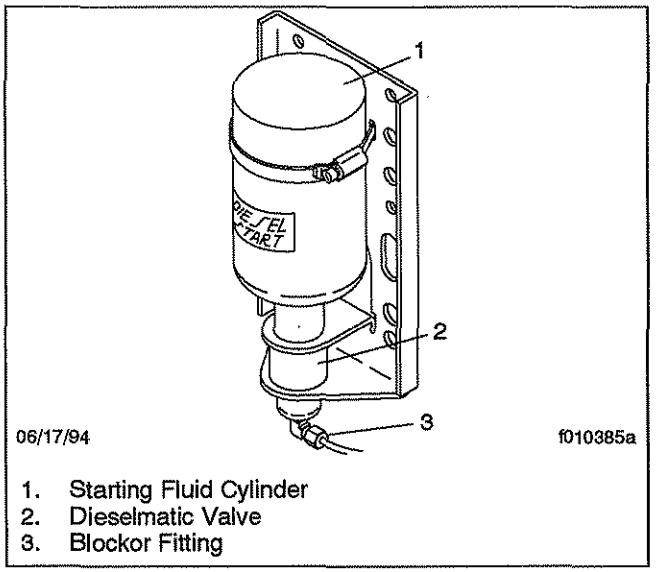
Using the starting fluid system reduces the necessary cranking time in cold weather, and it prevents excessive wear on the battery and starter.

When the engine is cold, the KBi system begins injecting ether when the starter is cranked. The system continues injecting ether vapor into the manifold for a short time to prevent stalling. The system consists of the starting fluid cylinder, the ether injection nozzle in the engine manifold, and the engine temperature sensor.

The starting fluid cylinder (**Fig. 1**) is mounted on the frame rail. It fits into the Dieselmatic® valve and Blockor® fitting which measure, hold, and release a controlled amount of fluid for each start attempt.

Ether travels through plastic tubing to the engine manifold where it sprays through the injection nozzle into the engine intake air. Inside the manifold, vaporized ether fills the cylinders and ignites.

If the weather is warm, or the engine is already warmed, the engine temperature sensor mounted in the engine water jacket prevents the KBi from injecting ether vapor. The system will inject ether only if the engine is cooler than about 40°F (4°C).



1. Starting Fluid Cylinder
2. Dieselmatic Valve
3. Blockor Fitting

Fig. 1, KBi Ether Start System

Ether Start Fluid Cylinder Replacement

Replacement (See Fig. 1)

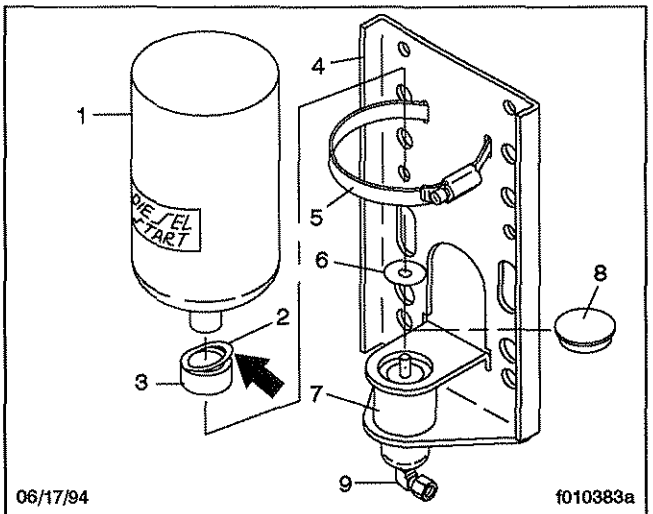
1. Park the vehicle, apply the parking brakes, and chock the tires.
2. Tilt the hood.

WARNING: Service starting fluid systems only in a well-ventilated area away from sparks and open flames. The ethyl ether in these systems is flammable and toxic. Wear protective gloves and glasses, and avoid breathing ether fumes. Failure to take these precautions could result in personal injury or property damage.

3. Remove the old cylinder.
   - 3.1 Clean all dirt from the neck of the cylinder and the top of the Dieselmatic® valve before removing the cylinder.
   - 3.2 Loosen the cylinder clamp.
   - 3.3 Pry the dirt eliminator collar off the neck of the cylinder.
   - 3.4 Unscrew the cylinder from the Dieselmatic valve.

NOTE: If not replacing the cylinder immediately, place the valve cap in the valve to prevent dirt or other debris from entering the system.

4. Remove the old dirt eliminator collar from the valve assembly.
5. Replace the Dieselmatic valve gasket. Spread the new gasket with a light film of clean oil.
6. Place a new dirt eliminator collar, adhesive-side up, on the valve assembly. Peel off the collar's paper backing to expose the adhesive.
7. Install the new cylinder.
   - 7.1 Place the new cylinder into the Dieselmatic valve and hand tighten it firmly.
   - 7.2 Slide the dirt eliminator collar up so it sticks to the cylinder.
   - 7.3 Tighten the clamp around the cylinder 60 lbf·in (680 N·cm).
8. If the ambient temperature is below 40°F (4°C), test the starting fuel system.
9. Lower the hood, and remove the chocks from the tires.



1. Starting Fluid Cylinder
2. Paper Backing
3. Dirt Eliminator Collar
4. Mounting Plate
5. Cylinder Clamp
6. Valve Gasket
7. Dieselmatic Valve
8. Valve Cap
9. Blockor Fitting

Fig. 1, KBi Ether Start System

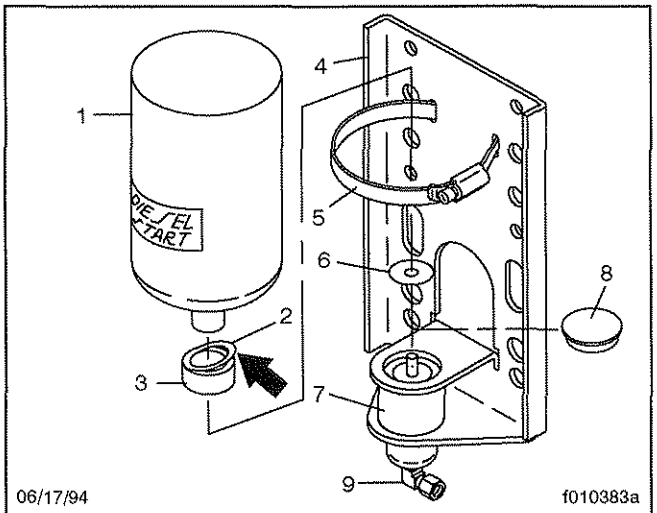
Troubleshooting

Use the following procedures to check for most common problems that may prevent starting fluid delivery.

WARNING: Service starting fluid systems only in a well-ventilated area away from sparks and open flames. The ethyl ether in these systems is flammable and toxic. Wear protective gloves and glasses, and avoid breathing ether fumes. Failure to take these precautions could result in personal injury or property damage.

EMPTY FLUID CYLINDER (See Fig. 1)

1. Remove the old cylinder.
   - 1.1 Clean all dirt from the neck of the cylinder and the top of the Dieselmatic® valve before removing the cylinder.
   - 1.2 Loosen the cylinder clamp.
   - 1.3 Pry the dirt eliminator collar off the neck of the cylinder.
   - 1.4 Unscrew the cylinder from the Dieselmatic valve.
   - 1.5 Remove the cylinder from the mounting plate. Cover the top of the valve after the cylinder is removed.
   - 1.6 Remove the old dirt eliminator collar from the valve assembly.
2. Weigh the cylinder to see if it is empty. See **Table 1** for the weight of each cylinder size.



1. Starting Fluid Cylinder
2. Paper Backing
3. Dirt Eliminator Collar
4. Mounting Plate
5. Cylinder Clamp
6. Valve Gasket
7. Dieselmatic Valve
8. Valve Cap
9. Blockor Fitting

Fig. 1, KBi Ether Start System

Cylinder Size oz (g)	Weight	
	Empty oz (g)	Full oz (g)
21 (595)	16 (455)	37 (1050)
18 (510)	15 (425)	33 (935)
8 (225)	10 (285)	18 (510)

Table 1, Ether Cylinder Weights

3. Replace the Dieselmatic valve gasket. Spread the new gasket with a light film of clean oil.
4. Check that the fluid cylinder has at least 120 psi pressure at 68°F (20°C).
5. If the cylinder is good, install it; if not, replace it.
   - 5.1 Place a new dirt eliminator collar, adhesive-side up, on the valve assembly. Peel off the collar's paper backing to expose the adhesive.
   - 5.2 Place the new cylinder into the Dieselmatic valve and hand-tighten it firmly.
   - 5.3 Slide the dirt eliminator collar up so it sticks to the cylinder.
   - 5.4 Tighten the clamp around the cylinder 60 lbf·in (680 N·cm).

ELECTRICAL PROBLEMS

1. Check for a blown fuse, and for loose wiring connections, shorts, and broken wires.
2. Check that the black ground wire from the valve assembly is connected to the engine temperature sensor, and that the ground wire from the sensor is connected to a good ground.

3. Check that the second wire from the valve assembly is connected to the "M" terminal of the starter.

WARNING: When testing the starting fluid system, wear protective gloves and glasses, and spray the vaporized ether into a container. Failure to do so could result in personal injury.

4. Test the valve.

   4.1 Remove the starting fluid cylinder.

   4.2 If the ambient air temperature is over 40°F (4°C), remove the black ground wire from the engine temperature sensor, and ground it.

   4.3 Crank the starter, and look for the valve plunger (see **Fig. 2**) to move up and stay up while the starter is cranked.

CAUTION: Do this test only two times. Activating the starting fluid system in this manner more than twice could result in damage to the system.

5. If the plunger does not move, disconnect both valve assembly wires and momentarily touch the leads across battery terminals. If the valve plunger still does not move up, replace the valve.

6. If the valve operates correctly, check the engine temperature sensor.

   6.1 Connect the appropriate wire to the "M" terminal of the starter.

   6.2 Remove the sensor from the engine water jacket, and chill it to below freezing for at least ten minutes.

   6.3 Install the sensor, grounding it at a good ground.

   6.4 Connect the black ground wire from the valve assembly to the sensor.

   6.5 Crank the engine, and look for the valve plunger to move up and stay up while the starter is cranked.

CAUTION: Do this test only two times. Activating the starting fluid system in this manner more than twice could result in damage to the system.

7. If the plunger does not move, replace the sensor.

CLOGGED ETHER NOZZLE

1. Disconnect the ether tubing from the nozzle, and cover the nozzle fitting.

2. Disconnect the black ground wire from the engine temperature sensor, and ground it.

WARNING: When testing the starting fluid system, wear protective gloves and glasses, and spray the vaporized ether into a container. Failure to do so could result in personal injury.

3. Start the engine, and look for ether to spray from the tubing.

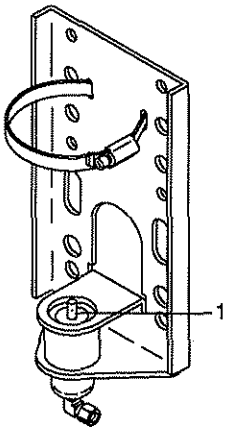
CAUTION: Do this test only two times. Activating the starting fluid system in this manner more than twice could result in damage to the system.

4. If no ether sprays from the tubing, disconnect the tubing at the Blockor® fitting in the base of the cylinder assembly. See **Fig. 1.**

5. Start the engine, and look for ether to spray from the Blockor fitting in the base of the cylinder assembly.

CAUTION: Do this test only two times. Activating the starting fluid system in this manner more than twice could result in damage to the system.

6. If ether sprays from the fitting, but not from the tubing, check for kinks or blockages in the ether tubing and the nozzle. Repair or replace the tubing and nozzle, as needed.



1. Plunger

Fig. 2, Valve Plunger

If no ether sprays from the fitting or tubing, check the Blockor fitting for blockages. Repair or replace the fitting, as needed.

If no ether sprays from the fitting or tubing, check the Blockor fitting for blockages. Repair or replace the fitting, as needed.

Specifications

Description	lbf·in (N·cm)
Cylinder Clamp	60 (680)

Table 1, Ether System Torques

Bypass Oil Filters

01.05

Contents

Subject **Subject Number**

General Information 050

Service Operations

- Oil Filter Element Replacement, Fleetguard® Model LF 750™ 100
- Oil Filter Element Replacement, Luber-finer® Model 750-CT 110
- Centrifuge Bowl Cleaning, Spinner II® 120

General Information

A bypass oil filter is a remote-mounted oil filter plumbed to the engine. Not all of the engine oil runs through a bypass filter, the filter bleeds some of the oil from the engine, the rest of the oil "bypasses" the filter and stays within the engine.

Normal engine operation produces a variety of contaminants such as resins, gums, and acids. The bypass oil filter – sometimes used with a full-flow filter (an engine-mounted filter that *all* the oil must run through) – traps these contaminants and prevents excessive wear of engine parts. The filtered oil then returns to the engine crankcase or sump.

Freightliner uses the following models of bypass oil filters:

- Fleetguard® Model 750™
- Luber-finer® Model 750-CT
- Spinner II®

FLEETGUARD MODEL LF 750 (See Fig. 1)

Engine oil enters the Fleetguard Model LF 750 through the inlet check valve and fills the filter housing around the filter element. Oil pressure within the housing builds until oil is forced through the filter. Inside the filter, the filtered oil moves through openings in the filter hold-down assembly, and collects in the outlet tube. From the outlet tube, the oil goes back to the engine through the outlet check valve assembly.

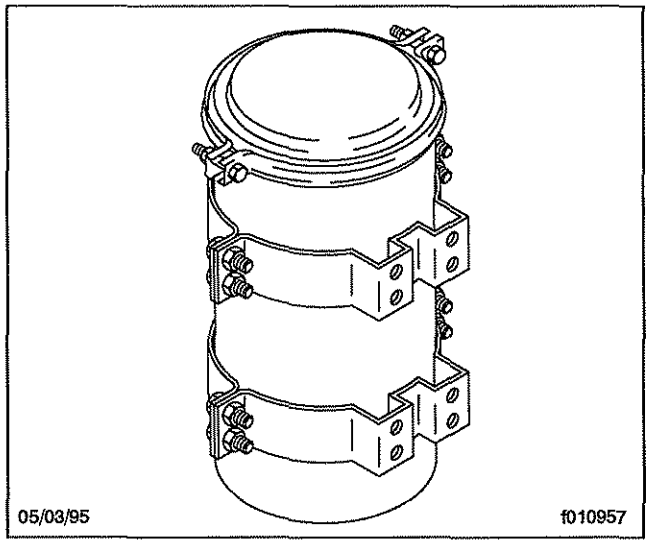


Fig. 1, Fleetguard Model LF 750 Bypass Oil Filter

An engine equipped with the Model 750 needs three gallons (11.3 liters) more oil than an engine without a bypass oil filter.

LUBER-FINER MODEL 750-CT (See Fig. 2 and Fig. 3)

To prevent thick, cold oil from clogging the filter, a thermostat within the Luber-finer model 750-CT allows engine oil to flow through the filter only after the oil has warmed to a specified temperature. The thermostat is inside the T-handle assembly that holds the filter pack in place.

Engine oil enters through the inlet check valve assembly on the bottom of the filter housing, and fills the filter housing around the filter pack (element). Inside the housing, oil pressure forces the oil through the sides of the filter pack. Inside the filter pack, filtered oil travels through openings in the T-handle hold-down assembly, then collects in the outlet tube. From the outlet tube, filtered oil goes back to the engine through the outlet check valve assembly.

The inlet and outlet valves normally have #8 orifices.

Normal continuous operating oil pressure is about 65 psi (448 kPa). An engine equipped with the Model 750-CT needs 3 1/2 gallons (13.2 liters) more oil than an engine without a bypass oil filter. Flow rate through the filter is about one or two gallons (3.7 or 7.5 liters) per minute at normal operating pressure.

SPINNER II (See Fig. 4 and Fig. 5)

The Spinner II uses centrifugal force to separate contaminants from the oil, and uses air pressure to force the filtered oil back to the engine.

Engine oil enters the top half of the filter housing, and travels up through a spindle in the center of a cylindrical centrifuge turbine lined with an optional paper lining. At the same time, the pressure of the oil entering the filter housing makes the centrifuge spin. The oil sprays out of the top of the spindle, and the centrifugal force of the spinning centrifuge drives the oil contaminants against the inside of the centrifuge turbine. The contaminants cake inside the centrifuge turbine, and the clean oil runs into the bottom half of the filter housing.

General Information

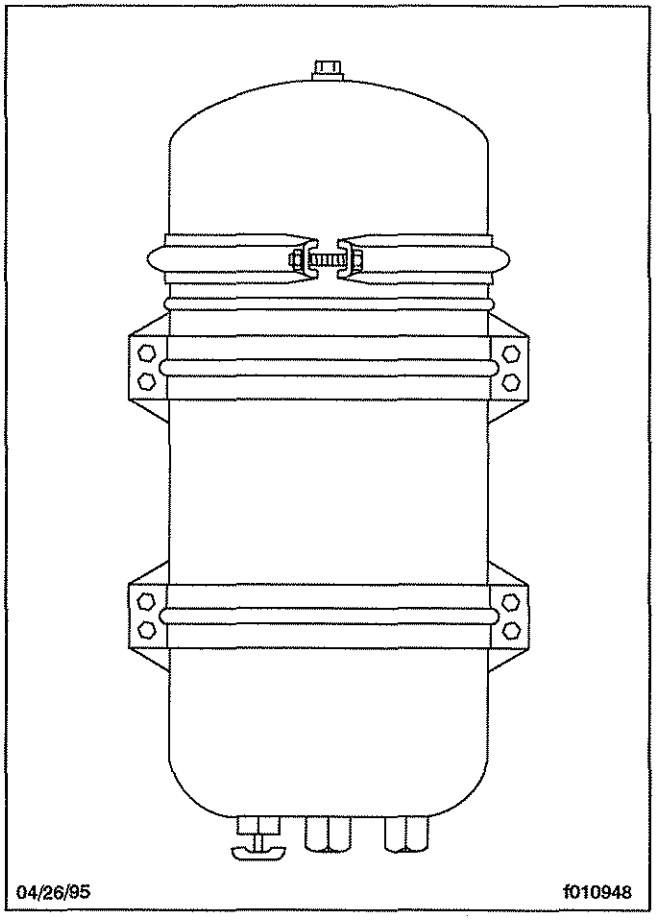
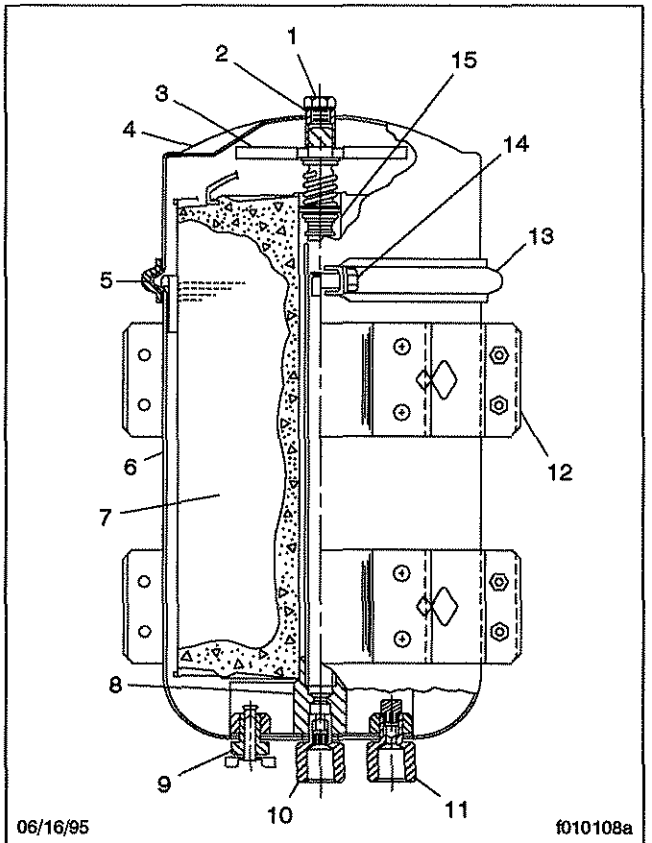


Fig. 2, Luber-finer Model 750-CT Bypass Oil Filter

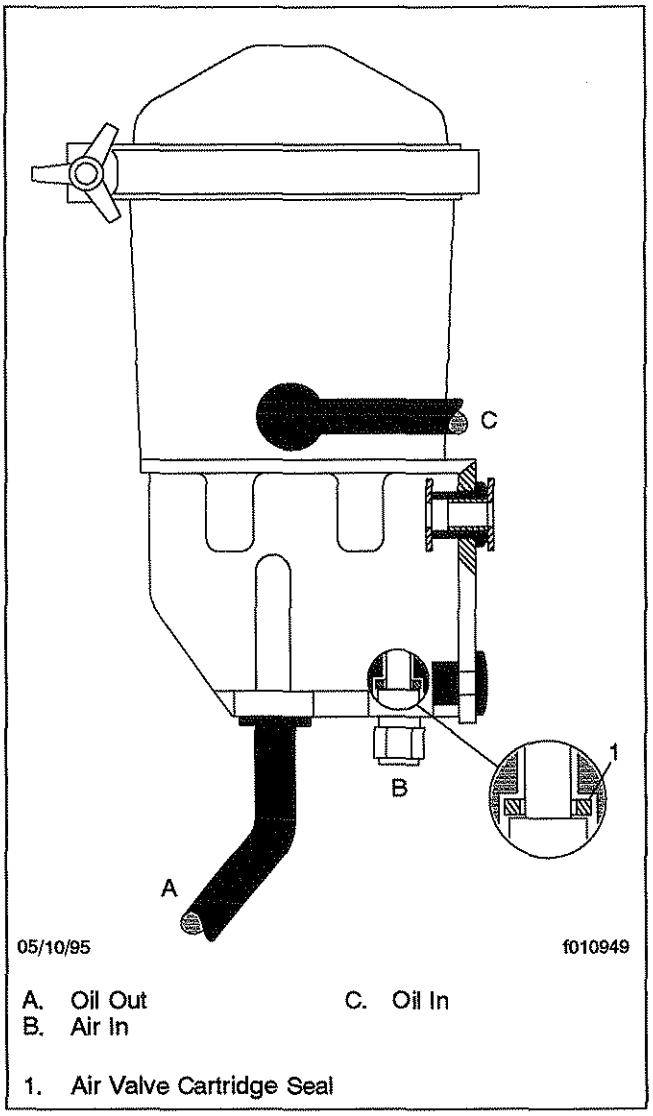
The clean oil collects in the bottom half of the filter housing where it lifts a float. The float opens a valve that allows brake system air to enter the housing, and the air pressure forces the cleaned oil out of the housing and back to the engine.

Normal continuous operating oil pressure is about 60 psi (413.6 kPa). An engine equipped with the Spinner II doesn't need any extra oil. Flow rate through the cleaner is about two gallons (7.5 liters) per minute at normal operating pressure.



1. Vent Plug Capscrew
2. Washer
3. T-Handle
4. Cover
5. Cover Gasket
6. Housing
7. Filter Element
8. Outlet Tube
9. Drain Cock
10. Outlet Check Valve Assembly
11. Inlet Check Valve Assembly
12. Mounting Bracket
13. Clamping Ring
14. Clamp-Ring Capscrew
15. Hold-Down Assembly

Fig. 3, Luber-finer Model 750-CT, Sectional View



A. Oil Out
B. Air In
C. Oil In

1. Air Valve Cartridge Seal

Fig. 4, Spinner II Bypass Oil Filter

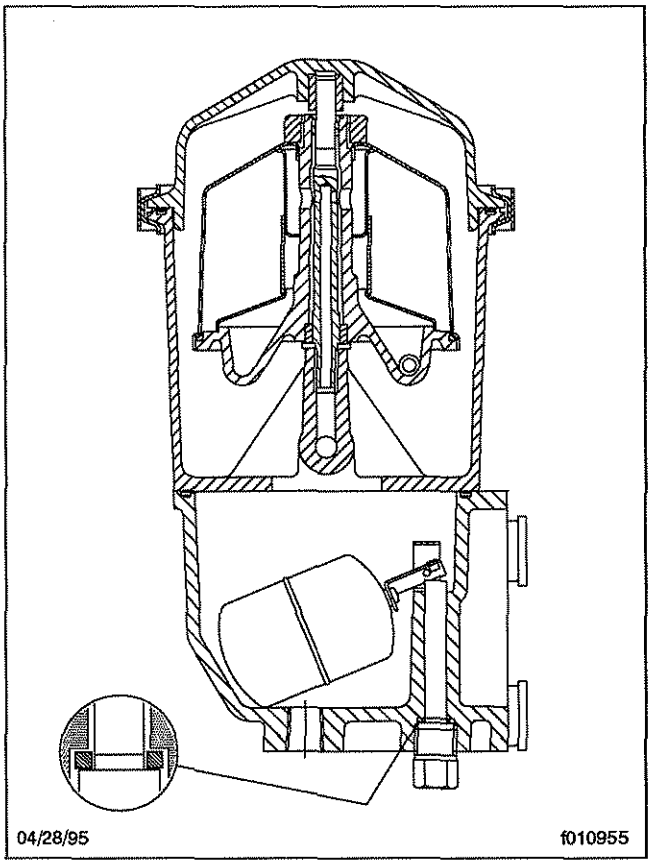


Fig. 5, Spinner II Bypass Oil Filter, Sectional View

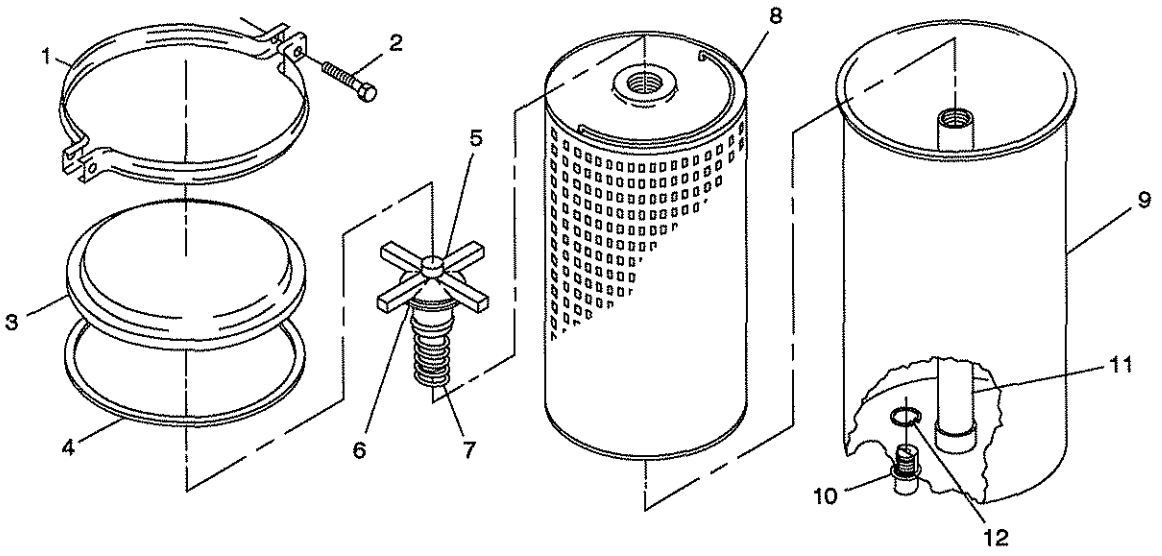
Oil Filter Element Replacement, Fleetguard® Model LF 750™

Replacement (See Fig. 1)

IMPORTANT: Do the following at every scheduled engine oil change. Refer to the engine maintenance manual for the quantity of oil that must be added to the lubrication system when replacing the bypass filter.

1. Remove the oil filter element.
   - 1.1 Remove the drain plug and allow the oil to drain.
   - 1.2 Remove the clamp-ring capscrews. Remove the clamp ring and lift the cover off the filter housing.
   - 1.3 Unscrew the hold-down assembly T-handle and remove the assembly from the housing. Check the O-ring and spring for damage. Replace if needed.
   - 1.4 Remove and discard the oil filter element.
2. Clean the inside of the housing, and the hold-down assembly, with solvent.
3. Assemble the filter.
   - 3.1 Install the drain plug.
   - 3.2 Install a new filter element.
   - 3.3 Install the hold-down assembly and securely tighten the T-handle.
   - 3.4 Check the cover gasket for damage, and replace it if needed. Position the gasket on the housing.
   - 3.5 Position the cover on the housing. Install the clamp ring and capscrews. Alternately tighten the capscrews to ensure a uniform seal between the cover and gasket.
   - 3.6 Start the engine and let it idle until normal operating oil pressure is reached.

CAUTION: Make sure the engine oil level is correct. Operating the engine with the oil level below the low ("L") mark, or above the high mark, could result in engine damage.



1. Clamp Ring
2. Clamp-Ring Capscrew
3. Cover
4. Cover Gasket
5. T-Handle
6. O-Ring
7. Spring
8. Filter Element
9. Housing
10. Inlet Check Valve Assembly
11. Outlet Tube
12. Retaining Ring

Fig. 1, Fleetguard Model LF 750, Exploded View

Oil Filter Element Replacement, Fleetguard® Model LF 750™

3.7 Add oil as needed to bring the oil level up to the high ("H") mark on the dipstick.

Contents

Subject	Subject Number
Service Operations	
MBE4000 Engine Removal and Installation	100
Specifications	400

MBE4000 Engine Removal and Installation

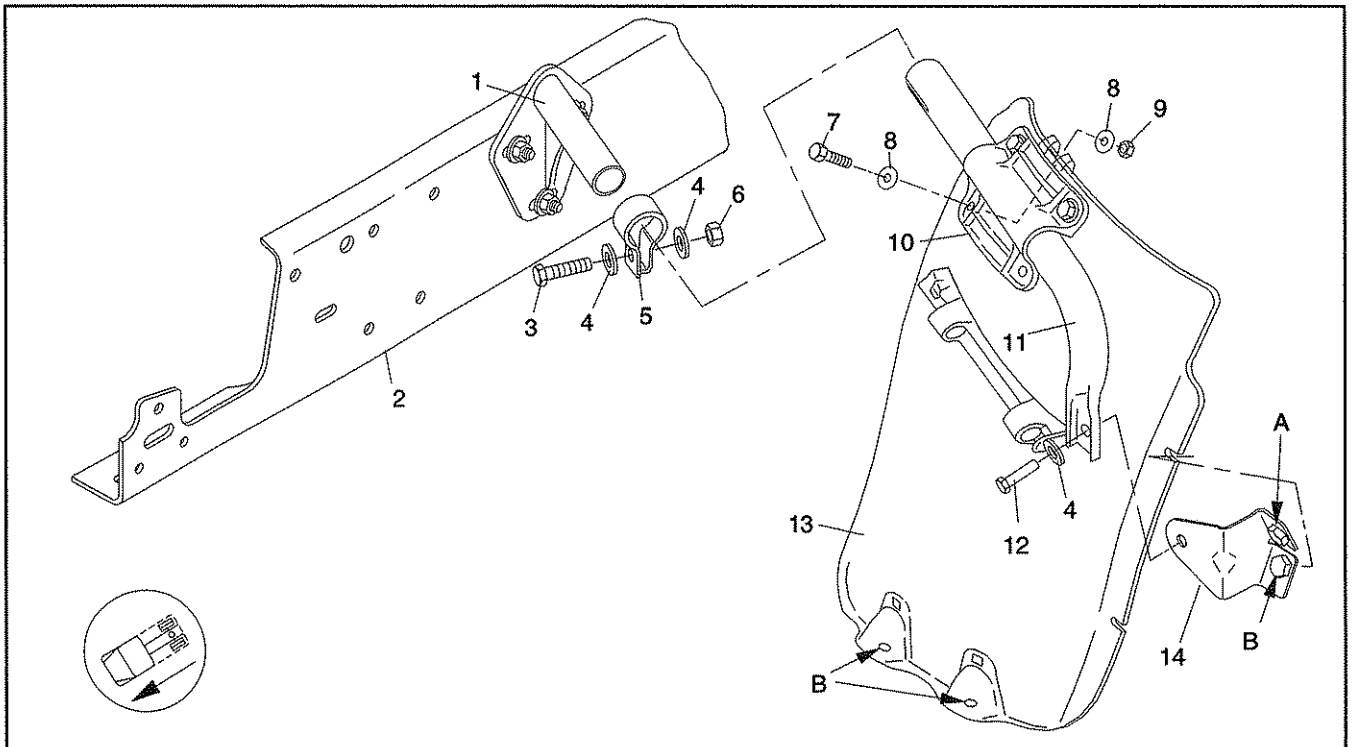
Removal

1. Apply the parking brakes, chock the tires, and drain the air system.
2. Disconnect the battery cables at the batteries.
3. On each side of the vehicle, remove the components in the wheel well (bumper, air dam, splash shield, support arm, etc.). See **Section 31.03** for bumper and air dam removal instructions. See **Fig. 1** for splash shield removal.
   - 3.1 Remove both side fenders.
   - 3.2 Remove the splash shields.
   - 3.3 Remove the bumper and air dam assembly.
   - 3.4 Remove the bumper support arm, and outboard bumper support bracket.
4. Remove the grille. For detailed instructions, see **Section 88.00**, Subject 110.
5. Remove the hood. For detailed instructions, see **Section 88.00**, Subject 100.

⚠ WARNING

Drain the coolant only when the coolant and engine are cool. Draining it when these are hot could cause severe personal injury due to scalding.

6. Drain the coolant from the radiator. See **Fig. 2.**



NOTE: Left-hand splash shield is shown; right-hand is similar.

A. To Bumper
B. To Air Dam

1. Support End
2. Frame Rail
3. Clamp Bolt, 1/2–13
4. Flatwasher, 0.053"
5. Clamp
6. Clamp Locknut, 1/2–13
7. Mounting Bolt, 5/16–18
8. Flatwasher, 5/16"
9. Mounting Locknut, 5/16–18
10. Flap
11. Support Arm
12. Bracket Capscrew, 1/2–13
13. Splash Shield
14. Outboard Bumper Support Bracket

Fig. 1, Splash Shield Removal

MBE4000 Engine Removal and Installation

7. Remove the charge air cooler pipes and hoses. See **Fig. 3** for the right-hand side and **Fig. 4** for the left-hand side.

   7.1 Remove, as a unit, the line connecting the turbocharger to the charge air cooler (warm air).

   7.2 Remove the pipe and hose connecting the charge air cooler to the charge air manifold (cold air).

   7.3 Plug the openings with a clean shop towel.

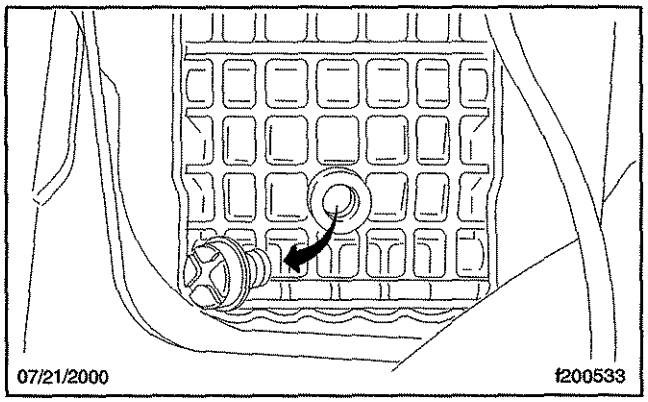
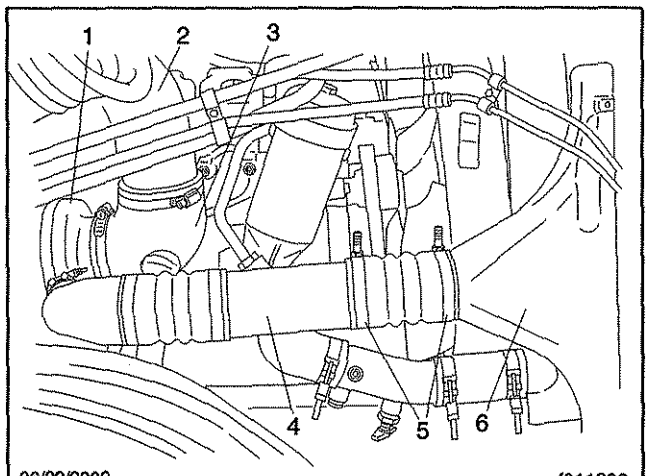


Fig. 2, Coolant Drain Plug



1. Turbocharger
2. Air Cleaner Pipe
3. Air Intake Elbow
4. Turbocharger Outlet Line
5. Constant-Torque Clamp
6. Charge Air Cooler

Fig. 3, Charge Air Piping, Warm-Air Side

8. When the coolant has fully drained, remove all the coolant hoses from the engine. See **Fig. 5** for the coolant delivery hoses from the surge tank, **Fig. 6** for the lower coolant tube, and **Fig. 7** for the upper coolant tube.

   8.1 Remove the two small-diameter hoses attached to the surge tank, one going to the engine, the other to the radiator.

   8.2 Remove the lower coolant tube.

   8.3 Remove the upper coolant tube.

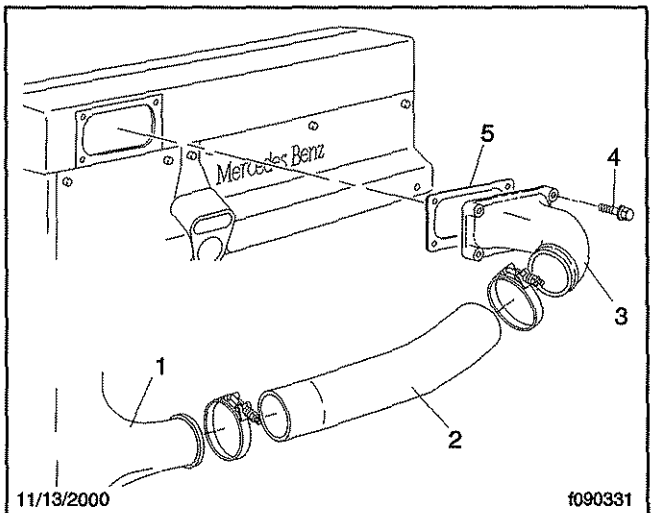
   8.4 Plug the openings with a clean shop towel.

IMPORTANT: When removing the refrigerant compressor and A/C condenser in the following steps, leave all air conditioning hoses attached to avoid depressurizing the A/C system.

9. Remove the refrigerant compressor belt. Remove the refrigerant compressor. See **Fig. 8.**

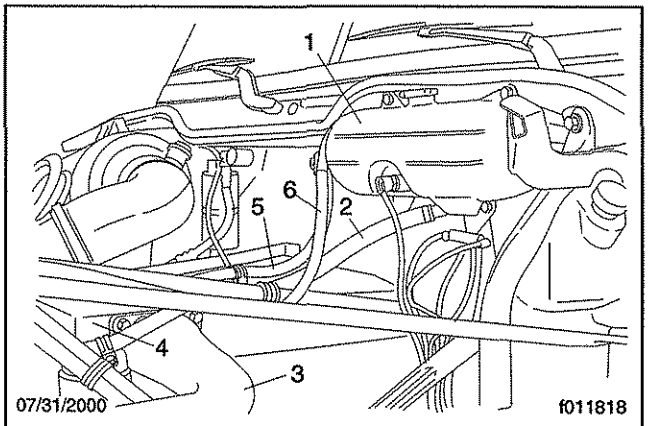
10. Remove the air-conditioning (A/C) condenser. See **Fig. 9**. Wrap the condenser, with hoses attached, in a protective blanket, and secure it out of the way.

11. Remove the radiator/charge air cooler assembly. See **Fig. 10.** For detailed procedures, see the instructions for radiators in **Section 20.01**, Subject 130, and for charge air coolers in **Section 09.02.**



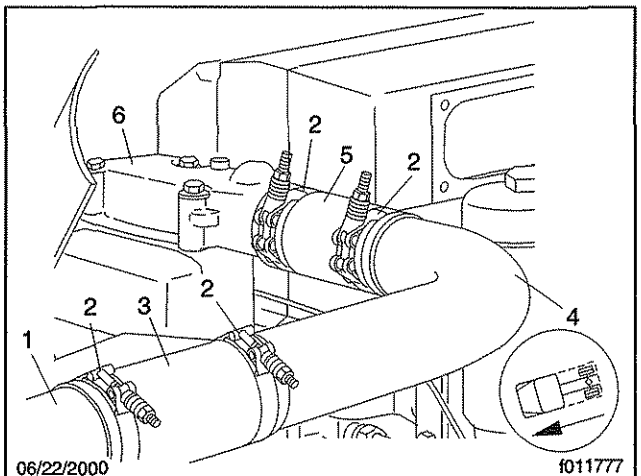
1. Charge Air Cooler
2. Charge Air Inlet Hose
3. Charge Air Inlet Pipe
4. Mounting Capscrew (4 qty.)
5. Gasket

Fig. 4, Charge Air Piping, Cold-Air Side



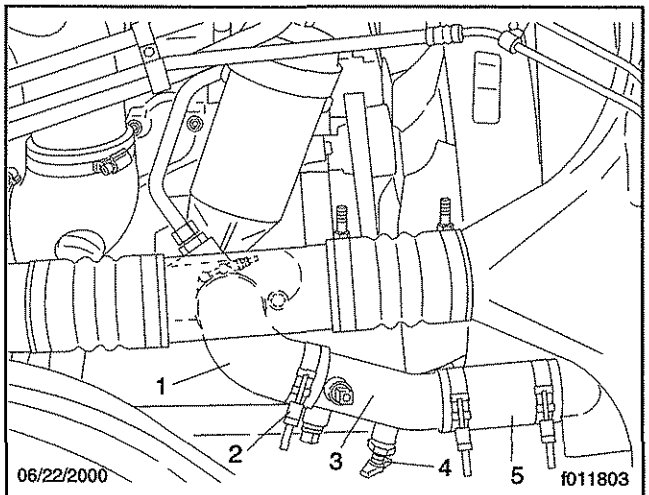
1. Surge Tank
2. Shunt Line
3. Charge Air Inlet Pipe
4. Charge Air Manifold
5. Coolant Line from Engine
6. Coolant Line to Radiator

Fig. 5, Radiator Hoses, Left-Hand Side



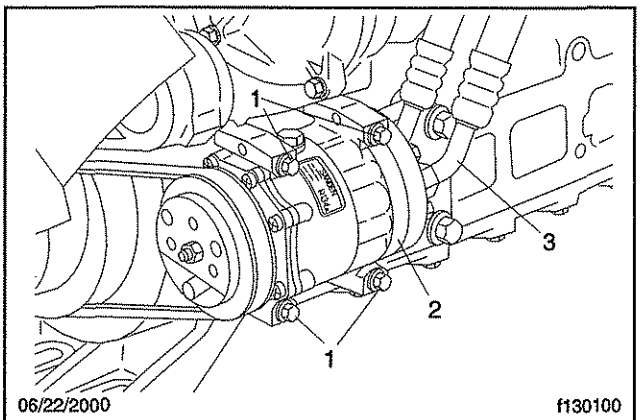
1. Radiator
2. Constant-Torque Clamp
3. Upper Coolant Hose
4. Upper Coolant Pipe
5. Coolant Pump Outlet Hose
6. Thermostat Housing

Fig. 7, Upper Coolant Tube



1. Coolant Pump Inlet Hose
2. Constant-Torque Clamp
3. Lower Coolant Pipe
4. Drain Petcock
5. Lower Coolant Hose

Fig. 6, Lower Coolant Tube



Remove the four mounting capscrews.

1. Mounting Capscrew(s)
2. Refrigerant Compressor
3. Refrigerant Line

Fig. 8, Refrigerant Compressor

12. Remove the air cleaner and the air intake piping between the turbocharger and the air cleaner. See **Fig. 11**.

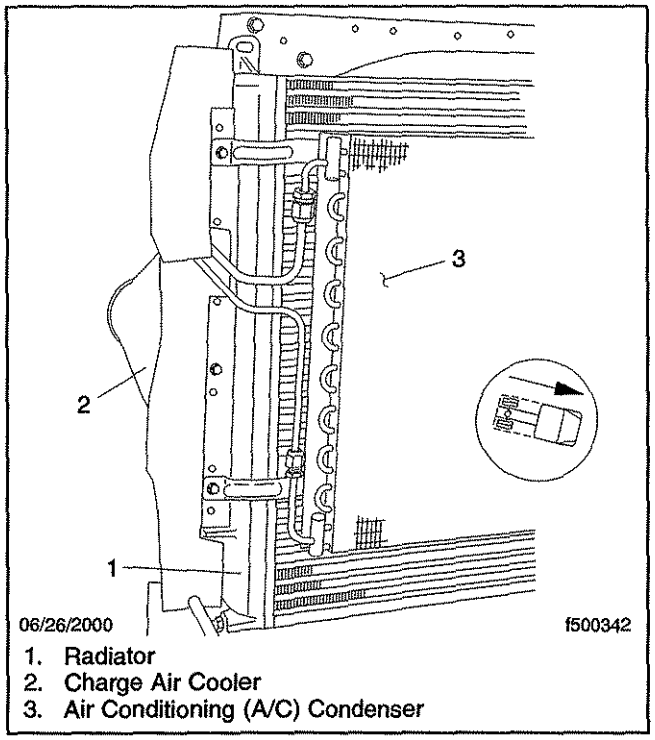
    12.1 Remove the air compressor hose from the air cleaner pipe.

    12.2 Remove the hood guide bracket from the upper air cleaner mounting bracket.

    12.3 Remove the air cleaner and flexible hose, as an assembly, from the upper and lower mounting brackets.

    12.4 Remove the air cleaner heat shield from the lower mounting bracket.

MBE4000 Engine Removal and Installation



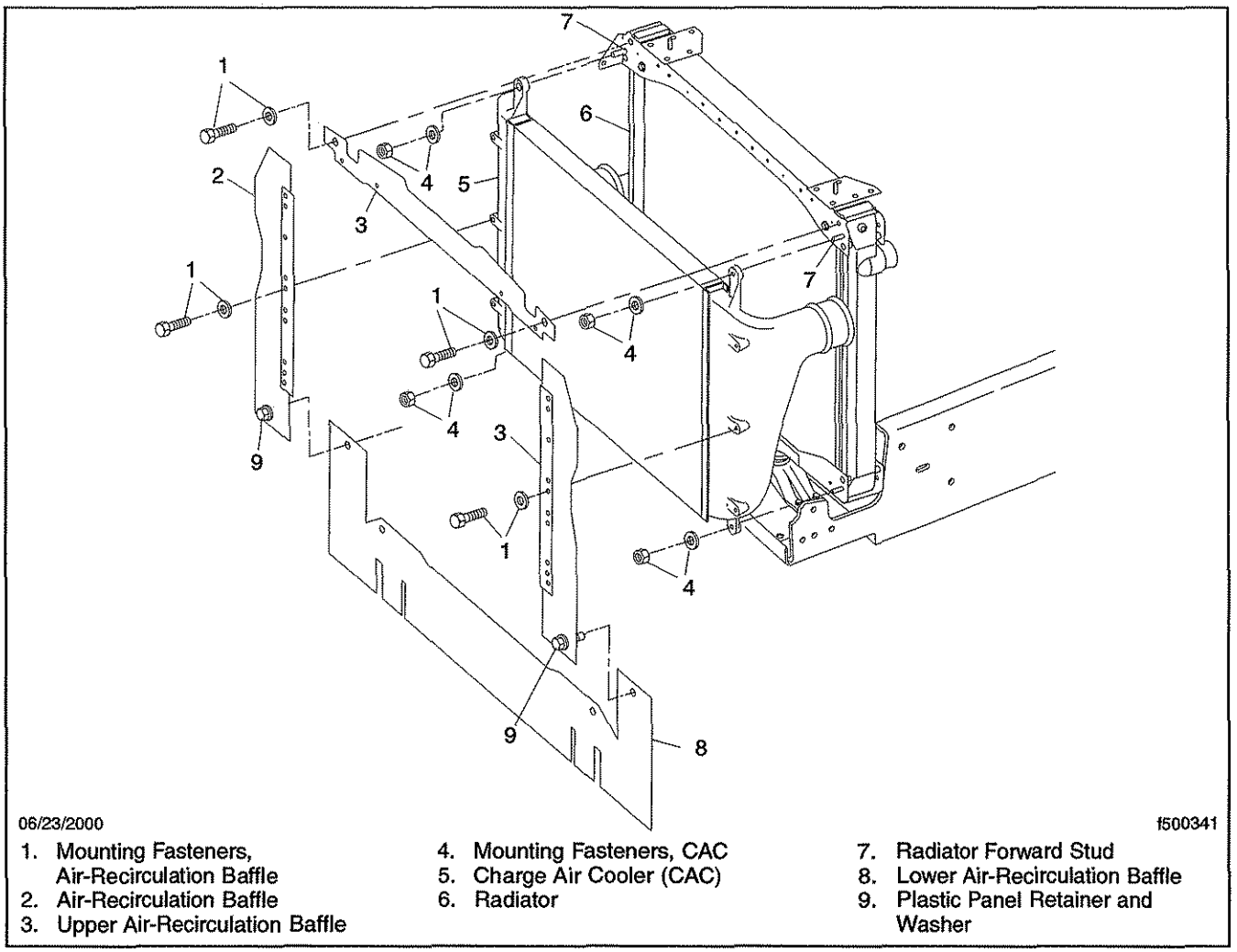
1. Radiator
2. Charge Air Cooler
3. Air Conditioning (A/C) Condenser

Fig. 9, A/C Condenser

13. Disconnect the fuel lines from the fuel filter housing. See **Fig. 12.**
    - 13.1 Remove the insulating foam, if any, around the fuel lines.
    - 13.2 Drain the fuel lines at the fuel/water separator and the heat exchanger. Use a clean container to catch any excess fuel.
    - 13.3 Disconnect the fuel feed and return lines at the fuel heat exchanger and fuel filter.
    - 13.4 Cap the fuel lines and secure them out of the way.
14. Remove the air compressor intake hose and discharge line. See **Fig. 13.**
15. Disconnect the electrical connectors from the engine.
    - 15.1 Disconnect the engine harness connector from the PLD (engine control unit). See **Fig. 14.**
    - 15.2 Disconnect the electronic engine harness connectors from the unit pumps, sensors, etc.
    - 15.3 Disconnect the other end of the electronic engine harness from the frontwall connectors. Remove the harness from the vehicle.
    - 15.4 Mark all connectors with paint pens for ease of installation.
16. Disconnect the electrical cable from the starter motor and solenoid. See **Fig. 15.**
17. Disconnect the exhaust pipe from the turbocharger. See **Fig. 16.**
18. Disconnect the power steering pump from the air compressor. Secure it, with the lines attached, up and out of the way. See **Fig. 17.**
19. Remove the lines from the air governor. See **Fig. 18.**
20. Disconnect the clutch linkage from the pedal. See **Fig. 19.**
21. Remove the driveline from the transmission. For detailed information, see **Section 41.00.**
22. Disconnect the fuel lines running alongside the transmission cooler lines.
23. Disconnect the transmission cooler lines at the transmission cooler.
24. Remove the battery cables from the engine and transmission that run along the top of the overslung crossmember.
25. Remove the shift lever and shift tower from the transmission. See **Fig. 20.**
26. Remove the overslung crossmember from both frame rails at the transmission. See **Fig. 21.**
27. Remove all transmission wiring and air shift assist lines from the transmission. Disconnect the clutch linkage from the transmission.
28. Remove both rear engine mounting bolts. See **Fig. 22.**

IMPORTANT: The rear-engine mounting bolts are 4-1/2 inches long. For purposes of clearance, the front-engine mounting bolts are only four inches long. Mark the bolts on removal.

29. Remove the front engine mount. See **Fig. 23.**



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1. Mounting Fasteners, Air-Recirculation Baffle
2. Air-Recirculation Baffle
3. Upper Air-Recirculation Baffle
4. Mounting Fasteners, CAC
5. Charge Air Cooler (CAC)
6. Radiator
7. Radiator Forward Stud
8. Lower Air-Recirculation Baffle
9. Plastic Panel Retainer and Washer

Fig. 10, Charge Air Cooler and Radiator

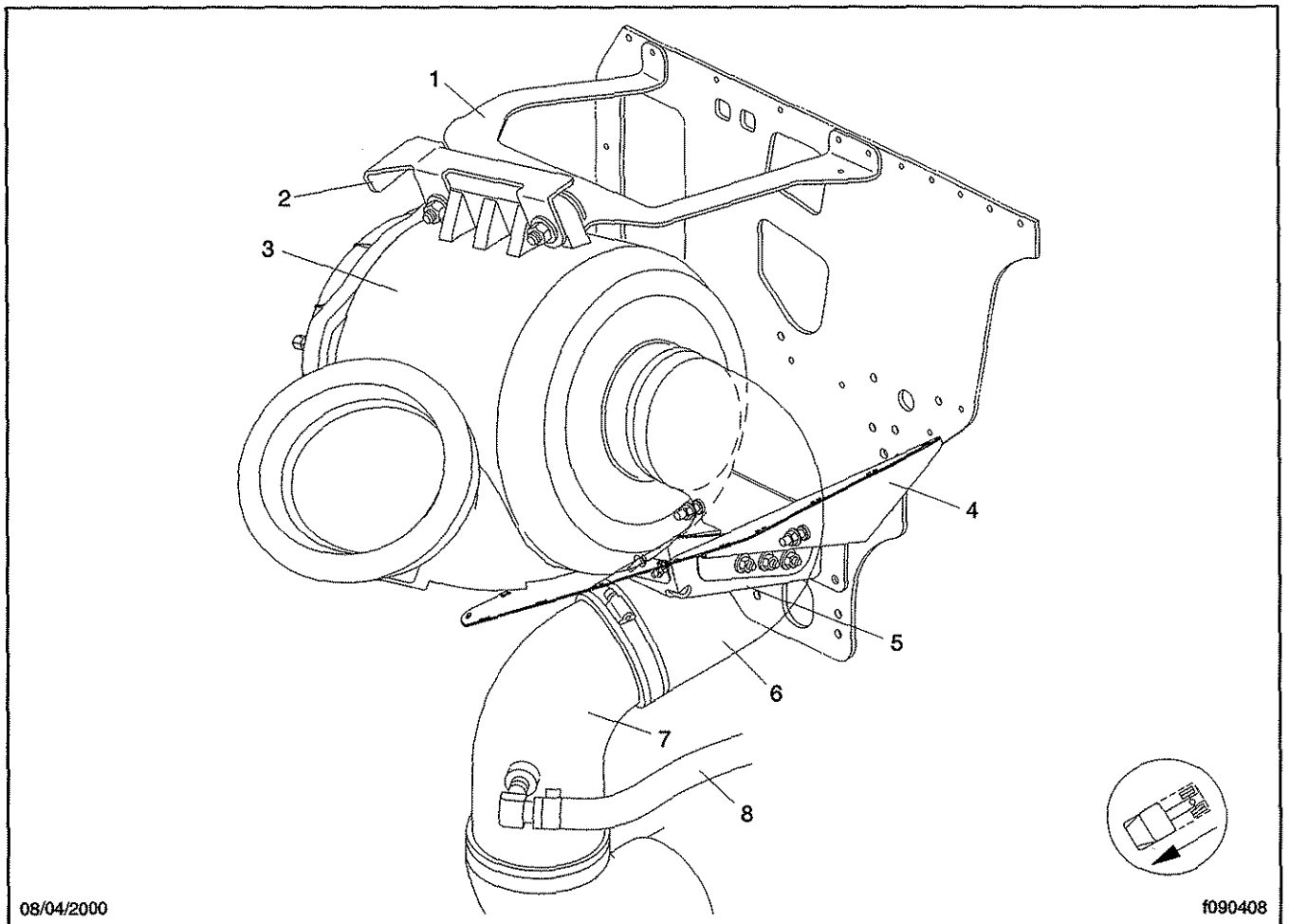
30. Attach a lifting hoist to the engine. Run the chains through the front lifting eye and rear lifting fixture. See **Fig. 24** for attachment to the front lifting eye and **Fig. 25** for attachment to the rear lifting fixture.
31. Support the rear of the transmission with a floor jack.
32. Remove the front crossmember to gain clearance for the engine and transmission.

⚠ WARNING

The crane and lifting chains used to remove the engine must be capable of safely lifting and supporting two metric tons. Once the engine mounts are disconnected, do not get under the engine until it is securely supported on engine stands. An unsecured engine may fall, causing personal injury or death, and component damage.

33. Remove the engine (including fan, transmission, etc.) from the vehicle. See **Fig. 26.**
    - 33.1 Raise the hoist slightly until it is holding the full weight of the engine.
    - 33.2 Pull the engine forward and up to clear the vehicle. If a new engine is to be installed, transfer all needed components from the old engine to the new engine.

MBE4000 Engine Removal and Installation



1. Upper Support Bracket
2. Hood Restraint Guide
3. Air Cleaner
4. Heat Shield
5. Lower Support Bracket
6. Air Cleaner Flexible Hose
7. Air Cleaner Pipe
8. Air Intake Line (to air compressor)

Fig. 11, Air Cleaner

Installation

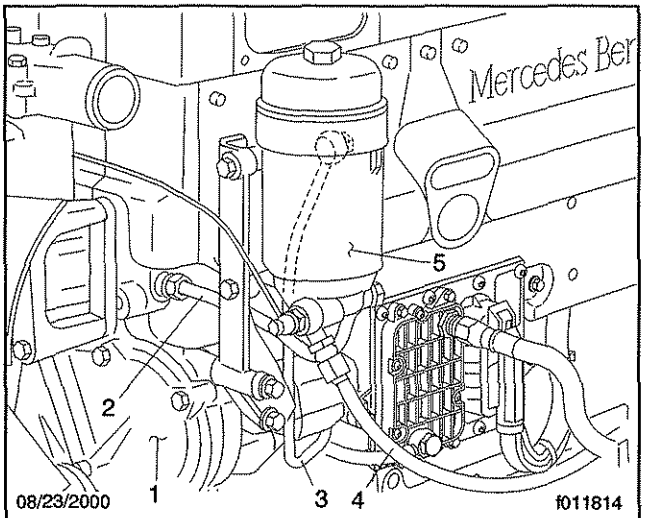
⚠ WARNING

The crane and lifting chains used to remove the engine must be capable of safely lifting and supporting two metric tons. Once the engine mounts are disconnected, do not get under the engine until it is securely supported on engine stands. An unsecured engine may fall, causing personal injury or death, and component damage.

1. Using the hoist as removed, lower the engine into the engine compartment until the rear of the engine and transmission are resting on the floor jack used during removal. Check clearances on all sides, as removed. See **Fig. 27.**
2. Lower the engine onto the front mount. Install both front engine mounting bolts, washers, and nuts. See **Fig. 23.** Tighten the nuts 240 lbf·ft (325 N·m).

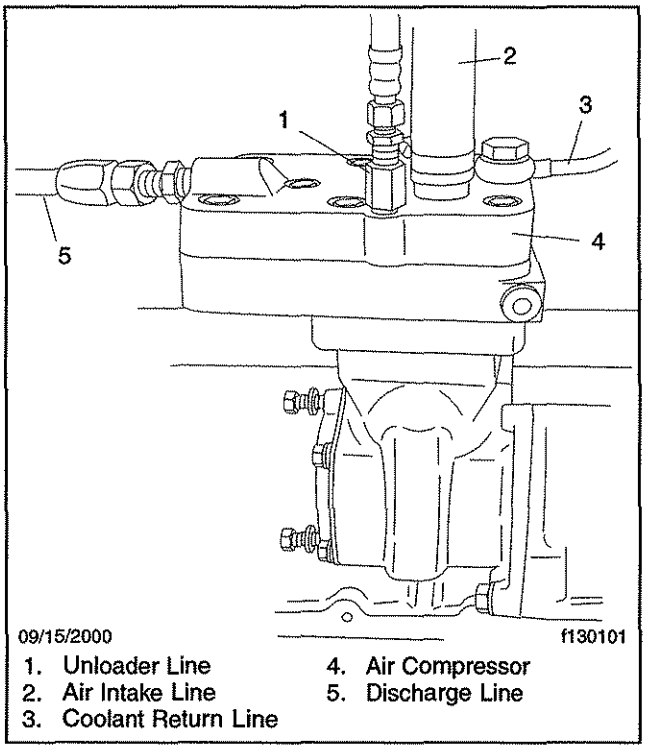
IMPORTANT: The rear-engine mounting bolts are 4-1/2 inches long. For purposes of clearance, the front-engine mounting bolts are only four inches long. Make sure to install the correct bolts in each location.

3. Install the front crossmember, as removed.



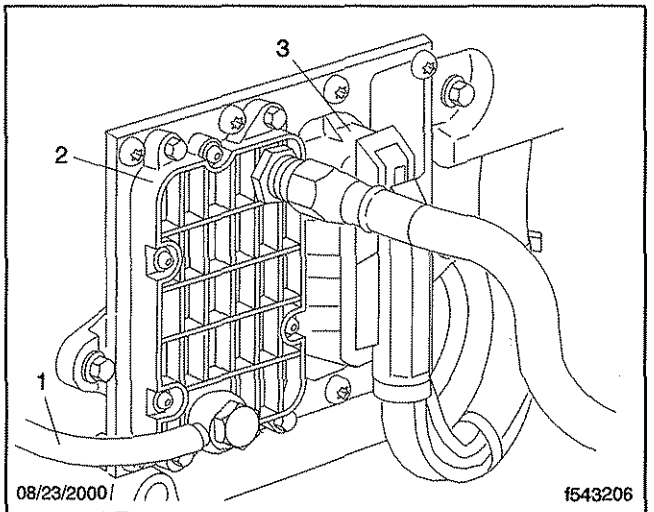
1. Front Camshaft Cover
2. Fuel Return Line
3. Fuel Feed Line
4. Fuel Drain Line
5. Fuel Filter Housing

Fig. 12, Fuel Lines



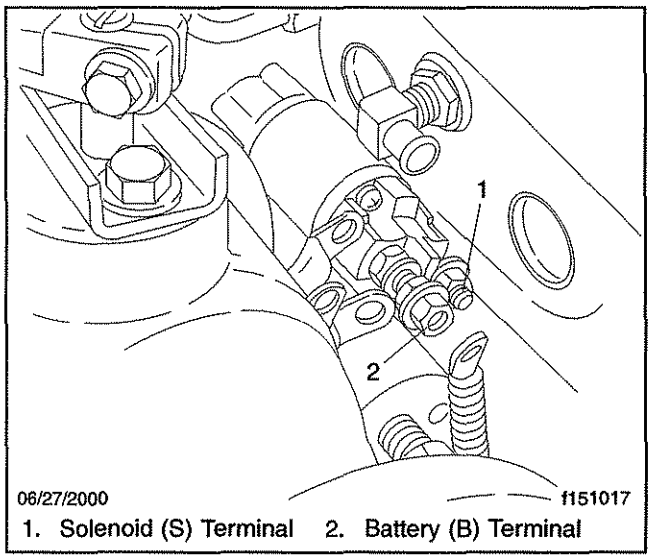
1. Unloader Line
2. Air Intake Line
3. Coolant Return Line
4. Air Compressor
5. Discharge Line

Fig. 13, Air Compressor



1. Fuel Feed Line
2. Fuel Heat Exchanger
3. Engine Harness Connector

Fig. 14, PLD Control Unit

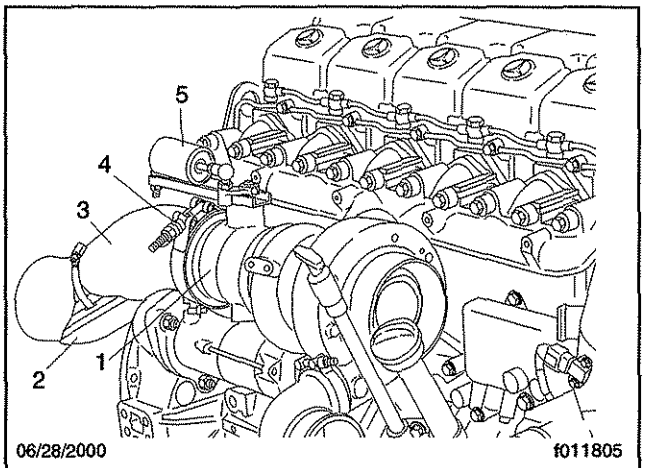


1. Solenoid (S) Terminal 2. Battery (B) Terminal

Fig. 15, Starter Terminals

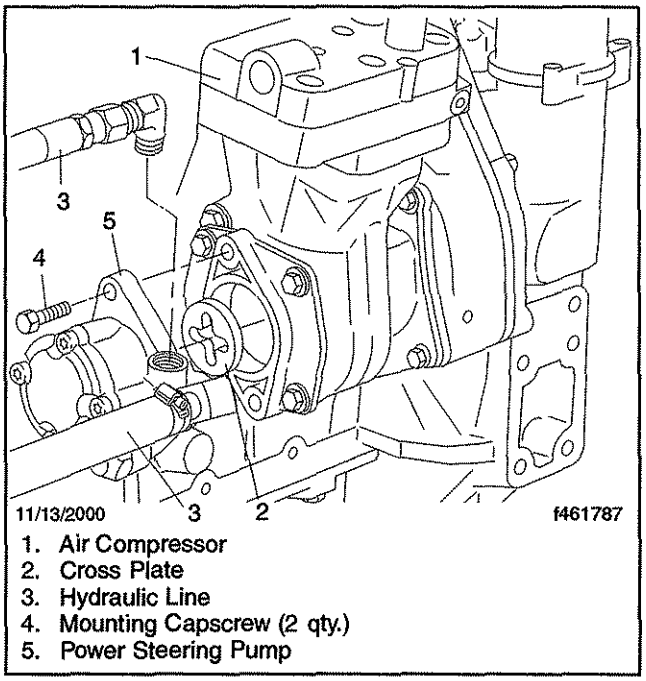
4. Install the rear engine mounting bolts, washers, and nuts (one on each side of the engine). See **Fig. 22.** Tighten the nuts 240 lbf·ft (325 N·m).
5. Remove the hoist from the front lifting eye and the rear lifting fixture. Remove the jack from the transmission.

MBE4000 Engine Removal and Installation



1. Brake Valve Housing
2. Heat Shield
3. Exhaust Pipe
4. Constant-Torque Clamp
5. Exhaust Brake Cylinder

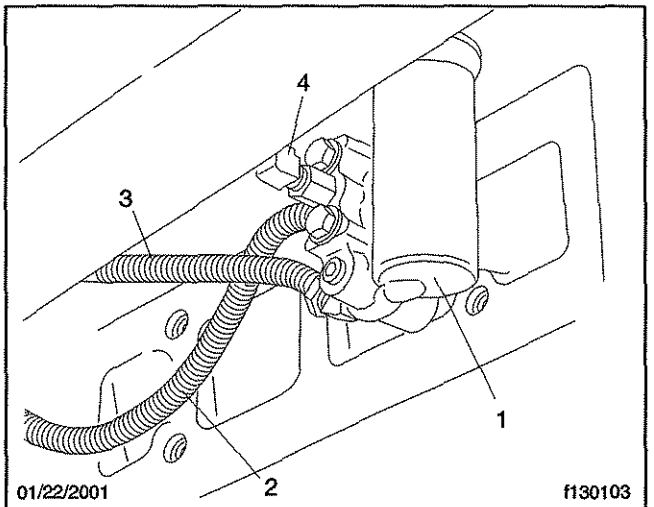
Fig. 16, Exhaust Pipe



1. Air Compressor
2. Cross Plate
3. Hydraulic Line
4. Mounting Capscrew (2 qty.)
5. Power Steering Pump

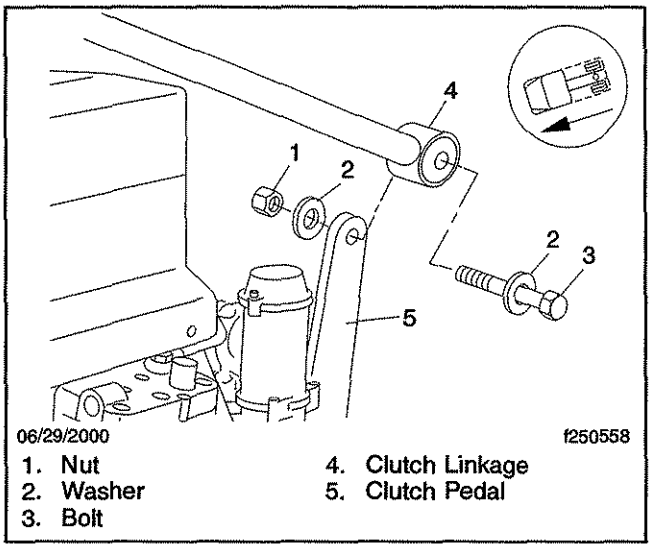
Fig. 17, Power Steering Lines

6. Install the transmission wiring, cooler hoses, fuel lines and air line. For detailed procedures, see **Group 26.**



1. Air Governor
2. Air Line
3. Coolant Line

Fig. 18, Air Governor



1. Nut
2. Washer
3. Bolt
4. Clutch Linkage
5. Clutch Pedal

Fig. 19, Clutch Pedal Linkage

6.1 Install all the electrical connectors on the transmission harness, as marked on removal.

6.2 Attach the cooler hoses running to the transmission cooler.

6.3 Connect the fuel lines in the back of the transmission.

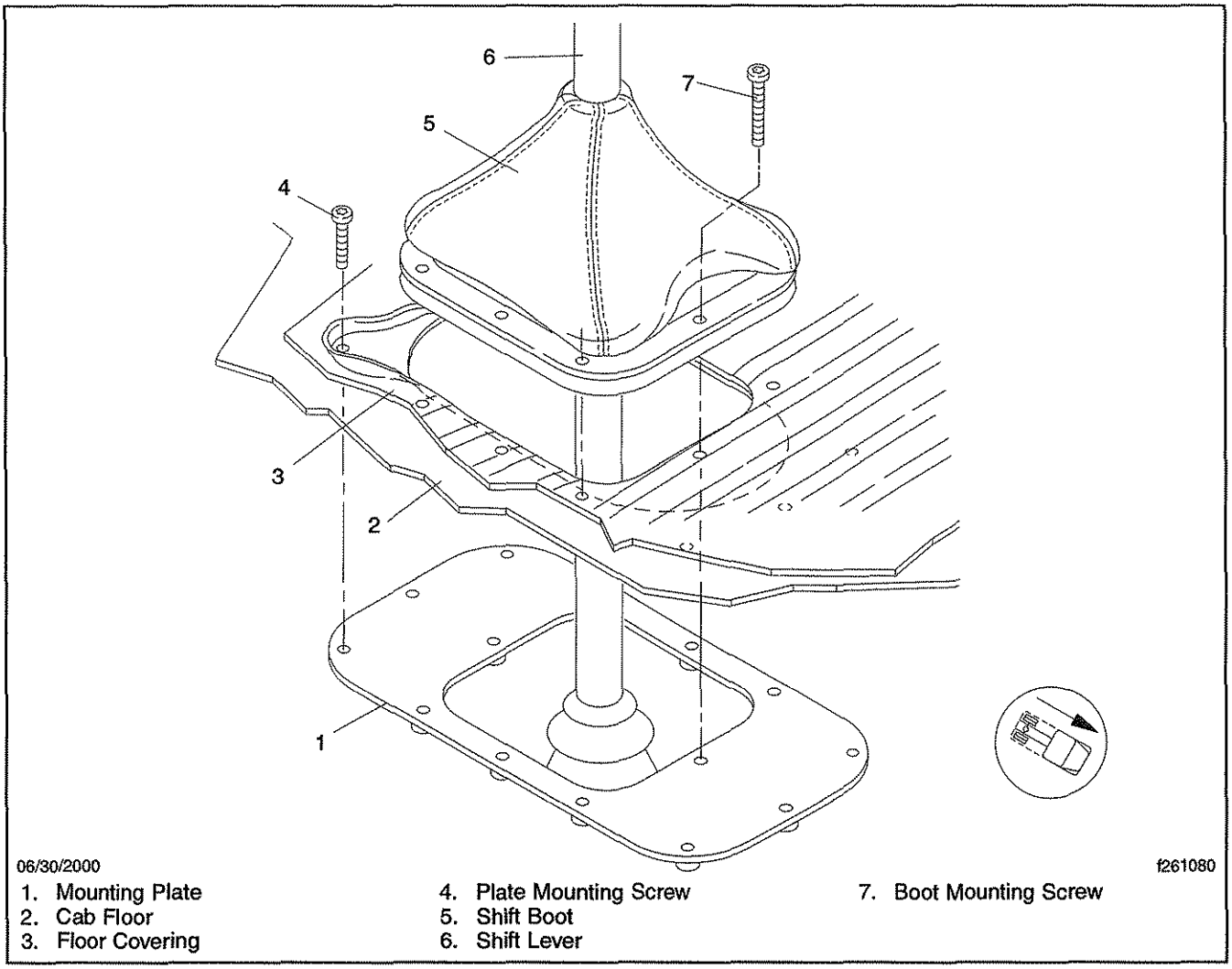


Fig. 20, Shift Lever and Boot

6.4 Connect the transmission air shift assist line, if removed.

6.5 Attach electrical wires and air lines with tie straps, as needed.

7. Attach the clutch linkage to the transmission. See **Fig. 19**.

8. Connect the electronic engine harness to the vehicle.

8.1 Attach the engine harness connector to the PLD control unit.

8.2 Connect all electrical connectors on the harness, as marked on removal.

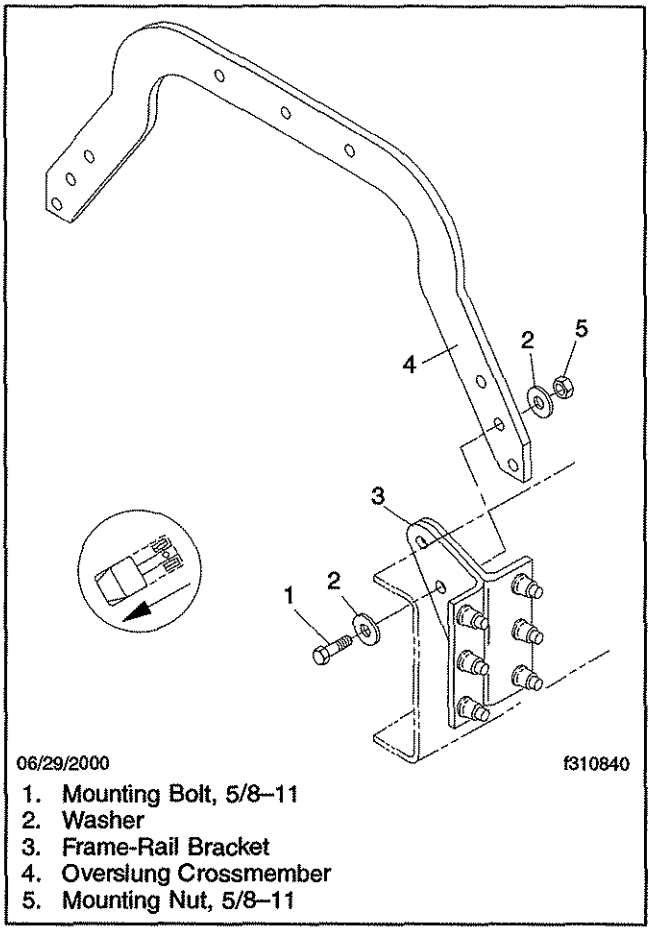
8.3 Connect the harness to the frontwall connector.

9. Connect the starter cables to the terminals on the starter motor and solenoid. Tighten the starter terminal nuts 16 to 30 lbf·in (180 to 340 N·cm).

10. Install the overslung crossmember on both frame rails. Tighten the locknuts on the mounting bolts 136 lbf·ft (184 N·m). See **Fig. 21**.

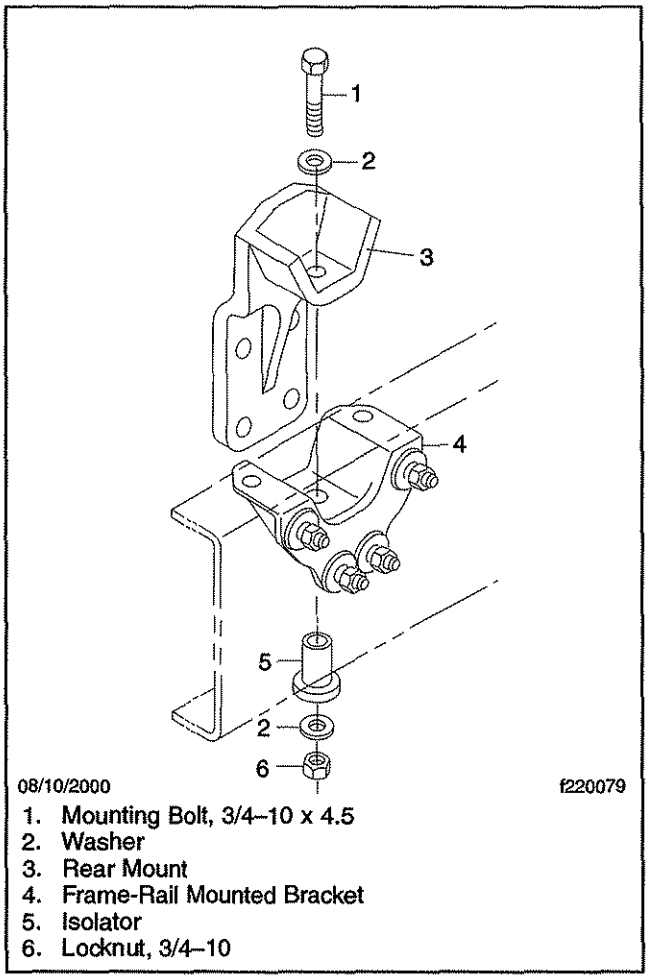
11. Mount the battery cables that run along the top of the crossmember, as removed. See **Fig. 28**.

MBE4000 Engine Removal and Installation



1. Mounting Bolt, 5/8–11
2. Washer
3. Frame-Rail Bracket
4. Overslung Crossmember
5. Mounting Nut, 5/8–11

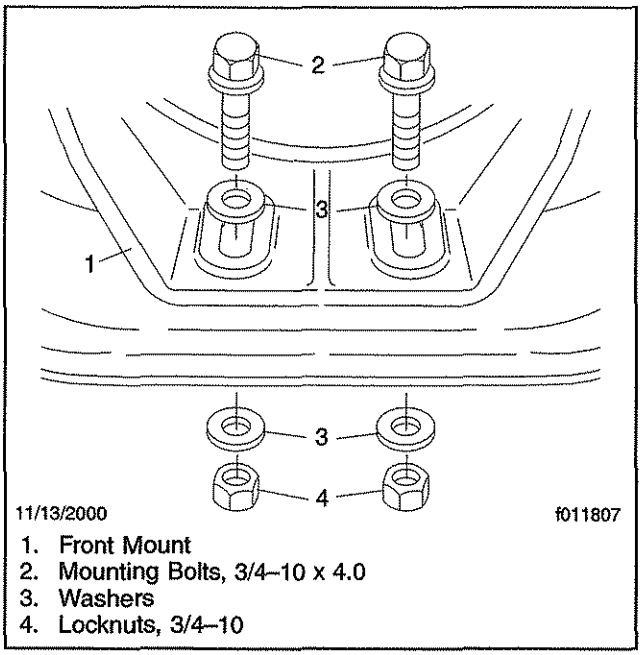
Fig. 21, Overslung Crossmember



1. Mounting Bolt, 3/4–10 x 4.5
2. Washer
3. Rear Mount
4. Frame-Rail Mounted Bracket
5. Isolator
6. Locknut, 3/4–10

Fig. 22, Rear Engine Mount

12. Install the shift tower and shift lever, as removed.
13. Connect the exhaust pipe to the turbocharger. See **Fig. 16.**
14. Connect the power steering pump to the air compressor. See **Fig. 17.** Tighten the mounting capscrews 33 lbf·ft (45 N·m).
15. Install the air compressor intake hose and discharge line, as removed.
16. Install the air lines on the air governor. See **Fig. 18.**
17. Install the radiator and charge air cooler assembly. See **Fig. 29.** For detailed instructions, see **Section 20.01**, Subject 130.
    - 17.1 Position the radiator on the radiator mounts. Install the radiator mounting bolts.
    - 17.2 Install the radiator struts. Leave the nuts fastened loosely.
    - 17.3 Install the upper and lower radiator hoses. Install the hoses leading to the surge tank.
18. Install the air cleaner and flexible hose, as removed. See **Fig. 11.** For detailed instructions, see **Section 09.01.**
    - 18.1 Install the air cleaner heat shield on the air cleaner lower mounting bracket.
    - 18.2 Install the air cleaner and flexible hose, as an assembly, on the upper and lower mounting brackets.
    - 18.3 Install the air cleaner pipe on the flexible hose and air cleaner intake elbow.



1. Front Mount
2. Mounting Bolts, 3/4–10 x 4.0
3. Washers
4. Locknuts, 3/4–10

Fig. 23, Front Engine Mount

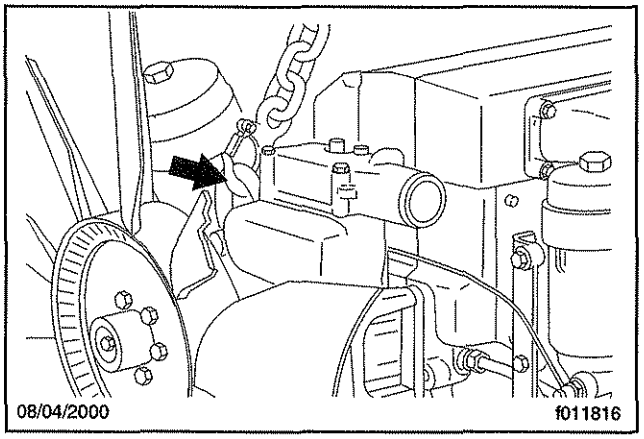


Fig. 24, Front Lifting Eye

18.4 Connect the air compressor hose to the air cleaner pipe.

18.5 Install the hood guide bracket.

19. Install the A/C condenser onto the charge air cooler. See **Fig. 9**. For detailed instructions, see **Section 20.01**, Subject 130.

20. Install the refrigerant compressor onto the crankcase. See **Fig. 8**. For detailed instructions, see **Group 83**.

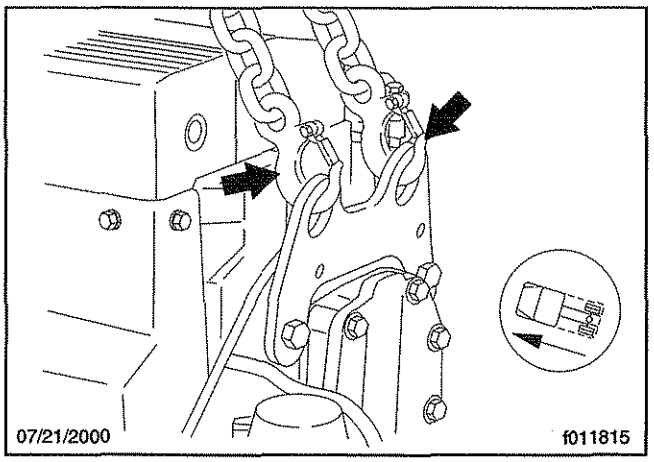


Fig. 25, Rear Lifting Fixture

21. Release the tension on the belt tensioner and install the refrigerant compressor belt.

22. Connect the fuel lines to the fuel filter housing. See **Fig. 12**.

23. Attach the clutch linkage to the pedal. For detailed instructions, see **Section 25.03**.

24. Install the charge air inlet piping (cold air side), as marked on removal. See **Fig. 4**.

    24.1 Install the charge air inlet pipe on the charge air manifold. Replace the gasket.

    24.2 Install the charge air inlet hose on the charge air cooler.

    24.3 Connect the charge air inlet pipe and hose. Make sure the pipe and hose are firmly connected, and the clamps are tight.

25. Install the charge air outlet piping (warm air side), as marked on removal.

    25.1 When installing the hose on the charge air cooler, make sure the hose fits well down on the charge air cooler, is firmly connected, and the clamp is tight.

    25.2 Make sure the turbo outlet pipe is tightly connected to the turbo and the clamp is tight.

    25.3 Check each clamp connection on the line. Make sure the are no loose fitting pipes or hoses, and the clamps are tight.

MBE4000 Engine Removal and Installation

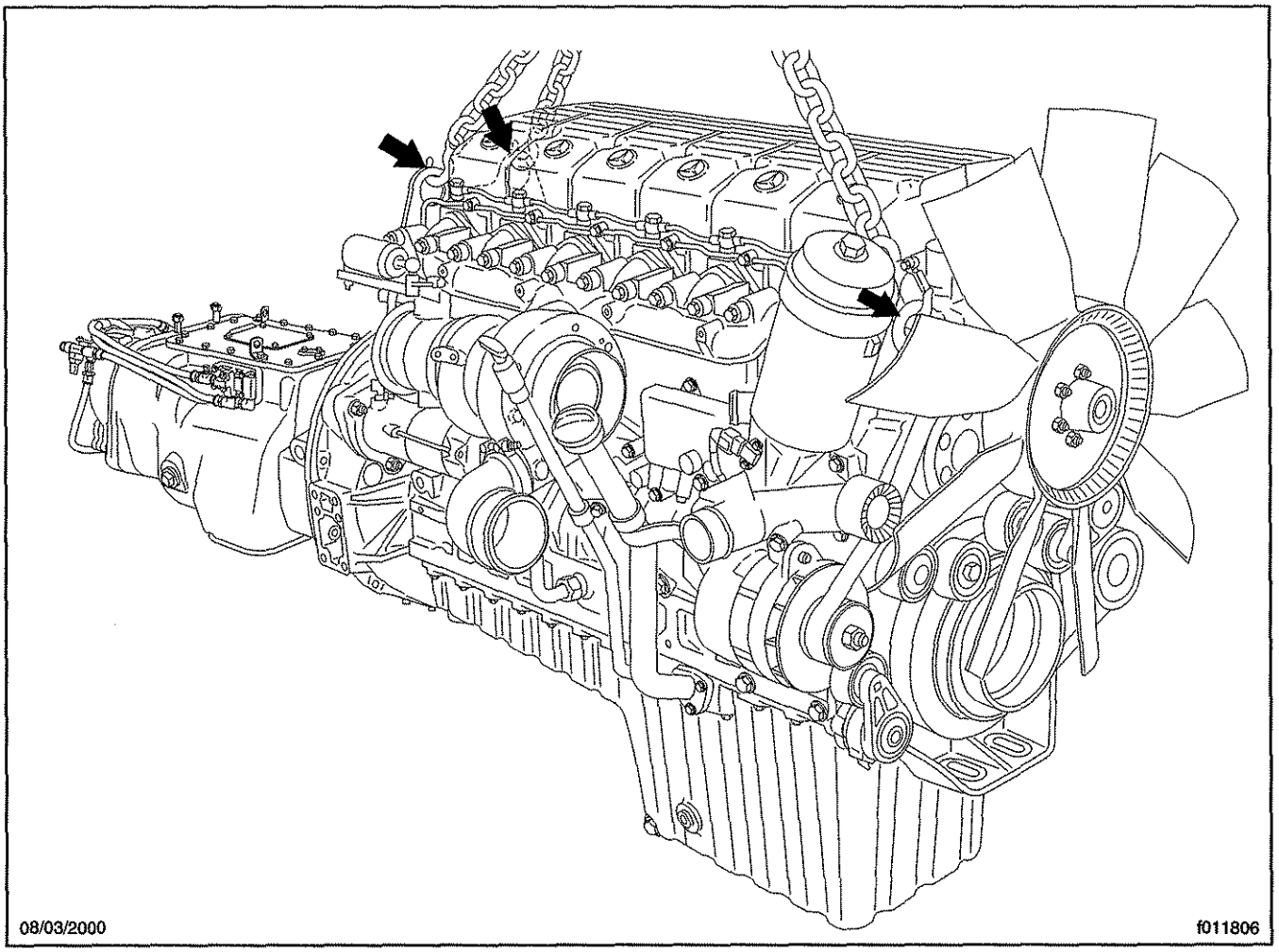
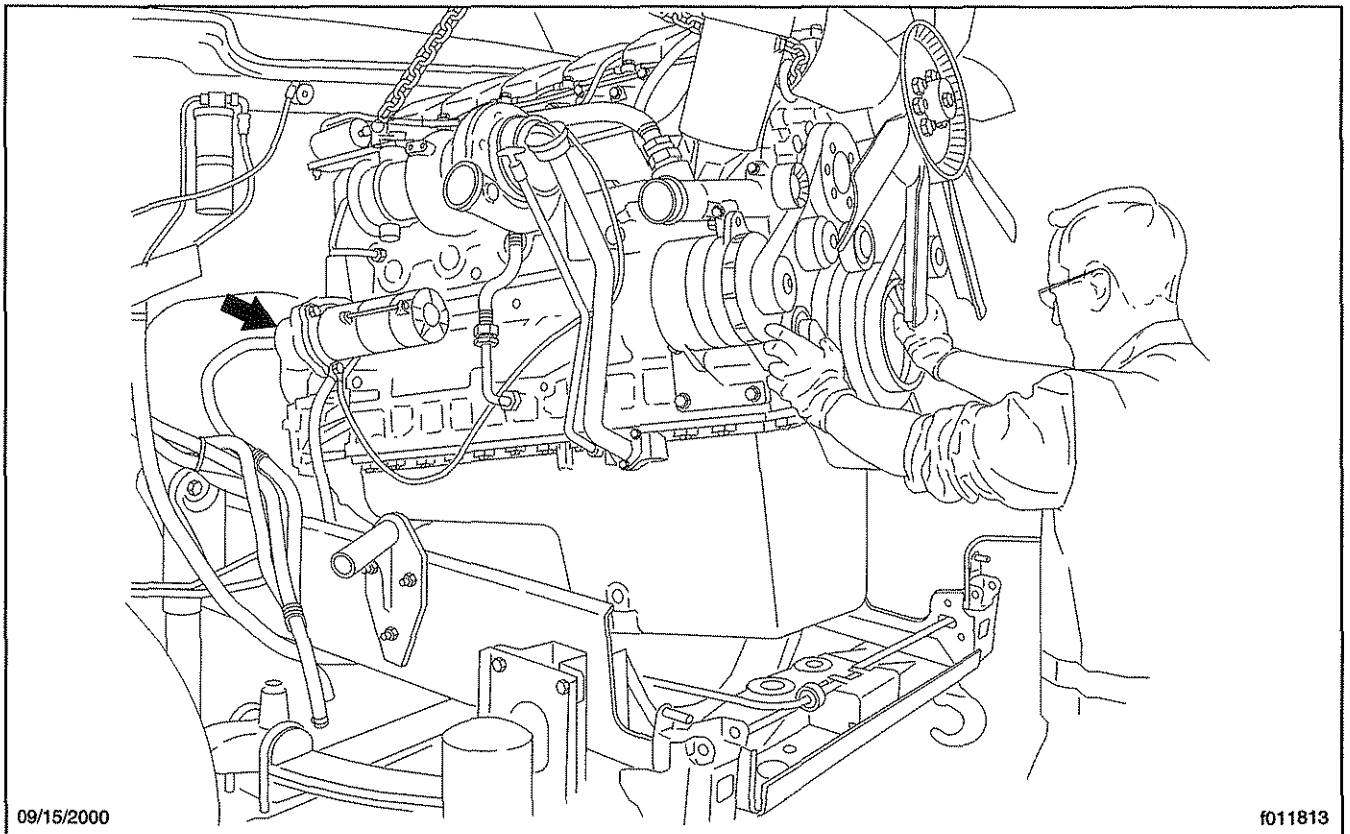


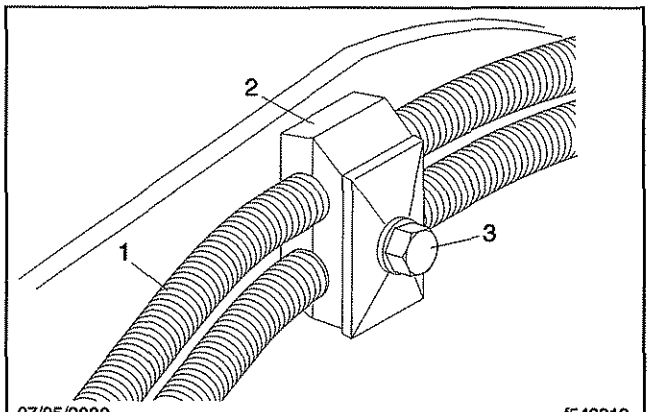
Fig. 26, Engine and Transmission Removed from the Vehicle

26. Tighten the nuts fastening the radiator struts to the radiator. Attach the coolant hose standoff brackets to the struts. See **Fig. 30**. For detailed instructions, see **Section 20.01**, Subject 130.
27. Attach the coolant hoses, as marked on removal.
28. Install the hood. For detailed instructions, see **Section 88.00**, Subject 140.
29. Install the grille. For detailed instructions, see **Section 88.00**, Subject 110.
30. Install the bumper and air dam assembly, including the bumper support arm, and outboard bumper support bracket (one on each side of the vehicle). For detailed instructions, see **Section 31.03**.
31. Install both side fenders. Install the splash shields. See **Fig. 1**.
32. Install the driveline on the transmission output yoke. For detailed information, see **Section 41.00**.
33. Install the coolant drain plug. Fill the radiator with coolant. Make sure the coolant drain plug is tight and is not leaking.
34. Connect the battery cables to the batteries.
35. Start the engine and check that it is operating properly. Pay attention to oil pressure, coolant temperature, warning lights, fluid leaks, and any other signs of a problem.
36. Remove the chocks from the tires.



Watch that the starter (arrow) clears the frame rail.

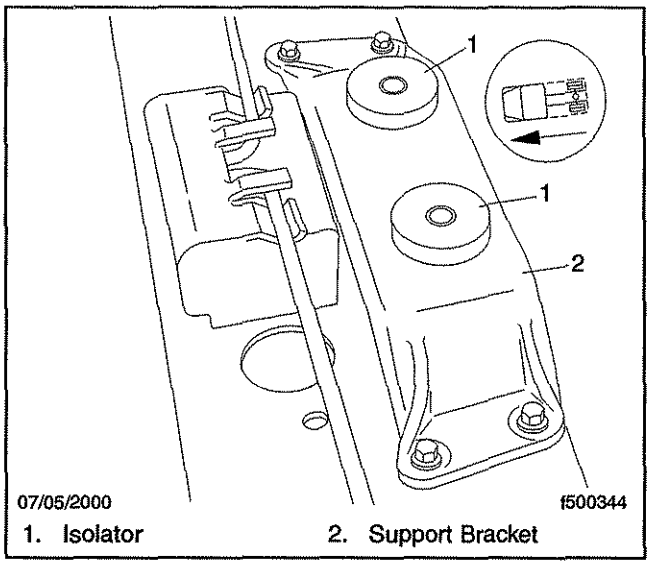
Fig. 27, Lowering the Engine into the Frame



1. Battery Cable
2. Mounting Clamp
3. Mounting Capscrew

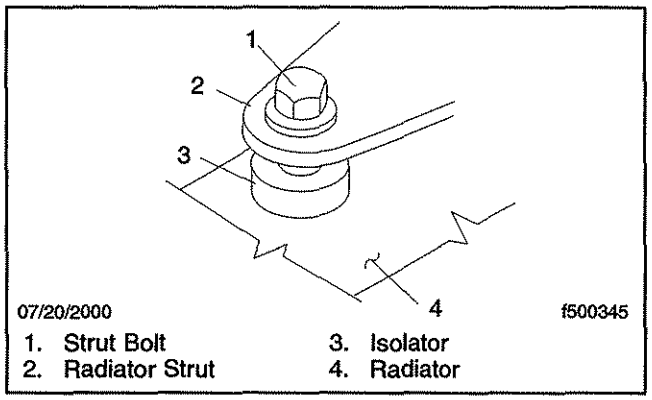
Fig. 28, Battery Cable Mounting

MBE4000 Engine Removal and Installation



1. Isolator
2. Support Bracket

Fig. 29, Radiator Mounts



1. Strut Bolt
2. Radiator Strut
3. Isolator
4. Radiator

Fig. 30, Radiator Strut Bolts

Specifications

Torque Values, Engine Removal and Installation			
Description	**Size**	**lbf·ft (N·m)**	**lbf·in (N·cm)**
Front Engine Mounting Locknuts	3/4–10 x 4.0	240 (325)	—
Overslung Crossmember Mounting Locknuts	5/8–11	136 (184)	—
Power Steering Pump Mounting Capscrews	M10	33 (45)	—
Rear Engine Mounting Locknuts	3/4–10 x 4.5	240 (325)	—
Starter Terminal Nuts	—	—	16–30 (180–340)

Table 1, Torque Values, Engine Removal and Installation

Air Intake Ducting 09.00

Contents

Subject	Subject Number
General Information	050
Service Operations	
Air Intake Ducting Removal and Installation	100
Vertical Air Intake Snorkel Removal and Installation, Argosy COE	110
Stationary Outboard Vertical Air Intake Snorkel Removal and Installation, Argosy COE	120

Air Intake Ducting 09.00

Contents

Subject	Subject Number
General Information	050
Service Operations	
Air Intake Ducting Removal and Installation	100
Vertical Air Intake Snorkel Removal and Installation, Argosy COE	110

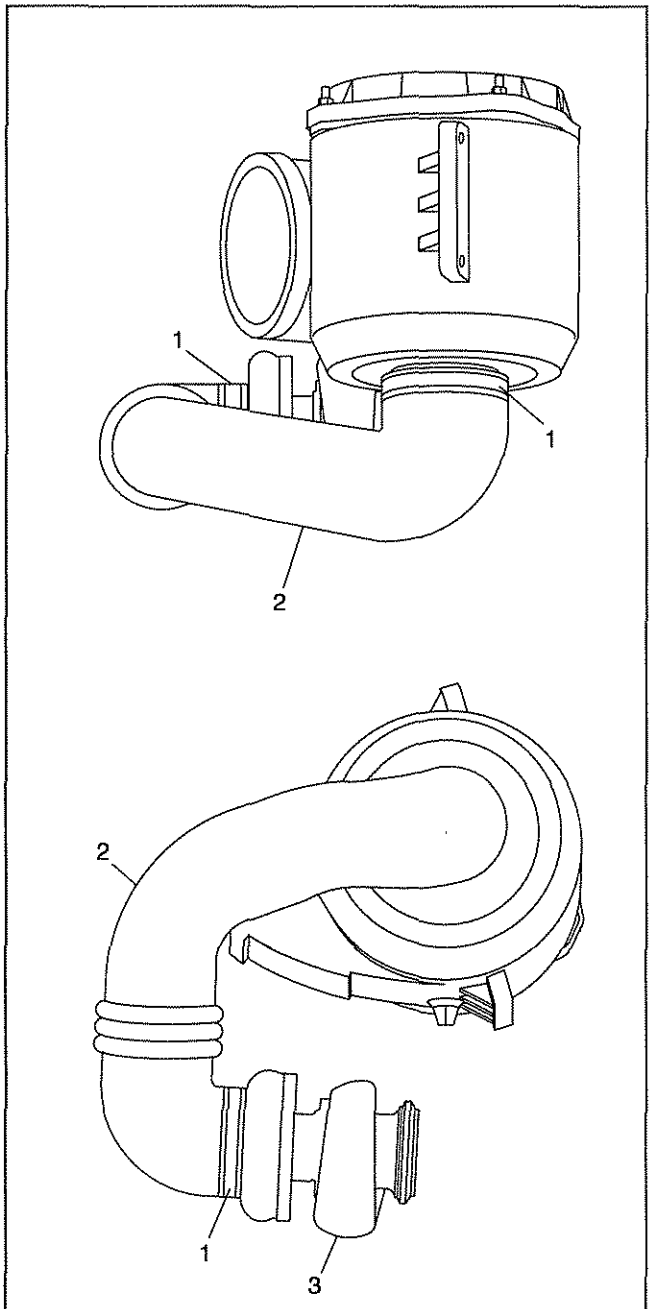
General Information

An average diesel truck engine needs over 10,000 gallons (38 000 liters) of clean air for each gallon (3.8 liters) of fuel burned. So that complete combustion occurs in each engine cylinder, more clean air than is needed is present in each cylinder. The air intake system routes this supply of outside air through an air cleaner, which filters out dust, dirt, abrasive particles, and other foreign material from the intake air, without restricting air flow.

From there, the air intake ducting routes this clean air to the engine. On Century Class Conventionals, the air intake ducting is made up of a one-piece rubber hose and stainless steel hose clamps. See **Fig. 1**. On Argosy COEs, there are four pieces of ducting between the air cleaner assembly and the turbocharger. See **Fig. 2**.

A lock-up (manual-reset) air restriction indicator mounts in a safety filter in the air intake ducting. See **Fig. 3**. As an option, the air restriction indicator or an air restriction (automatic-reset) gauge mounts in the dashboard. Nylon tubing connects the remote-mounted indicator or gauge to the safety filter in the ducting.

The air restriction indicator or gauge indicates when the air cleaner filter element needs to be replaced. The safety filter protects the clean-side of the air intake system in case the air restriction indicator or nylon tubing leaks or is damaged.



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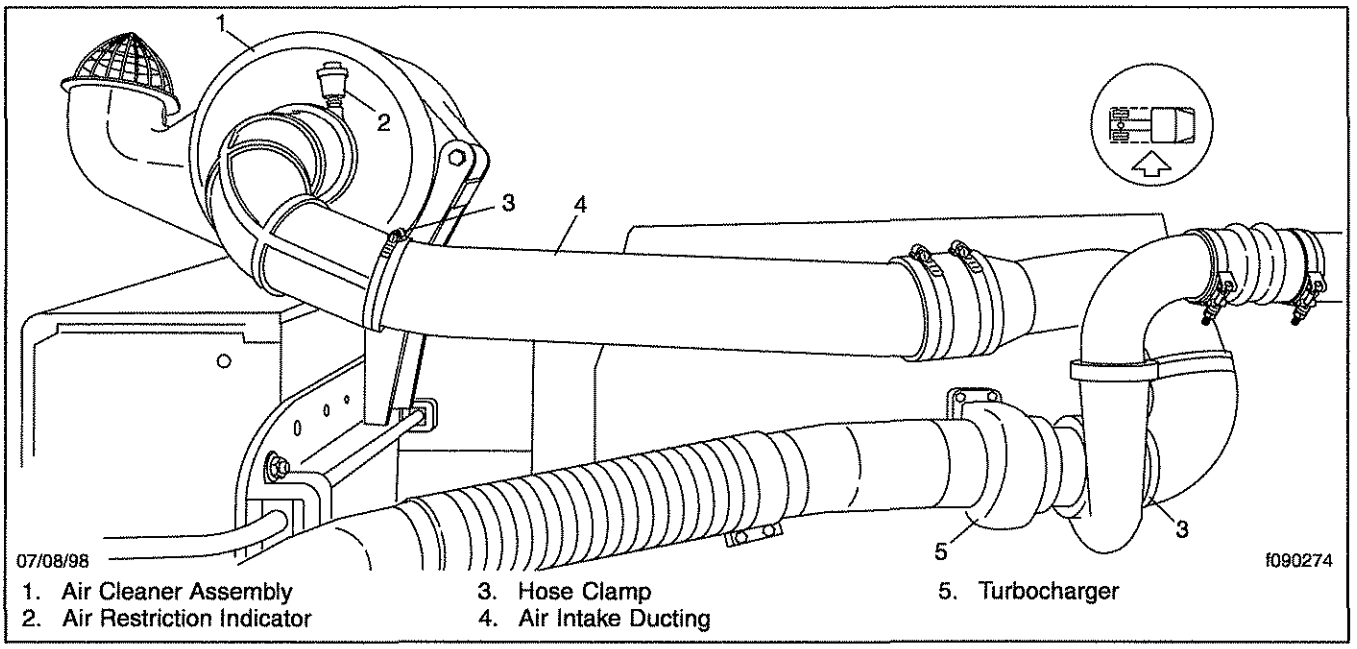
1. Stainless Steel Hose Clamp
2. One-Piece Air Duct Assembly (rubber hose)
3. Turbocharger

Fig. 1, Air Intake Ducting, Century Class Conventional With Detroit Diesel Series 55 Engine

General Information



1. Air Cleaner Assembly
2. Air Restriction Indicator
3. Hose Clamp
4. Air Intake Ducting
5. Turbocharger

Fig. 2, Air Intake Ducting, Argosy COE With Detroit Diesel Series 60 Engine

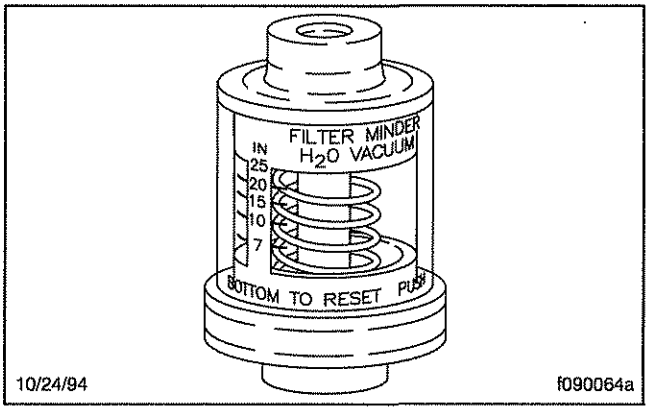


Fig. 3, Manual-Reset Air Restriction Indicator

Air Intake Ducting Removal and Installation

Removal and Installation

⚠ WARNING

Do not operate the engine with any component of the air intake system removed. Doing so could result in engine damage, and serious personal injury can occur if the turbocharger impeller is touched when it is rotating.

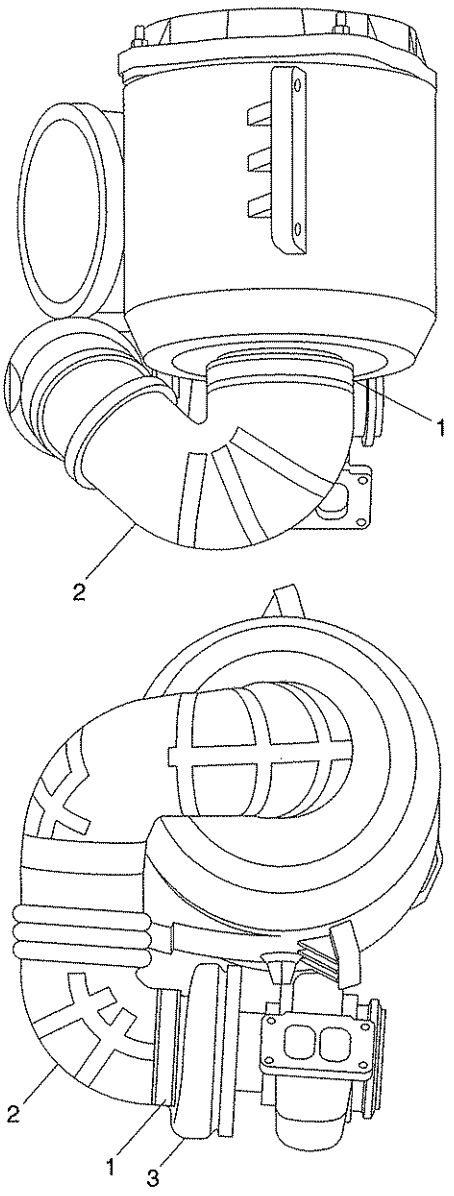
⚠ CAUTION

Do not operate the vehicle with the air filter element or any air intake component removed. All air intake components and connections must be air- and water-tight. Dirt or dust entering the engine can cause internal engine damage. Most of the dirt and dust particles are silicates, which fuse into abrasive glass-like particles when exposed to engine combustion. These particles can grind piston rings, pistons, and cylinder liners.

1. Turn off the engine, apply the brakes, and chock the tires.
2. Open the hood or tilt the cab. For cab tilt instructions, see **Group 60**.
3. On Century Class Conventionals, loosen the hose clamps on the air intake ducting at the air cleaner outlet and the turbocharger inlet. See **Fig. 1**, **Fig. 2**, **Fig. 3**, **Fig. 4**, **Fig. 5**, **Fig. 6** and **Fig. 7**. On Argosy COEs, loosen the hose clamps on the air intake ducting between the air cleaner outlet and the turbocharger inlet. See **Fig. 8**.
4. Remove the air intake ducting.
5. Replace any damaged parts with new identical parts.

IMPORTANT: Air intake ducting that has been enlarged, extended, or modified by bonding after original molding, are not acceptable for installation between the air cleaner and the engine.

6. Install the air intake ducting. Place the ducting over each connection so that it overlaps at least 1 inch (25 mm).
7. Tighten the hose clamp at the turbocharger 70 to 80 lbf·in (800 to 900 N·cm). Tighten the hose clamp at the air cleaner outlet 35 to 40 lbf·in (400 to 450 N·cm).
8. Return the hood or cab to the operating position. For cab tilt instructions, see **Group 60**.
9. Remove the chocks from the tires.



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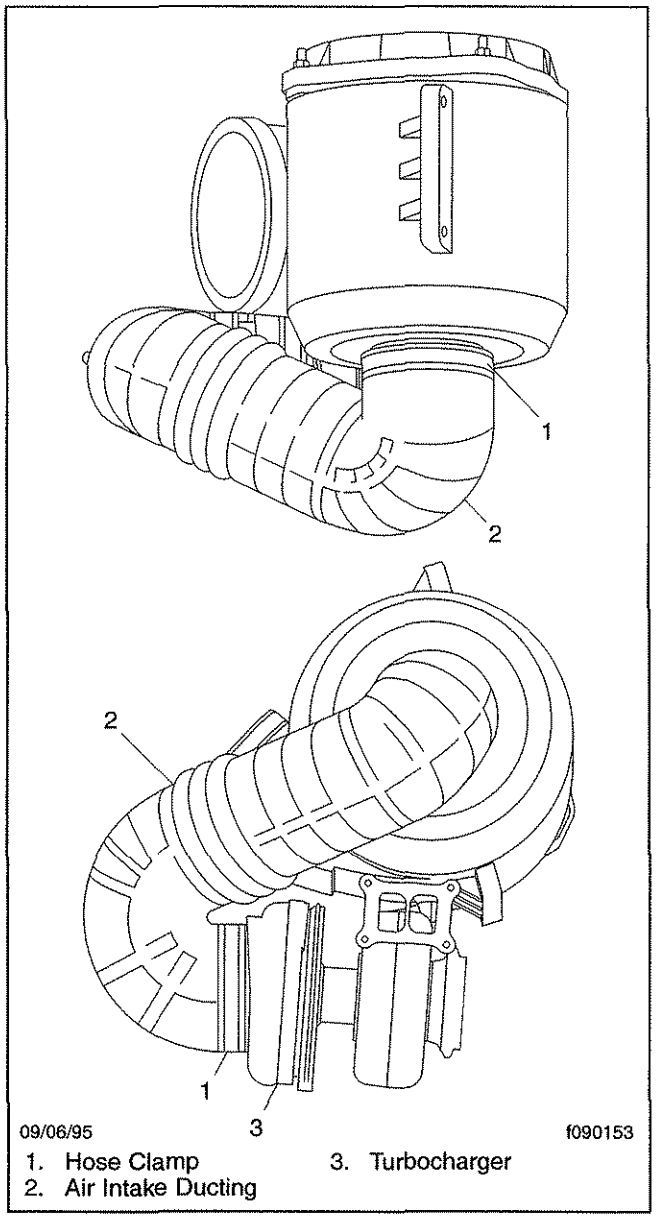
1. Hose Clamp
2. Air Intake Ducting
3. Turbocharger

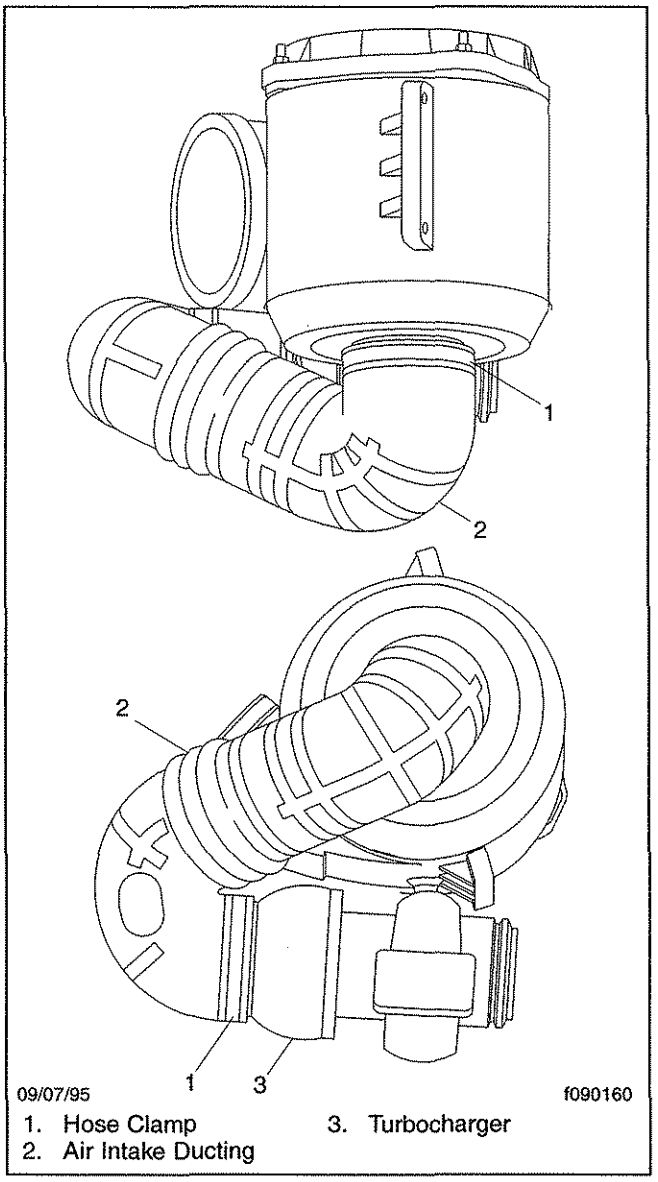
Fig. 1, Air Intake Ducting, Century Class Conventional With Detroit Diesel Series 60 Engine

Air Intake Ducting Removal and Installation



1. Hose Clamp
2. Air Intake Ducting
3. Turbocharger

Fig. 2, Air Intake Ducting, Century Class Conventional With Cummins N14 Engine



1. Hose Clamp
2. Air Intake Ducting
3. Turbocharger

Fig. 3, Air Intake Ducting, Century Class Conventional With Caterpillar 3406 Engine

Air Intake Ducting Removal and Installation

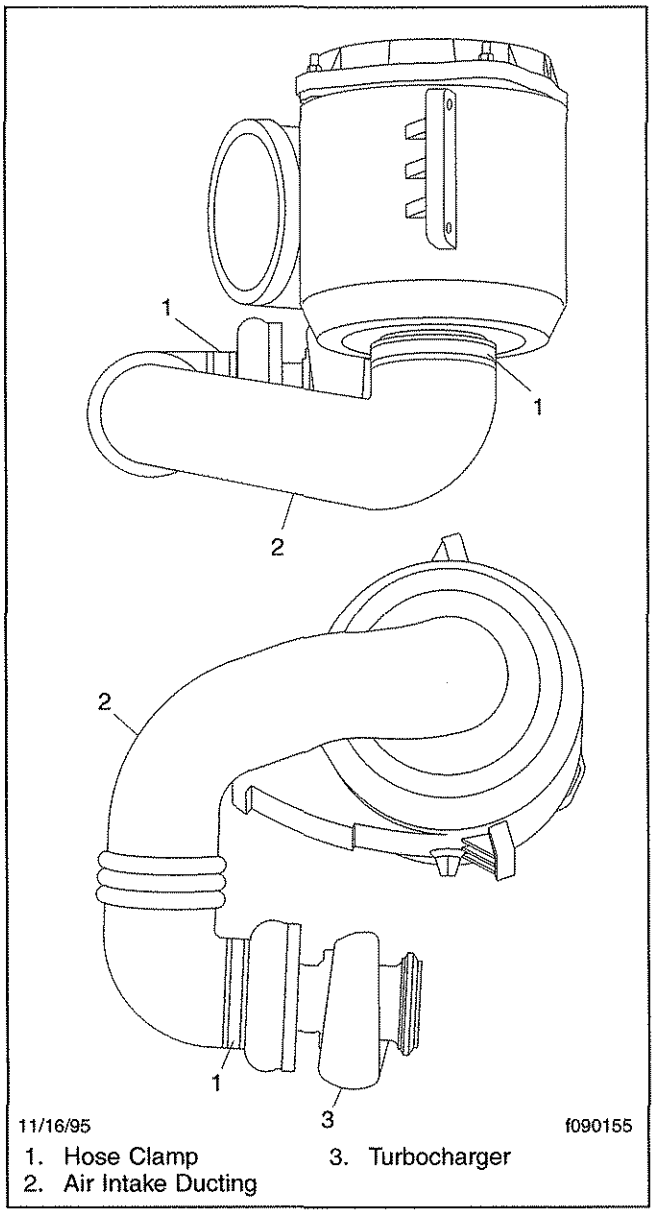


Fig. 4, Air Intake Ducting, Century Class Conventional With Detroit Diesel Series 55 Engine

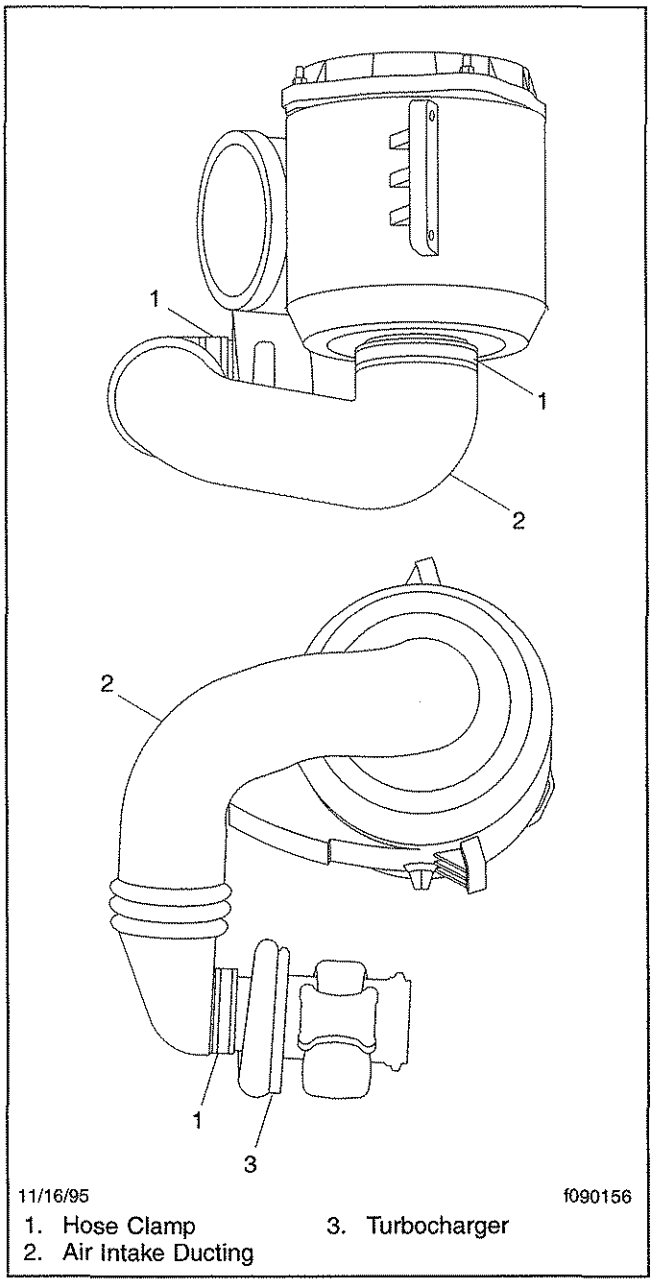


Fig. 5, Air Intake Ducting, Century Class Conventional With Cummins M11 Engine

Air Intake Ducting Removal and Installation

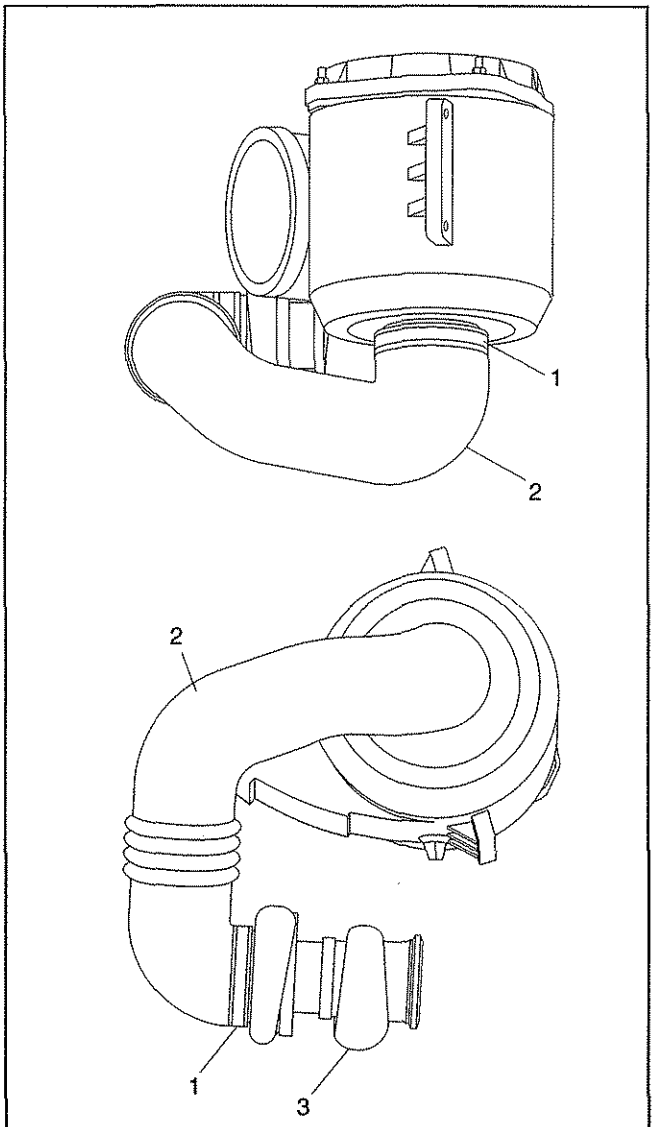


Fig. 6, Air Intake Ducting, Century Class Conventional With Caterpillar 3176 Engine

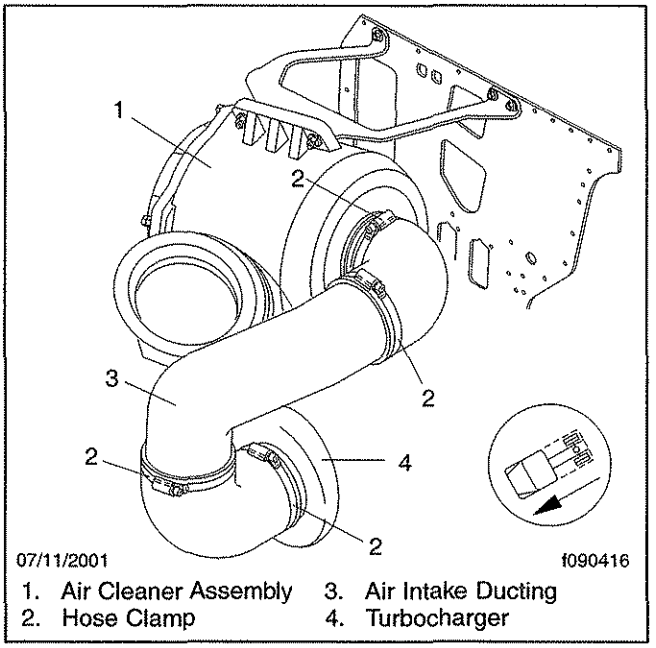
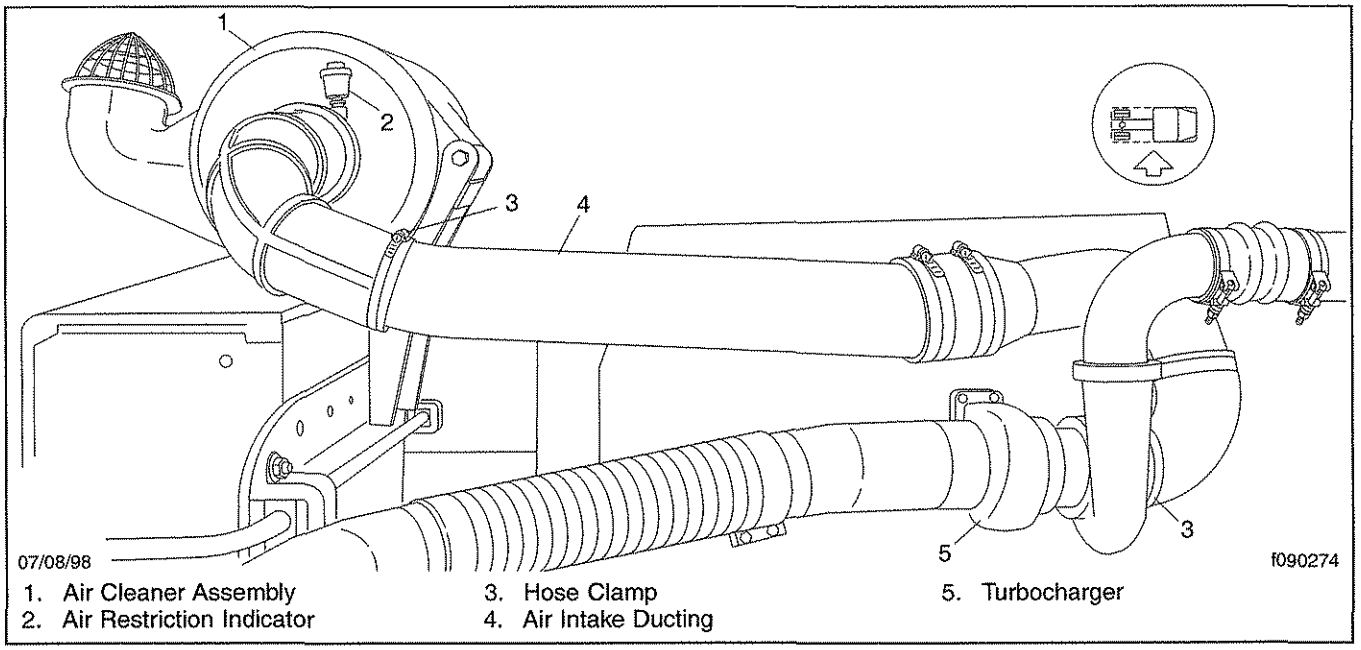


Fig. 7, Air Intake Ducting, Coronado With Detroit Diesel 60 Series Engine

Air Intake Ducting Removal and Installation



1. Air Cleaner Assembly
2. Air Restriction Indicator
3. Hose Clamp
4. Air Intake Ducting
5. Turbocharger

Fig. 8, Air Intake Ducting, Argosy COE With Detroit Diesel 60 Series Engine

Vertical Air Intake Snorkel Removal and Installation, Argosy COE

Removal

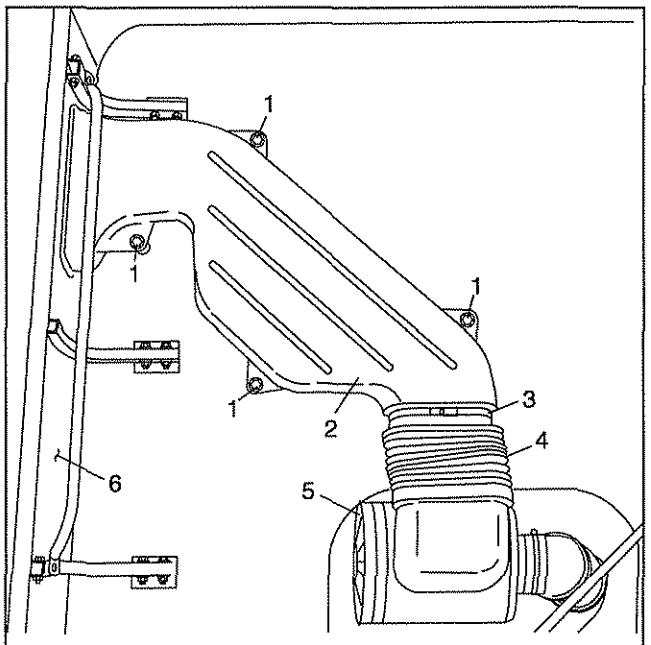
⚠ WARNING

Do not operate the engine with any component of the air intake system removed. Doing so could result in engine damage, and serious personal injury can occur if the turbocharger impeller is touched when it is rotating.

⚠ CAUTION

Do not operate the vehicle with the air filter element or any air intake component removed. All air intake components and connections must be air- and water-tight. Dirt or dust entering the engine can cause internal engine damage. Most of the dirt and dust particles are silicates, which fuse into abrasive glass-like particles when exposed to engine combustion. These particles can grind piston rings, pistons, and cylinder liners.

1. Turn off the engine, apply the brakes, and chock the tires.
2. Remove the bolts and washers that fasten the vertical air intake snorkel to the back of the cab. See **Fig. 1**.
3. Remove the vertical air intake snorkel from the side extender.
4. Loosen the clamp that attaches the vertical air intake snorkel to the air intake ducting, and remove the air intake ducting.



1. Mounting Fasteners
2. Vertical Air Intake Snorkel
3. Clamp
4. Air Intake Ducting
5. Air Intake Assembly
6. Side Extender

Fig. 1, Vertical Air Intake Snorkel

Installation

1. Replace any damaged parts with new identical parts.
2. Attach the air intake ducting to the vertical air intake snorkel using the clamp. Tighten the clamp securely.
3. Install the vertical air intake snorkel and air intake ducting on the back of the cab. Attach the bolts and washers and tighten securely.
4. Remove the chocks from the tires.

Stationary Outboard Vertical Air Intake Snorkel Removal and Installation, Argosy COE

Removal

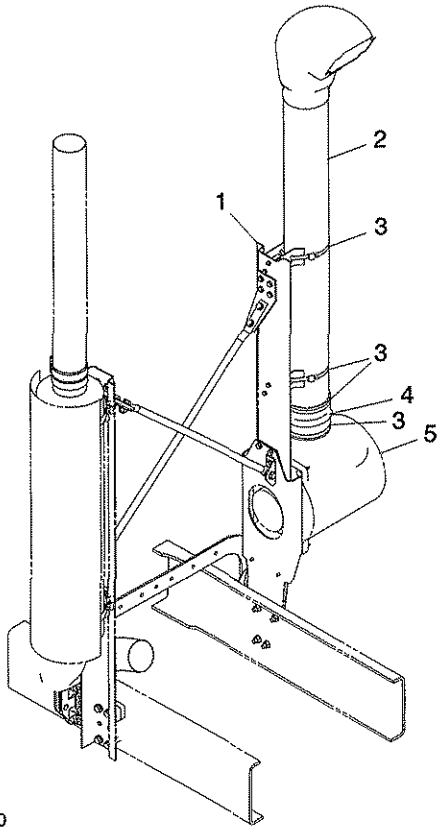
⚠ WARNING

Do not operate the engine with any component of the air intake system removed. Doing so could result in engine damage, and serious personal injury can occur if the turbocharger impeller is touched when it is rotating.

⚠ CAUTION

Do not operate the vehicle with the air filter element or any air intake component removed. All air intake components and connections must be air- and water-tight. Dirt or dust entering the engine can cause internal engine damage. Most of the dirt and dust particles are silicates, which fuse into abrasive glass-like particles when exposed to engine combustion. These particles can grind piston rings, pistons, and cylinder liners.

1. Turn off the engine, apply the brakes, and chock the tires.
2. Loosen the clamps at the neoprene connector hose, between the air intake and filter housing. See **Fig. 1**.
3. Loosen the clamps that attach the stationary vertical air intake snorkel to the mounting bracket.
4. Remove the air intake snorkel.



1. Upright Support
2. Vertical Air Intake Snorkel
3. Clamp
4. Neoprene Connector Hose
5. Air Filter Housing

Fig. 1, Vertical Air Intake Snorkel

Installation

1. Replace any damaged parts with new identical parts.
2. Attach the vertical air intake snorkel to the mounting bracket using the clamps.
3. Insert the vertical air intake snorkel into the neoprene connector hose.
4. Position the air intake snorkel opening forward, then securely tighten all hose clamps.
5. Remove the chocks from the tires.

Air Cleaner and Element 09.01

Contents

Subject	Subject Number
Service Operations	
Air Cleaner Element Checking	100
Donaldson Air Cleaner Element Replacement	110
Donaldson Air Cleaner Assembly Replacement, Century Class Conventional	120
Donaldson Air Cleaner Assembly Replacement, Argosy COE	130
Air Cleaner Piping Removal and Installation, MBE4000 Engine	140

Air Cleaner Element Checking

Measure restriction of air flow through the air cleaner element. Air restriction is measured at the tap in the air cleaner outlet.

For vehicles equipped with a manual-reset intake-air restriction indicator (**Fig. 1**), check the indicator with the engine off to see if air restriction equals or exceeds the value shown in **Table 1** for maximum air restriction at *full-load* and governed rpm. If air restriction is at or above the maximum, push the reset button on the indicator, then operate the engine at *no-load* and governed rpm, and compare the indicator reading with the value shown in **Table 1** for maximum air restriction at *no-load* and governed rpm.

For vehicles equipped with an automatic-reset intake-air restriction indicator (that resets automatically when the engine is shut down), operate the engine at *no-load* and governed rpm, and compare the indicator reading with the value shown in **Table 1** for maximum air restriction at *no-load* and governed rpm.

If air restriction equals or exceeds the value shown in **Table 1** for maximum air restriction at *no-load* and governed rpm, replace the air cleaner element.

When replacing the cleaner element, check for signs of soot or oil. If there is soot inside the element, check for leaks in the engine exhaust system, exhaust blow-back into the air intake, or exhaust from other equipment. If the element appears oily, check for fumes escaping from the engine crankcase breather. Excessive oil mist shortens the life of any dry-type filter, and must be corrected.

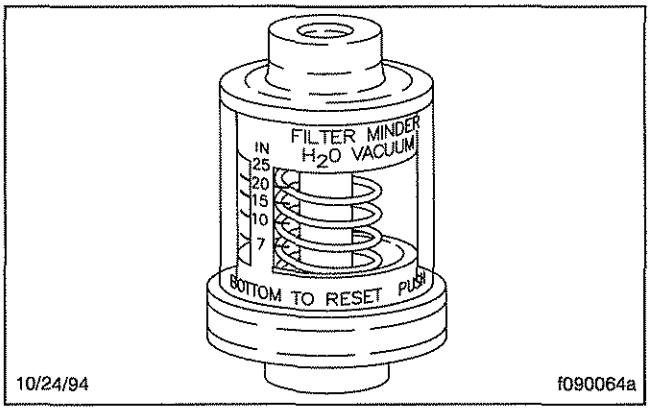


Fig. 1, Manual-Reset Air Restriction Indicator

Air Cleaner Element Maximum Restriction		
Engine	**Maximum Restriction at Full-Load and Governed rpm**	**Maximum Restriction at No-Load and Governed rpm**
Cummins	25 inH_2O	12 inH_2O
Detroit Diesel	20 inH_2O	10 inH_2O
Caterpillar	25 inH_2O	12 inH_2O

Table 1, Air Cleaner Element Maximum Restriction

Donaldson Air Cleaner Element Replacement

Element Replacement

⚠ CAUTION

All air intake components and connections must be air- and water-tight. Dirt or dust entering the engine can cause internal engine damage. Most of the dirt and dust particles are silicates, which fuse into abrasive glass-like particles when exposed to engine combustion. These particles can grind piston rings, pistons, and cylinder liners. Do not operate the engine with the air filter element or any air intake component removed.

IMPORTANT: Do not modify, or use modified air cleaners and ducting components.

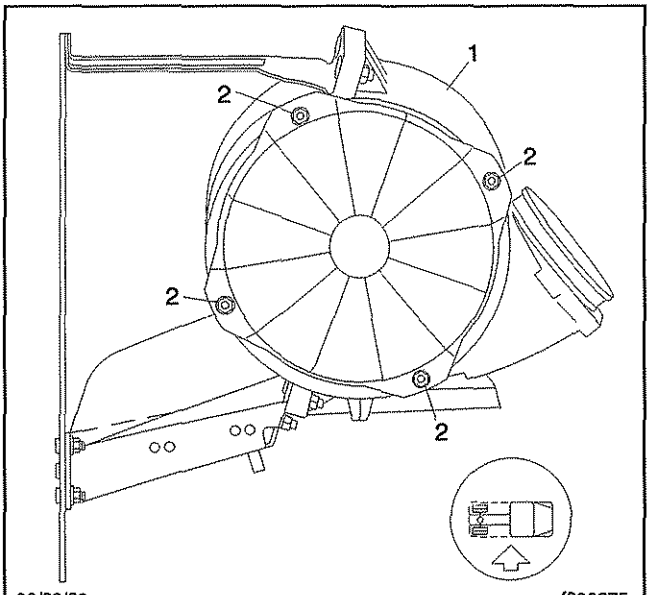
If the air cleaner housing has been damaged, immediately check all ducting and connections to the air cleaner for leakage. Adjust or replace parts as necessary. If needed, replace the air cleaner assembly using the instructions in **Subject 120** or **Subject 130**.

1. Turn off the engine, apply the brakes, and chock the tires.
2. Open the hood or tilt the cab. For cab tilt instructions, see **Group 60**.
3. Remove the four capnuts or open the clips that attach the air cleaner cover to the air cleaner assembly. See **Fig. 1** and **Fig. 2**.

⚠ CAUTION

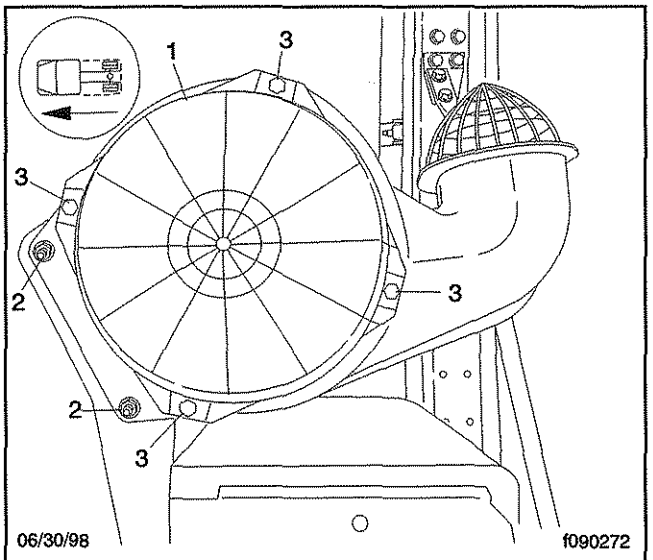
Never use impact or shock (pounding with a hammer) to release the air cleaner cover. This may distort the cover and allow the entry of dirt and contaminants into the sealed system, causing engine damage.

4. Due to high gasket-loading pressures, removing the air cleaner cover may be difficult. After removing the capnuts, gently pry around the outside of the cover to remove it from the air cleaner housing.
5. Remove the air cleaner filter element. Removal may be difficult because the inboard element-gasket can stick to the cleaner housing. Push up and down on the outboard end of the element to release the gasket.



1. Air Cleaner Assembly 2. Capnut or Clip

Fig. 1, Air Cleaner Assembly, Century Class Conventional



1. Air Cleaner Assembly 3. Capnut or Clip
2. Mounting Fasteners

Fig. 2, Air Cleaner Assembly, Argosy COE

Donaldson Air Cleaner Element Replacement

⚠ CAUTION

Do not leave any dirt on the inside of the air cleaner. If dirt gets inside the filter element, it may get into the engine and cause damage.

6. Check the housing and sealing surfaces for damage or dirt buildup that may cause sealing problems. Remove any dirt buildup.
7. Wipe the inside of the air cleaner housing with a clean damp cloth.
8. Inspect a new filter element for damaged gaskets and dented metal parts. If the gaskets are not smooth and flat or are damaged to the extent that dust might bypass them, discard the element.

   Place a bright light inside the new element and turn the element while looking through it from the outside. The light will reveal any hole or rupture. Holes in the element will allow dust to enter the engine. Discard the element if it is damaged.
9. Install the new filter element.

⚠ CAUTION

Do not force the air cleaner cover on the air cleaner assembly. Forcing the cover on the air cleaner assembly may indicate that the filter element is not seated correctly in the air cleaner assembly. If the cover is forced on the air cleaner assembly, dirt may get into the engine and cause damage.

10. Install the air cleaner cover. Secure the cover to the air cleaner assembly using capnuts or clips. Tighten the capnuts 95 lbf·in (1080 N·cm) evenly in a cross pattern to prevent distortion of the cover.
11. Check all connections for tightness.
12. Return the hood or cab to the operating position. For cab tilt instructions, see **Group 60.**
13. Remove the chocks from the tires.

Donaldson Air Cleaner Assembly Replacement, Century Class Conventional

Air Cleaner Assembly Replacement

⚠ CAUTION

All air intake components and connections must be air- and water-tight. Dirt or dust entering the engine can cause internal engine damage. Most of the dirt and dust particles are silicates, which fuse into abrasive glass-like particles when exposed to engine combustion. These particles can grind piston rings, pistons, and cylinder liners. Do not operate the engine with the air filter element or any air intake component removed.

IMPORTANT: Do not modify, or use modified air cleaners and ducting components.

If the air cleaner housing has been damaged, immediately check all ducting and connections to the air cleaner for leakage. Adjust or replace parts as necessary. If needed, replace the air cleaner assembly as follows:

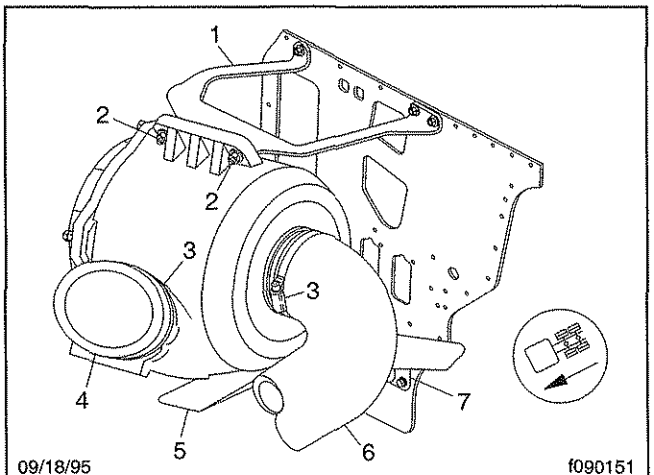
1. Apply the parking brakes, chock the tires, and tilt the hood.
2. Examine the hood-to-cleaner-housing seal. If the seal is in serviceable condition, remove the hose clamp and seal for installation on the new air-cleaner housing. See **Fig. 1**.
3. Loosen the hose clamp that attaches the flexible duct to the air cleaner outlet port. Pull the flexible duct off the outlet port.
4. Using a socket and a long extension, remove the two sets of locknuts, washers, and spacers from the air cleaner mounting studs extending from the lower mounting bracket, above the turbocharger heat shield.
5. Remove the two sets of locknuts and washers from the air cleaner mounting studs at the upper mounting bracket.
6. Work the air cleaner housing off the four mounting studs.
7. Install the new air cleaner housing on the mounting studs.
8. Install the two sets of locknuts and washers on the air cleaner mounting studs at the upper mounting bracket.

   Install the two sets of locknuts and washers on the air cleaner mounting studs at the lower mounting bracket. If a socket and long extension are used, removal of the turbocharger heat shield is not necessary.

   Tighten all four locknuts 26 lbf·ft (35 N·m).
9. Remove the cover from the flexible duct. Attach the duct to the air cleaner outlet port. The hose must be installed all the way onto the port.

   Secure the connection with the hose clamp. Tighten the hose clamp 35 to 40 lbf·in (400 to 450 N·cm).
10. Inspect a new filter element for damaged gaskets and dented metal parts. If the gaskets are not smooth and flat or are damaged to the extent that dust might bypass them, discard the element.

    Place a bright light inside the new element and turn the element while looking through it from the outside. The light will reveal any hole or rupture. Holes in the element will allow dust to enter the engine. Discard the element if it is damaged.
11. Remove the four capnuts or open the clips that attach the air cleaner cover to the air cleaner



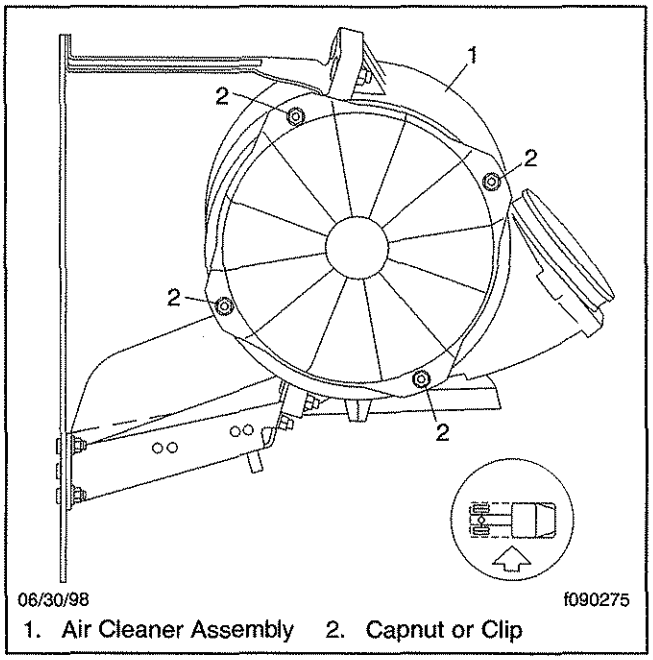
1. Upper Mounting Bracket
2. Locknut and Washer
3. Hose Clamp
4. Hood-to-Cleaner-Housing Seal
5. Turbocharger Heat Shield
6. Flexible Outlet Duct
7. Lower Mounting Bracket

Fig. 1, Air Cleaner Assembly Installation

Donaldson Air Cleaner Assembly Replacement, Century Class Conventional

assembly. See **Fig. 2**. Remove the cover and install the new filter element.

12. Install the air cleaner cover. Secure the cover to the air cleaner assembly using capnuts or clips. Tighten the capnuts 95 lbf·in (1070 N·cm) evenly in a cross pattern to prevent distortion of the cover.
13. Install the hose clamp and a new or serviceable hood-to-cleaner-housing seal on the new air-cleaner housing. Tighten the hose clamp 45 lbf·in (500 N·cm).
14. Check all connections for tightness.
15. Return the hood to the operating position.
16. Remove the chocks from the tires.



1. Air Cleaner Assembly 2. Capnut or Clip

Fig. 2, Air Cleaner Assembly Mounting

Donaldson Air Cleaner Assembly Replacement, Argosy COE

Air Cleaner Assembly Replacement

⚠ CAUTION

All air intake components and connections must be air- and water-tight. Dirt or dust entering the engine can cause internal engine damage. Most of the dirt and dust particles are silicates, which fuse into abrasive glass-like particles when exposed to engine combustion. These particles can grind piston rings, pistons, and cylinder liners. Do not operate the engine with the air filter element or any air intake component removed.

IMPORTANT: Do not modify, or use modified air cleaners and ducting components.

If the air cleaner housing has been damaged, immediately check all ducting and connections to the air cleaner for leakage. Adjust or replace parts as necessary. If needed, replace the air cleaner assembly as follows:

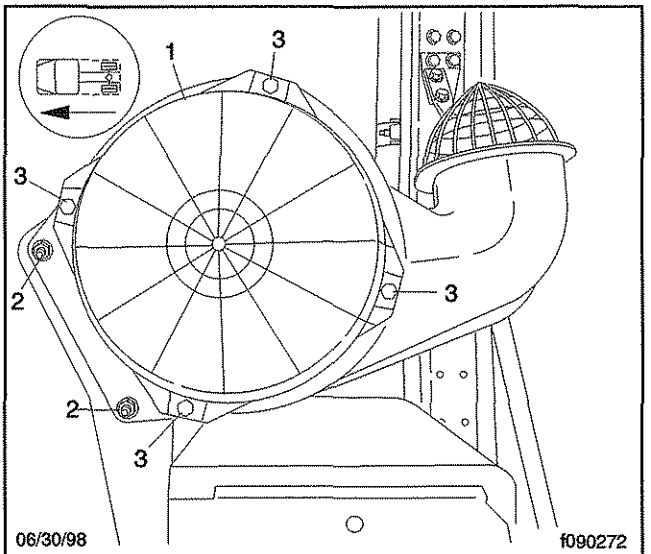
1. Turn off the engine, apply the parking brakes, and chock the tires.
2. Tilt the cab. For cab tilt instructions, see **Group 60.**
3. Loosen the hose clamp that attaches the air intake ducting to the air cleaner assembly. Remove the air intake ducting.
4. Remove the four nuts and washers that attach the air cleaner assembly to the mounting bracket, and remove the air cleaner assembly. See **Fig. 1.**
5. Attach the new air cleaner assembly to the mounting bracket. Attach the four washers and nuts and tighten 26 lbf·ft (35 N·m).
6. Attach the air intake ducting to the air cleaner assembly. Attach the hose clamp and tighten 35 to 40 lbf·in (400 to 450 N·cm).
7. Inspect a new filter element for damaged gaskets and dented metal parts. If the gaskets are not smooth and flat or are damaged to the extent that dust might bypass them, discard the element.

   Place a bright light inside the new element and turn the element while looking through it from the outside. The light will reveal any hole or rupture. Holes in the element will allow dust to enter the engine. Discard the element if it is damaged.
8. Remove the four capnuts or open the clips that attach the air cleaner cover to the air cleaner assembly. Remove the cover and install the new filter element.

⚠ CAUTION

Do not force the air cleaner cover on the air cleaner assembly. Forcing the cover on the air cleaner assembly may indicate that the filter element is not seated correctly in the air cleaner assembly. If the cover is forced on the air cleaner assembly, dirt may get into the engine and cause damage.

9. Install the air cleaner cover. Secure the cover to the air cleaner assembly using capnuts or clips. Tighten the capnuts 95 lbf·in (1070 N·cm) evenly in a cross pattern to prevent distortion of the cover.
10. Return the cab to the operating position. For cab tilt instructions, see **Group 60.**
11. Remove the chocks from the tires.



1. Air Cleaner Assembly
2. Mounting Fasteners
3. Capnut or Clip

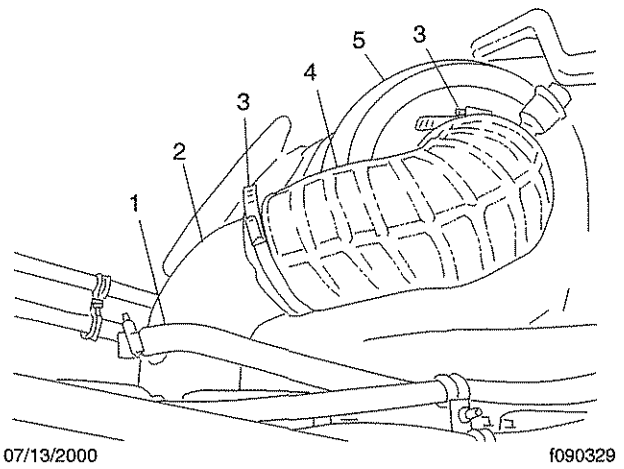
Fig. 1, Air Cleaner Assembly

Air Cleaner Piping Removal and Installation, MBE4000 Engine

NOTE: These procedures apply to vehicles with MBE4000 engines.

Removal

1. Apply the parking brakes, shut down the engine, and chock all the tires. Raise the hood.
2. Disconnect the batteries.
3. Disconnect the pipe fitting attaching the air compressor inlet hose to the air cleaner hose. Tie the air compressor inlet hose up and out of the way. See **Fig. 1**.
4. Disconnect the clamps attaching the air cleaner flexible hose to the air cleaner housing.
5. Disconnect the clamp attaching the air intake elbow to the turbocharger. Remove the air intake piping assembly, as a unit, from the vehicle. See **Fig. 2**.
6. Check the piping and all clamps for condition. Replace them if necessary.



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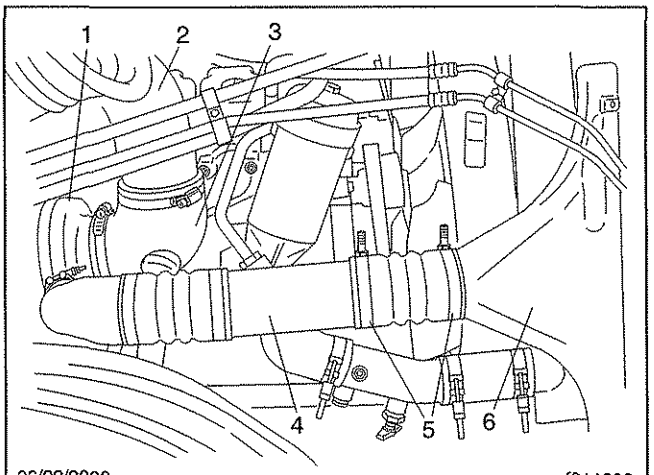
1. Air Compressor Inlet Hose
2. Air Cleaner Pipe
3. Constant-Torque Clamp
4. Air Cleaner Flexible Hose
5. Air Cleaner Housing

Fig. 1, Connection to the Air Cleaner

Installation

1. Install the air intake piping assembly, as a unit, and attach clamps to the air cleaner housing and the turbocharger.
2. Tighten all clamps 84 lbf·in (1000 N·cm). When installing all piping, make sure the component fits well down on its attachment and is firmly connected. Make sure the clamp is tight.
3. Connect the pipe fitting attaching the air compressor inlet hose to the air cleaner pipe.
4. Connect the batteries.
5. Check the air compressor inlet hose at the fitting for leaks.
6. Lower the hood and remove the chocks from the tires.



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1. Turbocharger
2. Air Cleaner Pipe
3. Air Intake Elbow
4. Turbocharger Outlet Tube
5. Constant-Torque Clamp
6. Charge Air Cooler

Fig. 2, Connection to the Turbocharger

Charge Air Cooler 09.02

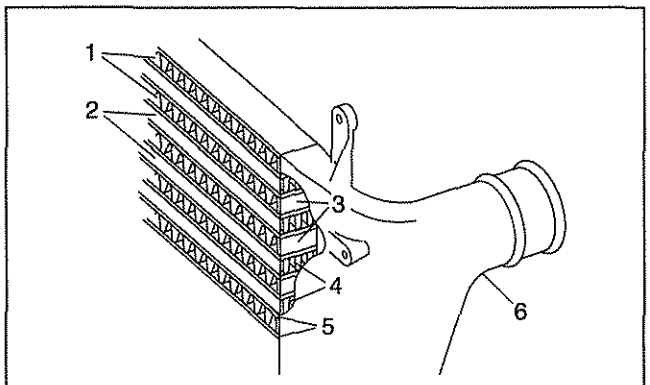
Contents

Subject	Subject Number
General Information	050
Service Operations	
Charge Air Cooler Removal and Installation, Century Class Conventional	100
Charge Air Cooler Inspection and Leakage Tests	110
Charge Air Cooler Flushing	120
Charge Air Cooler Restriction Test	130
Charge Air Cooler Removal and Installation, Argosy COE	140

General Information

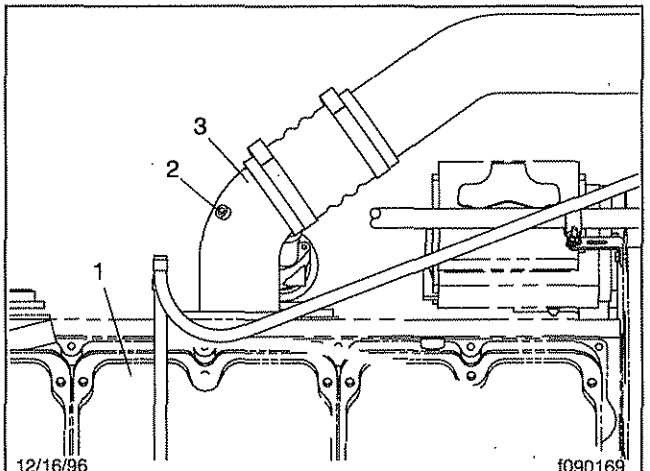
The charge air cooler (CAC) is attached to the front of the radiator, and is similar to a radiator. See **Fig. 1**. Outside ambient air passing through the charge-air-cooler core cools the engine's intake air charge. The air charge leaving the turbocharger is hot compressed air, about 275° to 325°F (135° to 162°C), depending on the ambient temperature. The charge air cooler reduces the air charge temperature to about 110°F (43°C), at 77°F (25°C) ambient, before the air charge enters the engine intake manifold. This temperature decrease lowers exhaust emissions, improves fuel economy, and increases horsepower.

On Century Class Conventionals, vehicles equipped with an ether-aided starting system have a different air intake elbow at the engine. See **Fig. 2**. See **Group 01** for information about the ether starting system.



1. Cold Fins
2. Cold Bars
3. Hot Bars
4. Hot Fins
5. Tube Plates
6. Header Tank

Fig. 1, Charge Air Cooler (CAC) Construction

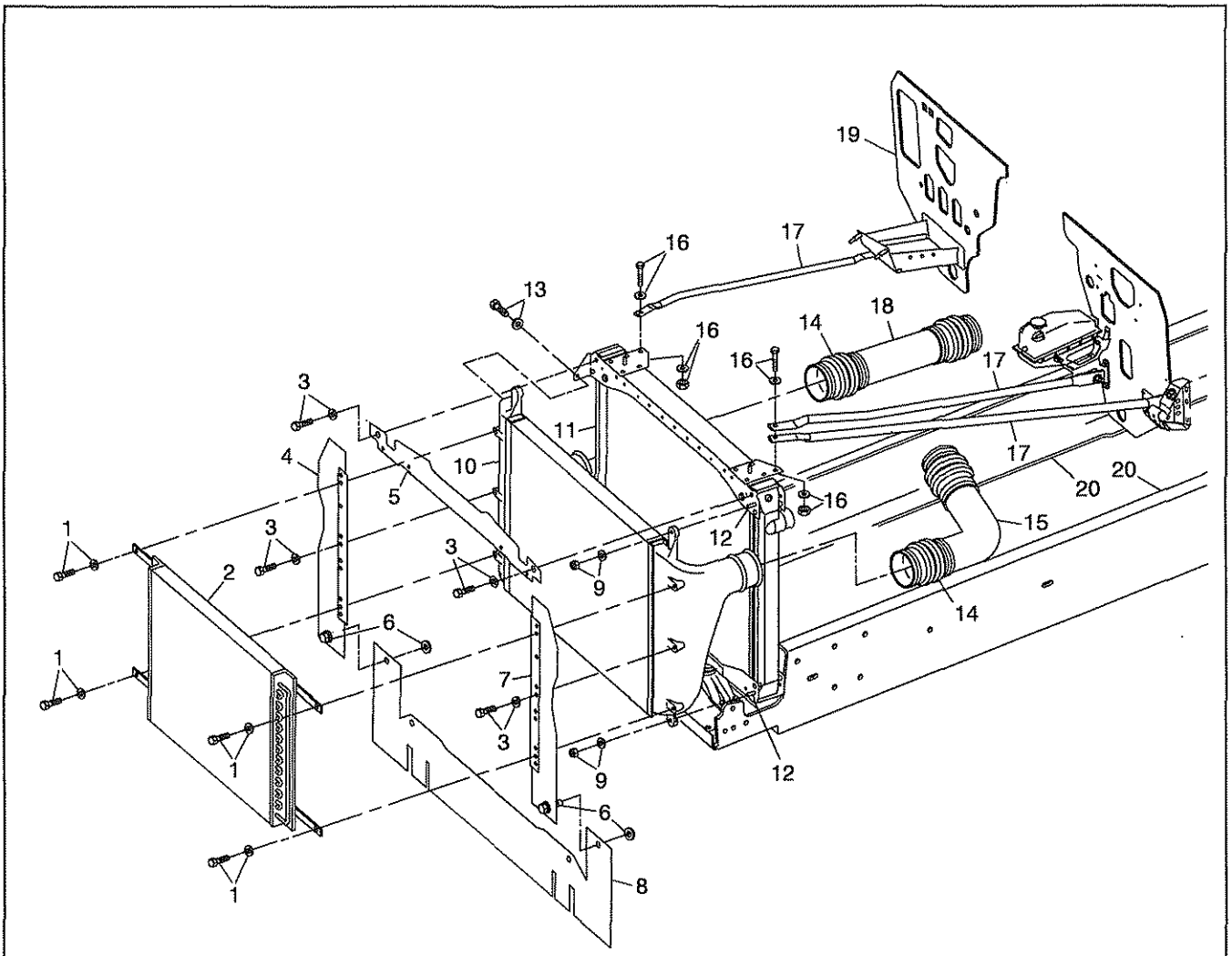


1. Engine
2. Nozzle
3. Elbow

Fig. 2, Air Intake Elbow with Ether Starting Nozzle

Charge Air Cooler Removal and Installation, Century Class Conventional

Removal (See Fig. 1)



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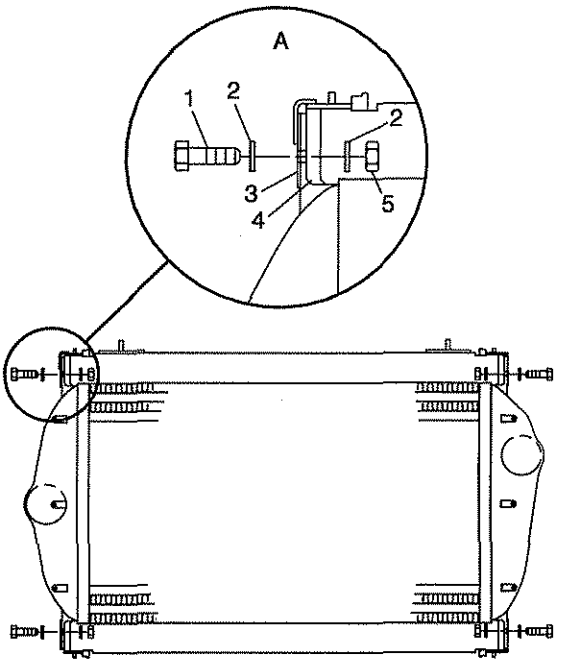
1. A/C Condenser Mounting Fasteners
2. A/C Condenser
3. Air-Recirculation Baffle Mounting Fasteners
4. Right-Side Air-Recirculation Baffle
5. Upper Air-Recirculation Baffle
6. Air-Recirculation-Baffle Plastic Panel Retainer and Fender Washer
7. Left-Side Air-Recirculation Baffle
8. Lower Air-Recirculation Baffle
9. CAC Mounting Nut and Washer
10. Charge Air Cooler (CAC)
11. 1200-Square-Inch Radiator
12. Radiator Forward Stud
13. CAC Mounting Bolt and Washer
14. Convoluted Hose
15. CAC Outlet Air Piping
16. Radiator Brace-Rod Fasteners
17. Radiator Brace Rod
18. CAC Inlet Air Piping
19. Cab Frontwall
20. Frame Rail

Fig. 1, Charge Air Cooler (CAC) Installation for 1200-Square-Inch Radiator

Charge Air Cooler Removal and Installation, Century Class Conventional

1. Apply the parking brakes, and chock the tires.
2. Remove the grille from the hood.
3. Tilt the hood, and support its front upper edge in a position that will allow the hood straps to be disconnected; place a support between the floor and the front of the hood, above the grille opening. Use cardboard, carpet, rags, or other padding on top of the support to protect the hood.
4. Disconnect both hood straps from the top of the radiator.
5. Loosen the constant-torque hose clamps at both ends of the convoluted hoses that attach the inlet and outlet air piping to the charge air cooler (CAC) connections. Push the clamps and hoses back onto the piping, until they are not touching the CAC connections.
6. To allow extra slack in the A/C condenser hoses, remove the hose clamp that attaches the hoses near the right side of the radiator.
7. While standing in the grille opening, remove both of the lower sets of fasteners that attach the right-side air-recirculation baffle to the CAC. Remove the plastic panel retainers and fender washers that attach both of the side air-recirculation baffles to the lower air-recirculation baffle.
8. Place shop towels or rags on top of the right-side tire. Remove the fasteners that attach the condenser to the CAC; then, with the A/C hoses still connected, swing the condenser around, and carefully lay it on top of the padding on the right-side tire.
9. For a CAC that is mounted on a 1200-square-inch radiator (see **Fig. 1**), remove the two bolts and washers that attach the CAC to the right side of the radiator; then, while pressing the CAC rearward, remove the two nuts and washers that secure the CAC on the forward studs at the left side of the radiator. Hold it there after the fasteners have been removed, until someone else can support the left side of the CAC.

   For a CAC that is mounted on a 1000-square-inch radiator (see **Fig. 2**), remove the two sets of fasteners that attach the CAC to the bottom of the radiator; then, while pressing the CAC rearward, remove the two nuts and washers, but not the bolts, that attach the CAC to the top of the radiator. Hold it there after the nuts have been removed, until someone else can support the left side of the CAC, then remove the bolts.
10. While someone else supports the left side of the CAC, pull both sides of the CAC far enough forward to clear the radiator's CAC mounting tabs or forward studs, as equipped. With the CAC held forward to clear the tabs and studs, move the CAC outboard to the right, then push the right side of the CAC back and inboard until the narrowest section of the CAC air-inlet connection is tight against the radiator end tank. Work the CAC air-outlet connection off the radiator's left end tank. Then move the CAC to the right until the CAC air-inlet connection clears the radiator's right end tank.
11. Pass the CAC out the left side of the vehicle.



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A. Typical, 4 places
1. 3/8–16 Hexbolt
2. Hardened Washer
3. CAC Mounting Tab of Radiator
4. Mounting Tab of CAC
5. Prevailing Torque Locknut

Fig. 2, Charge Air Cooler (CAC) Installation for 1000-Square-Inch Radiator

Charge Air Cooler Removal and Installation, Century Class Conventional

12. If a new charge air cooler is being installed, remove both of the side air-recirculation baffles from the old CAC.

Installation (See Fig. 1)

1. With the hood supported at its full-open position, and one person standing inside the grille opening, pass the CAC in from the left side of the vehicle.
2. With someone supporting the left side of the CAC, move the CAC outboard to the right, then push the right side of the CAC back and inboard until the narrowest section of the CAC air-inlet connection is tight against the radiator end tank. Work the CAC air-outlet connection onto the radiator's left end tank.
3. Pull both sides of the CAC far enough forward to clear the radiator's CAC mounting tabs or forward studs, as equipped. Then push the CAC mounting tabs onto the 1200-square-inch radiator's forward studs (see **Fig. 1**), or push the CAC mounting tabs between the mounting tabs of the 1000-square-inch radiator (see **Fig. 2**).
4. Install the fasteners that attach the CAC to the radiator. Tighten all CAC mounting fasteners 28 lbf·ft (38 N·m).
5. If the side air-recirculation baffles were removed, or a new CAC is being installed, attach both of the side air-recirculation baffles to the *center* holes of the CAC.
6. Swing the A/C condenser around, and install it on the front of the CAC. Tighten all condenser and air-recirculation-baffle fasteners 96 lbf·in (1085 N·cm). Install the air-recirculation-baffle plastic panel retainers and fender washers that attach the lower air-recirculation baffle to the side air-recirculation baffles. See **Fig. 1**. Install any A/C condenser hose clamps that were removed.
7. Tilt the hood to an angle that will allow attachment of the hood straps to the top of the radiator. Attach the hood straps. Remove the hood support, then tilt the hood.
8. Pull the convoluted hoses and constant-torque hose clamps forward until the hoses cover the CAC inlet and outlet connections up to the hose stops that are cast into the CAC connections.
9. Turn the constant-torque hose clamps so their tightening screws are under the hoses or facing inboard. Tighten the clamp screws 45 lbf·in (500 N·cm).
10. Return the hood to the operating position, then install the grille.

Charge Air Cooler 09.02

Contents

Subject	Subject Number
General Information	050
Service Operations	
Charge Air Cooler Removal and Installation, Century Class Conventional	100
Charge Air Cooler Inspection and Leakage Test	110
Charge Air Cooler Flushing	120
Charge Air Cooler Restriction Test	130
Charge Air Cooler Removal and Installation, Argosy COE	140

Charge Air Cooler Inspection and Leakage Test

Inspection

1. Turn off the engine, apply the parking brakes, and chock the tires.
2. Open the hood or tilt the cab. For cab tilt instructions, see **Group 60** in this manual.
3. Check the charge air cooler (CAC) convoluted hoses and the inlet and outlet piping for holes or other damage. Also check for loose or damaged constant-torque hose clamps. Replace damaged parts. If hose clamps are loose, turn them so their tightening screws are under the hoses or facing inboard. Tighten the screws 45 lbf·in (500 N·cm).
4. Check the CAC core fins. If the fins are bent, use a small pair of needle-nose pliers or a small screwdriver to straighten them.
5. Check the CAC core for clogged fins. Use compressed air or water to dislodge any material restricting airflow through the core.
6. Perform the "CAC Core Leakage Test."

Leakage Test

Charge air coolers are designed in such a way that they may bleed an insignificant amount of air. The allowable leakage mentioned in **Table 1** represents a loss of less than 0.1 percent of charge airflow. Based on this rate, there should be no measurable loss of performance.

Leakage Rate Specifications		
Engine	**Pressure Drop in 15 Seconds psi (kPa)**	**Start Pressure psi (kPa)**
Caterpillar	5 (34)	30 (207)
Detroit Diesel	5 (34)	25 (172)
Cummins	7 (48)	30 (207)

Table 1, Leakage Rate Specifications

The CAC core leakage test should be performed using a charge air cooler test kit, part number 5039, which can be purchased from Kent-Moore/SPX at 1.800.328.6657.

CAC CORE LEAKAGE TEST

1. Turn off the engine, apply the parking brakes, and chock the tires.
2. Connect the test equipment to the CAC core. See **Fig. 1**.
   - 2.1 Remove the inlet and outlet air piping from the convoluted hoses that attach them to the CAC air inlet and air outlet.
   - 2.2 Slip a safety ring with thumbscrew over each convoluted hose and onto the CAC air inlet and air outlet. Turn the rings so the thumbscrews are facing outboard and the safety chains) are inboard. Tighten the thumbscrews securely.
   - 2.3 Install an additional constant-torque hose clamp on each convoluted hose.
   - 2.4 Install the test plug without an adapter in the CAC air inlet and turn the plug so the safety chain is inboard. Tighten each constant-torque hose clamp 72 lbf·in (813 N·cm).
   - 2.5 Install the test plug with adapter in the CAC air outlet and turn the plug so the safety chain is inboard. Tighten each constant-torque hose clamp 72 lbf·in (813 N·cm).

⚠ WARNING

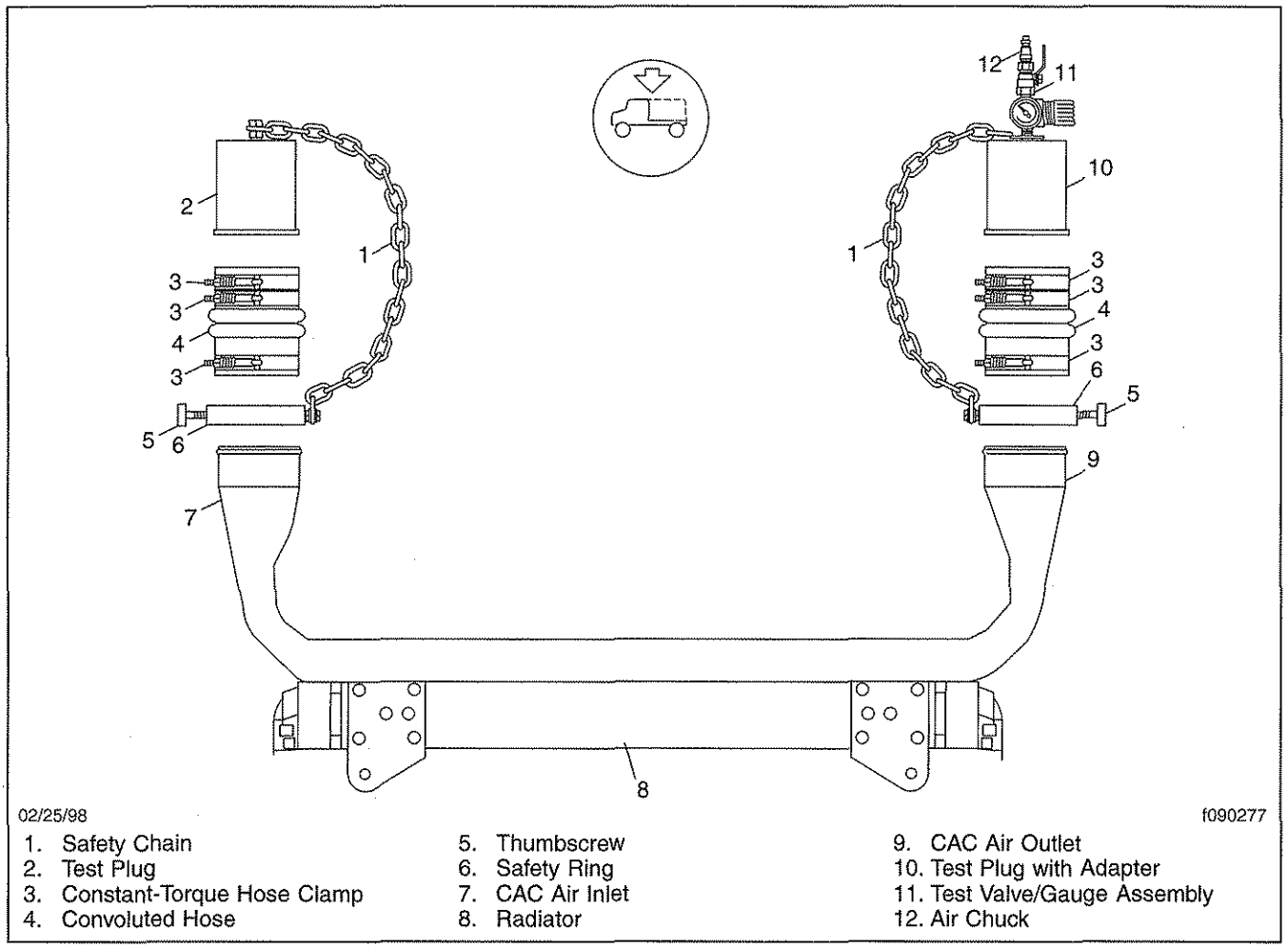
Always secure the test plugs with the safety rings. Test pressures could blow out an unsecured test plug at high speed, possibly causing eye injury or other serious personal injury.

   - 2.6 If not already installed, install a test valve/gauge assembly and air chuck in the test plug with adapter.
   - 2.7 Attach a pressurized air line to the air chuck on the pressure regulator valve.
3. Test the CAC core.

⚠ WARNING

Always wear safety glasses when doing this procedure. Do not stand in front of the test plugs while the core is pressurized. A plug could suddenly re-

Charge Air Cooler Inspection and Leakage Test



1. Safety Chain
2. Test Plug
3. Constant-Torque Hose Clamp
4. Convoluted Hose
5. Thumbscrew
6. Safety Ring
7. CAC Air Inlet
8. Radiator
9. CAC Air Outlet
10. Test Plug with Adapter
11. Test Valve/Gauge Assembly
12. Air Chuck

Fig. 1, CAC Core Testing

lease debris at high speed, possibly resulting in eye injury or other serious personal injury.

3.1 Open the test valve, then slowly open the pressure regulator valve and allow the charge air cooler to gradually fill with air to the start pressure. See **Table 1**.

3.2 Close the test valve and watch the gauge for 15 seconds. If there is more than the specified drop in the charge air cooler pressure in 15 seconds, replace the charge air cooler. See **Table 1**.

IMPORTANT: Do not attempt to repair the charge air cooler.

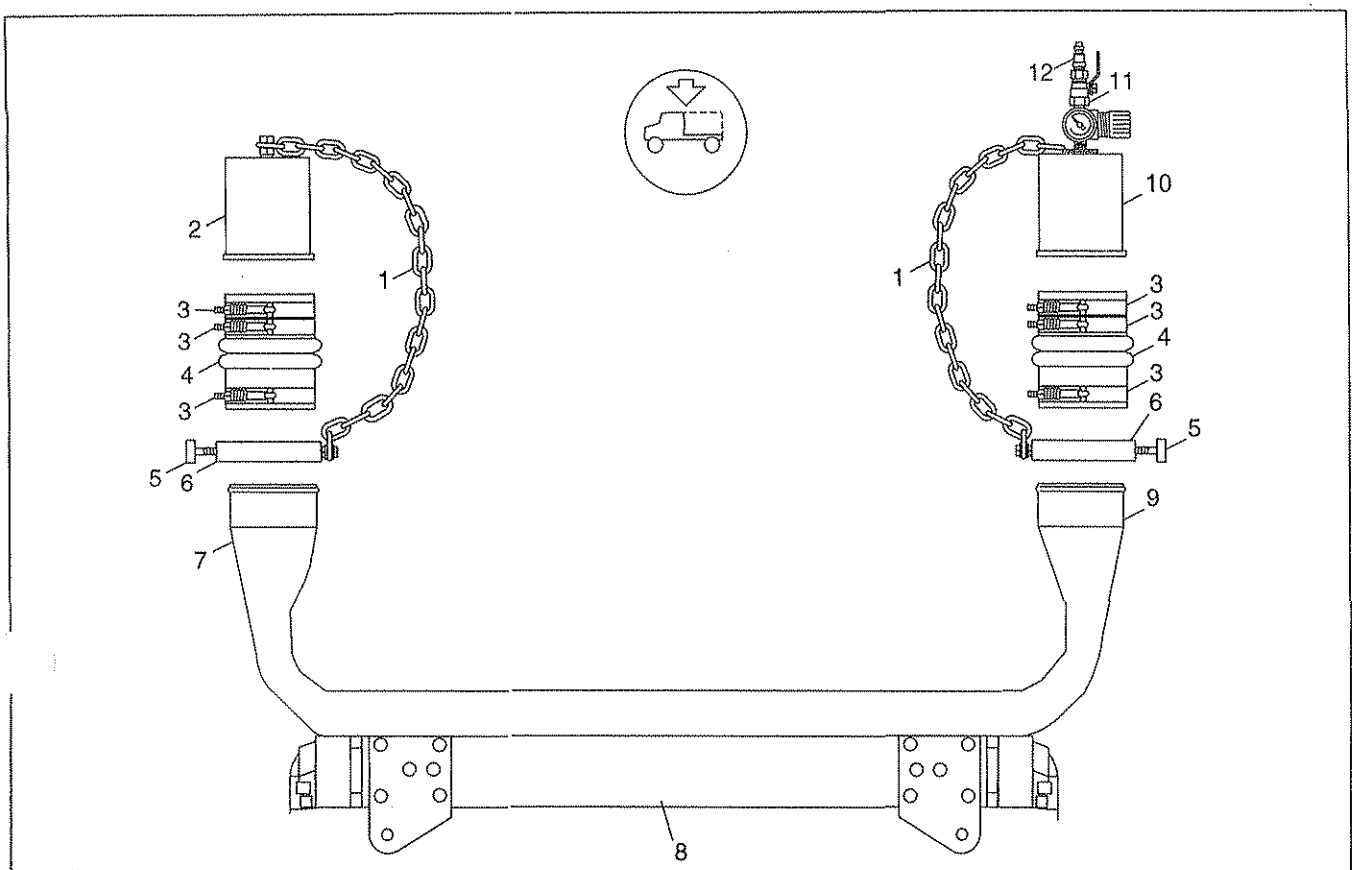
3.3 When testing is completed, reduce the pressure on the pressure regulator valve to bleed air from the charge air cooler.

4. Remove the test equipment (and the additional constant-torque hose clamps) from the convoluted hoses.

5. Pull the convoluted hoses and constant-torque hose clamps rearward until the hoses cover about 1-1/2 inches (38 mm) of the CAC air inlet and air outlet piping.

6. Turn the clamps so their tightening screws are under the hoses or facing inboard. Tighten the screws 45 lbf·in (500 N·cm).

Charge Air Cooler Inspection and Leakage Test



1. Safety Chain
2. Test Plug
3. Constant-Torque Hose Clamp
4. Convoluted Hose
5. Thumbscrew
6. Safety Ring
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Fig. 1, CAC Core Testing

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IMPORTANT: Do not attempt to repair the charge air cooler.

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4. Remove the test equipment (and the additional constant-torque hose clamps) from the convoluted hoses.

5. Pull the convoluted hoses and constant-torque hose clamps rearward until the hoses cover about 1-1/2 inches (38 mm) of the CAC air inlet and air outlet piping.

6. Turn the clamps so their tightening screws are under the hoses or facing inboard. Tighten the screws 45 lbf·in (500 N·cm).

7. Return the hood or cab to the operating position. For cab tilt instructions, see **Group 60** in this manual.
8. Remove the chocks from the tires.

Charge Air Cooler Flushing

If the charge air cooler is suspected of being contaminated, flush the charge air cooler.

1. Turn off the engine, apply the brakes, and chock the tires.
2. Remove the charge air cooler. For instructions, see **Subject 100** for Century Class Conventionals, and **Subject 140** for Argosy COEs.
3. Set the charge air cooler in a horizontal position with the inlet and outlet ports facing up.

⚠ CAUTION

Use only naphtha or mineral spirits to clean the charge air cooler. Do not use caustic solutions such as those that are commonly used in radiator shops. Do not use steam or high-temperature cleaning operations. Caustic solutions, steam, and high-temperature cleaning operations will damage the RTV that seals the charge air cooler tubes to the headers, which may result in leaking.

4. Pour a filtered naphtha or mineral spirits solution into the charge air cooler until it is 40 percent full.
5. Cap the inlet and outlet ports on the charge air cooler.
6. Rock the charge air cooler back and forth so that the solvent travels form one tank, through the tubes, to the other tank and back. Repeat this process ten times.

NOTE: Do not leave the solvent in the charge air cooler for more than ten minutes.

7. Remove the caps from the inlet and outlet ports.
8. Drain the charge air cooler and properly dispose of the solvent.
9. Leave the caps off and allow the residual solvent to evaporate.
10. Install the charge air cooler. For instructions, see **Subject 100** for Century Class Conventionals, and **Subject 140** for Argosy COEs.
11. Remove the chocks form the tires.

Restriction Test

After flushing the charge air cooler because of turbocharger or engine damage, test the pressure drop across the charge air cooler and air piping, as follows:

1. Remove the pipe plug (if so equipped) from the tapped hole in the turbocharger air outlet elbow.

   Remove the pipe plug, or the nylon tube and atomizer for the ether start system (if so equipped), or the air line to the turbocharger air-pressure gauge (if so equipped), from the tapped hole in the left-hand rear of the intake manifold.

   Install an air pressure gauge in each tapped hole.

2. Operate the engine at rated speed and horsepower; there is no need to operate the engine at its peak torque rating. While operating the engine, read both air pressure gauges.

   Because of the turbulence of the air at the turbocharger outlet, subtract 0.3 inHg (1 kPa) from the pressure measurement taken at the turbocharger outlet, to make it a true reading.

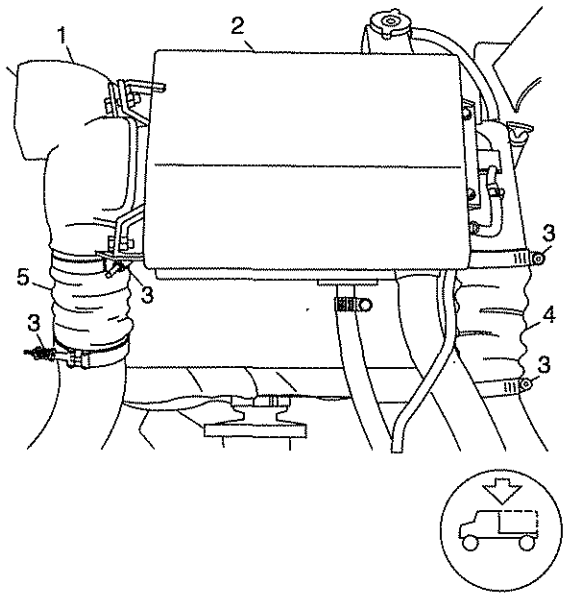
   From that reading, subtract the reading taken at the intake manifold. This is the pressure drop of the charge air cooler.

   If the pressure drop is more than 4 inHg (14 kPa), flush or replace the charge air cooler as needed.

Charge Air Cooler Removal and Installation, Argosy COE

Removal

1. Turn off the engine, apply the parking brakes, and chock the tires.
2. Open the access panel on the front of the vehicle.
3. Drain the coolant from the cooling system. For instructions, see **Group 20** in this manual.
4. Remove the lower grille panel from the cab. For instructions, see **Group 60** in this manual.
5. Tilt the cab. For instructions, see **Group 60** in this manual.
6. Loosen the constant-torque hose clamps that attach the inlet and outlet hoses to the charge air cooler. Remove the hoses from the charge air cooler. See **Fig. 1**.
7. Remove the capscrews and washers that attach the engine oil dipstick and filler to the charge air cooler.



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1. Charge Air Cooler
2. Surge Tank
3. Hose Clamp
4. Inlet Hose
5. Outlet Hose

Fig. 1, Charge Air Cooler

8. Remove the nuts that attach the condenser to the charge air cooler. Swing the condenser out from the charge air cooler without removing the refrigerant lines. Support the condenser by attaching tie straps to the condenser and to parts on the vehicle.
9. Remove the two bolts, washers, and nuts that attach the surge tank to the mounting bracket on the radiator. See **Fig. 2**. Remove the two bolts, washers, and nuts that attach the surge tank to the charge air cooler. See **Fig. 1**.
10. Remove the short hose between the surge tank and the radiator. See **Fig. 2**. Move the surge tank off of the charge air cooler and radiator.
11. Remove the two mounting bolts, washers, and nuts on the left-hand side of the charge air cooler. Remove the two mounting capscrews on the right-hand side of the charge air cooler, and remove the charge air cooler.

Installation

1. Install the charge air cooler on the mounting brackets on the radiator. Attach the bolts, washers, and nuts on the left-hand side of the charge air cooler, and capscrews on the right-hand side of the vehicle.
2. Place the surge tank on the radiator and the charge air cooler and attach it using four bolts, washers, and nuts. Attach the short hose between the radiator and the surge tank and fasten it with a hose clamp.
3. Remove the tie straps that are supporting the condenser. Swing the condenser back on the charge air cooler. Attach the nuts and tighten 84 lbf·in (950 N·cm).
4. Attach the engine oil dipstick and filler to the charge air cooler using washers and capscrews. Tighten the capscrews securely.
5. Attach the inlet and outlet hoses to the charge air cooler. Slide the constant torque hose clamps over the hoses and tighten the hose clamps 45 lbf·in (500 N·cm).
6. Attach the lower grille panel to the cab. For instructions, see **Group 60** in this manual.

Charge Air Cooler Removal and Installation, Argosy COE

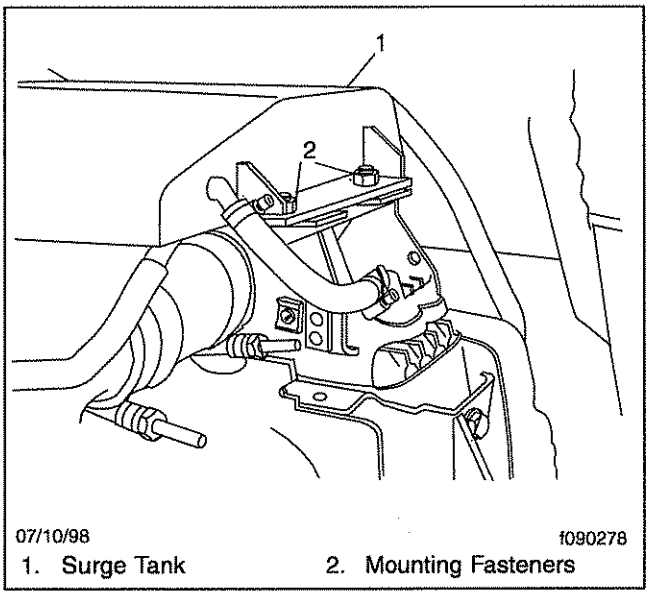


Fig. 2, Surge Tank

7. Fill the cooling system with coolant. For coolant specifications, refer to **Group 20** in the vehicle maintenance manual.
8. Return the cab to the operating position. For cab tilt instructions, see **Group 60** in this manual.
9. Close the access panel.
10. Remove the chocks from the tires.

Group Index, Alphabetical

Section	Section Number
Air Compressors, Bendix Tu-Flo 550 and Tu-Flo 750	13.00
Air Compressor, Cummins	13.03
Air Compressors, Midland EL-1300 and EL-1600	13.02
Air Governor, Bendix D–2	13.01

Contents

Subject	Subject Number
General Description	050
Service Operations	
Air Compressor Removal and Installation	100
Cylinder Head Removal and Installation	110
Cylinder Head Disassembly, Cleaning and Inspection, and Assembly	120
Crankcase Disassembly, Cleaning and Inspection, and Assembly	130
Troubleshooting	300
Specifications	400

General Description

The Tu-Flo 550 and the Tu-Flo 750 are two cylinder, single-stage, reciprocating air compressors, which supply compressed air to the vehicle air system. The Tu-Flo 550 has a rated displacement of 13.2 cfm (374 L/min) of air at 1250 rpm.

The Tu-Flo 750 has a rated displacement of 16.5 cfm (468 L/min) of air at 1250 rpm. The compressor draws air from the air intake pipe, compresses the air, and delivers it to the air system supply reservoir. The compressor runs continuously but has "loaded" and "unloaded" modes, which are regulated by the air governor and the compressor loading assembly. When the governor sends an air signal to the unloader assembly, the unloader assembly holds the compressor air intake valve open so that no more compressed air is forced into the air system. As air in the system is used, its pressure drops, and at 90 psi (620 kPa), the air governor stops the signal to the compressor. Without the signal, the unloader assembly automatically closes the compressor air intake valve to force more air into the system.

On vehicles with air dryers, when the system reaches the cut-out pressure of 120 psi (825 kPa), the air governor also sends an air signal to open the sludge ejector in the air dryer.

Air Compressor Removal and Installation

Removal

1. Apply the parking brakes, chock the tires, and tilt the hood or cab. For cab tilting instructions, see the applicable section in **Group 60** of this manual.
2. Drain the air system.

⚠ WARNING

Wear goggles when using compressed air to clean or dry parts, as permanent harm to eyes could result from flying debris.

3. Using a cleaning solvent, remove road dirt and grease from the outside of the compressor, then dry the compressor with compressed air.
4. Drain the radiator coolant; refer to **Group 20** in this manual for instructions.
5. On Century Class conventionals, loosen the constant-torque hose clamps at both ends of the charge air cooler outlet air piping. Remove the piping to access the air compressor.
6. Marking their locations and positions, disconnect all air, coolant, and oil lines attached to the compressor. Remove tie straps as needed to move the lines out of the way.

NOTE: On vehicles with combined air dryers and air reservoir modules, the air governor is mounted on the module not the air compressor.

7. If the air governor is mounted on the compressor, remove it and the governor mounting gasket.
8. On Cummins and Detroit Diesel engines, disconnect the wire to the fuel shutoff valve (if so equipped). Remove the fuel pump and gasket; refer to the engine shop manual or rebuild manual for instructions.
9. Remove the compressor support bracket, if so equipped.

NOTE: On Argosy COE vehicles, you must remove this bracket (at the rear of the compressor) in order to remove all the fasteners holding the compressor to the drive gear flange.

10. Support the compressor, and remove the bolts that attach it to the auxiliary drive housing, accessory drive, or timing gear plate. Remove the compressor, gasket, and splined coupling.

NOTE: On Argosy COE vehicles, the compressor is mounted on an alignment stud. The stud is at the top of the compressor mounting and allows the compressor to hang in place as you're removing or installing it. The stud is threaded and a nut is installed to secure the compressor.

11. Discard all mounting gaskets.

Installation

IMPORTANT: Be sure the gasket surfaces are cleaned and not damaged.

NOTE: On Argosy COE vehicles, the compressor is mounted on an alignment stud. The stud is at the top of the compressor mounting and allows the compressor to hang in place as you're removing or installing it. The stud is threaded and a nut is installed to secure the compressor.

1. Install the splined coupling (if so equipped) and a new compressor gasket. Hold the compressor in place, and install the bolts that attach it to the auxiliary drive housing, accessory drive, or timing gear plate. Refer to the engine shop manual or rebuild manual for final torque specification.
2. Install the compressor support bracket, if so equipped.
3. On Cummins and Detroit Diesel engines, install a new gasket, install the fuel pump. Connect the wire to the fuel shutoff valve (if so equipped). Refer to the engine shop manual or rebuild manual for instructions.
4. If applicable, use a new air governor mounting gasket, install the air governor on the compressor.
5. Identify and connect all air, coolant, and oil lines to the compressor. Secure the lines as needed with tie straps.
6. On Century Class conventionals, install the charge air cooler outlet air piping. Tighten the constant-torque hose clamp screws 45 lbf·in (500 N·cm).
7. Fill the engine cooling system; refer to **Group 20** in this manual for instructions.
8. Operate the engine and check for leaks.

Air Compressor Removal and Installation

9. Remove the chocks from the tires and return the hood or cab to the operating position. For cab tilting instructions, see the applicable section in **Group 60** of this manual.

Cylinder Head Removal and Installation

Removal

1. Chock the tires; then drain the air from all air reservoirs.

WARNING: Wear goggles when using compressed air to clean or dry parts, as permanent harm to eyes could result from flying debris.

2. Using a cleaning solvent, remove road dirt and grease from the outside of the compressor, then dry the compressor with compressed air.

3. Drain the radiator coolant; refer to **Group 20** in the vehicle workshop manual for instructions.

4. Remove the cylinder head from the crankcase. **See Fig. 1.**

   4.1 Scribe an alignment mark across the cylinder head and the crankcase, for assembly alignment.

   IMPORTANT: Do not use a marking method, such as chalk, that can be wiped off during assembling.

   4.2 Note positions of any attached components, then remove the cylinder head capscrews.

   4.3 Tap the cylinder head with a soft mallet to break the gasket seal. Remove the cylinder head.

Installation

1. Scrape off any gasket material from the cylinder head and the crankcase.

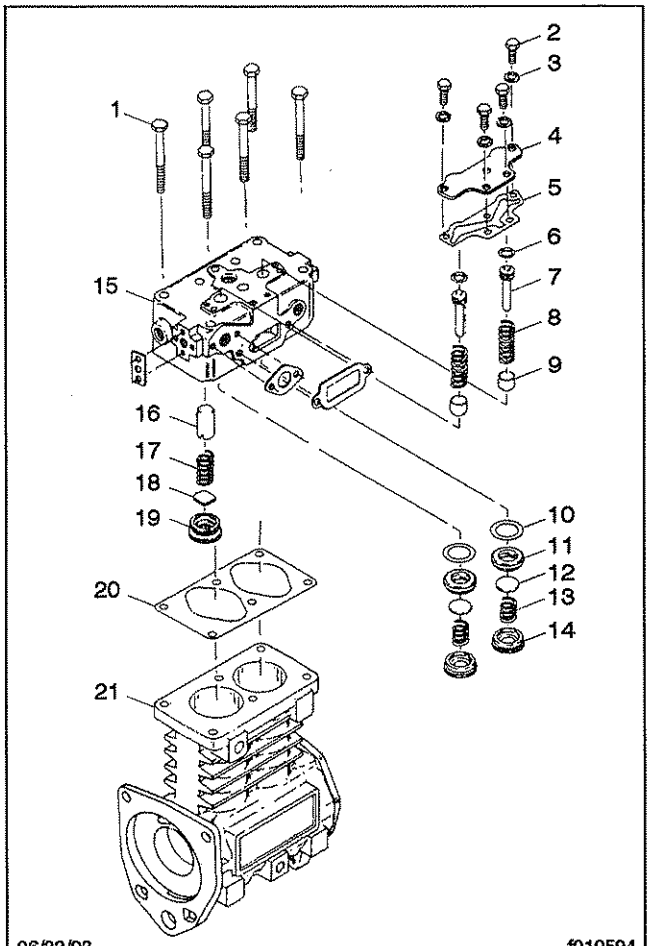
WARNING: Wear goggles when using compressed air to clean or dry parts, as permanent harm to eyes could result from flying debris.

2. Using compressed air, blow dirt particles or gasket material from all cylinder cavities.

3. Install the cylinder head on the compressor crankcase.

   3.1 Place a new cylinder head gasket on the crankcase. If the cylinder head gasket has a bead on one side, install the gasket with the bead side up.

   3.2 Using the previously marked alignment, position the cylinder head on the crankcase.



1. Cylinder Head Capscrew
2. Unloader Plate Capscrew
3. Unloader Plate Lockwasher
4. Unloader Plate
5. Unloader Plate Gasket
6. O-Ring
7. Unloader Piston
8. Spring
9. Unloader Bushing
10. Gasket
11. Inlet Valve Seat
12. Inlet Valve
13. Inlet Valve Spring
14. Inlet Valve Stop
15. Cylinder Head
16. Discharge Valve Stop
17. Discharge Valve Spring
18. Discharge Valve
19. Discharge Valve Seat
20. Cylinder Head Gasket
21. Crankcase

Fig. 1, Cylinder Head, Exploded View

Cylinder Head Removal and Installation

3.3 Position on the cylinder head any brackets, spacers, or clamps that were removed; then install the cylinder head capscrews and tighten them evenly, in a cross pattern 37 to 42 lbf·ft (50 to 57 N·m).

4. Connect the air discharge line and the water lines to the cylinder head.

5. Fill the engine cooling system; refer to **Group 20** in the vehicle workshop manual.

6. Operate the engine and make sure there are no coolant leaks.

Cylinder Head Disassembly, Cleaning and Inspection, and Assembly

Disassembly (See Fig. 1)

1. Remove the compressor from the vehicle. For instructions, refer to **Subject 100.**
2. Place the compressor on a suitable work surface. Remove the cylinder head from the crankcase. For instructions, refer to **Subject 110.**
3. Remove the unloader mechanism.
   - 3.1 Remove the unloader plate capscrews, lockwashers, and the unloader plate. Scrape off any gasket material from the unloader plate and the cylinder head.
   - 3.2 Remove and discard the unloader pistons, O-rings, and springs.
4. Check the unloader piston bushings. If damaged or worn excessively, replace the compressor.

NOTE: Before disassembling the discharge valve mechanism, measure and record the discharge valve travel from closed to completely open. If the measurement exceeds 0.046 inch (1.17 mm), replace the compressor. If the measurement is within 0.046 inch, proceed to the next step.

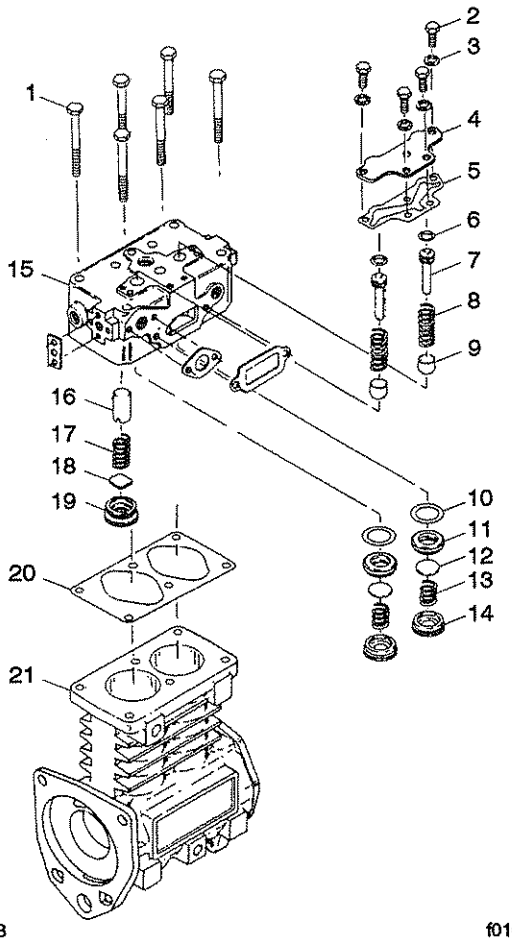
5. Using a 9/16-inch Allen wrench, remove and discard the discharge valve seats, discharge valves, and discharge valve springs.
6. Remove and discard the inlet valve stops and springs, along with the inlet valves, inlet valve seats, and gaskets.

Cleaning and Inspection

1. Remove carbon deposits from the discharge cavity, rust and scale from the cooling cavities.
2. Clean carbon and dirt from the inlet and unloader passages.
3. Scrape all foreign material from the body surfaces.

WARNING: Wear goggles when using compressed air to clean or dry parts, as permanent harm to eyes could result from flying debris.

4. Using solvent, thoroughly clean all metal parts removed from the cylinder head. Using shop air, blow the dirt particles from the cavities and passages.



1. Cylinder Head Capscrew
2. Unloader Plate Capscrew
3. Unloader Plate Lockwasher
4. Unloader Plate
5. Unloader Plate Gasket
6. O-Ring
7. Unloader Piston
8. Spring
9. Unloader Bushing
10. Gasket
11. Inlet Valve Seat
12. Inlet Valve
13. Inlet Valve Spring
14. Inlet Valve Stop
15. Cylinder Head
16. Discharge Valve Stop
17. Discharge Valve Spring
18. Discharge Valve
19. Discharge Valve Seat
20. Cylinder Head Gasket
21. Crankcase

Fig. 1, Cylinder Head, Exploded View

Cylinder Head Disassembly, Cleaning and Inspection, and Assembly

5. Check that all cavities and passages are clear, including the inlet and unloader.
6. Check that all mating surfaces are clean of old gasket material. Remove any old material.
7. Inspect the cylinder head for cracks or damage.
8. With the cylinder head and head gasket secured to a flat surface or to the crankcase, apply shop air pressure to one of the coolant ports with all other ports plugged.
9. Check for leaks by applying a soap solution to the exterior of the body. If leakage is detected, replace the compressor.

Assembly (See Fig. 1)

1. Install the unloader mechanism.
   - 1.1 With the unloader pistons being prelubricated from the manufacturer, install the new unloader springs, and the new unloader pistons. The unloader piston O-rings are pre-installed on the unloader pistons.
   - 1.2 Install the new unloader plate gasket and the unloader plate.
   - 1.3 Install the unloader plate lockwashers and capscrews. Tighten the capscrews 15 to 18 lbf·ft (20 to 25 N·m) in a cross pattern.
2. Install the inlet valve mechanism.
   - 2.1 Install the new inlet valve gaskets, new inlet valve seats, new inlet valves, and the new inlet valve springs into their bores.
   - 2.2 Install the new inlet valve stops and tighten 70 to 90 lbf·ft (95 to 122 N·m).
3. Install the new discharge valve springs, new discharge valves, and the new discharge valve seats into their bores. Tighten the seats 70 to 90 lbf·ft (95 to 122 N·m). The discharge valve travel should be 0.030 inches to 0.046 inch (0.762 mm to 1.17 mm).
4. Test for leakage at the discharge valves by applying 100 psi (690 kPa) through the cylinder head discharge port and apply soap solution to the discharge valve and seat. Leakage in the form of soap bubbles is permissible.

   If there's extreme leakage, leave the air pressure applied and with a hardwood dowel and a hammer, tap the discharge valves off of their seats several times. This will improve the seal between the discharge valve and the valve seat and should reduce leakage.

   If there's still extreme leakage, replace the discharge valve seats.

   With the air pressure still applied at the discharge port of the cylinder head, check for leakage around the discharge valve stop on top of the cylinder head. No leakage is permitted.
5. Install the compressor cylinder head. For instructions, refer to **Subject 110.**
6. Tighten the unloader plate capscrews 15 to 18 lbf·ft (20 to 25 N·m).
7. Install the compressor on the engine. For instructions, refer to **Subject 100.**

Crankcase Disassembly, Cleaning and Inspection, and Assembly

Disassembly

1. Remove the compressor from the vehicle and place it on a suitable work surface. For instructions, refer to **Subject 100.**
2. Remove the air compressor cylinder head. For instructions, refer to **Subject 110.**
3. Before disassembling the compressor, use a metal scribe to mark the parts with matching numbers or lines.

IMPORTANT: Do not use a marking method, such as chalk, that can be wiped off during assembling.

4. Remove the pistons and connecting rods. See **Fig. 1.**
   - 4.1 Remove the base plate capscrews.
   - 4.2 Tap the base plate with a soft mallet to break the gasket seal.
   - 4.3 Scrape off any gasket material from the crankcase and base plate.
   - 4.4 Remove the connecting rod bolts and connecting rod caps.
   - 4.5 Push the pistons and connecting rods out through the cylinder bore of the crankcase. Discard the pistons and connecting rod assemblies including the connecting rod caps and the connecting rod bolts.
5. Remove the crankshaft.
   - 5.1 Remove the key or keys from the crankshaft and any burrs from the crankshaft where the key or keys were removed.

   NOTE: Some compressors may have a crankshaft key at each end.
   - 5.2 Remove the end-cover capscrews, the end cover, end-cover seal, and the rear thrustwasher.
   - 5.3 If the compressor has sleeve bearings, remove and discard the sleeve bearings from the crankcase and the end cover.
   - 5.4 If the compressor has a ball-type main bearing, remove the rear snap ring (if so equipped). Press the crankshaft and ball bearing from the crankcase, then press the ball bearing from the crankshaft.
   - 5.5 Remove and discard the front and rear thrustwashers.

Cleaning and Inspection

1. Scrape off any gasket material from the top and bottom of the crankcase.

⚠ WARNING

Wear goggles when using compressed air to clean or dry parts, as permanent harm to eyes could result from flying debris.

2. Clean all parts with solvent, before inspecting them, and dry the parts with compressed air.
3. Clean all oil passages through the crankshaft, crankcase, end cover, and base plate. Inspect the passages with a wire to be sure they are clear.
4. Check the fit of the new pistons, piston rings, and connecting rods.
   - 4.1 The pistons for the Tu-Flo 750 compressor are similar to the Tu-Flo 550 and may be identified by the distance from the center of the wrist pin to the top of the piston. See **Fig. 2.**
   - 4.2 To check the ring gap, place the ring in the top of the cylinder bore and, using a piston, push the ring to mid-point of the cylinder bore and check the ring gap. The gap for compression rings must be 0.002 to 0.013 inch (0.050 to 0.330 mm).

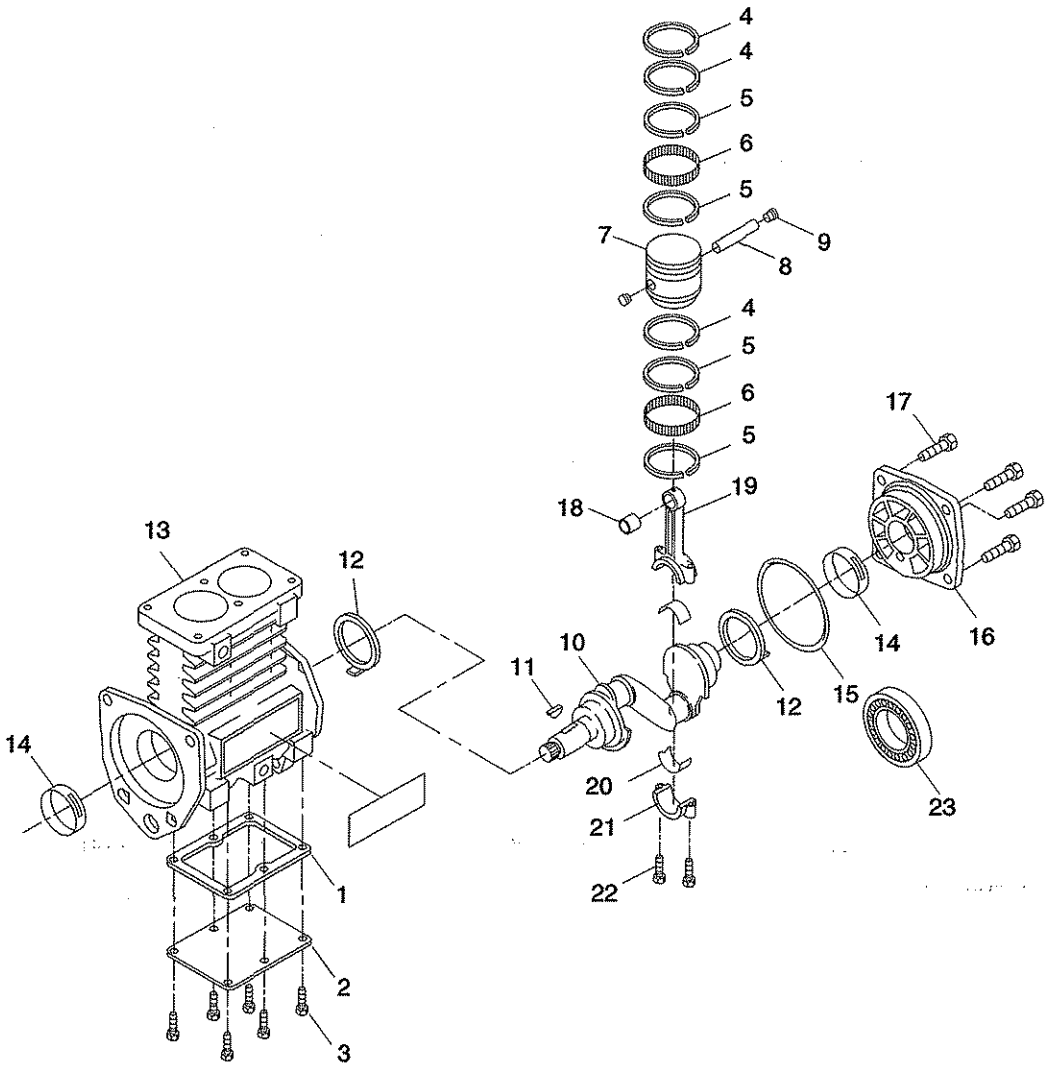
     The gap for oil ring and expander ring must be 0.010 to 0.040 inch (0.254 to 1.016 mm). See **Fig. 3**, and **Table 1.**

Allowable End Gap	
Ring	**End Gap in inch (mm)**
Compression	0.002–0.013 (0.050–0.330)
Oil and Expander	0.010–0.040 (0.254–1.016)

Table 1, Allowable End Gap

   - 4.3 Check the fit of the piston rings in the piston ring grooves. Groove clearance for the compression ring is 0.002 to 0.004 inch (0.051 to 0.101 mm). Groove clearance for

Crankcase Disassembly, Cleaning and Inspection, and Assembly



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1. Base Gasket
2. Base Plate
3. Base Plate Capscrew
4. Compression Ring
5. Oil Ring
6. Expander Ring
7. Piston
8. Wrist Pin
9. Wrist Pin Button
10. Crankshaft
11. Crankshaft Key
12. Thrust Washer
13. Crankcase
14. Sleeve Bearing
15. End Cover Seal
16. End Cover
17. End Cover Capscrew
18. Wrist Pin Bushing
19. Connecting Rod
20. Connecting Rod Bearing (Sets)
21. Connecting Rod Cap
22. Connecting Rod Bolt
23. Ball Bearing

Fig. 1, Crankcase, Exploded View

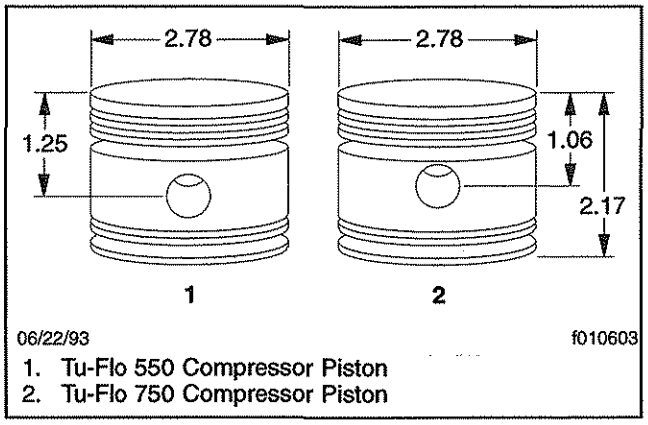
the expander and oil rings is 0.000 to 0.006 inch (0.000 to 0.152 mm).

5. Inspect the crankcase.

5.1 Check the crankcase surfaces for cracks and damage.

5.2 On compressors where main ball bearings are used, measure the difference be-

Crankcase Disassembly, Cleaning and Inspection, and Assembly



1. Tu-Flo 550 Compressor Piston
2. Tu-Flo 750 Compressor Piston

Fig. 2, Piston Comparison

tween the outside diameter of the ball bearing outer race and the inside diameter of the crankcase bore should be 0.0003 inch (0.008 mm) tight to 0.0023 inch (0.058 mm) loose. This is to maintain a correct fit. Replace the compressor if the fit is too loose.

5.3 Check the end cover for cracks and damage. Replace them as necessary.

5.4 Check the cylinder bore with an inside micrometer or with calipers. Cylinder bores which are scored, out-of-round, or tapered more than 0.0005 inch (0.013 mm) should be rebored and honed oversize. Oversized pistons and piston rings are available in 0.010 inch (0.254 mm), 0.020 inch (0.508 mm), and 0.030 inch (0.762 mm) oversize.

6. Inspect the crankshaft.

6.1 Check the crankshaft splines, gear teeth, tapered ends, and all machined and ground surfaces for wear, scoring, or damage. Repair the damage, or replace the crankshaft if needed.

6.2 Check the crankshaft connecting rod journals for extreme scoring, and measure them for out-of-round wear. Standard crankshaft journals are 1.1242 to 1.1250 inches (28.555 to 28.575 mm) in diameter. If the crankshaft is extremely scored or worn out-of-round, and cannot be reground, replace it.

NOTE: If the crankshaft needs to be reground or replaced, do so before proceeding to the next step.

For compressors having reground crankshafts, connecting rod bearing inserts are available in 0.010 inch (0.254 mm), 0.020 inch (0.508 mm), and 0.030 inch (0.762 mm) undersize.

Assembly (See Fig. 1)

1. For compressor with sleeve bearings, install the crankshaft and end cover.

1.1 Press the new sleeve bearings into the end cover and crankcase. Make sure the slot in the bearings line up with the oil passages in the end cover and crankcase.

If there is no oil passage present in the crankcase, press the sleeve bearing into the crankcase with the slot located 90 degrees from vertical.

1.2 Install the new front thrustwasher with the tang inserted in the slot toward the flange.

1.3 Insert the crankshaft and the rear thrustwasher with the tang toward the end cover of the compressor.

1.4 Place the end-cover seal on the boss of the end cover.

1.5 Install the end cover making sure not to pinch the end cover seal and the tang of the rear thrustwasher is inserted in the slot of the end cover. Install the capscrews and tighten the capscrews 15 to 18 lbf·ft (20 to 25 N·m) in a cross pattern.

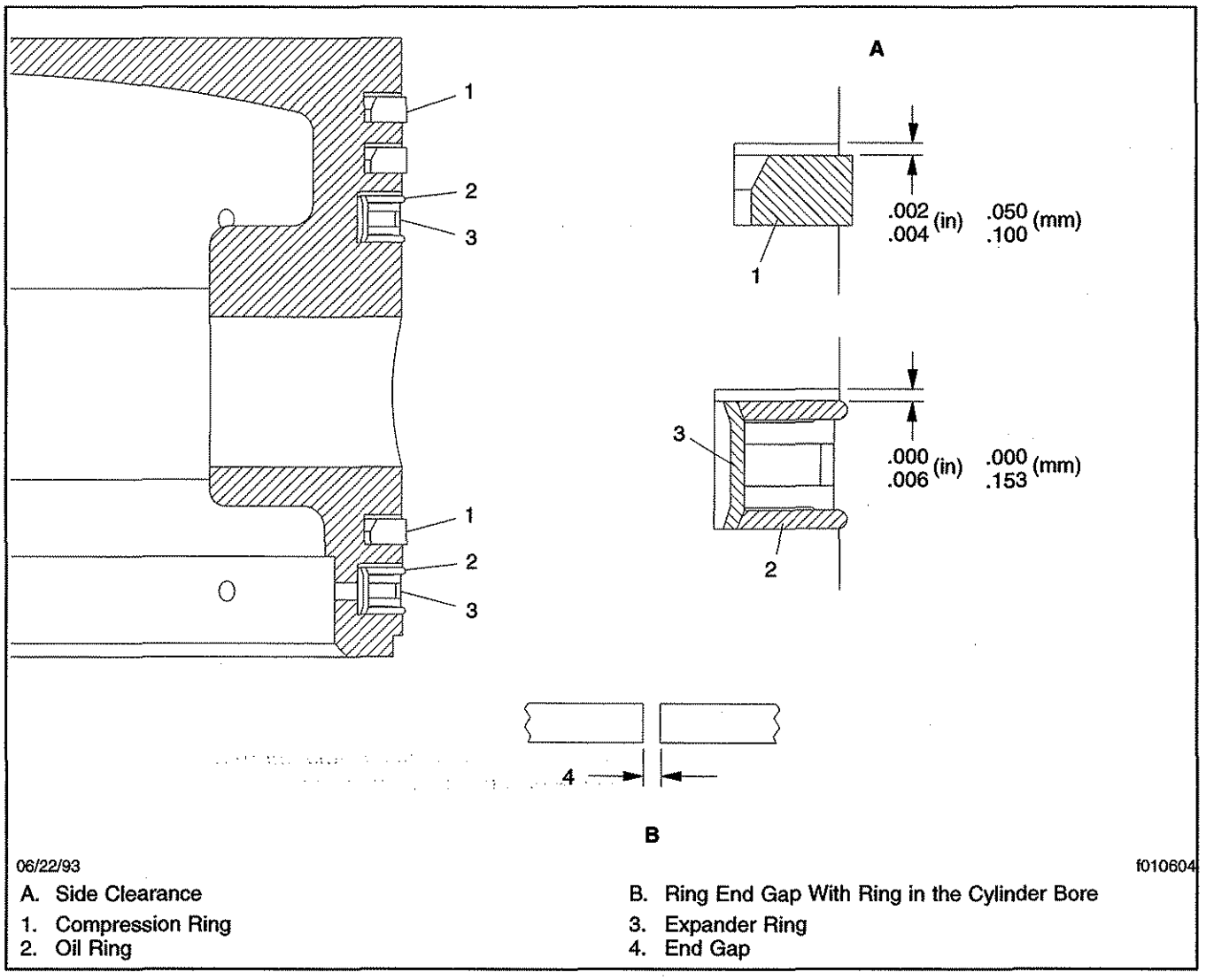
2. If one end of the compressor uses a ball-type main bearing, install the crankshaft and end-covers.

2.1 Press the new sleeve bearings into the crankcase. Make sure the slots in the bearings line up with the oil passage in the end cover and crankcase.

If there is no oil passage present in the crankcase, press the sleeve bearing into the crankcase with the slot located 90 degrees from vertical.

2.2 Install the new front thrustwasher with the tang inserted in the slot toward the flange.

Crankcase Disassembly, Cleaning and Inspection, and Assembly



A. Side Clearance
1. Compression Ring
2. Oil Ring
B. Ring End Gap With Ring in the Cylinder Bore
3. Expander Ring
4. End Gap

Fig. 3, Piston Specifications

2.3 Press the ball bearing onto the correct end of the crankshaft, so that the drive end of the crankshaft will be positioned in the crankcase as marked before disassembly. Using an arbor press, carefully press the ball bearing and the crankshaft into the crankcase. Install the retainer ring if so equipped.

3. Assemble the new piston rings on the new pistons.

IMPORTANT: To properly test a compressor under operating conditions, a test rack is necessary for correct mounting, cooling, lubricating, and driving the compressor.

NOTE: Install the piston rings on the pistons starting at the center of the piston and moving outward. Rotate the piston rings in their respective grooves so that the end gap is at least 90 degrees from the previous ring's end gap.

3.1 Install the expander ring in the piston groove. The ends of the expander ring must butt and must not overlap.

3.2 Install the bottom oil ring by inserting one end below the expander ring in the ring groove, and wind the ring into position. Install the top oil ring in the same manner above the expander ring making sure the gap is staggered from the bottom oil ring and the expander ring.

3.3 Install the compression rings in the correct grooves, with the bevel or "pip" mark (if any) toward the top of the piston.

4. Assemble the new connecting rods on the new pistons.

4.1 Lubricate the wrist pins and the wrist pin bushings in the connecting rods with clean engine oil.

4.2 Position the connecting rods in the pistons and press in the wrist pins. Secure the wrist pins by installing the wrist pin buttons in the ends of the wrist pins.

5. Install the new pistons and new connecting rods.

5.1 Apply clean engine oil to both pistons, the piston rings, the wrist pins, the connecting rod caps and the new connecting rod bearings.

5.2 Turn the crankshaft so its number-one rod journal (the one nearer the drive end) is down and centered.

5.3 Using a piston ring compressor, insert the number-one connecting rod and piston through the top of the number-one cylinder bore.

NOTE: The connecting rods and connecting rod caps are matched sets, therefore the caps must not be switched or rotated end for end.

5.4 Install the connecting rod bearings on the connecting rod and connecting rod cap.

5.5 Tighten the new connecting rod bolts evenly in increments of 11 to 13 lbf·ft (15 to 17 N·m).

5.6 Turn the crankshaft so its number-two connecting rod journal is in the downward, center position.

5.7 Install the number-two connecting rod and piston in the same manner as described above.

6. Before replacing the cylinder head on the crankcase, ensure that the correct pistons have been used by turning the crankshaft one complete revolution such that each piston moves to its maximum upward stroke. At the upward stroke position, each piston should move to the top of the crankcase. If the piston does not approach the top of the crankcase, the piston is incorrect and if not replaced could result in compressor damage.

7. Install the base plate.

7.1 Position the gasket on the crankcase. Install the base plate on the crankcase as marked before disassembly.

7.2 Tighten the six capscrews 15 to 18 lbf·ft (20 to 25 N·m) in a cross pattern.

8. Install the cylinder head on the crankcase. For instructions, refer to **Subject 110.**

9. Install the compressor on the engine. For instructions, refer to **Subject 100.**

10. Operate the engine and check for leaks.

Problem—Excessive Oil Passage

Possible Cause	Remedy
Restricted air intake.	Check engine air filter and replace if necessary. Check compressor air inlet for kinks and excessive bends. Repair as needed.
Restricted oil return line to engine.	Check for excessive bends, kinks, and restrictions in oil return line. Return line must descend from compressor to engine crankcase. Repair as needed.
Damaged oil seal ring or loose end cover.	Inspect oil seal ring for wear or damage. Repair as needed. Check the end cover capscrew torques and tighten as necessary.
Insufficient compressor cooling (compressor runs hot).	Remove grease, grime, or dirt from the cooling fins of the compressor. Check for damaged cooling fins. Replace components found damaged. Check for correct coolant line sizes. Check the coolant flow through the compressor. Minimum allowable flow is 2.5 gallons per minute at maximum engine governed speed, and minimum allowable flow is 0.5 gallons per minute at engine idle. If low, inspect the coolant lines for rust scale, kinks, and restrictions. Repair or replace as necessary.
Compressor runs loaded an excessive amount of time.	Check air lines and connections for leakage. Repair or replace lines and connections until leakage is eliminated.
Back pressure from the engine crankcase.	Check for excessive engine crankcase pressure. Repair or replace ventilation components as necessary. NOTE: An indication of crankcase pressure is a loose or partially lifted dipstick.
Excessive engine oil pressure.	Check the engine oil pressure with a test gauge, and compare the reading to the engine specification. Do not restrict the compressor oil supply line.
Malfunctioning compressor.	Replace or repair the compressor after making certain none of the preceding conditions exist.

Problem—Noisy Compressor Operation

Possible Cause	Remedy
Loose drive coupling or gear (as indicated).	Inspect the fit of the drive coupling and gear on the compressor crankshaft. Tighten or replace the components. If the crankshaft keyway is damaged, replace the compressor.
Compressor cylinder head or discharge line restrictions.	Inspect the compressor discharge port and discharge line for carbon build-up. If carbon is detected, remove the carbon and check for proper coolant flow to the compressor. Inspect the discharge line for kinks and restrictions. Replace the discharge line as necessary.
Air compressor bearing damaged or worn.	Replace the bearings.
Malfunctioning compressor.	Rebuild or replace the compressor after making certain none of the preceding conditions exist.

Troubleshooting

Problem—Excessive Build-Up and Recovery Time

Possible Cause	Remedy
Restricted air intake.	Check engine air filter and replace if necessary. Check compressor air inlet for kinks and excessive bends. Repair as needed.
Restricted discharge or compressor discharge cavity.	Inspect the compressor discharge port and line for restrictions and carbon build-up. If carbon is detected, remove the carbon. Check for proper cooling to the compressor. Inspect the discharge line for kinks and restrictions. Replace the discharge line as necessary.
Slipping drive components.	Check for faulty drive gears and coupling, and replace as necessary.
Excessive air system leakage (not including the air compressor).	Check all valves, air lines, and connections for leakage. Repair or replace valves and lines until leakage is eliminated.
Unloader pistons seized.	Check the operation of the unloading mechanism. Check for corrosion and contamination of unloader pistons. Check for correct operation of the compressor air governor. If the governor is operating properly, repair or replace the unloading mechanism.
Malfunctioning compressor.	Rebuild or replace the compressor after making certain none of the preceding conditions exist.

Problem—Compressor Fails to Unload

Possible Cause	Remedy
Faulty or worn unloader pistons or bores.	Inspect for worn, dirty, or corroded unloader pistons and bores. Replace as necessary.
Malfunctioning governor.	Check the setting with an accurate test gauge. Repair or replace the air governor.
Unloader air lines from governor damaged.	Inspect the air lines to and from the governor for kinks or restrictions. Repair or replace the air lines.

Fastener Torque Values	
Description	**Torque: lbf.ft (N.m)**
Cylinder Head	37–42 (50–57)
Unloader Cover Plate	15–18 (20–25)
Discharge Valve Seat	70–90 (95–122)
Inlet Valve Stop	70–90 (95–122)
End Cover	15–18 (20–25)
Connecting Rod	11–13 (15–17)
Bottom Cover	15–18 (20–25)
Inlet Fitting	15–18 (20–25)
Discharge Fitting	15–18 (20–25)
Governor or Governor Adaptor	15–18 (20–25)

Table 1, Fastener Torque Values

Compressor Specifications	
Description	**inches (mm)**
Discharge Valve Travel (minimum/maximum)	0.030/0.046 (0.762/1.168)
Fit Between Crankcase Bore and Ball-Type Main Bearing (minimum/maximum)	0.0003/0.0023 (0.008/0.058)
Clearance for Crankshaft Main Journals to i.d. of Sleeve-Type Main Bearing (maximum)	0.005 (0.13)
Crankshaft Main Journal Standard Diameter	1.1242–1.1250 (28.555–28.575)
Clearance Between Crankshaft Rod Journals and Connecting Rod Bearing (minimum/maximum)	0.0003/0.0021 (0.008/0.053)
Crankshaft Rod Journal Standard Diameter*	1.1242–1.1250 (28.555–28.575)
Cylinder Bore Out-of-Round (maximum)	0.0005 (0.013)
Cylinder Bore Taper (maximum)	0.0005 (0.013)
Clearance Between Cylinder Bore and Cast Iron Piston (minimum/maximum) †	0.002/0.004 (0.050 /0.101)
Clearance Between Wrist Pins and Connecting Rod Bushings (maximum)	0.0007 (0.0178)
Compression Ring Groove Clearance	0.002–0.004 (0.050–0.101)
Oil and Expander Ring Groove Clearance	0.00–0.006 (0.00–0.152)
Compression Ring Gap (installed in cylinder)	0.002–0.013 (0.050–0.330)
Oil and Expander Ring Gap (installed in cylinder)	0.010–0.040 (0.254–1.016)

* For compressors having reground crankshafts, undersize connecting rod bearing inserts are available in 0.010 inch (0.254 mm), 0.020 inch (0.508 mm), and 0.030 inch (0.762 mm).

† Oversized pistons and piston rings are available in 0.010 inch (0.254 mm), 0.020 inch (0.508 mm), and 0.030 inch (0.762 mm).

Table 2, Compressor Specifications

Contents

Subject	Subject Number
General Description and Principles of Operation	050
Service Operations	
Air Governor Operating and Leakage Tests	100
Air Governor Removal and Installation	110
Air Governor Disassembly, Cleaning and Inspection, and Assembly	120
Air Governor Adjustment	130

General Description

The governor **(Fig. 1)**, operating in conjunction with the compressor unloading mechanism, automatically controls the air pressure in the air brake or air supply system between the desired, predetermined maximum and minimum pressures. Normal air pressure in all Freightliner vehicles is 95 to 125 psi (655 to 862 kPa). The compressor runs continuously while the engine runs, but the actual compression of air is controlled by the governor actuating the compressor unloading mechanism, which stops or starts compression when the maximum or minimum reservoir pressures are reached. The D-2 governor has a piston upon which air pressure acts to overcome the pressure setting spring, and control the inlet and exhaust valve to either admit or exhaust air to or from the compressor unloading mechanism.

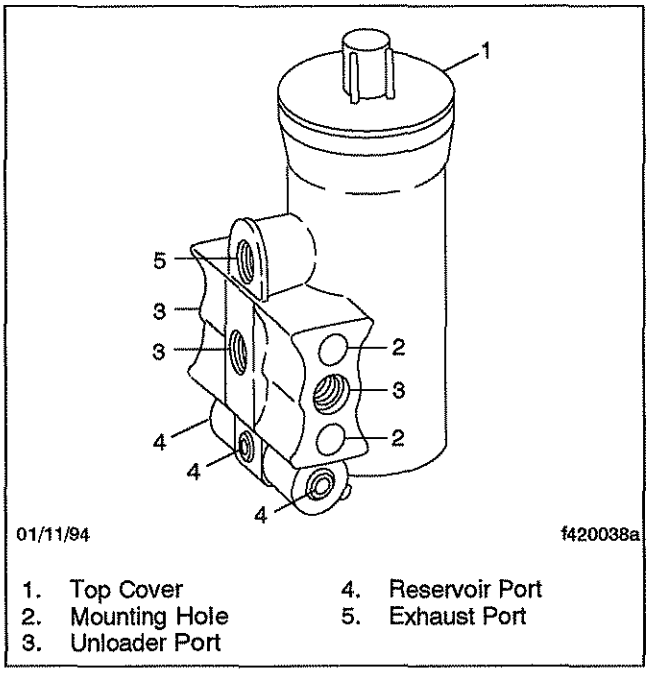
D-2 governors have mounting holes, which allow for direct mounting to the compressor.

Porting consists of 3 reservoir ports (1/8-inch NPT), 3 unloader ports (1/8-inch NPT), and 1 exhaust port (1/8-inch NPT).

Principles of Operation

Pressurized air enters the D-2 governor at one of its reservoir ports, and acts on the area of the piston and beneath the inlet and exhaust valve. **See Fig. 2.** As air pressure builds up, the piston moves against the resistance of the pressure-setting spring. The piston and inlet and exhaust valve move up when the reservoir air pressure reaches the cut-out setting of the governor. The exhaust stem seats on the inlet and exhaust valve, and then the inlet passage opens. Reservoir air then flows by the open inlet valve, through the passage in the piston, and out the unloader port to the compressor unloading mechanism. Air also flows around the piston, and acts upon the additional area of the piston. This added force, which results from a larger area on the piston, ensures a positive action and fully opens the inlet valve.

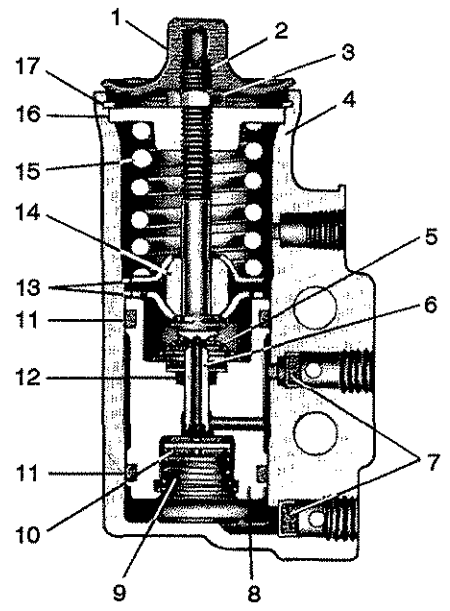
As the system reservoir air pressure drops to the cut-in setting of the governor, the force exerted by the air pressure on the piston will be reduced so that the pressure-setting spring will move the piston down. The inlet valve will close and the exhaust will open. With the exhaust open, the air in the unloader line will escape back through the piston, through the exhaust stem and out the exhaust port.



1. Top Cover
2. Mounting Hole
3. Unloader Port
4. Reservoir Port
5. Exhaust Port

Fig. 1, Governor

General Description and Principles of Operation



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1. Cover
2. Adjusting Screw
3. Adjusting Screw Locknut
4. Body
5. Exhaust Stem Spring
6. Exhaust Stem
7. Filters
8. Piston
9. Inlet and Exhaust Valve Spring
10. Inlet and Exhaust Valve
11. O-Rings
12. Exhaust Stem O-Ring
13. Lower Spring Seats
14. Spring Guide
15. Pressure-Setting Spring
16. Upper Spring Seat
17. Retaining Ring

Fig. 2, Governor, Cross Section View

Air Governor Operating and Leakage Tests

Tests

The following test should be performed whenever the vehicle air pressure is incorrect and the causes are unknown.

If the air governor does not function as described or if leakage is excessive, replace it with a new or remanufactured unit, or repair it using genuine Bendix parts and the instructions in this section.

1. Apply the parking brakes and chock the tires. Tilt the hood or cab. For cab tilting instructions, see **Group 60**.
2. Start the engine and build up air pressure in the air brake system.

IMPORTANT: Make sure the test gauge is registering accurately before using it to check or adjust the air governor.

3. Using a test gauge attached to the supply reservoir, check the pressure at the time the air governor cuts out. For vehicles with a dryer reservoir module (DRM), the cut-out pressure should be 125 to 135 psi (862 to 931 kPa).

   For vehicles without a dryer reservoir module, the cut-out pressure should be 120 to 130 psi (827 to 896 kPa).

4. With the engine still running, make a series of brake applications to reduce the air pressure and observe at what pressure the air governor cuts in the compressor. For vehicles with a dryer reservoir module (DRM), the minimum cut-in pressure should be 105 psi (724 kPa).

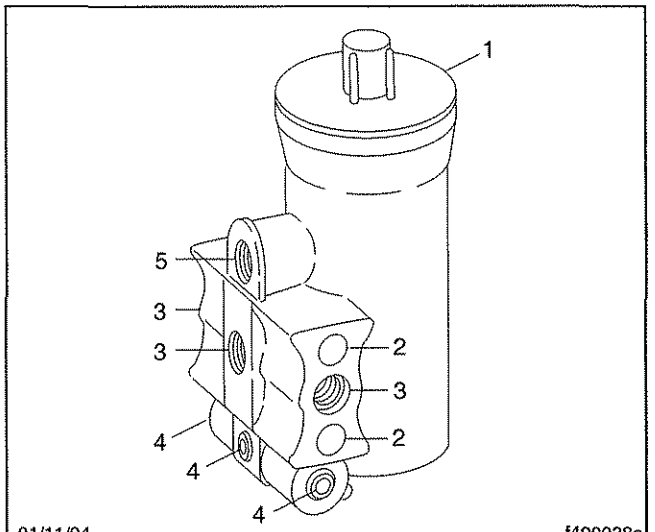
   For vehicles without a dryer reservoir module, the minimum cut-in pressure should be 100 psi (689 kPa).

5. If either the cut-out or cut-in pressures are incorrect, proceed to **Subject 130**.
6. Test the leakage on the air governor in both the cut-in and cut-out positions.

   6.1 With the compressor in the cut-in position, apply a soap solution to the air governor exhaust port. See **Fig. 1**. A slight bubble leakage is permitted. Excessive leakage indicates that the inlet valve or lower piston O-ring is worn out.

   6.2 With the compressor in the cut-out position, apply a soap solution to the air governor exhaust port. See **Fig. 1**. A slight bubble leakage is permitted. Excessive leakage indicates that the exhaust valve seat, stem, O-ring, or upper piston O-ring is worn out.

7. Return the hood or cab to the operating position and remove the chocks from the tires. For cab tilting instructions, see **Group 60**.



1. Top Cover
2. Mounting Hole
3. Unloader Port
4. Reservoir Port
5. Exhaust Port

Fig. 1, Air Governor

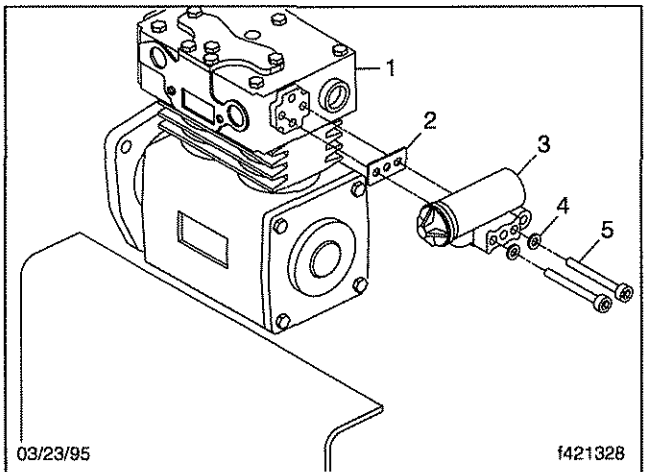
Removal (See Fig. 1)

NOTE: The governor may be mounted on the air compressor, on the air dryer, or remote mounted on the vehicle frame.

1. Chock the tires, and drain the air brake system. Tilt the hood or cab. For cab tilting instructions, see the applicable section in **Group 60** of this manual.
2. Disconnect the reservoir and unloader port air lines. Mark the lines for later reference. Cap the air lines tightly to keep out contaminants.
3. Remove the governor mounting capscrews and lockwashers, and remove the governor.

Installation

1. Clean the mounting pad on both the compressor and the governor block, and be sure the compressor unloading port is clear and clean.
2. Using a new governor mounting gasket, install the governor and its mounting capscrews and lockwashers. Tighten the bolts 11 to 15 lbf·ft (15 to 20 N·m).
3. Clean the connecting lines after removing the caps, and apply Loctite® 242, or equivalent sealant in small quantities, to the reservoir and unloader fittings.



1. Air Compressor
2. Gasket
3. Air Governor
4. Lockwasher
5. Capscrew

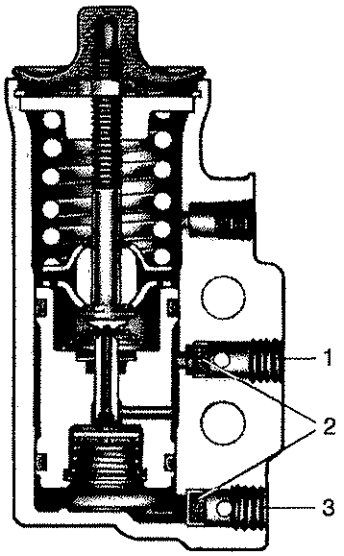
Fig. 1, Governor Mounting (mounting location may change to improve air line routing)

⚠ CAUTION

Make sure excess sealant does not get inside the fittings. Loose material inside the plumbing may clog the governor or other components, causing damage.

4. Connect the reservoir and unloader port air lines as referenced earlier. Tighten the fittings 11 to 13 lbf·ft (15 to 18 N·m).
5. Perform the operating and leakage tests in **Subject 100**.
6. After the tests have been completed and the governor is operating properly, screw the top cover on tightly until it seals the body, preventing the entry of any foreign matter.
7. If necessary, install new filters (**Fig. 2**) in the reservoir and unloader ports. These cup-shaped filters can be installed with the head of a pencil.
8. Return the hood or cab to the operating position, and remove the chocks from the tires. For cab tilting instructions, see the applicable section in **Group 60** of this manual.

Air Governor Removal and Installation



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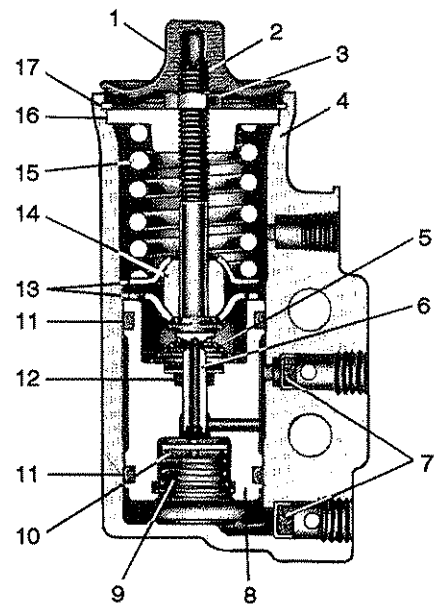
1. Unloader Port
2. Port Filters
3. Reservoir Port

Fig. 2, Filter Installation

Air Governor Disassembly, Cleaning and Inspection, and Assembly

Disassembly (See Fig. 1)

1. Remove the governor from the vehicle, using the instructions in **Subject 110.**
2. Clean the governor exterior of road dirt and grease.
3. Unscrew the top cover (Ref. 1).
4. With a pair of retaining ring pliers, remove the spring assembly retaining ring (Ref. 16).
5. Remove the adjusting screw (Ref. 2) and spring assembly.



1. Cover
2. Adjusting Screw
3. Adjusting Screw Locknut
4. Body
5. Exhaust Stem Spring
6. Exhaust Stem
7. Filters
8. Piston
9. Inlet and Exhaust Valve Spring
10. Inlet and Exhaust Valve
11. O-Rings
12. Exhaust Stem O-Ring
13. Lower Spring Seats
14. Spring Guide
15. Pressure-Setting Spring
16. Upper Spring Seat
17. Retaining Ring

Fig. 1, Governor, Cross Section View

6. Remove the locknut (Ref. 3), then the hex-shaped upper spring seat (Ref. 15) from the adjusting screw.
7. Remove the pressure-setting spring (Ref. 14), lower spring seat (Ref. 12), spring guide (Ref. 13), and the other lower spring seat (Ref. 12) from the adjusting screw.
8. Remove the exhaust stem and its spring from the top of the piston. With the body in the inverted position, tap lightly and remove the piston.
9. Remove the inlet and exhaust valve spring (Ref. 9) and the valve (Ref. 10) from the piston.
10. Remove the two piston O-rings (Ref. 11), and with a hooked wire, remove the exhaust stem O-ring (Ref. 11).
11. Clean or remove the unloader and reservoir port filters (Ref. 7).

Cleaning and Inspection

1. Clean all metal parts in mineral spirits.
2. Wipe all rubber parts dry, using a clean cloth.
3. Inspect the governor body for cracks or other damage. Be particularly careful that all air passages in the body, filters, exhaust stem, and piston are not obstructed.
4. Check the springs for cracks, distortion, or corrosion.
5. Replace all worn or damaged parts.

Assembly (See Fig. 1)

Prior to assembly, lubricate the lower body bore, the top of the piston, the piston grooves, piston O-rings, and the spring guide and adjusting screw with Dow Corning 55-M pneumatic grease, or equivalent.

1. Install the exhaust stem O-ring (Ref. 11) in its groove in the stem bore of the piston.
2. Install the upper and lower piston O-rings (Ref. 11).
3. Drop the inlet and exhaust valve (Ref. 10) into place at the bottom of the piston.

Air Governor Disassembly, Cleaning and Inspection, and Assembly

4. Install the inlet and exhaust valve spring (Ref. 9) with the small end against the valve. Press the spring down until the larger coiled end snaps into the groove inside the piston.
5. Position the exhaust stem spring (Ref. 5) over the exhaust stem. Carefully press the stem into the stem bore of the piston.
6. Install the piston in the body.
7. Install one lower spring seat (Ref. 12), spring guide (Ref. 13), the other lower spring seat (Ref. 12), pressure-setting spring (Ref. 14), and the hex-shaped upper spring seat (Ref. 15) on the adjusting screw, in that order. Screw the upper spring seat (Ref. 15) down until the distance from the top of the seat to the bottom of the stem head is about 1-7/8 inches (48 mm).
8. Install the locknut (Ref. 3).
9. Before placing the adjusting screw and stem assembly in the governor body, check that the exhaust stem (Ref. 6) and its spring are in place in the piston.
10. Install the adjusting screw (Ref. 2) and spring assembly, and the retaining ring (Ref. 16).
11. Install the governor on the vehicle, using the instructions **in Subject 110.**

Adjustment

NOTE: An air governor with a dryer reservoir module (DRM) is not adjustable.

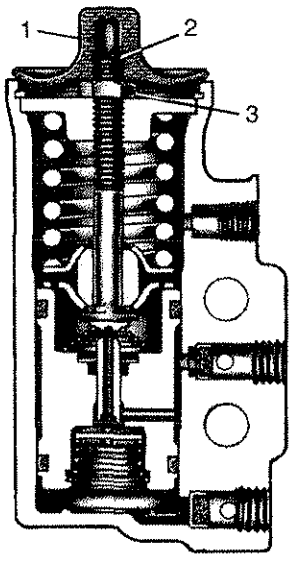
If the pressure settings of the governor are inaccurate or if they need to be changed, proceed as follows:

1. Apply the parking brakes and chock the tires. Open the hood.
2. Remove the top cover from the governor and loosen the adjusting screw locknut. See **Fig. 1.**
3. To raise the pressure settings, turn the adjusting screw counterclockwise. To lower the pressure setting, turn the adjusting screw clockwise.

NOTE: The pressure range between cut in and cut out is not adjustable.

If these adjustments do not correct the pressure settings, repair or replace the governor.

4. Tighten the adjusting screw locknut and install the top cover.
5. Return the hood to the operating position and remove the chocks from the tires.



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1. Top Cover
2. Adjusting Screw
3. Adjusting Screw Locknut

Fig. 1, Air Governor, Cross Section View

Contents

Subject	Subject Number
General Information	050
Service Operations	
Air Compressor Removal and Installation	100
Air Compressor Disassembly, Cleaning, Inspection, Assembly, and Testing	110
Troubleshooting	300
Specifications	400

General Information

The Midland EL–1300 and EL–1600 are two cylinder, reciprocating-type, water-cooled, and pressure lubricated air compressors. They supply compressed air to the vehicle air system. The EL–1300 has a rated displacement of 12.9 cfm (365 L/min) of air at 1250 rpm. The EL–1600 has a rated displacement of 16.1 cfm (456 L/min).

The compressor draws air from the air intake pipe, compresses the air, and delivers it to the air system supply reservoir. The compressor runs continuously while the engine is running, but has "loaded" and "unloaded" modes, which are regulated by the air governor and the compressor loading assembly. When the governor sends an air signal to the unloader assembly, the unloader assembly holds the compressor air intake valve open and no more compressed air is forced into the air system. As air in the system is used, system air pressure drops, and at 90 psi (620 kPa) the air governor stops the signal to the compressor. Without the signal, the unloader assembly automatically closes the compressor air intake valve to force more air into the system.

On vehicles with air dryers, when the system reaches the cut-out pressure of 120 psi (825 kPa), the air governor also sends an air signal to open the sludge ejector in the air dryer.

Air Compressor Removal and Installation

Removal

1. Apply the parking brakes, chock the tires, and tilt the hood.
2. Drain the air system.

⚠ WARNING

Wear goggles when using compressed air to clean or dry parts, as permanent harm to eyes could result from flying debris.

3. Using a cleaning solvent, remove road dirt and grease from the outside of the compressor, then dry the compressor with compressed air.
4. Drain the radiator coolant; see **Group 20** in the vehicle workshop manual for instructions.
5. Loosen the constant-torque hose clamps at both ends of the charge air cooler outlet air piping. Remove the piping to access the air compressor.
6. Marking their locations and positions, disconnect all air, coolant, and oil lines attached to the compressor. Remove tie straps as needed to move the lines out of the way.
7. Remove the air governor, and the governor mounting gasket.
8. On Cummins and Detroit Diesel engines, disconnect the wire to the fuel shutoff valve (if so equipped). Remove the fuel pump and gasket; see the engine shop manual or rebuild manual for instructions.
9. Remove the compressor support bracket, if so equipped.
10. Support the compressor, and remove the bolts that attach it to the auxiliary drive housing, accessory drive, or timing gear plate. Remove the compressor, gasket, and splined coupling, if so equipped.
11. Discard all mounting gaskets.

Installation

IMPORTANT: Be sure the gasket surfaces are cleaned and not damaged.

1. Install the splined coupling (if so equipped) and a new compressor gasket. Hold the compressor in place, and install the bolts that attach it to the auxiliary drive housing, accessory drive, or timing gear plate. See the engine shop manual or rebuild manual for final torque specification.
2. Install the compressor support bracket, if so equipped.
3. On Cummins and Detroit Diesel engines, install a new gasket, install the fuel pump. Connect the wire to the fuel shutoff valve (if so equipped). See the engine shop manual or rebuild manual for instructions.
4. With a new air governor mounting gasket, install the air governor.
5. Identify and connect all air, coolant, and oil lines to the compressor. Secure the lines as needed with tie straps.
6. Install the charge air cooler outlet air piping. Tighten the constant-torque hose clamp screws 45 lbf·in (500 N·cm).
7. Fill the engine cooling system; see **Group 20** in the vehicle workshop manual for instructions.
8. Operate the engine and check for leaks.
9. Remove the chocks from the tires and return the hood to the operating position.

Air Compressor Disassembly, Cleaning, Inspection, Assembly, and Testing

Disassembly (See Fig. 1)

Be sure that required tools are available before beginning the service procedures described here. See the special tools table in **Specifications, 400**. The special tools required for the disassembly and assembly of the air compressor components are available from the Kent-Moore Tool Division, or an affiliated dealer.

1. Chock the front and rear tires.
2. Release the pressure from the air reservoirs.
3. On head-mounted governors, remove the two governor mounting bolts, then remove the governor and the gasket from the head.

   On remote-mounted governors, disconnect both ends of the unloader tube, and remove the tube assembly.
4. Remove the two mounting bolts holding the air cleaner and the manifold to the head. Remove the air cleaner and the manifold as a unit.

NOTE: Some units are equipped with an air hose. In these applications, remove the air hose and then remove the air manifold from the head.

5. Remove the two unloader cover mounting bolts and the cylinder head bolt located through the center of the unloader cover. Remove the unloader cover and pull the unloader pin assemblies from the head.
6. Remove the five remaining head bolts. With a soft hammer, lightly tap the head assembly to loosen the head from the block. Lift the head from the block. Remove the gasket and discard.
7. Place the cylinder head on a table with the valve side up. Using an allen wrench, remove the exhaust valve seats. See **Fig. 2**. Remove the exhaust valve discs, springs and washers.
8. Using Kent-Moore socket J–25447–A, remove the intake valve cages. Remove the intake valve springs, valve discs, valve seats, and washers.
9. Remove the six cylinder block-to-crankcase mounting bolts and washers. Tap the cylinder lightly with a soft hammer to loosen the cylinder block from the crankcase. Remove the cylinder block from the crankcase leaving the pistons attached to the crankshaft. Remove the gasket and discard.
10. Remove the bottom plate on flange-mounted air compressors. Place flange- or base-mounted compressors on their side. Mark the rods and the rod caps to ensure reassembly to the original location. The rod, rod caps, and pistons must be reassembled exactly as they were removed.
11. Turn the crankshaft so that one rod and piston are at the full down stroke. Remove the two rod retaining bolts and remove the rod cap. Push the piston out of the top side of the crankcase. Repeat this step for the other piston.
12. Remove the rings from the pistons. Remove the retaining nylon buttons from the piston pins. Press the piston pin out of the piston and rod assembly.

⚠ CAUTION

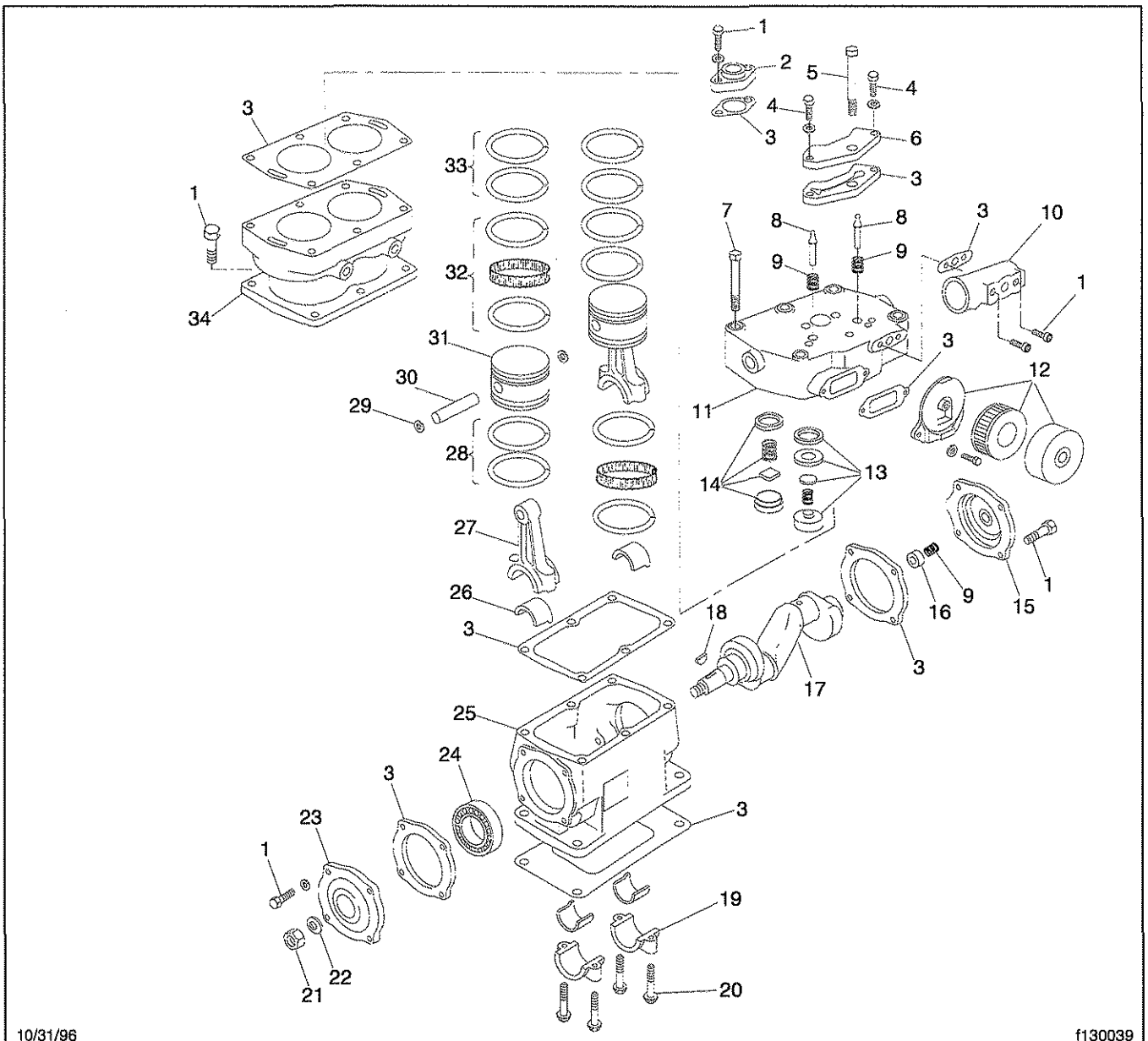
Do not pry the main bearing caps off of the crankcase as damage to the caps may occur.

13. Remove the front and rear main bearing cap retaining bolts. Tap the main bearing caps loose from the crankcase. Remove the main bearing caps and gaskets from the crankcase. Remove and replace the oil seal from the front main bearing cap. If equipped, remove and replace the rear seal and spring.

NOTE: Do not remove the main bearings or the crankshaft unless replacing unsatisfactory parts.

14. On flange-mounted models, remove the drive hub with puller J–24420. Remove the flange mount.
15. On models with a rear ball bearing, place the crankcase assembly in a press supporting the rear bearing bore. Using bearing remover J–5154–B, press until the rear bearing is out of the bore.
16. On a sleeve-type rear bearing, place the crankcase assembly in a press with the front bearing bore supported. Using bearing remover J–5154–B, press until the front bearing is out of the bore.
17. With either the front or rear bearing out of the bore, remove the bearing from the crankshaft with puller J–4558–01 and J–22912–01. Use bearing remover J–5154–B and remove the opposite bear-

Air Compressor Disassembly, Cleaning, Inspection, Assembly, and Testing



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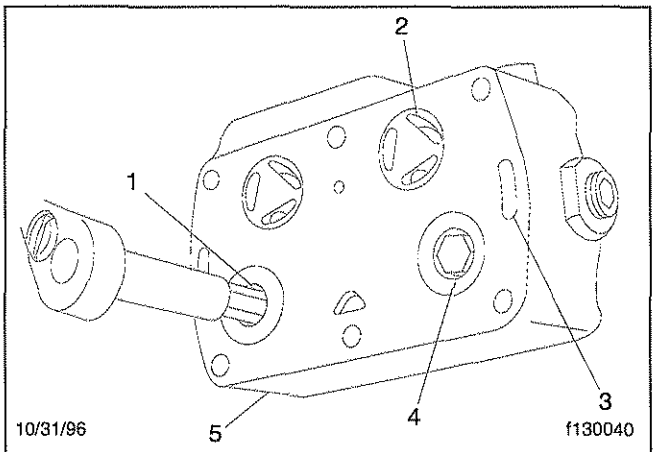
1. Bolt
2. Manifold
3. Gasket
4. Cover Bolt
5. Head Bolt, Long (1)
6. Unloader Cover
7. Head Bolt, Short (5)
8. Unloader Piston (with O-ring)
9. Spring
10. Governor
11. Head Assembly
12. Air Cleaner Assembly
13. Intake Valve Assembly
14. Exhaust Valve Assembly
15. Rear Cover
16. Seal (rear ball-bearing-type)
17. Crankshaft
18. Key
19. Rod Cap
20. Rod Bolt
21. Crankshaft Nut
22. Oil Seal
23. Front Cover
24. Main Bearing
25. Crankcase
26. Rod Bearing
27. Rod
28. Compression Rings
29. Nylon Button
30. Piston Pin
31. Piston
32. Oil Rings
33. Compression Rings
34. Cylinder Block

Fig. 1, Midland Air Compressor, Exploded View

Air Compressor Disassembly, Cleaning, Inspection, Assembly, and Testing



1. Allen Wrench
2. Intake Valve
3. Cooling Port
4. Exhaust Valve Seat
5. Head Assembly

Fig. 2, Intake and Exhaust Valve Removal

ing from the bore. Using puller J–4558–01 and J–22912–01, remove the bearing from the crankshaft.

18. On the crankcase with a notch in the front bearing bore, rotate the crankshaft until the front journal is aligned with the notch, and remove the crankshaft. On the type with no notch, remove the crankshaft through the top of the crankcase.

Cleaning

1. Clean all parts with a cleaning solvent and dry with clean compressed air. Clean all passageways with compressed air to ensure no restrictions are present.

⚠ CAUTION

Make sure not to damage surfaces when cleaning. Surface damage could cause leakage.

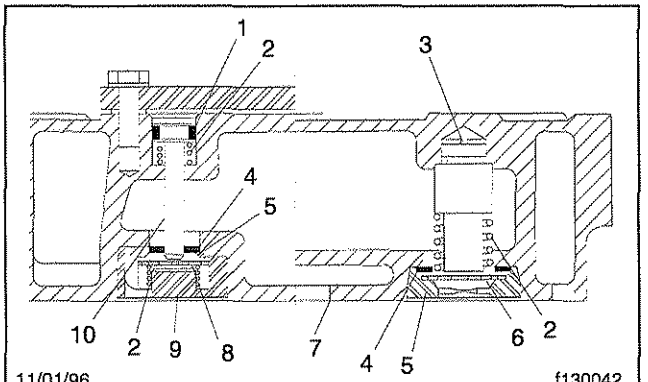
2. Clean and remove all carbon build-up on the cylinder walls and head.
3. Clean the piston ring grooves and pistons.
4. Clean all gasket mating surfaces carefully.

Inspection

NOTE: See the applicable table in **Specifications, 400** for compressor specifications.

Cylinder Head Inspection

1. Check the cylinder head for cracks and damaged threads.
2. Check the valve discs for wear, cracks, pits, or grooves.
3. Check the unloader and valve springs for load at the specified height.
4. Check the exhaust valve guide diameter.
5. Measure the distance from the top of the exhaust valve seat to the valve seating surface. Measure the distance from the end of the exhaust valve stop spring seat surface.
6. Check the intake valve discs and seats.
7. Check the intake valve guide diameter.
8. Measure the distance from the top of the cage to the intake valve stop. Measure the distance from the intake valve seating surface to the valve cage contact surface. See **Fig. 3**.
9. Inspect all valve parts for wear, looseness, or damage. Replace defective parts as necessary.



1. Seal
2. Spring
3. Stop
4. Washer
5. Seat
6. Exhaust Valve Disc
7. Head Assembly
8. Intake Valve Disc
9. Valve Cage
10. Unloader Pin

Fig. 3, Valve Assembly, Cutaway View

Air Compressor Disassembly, Cleaning, Inspection, Assembly, and Testing

10. Replace the head if the exhaust valve stop surface-to-valve spring seating surface measurement is not within specifications.
11. Check the unloader valve bore for wear, scoring, or pitting. Measure the unloader pin length.

Piston and Piston Rod Inspection

1. Check the pistons for wear, scoring, or cracks. Ensure the piston ring groves are not cracked or broken.
2. Measure the piston diameter 90 degrees from the piston pin bore. Measure the cylinder wall bore. Ensure the piston-to-cylinder bore clearance does not exceed 0.008 inch (0.2 mm). Pistons are available in 0.02 inch (0.51 mm) oversize. If the clearance is beyond specifications, the piston must be replaced and the cylinder block must be rebored or replaced.
3. Check the piston pin fit. The pin should have a slip fit in both the piston and the rod. Maximum variation in the piston pin diameter is 0.003 inch (0.076 mm). Replace any part that does not meet specification. The rod and rod cap must be replaced as a unit.
4. Check the rod bearing inserts for scoring, pitting and wear. Ensure that the rod bearing-to-crankshaft clearance is 0.0021–0.0050 inch (0.053–0.127 mm). Replace the rod bearing inserts if they are not within specifications. Bearing inserts are available in 0.10 inch and 0.20 inch (0.25 and 0.51 mm) undersize.
5. Check the connecting rod side clearance between the rod bearing cap and the crankshaft. Clearance must not exceed 0.010 inch (0.25 mm). If not within specification, the rod and rod cap must be replaced as a unit.
6. Place new rings in the cylinder bore and measure the gap between the ring ends. Place the rings in each piston groove and measure the clearance between the ring groove and the ring. If not within specification, replace parts as necessary.

Cylinder Block, Crankcase and Crankshaft Inspection

1. Check the cylinder walls for cracks, scratches, scoring, and pitting.
2. Check the bore for out-of-round and taper. If out-of-round is more than 0.0005 inch (0.013 mm), the cylinder must be honed, rebored, or replaced. If the taper is more than 0.001 inch (0.03 mm), the cylinder must be honed, rebored, or replaced.
3. If the cylinder is within specifications, hone the cylinder walls to ensure a good crosshatch pattern.
4. Check the crankshaft and replace it if it is bent or twisted. If the crankshaft journals are worn or scored beyond repair, replace the crankshaft and the connecting rod as necessary.
5. Check the main bearing outside diameter and the crankcase bearing bore. Main bearings are not available in oversize or undersize. Check for excessive wear of the crankshaft main bearing journals. Replace the bearing or the crankcase as necessary.
6. On models with sleeve-type rear bearings, check the inside diameter of the rear bearing located in the rear cap. If the rear bearing cap assembly is not within specifications, replace it. Check the caps for cracks or excessive wear. Replace if necessary.
7. On models with a rear ball bearing, check the wear of the seal to the crankshaft. If the seal is grooved more than 0.005 inch (0.31 mm), replace it. Measure the outside diameter of the seal ring. Replace if necessary.
8. Some air compressors have bowed washers rather than oil seal springs. Check the washers for wear and replace them if worn.
9. Check the crankcase for cracks and damaged surfaces. Check the studs, if used, and replace them if they are bent or damaged.

Assembly

1. Coat the crankshaft, main bearings, rod bearings, pistons, piston rings, piston pins, and cylinder walls with new engine oil. If the crankshaft was removed, install the crankshaft and the main bearings in the crankcase.
    1.1 If equipped with a crankcase that has a notch in the front bearing bore, rotate the crankshaft until the front journal is aligned with the notch and install the crankshaft.

If equipped with a crankcase that has no notch, install the crankshaft through the top of the crankcase.

1.2 With either the front or the rear bearing out of the bore, install the bearing in the crankshaft with puller J–4558–01 and J–22912–01. Use bearing remover J–5154–B to install the opposite bearing in the bore. Using puller J–4558–01 and J–22912–01, install the bearing in the crankshaft.

1.3 On models with a sleeve-type rear bearing, place the crankcase assembly in a press with the front bearing bore supported. Using bearing remover J–5154–B, press until the front bearing is in the bore.

1.4 On models with a rear ball bearing, place the crankcase assembly in a press supporting the rear bearing bore. Using bearing remover J–5154–B, press until the rear bearing is in the bore.

2. Replace the front main bearing cap seal. Coat the outside diameter of the seal with sealant. With the seal installed in the cap, it should be 0.00–0.005 inch (0.00–0.31 mm) below the front cap surface.

3. Replace the front cap gasket. Coat the front cap seal lip with new oil. Carefully slide the front cap over the crankshaft end. Install the mounting bolts and tighten evenly around the cap 10–14 lbf·ft (14–19 N·m).

4. On models with a sleeve-type rear main bearing cap, coat the bearing with new oil. Replace the gasket and install the rear cap on the crankshaft. Align the rear cap with the crankshaft bearing journal and the crankcase bearing bore. Install the mounting bolts and tighten evenly around the cap 10–14 lbf·ft (14–19 N·m).

5. On models with a rear main ball bearing, install the sealing ring spring or bowed washers in the cap. If bowed washers are used, make sure the outer diameter of the washer contacts the bottom of the rear cap bore. Place the sealing ring in the rear cap and lube with new oil.

6. Replace the gasket and install the rear cap on the crankshaft. Make sure the sealing ring or bowed washers are in the proper position. Install the mounting bolts and tighten them evenly around the cap 10–14 lbf·ft (14–19 N·m). After the front and rear main caps are installed, check the crankshaft to make sure it rotates freely.

7. Install a new gasket on the crankcase and place the cylinder block assembly on the gasket. Make sure the cylinder block is installed in the same position from which it was removed. Install the six mounting bolts and lockwashers. Tighten the two center bolts 8 lbf·ft (11 N·m), then tighten the four other bolts 8 lbf·ft (11 N·m). In the same sequence, tighten the bolts 27–33 lbf·ft (36–45 N·m).

8. Assemble the pistons and rods if disassembled. The piston and rod should move freely and the pin should not protrude from either side of the piston. Install the piston-pin retainer nylon buttons on both ends of the piston pin.

9. Each piston uses seven piston rings. Install two compression rings in the upper piston ring groove and two compression rings in the lower piston ring groove. Install two oil rings and one expansion ring in the middle piston ring groove. The compression rings are to be installed with the marked surface facing upward.

10. Position the piston ring gaps 120 degrees apart. Install the rod bearings on the piston rod assembly and the rod cap. Align the tab on the rod bearing with the notch in the rod and the rod cap. Install the rod and the rod cap in their original position.

11. Coat the rod bearing with new oil and remove the rod cap. Coat the cylinder walls with new oil. Compress the piston rings with a piston ring compressor and push the pistons into the cylinder until they are flush with the top of the cylinder. Rotate the crankcase assembly and install the cap on the rod with the arrows on the rod and cap aligned. Install the rod retaining bolts and tighten to specifications.

12. Repeat the above procedure for the second rod assembly.

13. Replace the gasket, install the bottom plate (if equipped), and tighten 9–13 lbf·ft (12–17 N·m). Rotate the crankshaft after assembly to ensure free movement. Some drag is allowed due to ring pressure on the cylinder walls.

14. Place the head on a table with the valve side up. Install a new washer in all four valve ports. See **Fig. 3**. Install the exhaust valve stop, spring, valve, and valve seat. Tighten the valve seat 70–90 lbf·ft

Air Compressor Disassembly, Cleaning, Inspection, Assembly, and Testing

(95–122 N·m). Repeat for the second exhaust valve assembly.

15. Install the intake valve seat, valve, spring, and cage. The intake valve and valve spring must be centered so that the valve disc is not pinched between the cage and the seat during assembly. Using socket J–25447–A, tighten the intake cage 70–80 lbf·ft (95–108 N·m).
16. Place the head with the valve side down, then install the unloader spring. Replace the O-ring on the unloader pins. Apply Dow-Corning (33) lubricant to the seals forming a 0.563 inch (14.29 mm) diameter ball. Install the unloader pins in the head.
17. Place a new gasket on the unloader cover. Install the unloader cover and gasket over the unloader pins, compressing the pins into the head. Hold the cover in place and install the mounting bolts. Tighten the mounting bolts 10 lbf·in (120 N·cm).
18. Place a new head gasket on the cylinder block surface and place the head assembly on the cylinder block. Install the long head bolt in the center hole of the unloader cover. Install all head bolts and tighten in sequence 18–22 lbf·ft (24–30 N·m). See **Fig. 4**.

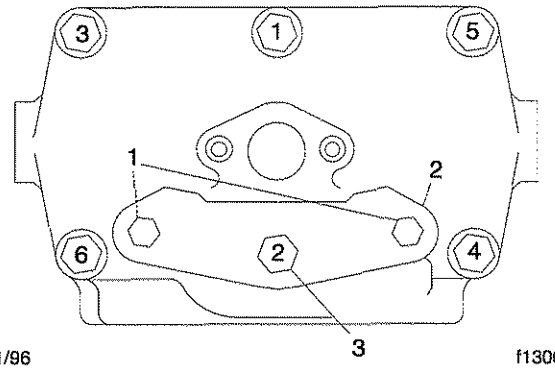
⚠ CAUTION

Do not tighten the unloader cover bolts by mistake or damage will occur.

19. In sequence, tighten the head bolts 27–33 lbf·ft (37–45 N·m). See **Fig. 4**. Tighten the unloader cover bolts 8–11 lbf·ft (11–15 N·m).
20. Install the air cleaner and intake manifold assembly with a new intake gasket. Tighten the mounting bolts. Install the governor on the head with a new gasket and tighten the mounting bolts. On remote-mounted governors, install the unloader line.

Testing

1. If the compressor is belt driven and the pulley was removed or replaced, ensure that the pulley installed is the same diameter as the one removed. Attach an oil supply line with at least 10 psi (69 kPa) to the rear main bearing cap. Oil drainage must be unrestricted.
2. Attach a water supply which provides 1.5 gal/min (5.7 L/min) to the compressor. Attach a 0.625 inch (15.86 mm) inside diameter copper tube to an air tank of known capacity and to the air compressor discharge port. The air tank must have a quick-release valve to exhaust the air pressure. Attach an air line from the air tank to the reservoir port of the governor.
3. Attach the air compressor to a power source with the capability of running the air compressor at 1250 rpm. Run the compressor for five minutes at 1250 rpm, pumping against 100 psi (690 kPa). Check and adjust the governor at this time.
4. Check the air compressor for abnormal noise, oil leakage, air leakage, and overheating. Correct any problems at this time. Drain the air tank to zero pressure and close the quick-release valve.
5. Note the time required to fill the air tank to 100 psi. For the EL–1300, the time must not exceed 30 seconds per 1000 cubic inches of tank volume. For the EL–1600, the time must not exceed 24 seconds per 1000 cubic inches of tank volume. If not within specifications, see **Subject 300** for troubleshooting procedures.



1. Unloader Cover Bolts
2. Unloader Cover
3. Long Head Bolt

Fig. 4, Head Bolt Tightening Sequence

Problem—Excessive Build-Up and Recovery Time

Problem—Excessive Build-Up and Recovery Time	
Possible Cause	**Remedy**
Restricted air intake.	Inspect the engine air filter and replace if necessary. Check the compressor air inlet for kinks and excessive bends. Repair if needed.
Restricted discharge or compressor discharge cavity.	Inspect the compressor discharge port and discharge line for carbon build-up. If carbon is detected, remove the carbon and check for proper coolant flow to the compressor. Inspect the discharge line for kinks and other restrictions. Repair or replace if necessary.
Loose drive coupling.	Inspect the fit of the drive coupling on the compressor crankshaft. Tighten or replace the components if necessary.
Excessive air system leakage (not including air compressor).	Inspect all the valves, air lines and connections for leakage. Repair or replace the valves and lines until the leakage is eliminated.
Malfunctioning unloading mechanism.	Check the operation of the unloading mechanism. Check for corrosion and contamination of the unloader pistons. Check for correct operation of the compressor governor. If the governor is operating properly, repair or replace the unloading mechanism.
Malfunctioning air pressure gauge.	Check the operation of the air pressure gauge. Replace if necessary.
Malfunctioning compressor.	Rebuild or replace the compressor after making certain that none of the preceding conditions exist.

Problem—Noisy Compressor Operation

Problem—Noisy Compressor Operation	
Possible Cause	**Remedy**
Loose drive coupling.	Inspect the fit of the drive coupling on the compressor crankshaft. Tighten or replace the components if necessary.
Compressor cylinder head or discharge lines.	Inspect the compressor discharge port and discharge line for carbon build-up. If carbon is detected, remove the carbon and check for proper coolant flow to the compressor. Inspect the discharge line for kinks and other restrictions. Repair or replace if necessary.
Damaged or worn bearings.	Replace the bearings.
Insufficient lubrication.	Inspect the oil lines for kinks or restrictions.
Malfunctioning compressor.	Rebuild or replace the compressor after making certain that none of the preceding conditions exist.

Problem—Compressor Fails to Unload

Problem—Compressor Fails to Unload	
Possible Cause	**Remedy**
Faulty or worn unloader pistons.	Inspect for worn, dirty, or corroded unloader pistons. Replace if necessary.
Malfunctioning governor.	Check the cut-in and cut-out pressures with an accurate test gauge. Repair or replace the governor if necessary.

Troubleshooting

Problem—Compressor Fails to Unload	
Possible Cause	**Remedy**
Restricted unloader air lines.	Inspect the air lines to and from the governor for kinks and restrictions. Repair or replace the air lines if necessary.
Defective air pressure gauge.	Check the operation of the air pressure gauge. Replace if necessary.

Problem—Excessive Oil Passage

Problem—Excessive Oil Passage	
Possible Cause	**Remedy**
Restricted air intake.	Inspect the engine air filter and replace if necessary. Check the compressor air inlet for kinks and excessive bends. Repair if needed.
Restricted oil return line to engine.	Check for excessive bends, kinks, and restrictions in the oil return line. The return line must be routed down from the compressor to the engine crankcase. Repair if needed.
Excessive engine oil pressure.	Check the engine oil pressure with a test gauge and compare the reading to the engine specification.
Damaged oil seal ring or loose end cover.	Inspect the oil seal ring for wear or damage. Repair as needed. Check the end cover capscrew torques and tighten if necessary.
Malfunctioning compressor.	Rebuild or replace the compressor after making certain that none of the preceding conditions exist.

Fastener Torque Values	
Description	**Torque lbf.ft (N.m)**
Air Cleaner Bolts, Head-Mounted	9–13 (12–17)
Connecting Rod Cap Bolts, 1/4-inch, 12 point	9–11 (12–15)
Connecting Rod Cap Bolts, 5/16-inch, 12 point	16–19 (21–25)
Crankcase Bottom Plate Bolts	9–13 (12–17)
Cylinder Block-to-Crankcase Bolts, First Step	8 (11)
Cylinder Block-to-Crankcase Bolts, Second Step	27–33 (37–45)
Cylinder Head Bolts, First Step	18–22 (24–30)
Cylinder Head Bolts, Second Step	27–33 (37–45)
Exhaust Valve Seats	70–90 (95–122)
Front Bearing Cap Bolts	10–14 (14–19)
Governor Bolts, Head-Mounted	9–13 (12–17)
Intake Valve Cages	70–80 (95–108)
Rear Bearing Cap Bolts	10–14 (14–19)
Unloader Cover Bolts	8–13 (15–17)

Table 1, Fastener Torque Values

Compressor Specifications	
Description	**inches (mm)**
Bearing Cap Seal Diameter	0.635–0.636 (16.13–16.15)
Crankcase Main Bearing Bore Diameter	2.8344–2.8350 (71.993–72.009) 3.5432–3.5440 (89.997–90.018)
Cylinder Bore	2.7495–2.7500 (69.837–69.850)
Main Bearing Diameter	1.3797–1.3812 (35.044–35.082)
Main Bearing (sleeve-type)	2.1699–2.1709 (55.115–55.141)
Oil Seal Ring Outside Diameter (in rear bearing cap, with ball-type rear bearing only)	0.632–0.633 (16.05–16.08)
Piston Diameter (near middle of piston body)	2.7455–2.7475 (69.74–69.79)
Piston Pin Outside Diameter	0.5618–0.5620 (14.270–14.275)
Piston Pin Bore Diameter, In Piston	0.5615–0.5618 (14.262–14.270)
Piston Pin Bore Diameter, In Connecting Rod	0.5622–0.5624 (14.280–14.285)
Piston Compression Rings End Gap	0.007–0.017 (0.178–0.432)
Piston Oil Control Rings End Gap	0.010–0.040 (0.254–1.016)
Piston Compression Rings Side Clearance	0.0005–0.0029 (0.013–0.074)
Piston Oil Control Rings Side Clearance	0.0005–0.0065 (0.013–0.165)
Unloader Pin Length	1.850–1.854 (46.99–47.09)
Crankshaft Dimensions	

Specifications

Compressor Specifications	
Description	**inches (mm)**
Main Bearing Journal Diameter	1.3779–1.3784 (34.999–34.011)
Rod Bearing Journal Diameter	1.1850–1.1855 (30.099–30.112)
Rod Bearing Journal Width	1.2650–1.3670 (32.131–34.722)
Crankshaft Main Bearing Dimensions	
O.D.	2.8341–2.8346 (71.986–71.999)
I.D.	1.3775–1.3780 (34.989–35.001)
O.D.	3.5427–3.5433 (89.985–90.000)
I.D.	2.1648–2.1654 (54.986–55.001)
Valve Dimensions	
Cylinder Head, Distance From End of Exhaust Valve Stop to Spring Seat Surface	0.72–0.74 (18.3–18.8)
Exhaust Valve Seat, Guide Diameter	1.145–1.151 (29.08–29.24)
Exhaust Valve Seat, Distance From Valve Seating Surface to Top of Valve Seat	0.125–0.128 (3.18–3.25)
Intake Valve Cage, Guide Diameter	0.916–0.920 (23.27–23.37)
Intake Valve Cage, Distance From End of Valve Stop to Top of Cage	0.131–0.137 (3.33–3.48)
Intake Valve Seat, Distance From Valve Seating Surface to Surface that Contacts Valve Cage	0.0235–0.0265 (0.597–0.673)
Springs	**lbs@in (kg@mm)**
Exhaust Valve	3.30–3.70@0.73 (1.50–1.68@18.5)
Intake Valve	0.36–0.62@0.287 (0.16–0.28@7.290)
Unloader	3.38–4.18@0.395 (1.5–1.9@10.03)

Table 2, Compressor Specifications

Kent-Moore Part Number	Tool
J–5154–B	Bearing Remover
J–4558–01	Puller
J–22912–01	Puller
J–24420	Puller
J–25447–A	Socket

Table 3, Kent-Moore Tools, Kent-Moore Tool Division, 29784 Little Mack, Roseville, MI 48066

Contents

Subject	Subject Number
General Information	050
Service Operations	
Air Compressor Removal and Installation	100
Cylinder Head Replacement	110
Troubleshooting	300

General Information

The Cummins 18.7 cfm compressor is used on the ISM and N14 engine. This compressor is a single cylinder engine-driven, piston-type compressor that supplies compressed air to operate air powered actuators on the vehicle. The compressor is geared directly to the engine which serves to operate the compressor and any accessory that is connected on the rear flange. The compressor will deliver air out of the exhaust port when the unloader port is at atmospheric pressure and will stop air delivery when the unloader port is pressurized to the system pressure between 100 to 125 psi (689 to 862 kPa). A governor determines the "cut-in" (start of pumping) and "cut-out" (termination of pumping) of the compressor by supplying the proper control signal to the unloader port. The governor is sensing the pressure in the air supply tank or "wet tank." If the output air pressure is inadvertently blocked or required to exceed 250 psi (1724 kPa), the compressor will stop air delivery. The air will be recycled within the compressor and no mechanical harm will be done.

Air Compressor Removal and Installation

Removal

1. Park the vehicle on a level surface and apply the parking brakes. Shut down the engine. Chock the rear tires.

⚠ DANGER

Before tilting the cab or returning the cab to the normal operating position. Read the instructions and hazard notices in Section 60.15, Subject 060 of this workshop manual. Failure to follow these instructions could cause the cab to fall and hit or crush a person, which will result in severe injury or death.

2. Tilt the hood or cab.
3. Drain the air reservoirs.

⚠ WARNING

Wear goggles when using compressed air to clean or dry parts, as permanent harm to eyes could result from flying debris.

4. Using a cleaning solvent, remove road dirt and grease from the outside of the air compressor, then dry the air compressor with compressed air.
5. Drain the radiator coolant below the level of the air compressor. See **Group 20** for instructions.
6. On Century Class conventionals, loosen the constant-torque hose clamps at both ends of the charge air cooler outlet air piping. Remove the piping to access the air compressor.
7. Marking their locations and positions, disconnect all air, coolant, and oil lines attached to the air compressor and governor. Remove the cushion clamps and tie straps as needed to move the lines out of the way. See **Fig. 1** and **Fig. 2**.
8. Disconnect the wire to the fuel shutoff valve (if equipped). Remove the fuel pump and gasket; refer to the engine shop manual or rebuild manual for instructions.
9. Remove the air compressor.
   - 9.1 Remove the air governor and mounting gasket from the compressor.
   - 9.2 Remove the compressor rear support bracket, if equipped.

   Note: On Argosy COE vehicles, the compressor is mounted on an alignment stud. The stud is at the top of the compressor mounting and allows the compressor to hang in place as you're removing or installing it. The stud is threaded and a nut is installed to secure the compressor.
   - 9.3 Support the air compressor, and remove the bolts that attach it to the auxiliary drive housing, accessory drive, or timing gear plate. Remove the compressor, gasket and splined coupling.
   - 9.4 Lift or lower the air compressor out of the engine compartment.
   - 9.5 Remove and discard the air compressor mounting gasket, and clean the mating surfaces.

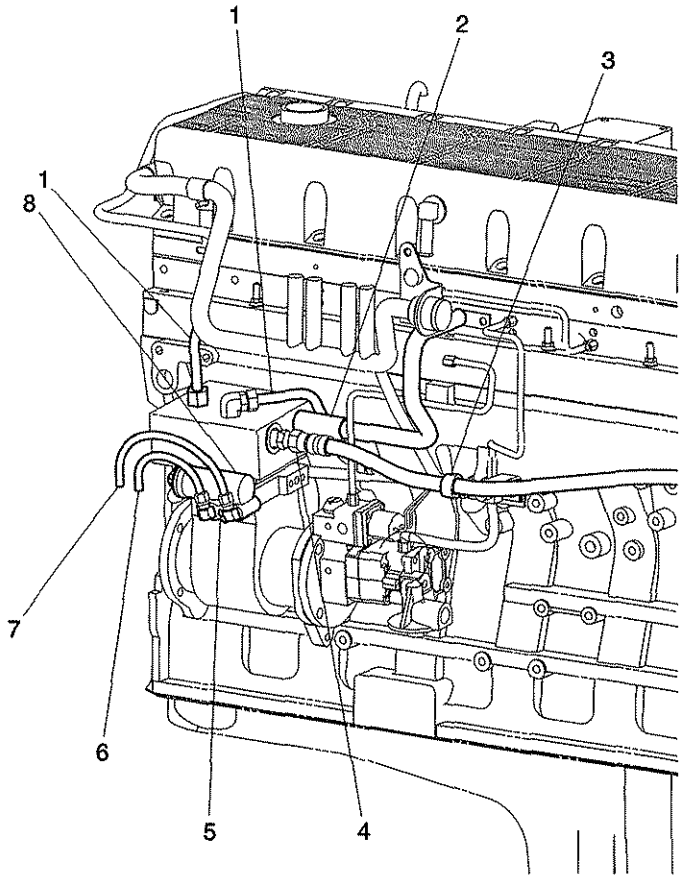
Installation

IMPORTANT: Be sure the gasket surfaces are cleaned and not damaged.

1. Install the air compressor.

   Note: On Argosy COE vehicles, the compressor is mounted on an alignment stud. The stud is at the top of the compressor mounting and allows the compressor to hang in place as you're removing or installing it. The stud is threaded and a nut is installed to secure the compressor.
   - 1.1 Install the splined coupling (if equipped) and a new compressor gasket. Hold the compressor in place, and install the bolts that attach it to the auxiliary drive housing, accessory drive, or timing gear plate. Refer to the engine shop manual or rebuild manual for final torque specification.
   - 1.2 Install the compressor support bracket If equipped.
   - 1.3 Using a new air governor mounting gasket, install the air governor on the compressor.
2. Using a new gasket install the fuel pump on the air compressor. Connect the wire to the fuel shutoff valve (if equipped). Refer to the engine

Air Compressor Removal and Installation



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1. Coolant Line
2. Compressor Air Inlet
3. Cushion Clamp
4. Compressor Air Outlet
5. Air Governor Mounting Bolt
6. Line to Air Dryer
7. Line to Wet Tank
8. Air Governor

Fig. 1, Air Compressor Removal, ISM

shop manual or rebuild manual for final torque specification.

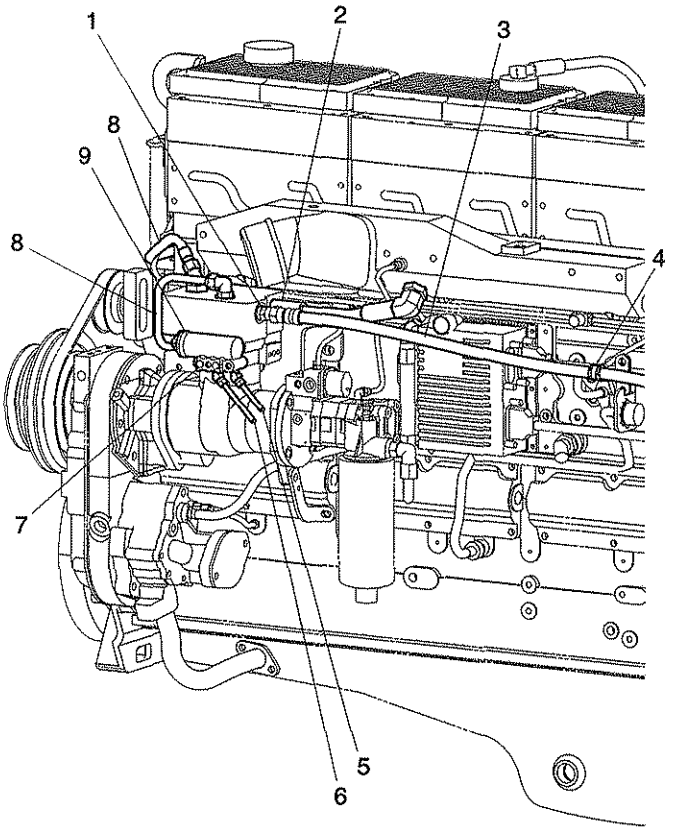
3. Identify and connect all air, coolant, and oil lines to the compressor and governor. Secure the lines as needed with cushion clamps and tie straps.
4. On Century Class conventionals, install the charge air cooler outlet air piping. Tighten the constant-torque hose clamp screws 45 lbf·in (500 N·cm).
5. Fill the engine cooling system. See **Group 20** for instructions.
6. Operate the engine and check for leaks.
7. Remove the chocks from the rear tires.

⚠ DANGER

Before tilting the cab or returning the cab to the normal operating position. Read the instructions and hazard notices in Section 60.15, Subject 060 of this workshop manual. Failure to follow these instructions could cause the cab to fall and hit or crush a person, which will result in severe injury or death.

8. Return the hood or cab to the operating position.

Air Compressor Removal and Installation



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1. Compressor Air Outlet Fitting
2. Compressor Air Inlet Hose
3. Compressor Air Outlet Hose
4. Cushion Clamp
5. Line to Wet Tank
6. Line to Air Dryer
7. Air Governor Mounting Bolt
8. Coolant Line
9. Air Governor

Fig. 2, Air Compressor Removal, N14

Cylinder Head Replacement

Replacement

1. Park the vehicle on a level surface and apply the parking brake. Shut down the engine. Chock the rear tires.
2. Drain the air from all air reservoirs.
3. Remove the compressor from the vehicle. See **Subject 100** for instructions.
4. Mount the compressor on a suitable holding fixture.

⚠ WARNING

Wear goggles when using compressed air to clean or dry parts, as permanent harm to eyes could result from flying debris.

5. Using a cleaning solvent, remove road dirt and grease from the outside of the compressor, then dry the compressor with compressed air.
6. Remove the cylinder head assembly, from the crankcase.

   6.1 Scribe an alignment mark across the cylinder head and the crankcase, for assembly alignment.

   IMPORTANT: Do not use a marking method, such as chalk, that can be wiped off during assembling.

   NOTE: There is no need to remove the smaller screws.

   6.2 Note the positions of any attached components, then remove the four M8 cylinder head capscrews. Discard the capscrews. See **Fig. 1.**

   6.3 Tap the cylinder head with a soft mallet to break the gasket seal. Remove the cylinder head assembly and discard the gasket. See **Fig. 2.** Note the position of the ports with respect to the crankcase for reassembly.

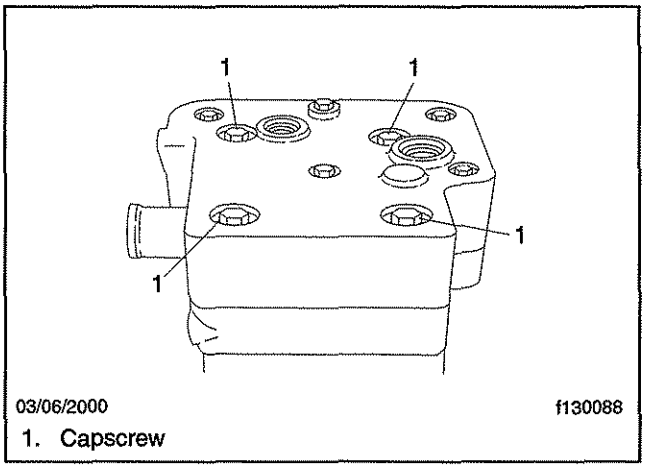
   6.4 Remove the coolant and air fittings for reuse. Discard the original cylinder head.

7. Clean the crankcase.

   7.1 Rotate the crankshaft until the piston is at the top of the cylinder bore.

   NOTE: Avoid the use of abrasive products similar to Scotch Brite® because of damage and abrasive grit left behind.

   7.2 Remove any accumulated carbon and varnish by carefully scraping and light application of solvents. Avoid getting debris and solvents into the clearance between the piston and bore. Avoid the use of abrasive products similar to Scotch Brite because of damage and abrasive grit left behind.



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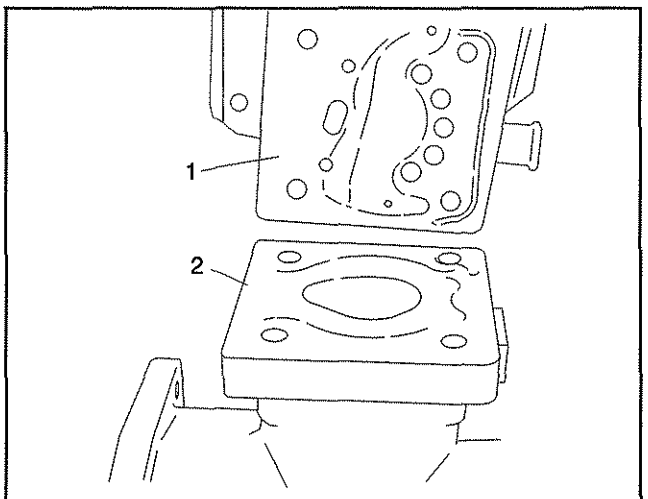
1. Capscrew

Fig. 1, Cylinder Head Capscrews



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1. Cylinder Head Assembly
2. Upper Crankcase

Fig. 2, Cylinder Head Removal

Cylinder Head Replacement

⚠ WARNING

Wear goggles when using compressed air to clean or dry parts, as permanent harm to eyes could result from flying debris.

7.3 Using compressed air, blow dirt particles or gasket material from all cylinder cavities.

8. Inspect the top crankcase surface. It should be smooth and free of scratches to enable resealing on assembly.
9. Transfer the alignment marks from the original cylinder head to the replacement cylinder head.
10. Install the coolant and air fittings on the replacement cylinder head.
11. Install the cylinder head on the compressor crankcase.

11.1 Position the sliding valve and the guide pins in the correct direction to enter the larger diameters in the valve body and crankcase.

11.2 Align the marks on the cylinder head and crankcase.

11.3 Using a new cylinder head gasket, position the gasket and head assembly on the crankcase.

Note: You should find five cover bolts loosely holding the head assembly together.

11.4 Install new capscrews.

⚠ CAUTION

A torque angle gauge and inch pound torque wrench must be used to perform the torque-turn capscrew tightening sequence. The tightening sequence in Table 1 must be followed to prevent damage to the cylinder head assembly.

11.5 Tighten the capscrews using the bolt tightening sequence in **Table 1**.

12. Install the compressor. See **Subject 100** for instructions.
13. Fill the engine cooling system. See **Group 20** for instructions.

Bolt Tightening Sequence			
Step	**Bolt**	**Torque: lbf.in (N.cm)**	**Rotation Degrees**
1	A	177 to 221 (2000 to 2500)	—
2	B	177 to 221 (2000 to 2500)	—
3	C	177 to 221 (2000 to 2500)	—
4	D	177 to 221 (2000 to 2500)	—
5	A	—	85 to 105
6	B	—	85 to 105
7	C	—	85 to 105
8	D	—	55 to 75
9	E	48 to 58 (540 to 660)	—
10	F	48 to 58 (540 to 660)	—
11	G	48 to 58 (540 to 660)	—
12	H	48 to 58 (540 to 660)	—
13	I	48 to 58 (540 to 660)	—
14	E	—	85 to 105
15	F	—	85 to 105
16	G	—	85 to 105
17	H	—	85 to 105
18	I	—	85 to 105

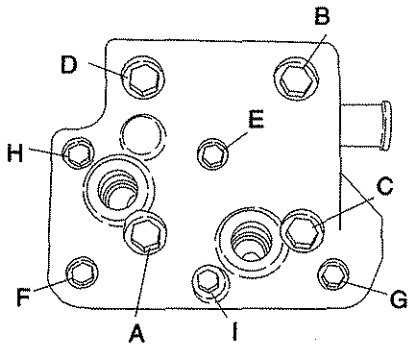


Table 1, Bolt Tightening Sequence

14. Operate the engine and check the compressor operation. Make sure there are no coolant or air leaks.
15. Remove the chocks from the rear tires.

Troubleshooting Tables

Problem—Excessive Oil Passage

Problem—Excessive Oil Passage	
Possible Cause	**Remedy**
Restricted air intake.	Check engine air filter and replace if necessary. Check compressor air inlet for kinks and excessive bends. Repair as needed.
Restricted oil return hole in front of compressor.	Remove compressor and check the oil return hole for restrictions. Repair as needed.
Defective or worn seal in the rear bearing cap.	Replace seal.
Compressor runs loaded an excessive amount of time.	Check air lines and connections for leakage. Check for a defective governor or restricted line. Replace the governor if necessary. Repair or replace lines and connections until leakage is eliminated.
Back pressure from the engine crankcase.	Check for excessive engine crankcase pressure. Repair or replace ventilation components as necessary. NOTE: An indication of crankcase pressure is a loose or partially lifted dipstick.
Excessive engine oil pressure.	Check the engine oil pressure with a test gauge, and compare the reading to the engine specification. Do not restrict the compressor oil supply line.
Malfunctioning compressor.	Replace the compressor after making certain none of the preceding conditions exist.

Problem—Noisy Compressor Operation

Problem—Noisy Compressor Operation	
Possible Cause	**Remedy**
Loose drive coupling or gear (as indicated).	Inspect the fit of the drive coupling and gear on the compressor crankshaft. Tighten or replace the components. If the crankshaft keyway is damaged, replace the compressor.
Compressor cylinder head or discharge line restrictions.	Inspect the compressor discharge port and discharge line for carbon build-up. If carbon is detected, remove the carbon and check for proper coolant flow to the compressor. Inspect the discharge line for kinks and restrictions. Replace the discharge line as necessary.
Compressor internal engine components damaged or worn.	Replace the compressor.

Problem—Excessive Build-Up and Recovery Time

Problem—Excessive Build-Up and Recovery Time	
Possible Cause	**Remedy**
Restricted air intake.	Check engine air filter and replace if necessary. Check compressor air inlet for kinks and excessive bends. Repair as needed.
Restricted discharge or compressor discharge cavity.	Inspect the compressor discharge port and line for restrictions and carbon build-up. If carbon is detected, remove the carbon. Check for proper cooling to the compressor. Inspect the discharge line for kinks and restrictions. Replace the discharge line as necessary.
Slipping drive components.	Check for faulty drive gears and coupling, and replace as necessary.

Troubleshooting

Problem—Excessive Build-Up and Recovery Time	
Possible Cause	**Remedy**
Excessive air system leakage (not including the air compressor).	Check all valves, air lines, and connections for leakage. Repair or replace valves and lines until leakage is eliminated.
Unloader piston seized.	Check the operation of the unloading mechanism. Check for corrosion and contamination of unloader pistons. Check for correct operation of the compressor air governor. If the governor is operating properly, replace the compressor.
Damaged compressor rings, valves, and gaskets.	Replace the compressor.

Problem—Compressor Fails to Unload

Problem—Compressor Fails to Unload	
Possible Cause	**Remedy**
Malfunctioning governor.	Check the setting with an accurate test gauge. Repair or replace the air governor.
Unloader air lines from governor damaged.	Inspect the air lines to and from the governor for kinks or restrictions. Repair or replace the air lines.
Faulty or worn unloader piston or bore.	Replace the compressor.

Problem—Air in Water System/Water in Air System

Problem—Air in Water System/Water in Air System	
Possible Cause	**Remedy**
Internal gasket leakage.	Replace the compressor.
Internal casting porosity.	Replace the compressor.

Group Index, Alphabetical

Section	Section Number
Alternator, Delco Remy 26–SI	15.03
Alternators, Delco Remy 30–SI, 33-SI, and 34–SI	15.02
Alternators, Leece-Neville	15.01
Starter, Mitsubishi	15.04
Starters, Delco Remy	15.00

Starters, Delco Remy 15.00

Contents

Subject	Subject Number
General Information and Principles of Operation	050
Service Operations	
Starter Removal and Installation	100
Ignition Keyswitch Removal and Installation	110
Troubleshooting	300
Specifications	400

General Information and Principles of Operation

The Delco Remy starter (**see Fig. 1**) is located at the forward face of the flywheel bell housing on the left-hand side of the vehicle.

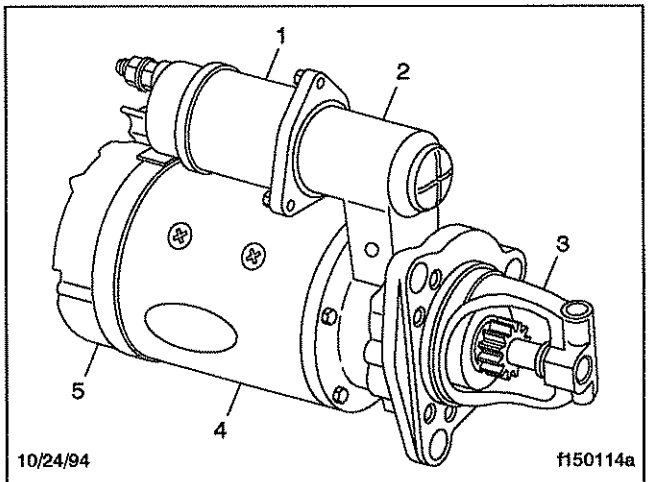
NOTE: On vehicles with the Detroit Diesel Series 55 engine, the starter is installed on the right-hand side.

The starter has a shift lever and solenoid plunger that are totally enclosed to protect them from exposure to dirt, icing conditions, and splash. The starter is equipped with a drive, solenoid, and brush rigging with one-piece brushes. The commutator end cap can be removed to inspect the brushes.

Lubrication is provided in the sintered bronze bushings by an oil-saturated wick. Oil can be added to each wick by removing an oil reservoir cup, which is accessible on the outside of the motor.

The solenoid engages the pinion with the ring gear and the pinion remains engaged until the solenoid circuit is interrupted. In case of a butt engagement, the pinion mechanism will rotate the pinion gear, clearing the butt engagement, engaging the ring gear, and causing the engine to crank.

Under normal operating conditions, no maintenance will be required between engine overhaul periods. At the time of engine overhaul, replace the starter with a remanufactured starter.



1. Solenoid
2. Lever Housing
3. Nose Housing
4. Field Frame
5. End Cap

Fig. 1, 42-MT Starter Cranking Motor and Solenoid

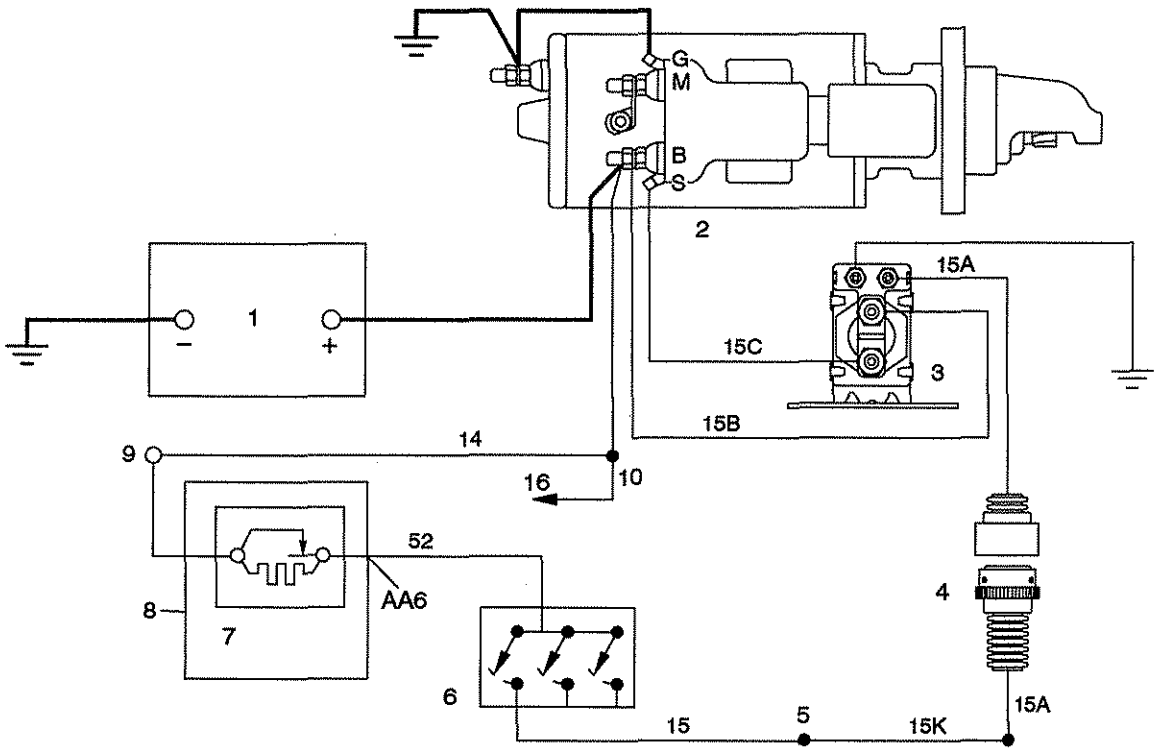
For the basic cranking circuit wiring, **see Fig. 2.**

Turning the ignition keyswitch to "Start" closes the magnetic switch contacts, connecting the battery to the solenoid. As a result, the plunger and the shift lever move, causing the pinion to engage the engine flywheel ring gear, closing the solenoid main contacts, and cranking the engine. When the engine starts, the pinion overruns, protecting the armature from excessive speed. When the ignition keyswitch is returned to the normal "Run" position, the pinion disengages.

To prevent overrun and damage to the drive and armature windings, release the ignition keyswitch from "Start" as soon as the engine starts. Never crank the motor longer than 30 seconds. Stop and allow the motor to cool for at least two minutes before cranking again.

The 42-MT starter is equipped with a thermal overcrank protection circuit. If overcranking should occur, a thermostat opens and stops the cranking cycle, protecting the cranking motor. After the motor cools, usually in 1 to 6 minutes, the thermostat will close and then a new start attempt can be made.

General Information and Principles of Operation



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NOTE: Wire 16 connects to the alternator.

1. Battery
2. Cranking Motor (top view)
3. Magnetic Switch
4. Firewall Connector (pin E1)
5. Splice Connector
6. Ignition Switch
7. 10-Amp Circuit Breaker
8. Cab/Firewall Power Stud
9. Engine Power Stud

Fig. 2, Cranking Circuit Wiring

Starter Removal and Installation

Removal

Before removing the starter from the vehicle for repair, perform the checks in **Troubleshooting 300.**

1. Turn off all electrical loads such as lights, ignition, and accessories.
2. Disconnect the batteries.
3. Tilt the hood or cab. For cab tilting instructions, refer to **Group 60** in this manual.
4. Disconnect the electrical leads attached to the starter. Mark the terminals and wires for ease of installation.

NOTE: It may be difficult to gain access to the starter mounting bolts. For ease of removal, straddle the front axle with arms extended around the leaf springs and use a long socket extender or breaker bar.

5. Remove the mounting bolts and lockwashers (**Fig. 1**) that attach the starter to the engine. Remove the starter.

Installation

1. Insert the starter nose housing through the mounting hole in the flywheel housing.
2. Install the three starter mounting bolts and lockwashers. Refer to the fastener and torque values table in **Specifications 400.**

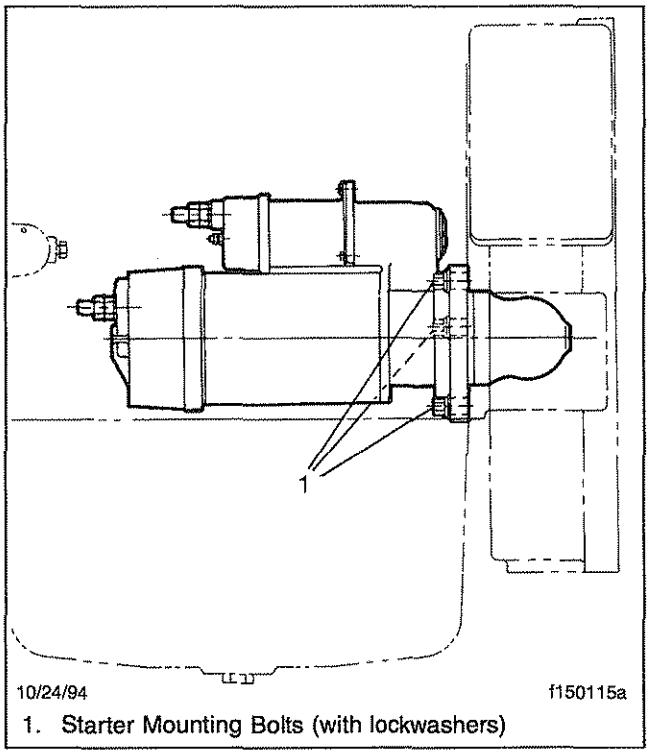
NOTE: Torque values differ according to type of engine installed.

3. Connect the wires to the starter as previously marked. Tighten the nuts 16 to 30 lbf·in (180 to 340 N·cm).
4. Spray any exposed terminal connectors with dielectric red enamel. See **Table 1.**

Protectant Material	Approved Brand
Dielectric Red Enamel Spray	MMM 1602 IVI–Spray Sealer, Red Electric Grade (Spray-On B–6–665)

Table 1, Approved Dielectric Spray

5. Connect the batteries.
6. Return the hood or cab to the operating position. For cab lowering instructions, refer to **Group 60** in this manual.



1. Starter Mounting Bolts (with lockwashers)

Fig. 1, Starter Installation

Ignition Keyswitch Removal and Installation

Removal

1. Disconnect the batteries.
2. Reach in underneath the keyswitch housing and remove the ignition keyswitch from the rubber grommet. It is not necessary to remove the keyswitch housing.
3. Remove the electrical connector from the rear of the keyswitch.

Installation

1. Connect the electrical connector to the ignition keyswitch.
2. Install the ignition keyswitch so that the flat side of the switch points inboard, towards the steering wheel.
3. Connect the batteries.

Troubleshooting Table

Problem—Starter Cranks Slowly Or Not At All

Problem—Starter Cranks Slowly Or Not At All	
Possible Cause	**Remedy**
The drive belt is loose.	Check the drive belt. Refer to the drive belt subject in the appropriate engine section in **Group 01** for instructions. If necessary, tighten to the manufacturer's specifications. Start the engine and check the alternator voltage and output. Refer to the troubleshooting subject in the appropriate alternator section in **Group 15** for instructions.
The drive belt is damaged or missing.	Check the drive pulleys for locked bearings. Repair or replace any damaged components. Replace the drive belt and start the engine. Check the alternator voltage and output. Refer to the troubleshooting subject in the appropriate alternator section in **Group 15** for instructions.
The batteries are undercharged.	Do a load test on the batteries. Refer to **Section 54.02** for instructions. Charge or replace batteries as needed. If the batteries were discharged, check the alternator voltage and output. Refer to the troubleshooting subject in the appropriate alternator section in **Group 15** for instructions. If the batteries were fully charged and passed the load test, check the cranking circuit. Go to "Cranking Circuit Test" for instructions.
The cranking circuit is broken.	Check the cranking circuit. Go to "Cranking Circuit Test" for instructions. Make repairs as needed. Start the engine to verify the repair.
The control circuit is broken.	Check the starter wiring. Go to "Starter Wiring Test" for instructions. Make repairs as needed. Start the engine to verify the repair.
The starter is cold.	Go to "Cold Weather Starting Test" for instructions.
The magnetic switch is broken.	Replace the magnetic switch. Go to **Section 54.04** for replacement instructions.
The battery cables do not deliver sufficient voltage to the starter.	Check the available cranking voltage. Go to "Available Cranking Voltage Test" for instructions.
The starter ring gear or pinion gear is damaged.	Visually check the ring and pinion gears. Go to "Ring and Pinion Gear Test" for instructions.
The starter is damaged.	Replace the starter.

Troubleshooting Chart

Problem—Starter Spins, But Does Not Crank

For troubleshooting instructions, **see Fig. 1.**

Problem—Starter Makes Clicking Noise, But Does Not Crank (Or Cranks Intermittently)

For troubleshooting instructions, **see Fig. 1.**

Cranking Circuit Test

The cranking circuit includes the battery, starter solenoid, cranking motor, magnetic switch, and ignition keyswitch. **See Fig. 2.**

If there is excessive voltage loss in the cranking circuit, the starter may not engage the flywheel at all, or it may drop out too soon when battery voltage goes down. Do the following test to check for excessive voltage loss in the cranking circuit.

Troubleshooting

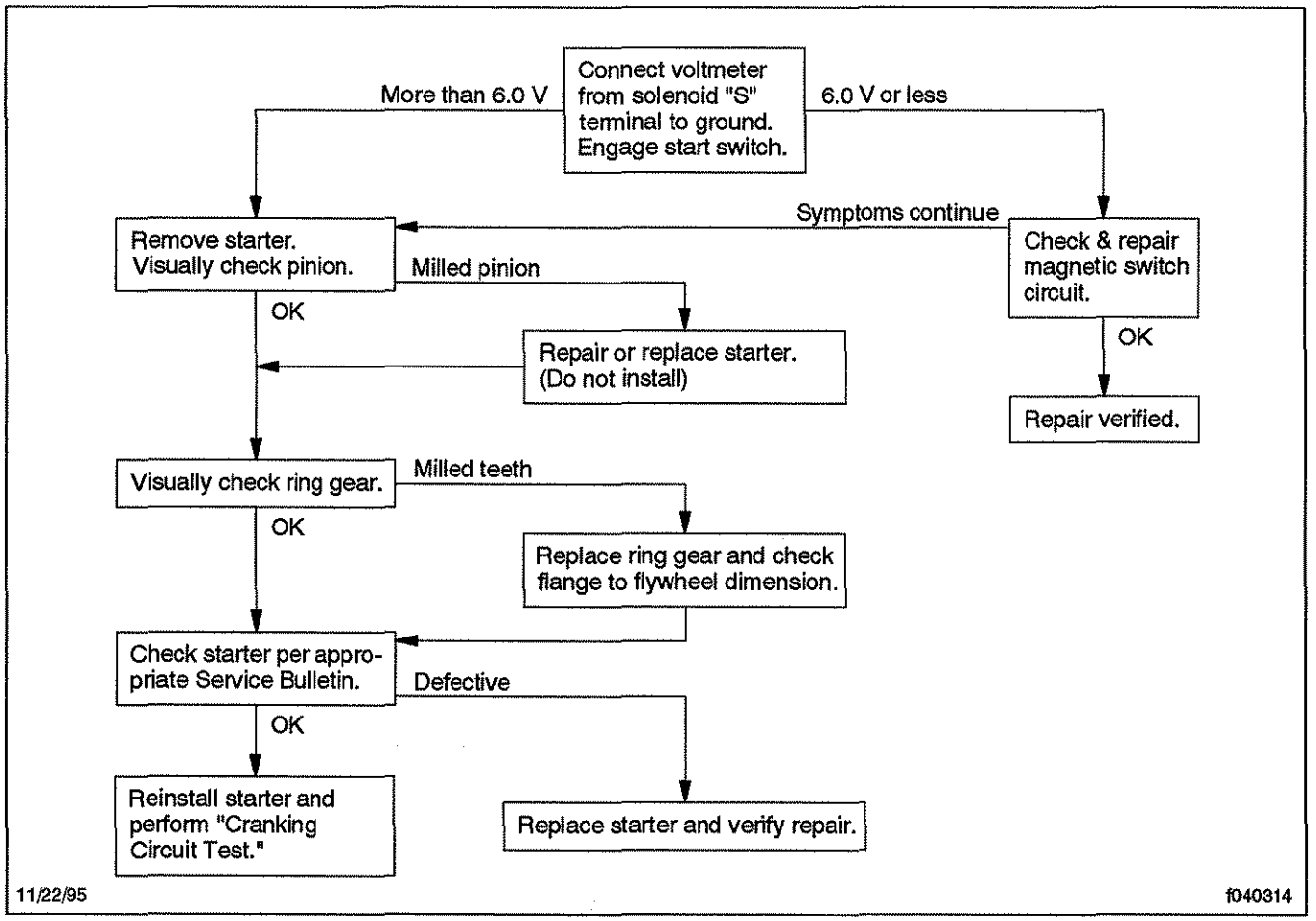


Fig. 1, Milled Pinion Symptoms

1. Disconnect the lead from the magnetic switch to the "S" (solenoid) terminal on the starter.
2. Use a small clamp or jumper wire to connect this lead to the positive lead of a carbon pile tester. Connect the negative lead of the carbon pile to the starter "G" (ground) terminal. **See Fig. 3.**
3. Set a digital voltmeter on the low scale and connect the positive lead to the magnetic switch wire lead to which the carbon pile is already connected. Connect the negative lead to the starter "B" (battery) terminal.
4. This step requires two persons. Have one person start the engine while the other person listens for the clicking sound of the magnetic switch closing. Read the voltage on the voltmeter. It should read zero.

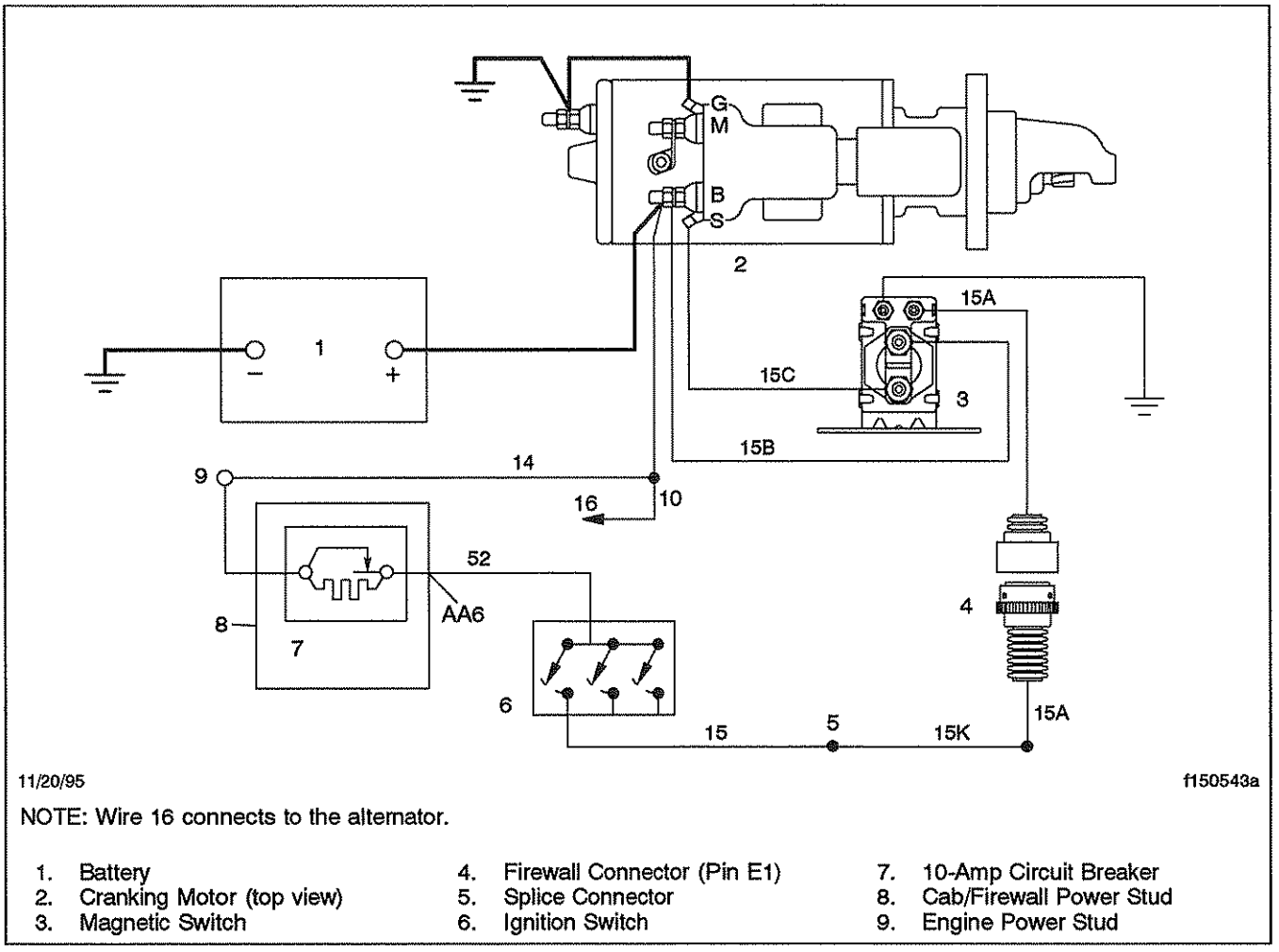
IMPORTANT: If the magnetic switch does not close, do the Magnetic Switch Circuit Test. For instructions, refer to **Section 54.04.**

5. Turn on the carbon pile and adjust it to a 100-amp load.

   5.1 Now read and record the voltage on the voltmeter. Turn off the carbon pile.

   5.2 If the voltage reads 11.0 volts or greater, the cranking circuit is OK. Do the Magnetic Switch Circuit Test. For instructions, refer to **Section 54.04.**

   If the voltage reads less than 11.0 volts, the voltage loss is excessive. Go to "Wiring Test."



NOTE: Wire 16 connects to the alternator.

1. Battery
2. Cranking Motor (top view)
3. Magnetic Switch
4. Firewall Connector (Pin E1)
5. Splice Connector
6. Ignition Switch
7. 10-Amp Circuit Breaker
8. Cab/Firewall Power Stud
9. Engine Power Stud

Fig. 2, Cranking Circuit Wiring

Starter Wiring Test

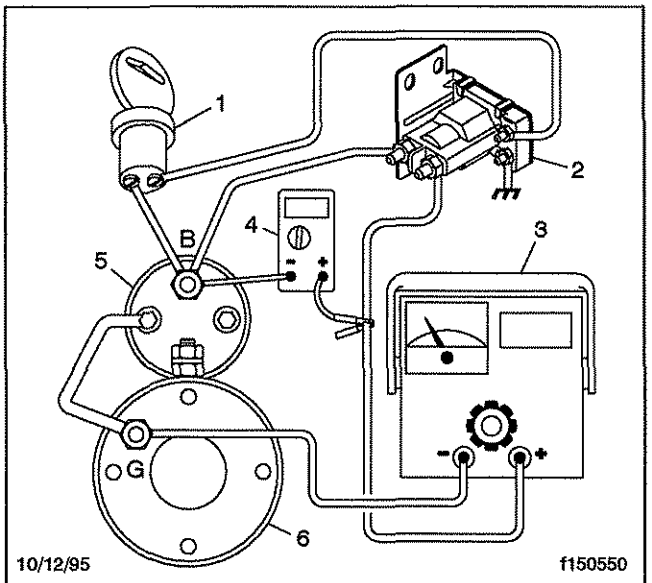
1. Disconnect the lead from the magnetic switch to the "S" (solenoid) terminal on the starter (leave as in "Cranking Circuit Test").
2. Connect this lead to the positive lead of a carbon pile tester. Connect the negative lead of the carbon pile to the starter "G" (ground) terminal (leave as in "Cranking Circuit Test").
3. Connect the positive lead of the digital voltmeter (set on low scale) to the starter "B" (battery) terminal. Connect the negative lead of the voltmeter to one of the large terminals on the magnetic switch. **See Fig. 4.** If any voltage shows, reconnect to the other large terminal.
4. Set a digital voltmeter on the low scale and connect the positive lead to the magnetic switch wire lead to which the carbon pile is already connected. Connect the negative lead to the starter "B" (battery) terminal.
5. Start the engine.

IMPORTANT: If the magnetic switch does not close, do the Magnetic Switch Circuit Test. For instructions, refer to **Section 54.04.**

6. Turn on the carbon pile and adjust it to a 100-amp load.

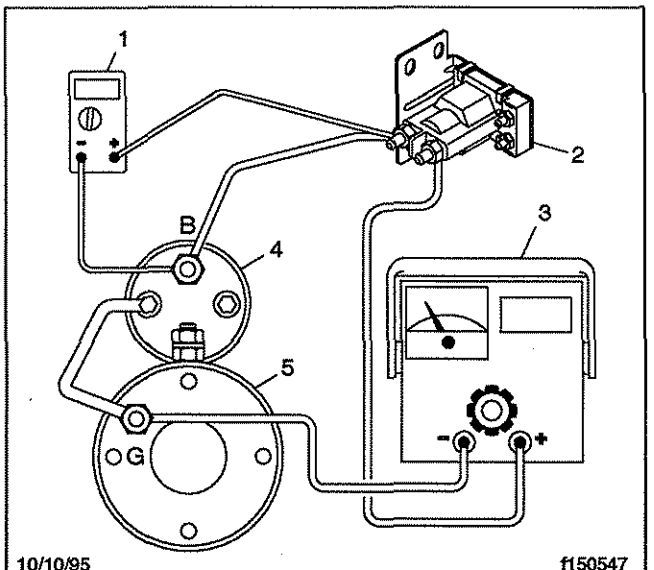
   6.1 Now read and record the voltage on the voltmeter. Turn off the carbon pile.

Troubleshooting



1. Ignition Keyswitch
2. Magnetic Switch
3. Carbon Pile
4. Digital Voltmeter
5. Starter Solenoid
6. Cranking Motor

Fig. 3, Cranking Circuit Test



1. Digital Voltmeter
2. Magnetic Switch
3. Carbon Pile
4. Starter Solenoid
5. Cranking Motor

Fig. 4, Starter Wiring Test—Setup 1

6.2 Subtract this voltage from 12.0 to get the first wire voltage loss (V1).

7. Now connect the positive lead of the digital voltmeter to the magnetic switch wire lead to which the carbon pile is already connected (as in "Cranking Circuit Test"). Connect the negative lead of the voltmeter to the other large terminal on the magnetic switch. **See Fig. 5.**

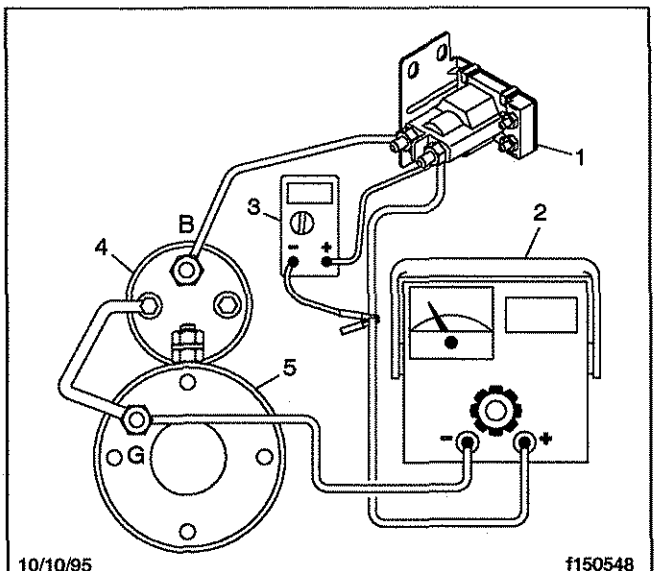
8. Turn on the carbon pile and again adjust it to a 100-amp load.

   8.1 Now read and record this voltage (V2). Turn off the carbon pile.

   8.2 Subtract this voltage from 12.0 to get the second wire voltage loss (V2). Add the two voltages (V1 and V2) together to get the total wire voltage loss.

   8.3 If the total wire voltage loss adds up to 0.8 volts or less, the wiring is OK. Do the Magnetic Switch Contactor Test. For instructions, refer to **Section 54.04.**

   If the total wire voltage loss adds up to more than 0.8 volts, the wiring needs repair or replacement.



1. Magnetic Switch
2. Carbon Pile
3. Digital Voltmeter
4. Starter Solenoid
5. Cranking Motor

Fig. 5, Starter Wiring Test—Setup 2

9. Disconnect the carbon pile and the voltmeter. Reconnect the magnetic switch to the starter "S" terminal.
10. Check all wiring and connections and repair or replace as needed. For instructions on wire repair, refer to **Section 54.00**.

Cold Weather Voltage Test

In cold weather, the starter may fail to engage, even though it performed well at higher temperatures. Do the following test to check for cold weather voltage loss in the cranking circuit.

1. With the ignition keyswitch on, clamp a heavy battery jumper cable between the two large studs on the magnetic switch. Remove the jumper immediately to stop the engine from cranking.
2. If the engine starts with the jumper in place, replace the magnetic switch.
3. If the engine now starts properly, check the starter mounting bolts for tightness.

   If the engine still does not start properly, go to "Available Cranking Voltage Test."

Available Cranking Voltage Test

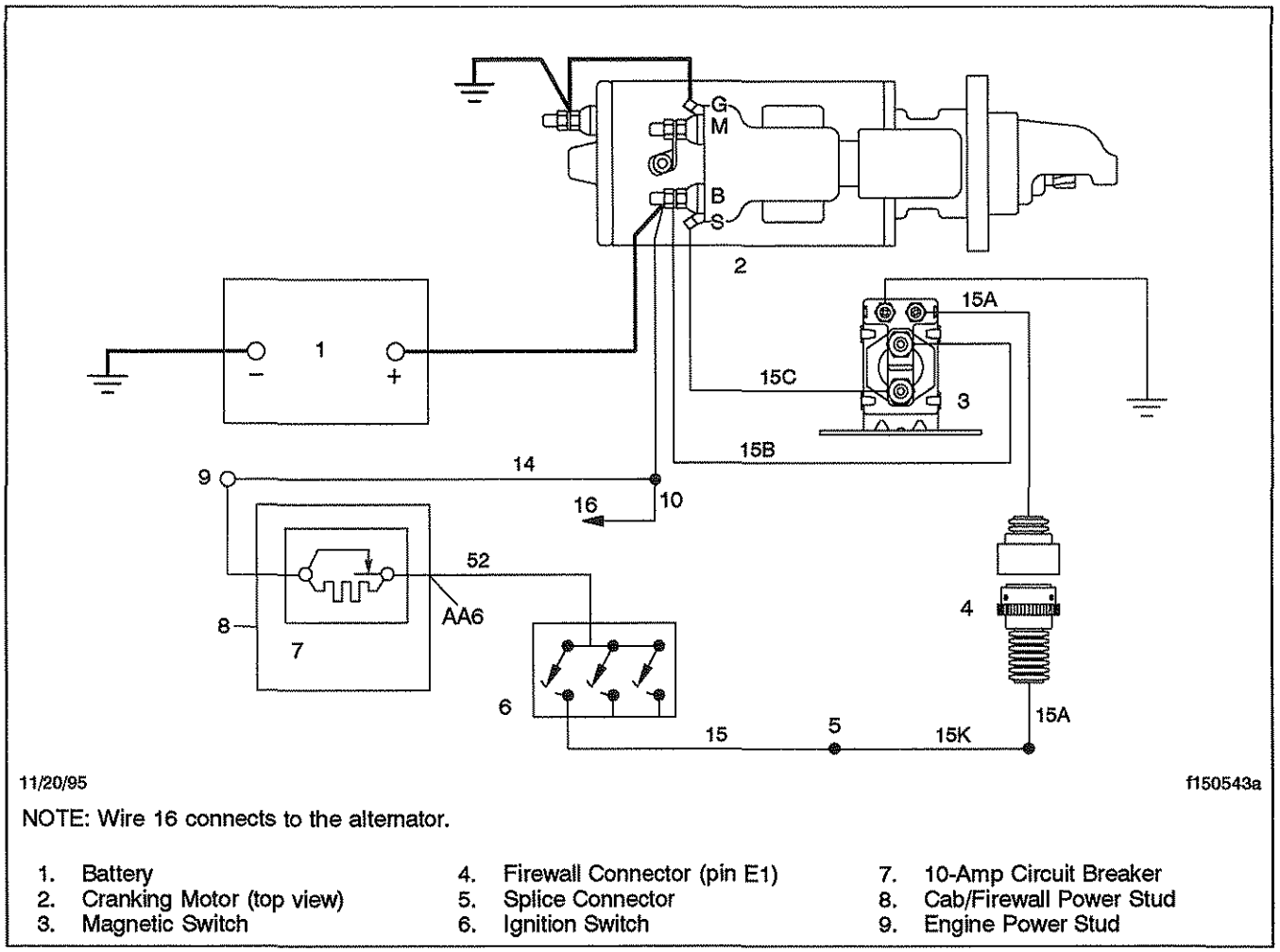
1. This test requires two persons. While the first person cranks the engine, the second person uses a voltmeter to measure the voltage across the starter "B" (battery) and "G" (ground) terminals.
2. If the voltage is 9.0 volts or less while cranking, check the battery interconnecting cables.
   - 2.1 While cranking, measure the voltage across each battery.
   - 2.2 If the difference between any two batteries in the same battery box is more than 0.5 volt, check and replace the interconnecting cables as required.
   - 2.3 If any cable or connection feels warm to the touch, check and replace the interconnecting cables as required.
3. If the starter still does not crank, go to "Ring and Pinion Gear Test."

Ring and Pinion Gear Test

1. This test requires two persons. While the first person bars the engine over, the second person visually checks the entire ring gear and pinion gear visually (check all the teeth in both gears).
2. If any damage is found, replace the starter.
3. If the engine still does not crank properly after replacing the starter, look for a mechanical problem in the engine. For instructions, refer to **Group 01** or the engine manufacturer's manuals.

For a cranking circuit wiring diagram, **see Fig. 1.**

For a schematic of the engine starting circuit wiring harness, **see Fig. 2.**



NOTE: Wire 16 connects to the alternator.

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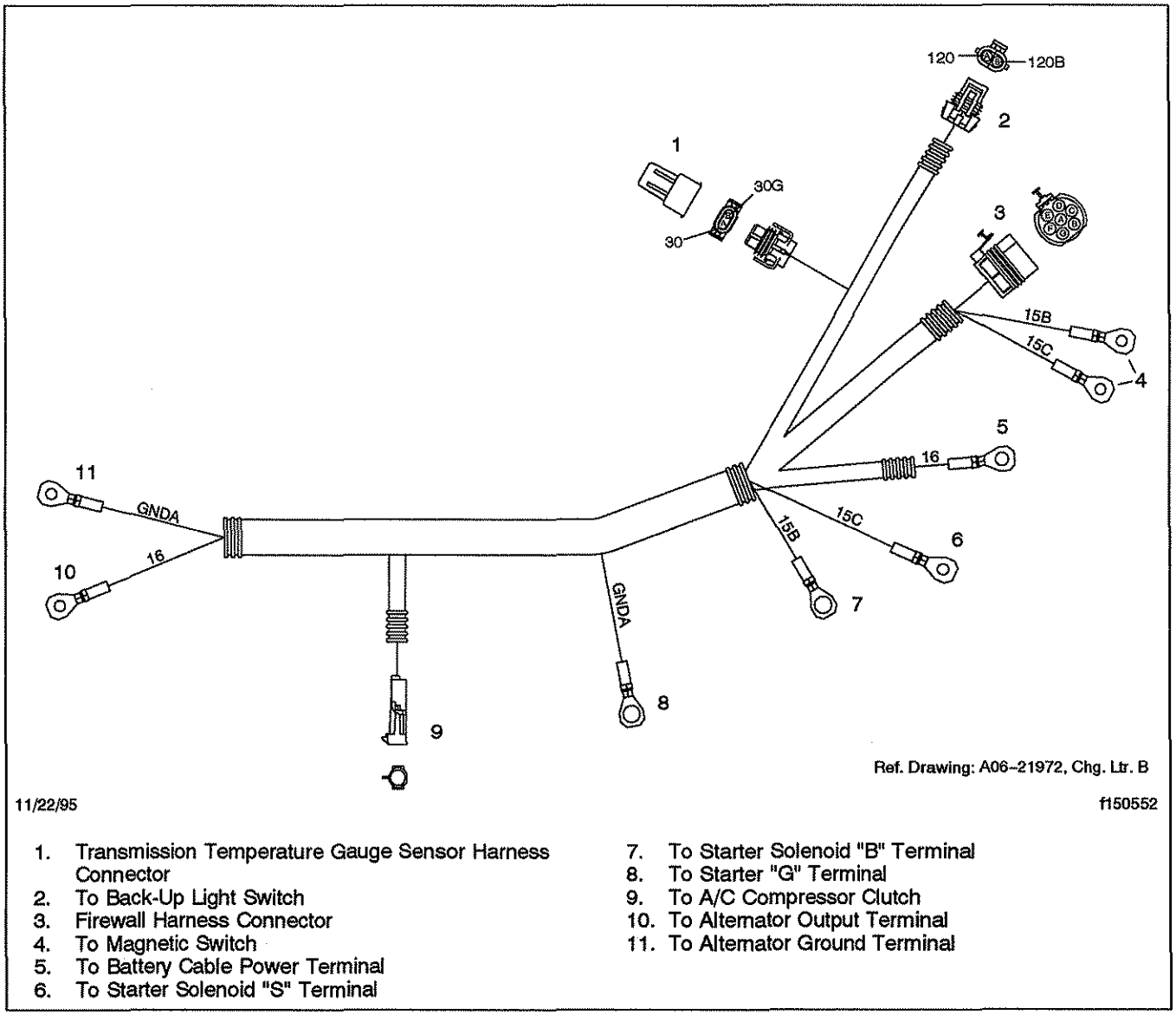
4. Firewall Connector (pin E1)
5. Splice Connector
6. Ignition Switch
7. 10-Amp Circuit Breaker
8. Cab/Firewall Power Stud
9. Engine Power Stud

Fig. 1, Cranking Circuit Wiring

Specifications



1. Transmission Temperature Gauge Sensor Harness Connector
2. To Back-Up Light Switch
3. Firewall Harness Connector
4. To Magnetic Switch
5. To Battery Cable Power Terminal
6. To Starter Solenoid "S" Terminal
7. To Starter Solenoid "B" Terminal
8. To Starter "G" Terminal
9. To A/C Compressor Clutch
10. To Alternator Output Terminal
11. To Alternator Ground Terminal

Fig. 2, Engine Charging Circuit Wiring Harness

Fastener Torque Values			
Fastener Description	Size	Torque Value	
		lbf·ft (N·m)	lbf·in (N·cm)
Nose Housing Bolts	5/16–18	13–17 (18–23)	—
Frame Capscrews (grade 8)	1/4–28	—	144–192 (1620–2160)
Solenoid Mounting Bolts (grade 8)	1/4–20	—	150–200 (1700–2260)
Copper Terminals	1/2–13	20–25 (27–34)	—

Fastener Torque Values			
Fastener Description	Size	Torque Value	
		lbf·ft (N·m)	lbf·in (N·cm)
Solenoid Side Terminals	10–32	—	16–30 (180–340)
Brush Screw	8–32	—	18–24 (200–280)
Frame Plug	1-3/8–18	—	48–72 (540–820)
Starter–Motor to Flywheel–Housing Bolts			
Detroit Diesel (steel housing)	5/8–16	137–147 (186–199)	—
Detroit Diesel (aluminum housing)	5/8–16	85–95 (115–129)	—
Caterpillar (steel or aluminum housing)	5/8–16	130–170 (176–230)	—
Cummins (tteel or aluminum housing)	5/8–16	130–170 (176–230)	—

Table 1, Fastener Torque Values

Alternators, Leece-Neville 15.01

Contents

Subject	Subject Number
General Information	050
Service Operations	
JB Series Alternator Removal and Installation, Cummins N14	100
JB Series Alternator Removal and Installation, Cummins M11	110
JB Series Alternator Removal and Installation, Caterpillar 3406	120
JB Series Alternator Removal and Installation, Caterpillar C–10/C–12	130
JB Series Alternator Removal and Installation, DDC 60	140
JB Series Alternator Removal and Installation, DDC 55	150
Voltage Regulator Adjustment	160
Troubleshooting	300
Specifications	400

General Description

The Leece-Neville JB series alternator is a 14-volt self-load-limiting alternator equipped with a three-step adjustable voltage regulator. See **Fig. 1**. For voltage regulator adjustment procedures, see **Subject 160**.

The optional SmartChek™ models feature a light-emitting diode (LED) that changes color to simplify troubleshooting. When the LED is green, the alternator is OK. When the LED is red, the alternator needs replacing.

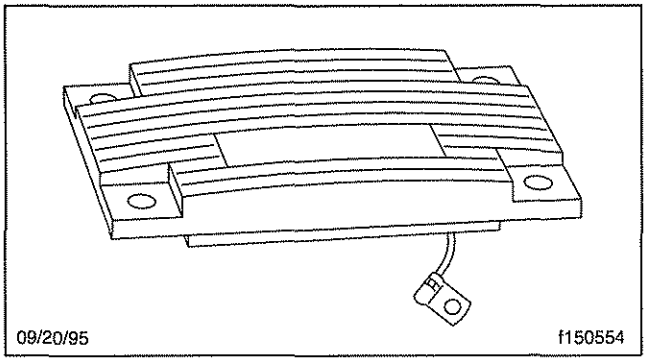
Six silicon diodes mounted in heat sinks convert alternating current from the delta-wound stator into direct current. A capacitor connected between the heat sinks helps suppress transient voltage spikes, which could possibly damage the diodes.

The brushes and voltage regulator are located in a waterproof housing that may be removed for replacement or inspection. An external relay terminal is also provided for operation of a 7V battery isolator relay or other accessories that might require power from such a source.

The voltage regulator is also equipped with transient voltage protection and will withstand instantaneous opening of the charging circuit under full load conditions.

The LC models are identical to the JB models but are improved in the following ways:

- The rear rotor bearings are stronger and more durable;
- The diode post installation has been improved;
- The rectifier heat sink has a larger capacity.



09/20/95 f150554

Fig. 1, Three-Step Adjustable Voltage Regulator

The LCF models have all the same improvements as the LC models. In addition, the front bearing is secured with five bolts instead of four.

Mounting hardware and vehicle wiring require periodic inspection. See **Group 15** in the vehicle maintenance manual for instructions.

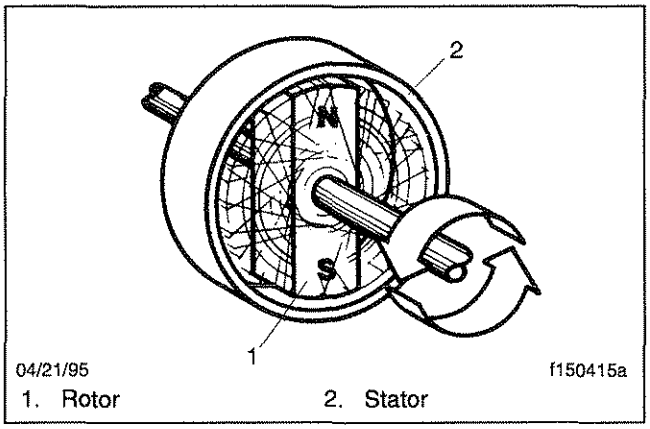
Principles of Operation

Current is produced by rotating a magnet inside a stationary winding. The rotating magnet is called a rotor and the stationary winding is called a stator. See **Fig. 2**.

The rotor is electrically magnetized by a small current flowing through the brushes, riding on smooth slip rings. See **Fig. 3**. Alternating current is then produced as the magnetic poles of the rotor pass the coil windings of the stator.

These alternators have 12 magnetic poles in the rotor (see **Fig. 4**) and three separate windings in the stator (see **Fig. 5**). Since the rotor produces alternating current as it passes the coil windings of the stator, increased engine speed produces more current.

Rectifier assemblies convert alternating current to direct current for storage in the batteries. Rectifiers consist of silicon diodes that work as electrical switches and permit current flow in only one direction. They are mounted in an aluminum casting, which is finned to dissipate heat. This is called a heat sink. See **Fig. 6**.



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1. Rotor 2. Stator

Fig. 2, Producing the Current

General Information

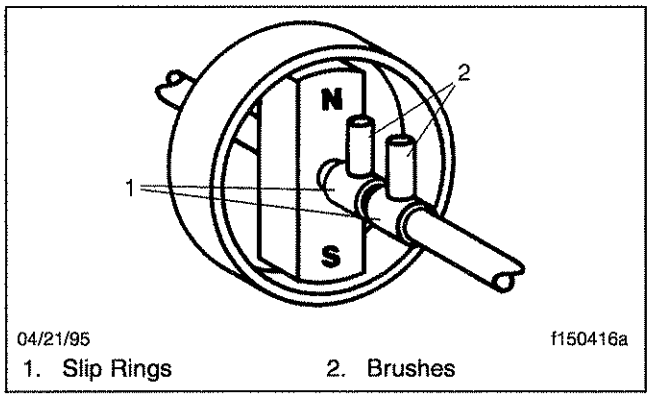


Fig. 3, Magnetizing the Rotor

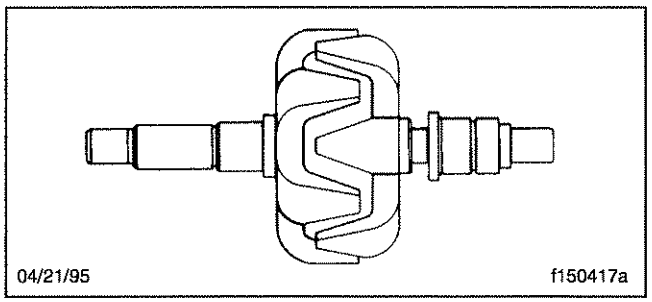


Fig. 4, Rotor

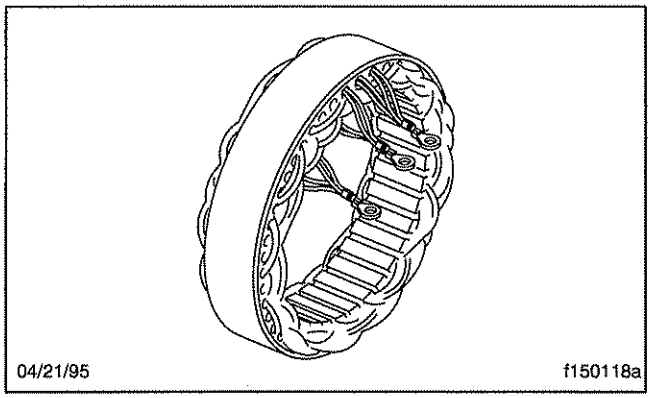


Fig. 5, Stator

The voltage regulator (see **Fig. 1**) controls the alternator output and the state of charge of the batteries. It is used in the charging system to regulate the battery voltage to the vehicle.

The diode trio converts a small amount of alternating current from the stator into direct current which is used as a signal to turn on the regulator.

When the battery is charged, the regulator reduces the field current flow to the rotor. Reducing the field current flow, in turn, reduces the alternator output. When the headlights or accessories place a load on the battery, the regulator increases the current flow to the rotor, and alternator output increases, to maintain voltage.

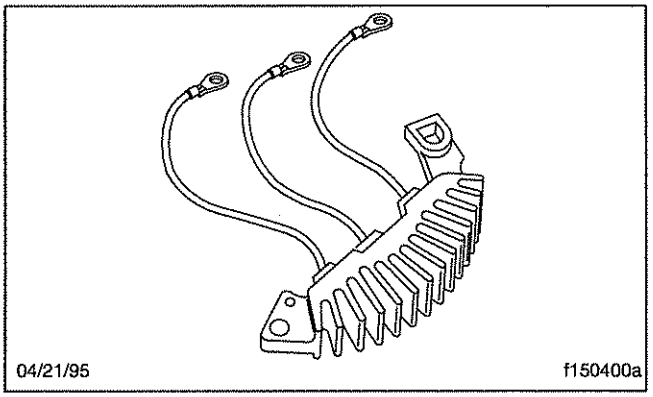


Fig. 6, Heat Sink

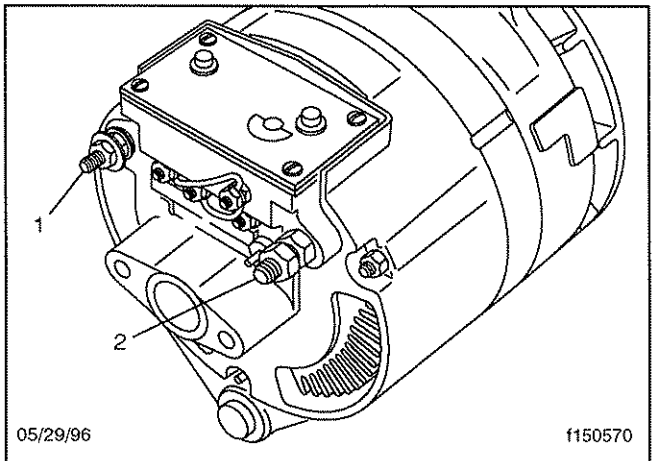
JB Series Alternator Removal and Installation, Cummins N14

Removal

1. Disconnect the batteries.
2. Mark all electrical leads and disconnect them from the alternator. See **Fig. 1**.
3. Loosen the adjusting rod mounting capscrew (see **Fig. 2**, Ref. 8).
4. Loosen the end link mounting capscrew and the alternator mounting capscrew (see **Fig. 2**, Refs. 2 and 3). Turn the adjusting nut (Ref. 6) counterclockwise, backing the alternator toward the drive pulley far enough to remove the dual drive belts without prying or twisting the belts. Remove the drive belts from the vehicle.
5. Remove the adjusting rod jam nut (Ref. 4) and alternator mounting capscrew. Remove the alternator from the vehicle with the end link attached.
6. Inspect the drive belts. For instructions, see **Section 01.01, Subject 100**.

Installation

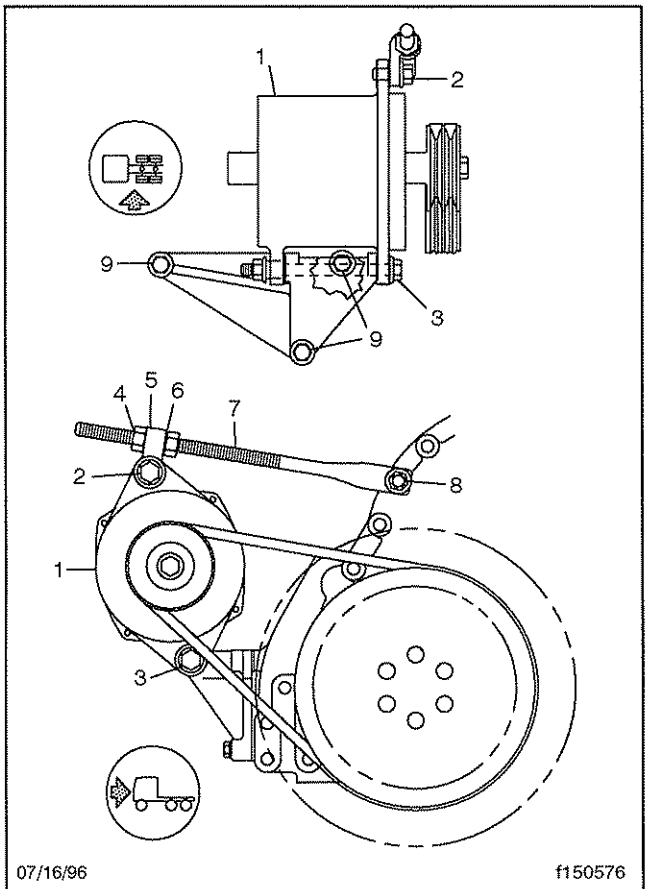
1. Check the torque of the alternator bracket fasteners. If necessary, tighten them 34 lbf·ft (46 N·m).
2. Install the alternator on the engine with the end link attached. Install the alternator mounting capscrew, but do not tighten it yet.



1. Ground (G) Terminal
2. Output (BAT) Terminal

Fig. 1, Battery Lead Connections

3. Install the drive belts on the pulleys. Do not pry or twist the belts. If installing a new pulley or a new alternator, tighten the pulley nut 75 lbf·ft (102 N·m).
4. Tighten the adjusting nut (see **Fig. 2**, Ref. 6) until the belt is correctly tensioned. For belt tightening procedures and specifications, see **Section 01.01, Subject 110**. While holding the adjusting nut in place, install the adjusting rod jam nut and tighten it 95 lbf·ft (130 N·m).



1. JB Series Alternator
2. End Link Mounting Capscrew
3. Alternator Mounting Capscrew
4. Adjusting Rod Jam Nut
5. End Link
6. Adjusting Nut
7. Adjusting Rod
8. Adjusting Rod Mounting Capscrew
9. Alternator Bracket Capscrew

Fig. 2, Alternator Installation, Cummins N14 Engine

JB Series Alternator Removal and Installation, Cummins N14

5. Tighten the end link mounting capscrew and the alternator mounting capscrew 65 lbf·ft (88 N·m). Tighten the adjusting rod mounting capscrew 50 lbf·ft (68 N·m).
6. Connect all leads to the back of the alternator as previously marked. Tighten the output terminal nut 100 lbf·in (1140 N·cm). Tighten the ground terminal nut 65 lbf·in (740 N·cm). For other terminals, tighten the nut 20 lbf·in (220 N·cm).
7. Spray any exposed terminal connectors with dielectric red enamel. See **Table 1**.

Protectant Material	Approved Brand
Dielectric Red Enamel Spray	MMM 1602 IVI–Spray Sealer, Red Electric Grade (Spray-On B–6–665)

Table 1, Approved Dielectric Red Enamel

8. Connect the batteries.
9. Before returning the vehicle to operation, test the alternator DC output voltage. For instructions, see "Alternator Voltage Test" in **Troubleshooting, 300**.

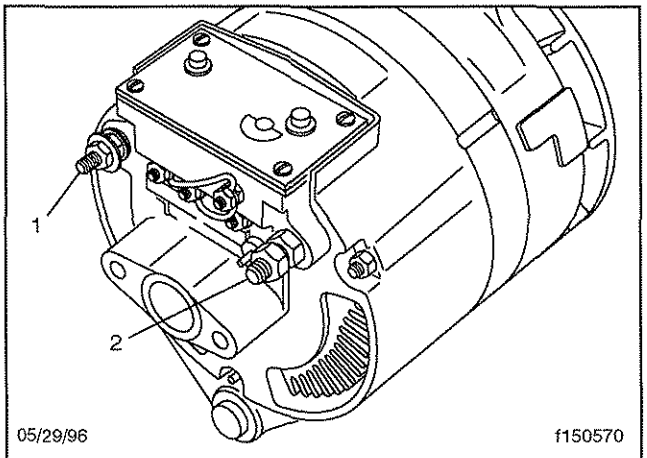
JB Series Alternator Removal and Installation, Cummins M11

Removal

1. Disconnect the batteries.
2. Mark all electrical leads and disconnect them from the alternator. See **Fig. 1**.
3. Loosen the adjusting block mounting bolt, adjusting arm mounting capscrew, and alternator mounting capscrew just enough to allow movement of the alternator. See **Fig. 2**.
4. Loosen the adjusting screw locknut. See **Fig. 2**, Ref. 4. Turn the adjusting screw (Ref. 7) counterclockwise, backing off the alternator toward the drive pulley far enough to remove the drive belt without prying or twisting the belt. Remove the belt from the vehicle.
5. Remove the adjusting block mounting bolt and the alternator mounting capscrew. Remove the alternator from the vehicle.
6. Inspect the drive belt. For instructions, see **Section 01.01, Subject 100**.

Installation

1. Check the torque of the alternator bracket fasteners. If necessary, tighten them 34 lbf·ft (46 N·m).



1. Ground (G) Terminal
2. Output (BAT) Terminal

Fig. 1, Battery Lead Connections

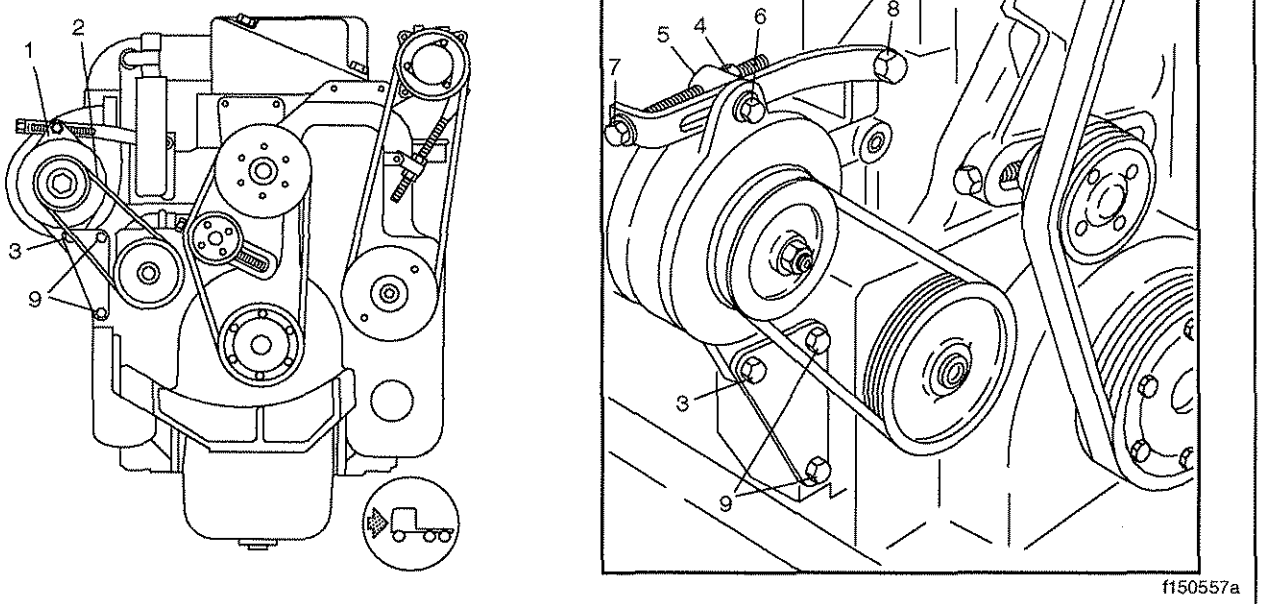
2. Install the alternator on the engine. Install the adjusting block mounting bolt and the alternator mounting capscrew, but do not tighten them yet.
3. Install the drive belt on the pulleys. Do not pry or twist the belt over the pulley. If installing a new pulley or a new alternator, tighten the pulley nut 75 lbf·ft (102 N·m).
4. Turn the adjusting screw (see **Fig. 2**, Ref. 7) clockwise until the belt is correctly tensioned. For belt tightening specifications, see **Section 01.01, Subject 105**. Tighten the adjusting screw locknut (Ref. 4) 95 lbf·ft (130 N·m).
5. Tighten the alternator mounting capscrew (see **Fig. 2**, Ref. 3) 65 lbf·ft (88 N·m); tighten the adjusting block mounting bolt (Ref. 6) 30 lbf·ft (41 N·m); tighten the adjusting arm mounting capscrew (Ref. 8) 55 lbf·ft (75 N·m).
6. Connect all leads to the back of the alternator as previously marked. Tighten the output terminal nut 100 lbf·in (1140 N·cm). Tighten the ground terminal nut 65 lbf·in (740 N·cm). For other terminals, tighten the nut 20 lbf·in (220 N·cm).
7. Spray any exposed terminal connectors with dielectric red enamel. See **Table 1**.

Protectant Material	Approved Brand
Dielectric Red Enamel Spray	MMM 1602 IVI–Spray Sealer, Red Electric Grade (Spray-On B–6–665)

Table 1, Approved Dielectric Red Enamel

8. Connect the batteries.
9. Before returning the vehicle to operation, test the alternator DC output voltage. For instructions, see "Alternator Voltage Test" in **Troubleshooting, 300**.

JB Series Alternator Removal and Installation, Cummins M11



1. JB Series Alternator
2. Drive Belt
3. Alternator Mounting Capscrew
4. Adjusting Screw Locknut
5. Adjusting Block
6. Adjusting Block Mounting Bolt
7. Adjusting Screw
8. Adjusting Arm Mounting Capscrew
9. Alternator Bracket Fasteners

Fig. 2, Alternator Installation, Cummins M11 Engine

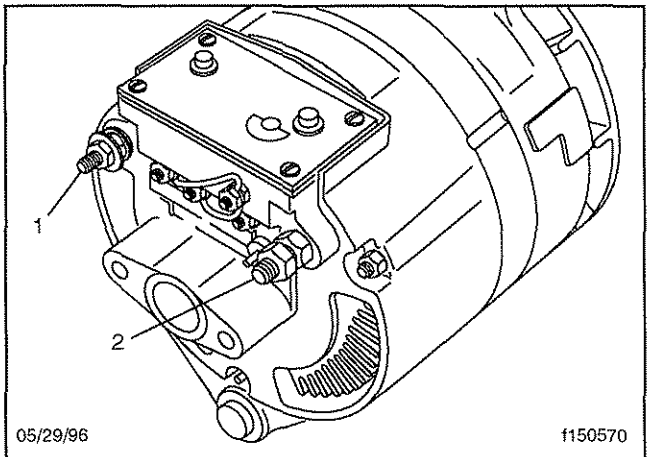
JB Series Alternator Removal and Installation, Caterpillar 3406

Removal

1. Disconnect the batteries.
2. Mark all electrical leads and disconnect them from the alternator. See **Fig. 1**.
3. Back off the adjusting nut (see **Fig. 2**, Ref. 6). Loosen the end link mounting capscrew and the alternator mounting capscrew enough to allow movement of the alternator.
4. Push the loosened alternator far enough toward the fan drive pulley to allow removal of the drive belts without using force.
5. Slip each drive belt (dual drive belts) off the pulleys and work it over one fan blade at a time. Remove both drive belts from the vehicle.
6. Remove the two mounting capscrews already loosened. Remove the alternator from the vehicle.
7. Inspect the drive belts. For instructions, see **Section 01.00, Subject 100**.

Installation

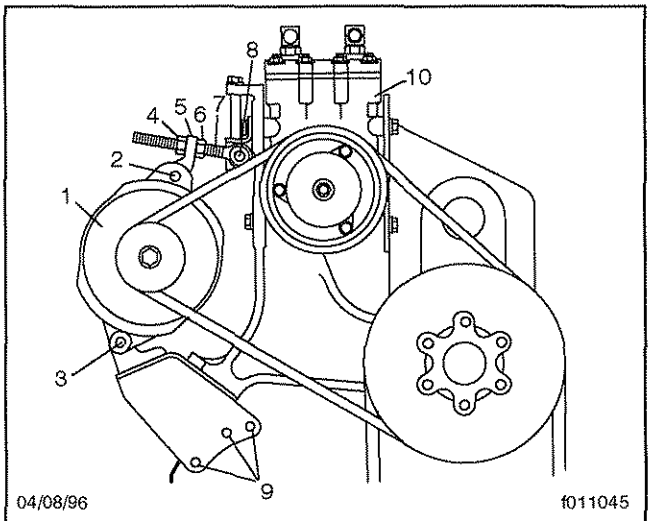
1. Check the torque of the alternator bracket fasteners. Tighten the fasteners 65 lbf·ft (88 N·m).



1. Ground (G) Terminal
2. Output (BAT) Terminal

Fig. 1, Battery Lead Connections

2. Install the alternator on the engine. Install the end link mounting capscrew and the alternator mounting capscrew, but do not tighten them yet.
3. Make sure the distance between the pulleys is short enough to allow belt installation without using force. If installing a new pulley or a new alternator, tighten the pulley nut 75 lbf·ft (102 N·m).
4. Work each belt over the fan blades, one blade at a time. Install both drive belts on the pulleys without prying or rolling them into place. For belt tightening procedures and specifications, see **Section 01.00, Subject 110**.
5. After each belt has been correctly tensioned, tighten the adjusting rod jam nut 65 lbf·ft (88 N·m).
6. Tighten both the end link and alternator mounting capscrews 65 lbf·ft (88 N·m).



1. JB Series Alternator
2. End Link Mounting Capscrew
3. Alternator Mounting Capscrew
4. Adjusting Rod Jam Nut
5. End Link
6. Adjusting Nut
7. Adjusting Rod
8. Adjusting Rod Mounting Capscrew
9. Alternator Bracket Fasteners
10. Refrigerant Compressor

Fig. 2, Alternator Installation, Caterpillar 3406 Engine

JB Series Alternator Removal and Installation, Caterpillar 3406

7. Connect all leads to the back of the alternator as previously marked. Tighten the output terminal nut 100 lbf·in (1140 N·cm). Tighten the ground terminal nut 65 lbf·in (740 N·cm). For other terminals, tighten the nut 20 lbf·in (220 N·cm).
8. Spray any exposed terminal connectors with dielectric red enamel. See **Table 1**.

Protectant Material	Approved Brand
Dielectric Red Enamel Spray	MMM 1602 IVi–Spray Sealer, Red Electric Grade (Spray-On B–6–665)

Table 1, Approved Dielectric Red Enamel

9. Connect the batteries.
10. Before returning the vehicle to operation, test the alternator DC output voltage. For instructions, see "Alternator Voltage Test" in **Troubleshooting, 300**.

JB Series Alternator Removal and Installation, Caterpillar C–10/C–12

Removal

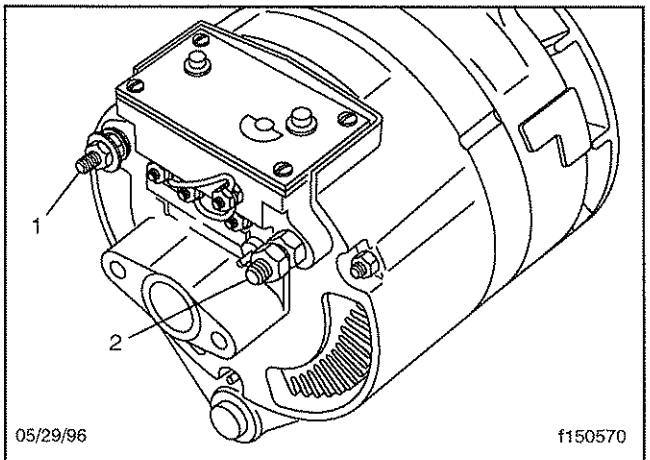
1. Disconnect the batteries.
2. Mark all electrical leads and disconnect them from the alternator. See **Fig. 1**.
3. Insert a breaker bar in the belt tensioner and rotate the tensioner down and off the alternator drive belt. See **Fig. 2**.

NOTE: There are two drive belts to remove. Before removing the alternator belt, it is necessary to remove the refrigerant compressor belt from the fan pulley.

4. Holding the belt tensioner down, remove the drive belt from its pulleys. Slowly release the belt tensioner and remove the breaker bar.
5. Lower the alternator drive belt, and take it off the vibration damper. It is not necessary to remove the belt from the vehicle.
6. Remove both alternator mounting capscrews. Remove the alternator from the vehicle.

NOTE: It is not necessary to remove the adjusting strap from the engine.

7. Inspect the drive belt. For instructions, see **Section 01.00, Subject 100**.

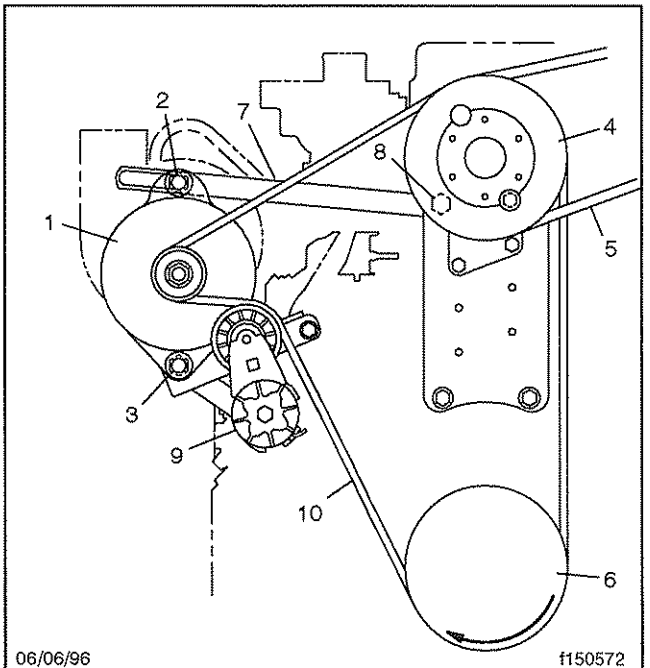


1. Ground (G) Terminal
2. Output (BAT) Terminal

Fig. 1, Battery Lead Connections

Installation

1. Check the torque of the adjusting strap mounting capscrew. If necessary, tighten it 65 lbf·ft (88 N·m).
2. Install the alternator on the engine. Install the alternator at the inboard edge of the slot initially. Install the top and bottom alternator mounting capscrews, but do not tighten them yet.
3. Install the drive belts on the pulleys, as removed. If installing a new pulley or a new alternator, tighten the pulley nut 75 lbf·ft (102 N·m). For



Rotate the belt tensioner down and off the belt.

1. JB Series Alternator
2. Alternator Mounting Capscrew, Top
3. Alternator Mounting Capscrew, Bottom
4. Fan Pulley
5. Refrigerant Compressor Drive Belt
6. Vibration Damper
7. Alternator Adjusting Strap
8. Adjusting Strap Mounting Capscrew
9. Belt Tensioner
10. Alternator Drive Belt

Fig. 2, Alternator Installation, Caterpillar C-10/ C-12 Engine

JB Series Alternator Removal and Installation, Caterpillar C–10/C–12

belt tightening procedures and specifications, see **Section 01.00, Subject 105**.

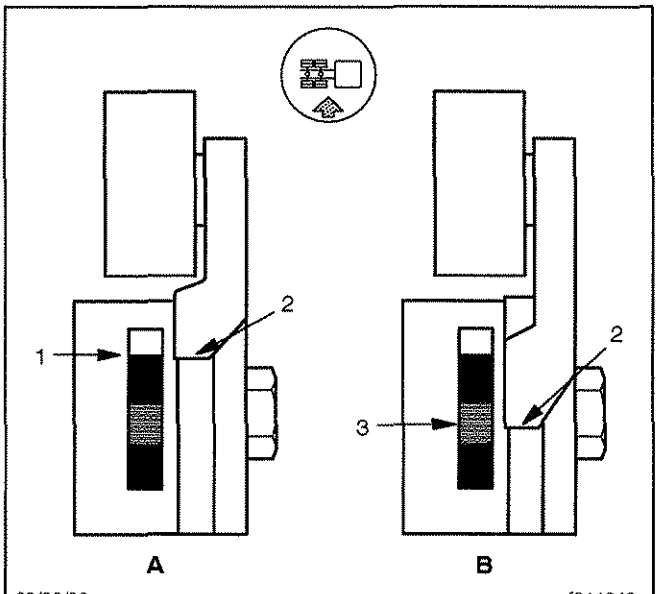
4. Verify that the edge of the tensioner arm is within the green zone on the decal. See **Fig. 3**. If within the red zone, pivot the alternator outboard until the tensioner arm enters the green zone.

NOTE: If the belt slips, repair or replace the tensioner. For instructions, see the Caterpillar C–10 & C–12 Diesel Truck Engine Service Manual.

5. When the alternator is correctly positioned, tighten both alternator mounting capscrews 65 lbf·ft (88 N·m).

6. Connect all leads to the back of the alternator as previously marked. Tighten the output terminal nut 100 lbf·in (1140 N·cm). Tighten the ground terminal nut 65 lbf·in (740 N·cm). For other terminals, tighten the nut 20 lbf·in (220 N·cm).

7. Spray any exposed terminal connectors with dielectric red enamel. See **Table 1**.



A. Belt Off, No Tension
B. Belt On, Correct Tension

1. Decal
2. Edge of Tensioner Arm
3. Green Zone (operating range)

Fig. 3, Belt Tensioner With Decal

Protectant Material	Approved Brand
Dielectric Red Enamel Spray	MMM 1602 IVI–Spray Sealer, Red Electric Grade (Spray-On B–6–665)

Table 1, Approved Dielectric Red Enamel

8. Connect the batteries.

9. Before returning the vehicle to operation, test the alternator DC output voltage. For instructions, see "Alternator Voltage Test" in **Troubleshooting, 300**.

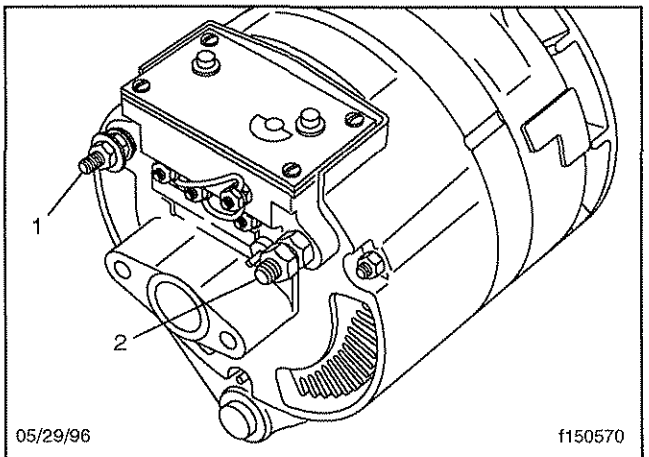
JB Series Alternator Removal and Installation, DDC 60

Removal

1. Disconnect the batteries.
2. Mark all electrical leads and disconnect them from the alternator. See **Fig. 1**.
3. Loosen the adjusting rod mounting capscrew (see **Fig. 2**, Ref. 8), the end link mounting capscrew (Ref. 2), and the alternator mounting capscrew (Ref. 3). Loosen these mounting capscrews enough to allow movement of the alternator.
4. Back off the adjusting nut (see **Fig. 2**, Ref. 6). Push the loosened alternator far enough toward the fan drive pulley to allow removal of the drive belts without using force.
5. Remove the drive belt from the pulleys without prying or twisting the belt.
6. Remove the end link mounting capscrew and the alternator mounting capscrew. Remove the alternator from the vehicle.
7. Inspect the drive belt. For instructions, see **Section 01.02, Subject 100**.

Installation

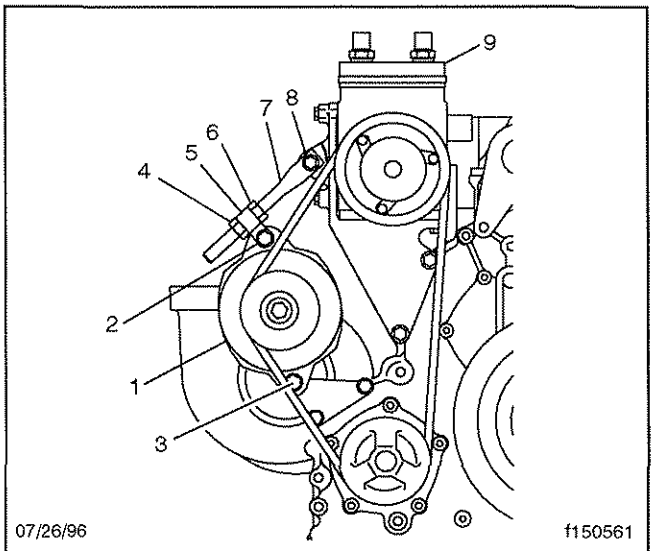
1. Check the torque of the alternator bracket fasteners. If necessary, tighten them 50 lbf·ft (68 N·m).



1. Ground (G) Terminal
2. Output (BAT) Terminal

Fig. 1, Battery Lead Connections

2. Install the alternator on the engine. Install the end link mounting capscrew and the alternator mounting capscrew, but do not tighten them yet.
3. Loop the drive belt around the pulleys.
4. Install the drive belt on the pulleys without prying or rolling it into place. If installing a new pulley or a new alternator, tighten the pulley nut 75 lbf·ft (102 N·m). For belt tightening procedures and specifications, see **Section 01.02, Subject 105**.
5. After the belt has been correctly tensioned, tighten the adjusting rod jam nut 95 lbf·ft (130 N·m).
6. Tighten the end link mounting capscrew and the alternator mounting capscrew 65 lbf·ft (88 N·m). Tighten the adjusting rod mounting capscrew 50 lbf·ft (68 N·m).
7. Connect all leads to the back of the alternator as previously marked. Tighten the output termi-



1. JB Series Alternator
2. End Link Mounting Capscrew
3. Alternator Mounting Capscrew
4. Adjusting Rod Jam Nut
5. End Link
6. Adjusting Nut
7. Adjusting Rod
8. Adjusting Rod Mounting Capscrew
9. Refrigerant Compressor

Fig. 2, Alternator Installation, Detroit Diesel Series 60 Engine

JB Series Alternator Removal and Installation, DDC 60

nal nut 100 lbf·in (1140 N·cm). Tighten the ground terminal nut 65 lbf·in (740 N·cm). For other terminals, tighten the nut 20 lbf·in (220 N·cm).

8. Spray any exposed terminal connectors with dielectric red enamel. See **Table 1**.

Protectant Material	Approved Brand
Dielectric Red Enamel Spray	MMM 1602 IVI–Spray Sealer, Red Electric Grade (Spray-On B–6–665)

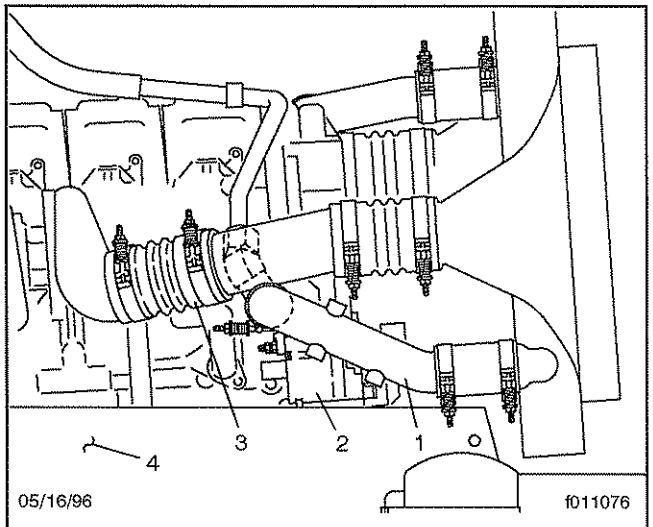
Table 1, Approved Dielectric Red Enamel

9. Connect the batteries.
10. Before returning the vehicle to operation, test the alternator DC output voltage. For instructions, see "Alternator Voltage Test" in **Troubleshooting, 300**.

JB Series Alternator Removal and Installation, DDC 55

Removal

1. Disconnect the batteries.
2. Drain the radiator. For instructions, see **Section 20.01, Subject 100**.
3. When the coolant has drained, remove the lower radiator tube. See **Fig. 1**.
4. Mark all electrical leads and disconnect them from the alternator. See **Fig. 2**.
5. Insert a breaker bar in the alternator belt tensioner (see **Fig. 3**, Ref. 4) and rotate the tensioner down and off the alternator drive belt.
6. Holding the belt tensioner down, remove the alternator drive belt from its pulley. Slowly release the belt tensioner and remove the breaker bar.
7. Lower the drive belt, and take it off the vibration damper. It is not necessary to remove the belt from the vehicle.
8. Remove the top and bottom alternator mounting capscrews. Remove the alternator from the vehicle.



1. Lower Coolant Tube
2. JB Series Alternator
3. Charge Air Cooler Hose
4. Frame Rail

Fig. 1, Alternator Access, Detroit Diesel Series 55 Engine

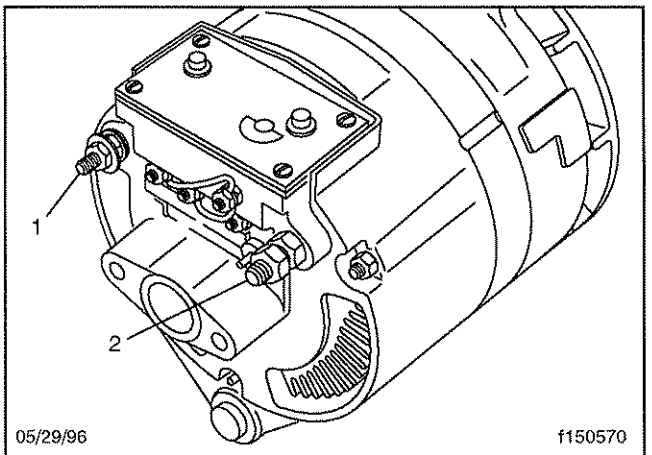
9. Inspect the drive belt. For instructions, see **Section 01.02, Subject 100**.

Installation

1. Check the torque of the adjusting strap mounting capscrew. If necessary, tighten it 65 lbf·ft (88 N·m).
2. Install the alternator on the engine. Install the two alternator mounting capscrews (top and bottom), but do not tighten them yet.
3. Install the alternator drive belt on the pulleys. If installing a new pulley or a new alternator, tighten the pulley nut 75 lbf·ft (102 N·m).

NOTE: The Detroit Diesel belt tensioner automatically adjusts the drive belt to the correct tension. If the belt slips, repair or replace the tensioner. For instructions, see the engine manufacturer's service literature.

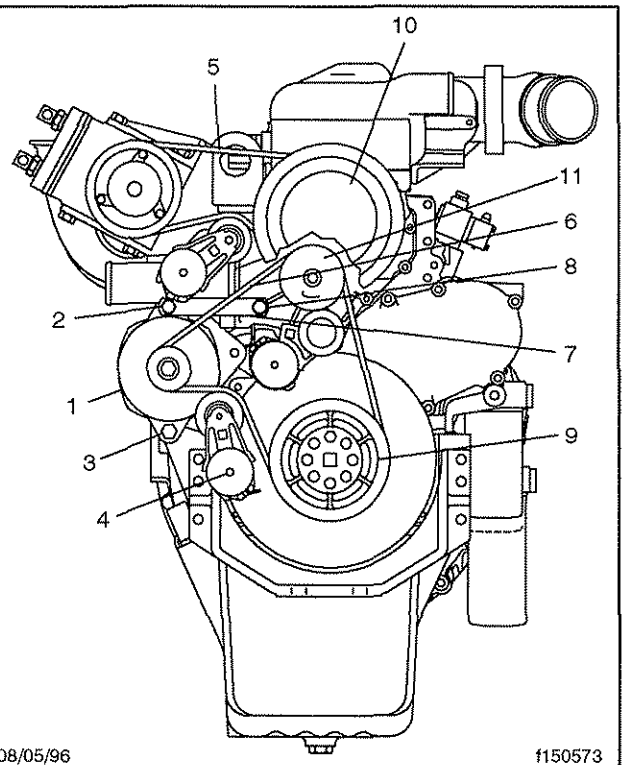
4. Tighten both alternator mounting capscrews 65 lbf·ft (88 N·m).
5. Connect all leads to the back of the alternator as previously marked. Tighten the output terminal nut 100 lbf·in (1140 N·cm). Tighten the ground terminal nut 65 lbf·in (740 N·cm). For other terminals, tighten the nut 20 lbf·in (220 N·cm).
6. Spray any exposed terminal connectors with dielectric red enamel. See **Table 1**.



1. Ground (G) Terminal
2. Output (BAT) Terminal

Fig. 2, Battery Lead Connections

JB Series Alternator Removal and Installation, DDC 55



Rotate the belt tensioner down and off the belt.

NOTE: Fan pulley cut away and fan drive belt removed to show alternator pulley and drive belt more clearly.

1. JB Series Alternator
2. Alternator Mounting Capscrew, Top
3. Alternator Mounting Capscrew, Bottom
4. Alternator Belt Tensioner
5. Refrigerant Compressor Drive Belt
6. Alternator Drive Belt
7. Alternator Adjusting Strap
8. Alternator Adjusting Strap Mounting Capscrew
9. Vibration Damper
10. Fan Pulley
11. Alternator Pulley

Fig. 3, Alternator Installation, Detroit Diesel Series 55 Engine

Protectant Material	Approved Brand
Dielectric Red Enamel Spray	MMM 1602 IVI–Spray Sealer, Red Electric Grade (Spray-On B–6–665)

Table 1, Approved Dielectric Red Enamel

7. Connect the batteries.
8. Install the lower radiator tube. See **Fig. 1**.
9. Fill the radiator. For instructions, see **Section 20.01, Subject 100**.
10. Before returning the vehicle to operation, test the alternator DC output voltage. For instructions, see "Alternator Voltage Test" in **Troubleshooting, 300**.

Adjustment

NOTE: Before checking or adjusting the alternator voltage, check the wiring, connections, and belt tension.

1. Turn off all accessories. Run the engine at fast idle (approximately 1200 RPM) and charge the batteries.
2. Connect an accurate voltmeter across the batteries to determine the charging voltage. If the voltage is below 13.8V, or above 14.1V, adjust the voltage regulator.
3. Shut down the engine.
4. If needed, adjust the charging voltage.
   - 4.1 Remove the small black cap on the regulator cover to expose the adjustment screw.
   - 4.2 Using a small screwdriver, turn the adjusting screw until the voltage is between 13.8V and 14.1V.
     - To increase the voltage, turn the adjusting screw clockwise.
     - To decrease the voltage, turn the adjusting screw counterclockwise.
5. Run the engine at fast idle (approximately 1200 RPM) and check the voltage again to make sure it has been properly adjusted. Readjust as necessary.

NOTE: If adjustment does not bring the voltage into the proper range, replace the voltage regulator.

6. Shut down the engine.
7. Replace the plastic cap on the access hole over the adjusting screw.

Troubleshooting

Many alternators have been replaced that later investigation reveals were working properly. This may be due to incorrectly diagnosing the problem.

IMPORTANT: Before testing, make sure:

- All belts are correctly tightened;
- The wiring and terminals are clean and in good condition;
- All terminal nuts are torqued and properly protected.

To troubleshoot the SmartChek™ diagnostic alternator perform the following steps:

1. With the engine off, clean the top of the regulator using a shop cloth until you can see the SmartChek indicator.
2. Start the engine. If the SmartChek indicator glows red, replace the alternator.

   If the indicator glows green, go to the next step.
3. Turn on several vehicle accessories, such as lights and heater fans. If the green indicator changes to red, replace the alternator.

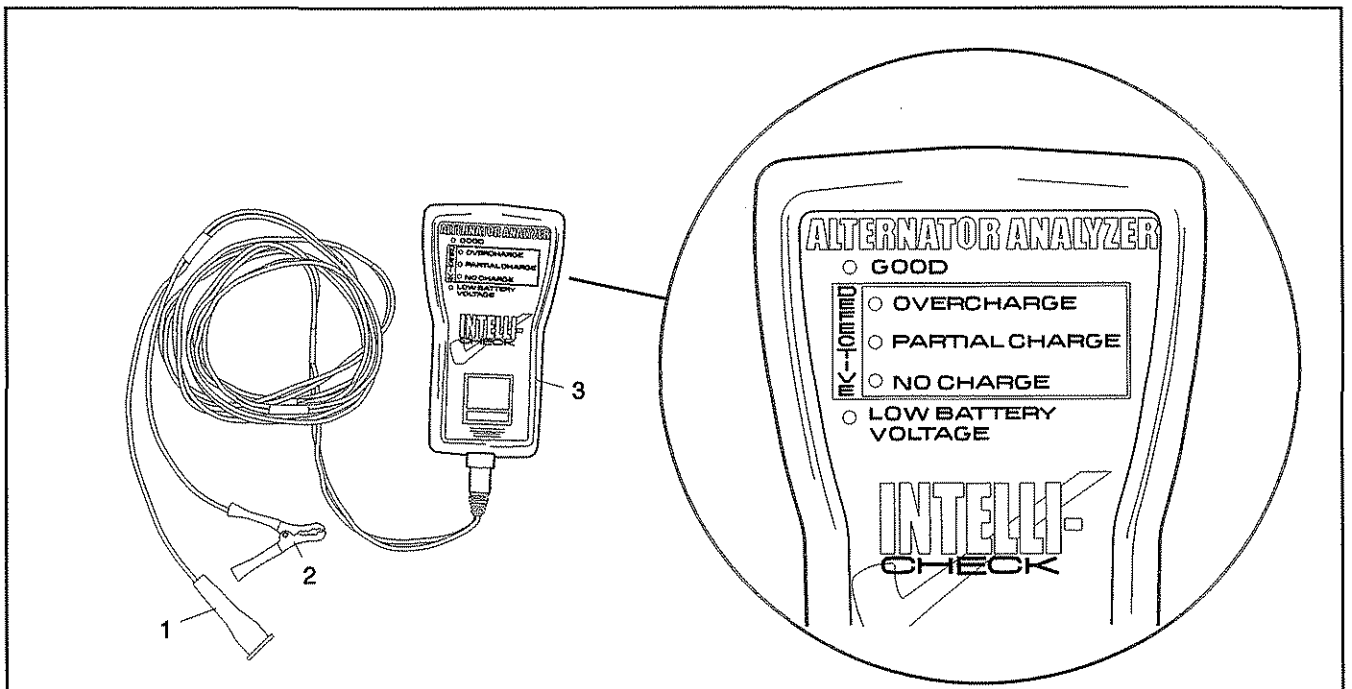
   If the indicator continues to glow green, the alternator is OK. Check the other components of the electrical system.

Delco Remy has an alternator testing tool called the Intelli-Check Alternator Analyzer. See **Fig. 1**. This tool (DR 10457848, a single tester, or DR 10457865, a four-pack of testers) is to be used as a quick check of the alternator to see if it is working correctly.

NOTE: If you do not have the Delco Intelli-Check Tester, or if the alternator rated output is above 145 amps, or if a total vehicle charging system analysis is required, see "Alternator/Charging System Testing."

Intelli-Check Alternator Analyzer

The following information includes a pre-test procedure and operating instructions for the Delco Intelli-Check



1. Red Alligator Clip
2. Black Alligator Clip
3. Hand-Held Alternator Analyzer

Fig. 1, Delco Remy Intelli-Check Alternator Analyzer

Troubleshooting

Tester, and is similar to the procedures provided by Delco with the Intelli-Check Tester.

Pre-Test Procedure (Engine Off)

1. Inspect the alternator connections to verify that all terminals are secured and tight. Verify that the sense wire is connected to the sense terminal on vehicles equipped with remote-sense alternators.
2. With the engine off, connect the red alligator clip to the output terminal of the alternator. Connect the black alligator clip to the alternator ground. An optional ground connection is to the body of the alternator. The tester LEDs will illuminate and then go off as it performs a self-test.
3. After 4 seconds the tester will activate. The following LEDs may illuminate depending on the condition of the batteries:
    - **GOOD** (green) LED indicates the battery voltage is above 12.8 and has a surface charge. The surface charge must be removed before proceeding with the alternator test. To remove the surface charge, do the following:
        A. Turn on the headlights and blower motor for 2 minutes without restarting the engine.
        B. Reset the tester by disconnecting, then reconnecting the tester alligator clips. The analyzer will again perform its self-test.
        C. Repeat the applicable steps of the Pre-Test Procedure.
    - **NO CHARGE** (red) LED indicates the battery voltage is below 12.8. This LED should illuminate for most tests. Proceed with the alternator test.
    - **LOW BATTERY VOLTAGE** (blue) LED indicates the battery voltage is below 12.35. If the batteries will start the vehicle, proceed with the alternator test. However, after completing the Intelli-Check alternator test, perform the procedures under "Alternator/Charging System Testing" to determine the condition of the rest of the charging system.

Tester Operating Instructions (Engine Running)

1. Start the engine using onboard batteries only. If the batteries will not start the engine, they must be charged for 2 hours. Start the test again after charging the batteries.
2. Verify the engine is at idle and all electrical loads are off.
3. Depress the accelerator to governed speed, hold for 10 seconds, then return to idle.
    - If the **GOOD** (green) LED illuminates, proceed to the next step.
    - If any LEDs illuminate indicating overcharge, partial charge or no charge (the three red lights in the **DEFECTIVE** section), replace the alternator and run the complete test again.
    - If the **LOW BATTERY VOLTAGE** (blue) LED illuminates, evaluate the charging system using the instructions in "Alternator/Charging System Testing."
4. With the engine running, turn on all electrical loads.
5. Depress the accelerator to governed speed, hold for 10 seconds, then return to idle.
6. If the **GOOD** (green) LED illuminates, the alternator is OK and the test is complete.

NOTE: If the alternator tests OK in the above tests, and the customer's complaint is reduced battery or headlight life, see "Alternator/Charging System Testing" to completely analyze the charging system.

7. If any LEDs illuminate indicating overcharge, partial charge or no charge (the three red lights in the **DEFECTIVE** section), replace the alternator and run the complete test again.
8. If the **LOW BATTERY VOLTAGE** (blue) LED illuminates, evaluate the charging system using the instructions in "Alternator/Charging System Testing."

Alternator/Charging System Testing

Battery Open Circuit Voltage Test, Alternator Output Voltage Test and Alternator Amperage Output Test

1. Use a digital volt-ohmmeter (VOM) set on the 2-20VDC (or similar) scale to test the battery open circuit voltage (OCV). With the engine shut down and the voltmeter set up as shown in **Fig. 2**, check for voltage of 12.4 volts or more.

   If the OCV is 12.4 volts or more, turn on the vehicle headlights for approximately 3 minutes.

   If the OCV is less than 12.4 volts, charge the batteries properly. For instructions, see **Group 54**.

IMPORTANT: Be sure to disconnect the batteries or remove them from the vehicle before charging.

2. Check the alternator output without a load. See **Fig. 3**.

   2.1 Start the engine and run it at 1500 rpm for 3 to 5 minutes to stabilize the system before proceeding to the next step.

   2.2 Connect the positive (+) lead of the digital voltmeter (still set on the 2-20VDC or similar scale) to the alternator (battery) terminal. Connect the negative (–) lead of the voltmeter to the alternator negative (–) ground terminal. See **Fig. 3**.

   2.3 If the voltmeter reads from 13.8 to 14.2 volts, record this reading (V1) and go to the next step. If the alternator reads less than 13.8 volts and is adjustable, try to adjust the voltage regulator to 13.8 to 14.2 volts. If unable to obtain acceptable output, replace the alternator.

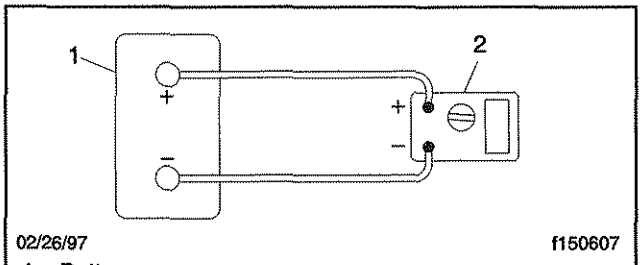
3. Check the alternator output under load. See **Fig. 3**.

   3.1 Attach a clamp-on induction ammeter around the positive (+) wire. See **Fig. 3**.

   NOTE: Locate the ammeter at least 6 inches (15 cm) away from the alternator.

   3.2 With the engine still running at 1500 rpm, turn on the following electrical accessories to load the alternator until the ammeter reads 60 to 75 amps.

   - Both front and rear heater blowers (on HIGH)
   - Headlights (high beams)
   - Road lights
   - Interior lights



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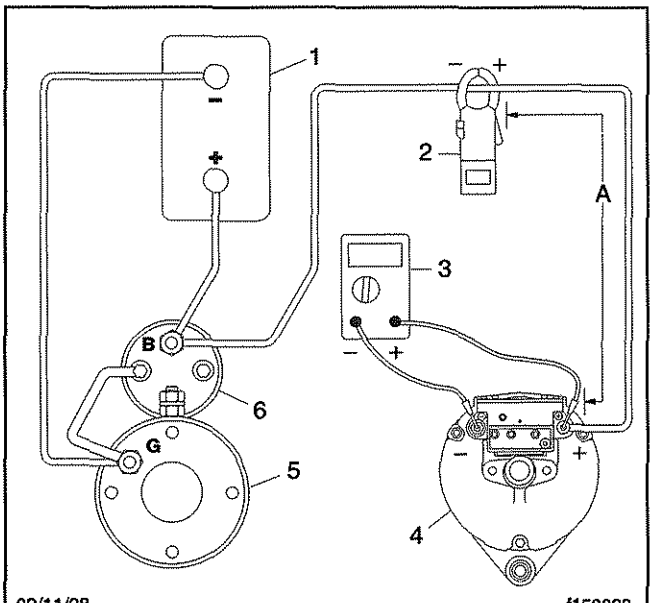
1. Battery
2. Digital Voltmeter

Fig. 2, Setup 1: Battery Open Circuit Voltage (and alternator amperage output)



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A. Locate the ammeter at least 6 inches (15 cm) away from the alternator.

1. Battery
2. Ammeter
3. Digital Voltmeter
4. Alternator
5. Cranking Motor
6. Solenoid

Fig. 3, Setup 2: Alternator Output Voltage

Troubleshooting

NOTE: As an alternate method of putting load on the alternator, connect a carbon pile tester and set it to 60 to 75 amps.

3.3 Keep the voltmeter connected as in the previous step; positive (+) lead connected to the alternator positive (+) terminal; negative (–) lead connected to the alternator negative (–) terminal.

3.4 If the voltmeter reads from 13.6 to 14.2 volts, record this reading (V2) and go to the next step.

If the voltmeter reads less than 13.6 volts, replace the alternator.

4. Perform an alternator amperage output test.

4.1 Connect a carbon pile tester across the vehicle batteries as shown in **Fig. 2**.

NOTE: **Figure 2** shows a voltmeter, but the connections for the carbon pile tester are the same.

4.2 Attach a clamp-on induction ammeter around the alternator output wire. See **Fig. 3**.

NOTE: Locate the ammeter at least 6 inches (15 cm) away from the alternator.

4.3 Start the engine and make sure all vehicle electrical accessories are turned off. Run it at fast speed and adjust the tester to the alternator maximum current output. Record this output value.

NOTE: Ensure that the alternator is turning at maximum available rpms and keep adjusting the tester dial until the ammeter reads its highest value.

4.4 Turn off the tester and shut down the engine.

4.5 If the output value recorded is less than 85 percent of the rated amperage output, repeat the test. If the output value recorded is still less than 85 percent of the rated amperage output, replace the alternator.

4.6 Make sure that all test instruments are removed and that the vehicle wiring is returned to its operational state.

5. To identify other problem areas within the vehicle, check the operation of the charging system. Set up the voltmeter as shown in **Fig. 2** and **Fig. 3**.

NOTE: For any load at 1500 rpm or more, battery voltage must be within 0.5 volts of the alternator voltage.

5.1 If readings at the batteries are within 0.5 volts of the readings at the alternator, the charging system is working correctly. Check other areas of the vehicle to locate the problem.

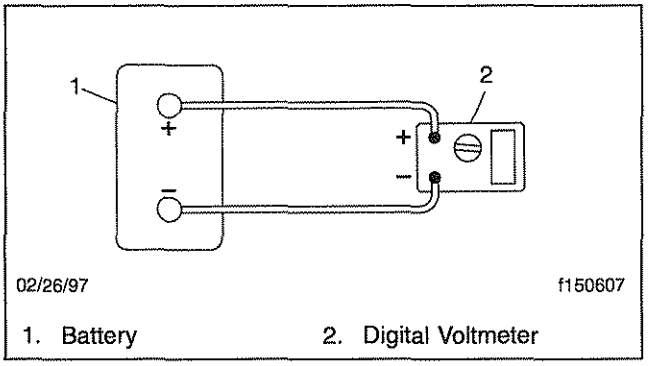
5.2 If the reading at the batteries is more than 0.5 volts lower than the reading at the alternator, do the next step.

6. Check charging system connections, cables and terminals.

6.1 Check all connections between the battery, starter and alternator for tightness and signs of corrosion. Tighten and clean as necessary.

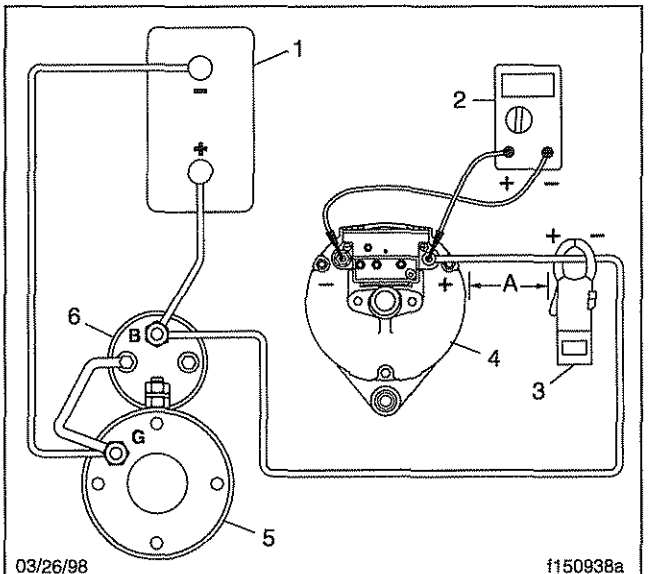
6.2 Check all cables for breaks or partial breaks. Repair or replace as necessary.

6.3 Check each ring terminal for breakage at the point where it attaches to its wire or cable.



1. Battery 2. Digital Voltmeter

Fig. 2, Test #1: Battery Open Circuit Voltage



A. Locate the ammeter at least six inches (15 cm) away from the alternator.

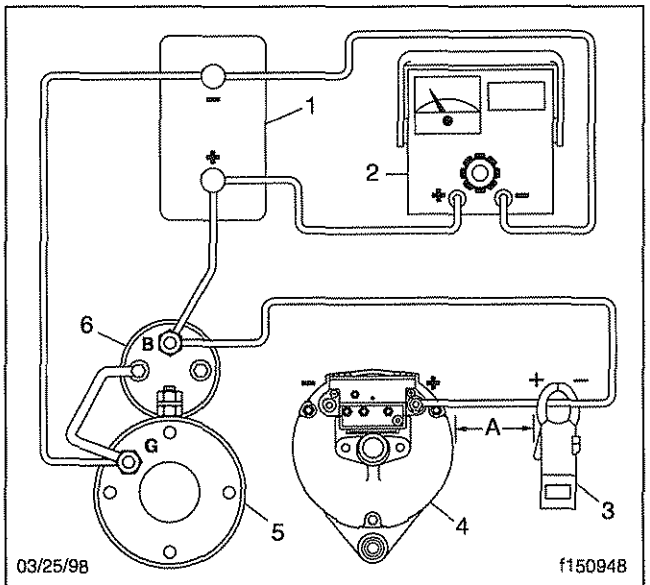
1. Battery
2. Digital Voltmeter
3. Ammeter
4. Alternator
5. Cranking Motor
6. Solenoid

Fig. 3, Test #2: Alternator Output Voltage

1.6 Make sure that all test instruments are removed and that the vehicle wiring is returned to its operational state.

2. To identify other problem areas within the vehicle, check the operation of the charging system.

NOTE: For any load at 1500 rpm or more, battery voltage must be within 0.5 volts of the alternator voltage.



A. Locate the ammeter at least six inches (15 cm) away from the alternator.

1. Battery
2. Carbon Pile Tester
3. Ammeter
4. Alternator
5. Cranking Motor
6. Solenoid

Fig. 4, Test #3: Alternator Amperage Output

2.1 Check the battery open circuit voltage as shown in **Fig. 2**. Make a note of this reading.

2.2 Check the alternator voltage output as shown in **Fig. 3**. Make a note of this reading also.

2.3 Compare the two readings. If the reading at the batteries is within 0.5 volts of the reading at the alternator, the charging system is working correctly. Check other areas of the vehicle to locate the problem.

If the reading at the batteries is more than 0.5 volts lower than the reading at the alternator, do the next step.

3. Check charging system connections, cables, and terminals.

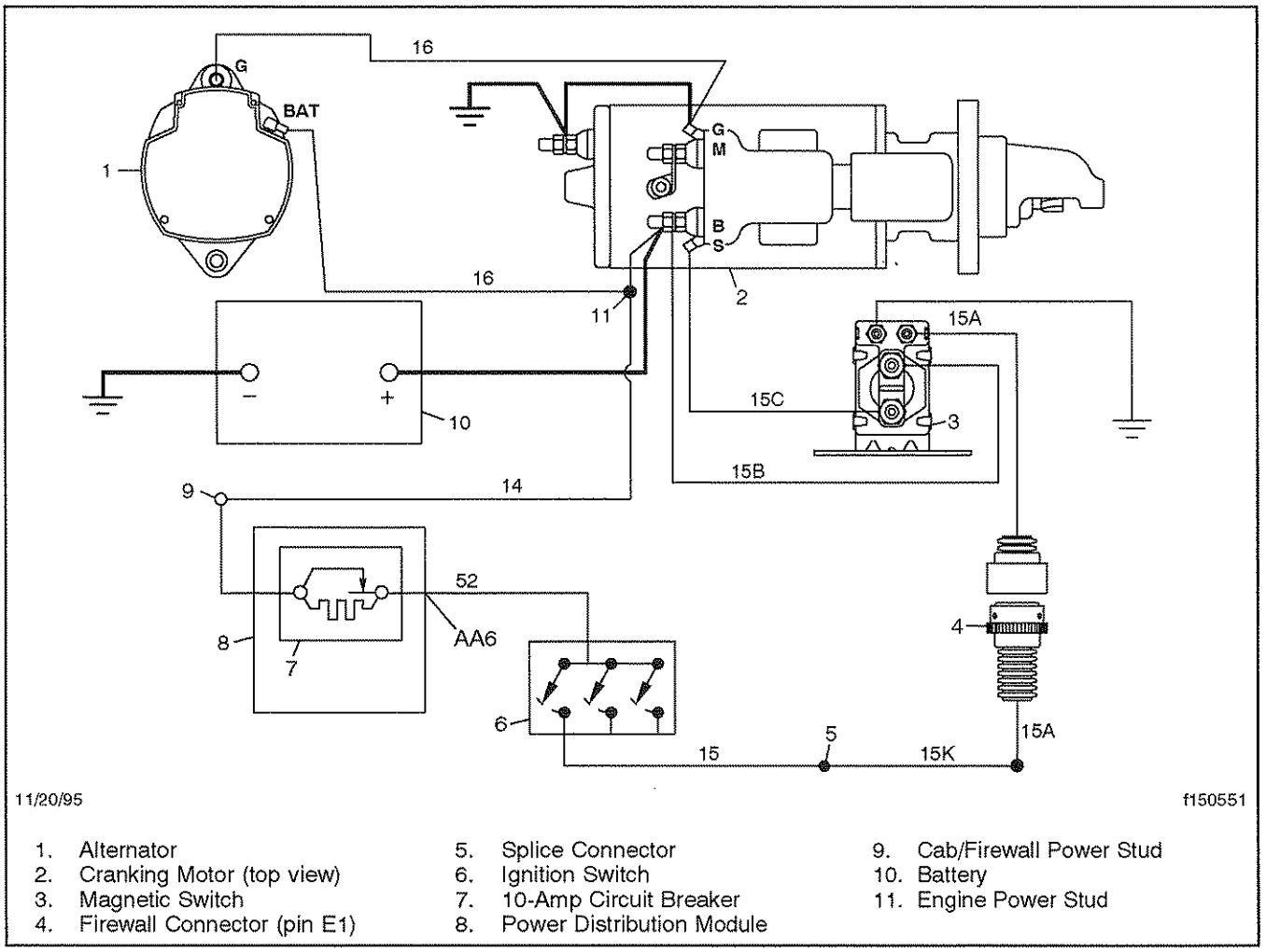
3.1 Check all connections between the battery, starter, and alternator for tightness and signs of corrosion. Tighten and clean as necessary.

Troubleshooting

3.2 Check all cables for breaks or partial breaks. Repair or replace as necessary.

3.3 Check each ring terminal for breakage at the point where it attaches to its wire or cable.

See **Fig. 1** for a charging circuit wiring diagram.



1. Alternator
2. Cranking Motor (top view)
3. Magnetic Switch
4. Firewall Connector (pin E1)
5. Splice Connector
6. Ignition Switch
7. 10-Amp Circuit Breaker
8. Power Distribution Module
9. Cab/Firewall Power Stud
10. Battery
11. Engine Power Stud

Fig. 1, Charging Circuit Wiring Diagram

Description	Grade	Size	Torque: lbf·in (N·cm)
Alternator Output ("BAT") Terminal Nut	5	5/16–18	100 (1140)
Alternator Ground ("G") Terminal Nut	5	1/4–20	65 (740)
Instrument ("I") or Relay ("R") Terminal Nut	8.8	M4	20 (220)

Table 1, Terminal Fastener Torques, All Engines

Description	Grade	Size	Torque: lbf·ft (N·m)
Pulley Nut	8PO	1/2–20	75 (102)

Table 2, Pulley Nut Torque, All Engines

Specifications

Mounting Fastener Torques, Caterpillar Engines			
Description	**Grade**	**Size**	**Torque: lbf.ft (N.m)**
Caterpillar 3406 Engine			
End Link Mounting Capscrew	8PO	1/2–13	65 (88)
Alternator Mounting Capscrew	8PO	1/2–13	65 (88)
Adjusting Rod Mounting Capscrew	8PO	1/2–13	65 (88)
Adjusting Rod Jam Nut	5	1/2	65 (88)
Alternator Bracket Capscrews	10.9PO	M12	65 (88)
Caterpillar C–10/C–12 Engine			
Alternator Mounting Capscrews	8PO	1/2–13	65 (88)
Adjusting Strap Mounting Capscrew	10.9PO	M12	65 (88)

Table 3, Mounting Fastener Torques, Caterpillar Engines

Mounting Fastener Torques, Cummins Engines			
Description	**Grade**	**Size**	**Torque: lbf.ft (N.m)**
Cummins N14 Engine			
End Link Mounting Capscrew	8PO	1/2–13	65 (88)
Alternator Mounting Capscrew	8PO	1/2–13	65 (88)
Adjusting Rod Mounting Capscrew	8PO	7/16–20	50 (68)
Adjusting Rod Jam Nut	5	5/8	95 (130)
Alternator Bracket Fasteners	5PO	3/8–16	34 (46)
Cummins M11 Engine			
Adjusting Block Mounting Bolt	10.9PO	M10	30 (41)
Alternator Mounting Capscrew	8PO	1/2–13	65 (88)
Adjusting Screw Locknut	5	5/8	95 (130)
Adjusting Arm Mounting Capscrew	5	1/2–13	55 (75)
Alternator Bracket Fasteners	10.9PO	M10	34 (46)

Table 4, Mounting Fastener Torques, Cummins Engines

Mounting Fastener Torques, Detroit Diesel Engines			
Description	**Grade**	**Size**	**Torque: lbf.ft (N.m)**
Detroit Diesel Series 60 Engine			
End Link Mounting Capscrew	8PO	1/2–13	65 (88)
Alternator Mounting Capscrew	8PO	1/2–13	65 (88)
Adjusting Rod Mounting Capscrew	10.9PO	M10	50 (68)
Adjusting Rod Jam Nut	5	5/8	95 (130)
Alternator Bracket Fasteners	10.9PO	M10	50 (68)

Mounting Fastener Torques, Detroit Diesel Engines			
Description	**Grade**	**Size**	**Torque: lbf·ft (N·m)**
Detroit Diesel Series 55 Engine			
Alternator Mounting Capscrews	8PO	1/2–13	65 (88)
Adjusting Strap Mounting Capscrew	8PO	1/2–13	65 (88)

Table 5, Mounting Fastener Torques, Detroit Diesel Engines

Contents

Subject	Subject Number
General Information	050
Service Operations	
30/33–SI Alternator Removal and Installation, Cummins N14	100
30/33–SI Alternator Removal and Installation, Cummins M11	110
30/33–SI Alternator Removal and Installation, Caterpillar 3406	120
30/33–SI Alternator Removal and Installation, Caterpillar C–10/C–12	130
30/34–SI and 34–SI QuadMount Alternator Removal and Installation, DDC 60	140
30/33–SI Alternator Removal and Installation, DDC 55	150
Troubleshooting	300
Specifications	400

General Information

The Delco Remy 30–SI series alternator features an integrated-circuit regulator mounted inside the end frame. See **Fig. 1** for cutaway end and sectional views.

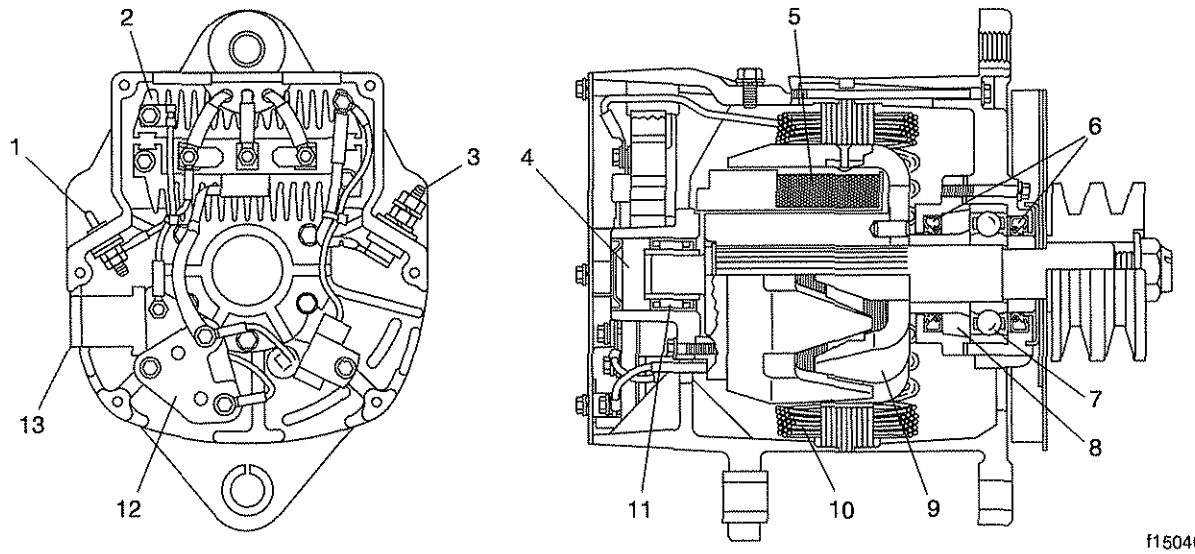
The Delco Remy 33–SI series alternator is an updated version of the 30–SI. It offers more output (135 amp maximum, instead of 105) and a higher performance curve. See **Fig. 2** for an end view cut away to show the regulator.

The 34–SI alternator is a specialized version of the 33–SI model, with two upper adjusting lugs for reduced susceptibility to vibration. It is installed only on the DDC Series 60 engine.

The only moving part in the assembly is the rotor, which is mounted on a ball bearing at the drive end, and a roller bearing at the rectifier end. For a sectional view, see **Fig. 1** for the 30–SI and **Fig. 3** for the 33–SI. The 34–SI is similar to the 33–SI. All current-carrying conductors are stationary. These conductors are the field-winding stator components. The regulator and diodes are enclosed in a sealed compartment.

A fan located on the drive end provides airflow for cooling. All bearings are sealed so that no periodic maintenance is required.

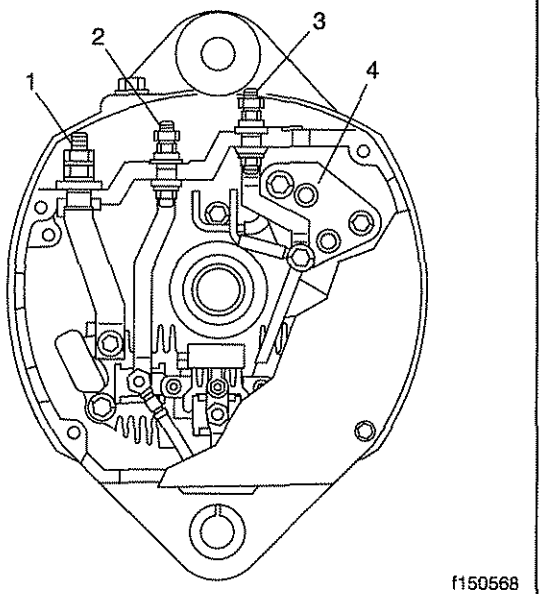
Only one wire connects the alternator to the battery, along with a ground return. See **Fig. 4** for terminal placement on the 30–SI, and **Fig. 5** for terminal placement on the 33–SI and 34–SI. Since the vehicle's system is negative ground, the output terminal connects to the battery's positive terminal. A relay terminal labeled "R" is available for use in some circuits to operate auxiliary equipment.



1. Relay Terminal
2. Rectifier Bridge
3. Output Terminal
4. Grease Reservoir, Rectifier End
5. Stationary Field Coil (brushless construction)
6. Lip Seals
7. Ball Bearing
8. Grease Reservoir, Drive End
9. Rotor
10. Stator
11. Roller Bearing with Lip Seal
12. Integrated-Circuit Regulator
13. External Voltage Adjustment

Fig. 1, 30-SI End View and Sectional View

General Information



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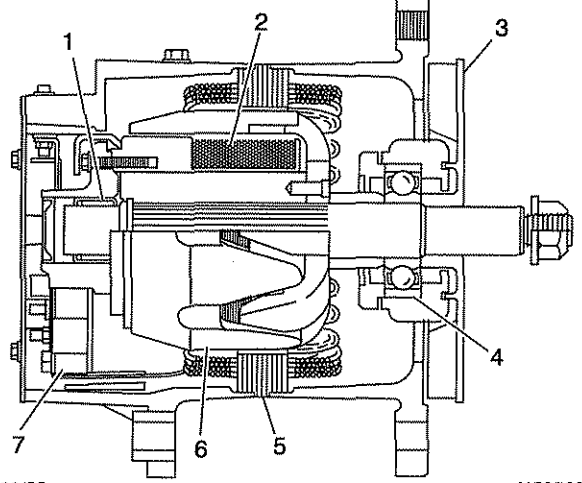
1. Output Terminal
2. Relay Terminal
3. Indicator Light Terminal
4. Voltage Regulator

Fig. 2, 33-SI End View



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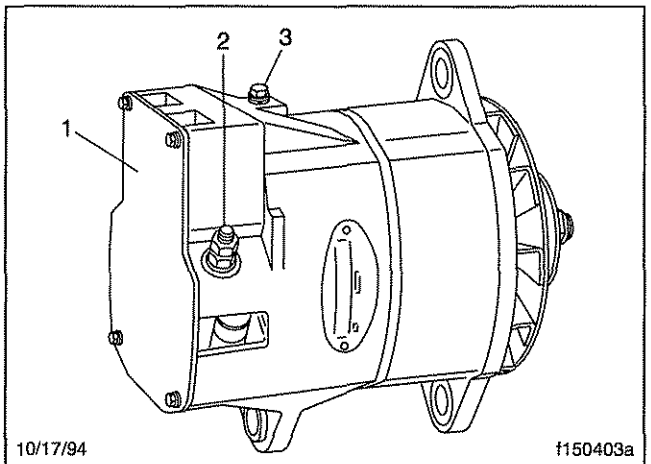
1. Roller Bearing
2. Stationary Field Coil (brushless construction)
3. Fan
4. Ball Bearing
5. Stator
6. Rotor
7. Rectifier Bridge

Fig. 3, 33-SI Sectional View



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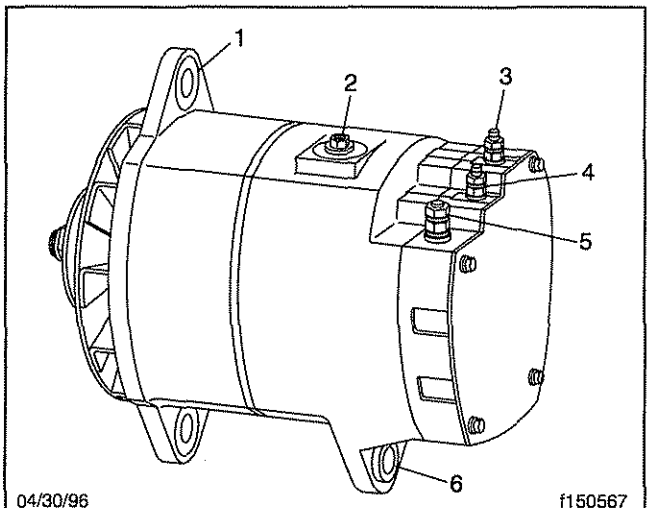
1. End Plate
2. Output Terminal
3. Ground Screw

Fig. 4, 30-SI Alternator Wiring Connectors



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1. Adjusting Lug
2. Ground (G) Terminal
3. Indicator Light (I) Terminal
4. Relay (R) Terminal
5. Output (BAT) Terminal
6. Mounting Lug

Fig. 5, 33-SI Alternator Wiring Connectors

30/33–SI Alternator Removal and Installation, Cummins N14

Removal

NOTE: Access to the alternator may be blocked by the radiator bypass tube and the heater pipe. The following information may be helpful in removing and replacing the alternator.

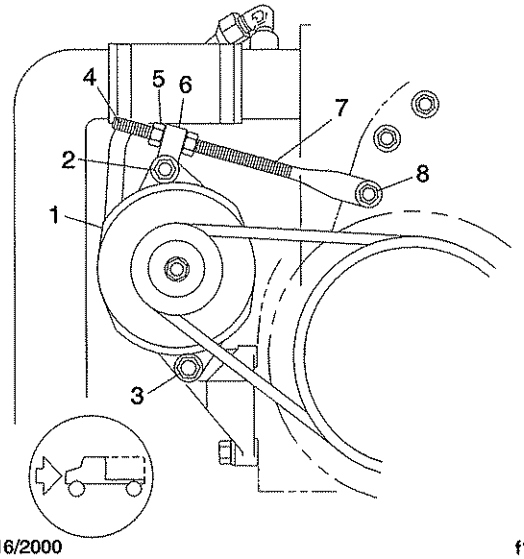
Draining the radiator and removing the heater pipe is quicker and easier than pulling the radiator fan. There are two tubes that cross over the top of the alternator. The smaller of the two is the heater pipe, while the larger one is the radiator bypass tube. The heater pipe is about 18 inches (46 cm) long and connects to a rubber hose on the frame rail. Disconnecting the brass fitting on the heater pipe where it enters the radiator bypass tube and pushing it to the side, allows easy access to the alternator. It is not necessary to remove the bypass tube.

Disconnect the electrical leads and the alternator bolts while the radiator is draining.

1. Disconnect the batteries.
2. Drain the radiator. For instructions, refer to **Group 20** in this manual.
3. Mark all electrical leads and disconnect them from the alternator.
4. Loosen the adjusting rod mounting capscrew (on the 33–SI, alternator, see **Fig. 1**; on the 30–SI, alternator, see **Fig. 2**).
5. Loosen the end link mounting capscrew and the alternator mounting capscrew (see **Fig. 1** or **Fig. 2**). Turn the adjusting nut counterclockwise, backing the alternator toward the drive pulley far enough to remove the dual drive belts without prying or twisting the belts. Remove the drive belts from the vehicle.
6. Disconnect the brass heater tube fitting at the radiator bypass tube and safely secure it out of the way.
7. Remove the adjusting rod jam nut and alternator mounting capscrew. Remove the alternator from the vehicle with the end link attached.
8. Inspect the drive belts. For instructions, see **Section 01.01, Subject 100.**

Installation

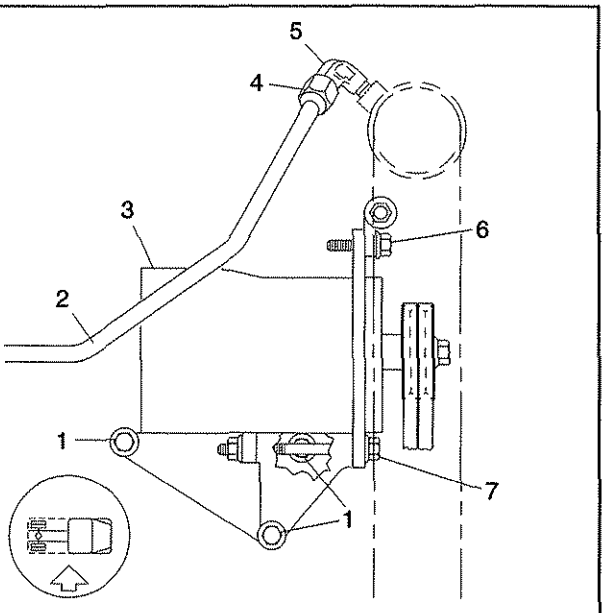
1. Check the torque of the alternator bracket fasteners. If necessary, tighten them 34 lbf·ft (46 N·m).
2. Install the alternator on the engine with the end link attached. Install the alternator mounting capscrew, but do not tighten it yet.
3. Install the drive belts on the pulleys. Do not pry or twist the belts. If installing a new pulley or a new alternator, tighten the pulley nut 75 lbf·ft (102 N·m).
4. Tighten the adjusting nut (see **Fig. 1** or **Fig. 2** until the belt is correctly tensioned. For belt tightening procedures and specifications, see **Section 01.01, Subject 110.** While holding the adjusting nut in place, install the adjusting rod jam nut and tighten it 95 lbf·ft (130 N·m).
5. Tighten the end link mounting capscrew and the alternator mounting capscrew 65 lbf·ft (88 N·m). Tighten the adjusting rod mounting capscrew 50 lbf·ft (68 N·m).



1. 33–SI Alternator
2. End Link Mounting Capscrew
3. Alternator Mounting Capscrew
4. Adjusting Rod Jam Nut
5. End Link
6. Adjusting Nut
7. Adjusting Rod
8. Adjusting Rod Mounting Capscrew

Fig. 1, 33-SI Alternator Installation, Cummins N14 Engine

30/33–SI Alternator Removal and Installation, Cummins N14



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1. Alternator Bracket Capscrew
2. Heater Tube
3. Alternator
4. Heater Tube Nut
5. Brass Heater Fitting
6. End Link Mounting Capscrew
7. Alternator Mounting Bolt

Fig. 2, 30-SI Alternator Installation, Cummins N14 Engine

6. Connect all electrical leads to the back of the alternator as previously marked. Tighten the output terminal nut 100 lbf·in (1140 N·cm). Tighten the ground terminal nut 65 lbf·in (740 N·cm). For other terminals, tighten the nut 20 lbf·in (220 N·cm).
7. Spray any exposed terminal connectors with dielectric red enamel. See **Table 1.**

Protectant Material	Approved Brand
Dielectric Red Enamel Spray	MMM 1602 IVI–Spray Sealer, Red Electric Grade (Spray-On B–6–665)

Table 1, Approved Dielectric Red Enamel

8. Connect the heater tube to the engine cooling inlet.
9. Service the radiator. For instructions, refer to **Group 20** in this manual.
10. Connect the batteries.
11. Before returning the vehicle to operation, test the alternator DC output voltage, or use the Delco Remy Intellicheck Alternator Analyzer. For instructions, see "Alternator Voltage Output Test" in **Troubleshooting, 300.**

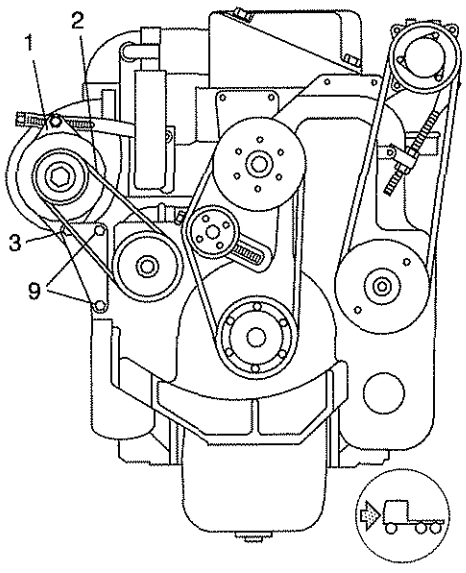
30/33–SI Alternator Removal and Installation, Cummins M11

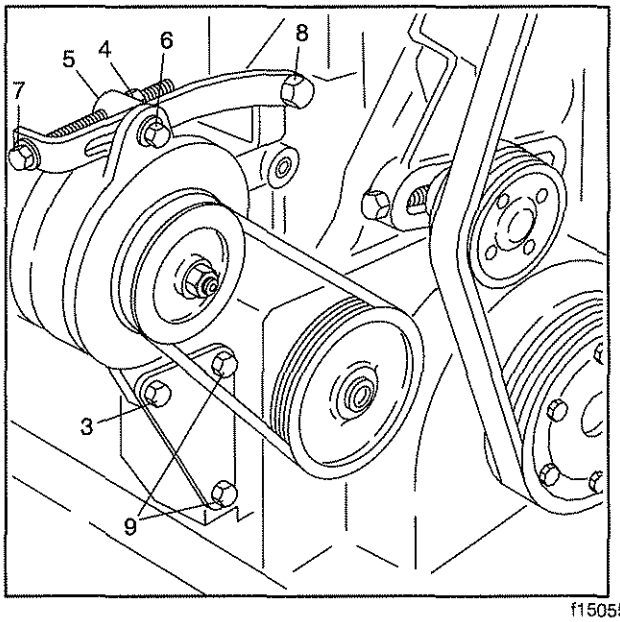
Removal

1. Disconnect the batteries.
2. Mark all electrical leads and disconnect them from the alternator.
3. Loosen the adjusting block mounting bolt, adjusting arm mounting capscrew, and alternator mounting capscrew just enough to allow movement of the alternator. See **Fig. 1**.
4. Loosen the adjusting screw locknut. See **Fig. 1**, Ref. 4. Turn the adjusting screw (Ref. 7) counterclockwise, backing off the alternator toward the drive pulley far enough to remove the drive belt without prying or twisting the belt. Remove the drive belt from the vehicle.
5. Remove the adjusting block mounting bolt and the alternator mounting capscrew. Remove the alternator from the vehicle.
6. Inspect the drive belts. For instructions, see **Section 01.01, Subject 100**.

Installation

1. Check the torque of the alternator bracket fasteners. If necessary, tighten them 34 lbf·ft (46 N·m).
2. Install the alternator on the engine. Install the adjusting block mounting bolt and the alternator mounting capscrew, but do not tighten them yet.
3. Install the drive belt on the pulleys. Do not pry or twist the belt over the pulley. If installing a new pulley or a new alternator, tighten the pulley nut 75 lbf·ft (102 N·m).
4. Turn the adjusting screw (see **Fig. 1**, Ref. 7) clockwise until the belt is correctly tensioned. For belt tightening procedures and specifications, see **Section 01.01, Subject 105**. Tighten the adjusting screw locknut (Ref. 4) 95 lbf·ft (130 N·m).
5. Tighten the alternator mounting capscrew (see **Fig. 1**, Ref. 3) 65 lbf·ft (88 N·m); tighten the adjusting block mounting bolt (Ref. 6) 30 lbf·ft





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1. 30/33–SI Alternator
2. Drive Belt
3. Alternator Mounting Capscrew
4. Adjusting Screw Locknut
5. Adjusting Block
6. Adjusting Block Mounting Bolt
7. Adjusting Screw
8. Adjusting Arm Mounting Capscrew
9. Alternator Bracket Fasteners

Fig. 1, Alternator Installation, Cummins M11 Engine

30/33–SI Alternator Removal and Installation, Cummins M11

(47 N·m); tighten the adjusting arm mounting capscrew (Ref. 8) 55 lbf·ft (75 N·m).

6. Connect all leads to the back of the alternator as previously marked. Tighten the output terminal nut 100 lbf·in (1140 N·cm). Tighten the ground terminal nut 65 lbf·in (740 N·cm). For other terminals, tighten the nut 20 lbf·in (220 N·cm).
7. Spray any exposed terminal connectors with dielectric red enamel. See **Table 1**.

Protectant Material	Approved Brand
Dielectric Red Enamel Spray	MMM 1602 IVI–Spray Sealer, Red Electric Grade (Spray-On B–6–665)

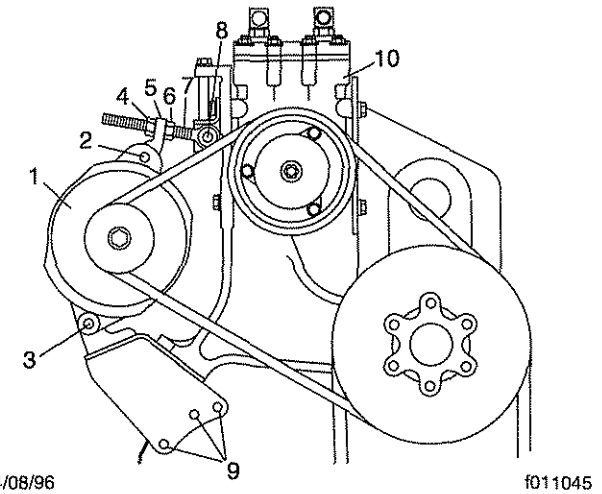
Table 1, Approved Dielectric Red Enamel

8. Connect the batteries.
9. Before returning the vehicle to operation, test the alternator DC output voltage. For instructions, see "Alternator Voltage Output Test" in **Troubleshooting, 300**.

30/33–SI Alternator Removal and Installation, Caterpillar 3406

Removal

1. Disconnect the batteries.
2. Mark all electrical leads and disconnect them from the alternator.
3. Back off the adjusting nut (see **Fig. 1**, Ref. 6). Loosen the end link mounting capscrew and the alternator mounting capscrew enough to allow movement of the alternator.
4. Push the loosened alternator far enough toward the fan drive pulley to allow removal of the drive belts without using force.
5. Slip each drive belt (dual drive belts) off the pulleys and work it over one fan blade at a time. Remove both belts from the vehicle.
6. Remove the two mounting capscrews already loosened. Remove the alternator from the vehicle.



1. 30/33–SI Alternator
2. End Link Mounting Capscrew
3. Alternator Mounting Capscrew
4. Adjusting Rod Jam Nut
5. End Link
6. Adjusting Nut
7. Adjusting Rod
8. Adjusting Rod Mounting Capscrew
9. Alternator Bracket Fasteners
10. Refrigerant Compressor

Fig. 1, Alternator Installation, Caterpillar 3406 Engine

7. Inspect the drive belts. For instructions, see **Section 01.00, Subject 100**.

Installation

1. Install the alternator on the engine. Install the end link mounting capscrew and the alternator mounting capscrew, but do not tighten them yet.
2. Make sure the distance between the pulleys is short enough to allow belt installation without using force.
3. Work each belt over the fan blades, one blade at a time. Install both drive belts on the pulleys without prying or rolling them into place. If installing a new pulley or a new alternator, tighten the pulley nut 75 lbf·ft (102 N·m). For belt tightening procedures and specifications, see **Section 01.00, Subject 110**.
4. After both belts have been correctly tensioned, tighten the adjusting rod jam nut 65 lbf·ft (88 N·m).
5. Tighten both the end link and alternator mounting capscrews 65 lbf·ft (88 N·m).
6. Connect all leads to the back of the alternator as previously marked. Tighten the output terminal nut 100 lbf·in (1140 N·cm). Tighten the ground terminal nut 65 lbf·in (740 N·cm). For other terminals, tighten the nut 20 lbf·in (220 N·cm).
7. Spray any exposed terminal connectors with dielectric red enamel. See **Table 1**.

Protectant Material	Approved Brand
Dielectric Red Enamel Spray	MMM 1602 IVI–Spray Sealer, Red Electric Grade (Spray-On B–6–665)

Table 1, Approved Dielectric Red Enamel

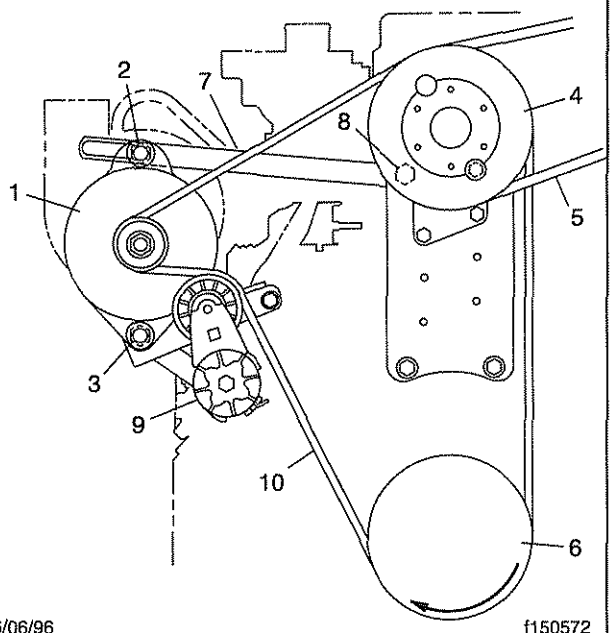
8. Connect the batteries.
9. Before returning the vehicle to operation, test the alternator DC output voltage. For instructions, see "Alternator Voltage Output Test" in **Troubleshooting, 300**.

30/33–SI Alternator Removal and Installation, Caterpillar C–10/C–12

Removal

1. Disconnect the batteries.
2. Mark all electrical leads and disconnect them from the alternator.
3. Insert a breaker bar in the belt tensioner and rotate the tensioner down and off the alternator drive belt. See **Fig. 1**.

NOTE: There are two drive belts to remove. Before removing the alternator belt, it is necessary to remove the refrigerant compressor belt from the fan pulley.



Rotate the belt tensioner down and off the belt.

1. 30/33–SI Alternator
2. Alternator Mounting Capscrew, Top
3. Alternator Mounting Capscrew, Bottom
4. Fan Pulley
5. Refrigerant Compressor Drive Belt
6. Vibration Damper
7. Alternator Adjusting Strap
8. Adjusting Strap Mounting Capscrew
9. Belt Tensioner
10. Alternator Drive Belt

Fig. 1, Alternator Installation, Caterpillar C-10/ C-12 Engine

4. Holding the belt tensioner down, remove the drive belt from the alternator pulley. Slowly release the belt tensioner and remove the breaker bar.
5. Lower the drive belt, and take it off the vibration damper. It is not necessary to remove the belt from the vehicle.
6. Remove both alternator mounting capscrews. Remove the alternator from the vehicle.

NOTE: It is not necessary to remove the adjusting strap from the engine.

7. Inspect the drive belt. For instructions, see **Section 01.00, Subject 100**.

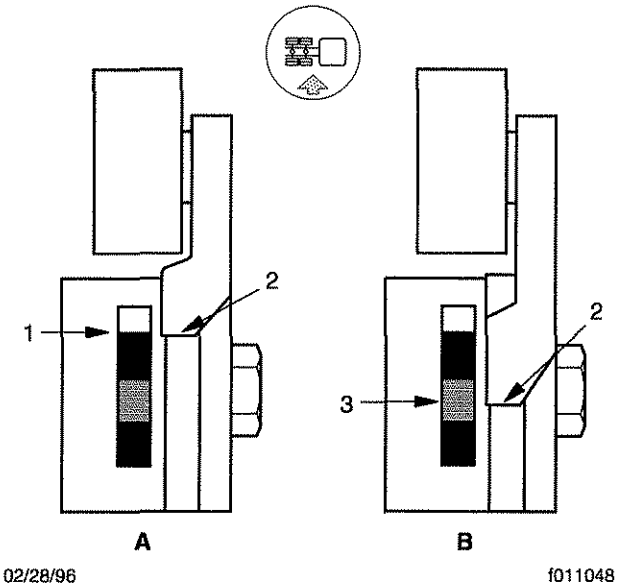
Installation

1. Check the torque of the adjusting strap mounting capscrew. If necessary, tighten it 65 lbf·ft (88 N·m).
2. Install the alternator on the engine. Install the alternator at the inboard edge of the slot initially. Install the top and bottom alternator mounting capscrews, but do not tighten them yet.
3. Install the drive belts on the pulleys, as removed. If installing a new pulley or a new alternator, tighten the pulley nut 75 lbf·ft (102 N·m). For belt tightening procedures and specifications, see **Section 01.00, Subject 105**.
4. Verify that the edge of the tensioner arm is within the green zone on the decal. See **Fig. 2**. If within the red zone, pivot the alternator outboard until the tensioner arm enters the green zone.

NOTE: If the belt slips, repair or replace the tensioner. For instructions, see the Caterpillar C–10 & C–12 Diesel Truck Engine Service Manual.

5. When the alternator is correctly positioned, tighten both alternator mounting capscrews 65 lbf·ft (88 N·m).
6. Connect all leads to the back of the alternator as previously marked. Tighten the output terminal nut 100 lbf·in (1140 N·cm). Tighten the ground terminal nut 65 lbf·in (740 N·cm). For other terminals, tighten the nut 20 lbf·in (220 N·cm).
7. Spray any exposed terminal connectors with dielectric red enamel. See **Table 1**.

30/33–SI Alternator Removal and Installation, Caterpillar C–10/C–12



A. Belt Off, No Tension
B. Belt On, Correct Tension

1. Decal
2. Edge of Tensioner Arm
3. Green Zone (operating range)

Fig. 2, Belt Tensioner With Decal

Protectant Material	Approved Brand
Dielectric Red Enamel Spray	MMM 1602 IVI–Spray Sealer, Red Electric Grade (Spray-On B–6–665)

Table 1, Approved Dielectric Red Enamel

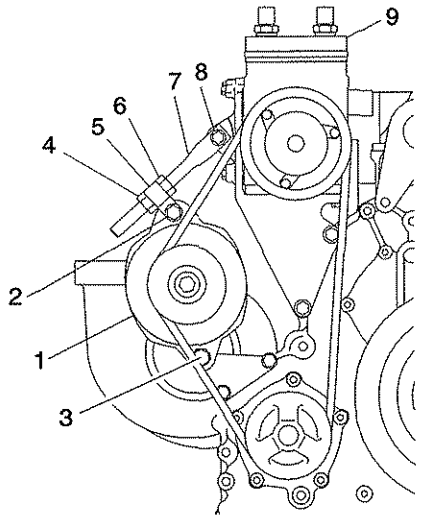
8. Connect the batteries.
9. Before returning the vehicle to operation, test the alternator DC output voltage. For instructions, see "Alternator Voltage Output Test" in **Troubleshooting, 300**.

30/34–SI and 34–SI Quadmount Alternator Removal and Installation, DDC 60

Removal

CENTURY CLASS CONVENTIONAL

1. Disconnect the batteries.
2. Mark all electrical leads and disconnect them from the alternator.
3. Loosen the adjusting rod mounting capscrew (**Fig. 1**, Ref. 8), the end link mounting capscrew (Ref. 2), and the alternator mounting capscrew (Ref. 3). Loosen these three mounting capscrews enough to allow movement of the alternator.
4. On vehicles with 34–SI alternators only, go to the rear of the alternator and loosen the alternator adjusting capscrew on the alternator strap bracket. See **Fig. 2**.
5. Loosen the tension on the drive belt by backing off the adjusting nut (**Fig. 3**, Ref. 6). Push the loosened alternator far enough toward the fan drive pulley to allow removal of the drive belt without using force.
6. Remove the drive belt from the pulleys without prying or twisting the belt.
7. On vehicles with 34–SI alternators only, remove the alternator adjusting capscrew from the alternator strap bracket.
8. Remove the end link mounting capscrew and the alternator mounting capscrew. Remove the alternator from the vehicle.
9. Inspect the drive belt. For instructions, see **Section 01.02, Subject 100**.



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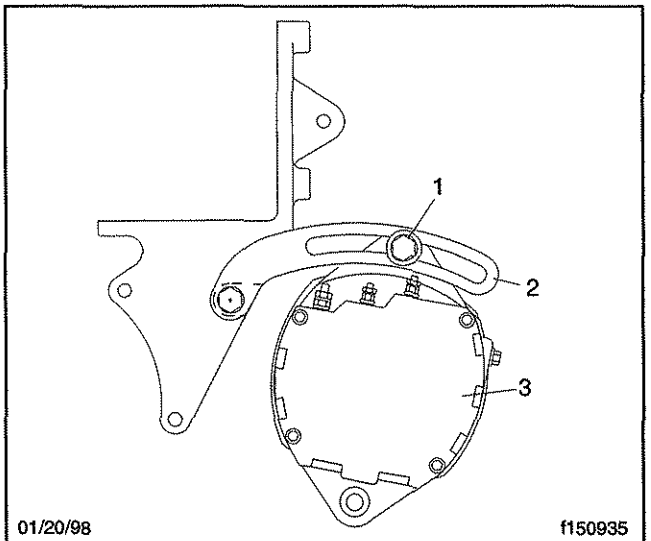
1. 30/34–SI Alternator
2. End Link Mounting Capscrew
3. Alternator Mounting Capscrew
4. Adjusting Rod Jam Nut
5. End Link
6. Adjusting Nut
7. Adjusting Rod
8. Adjusting Rod Mounting Capscrew
9. Refrigerant Compressor

Fig. 1, Alternator Installation, Detroit Diesel Series 60 Engine, Conventional

ARGOSY COE

1. Tilt the cab. For cab tilting instructions, refer to **Group 60** in this workshop manual.
2. Disconnect the batteries.
3. Mark all electrical leads and disconnect them from the alternator.
4. Loosen the tension on the belt by inserting a 1/2-inch drive ratchet into the square port at the end of the tensioner (**Fig. 3**, Ref. 5). Pull the tensioner to remove tension from the belt.



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1. Alternator Adjusting Capscrew
2. Alternator Strap Bracket
3. 34–SI Alternator

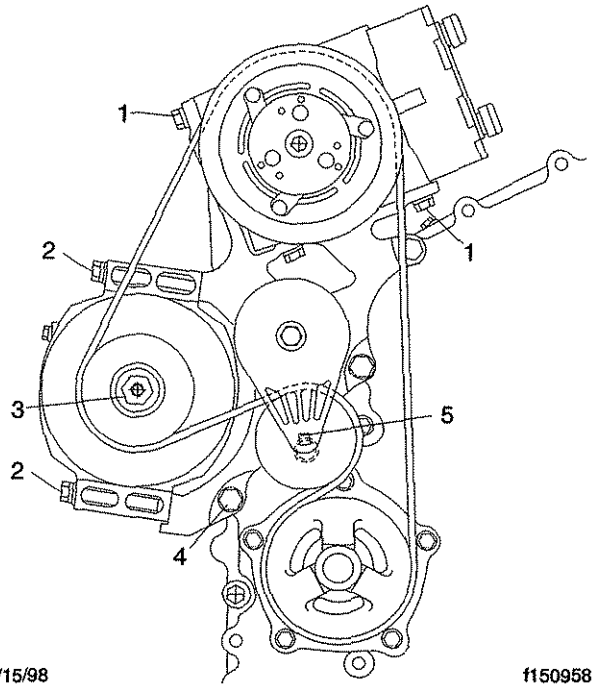
Fig. 2, 34-SI Alternator Strap Bracket, Conventional

30/34–SI and 34–SI Quadmount Alternator Removal and Installation, DDC 60

5. Remove the drive belt from the pulleys without prying or twisting the belt.
6. Support the alternator and remove the four capscrews securing the alternator to the engine (**Fig. 3**, Ref. 2). Remove the alternator from the vehicle.
7. Inspect the drive belt. For instructions, see **Section 01.02, Subject 100.**

34–SI QuadMount

1. Park the vehicle on a level surface, turn off all electrical loads such as lights, ignition, and accessories, set the parking brake, and chock the tires.
2. Rotate the battery switch to the OFF position or disconnect the batteries.



1. Refrigerant Compressor Mounting Capscrew, 3/8–16 x 1.75
2. Alternator Mounting Capscrew, M10 x 100
3. Alternator Pulley Nut
4. Alternator Bracket Bolt, 7/16–14 x 5.5
5. Tensioner Mounting Bolt, M12 x 80

Fig. 3, Alternator, Detroit Diesel Series 60 Engine, Argosy COE

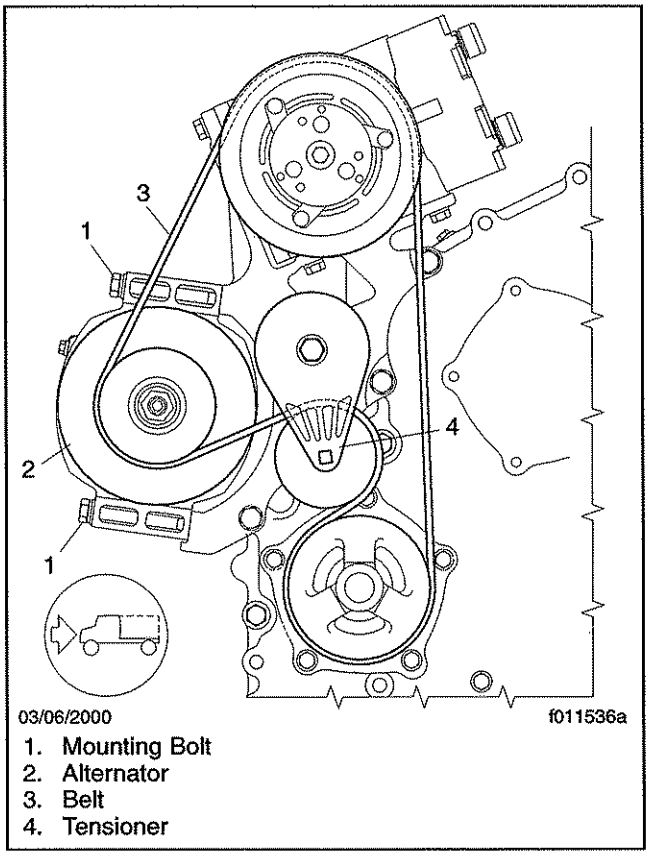
3. Tilt the hood or cab. For cab tilting instructions, refer to **Group 60** in this manual.
4. Disconnect the electrical leads attached to the alternator. Mark the terminals and wires for ease of installation.
5. Using a 1/2-inch drive wrench in the square hole of the belt tensioner, rotate the tensioner until the belt tension is relieved and remove the belt. See **Fig. 4.**
6. Support the alternator and remove the four mounting bolts and lockwashers that attach the alternator to the engine. See **Fig. 4.** Remove the alternator.

Installation

CENTURY CLASS CONVENTIONAL

1. Check the torque of the alternator bracket fasteners. If necessary, tighten them 50 lbf·ft (68 N·m).
2. Position the alternator on the engine. Install the end link mounting capscrew and the alternator mounting capscrew, but do not tighten them yet.
3. On vehicles with 34–SI alternators only, install the alternator adjusting capscrew on the alternator strap bracket.
4. Loop the drive belt around the pulleys.
5. Install the drive belt on the pulleys without prying or rolling it into place. If installing a new pulley or a new alternator, tighten the pulley nut 75 lbf·ft (102 N·m). For belt tightening procedures and specifications, see **Section 01.02, Subject 105.**
6. Tighten the adjusting rod jam nut after the belt has been correctly tensioned. Tighten the jam nut 95 lbf·ft (130 N·m).
7. Tighten the end link mounting capscrew and the alternator mounting capscrew 65 lbf·ft (88 N·m). Tighten the adjusting rod mounting capscrew 50 lbf·ft (68 N·m).
8. On vehicles with 34–SI alternators only, tighten the alternator adjusting capscrew 65 lbf·ft (88 N·m).
9. Connect all leads to the back of the alternator as previously marked. Tighten the output terminal nut 100 lbf·in (1140 N·cm). Tighten the ground termi-

30/34–SI and 34–SI Quadmount Alternator Removal and Installation, DDC 60



1. Mounting Bolt
2. Alternator
3. Belt
4. Tensioner

Fig. 4, Alternator Installation

nal nut 65 lbf·in (740 N·cm). For other terminals, tighten the nut 20 lbf·in (220 N·cm).

10. Spray any exposed terminal connectors with dielectric red enamel. See **Table 1**.

Protectant Material	Approved Brand
Dielectric Red Enamel Spray	MMM 1602 IVI–Spray Sealer, Red Electric Grade (Spray-On B–6–665)

Table 1, Approved Dielectric Red Enamel

11. Connect the batteries.
12. Before returning the vehicle to operation, test the alternator DC output voltage. For instructions, see "Alternator Voltage Output Test" in **Troubleshooting 300.**

ARGOSY COE

1. Position the alternator on the engine and install the four mounting capscrews. Tighten the capscrews 43 to 54 lbf·ft (58 to 73 N·m).
2. Loop the drive belt around the pulleys.
3. Install the drive belt on the pulleys without prying or rolling it into place. If installing a new pulley or a new alternator, tighten the pulley nut 75 lbf·ft (102 N·m). For belt tightening procedures and specifications, see **Section 01.02, Subject 105.**
4. Connect all leads to the back of the alternator as previously marked. Tighten the output terminal nut 100 lbf·in (1140 N·cm). Tighten the ground terminal nut 65 lbf·in (740 N·cm). For other terminals, tighten the nut 20 lbf·in (220 N·cm).
5. Spray any exposed terminal connectors with dielectric red enamel. See **Table 1**.
6. Connect the batteries.
7. Before returning the vehicle to operation, test the alternator DC output voltage. For instructions, see "Alternator Voltage Output Test" in **Troubleshooting 300.**
8. Return the cab to the operating position. For cab lowering instructions, refer to **Group 60** in this manual.

34–SI QuadMount

1. Locate and support the alternator.
2. Install the four mounting bolts and lockwashers that attach the alternator to the engine. Tighten the capscrews 43 to 54 lbf·ft (58 to 73 N·m).
3. Connect the wires to the alternator as previously marked. Torque the nut for the battery cable 80 to 120 lbf·in (900 to 1350 N·cm). Torque the nut for the ground cable 50 to 60 lbf·in (560 to 680 N·cm).
4. Spray any exposed terminal connectors with dielectric red enamel. See **Table 1**.
5. Rotate the battery switch to the ON position or reconnect the batteries.
6. Before returning the vehicle to operation, test the alternator DC output voltage. For instructions, see *Alternator Voltage Output Test* in **Troubleshooting, 300**, or use the Delco Remy Intellicheck.

30/34–SI and 34–SI Quadmount Alternator Removal and Installation, DDC 60

7. Return the hood or cab to the operating position. For cab lowering instructions, refer to **Group 60** in this manual.

"Alternator Voltage Output Test" in **Troubleshooting 300**.

ARGOSY COE

1. Position the alternator on the engine and install the four mounting capscrews. Tighten the capscrews 43 to 54 lbf·ft (58 to 73 N·m).
2. Loop the drive belt around the pulleys.
3. Install the drive belt on the pulleys without prying or rolling it into place. If installing a new pulley or a new alternator, tighten the pulley nut 75 lbf·ft (102 N·m). For belt tightening procedures and specifications, see **Section 01.02, Subject 105**.
4. Connect all leads to the back of the alternator as previously marked. Tighten the output terminal nut 100 lbf·in (1140 N·cm). Tighten the ground terminal nut 65 lbf·in (740 N·cm). For other terminals, tighten the nut 20 lbf·in (220 N·cm).
5. Spray any exposed terminal connectors with dielectric red enamel. See **Table 1**.
6. Connect the batteries.
7. Before returning the vehicle to operation, test the alternator DC output voltage. For instructions, see "Alternator Voltage Output Test" in **Troubleshooting 300**.
8. Return the cab to the operating position. For cab lowering instructions, refer to **Group 60** in this manual.

30/33–SI Alternator Removal and Installation, DDC 55

Removal

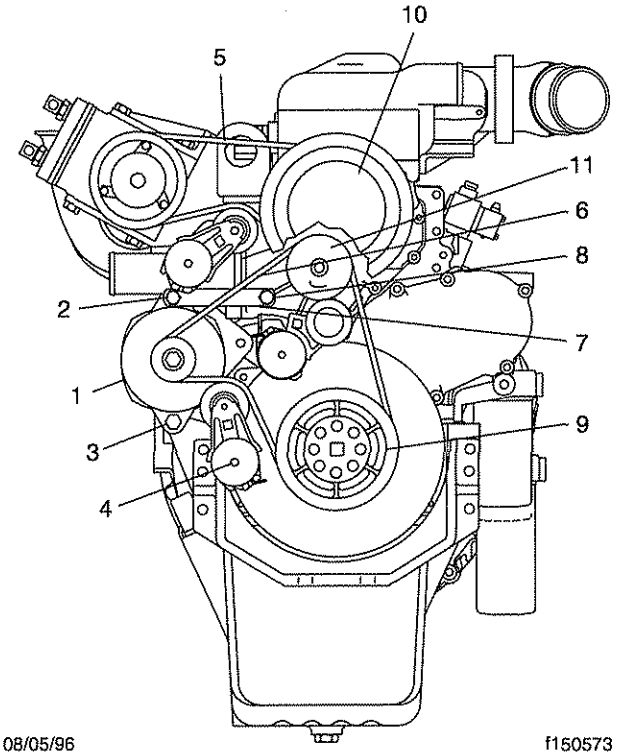
1. Disconnect the batteries.
2. Mark all electrical leads and disconnect them from the alternator.
3. Insert a breaker bar in the alternator belt tensioner (see **Fig. 1**, Ref. 4) and rotate the tensioner down and off the alternator drive belt.
4. Holding the belt tensioner down, remove the alternator belt from the alternator pulley. Slowly release the belt tensioner and remove the breaker bar.
5. Lower the drive belt, and take it off the vibration damper. It is not necessary to remove the belt from the vehicle.
6. Remove the top and bottom alternator mounting capscrews. Remove the alternator from the vehicle.
7. Inspect the drive belt. For instructions, see **Section 01.02, Subject 100**.

Installation

1. Check the torque of the adjusting strap mounting capscrew. If necessary, tighten it 65 lbf·ft (88 N·m).
2. Install the alternator on the engine. Install the two alternator mounting capscrews (top and bottom), but do not tighten them yet.
3. Install the alternator belt on the pulleys. If installing a new pulley or a new alternator, tighten the pulley nut 75 lbf·ft (102 N·m). For belt tightening procedures and specifications, see **Section 01.02, Subject 110**.

NOTE: The Detroit Diesel belt tensioner automatically adjusts the alternator belt to the correct tension. If the belt slips, repair or replace the tensioner. For instructions, see the engine manufacturer's service literature.

4. Tighten both alternator mounting capscrews 65 lbf·ft (88 N·m).
5. Connect all leads to the back of the alternator as previously marked. Tighten the output terminal nut 100 lbf·in (1140 N·cm). Tighten the ground terminal nut 65 lbf·in (740 N·cm). For other terminals, tighten the nut 20 lbf·in (220 N·cm).
6. Spray any exposed terminal connectors with dielectric red enamel. See **Table 1**.



Rotate the belt tensioner down and off the belt.

NOTE: Fan pulley cut away and fan drive belt removed to show water pump pulley and alternator drive belt more clearly.

1. 30/33–SI Alternator
2. Alternator Mounting Capscrew, Top
3. Alternator Mounting Capscrew, Bottom
4. Alternator Belt Tensioner
5. Refrigerant Compressor Drive Belt
6. Alternator Drive Belt
7. Alternator Adjusting Strap
8. Alternator Adjusting Strap Mounting Capscrew
9. Vibration Damper
10. Fan Pulley
11. Water Pump Pulley

Fig. 1, Alternator Installation, Detroit Diesel Series 55 Engine

30/33–SI Alternator Removal and Installation, DDC 55

Protectant Material	Approved Brand
Dielectric Red Enamel Spray	MMM 1602 IVI–Spray Sealer, Red Electric Grade (Spray-On B–6–665)

Table 1, Approved Dielectric Red Enamel

7. Connect the batteries.
8. Before returning the vehicle to operation, test the alternator DC output voltage. For instructions, see "Alternator Voltage Output Test" in **Troubleshooting, 300**.

Troubleshooting

Many alternators have been replaced that later investigation reveals were working properly. This may be due to incorrectly diagnosing the problem.

IMPORTANT: Before testing, make sure:

- All belts are correctly tightened;
- The wiring and terminals are clean and in good condition;
- All terminal nuts are torqued and properly protected.

Delco Remy has an alternator testing tool called the Intelli-Check Alternator Analyzer. See **Fig. 1**. This tool (DR 10457848, a single tester, or DR 10457865, a four-pack of testers) is to be used as a quick check of the alternator to see if it is working correctly.

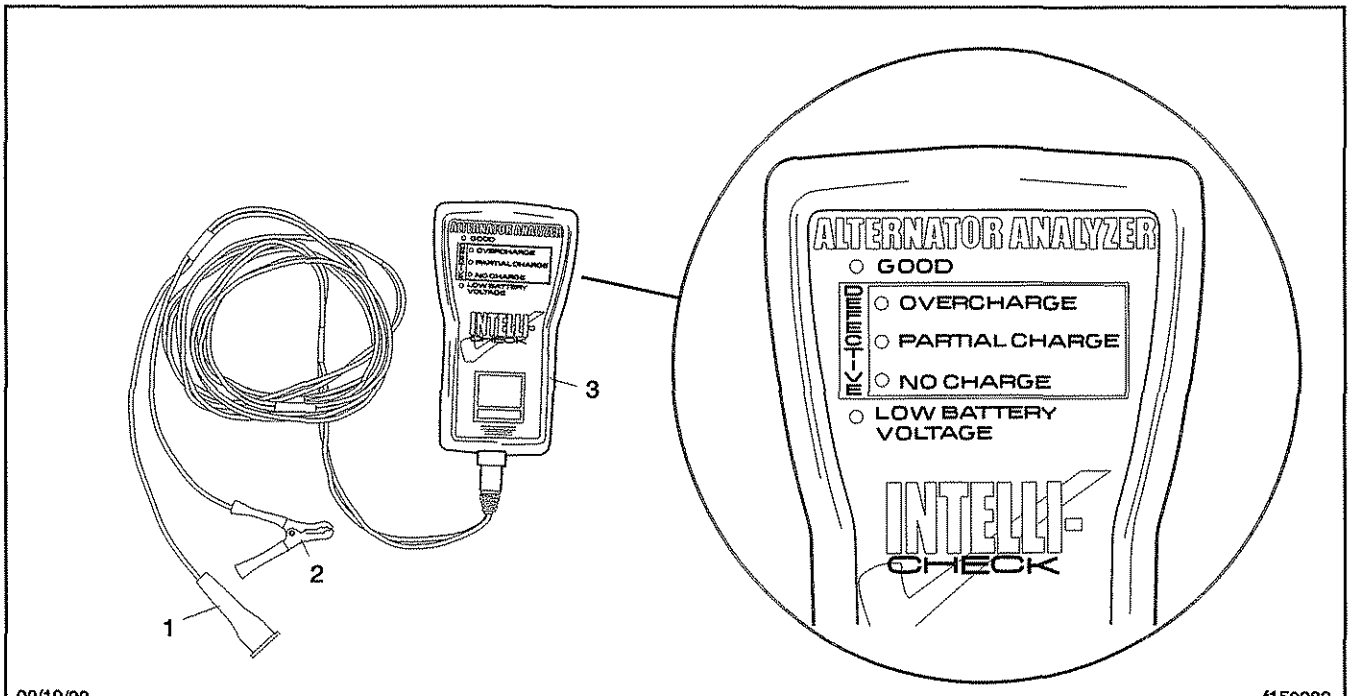
NOTE: If you do not have the Delco Intelli-Check Tester, or if the alternator rated output is above 145 amps, or if a total vehicle charging system analysis is required, see "Alternator/Charging System Testing."

Intelli-Check Alternator Analyzer

The following information includes a pre-test procedure and operating instructions for the Delco Intelli-Check Tester, and is similar to the procedures provided by Delco with the Intelli-Check Tester.

Pre-Test Procedure (Engine Off)

1. Inspect the alternator connections to verify that all terminals are secured and tight. Verify that the sense wire is connected to the sense terminal on vehicles equipped with remote-sense alternators.
2. With the engine off, connect the red alligator clip to the output terminal of the alternator. Connect the black alligator clip to the alternator ground. An optional ground connection is to the body of the alternator. The tester LEDs will illuminate and then go off as it performs a self-test.



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1. Red Alligator Clip
2. Black Alligator Clip
3. Hand-Held Alternator Analyzer

Fig. 1, Delco Remy Intelli-Check Alternator Analyzer

Troubleshooting

3. After 4 seconds the tester will activate. The following LEDs may illuminate depending on the condition of the batteries:
    - **GOOD** (green) LED indicates the battery voltage is above 12.8 and has a surface charge. The surface charge must be removed before proceeding with the alternator test. To remove the surface charge, do the following:
        A. Turn on the headlights and blower motor for 2 minutes without restarting the engine.
        B. Reset the tester by disconnecting, then reconnecting the tester alligator clips. The analyzer will again perform its self-test.
        C. Repeat the applicable steps of the Pre-Test Procedure.
    - **NO CHARGE** (red) LED indicates the battery voltage is below 12.8. This LED should illuminate for most tests. Proceed with the alternator test.
    - **LOW BATTERY VOLTAGE** (blue) LED indicates the battery voltage is below 12.35. If the batteries will start the vehicle, proceed with the alternator test. However, after completing the Intelli-Check alternator test, perform the procedures under "Alternator/Charging System Testing" to determine the condition of the rest of the charging system.

Tester Operating Instructions (Engine Running)

1. Start the engine using onboard batteries only. If the batteries will not start the engine, they must be charged for 2 hours. Start the test again after charging the batteries.
2. Verify the engine is at idle and all electrical loads are off.
3. Depress the accelerator to governed speed, hold for 10 seconds, then return to idle.
    - If the **GOOD** (green) LED illuminates, proceed to the next step.
    - If any LEDs illuminate indicating overcharge, partial charge or no charge (the three red lights in the **DEFECTIVE** section), replace the alternator and run the complete test again.
    - If the **LOW BATTERY VOLTAGE** (blue) LED illuminates, evaluate the charging system using the instructions in "Alternator/Charging System Testing."
4. With the engine running, turn on all electrical loads.
5. Depress the accelerator to governed speed, hold for 10 seconds, then return to idle.
6. If the **GOOD** (green) LED illuminates, the alternator is OK and the test is complete.

NOTE: If the alternator tests OK in the above tests, and the customer's complaint is reduced battery or headlight life, see "Alternator/Charging System Testing" to completely analyze the charging system.

7. If any LEDs illuminate indicating overcharge, partial charge or no charge (the three red lights in the **DEFECTIVE** section), replace the alternator and run the complete test again.
8. If the **LOW BATTERY VOLTAGE** (blue) LED illuminates, evaluate the charging system using the instructions in "Alternator/Charging System Testing".

Alternator/Charging System Testing

Battery Open Circuit Voltage Test, Alternator Output Voltage Test and Alternator Amperage Output Test

1. Use a digital volt-ohmmeter (VOM) set on the 2-20VDC (or similar) scale to test the battery open circuit voltage (OCV). With the engine shut down and the voltmeter set up as shown in **Fig. 2**, check for voltage of 12.4 volts or more.

    If the OCV is 12.4 volts or more, turn on the vehicle headlights for approximately 3 minutes.

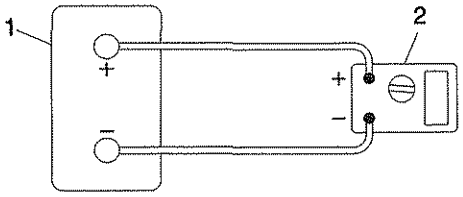
    If the OCV is less than 12.4 volts, charge the batteries properly. For instructions, see **Group 54**.

IMPORTANT: Be sure to disconnect the batteries or remove them from the vehicle before charging.

2. Check the alternator output without a load. See **Fig. 3**.

2.1 Start the engine and run it at 1500 rpm for 3 to 5 minutes to stabilize the system before proceeding to the next step.

2.2 Connect the positive (+) lead of the digital voltmeter (still set on the 2-20VDC or similar scale) to the alternator (battery) terminal. Connect the negative (–) lead of the voltmeter to the alternator negative (–) ground terminal. See **Fig. 3.**



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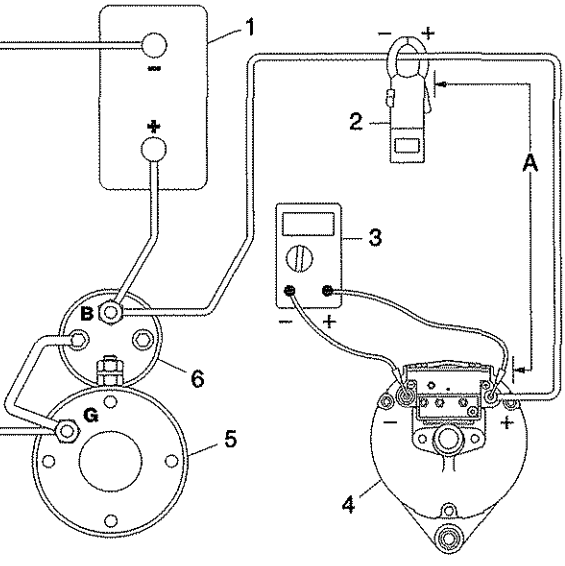
1. Battery
2. Digital Voltmeter

Fig. 2, Setup 1: Battery Open Circuit Voltage (and alternator amperage output)



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A. Locate the ammeter at least 6 inches (15 cm) away from the alternator.

1. Battery
2. Ammeter
3. Digital Voltmeter
4. Alternator
5. Cranking Motor
6. Solenoid

Fig. 3, Setup 2: Alternator Output Test

2.3 If the voltmeter reads from 13.8 to 14.2 volts, record this reading (V1) and go to the next step. If the alternator reads less than 13.8 volts and is adjustable, try to adjust the voltage regulator to 13.8 to 14.2 volts. If unable to obtain acceptable output, replace the alternator.

3. Check the alternator output under load. See **Fig. 3.**

3.1 Attach a clamp-on induction ammeter around the positive (+) wire. See **Fig. 3.**

NOTE: Locate the ammeter at least 6 inches (15 cm) away from the alternator.

3.2 With the engine still running at 1500 rpm, turn on the following electrical accessories to load the alternator until the ammeter reads 60 to 75 amps.

- Both front and rear heater blowers (on HIGH)
- Headlights (high beams)
- Road lights
- Interior lights

NOTE: As an alternate method of putting load on the alternator, connect a carbon pile tester and set it to 60 to 75 amps.

3.3 Keep the voltmeter connected as in the previous step; positive (+) lead connected to the alternator positive (+) terminal; negative (–) lead connected to the alternator negative (–) terminal.

3.4 If the voltmeter reads from 13.6 to 14.2 volts, record this reading (V2) and go to the next step.

If the voltmeter reads less than 13.6 volts, replace the alternator.

4. Perform an alternator amperage output test.

4.1 Connect a carbon pile tester across the vehicle batteries as shown in **Fig. 2.**

NOTE: **Figure 2** shows a voltmeter, but the connections for the carbon pile tester are the same.

4.2 Attach a clamp-on induction ammeter around the alternator output wire. See **Fig. 3.**

Troubleshooting

NOTE: Locate the ammeter at least 6 inches (15 cm) away from the alternator.

4.3 Start the engine and make sure all vehicle electrical accessories are turned off. Run it at fast speed and adjust the tester to the alternator maximum current output. Record this output value.

NOTE: Ensure that the alternator is turning at maximum available rpms and keep adjusting the tester dial until the ammeter reads its highest value.

4.4 Turn off the tester and shut down the engine.

4.5 If the output value recorded is less than 85 percent of the rated amperage output, repeat the test. If the output value recorded is still less than 85 percent of the rated amperage output, replace the alternator.

4.6 Make sure that all test instruments are removed and that the vehicle wiring is returned to its operational state.

5. To identify other problem areas within the vehicle, check the operation of the charging system. Set up the voltmeter as shown in **Fig. 2** and **Fig. 3.**

NOTE: For any load at 1500 rpm or more, battery voltage must be within 0.5 volts of the alternator voltage.

5.1 If readings at the batteries are within 0.5 volts of the readings at the alternator, the charging system is working correctly. Check other areas of the vehicle to locate the problem.

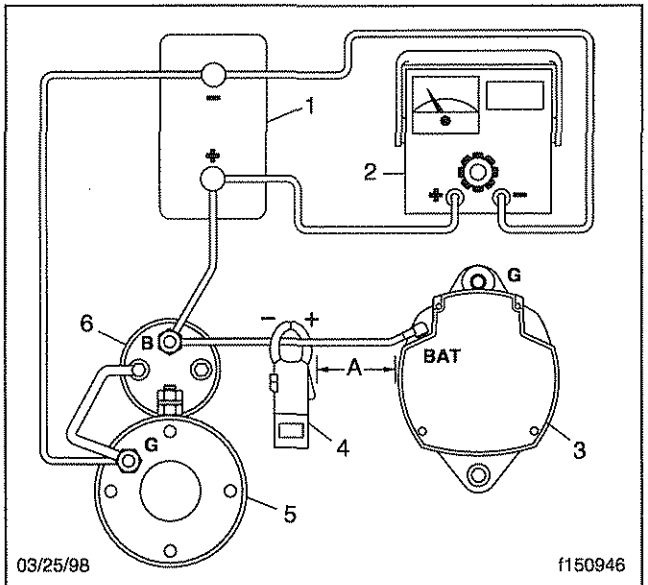
5.2 If the reading at the batteries is more than 0.5 volts lower than the reading at the alternator, do the next step.

6. Check charging system connections, cables and terminals.

6.1 Check all connections between the battery, starter and alternator for tightness and signs of corrosion. Tighten and clean as necessary.

6.2 Check all cables for breaks or partial breaks. Repair or replace as necessary.

6.3 Check each ring terminal for breakage at the point where it attaches to its wire or cable.



A. Locate the ammeter at least six inches (15 cm) away from the alternator.

1. Battery
2. Carbon Pile Tester
3. Alternator
4. Ammeter
5. Cranking Motor
6. Solenoid

Fig. 4, Test #3: Alternator Amperage Output

1.5 If the output value recorded is less than 85% of the rated amperage output, repeat the test. If the output value recorded is still less than 85% of the rated amperage output, replace the alternator.

1.6 Make sure that all test instruments are removed and that the vehicle wiring is returned to its operational state.

2. To identify other problem areas within the vehicle, check the operation of the charging system.

   NOTE: For any load at 1500 rpm or more, battery voltage must be within 0.5 volts of the alternator voltage.

   2.1 Check the battery open circuit voltage as shown in **Fig. 2**. Make a note of this reading.

   2.2 Check the alternator voltage output as shown in **Fig. 3**. Make a note of this reading also.

   2.3 Compare the two readings. If the reading at the batteries is within 0.5 volts of the reading at the alternator, the charging system is working correctly. Check other areas of the vehicle to locate the problem.

   If the reading at the batteries is more than 0.5 volts lower than the reading at the alternator, do the next step.

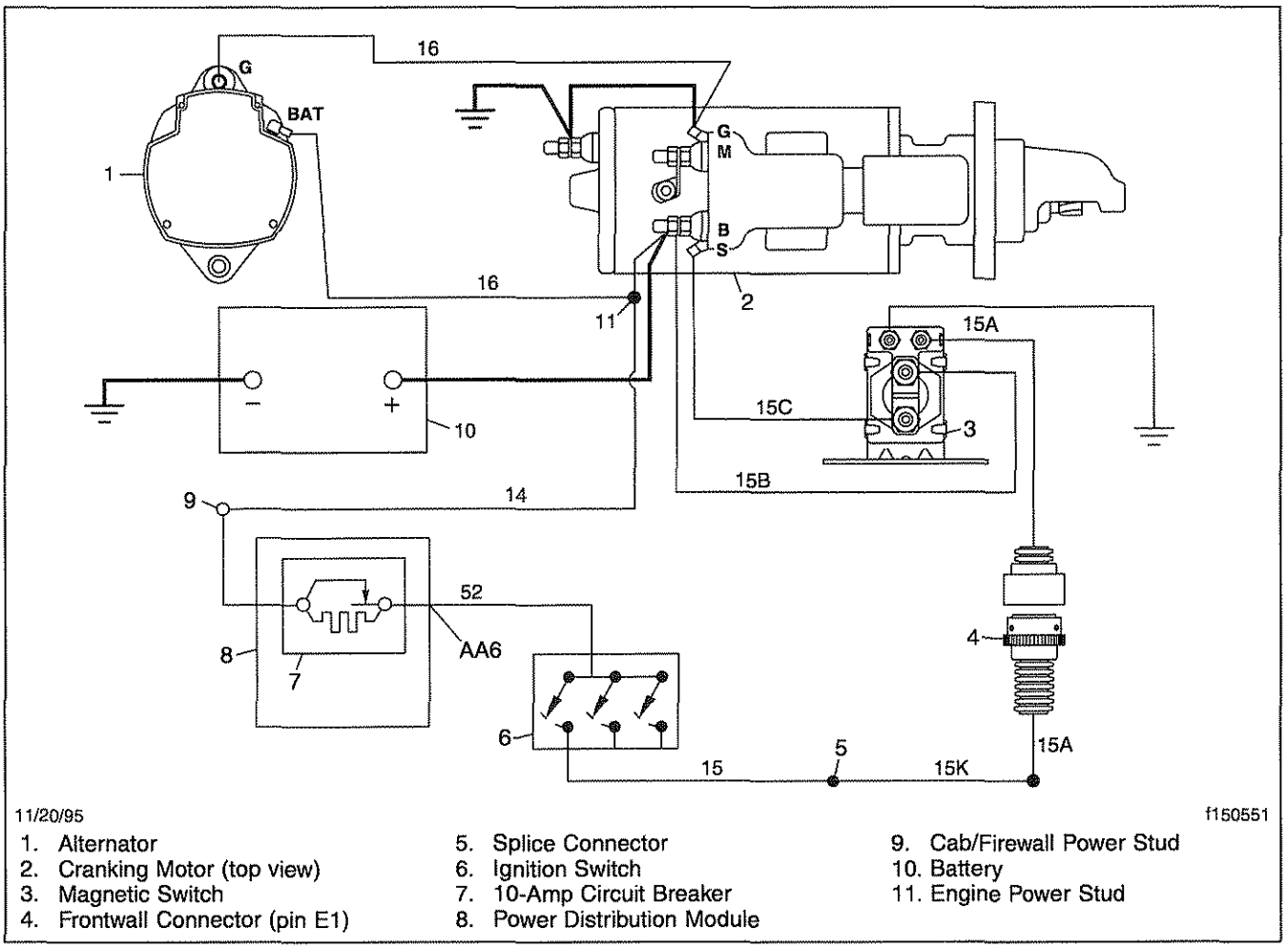
3. Check charging system connections, cables, and terminals.

   3.1 Check all connections between the battery, starter, and alternator for tightness and signs of corrosion. Tighten and clean as necessary.

   3.2 Check all cables for breaks or partial breaks. Repair or replace as necessary.

   3.3 Check each ring terminal for breakage at the point where it attaches to its wire or cable.

See **Fig. 1** for a charging circuit wiring diagram. The charging circuit consists of the battery, starter, alternator, and magnetic switch.



1. Alternator
2. Cranking Motor (top view)
3. Magnetic Switch
4. Frontwall Connector (pin E1)
5. Splice Connector
6. Ignition Switch
7. 10-Amp Circuit Breaker
8. Power Distribution Module
9. Cab/Firewall Power Stud
10. Battery
11. Engine Power Stud

Fig. 1, Charging Circuit Wiring Diagram

Mounting Fastener Torques, Caterpillar Engines			
Description	**Grade**	**Size**	**Torque: lbf.ft (N.m)**
Caterpillar 3406 Engine			
End Link Mounting Capscrew	8PO	1/2–13	65 (88)
Alternator Mounting Capscrew	8PO	1/2–13	65 (88)
Adjusting Rod Mounting Capscrew	8PO	1/2–13	65 (88)
Adjusting Rod Jam Nut	5	1/2	65 (88)
Alternator Bracket Capscrews	10.9PO	M12	65 (88)

Specifications

Mounting Fastener Torques, Caterpillar Engines			
Description	**Grade**	**Size**	**Torque: lbf.ft (N.m)**
Caterpillar C–10/C–12 Engine			
Alternator Mounting Capscrews	8PO	1/2–13	65 (88)
Adjusting Strap Mounting Capscrew	10.9PO	M12	65 (88)

Table 1, Mounting Fastener Torques, Caterpillar Engines

Mounting Fastener Torques, Cummins Engines			
Description	**Grade**	**Size**	**Torque: lbf.ft (N.m)**
Cummins N14 Engine			
End Link Mounting Capscrew	8PO	1/2–13	65 (88)
Alternator Mounting Capscrew	8PO	1/2–13	65 (88)
Adjusting Rod Mounting Capscrew	8PO	7/16–20	50 (68)
Adjusting Rod Jam Nut	5	5/8	95 (130)
Alternator Bracket Fasteners	5PO	3/8–16	34 (46)
Cummins M11 Engine			
Adjusting Block Mounting Bolt	8.8	M10	30 (41)
Alternator Mounting Capscrew	8PO	1/2–13	65 (88)
Adjusting Screw Locknut	5	1/2	95 (130)
Adjusting Arm Mounting Capscrew	5	1/2–13	55 (75)
Alternator Bracket Fasteners	10.9PO	M10	34 (46)

Table 2, Mounting Fastener Torques, Cummins Engines

Mounting Fastener Torques, Detroit Diesel Engines			
Description	**Grade**	**Size**	**Torque: lbf.ft (N.m)**
Detroit Diesel Series 60 Engine			
End Link Mounting Capscrew	8PO	1/2–13	65 (88)
Alternator Mounting Capscrew	8PO	1/2–13	65 (88)
Adjusting Rod Mounting Capscrew	10.9PO	M10	50 (68)
Adjusting Rod Jam Nut	5	5/8	95 (130)
Alternator Bracket Fasteners	10.9PO	M10	50 (68)
Alternator Adjusting Capscrew	8PO	1/2–13	65 (88)
Detroit Diesel Series 55 Engine			
Alternator Mounting Capscrews	8PO	1/2–13	65 (88)
Adjusting Strap Mounting Capscrew	8PO	1/2–13	65 (88)

Table 3, Mounting Fastener Torques, Detroit Diesel Engines

Specifications

Description	Grade	Size	Torque: lbf.in (N.cm)
Alternator Output ("BAT") Terminal Nut	5	5/16–18	100 (1140)
Alternator Ground ("G") Terminal Nut	5	1/4–20	65 (740)
Alternator Instrument ("I") Terminal Nut	8.8	M4	20 (220)

Table 4, Terminal Fastener Torques, All Engines

Description	Grade	Size	Torque: lbf.ft (N.m)
Pulley Nut	8PO	1/2–20	75 (102)

Table 5, Pulley Nut Torque, All Engines

Alternator, Delco Remy 26-SI

15.03

Contents

Subject	Subject Number
General Information	050
Service Operations	
26–SI Alternator Removal and Installation, Cummins N14	100
26–SI Alternator Removal and Installation, Cummins M11	110
26–SI Alternator Removal and Installation, Caterpillar 3406	120
26–SI Alternator Removal and Installation, Caterpillar C–10/C–12	130
26–SI Alternator Removal and Installation, DDC 60	140
26–SI Alternator Removal and Installation, DDC 55	150
Troubleshooting	300
Specifications	400

General Description

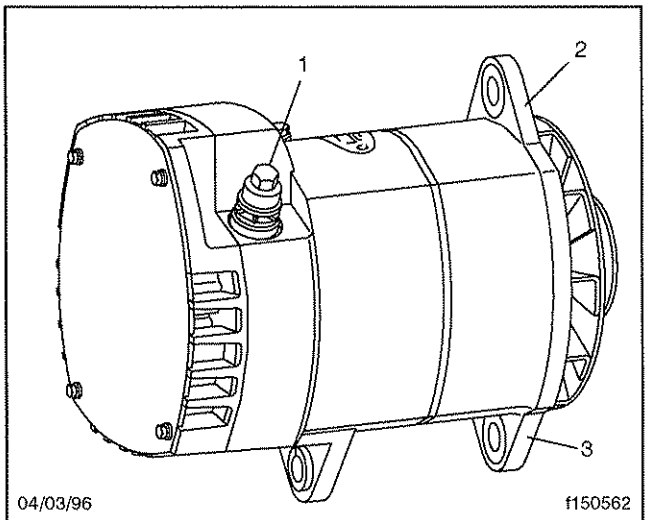
The Delco Remy 26–SI alternator (see **Fig. 1**) is a self-rectifying, brushless unit. The integrated-circuit voltage regulator is designed for low-speed start-up. See **Fig. 2**. A special diode trio/capacitor assembly provides superior radio frequency interference (RFI) suppresion.

The only moving part in the assembly is the rotor, which is mounted on a ball bearing at the drive end, and a roller bearing at the rectifier end. The field coil, stator windings, six rectifying diodes, and regulator circuit components are all stationary (brushless construction). See **Fig. 3**.

Standard load dump protection guards against voltage spikes caused by loose connections or interruptions in the charging line. The entire alternator is environmentally sealed to protect against dirt, road salt, and other corrosive materials.

A fan located on the drive end provides airflow for cooling. Extra-large grease reservoirs contain an adequate supply of lubricant so that no periodic maintenance is required.

Only one wire connects the alternator to the battery, along with a ground return. See **Fig. 1**. The specially designed output terminal (labeled "BAT") is connected directly to the battery. Since the vehicle's system is negative ground, the output terminal connects to the battery's positive terminal. A relay terminal (labeled "R") is available for use in some circuits to operate auxiliary equipment. The hexhead bolt on the output terminal is electrically insulated; no voltage reading can be obtained by connecting to the hexhead bolt.



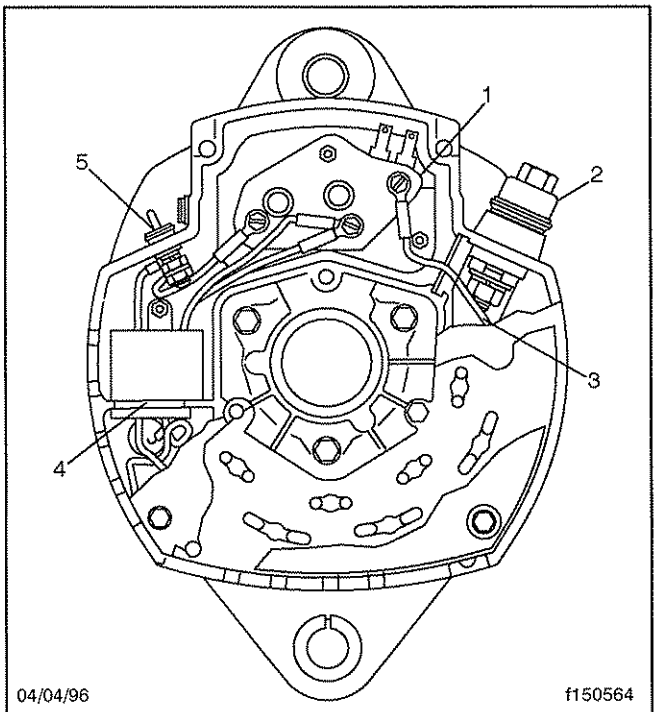
1. Output (BAT) Terminal
2. Adjusting Lug
3. Mounting Lug

Fig. 1, 26-SI Alternator

Principles of Operation

As the rotor begins to turn, the permanent magnetism within induces voltage in the stator windings. The voltage across the six diodes causes current to flow, charging the battery. See **Fig. 4**.

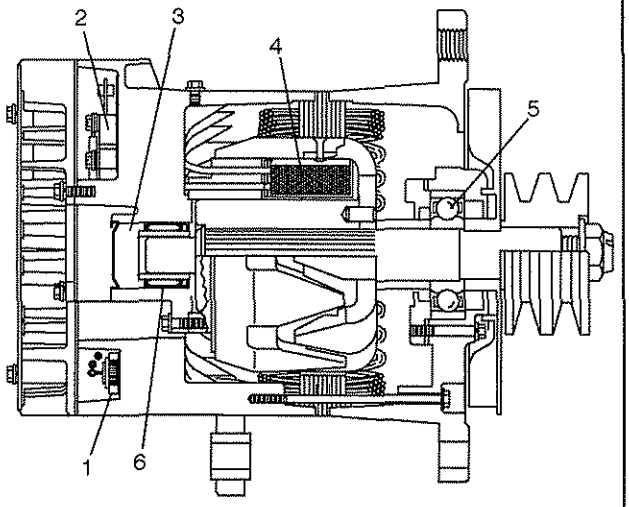
Current from the stator flows through the three diodes to resistor R6 and the base-emitter of TR2 and TR1, to turn on these transistors.



1. Voltage Regulator
2. Output (BAT) Terminal
3. Sensing Lead
4. Diode Trio/Capacitor
5. Relay (R) Terminal

Fig. 2, 26-SI Alternator Components (view from rectifier end)

General Information



1. Rectifiers
2. Voltage Regulator
3. Grease Reservoir
4. Field Coil
5. Ball Bearing
6. Roller Bearing

Fig. 3, 26-SI Alternator Components (side view)

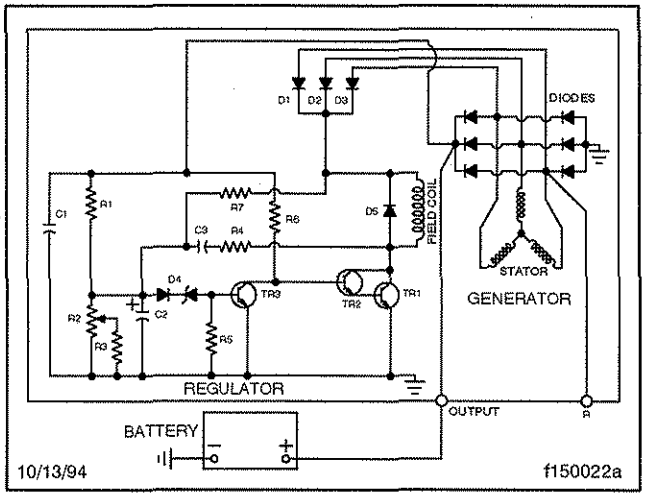


Fig. 4, Wiring Diagram, Negative Ground Circuit

Current also flows from the stator through the diode trio D1, D2, and D3, the field coil and transistor TR1, returning to the stator through the other three diodes. All stator current, except through the diode trio D1, D2, and D3, flows through the six diodes connected to the stator.

Current flow through R1, R2, and R3 causes voltage to appear at the zener diode D4. When the voltage becomes high enough due to increasing alternator speed, D4 and the base-emitter of TR3 conduct current and turn on TR3. TR2 and TR1 then turn off, decreasing the field current and the system voltage. The voltage at D4 decreases; D4 and TR3 turn off; TR2 and TR1 turn back on and the system voltage increases. This cycle then repeats many times per second limiting the system voltage as determined by the setting of the potentiometer R2, and R3.

The capacitor C1 protects the diodes from high transient voltages and suppresses radio interference.

The resistor R5 prevents current leakage through TR3 at high temperatures.

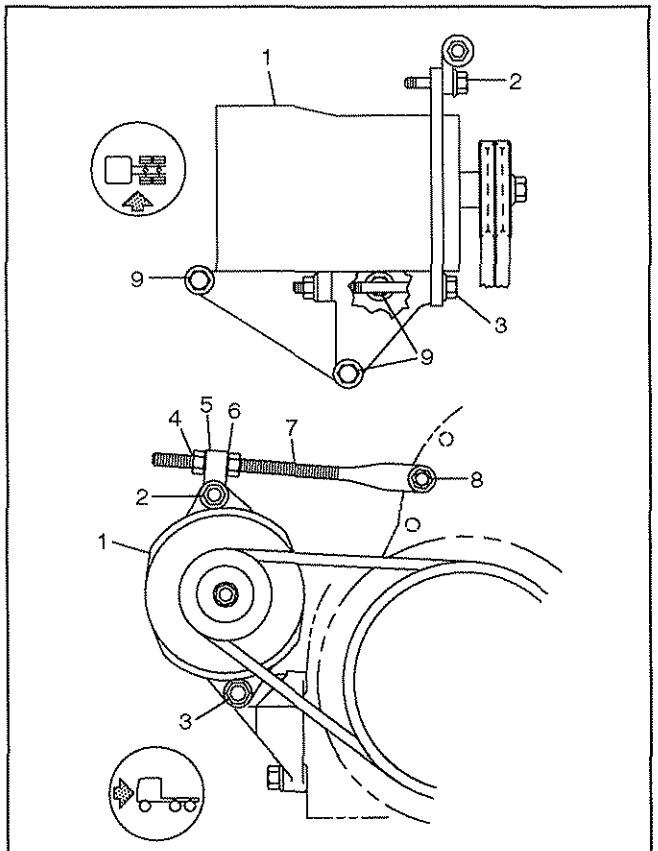
The diode D5 prevents high transient voltages in the field coil when the field current is decreasing.

The resistor R7, capacitor C3, and resistor R4 all cause transistors TR2 and TR1 to turn on and off quickly.

26–SI Alternator Removal and Installation, Cummins N14

Removal

1. Disconnect the batteries.
2. Mark all electrical leads and disconnect them from the alternator.
3. Loosen the adjusting rod mounting capscrew (see **Fig. 1**, Ref. 8).
4. Loosen the end link mounting capscrew and the alternator mounting capscrew (see **Fig. 1**, Refs. 2 and 3). Turn the adjusting nut (Ref. 6) counterclockwise, backing the alternator toward the drive pulley far enough to remove the dual drive belts without prying or twisting the belts. Remove the drive belts from the vehicle.
5. Remove the adjusting rod jam nut (Ref. 4) and alternator mounting capscrew. Remove the alternator from the vehicle with the end link attached.
6. Inspect the drive belts. For instructions, see **Section 01.01, Subject 100**.



1. 26–SI Alternator
2. End Link Mounting Capscrew
3. Alternator Mounting Capscrew
4. Adjusting Rod Jam Nut
5. End Link
6. Adjusting Nut
7. Adjusting Rod
8. Adjusting Rod Mounting Capscrew
9. Alternator Bracket Capscrew

Fig. 1, Alternator Installation, Cummins N14 Engine

Installation

1. Check the torque of the alternator bracket fasteners. If necessary, tighten them 34 lbf·ft (46 N·m).
2. Install the alternator on the engine with the end link attached. Install the alternator mounting capscrew, but do not tighten it yet.
3. Install the drive belts on the pulleys. Do not pry or twist the belts. If installing a new pulley or a new alternator, tighten the pulley nut 75 lbf·ft (102 N·m).
4. Tighten the adjusting nut (see **Fig. 1**, Ref. 6) until the belt is correctly tensioned. For belt tightening procedures and specifications, see **Section 01.01, Subject 110**. While holding the adjusting nut in place, install the adjusting rod jam nut and tighten it 95 lbf·ft (130 N·m).
5. Tighten the end link mounting capscrew and the alternator mounting capscrew 65 lbf·ft (88 N·m). Tighten the adjusting rod mounting capscrew 50 lbf·ft (68 N·m).
6. Connect all leads to the back of the alternator as previously marked. Tighten the output terminal nut 100 lbf·in (1140 N·cm). Tighten the ground terminal nut 65 lbf·in (740 N·cm). For other terminals, tighten the nut 20 lbf·in (220 N·cm).
7. Spray any exposed terminal connectors with dielectric red enamel. See **Table 1**.

Protectant Material	Approved Brand
Dielectric Red Enamel Spray	MMM 1602 IVI–Spray Sealer, Red Electric Grade (Spray-On B–6–665)

Table 1, Approved Dielectric Red Enamel

26–SI Alternator Removal and Installation, Cummins N14

8. Connect the batteries.
9. Before returning the vehicle to operation, test the alternator DC output voltage. For instructions, see "Alternator Voltage Output Test" in **Troubleshooting, 300**.

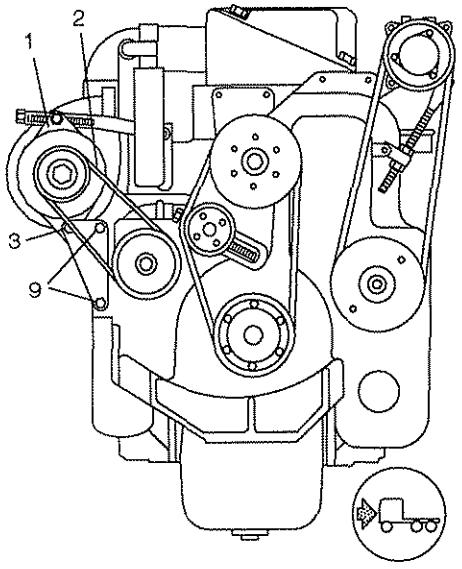
26–SI Alternator Removal and Installation, Cummins M11

Removal

1. Disconnect the batteries.
2. Mark all electrical leads and disconnect them from the alternator.
3. Loosen the adjusting block mounting bolt, adjusting arm mounting capscrew, and alternator mounting capscrew just enough to allow movement of the alternator. See **Fig. 1**.
4. Loosen the adjusting screw locknut. See **Fig. 1**, Ref. 4. Turn the adjusting screw (Ref. 7) counterclockwise, backing off the alternator toward the drive pulley far enough to remove the drive belt without prying or twisting the belt. Remove the drive belt from the vehicle.
5. Remove the adjusting block mounting bolt and the alternator mounting capscrew. Remove the alternator from the vehicle.
6. Inspect the drive belt. For instructions, see **Section 01.01, Subject 100**.

Installation

1. Check the torque of the alternator bracket fasteners. If necessary, tighten them 34 lbf·ft (46 N·m).
2. Install the alternator on the engine. Install the adjusting block mounting bolt and the alternator mounting capscrew, but do not tighten them yet.
3. Install the drive belt on the pulleys. Do not pry or twist the belt over the pulley. If installing a new pulley or a new alternator, tighten the pulley nut 75 lbf·ft (102 N·m).
4. Turn the adjusting screw (see **Fig. 1**, Ref. 7) clockwise until the belt is correctly tensioned. For belt tightening specifications, see **Section 01.01, Subject 105**. Tighten the adjusting screw locknut (Ref. 4) 95 lbf·ft (130 N·m).



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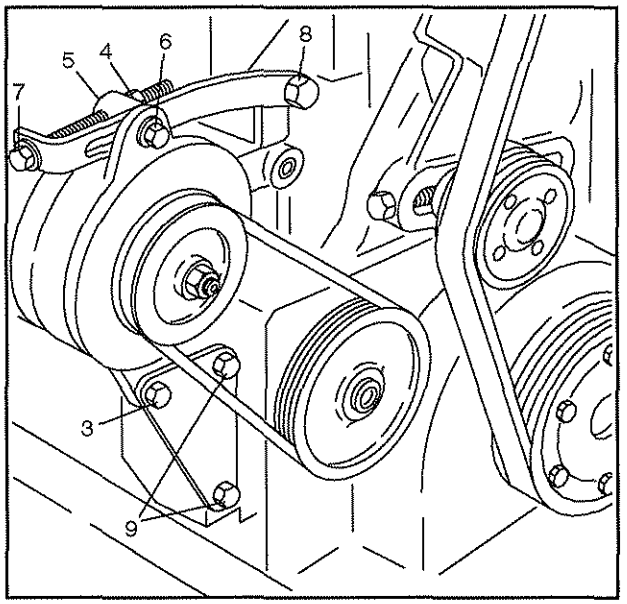

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1. 26–SI Alternator
2. Drive Belt
3. Alternator Mounting Capscrew
4. Adjusting Screw Locknut
5. Adjusting Block
6. Adjusting Block Mounting Bolt
7. Adjusting Screw
8. Adjusting Arm Mounting Capscrew
9. Alternator Bracket Fasteners

Fig. 1, Alternator Installation, Cummins M11 Engine

26–SI Alternator Removal and Installation, Cummins M11

5. Tighten the alternator mounting capscrew (see **Fig. 1**, Ref. 3) 65 lbf·ft (88 N·m); tighten the adjusting block mounting bolt (Ref. 6) 30 lbf·ft (41 N·m); tighten the adjusting arm mounting capscrew (Ref. 8) 55 lbf·ft (75 N·m).
6. Connect all leads to the back of the alternator as previously marked. Tighten the output terminal nut 100 lbf·in (1140 N·cm). Tighten the ground terminal nut 65 lbf·in (740 N·cm). For other terminals, tighten the nut 20 lbf·in (220 N·cm).
7. Spray any exposed terminal connectors with dielectric red enamel. See **Table 1**.

Protectant Material	Approved Brand
Dielectric Red Enamel Spray	MMM 1602 IVI–Spray Sealer, Red Electric Grade (Spray-On B–6–665)

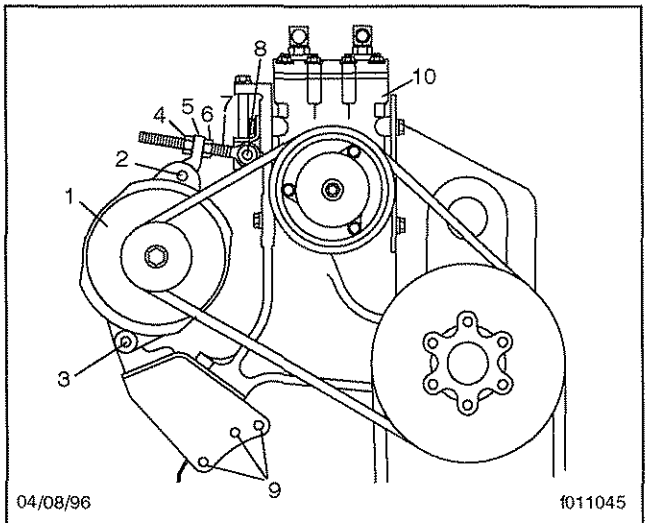
Table 1, Approved Dielectric Red Enamel

8. Connect the batteries.
9. Before returning the vehicle to operation, test the alternator DC output voltage. For instructions, see "Alternator Voltage Output Test" in **Troubleshooting, 300**.

26–SI Alternator Removal and Installation, Caterpillar 3406

Removal

1. Disconnect the batteries.
2. Mark all electrical leads and disconnect them from the alternator.
3. Back off the adjusting nut (see **Fig. 1**, Ref. 6). Loosen the end link mounting capscrew and the alternator mounting capscrew enough to allow movement of the alternator.
4. Push the loosened alternator far enough toward the fan drive pulley to allow removal of the drive belts without using force.
5. Slip each drive belt (dual drive belts) off the pulleys and work it over one fan blade at a time. Remove both belts from the vehicle.
6. Remove the two mounting capscrews already loosened. Remove the alternator from the vehicle.



1. 26–SI Alternator
2. End Link Mounting Capscrew
3. Alternator Mounting Capscrew
4. Adjusting Rod Jam Nut
5. End Link
6. Adjusting Nut
7. Adjusting Rod
8. Adjusting Rod Mounting Capscrew
9. Alternator Bracket Fasteners
10. Refrigerant Compressor

Fig. 1, Alternator Installation, Caterpillar 3406 Engine

7. Inspect the drive belts. For instructions, see **Section 01.00, Subject 100**.

Installation

1. Check the torque of the alternator bracket fasteners. If necessary, tighten them 65 lbf·ft (88 N·m).
2. Install the alternator on the engine. Install the end link mounting capscrew and the alternator mounting capscrew, but do not tighten them yet.
3. Make sure the distance between the pulleys is short enough to allow belt installation without using force.
4. Work each belt over the fan blades, one blade at a time. Install both drive belts on the pulleys without prying or rolling them into place. If installing a new pulley or a new alternator, tighten the pulley nut 75 lbf·ft (102 N·m). For belt tightening procedures and specifications, see **Section 01.00, Subject 110**.
5. After each belt has been correctly tensioned, tighten the adjusting rod jam nut 65 lbf·ft (88 N·m).
6. Tighten both the end link and the alternator mounting capscrews 65 lbf·ft (88 N·m).
7. Connect all leads to the back of the alternator as previously marked. Tighten the output terminal nut 100 lbf·in (1140 N·cm). Tighten the ground terminal nut 65 lbf·in (740 N·cm). For other terminals, tighten the nut 20 lbf·in (220 N·cm).
8. Spray any exposed terminal connectors with dielectric red enamel. See **Table 1**.

Protectant Material	Approved Brand
Dielectric Red Enamel Spray	MMM 1602 IVI–Spray Sealer, Red Electric Grade (Spray-On B–6–665)

Table 1, Approved Dielectric Red Enamel

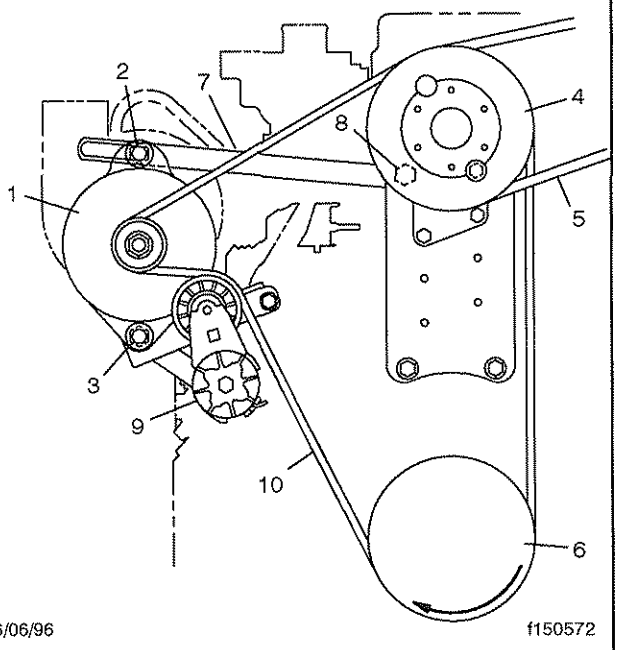
9. Connect the batteries.
10. Before returning the vehicle to operation, test the alternator DC output voltage. For instructions, see "Alternator Voltage Output Test" in **Troubleshooting, 300**.

26–SI Alternator Removal and Installation, Caterpillar C–10/C–12

Removal

1. Disconnect the batteries.
2. Mark all electrical leads and disconnect them from the alternator.
3. Insert a breaker bar in the belt tensioner and rotate the tensioner down and off the alternator drive belt. See **Fig. 1**.

NOTE: There are two drive belts to remove. Before removing the alternator belt, it is necessary to remove the refrigerant compressor belt from the fan pulley.



Rotate the belt tensioner down and off the belt.

1. 26–SI Alternator
2. Alternator Mounting Capscrew, Top
3. Alternator Mounting Capscrew, Bottom
4. Fan Pulley
5. Refrigerant Compressor Drive Belt
6. Vibration Damper
7. Alternator Adjusting Strap
8. Adjusting Strap Mounting Capscrew
9. Belt Tensioner
10. Alternator Drive Belt

Fig. 1, Alternator Installation, Caterpillar C-10/ C-12 Engine

4. Holding the belt tensioner down, remove the drive belt from the alternator pulley. Slowly release the belt tensioner and remove the breaker bar.
5. Lower the drive belt, and take it off the vibration damper. It is not necessary to remove the belt from the vehicle.
6. Remove both alternator mounting capscrews. Remove the alternator from the vehicle.

NOTE: It is not necessary to remove the adjusting strap from the engine.

7. Inspect the drive belt. For instructions, see **Section 01.00, Subject 100**.

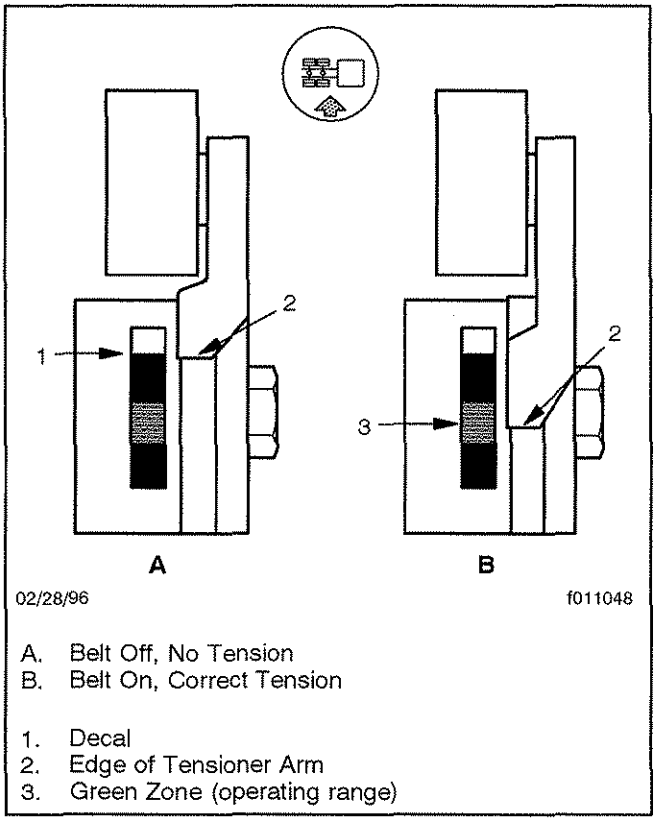
Installation

1. Check the torque of the adjusting strap mounting capscrew. If necessary, tighten it 65 lbf·ft (88 N·m).
2. Install the alternator on the engine. Install the alternator at the inboard edge of the slot initially. Install the top and bottom alternator mounting capscrews, but do not tighten them yet.
3. Install the drive belts on the pulleys, as removed. If installing a new pulley or a new alternator, tighten the pulley nut 75 lbf·ft (102 N·m). For belt tightening procedures and specifications, see **Section 01.00, Subject 105**.
4. Verify that the edge of the tensioner arm is within the green zone on the decal. See **Fig. 2**. If within the red zone, pivot the alternator outboard until the tensioner arm enters the green zone.

NOTE: If the belt slips, repair or replace the tensioner. For instructions, see the Caterpillar C–10 & C–12 Diesel Truck Engine Service Manual.

5. When the alternator is correctly positioned, tighten both alternator mounting capscrews 65 lbf·ft (88 N·m).
6. Connect all leads to the back of the alternator as previously marked. Tighten the output terminal nut 100 lbf·in (1140 N·cm). Tighten the ground terminal nut 65 lbf·in (740 N·cm). For other terminals, tighten the nut 20 lbf·in (220 N·cm).
7. Spray any exposed terminal connectors with dielectric red enamel. See **Table 1**.

26–SI Alternator Removal and Installation, Caterpillar C–10/C–12



A. Belt Off, No Tension
B. Belt On, Correct Tension

1. Decal
2. Edge of Tensioner Arm
3. Green Zone (operating range)

Fig. 2, Belt Tensioner With Decal

Protectant Material	Approved Brand
Dielectric Red Enamel Spray	MMM 1602 IVI–Spray Sealer, Red Electric Grade (Spray-On B–6–665)

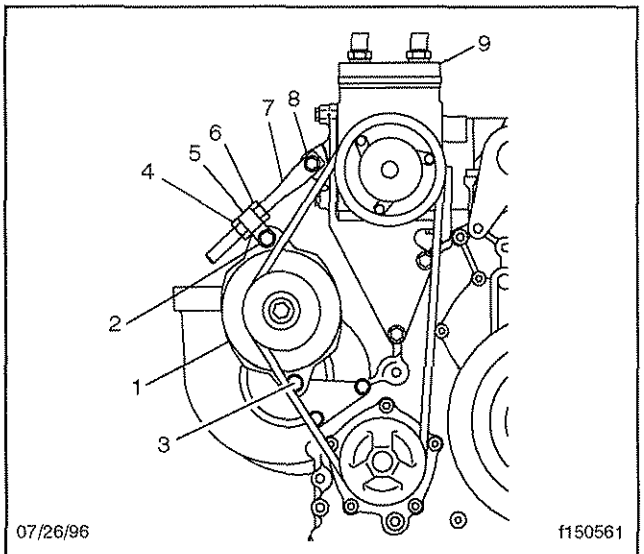
Table 1, Approved Dielectric Red Enamel

8. Connect the batteries.
9. Before returning the vehicle to operation, test the alternator DC output voltage. For instructions, see "Alternator Voltage Output Test" in **Troubleshooting, 300.**

26–SI Alternator Removal and Installation, DDC 60

Removal

1. Disconnect the batteries.
2. Mark all electrical leads and disconnect them from the alternator.
3. Loosen the adjusting rod mounting capscrew (see **Fig. 1**, Ref. 8), the end link mounting capscrew (Ref. 2), and the alternator mounting capscrew (Ref. 3). Loosen these three mounting capscrews enough to allow movement of the alternator.
4. Back off the adjusting nut (see **Fig. 1**, Ref. 6). Push the loosened alternator far enough toward the fan drive pulley to allow removal of the drive belt without using force.
5. Remove the drive belt from the pulleys without prying or twisting the belt.



1. 26–SI Alternator
2. End Link Mounting Capscrew
3. Alternator Mounting Capscrew
4. Adjusting Rod Jam Nut
5. End Link
6. Adjusting Nut
7. Adjusting Rod
8. Adjusting Rod Mounting Capscrew
9. Refrigerant Compressor

Fig. 1, Alternator Installation, Detroit Diesel Series 60 Engine

6. Remove the end link mounting capscrew and the alternator mounting capscrew. Remove the alternator from the vehicle.
7. Inspect the drive belt. For instructions, see **Section 01.02, Subject 100**.

Installation

1. Check the torque of the alternator bracket fasteners. If necessary, tighten them 50 lbf·ft (68 N·m).
2. Install the alternator on the engine. Install the end link mounting capscrew and the alternator mounting capscrew, but do not tighten them yet.
3. Loop the drive belt around the pulleys.
4. Install the drive belt on the pulleys without prying or rolling it into place. If installing a new pulley or a new alternator, tighten the pulley nut 75 lbf·ft (102 N·m). For belt tightening procedures and specifications, see **Section 01.02, Subject 105**.
5. After the belt has been correctly tensioned, tighten the adjusting rod jam nut 95 lbf·ft (130 N·m).
6. Tighten the end link mounting capscrew, and the alternator mounting capscrew 65 lbf·ft (88 N·m). Tighten the adjusting rod mounting capscrew 50 lbf·ft (68 N·m)
7. Connect all leads to the back of the alternator as previously marked. Tighten the output terminal nut 100 lbf·in (1140 N·cm). Tighten the ground terminal nut 65 lbf·in (740 N·cm). For other terminals, tighten the nut 20 lbf·in (220 N·cm).
8. Spray any exposed terminal connectors with dielectric red enamel. See **Table 1**.

Protectant Material	Approved Brand
Dielectric Red Enamel Spray	MMM 1602 IVI–Spray Sealer, Red Electric Grade (Spray-On B–6–665)

Table 1, Approved Dielectric Red Enamel

9. Connect the batteries.
10. Before returning the vehicle to operation, test the alternator DC output voltage. For instructions, see "Alternator Voltage Output Test" in **Troubleshooting, 300**.

26–SI Alternator Removal and Installation, DDC 55

Removal

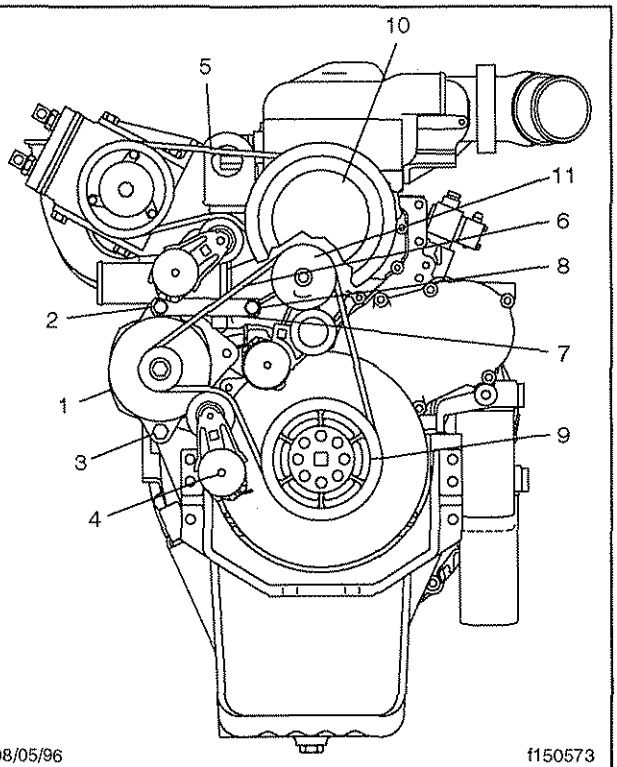
1. Disconnect the batteries.
2. Mark all electrical leads and disconnect them from the alternator.
3. Insert a breaker bar in the alternator belt tensioner (see **Fig. 1**, Ref. 4) and rotate the tensioner down and off the alternator drive belt.
4. Holding the belt tensioner down, remove the alternator drive belt from its pulley. Slowly release the belt tensioner and remove the breaker bar.
5. Lower the drive belt, and take it off the vibration damper. It is not necessary to remove the belt from the vehicle.
6. Remove the top and bottom alternator mounting capscrews. Remove the alternator from the vehicle.
7. Inspect the drive belt. For instructions, see **Section 01.02, Subject 100**.

Installation

1. Check the torque of the adjusting strap mounting capscrew. If necessary, tighten it 65 lbf·ft (88 N·m).
2. Install the alternator on the engine. Install the two alternator mounting capscrews (top and bottom), but do not tighten them yet.
3. Install the alternator drive belt on the pulleys. If installing a new pulley or a new alternator, tighten the pulley nut 75 lbf·ft (102 N·m).

NOTE: The Detroit Diesel belt tensioner automatically adjusts the drive belt to the correct tension. If the belt slips, repair or replace the tensioner. For instructions, see the engine manufacturer's service literature.

4. Tighten both alternator mounting capscrews 65 lbf·ft (88 N·m).
5. Connect all leads to the back of the alternator as previously marked. Tighten the output terminal nut 100 lbf·in (1140 N·cm). Tighten the ground terminal nut 65 lbf·in (740 N·cm). For other terminals, tighten the nut 20 lbf·in (220 N·cm).
6. Spray any exposed terminal connectors with dielectric red enamel. See **Table 1**.



Rotate the belt tensioner down and off the belt.

NOTE: Fan pulley cut away and fan drive belt removed to show alternator pulley and drive belt more clearly.

1. 26–SI Alternator
2. Alternator Mounting Capscrew, Top
3. Alternator Mounting Capscrew, Bottom
4. Alternator Belt Tensioner
5. Refrigerant Compressor Drive Belt
6. Alternator Drive Belt
7. Alternator Adjusting Strap
8. Alternator Adjusting Strap Mounting Capscrew
9. Vibration Damper
10. Fan Pulley
11. Alternator Pulley

Fig. 1, Alternator Installation, Detroit Diesel Series 55 Engine

26–SI Alternator Removal and Installation, DDC 55

Protectant Material	Approved Brand
Dielectric Red Enamel Spray	MMM 1602 IVI–Spray Sealer, Red Electric Grade (Spray-On B–6–665)

Table 1, Approved Dielectric Red Enamel

7. Connect the batteries.
8. Before returning the vehicle to operation, test the alternator DC output voltage. For instructions, see "Alternator Voltage Output Test" in **Troubleshooting, 300**.

Troubleshooting

Many alternators have been replaced that later investigation reveals were working properly. This may be due to incorrectly diagnosing the problem.

IMPORTANT: Before testing, make sure:

- All belts are correctly tightened;
- The wiring and terminals are clean and in good condition;
- All terminal nuts are torqued and properly protected.

Delco Remy has an alternator testing tool called the Intelli-Check Alternator Analyzer. See **Fig. 1**. This tool (DR 10457848, a single tester, or DR 10457865, a four-pack of testers) is to be used as a quick check of the alternator to see if it is working correctly.

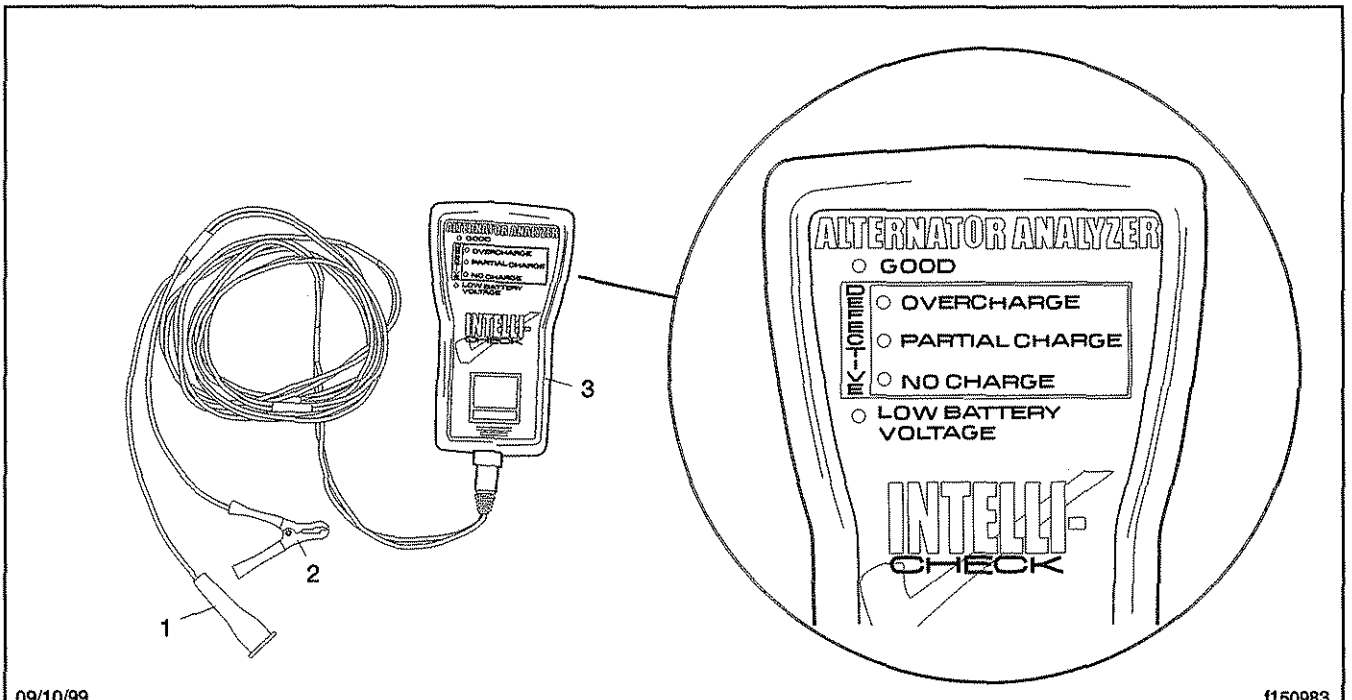
NOTE: If you do not have the Delco Intelli-Check Tester, or if the alternator rated output is above 145 amps, or if a total vehicle charging system analysis is required, see "Alternator/Charging System Testing."

Intelli-Check Alternator Analyzer

The following information includes a pre-test procedure and operating instructions for the Delco Intelli-Check Tester, and is similar to the procedures provided by Delco with the Intelli-Check Tester.

Pre-Test Procedure (Engine Off)

1. Inspect the alternator connections to verify that all terminals are secured and tight. Verify that the sense wire is connected to the sense terminal on vehicles equipped with remote-sense alternators.
2. With the engine off, connect the red alligator clip to the output terminal of the alternator. Connect the black alligator clip to the alternator ground. An optional ground connection is to the body of the alternator. The tester LEDs will illuminate and then go off as it performs a self-test.



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1. Red Alligator Clip
2. Black Alligator Clip
3. Hand-Held Alternator Analyzer

Fig. 1, Delco Remy Intelli-Check Alternator Analyzer

Troubleshooting

3. After 4 seconds the tester will activate. The following LEDs may illuminate depending on the condition of the batteries:
    - **GOOD** (green) LED indicates the battery voltage is above 12.8 and has a surface charge. The surface charge must be removed before proceeding with the alternator test. To remove the surface charge, do the following:
        A. Turn on the headlights and blower motor for 2 minutes without restarting the engine.
        B. Reset the tester by disconnecting, then reconnecting the tester alligator clips. The analyzer will again perform its self-test.
        C. Repeat the applicable steps of the Pre-Test Procedure.
    - **NO CHARGE** (red) LED indicates the battery voltage is below 12.8. This LED should illuminate for most tests. Proceed with the alternator test.
    - **LOW BATTERY VOLTAGE** (blue) LED indicates the battery voltage is below 12.35. If the batteries will start the vehicle, proceed with the alternator test. However, after completing the Intelli-Check alternator test, perform the procedures under "Alternator/Charging System Testing" to determine the condition of the rest of the charging system.

Tester Operating Instructions (Engine Running)

1. Start the engine using onboard batteries only. If the batteries will not start the engine, they must be charged for 2 hours. Start the test again after charging the batteries.
2. Verify the engine is at idle and all electrical loads are off.
3. Depress the accelerator to governed speed, hold for 10 seconds, then return to idle.
    - If the **GOOD** (green) LED illuminates, proceed to the next step.
    - If any LEDs illuminate indicating overcharge, partial charge or no charge (the three red lights in the **DEFECTIVE** section), replace the alternator and run the complete test again.
    - If the **LOW BATTERY VOLTAGE** (blue) LED illuminates, evaluate the charging system using the instructions in "Alternator/Charging System Testing."
4. With the engine running, turn on all electrical loads.
5. Depress the accelerator to governed speed, hold for 10 seconds, then return to idle.
6. If the **GOOD** (green) LED illuminates, the alternator is OK and the test is complete.

NOTE: If the alternator tests OK in the above tests, and the customer's complaint is reduced battery or headlight life, see "Alternator/Charging System Testing" to completely analyze the charging system.

7. If any LEDs illuminate indicating overcharge, partial charge or no charge (the three red lights in the **DEFECTIVE** section), replace the alternator and run the complete test again.
8. If the **LOW BATTERY VOLTAGE** (blue) LED illuminates, evaluate the charging system using the instructions in "Alternator/Charging System Testing".

Alternator/Charging System Testing

Battery Open Circuit Voltage Test, Alternator Output Voltage Test and Alternator Amperage Output Test

1. Use a digital volt-ohmmeter (VOM) set on the 2-20VDC (or similar) scale to test the battery open circuit voltage (OCV). With the engine shut down and the voltmeter set up as shown in **Fig. 2**, check for voltage of 12.4 volts or more.

    If the OCV is 12.4 volts or more, turn on the vehicle headlights for approximately 3 minutes.

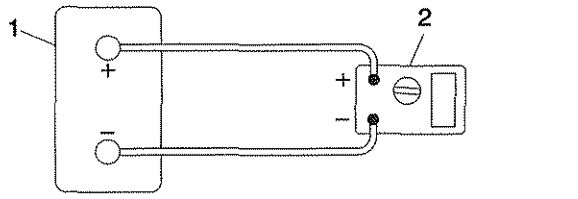
    If the OCV is less than 12.4 volts, charge the batteries properly. For instructions, see **Group 54**.

IMPORTANT: Be sure to disconnect the batteries or remove them from the vehicle before charging.

2. Check the alternator output without a load. See **Fig. 3**.

2.1 Start the engine and run it at 1500 rpm for 3 to 5 minutes to stabilize the system before proceeding to the next step.

2.2 Connect the positive (+) lead of the digital voltmeter (still set on the 2-20VDC or similar scale) to the alternator (battery) terminal. Connect the negative (–) lead of the voltmeter to the alternator negative (–) ground terminal. See **Fig. 3.**



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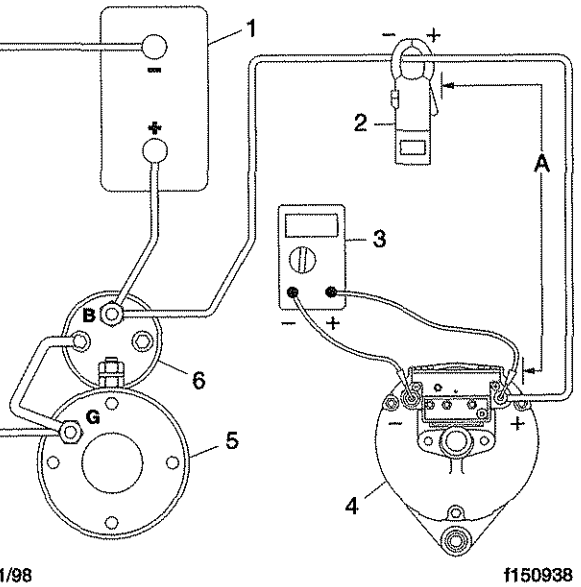
1. Battery
2. Digital Voltmeter

Fig. 2, Setup 1: Battery Open Circuit Voltage (and alternator amperage output)



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A. Locate the ammeter at least 6 inches (15 cm) away from the alternator.

1. Battery
2. Ammeter
3. Digital Voltmeter
4. Alternator
5. Cranking Motor
6. Solenoid

Fig. 3, Setup 2: Alternator Output Test

2.3 If the voltmeter reads from 13.8 to 14.2 volts, record this reading (V1) and go to the next step. If the alternator reads less than 13.8 volts and is adjustable, try to adjust the voltage regulator to 13.8 to 14.2 volts. If unable to obtain acceptable output, replace the alternator.

3. Check the alternator output under load. See **Fig. 3.**

3.1 Attach a clamp-on induction ammeter around the positive (+) wire. See **Fig. 3.**

NOTE: Locate the ammeter at least 6 inches (15 cm) away from the alternator.

3.2 With the engine still running at 1500 rpm, turn on the following electrical accessories to load the alternator until the ammeter reads 60 to 75 amps.

- Both front and rear heater blowers (on HIGH)
- Headlights (high beams)
- Road lights
- Interior lights

NOTE: As an alternate method of putting load on the alternator, connect a carbon pile tester and set it to 60 to 75 amps.

3.3 Keep the voltmeter connected as in the previous step; positive (+) lead connected to the alternator positive (+) terminal; negative (–) lead connected to the alternator negative (–) terminal.

3.4 If the voltmeter reads from 13.6 to 14.2 volts, record this reading (V2) and go to the next step.

If the voltmeter reads less than 13.6 volts, replace the alternator.

4. Perform an alternator amperage output test.

4.1 Connect a carbon pile tester across the vehicle batteries as shown in **Fig. 2.**

NOTE: **Figure 2** shows a voltmeter, but the connections for the carbon pile tester are the same.

4.2 Attach a clamp-on induction ammeter around the alternator output wire. See **Fig. 3.**

Troubleshooting

NOTE: Locate the ammeter at least 6 inches (15 cm) away from the alternator.

4.3 Start the engine and make sure all vehicle electrical accessories are turned off. Run it at fast speed and adjust the tester to the alternator maximum current output. Record this output value.

NOTE: Ensure that the alternator is turning at maximum available rpms and keep adjusting the tester dial until the ammeter reads its highest value.

4.4 Turn off the tester and shut down the engine.

4.5 If the output value recorded is less than 85 percent of the rated amperage output, repeat the test. If the output value recorded is still less than 85 percent of the rated amperage output, replace the alternator.

4.6 Make sure that all test instruments are removed and that the vehicle wiring is returned to its operational state.

5. To identify other problem areas within the vehicle, check the operation of the charging system. Set up the voltmeter as shown in **Fig. 2** and **Fig. 3**.

NOTE: For any load at 1500 rpm or more, battery voltage must be within 0.5 volts of the alternator voltage.

5.1 If readings at the batteries are within 0.5 volts of the readings at the alternator, the charging system is working correctly. Check other areas of the vehicle to locate the problem.

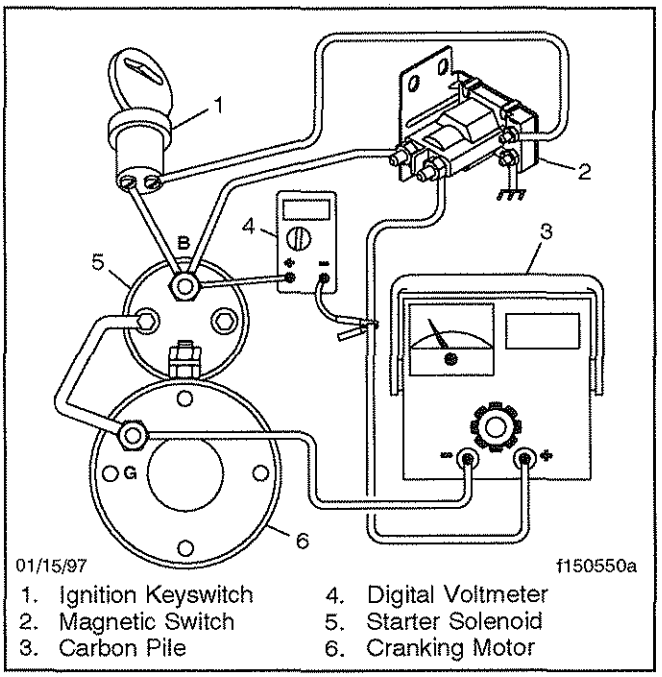
5.2 If the reading at the batteries is more than 0.5 volts lower than the reading at the alternator, do the next step.

6. Check charging system connections, cables and terminals.

6.1 Check all connections between the battery, starter and alternator for tightness and signs of corrosion. Tighten and clean as necessary.

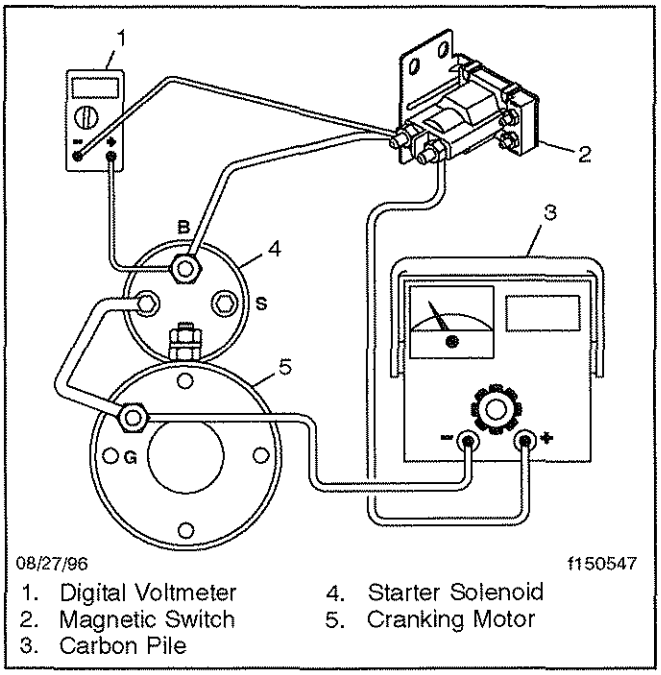
6.2 Check all cables for breaks or partial breaks. Repair or replace as necessary.

6.3 Check each ring terminal for breakage at the point where it attaches to its wire or cable.



1. Ignition Keyswitch
2. Magnetic Switch
3. Carbon Pile
4. Digital Voltmeter
5. Starter Solenoid
6. Cranking Motor

Fig. 4, Starter Solenoid Circuit Test



1. Digital Voltmeter
2. Magnetic Switch
3. Carbon Pile
4. Starter Solenoid
5. Cranking Motor

Fig. 5, Starter Wiring Test—First Wire Voltage Loss (V5)

4. Have a second person start the engine momentarily.

IMPORTANT: If the magnetic switch does not close, do the "Magnetic Switch Circuit Test." For instructions, see **Section 54.04**.

5. Check the first wire voltage loss (V5).

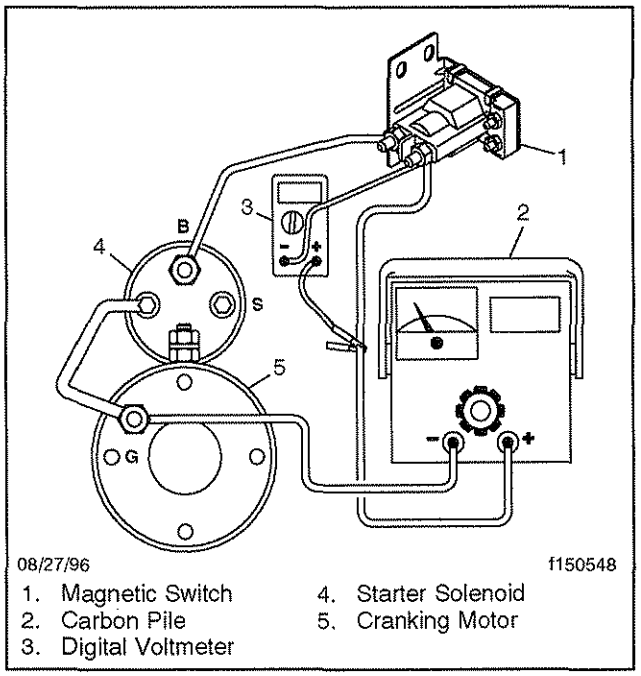
   5.1 Turn the ignition key to the START position, then turn on the carbon pile and adjust it to a 100-amp load.

   5.2 Now read and record the voltage (V5) on the voltmeter. Turn off the carbon pile.

6. Now connect the positive lead of the digital voltmeter (still set on the low scale) to the magnetic switch lead which is already connected to the carbon pile (as in "Starter Solenoid Circuit Test"). Connect the negative lead of the voltmeter to the other large terminal on the magnetic switch (circuit 15C). See **Fig. 6**.

7. Have a second person start the engine momentarily.

8. Check the second wire voltage loss (V6).



1. Magnetic Switch
2. Carbon Pile
3. Digital Voltmeter
4. Starter Solenoid
5. Cranking Motor

Fig. 6, Starter Wiring Test—Second Wire Voltage Loss (V6)

Troubleshooting

NOTE: Ignore the minus (–) sign.

8.1 Turn the ignition key to the START position, then turn on the carbon pile and again adjust it to a 100-amp load.

8.2 Now read and record the voltage (V6) on the voltmeter. Turn off the carbon pile.

8.3 Add the two voltages (V5 and V6) together to get the total wire voltage loss. If the total wire voltage loss adds up to 0.8 volts or less, the wiring is OK. Replace the magnetic switch. For instructions, see **Section 54.04, Subject 100**.

If the total wire voltage loss adds up to more than 0.8 volts, check the wire connections for tightness and the terminals for corrosion. Repair or replace as necessary.

9. Disconnect the carbon pile and the voltmeter. Reconnect the magnetic switch to the starter "S" terminal.

10. Check all wiring and connections and repair or replace as needed. For instructions on wire repair, see **Section 54.00**.

Magnetic Switch Circuit Test

For the "Magnetic Switch Circuit Test," see **Section 54.04**.

Ring and Pinion Gear Test

1. This test requires two persons. While the first person bars the engine over, the second person visually checks the entire flywheel ring gear and starter pinion gear visually (check all the teeth in both gears).

2. If the pinion teeth are damaged, replace the starter. If the ring gear teeth are damaged, replace the ring gear.

NOTE: For ring gear replacement procedures, see the engine manufacturer's manuals.

3. If the engine still does not crank properly after replacing the starter, look for a mechanical problem in the engine. For instructions, see **Group 01** or the engine manufacturer's manuals.

Cold Weather Voltage Test

In cold weather, the starter may fail to engage, even though it performed well at higher temperatures. Do the following test to check for cold weather voltage loss in the cranking circuit.

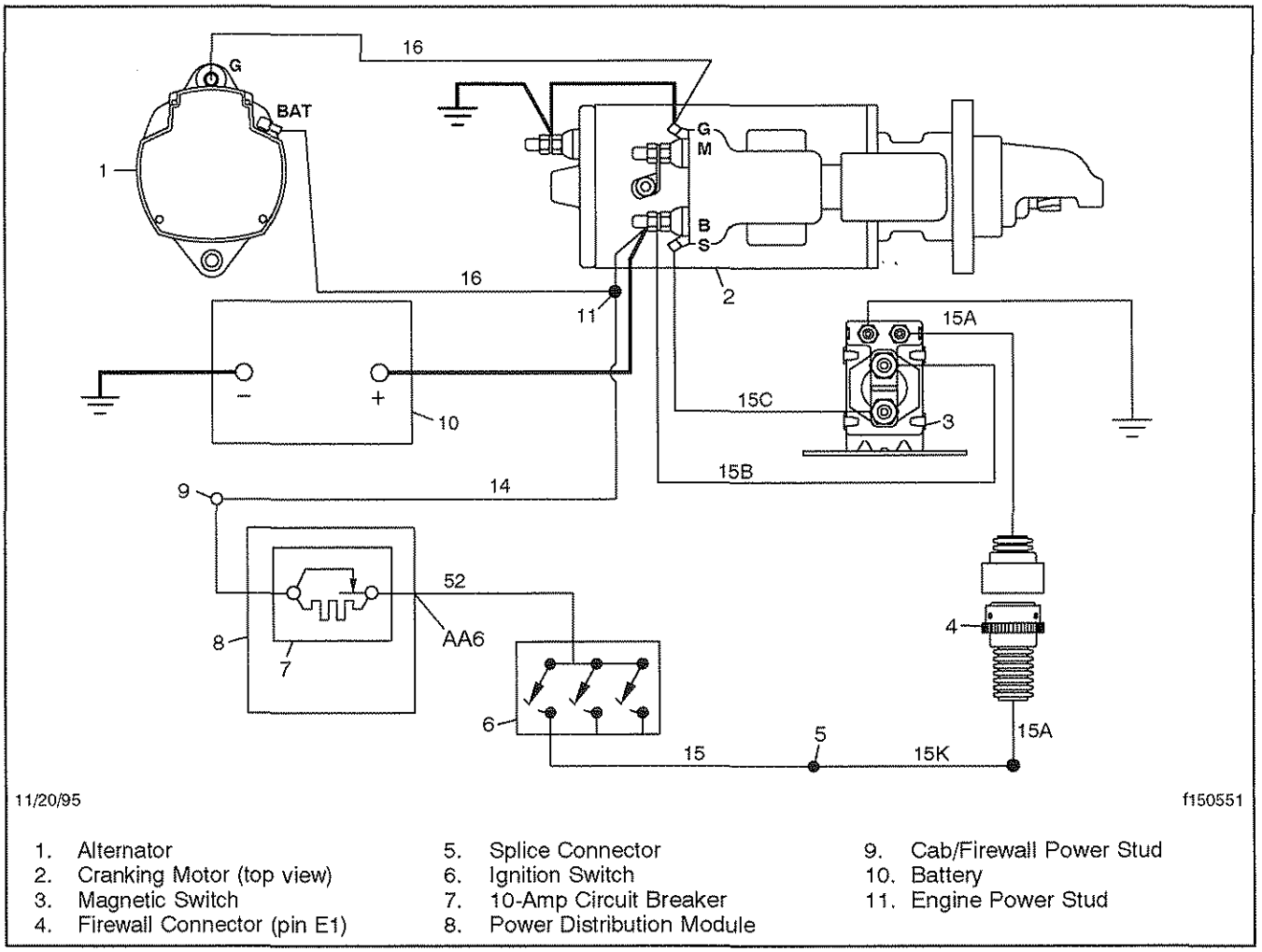
1. With the ignition keyswitch on, clamp a heavy battery jumper cable between the two large studs on the magnetic switch. Remove the jumper immediately to stop the engine from cranking.

2. If the engine starts with the jumper in place, do the "Starter Wiring Test." Repair/replace the wiring connections, terminals, and/or magnetic switch as necessary.

3. If the engine now starts properly, check the starter mounting bolts for tightness and do the "Alternator Wiring Test." See the troubleshooting subject in the appropriate alternator section in **Group 15** for instructions.

4. If the engine still does not start properly, go to "Available Cranking Voltage Test."

See **Fig. 1** for a charging circuit wiring diagram.



1. Alternator
2. Cranking Motor (top view)
3. Magnetic Switch
4. Firewall Connector (pin E1)
5. Splice Connector
6. Ignition Switch
7. 10-Amp Circuit Breaker
8. Power Distribution Module
9. Cab/Firewall Power Stud
10. Battery
11. Engine Power Stud

Fig. 1, Charging Circuit Wiring Diagram

Mounting Fastener Torques, Caterpillar Engines			
Description	**Grade**	**Size**	**Torque: lbf·ft (N·m)**
Caterpillar 3406 Engine			
End Link Mounting Capscrew	8PO	1/2–13	65 (88)
Alternator Mounting Capscrew	8PO	1/2–13	65 (88)
Adjusting Rod Mounting Capscrew	8PO	1/2–13	65 (88)
Adjusting Rod Jam Nut	5	1/2	65 (88)
Alternator Bracket Capscrews	10.9PO	M12	65 (88)
Caterpillar C–10/C–12 Engine			

Specifications

Mounting Fastener Torques, Caterpillar Engines			
Description	**Grade**	**Size**	**Torque: lbf·ft (N·m)**
Alternator Mounting Capscrews	8PO	1/2–13	65 (88)
Adjusting Strap Mounting Capscrew	10.9PO	M12	65 (88)

Table 1, Mounting Fastener Torques, Caterpillar Engines

Mounting Fastener Torques, Cummins Engines			
Description	**Grade**	**Size**	**Torque: lbf·ft (N·m)**
Cummins N14 Engine			
End Link Mounting Capscrew	8PO	1/2–13	65 (88)
Alternator Mounting Capscrew	8PO	1/2–13	65 (88)
Adjusting Rod Mounting Capscrew	8PO	7/16–20	50 (68)
Adjusting Rod Jam Nut	5	5/8	95 (130)
Alternator Bracket Fasteners	5PO	3/8–16	34 (46)
Cummins M11 Engine			
Adjusting Block Mounting Bolt	8.8	M10	30 (41)
Alternator Mounting Capscrew	8PO	1/2–13	65 (88)
Adjusting Screw Locknut	5	1/2	95 (130)
Adjusting Arm Mounting Capscrew	5	1/2–13	55 (75)
Alternator Bracket Fasteners	10.9PO	M10	34 (46)

Table 2, Mounting Fastener Torques, Cummins Engines

Mounting Fastener Torques, Detroit Diesel Engines			
Description	**Grade**	**Size**	**Torque: lbf·ft (N·m)**
Detroit Diesel Series 60 Engine			
End Link Mounting Capscrew	8PO	1/2–13	65 (88)
Alternator Mounting Capscrew	8PO	1/2–13	65 (88)
Adjusting Rod Mounting Capscrew	10.9PO	M10	50 (68)
Adjusting Rod Jam Nut	5	5/8	95 (130)
Alternator Bracket Fasteners	10.9PO	M10	50 (68)
Detroit Diesel Series 55 Engine			
Alternator Mounting Capscrews	8PO	1/2–13	65 (88)
Adjusting Strap Mounting Capscrew	8PO	1/2–13	65 (88)

Table 3, Mounting Fastener Torques, Detroit Diesel Engines

Description	Grade	Size	Torque: lbf.in (N.cm)
Alternator Output ("BAT") Terminal Nut	5	5/16–18	100 (1140)
Alternator Ground ("G") Terminal Nut	5	1/4–20	65 (740)
Alternator Instrument ("I") Terminal Nut	8.8	M4	20 (220)

Table 4, Terminal Fastener Torques, All Engines

Description	Grade	Size	Torque: lbf.ft (N.m)
Pulley Nut	8PO	1/2–20	75 (102)

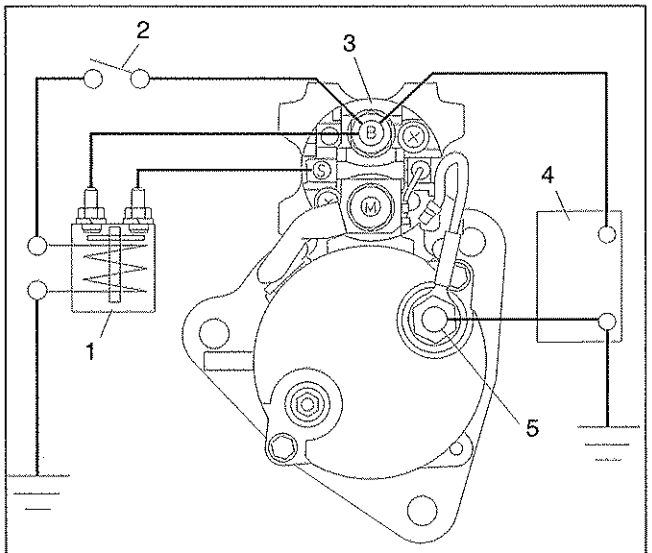
Table 5, Pulley Nut Torque, All Engines

Contents

Subject	Subject Number
General Information	050
Service Operations	
Starter Removal and Installation	100
Troubleshooting	300
Specifications	400

General Information

The Mitsubishi starter (MIB 970379FL), which weighs approximately 28 pounds (12.7 kg), uses a planetary gear reduction system. The starter attaches to the flywheel housing. In the area of the output shaft, the starter provides protection from dust, water, or oil splash for the inner starter parts. See **Fig. 1**, for a circuit diagram of the Mitsubishi isolated-ground type starter.



1. Magnetic Switch
2. Start Switch
3. Starter Solenoid
4. Battery
5. Starter Motor

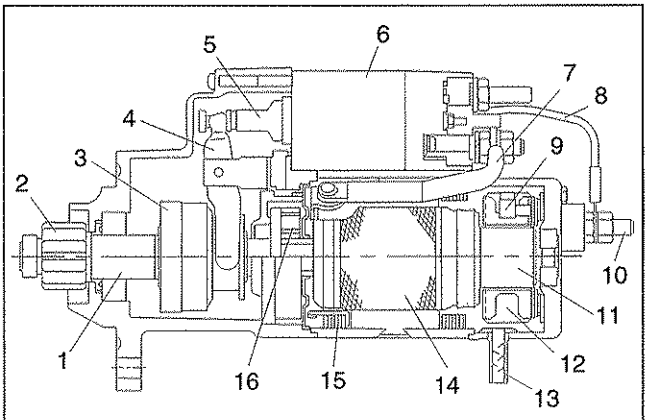
Fig. 1, Basic Starting Circuit (isolated-ground type)

Principles of Operation

When the start switch is closed (the switch is in the start position) current flows through the magnetic switch windings. The magnetic switch contacts close and current flows through the starter solenoid windings.

The starter clutch is thrust forward by movement of the plunger and the lever. See **Fig. 2**. Current flowing in the starter solenoid windings causes the pinion gear to slowly rotate. The pinion engages the ring gear and, when the pinion is securely engaged, the main solenoid contacts close and the starter cranks.

When the engine starts, the starter clutch prevents excessive overrun of the armature.



1. Output Shaft
2. Pinion
3. Clutch
4. Lever
5. Plunger
6. Solenoid
7. M-Lead
8. Ground Wire
9. Brush Spring
10. Ground Terminal
11. Commutator
12. Brush
13. Drain Tube
14. Armature
15. Field Coil
16. Planetary Gear

Fig. 2, Starter Cross-Section (isolated-ground stud type)

⚠ CAUTION

Release the start switch immediately when the engine starts, to prevent damage to the starter. Do not crank the starter for more than 30 seconds at one time or the starter may overheat. If you do crank the starter continuously for 30 seconds, wait 10 minutes to allow the starter to cool before attempting starting again.

Removal

Before removing the starter from the vehicle for repair, perform the checks in **Troubleshooting 300**.

1. Park the vehicle on a level surface. Shut down the engine, set the parking brake, and chock the tires.
2. Turn off all electrical loads such as lights, ignition, and accessories.
3. Disconnect the batteries.

⚠ DANGER

Before tilting the cab, review the cab tilting information in Section 60.15 in this manual. Failure to read the warnings and to be aware of the dangers of tilting and lowering the cab could result in serious injury or death.

4. Open the hood or tilt the cab.
5. Disconnect the electrical leads attached to the starter, making note of the number of each and where they attach. Mark the terminals and wires for installation.

NOTE: It may be difficult to access the starter mounting bolts. Straddle the front axle with arms extended around the leaf springs and use a long socket extender or breaker bar.

6. Remove the three mounting bolts and lockwashers that attach the starter to the engine. Remove the starter.

Installation

1. Insert the starter nose housing through the mounting hole in the flywheel housing.
2. Install the three starter mounting bolts and lockwashers and tighten them securely.
3. Connect the wires to the starter as previously marked, making sure that all are accounted for. Make sure that all battery cables are routed so as to avoid contact with sharp edges and other chafe sites. Tighten the nuts 16 to 30 lbf·in (180 to 340 N·cm).
4. Spray any exposed terminal connectors with dielectric red enamel. See **Table 1**.

Approved Dielectric Red Enamel	
Protectant Material	**Approved Brand**
Dielectric Red Enamel Spray	MMM 1602 IVI–Spray Sealer, Red Electric Grade (Spray-On B–6–665)

Table 1, Approved Dielectric Red Enamel

5. Connect the batteries.

⚠ DANGER

Before tilting the cab, review the cab tilting information in Section 60.15 in this manual. Failure to read the warnings and to be aware of the dangers of tilting and lowering the cab could result in serious injury or death.

6. Lower the hood or cab to the operating position.
7. Remove the chocks from the tires.

Battery

IMPORTANT: Before troubleshooting the starting system, ensure that the batteries are fully charged and in good condition. See **Group 54** for battery safety, testing, and charging procedures.

Wiring

Inspect the starting system wiring for damage, corrosion, and loose connections at the battery, the start switch, the magnetic switch, and at the starter solenoid. Make any necessary repairs.

Magnetic Switch

For magnetic switch test procedures, see **Section 54.04** Subject 300.

Ring Gear and Pinion

If the batteries, wiring, and magnetic switch are not faulty there may be damage to the ring gear and starter pinion teeth. This can cause the pinion to become locked by the ring gear and prevent pinion rotation and thrust motion. If you suspect this problem, remove the starter and inspect the pinion and ring gear end faces for damage or burrs. If necessary, replace the ring gear and the starter.

Starter

Pinion Movement/Solenoid Operation Test

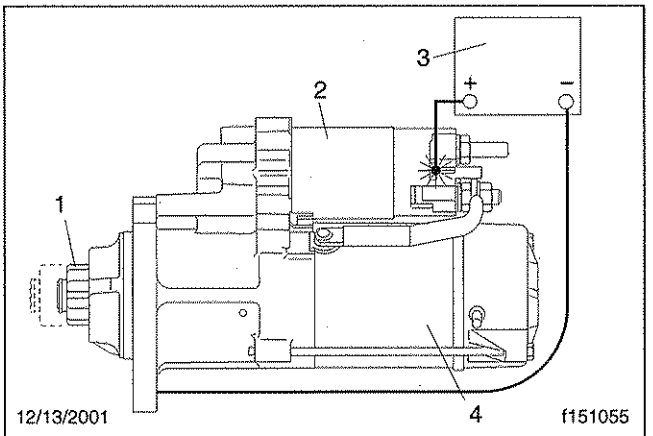
Apply 8 to 12 volts between the solenoid S-terminal and ground. Watch the pinion to see if it moves forward. See **Fig. 1**.

NOTE: The starter will slowly turn at a few hundred rpms.

⚠ CAUTION

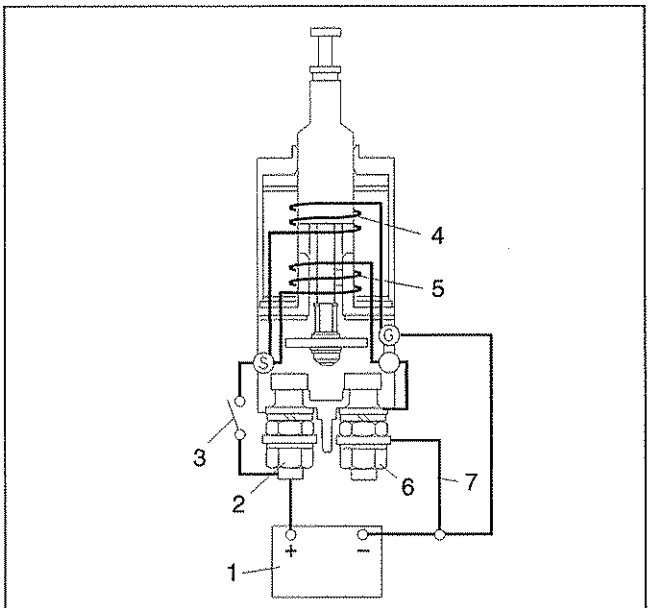
Do not apply voltage for more than 3 seconds or the solenoid may be damaged.

If the pinion does not move forward, replace the starter. The pull-in winding in the solenoid may be shorted or the pinion may be blocked and will not slide. See **Fig. 2** for switch circuit diagrams for starter switch coils.



1. Pinion
2. Starter Solenoid
3. Battery
4. Starter Motor

Fig. 1, Testing Pinion Movement



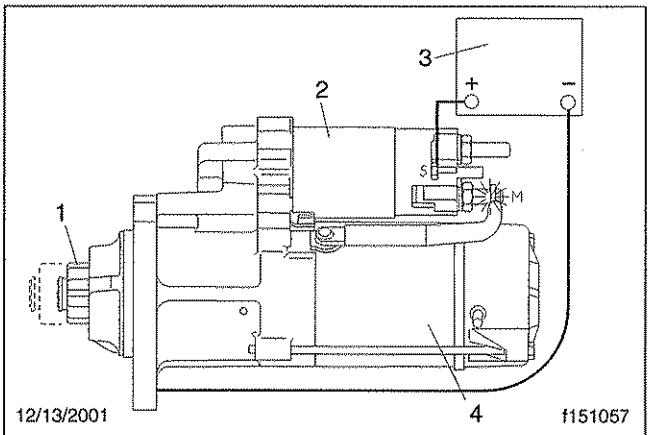
1. Battery
2. Battery Terminal
3. Start Switch
4. Hold-In Winding
5. Pull-In Winding
6. M Terminal
7. To Motor Windings

Fig. 2, Switch Circuit Diagram (starter switch coil)

Troubleshooting

If the pinion is working properly, inspect the starter solenoid hold-in coil. Remove the M-terminal nut but keep the end of the wire in contact with the terminal. See **Fig. 3.** Apply voltage between the S-terminal and the ground (voltage applied to hold-in coil only) to cause the pinion to move forward. Immediately, remove the wire from the M-terminal and watch if the pinion remains in the forward position. If the pinion returns, you may assume that the hold-in coil is shorted. Replace the starter.

See **Specifications 400** for hold-in and pull-in coil resistance values.



1. Pinion
2. Starter Solenoid
3. Battery
4. Starter Motor

Fig. 3, Testing Hold-In Windings

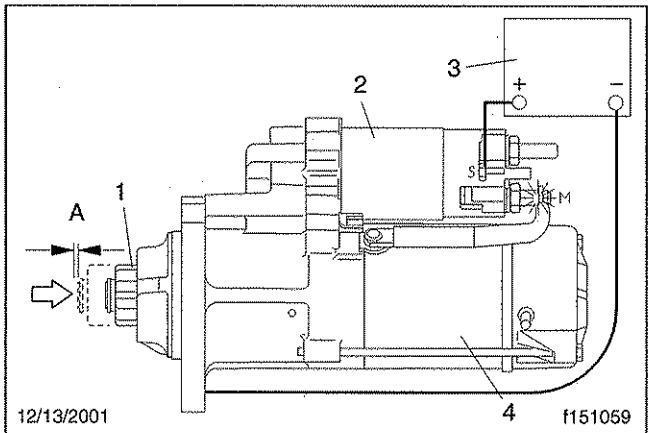
Checking Output Shaft End Play

NOTE: Check the output shaft clearance before installing the starter on the engine.

1. Remove the M-terminal nut but keep the wire in contact with the terminal.
2. Apply voltage between the S-terminal and ground so that the pinion moves forward. Then, immediately remove the wire from the M-terminal.

NOTE: The pinion will remain in the forward position until the battery is disconnected.

3. Press in and pull out on the shaft to measure the end play distance. See **Fig. 4.**



A. Press in and pull out on the pinion shaft to measure the end play distance.
1. Pinion
2. Starter Solenoid
3. Battery
4. Starter Motor

Fig. 4, Checking Output Shaft End Play

NOTE: End play should measure 0.004 to 0.118 inch (0.1 to 3.0 mm). If the measurement is not within specification, replace the starter.

See **Table 1** for starter fastener torque values.

Fastener Torque Values		
Description	**Size**	**Torque: lbf·ft (N·m)**
Starter to Flywheel Housing	M12 x 1.5	53–63 (72–85)
Nut, Copper Stud	M12	15–22 (20–30)

Table 1, Fastener Torque Values

Group Index, Alphabetical

Section	Section Number
Cooling System Troubleshooting	20.00
Block Heater	20.03
Fan Clutch, Horton DriveMaster	20.04
Fan Clutches	20.02
Radiator Assembly	20.01

Cooling System Troubleshooting 20.00

Contents

Subject	Subject Number
General Information	050
Troubleshooting	300

General Information

Freightliner uses three sizes of traditional high-flow radiators in these vehicles. Century Class Conventionals use radiators that are 1000-square-inch and 1200-square-inch front areas. Argosy COEs use a 1300-square-inch radiator. All sizes are high-flow, single-pass radiators with plastic end-tanks. All are two-row radiators with 14 fins per inch. Century Class Conventional radiators are cross-flow and Argosy COE radiators are down-flow.

In high-flow cooling systems, most coolant in a warm engine is routed through the radiator. The coolant moves relatively quickly through the radiator in a single pass.

In a typical engine and radiator system, coolant flows from the radiator outlet to the water pump, from the water pump through the oil cooler, then the engine cylinder block water jacket, then the head. For typical engine coolant plumbing, see **Fig. 1**.

If the engine is cold, the engine thermostat stays closed, and water leaving the head flows back down to the water pump and the oil cooler.

If the engine is warm, the thermostat opens and coolant is forced to flow into the upper end of the driver-side radiator end tank. The coolant flows across the core, where is is cooled by ram air entering through the vehicle grille. When the coolant reaches the bottom end of the radiator passenger-side end tank, the coolant flows back out to the water pump. For the temperature that opens the thermostat on each model of engine, see **Table 1**.

The surge tank holds extra coolant, which travels down through the fill hose to the engine as needed. The low coolant level sensor in the surge tank warns the driver when coolant is running low. The surge tank is translucent polypropylene so you can see the coolant level and compare it to the maximum and minimum levels marked on the tank. See **Fig. 2**.

To prevent gas from getting trapped in the radiator or engine, vent lines run from the highest point in the radiator and engine to the surge tank. To prevent the coolant from boiling, the coolant is pressurized 11 to 12 psi.

To add coolant to Century Class Conventionals, remove the large cap on the outboard end of the tank. The standard, metal SAE cap on top of the tank is used for pressure relief and vacuum-break functions only. If too much pressure builds up in the coolant system, excess coolant will vent through the SAE cap and escape through an overflow hose.

Cooling System Control Temperatures						
Cooling Component	Detroit Diesel Series 60	Caterpillar Engines		Cummins Engines		
		C10/C12	C15/C16/ 3406E	C8.3	N14/M11/ISM	ISX/Signature
	Temperature °F (°C)					
Thermostat Starts to Open	190 (88)	190 (88)	190 (88)	180 (82)	180 (82)	180 (82)
Thermostat Fully Open	205 (96)	208 (98)	208 (98)	195 (91)	200 (93)	200 (93)
Engine Fan Activates	208 (98)	205 (96)	216 (101)	N/A	205 (96)	210 (99)
Engine Fan Stops	198 (92)	198 (92)	208 (98)	N/A	195 (91)	205 (96)
High Coolant Temperature Warning Activates	221 (105)	218 (103)	226 (108)	N/A	220 (104)	225 (107)
High Coolant Temperature Engine Shutdown Activates	225 (107)	224 (106)	234 (112)	N/A	223 (106)	228 (109)
Intake Air Temperature Activates the Engine Fan	150 (66)	188 (87)*	188 (87)*	N/A	160 (71)	160 (71)

* The fan is activated at 162°F (72°C) if the turbo boost pressure is greater than 10 psi (69 kPa).

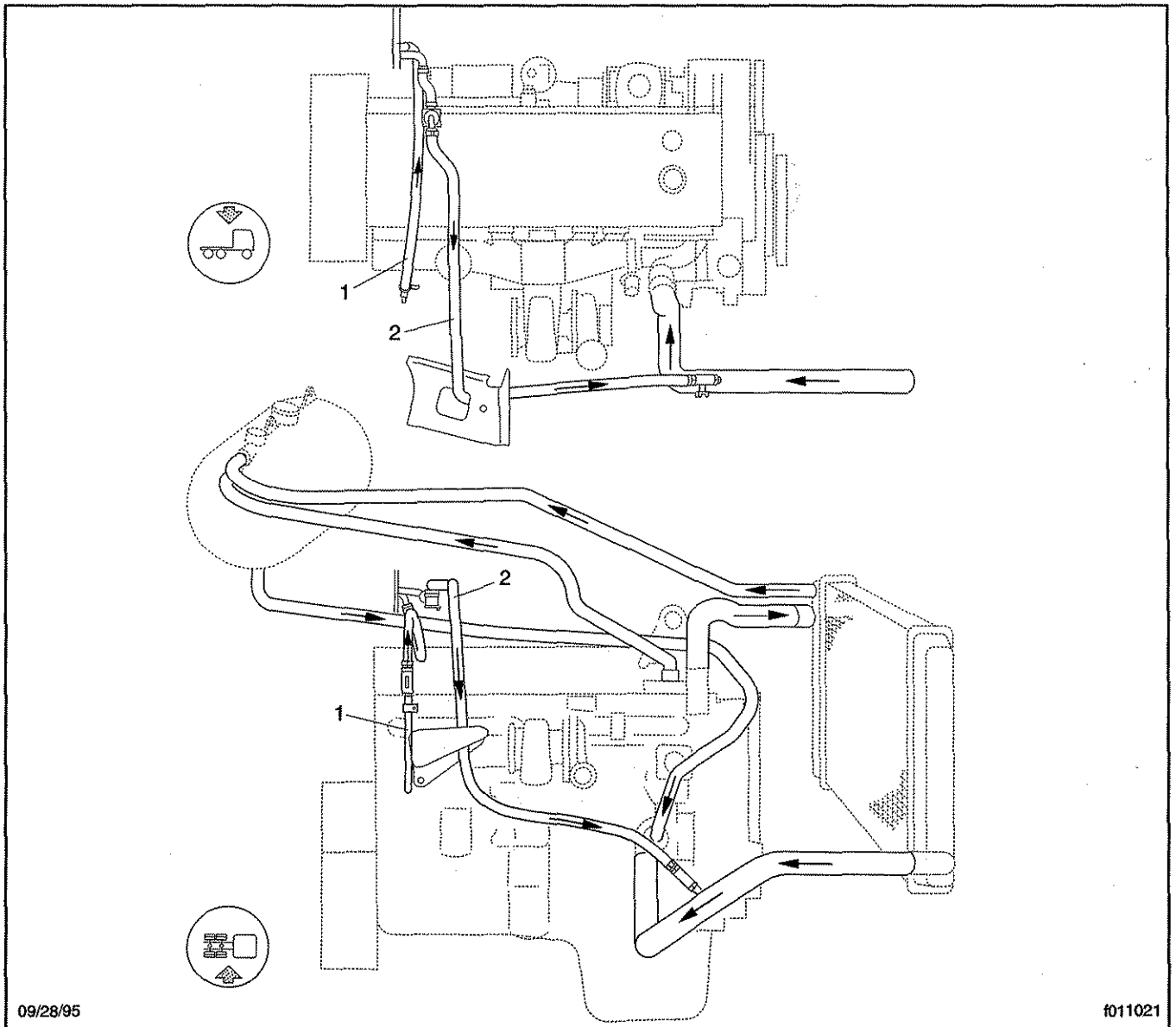
Table 1, Cooling System Control Temperatures

General Information

To add coolant to Argosy COEs, remove the metal cap from the right side of the surge tank. The surge tank is mounted on top of the radiator.

When the cab heater is activated, hoses carry some of the coolant into the cab where it flows through the heater core to warm the cab air. This coolant returns to the engine/radiator cooling system.

For more information about the radiator and surge tank, see **Section 20.01.**



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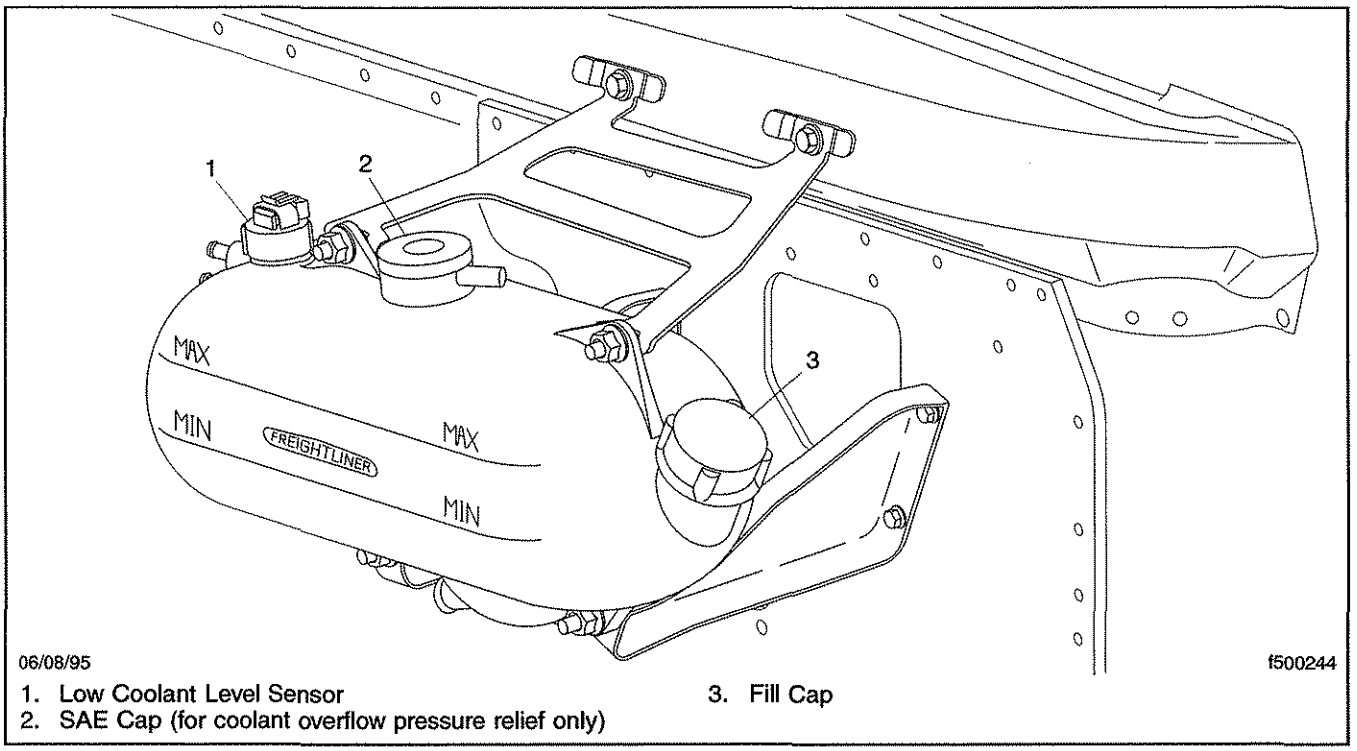
NOTE: Optional heater hose shut-off valves shown here.

1. Heater Supply Hose
2. Heater Return Hose

Fig. 1, Coolant Plumbing, Cummins M11 Engine (Century Class Conventional shown)



1. Low Coolant Level Sensor
2. SAE Cap (for coolant overflow pressure relief only)
3. Fill Cap

Fig. 2, Surge Tank (Century Class Conventional shown)

Troubleshooting

Possible causes of hot or cold engine coolant temperatures are listed below. For repairs, refer to other sections of this manual or to the engine and component manufacturers' service publications.

Problem—Coolant Temperature Above Normal

Problem—Coolant Temperature Above Normal	
Possible Cause	**Remedy**
Coolant leakage (see possible sources below) is causing a low coolant level. External Leakage:hoses and hose connections, radiator seams, core, draincock and cap, block core and drain plugs, water pump thermostat housing(s), overflow and surge tank, heater hoses and core, temperature sending unit(s), cylinder head(s) mating (gasket) surfaces, coolant filter, oil cooler(s) Internal Leakage: cylinder head gasket, warped head or block surfaces, cracked cylinder head or block, cylinder head capscrews loose, missing, or tightened unevenly; oil cooler, air compressor cylinder head and gasket cylinder liners, liner seals aftercooler	Perform the repairs necessary to stop leakage. Fill to the bottom of the radiator fill neck with the correct mixture of antifreeze and water.
The temperature gauge is not working.	Check the gauge circuit wires, circuit breaker, and sending unit. If the gauge circuit is okay, replace the temperature gauge. If the gauge circuit is broken, repair it and then check temperature gauge operation
The radiator fins, the aftercooler, or the air conditioner condenser fins are clogged.	Clean the outside of the core, the aftercooler, and the condenser with compressed air directed from the fan side, or with water and a mild laundry soap. Straighten bent fins.
A radiator hose is collapsed or plugged.	Replace hoses.
A fan drive belt or the water pump belt is loose.	Adjust belt tension.
The cooling fan shroud is damaged.	Repair or replace the shroud.
The radiator cap is incorrect or malfunctioning.	Make sure the correct radiator cap is installed. If the cap does not hold the correct pressure, replace it.
The on-off fan clutch is not working.	Check the solenoid valve in the fan clutch air supply line, the sending unit for the valve, and the operating air pressure to the valve. If valve operation and air pressure are okay, repair or replace the fan clutch. If the valve doesn't work or if air pressure is low, make repairs and then check fan clutch operation.
The engine oil level is incorrect.	Fill to the high (H) mark on the dipstick.
There is too much antifreeze or coolant additive in the system.	Clean and flush the cooling system. Refill the system with the correct mixture of antifreeze and water, and install the correct additive and filter, or treatment filter.
One or both of the thermostats is incorrect or inoperative.	Make sure the correct thermostat is installed. Test the thermostat according to the engine manufacturer's instructions. Replace it if it does not operate correctly.

Troubleshooting

Problem—Coolant Temperature Above Normal	
Possible Cause	**Remedy**
The water pump is not working correctly.	Repair or replace the water pump.
The radiator core is internally plugged or damaged.	To check for blockages, warm the engine to normal operating temperature. Turn off the engine, and run your hand over the finned surface of the radiator. If there is a blockage in the radiator, it should cause an obvious temperature difference from one area of the core to another. An obvious difference between inlet and outlet temperature is normal. If blockage is suspected, clean and flush the cooling system. Repair or replace a damaged core.
Air or combustion gases are entering the cooling system.	Check the cylinder head(s), head gasket(s), cylinder liners, aftercooler, air compressor cylinder head, and fan/shutter air control valve (if applicable) for leaks. Repair or replace parts, as necessary.
The aftercooler is plugged or damaged.	Repair or replace the aftercooler.
The oil cooler is plugged or damaged.	Repair or replace the oil cooler.
The engine is receiving too much fuel.	Refer to the engine manufacturer's fuel delivery system adjustment procedures
The wrong fan (replacement unit) is installed.	Install the correct fan.
The wrong radiator (replacement unit) is installed.	Install the correct radiator.
There is exhaust blockage.	Repair the exhaust system.
There is frozen coolant in the radiator.	Use the proper antifreeze-to-water ratio needed for winter temperatures.

Problem—Coolant Temperature Below Normal

Problem—Coolant Temperature Below Normal	
Possible Cause	**Remedy**
The temperature gauge is not working.	Check the gauge circuit wires, circuit breaker, and sending unit. If the gauge circuit is okay, replace the temperature gauge. If the gauge circuit is broken, repair it and then check temperature gauge operation.
The on-off fan clutch operates continuously.	Check the solenoid valve in the fan clutch air supply line, the sending unit for the valve, and the operating air pressure to the valve. If valve operation and air pressure are okay, repair or replace the fan clutch. If the valve doesn't work or if air pressure is low, make repairs and then check fan clutch operation.
One or both thermostats are incorrect or inoperative.	Make sure the correct thermostat is installed. Test the thermostat according to the engine manufacturer's instructions. Replace it if it does not operate correctly.

Radiator Assembly 20.01

Contents

Subject	Subject Number
General Information	050
Service Operations	
Coolant Draining and Filling	100
Fan Removal and Installation	110
Fan Shroud Removal and Installation	120
Radiator Removal and Installation	130
Radiator Mount Removal and Installation, Century Class Conventionals	140
Radiator Pressure Testing	150
Surge Tank Removal and Installation, Century Class Conventionals	160
Surge Tank Removal and Installation, Argosy COEs	165
Radiator Disassembly and Assembly	170
Air Recirculation Shield Removal and Installation, Century Class Conventionals	180
Fan Ring Assembly Removal and Installation, Coronado	190
Radiator, 1350-Square-Inch, Removal and Installation	200
Troubleshooting	300
Specifications	400

General Information

The main function of a cooling system is to keep the engine at its optimum operating temperature. This results in the most efficient use of fuel and allows the engine oil to provide a good lubricating film.

The central component of the cooling system, the radiator assembly, includes the surge tank (remote mounted on the firewall), the radiator, and the surge tank pressure relief cap. **See Fig. 1.**

The surge tank provides storage space for reserve coolant, expansion space for heated coolant, and deaeration space. **See Fig. 2.** When coolant in the radiator runs low, reserve coolant stored in the surge tank flows from the tank, through the fill hose, to the water pump. As the coolant heats and expands beyond radiator capacity, excess coolant travels back through the fill hose from the water pump to the surge tank. Any air trapped in the engine block or radiator rises to the top of the engine or radiator and escapes through the vent hoses to the surge tank.

The low coolant level sensor in the surge tank warns the driver when coolant is running low. The surge tank is translucent polypropylene so you can see the coolant level and compare it to the maximum and minimum levels marked on the tank.

These vehicles use full-flow (or high-flow) radiators. With full-flow radiators, the coolant flows into the radiator at the top of the left side tank and flows out of the radiator at the bottom of the right side tank. Most of the engine coolant is routed through the radiator, and it moves relatively quickly in a single pass.

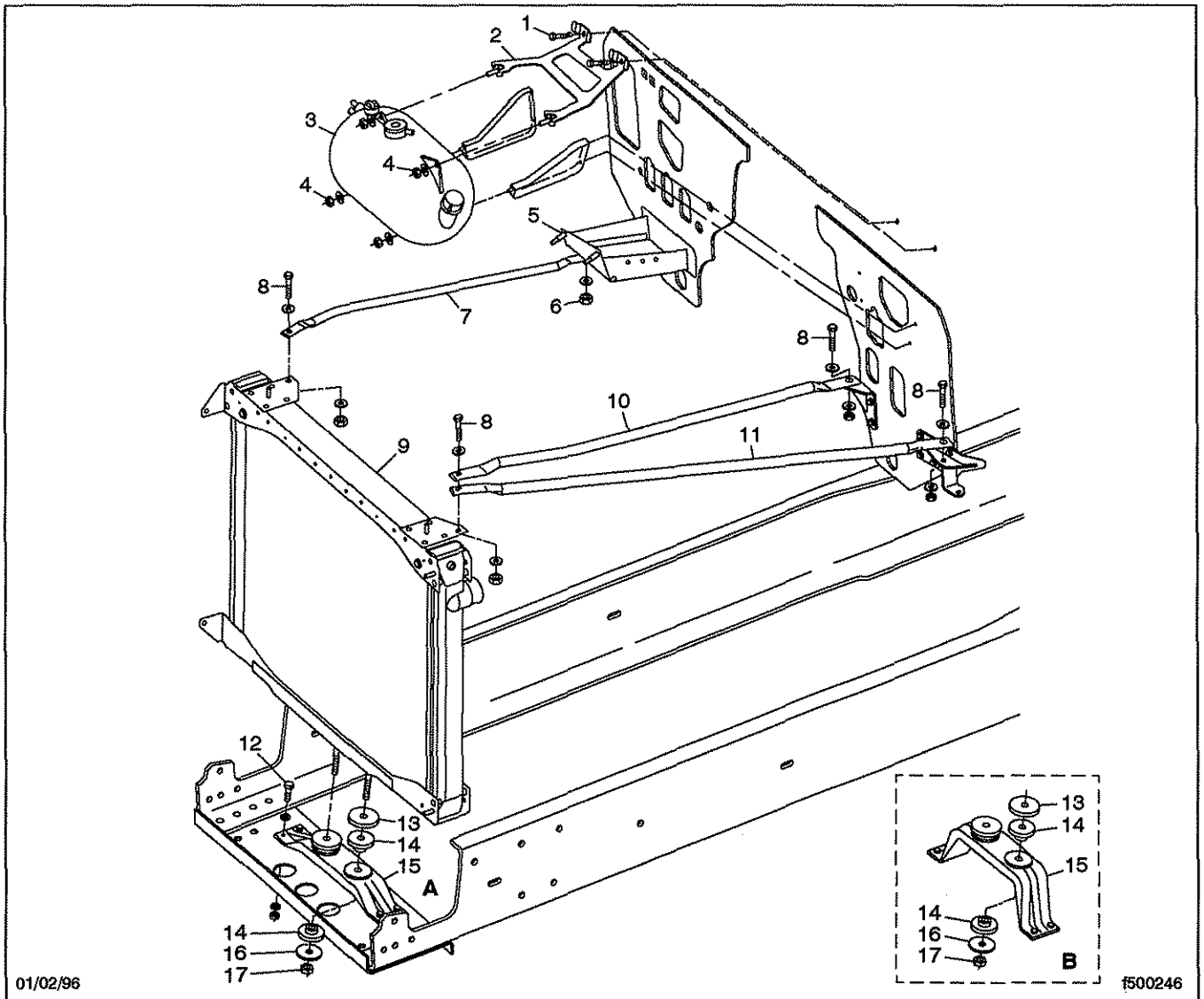
There are two sizes of two-row radiators in use: one radiator has 1000 square inches of front area and the other has 1200 square inches. **See Fig. 3** and **Fig. 4.**

The radiators use glass-filled nylon side tanks. The edges of the radiator core header are compressed in a "dimple wave lock" crimp (**see Fig. 5**) that holds the tanks on the radiator core, and the tanks and core are held in steel channels that mount on the front closing crossmember. The radiator is also secured by brace rods that run between the top of the radiator and the firewall. The fins of the radiator core are reinforced along their forward edge to resist damage from road debris and pressure washing.

Because crimping holds the nylon side tanks tanks in place, the radiators can be disassembled and assembled.

The surge tank cap limits system pressure to about 11 to 12 psi, which raises the boiling point of the coolant. If the cooling system overheats, excess coolant is released through the overflow tube.

For more general information about the radiator and surge tank, and for cooling system troubleshooting procedures, refer to **Section 20.00** in this workshop manual.

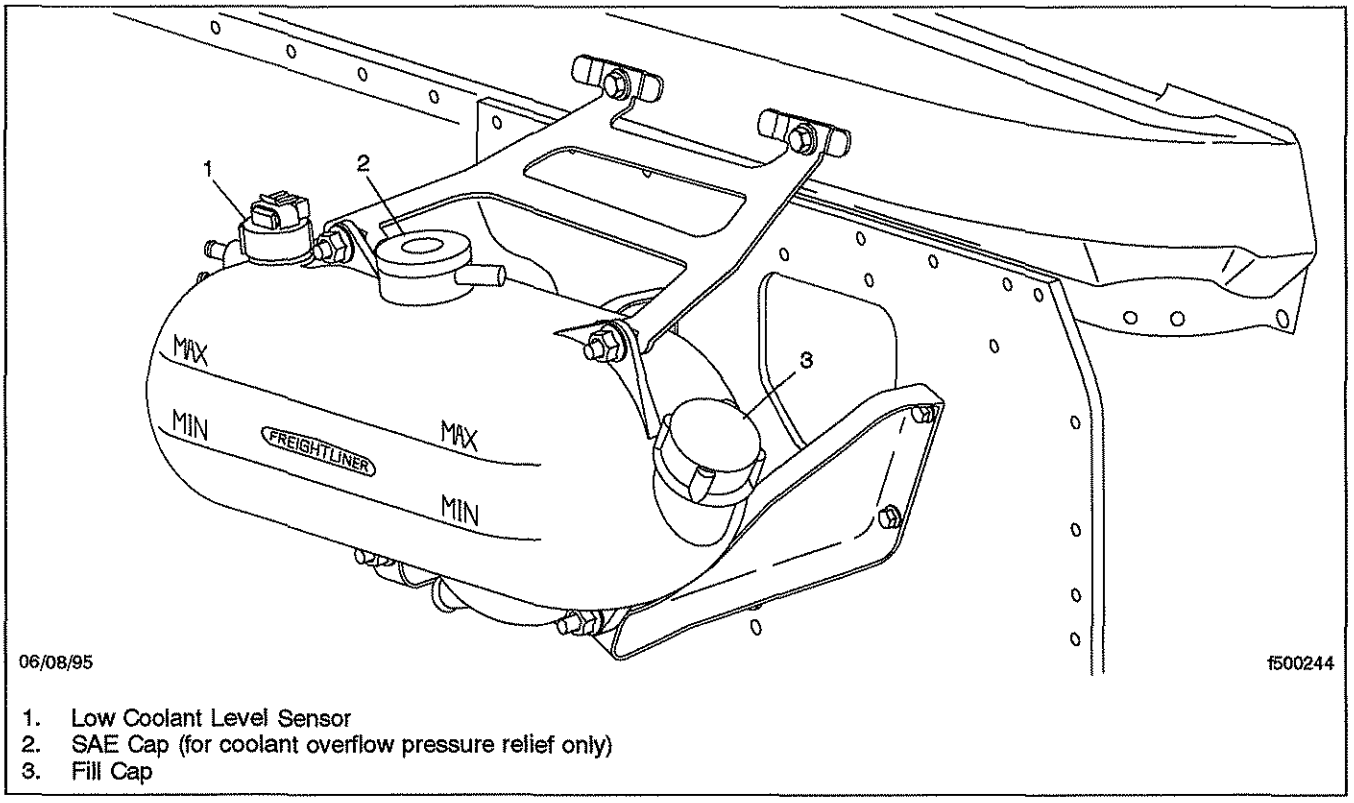


A. Support Bracket for a 1200-Square-Inch Radiator

B. Support Bracket for a 1000-Square-Inch Radiator

1. Machine Screw, 5/16-18 Stainless Steel
2. Upper Surge Tank Bracket
3. Surge Tank
4. Locknut, 3/8–16; Washer
5. Air Cleaner Mounting Bracket
6. Nut, 1/2–13, Grade 8; Washer
7. Right-Hand Radiator Strut Rod
8. Capscrew, 1/2–13x 2 Inches, Grade 8; Washer; Nut
9. Radiator
10. Left-hand Radiator Strut Rod, Inboard
11. Left-Hand Radiator Strut Rod, Outboard
12. Capscrew, 3/8–16, Grade 8; Washer; Nut
13. Spacer (used only with 11-inch frame rails)
14. Isolator
15. Radiator Support Bracket
16. Washer
17. Nut, 5/8–11, Grade 8

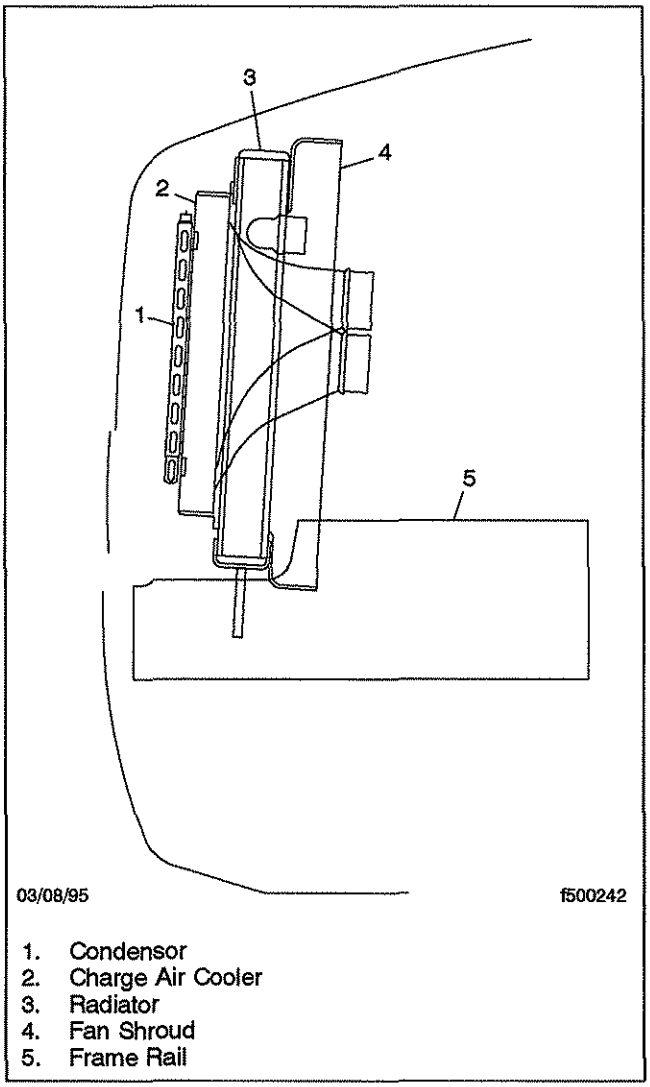
Fig. 1, Standard Radiator Installation



1. Low Coolant Level Sensor
2. SAE Cap (for coolant overflow pressure relief only)
3. Fill Cap

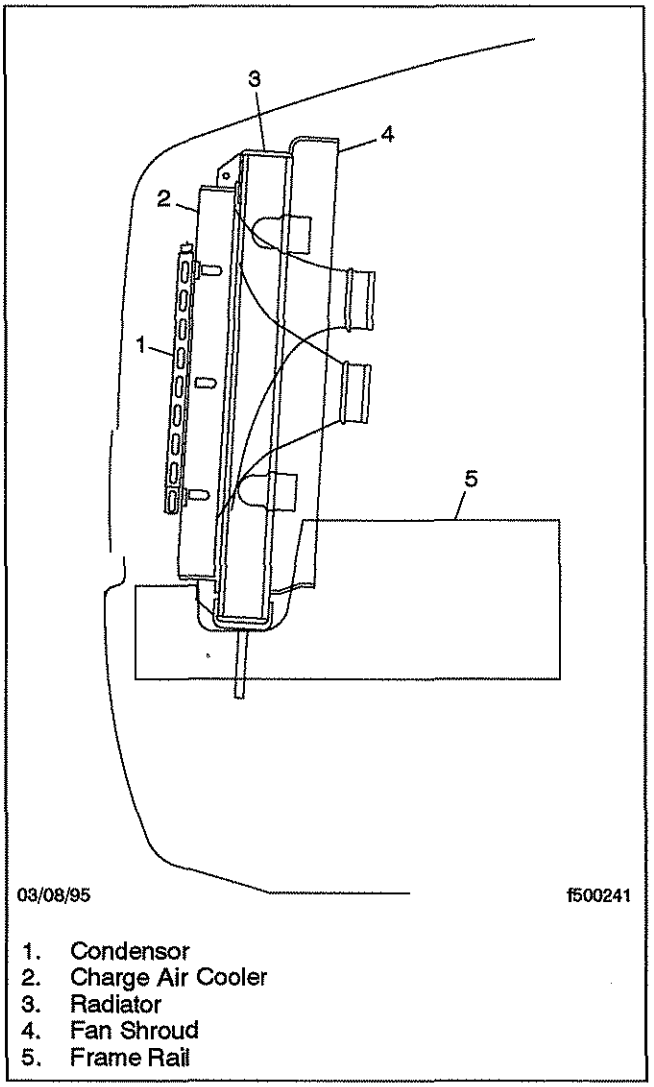
Fig. 2, Surge Tank

General Information



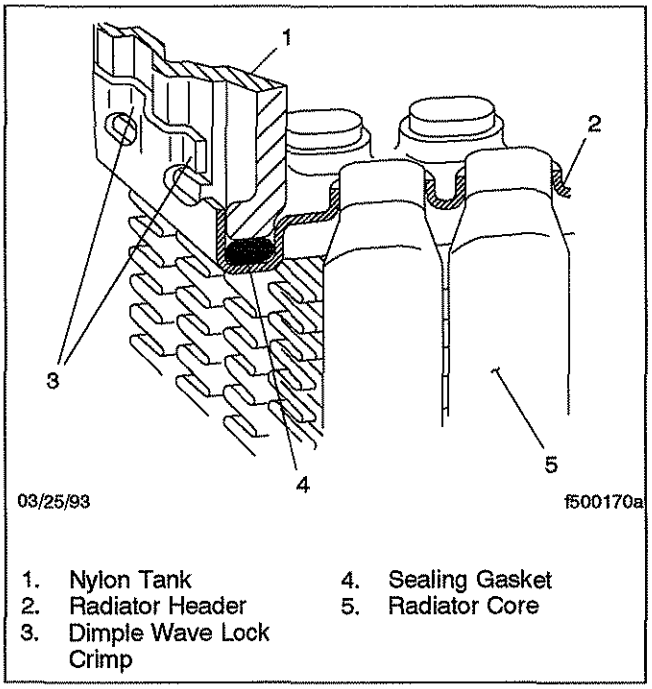
1. Condensor
2. Charge Air Cooler
3. Radiator
4. Fan Shroud
5. Frame Rail

Fig. 3, 1000-Square-Inch Radiator



1. Condensor
2. Charge Air Cooler
3. Radiator
4. Fan Shroud
5. Frame Rail

Fig. 4, 1200-Square-Inch Radiator



1. Nylon Tank
2. Radiator Header
3. Dimple Wave Lock Crimp
4. Sealing Gasket
5. Radiator Core

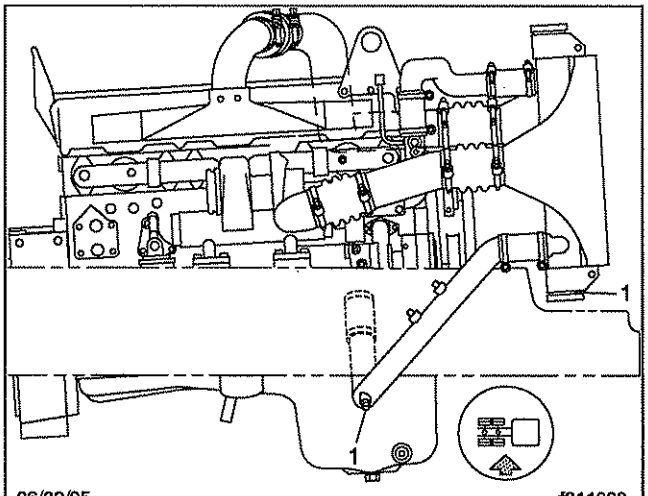
Fig. 5, Radiator Core and Header, Cutaway View

Draining

1. Park the vehicle, apply the parking brakes, and tilt the hood.

WARNING: Drain the coolant only when the coolant and engine are cool. Draining it when these are hot could cause severe personal injury due to scalding.

2. Place a suitable container under the elbow of the radiator outlet pipe. The container should hold at least 60 quarts (56.8 liters).
3. Remove the surge tank cap.
4. Remove the plugs from the lowest points of the coolant system. This will be a plug in the radiator side tank and a plug in the elbow of the radiator outlet pipe. **See Fig. 1.**
5. Allow all the coolant to drain.
6. Install the plugs in the radiator elbow and the radiator side tank.



NOTE: Cummins M11 engine shown.

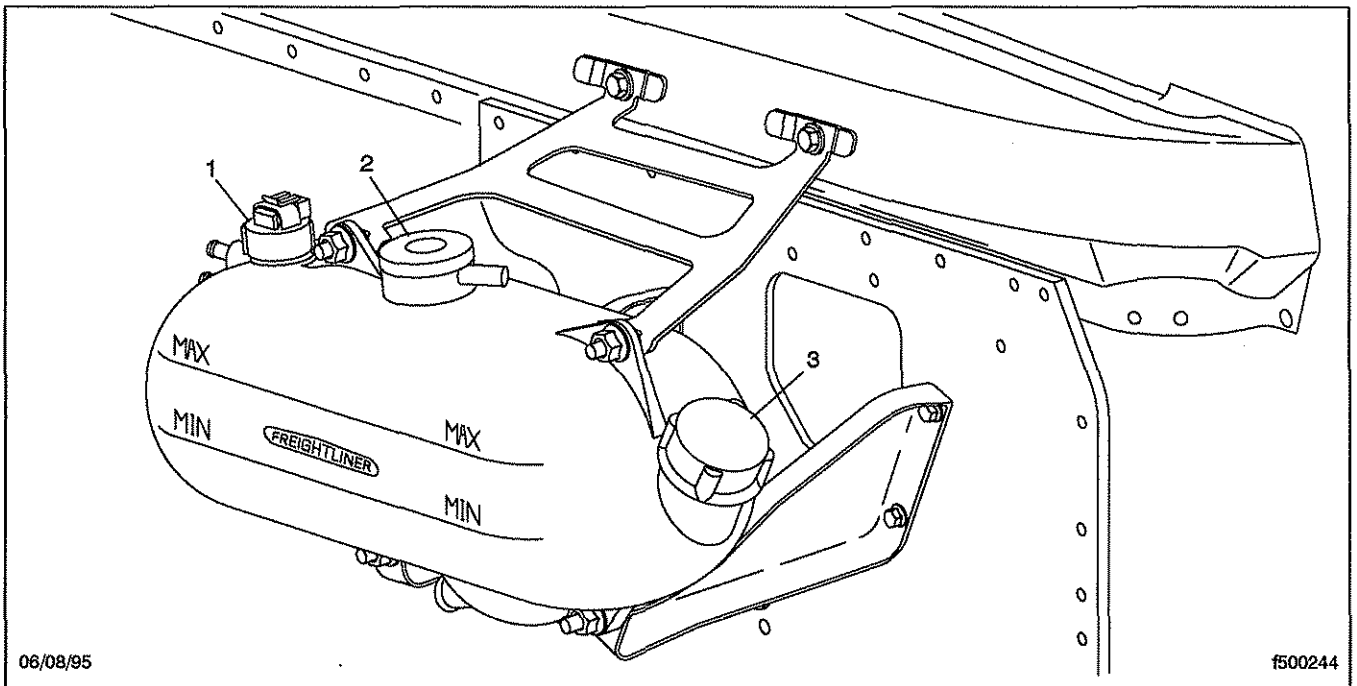
1. Coolant Drain Plug

Fig. 1, Coolant Drain Plug Location

Filling

1. Make sure the plugs are installed securely in the bottom of the radiator and the elbow of the radiator outlet pipe.
2. At the surge tank, fill the system with coolant until the level of coolant shows between the minimum and maximum coolant level lines on the surge tank. **See Fig. 2.** For approved coolant, and the coolant capacity for your engine, refer to the vehicle maintenance manual.
3. Run the engine for ten minutes, and add coolant as needed.

Coolant Draining and Filling

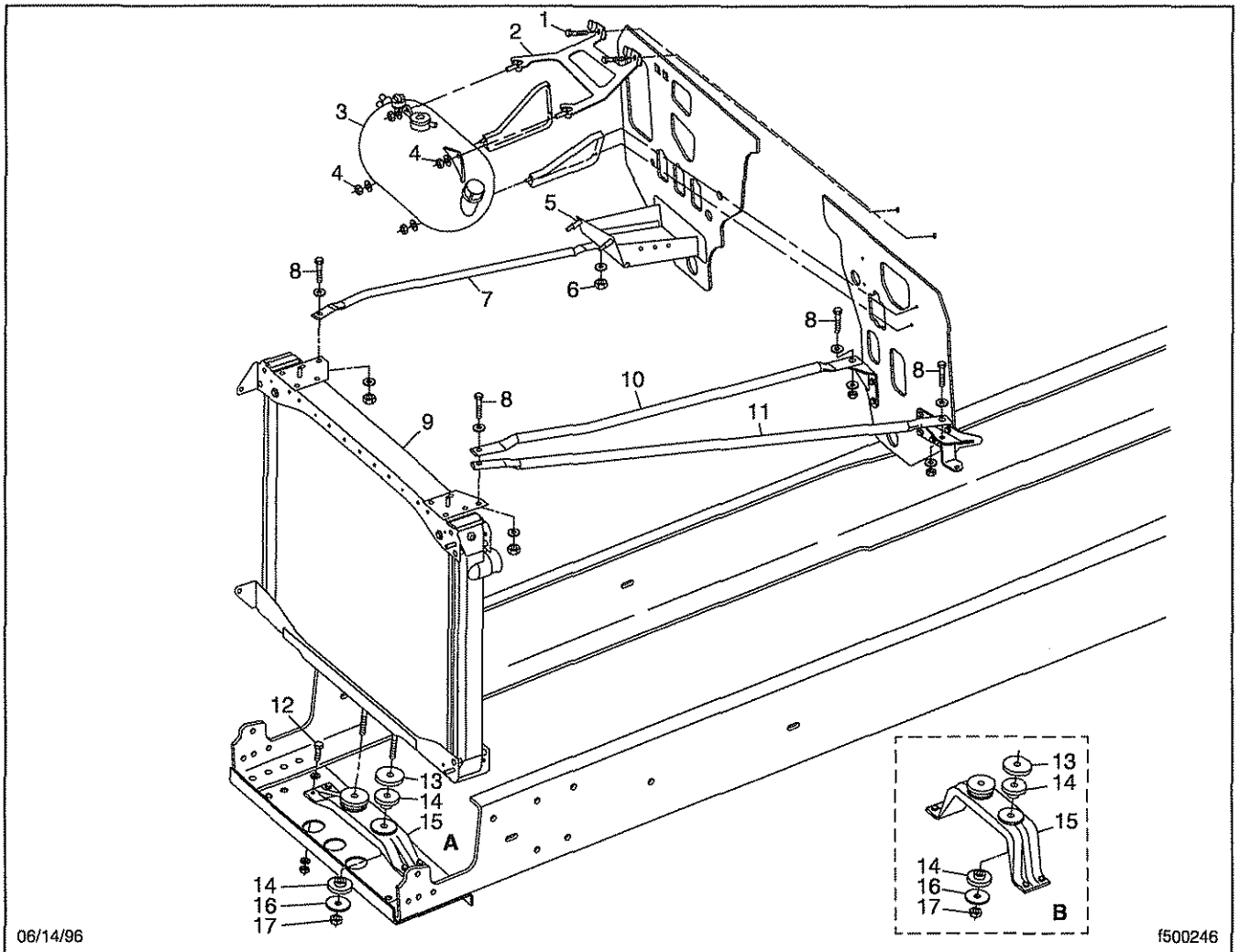


1. Low Coolant Level Sensor
2. SAE Cap (for coolant overflow pressure relief only)
3. Fill Cap

Fig. 2, Surge Tank

Radiator Removal and Installation

Removal (See Fig. 1 or Fig. 2)



A. Support Bracket for a 1200-Square-Inch Radiator
1. Machine Screw, 5/16-18 Stainless Steel
2. Upper Surge Tank Bracket
3. Surge Tank
4. Locknut, 3/8–16; Washer
5. Air Cleaner Mounting Bracket
6. Nut, 1/2–13, Grade 8; Washer
7. Right-Hand Radiator Strut Rod
8. Capscrew, 1/2–13x 2 Inches, Grade 8; Washer; Nut
9. Radiator

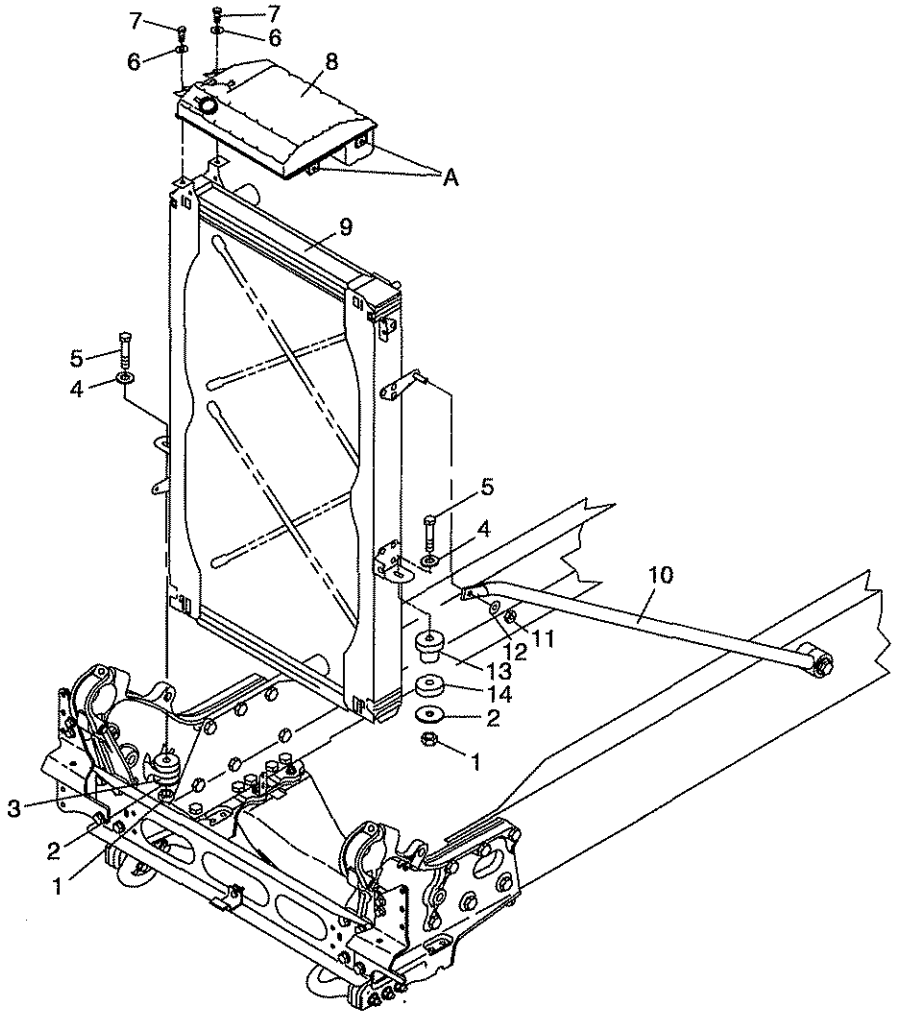
B. Support Bracket for a 1000-Square-Inch Radiator
10. Left-Hand Radiator Strut Rod, Inboard
11. Left-Hand Radiator Strut Rod, Outboard
12. Capscrew, 3/8–16, Grade 8; Washer; Nut
13. Spacer (used only with 11-inch frame rails)
14. Isolator
15. Radiator Support Bracket
16. Washer
17. Nut, 5/8–11, Grade 8

Fig. 1, Standard Radiator Installation, Century Class Conventional

1. Park the vehicle, and apply the parking brakes. Chock the tires.

For Century Class Conventionals, remove the grille. For instructions, refer to **Group 88**.

Radiator Removal and Installation



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A. Attaches to the Charge Air Cooler Outlet

1. Hexnut, 5/8-11
2. Flatwasher
3. Right-Hand Radiator Mounting Bracket
4. Washer
5. Hexbolt, 5/8–11
6. Washer
7. Hexbolt, 3/8–16, Grade 5 (hexnut not shown)
8. Surge Tank
9. Radiator
10. Left-Hand Radiator Strut Rod
11. Hexnut, 1/2–13
12. Flatwasher
13. Radiator Support Isolator, Upper
14. Radiator Support Isolator, Lower

Fig. 2, Radiator Installation, Argosy COE

For Argosy COEs, remove the upper and lower grille. For instructions, refer to **Group 60**.

2. *For Century Class Conventionals,* tilt the hood, and support it in the tilted position with a padded table or bench

For Argosy COEs, tilt the cab. For cab tilting instructions, refer to **Group 60**.

3. Drain the coolant. For instructions, refer to **Subject 100** in this workshop manual section.
4. For Century Class Conventionals, disconnect the hood straps. For instructions, refer to **Group 88**.
5. If so equipped, remove the air recirculation shields along the bottom and passenger side of the radiator.
6. Disconnect the condensor mounts and move the condensor aside without breaking the refrigerant lines. For instructions, refer to **Group 83**.
7. Disconnect the hoses from the radiator.
8. Disconnect the hoses from the charge air cooler.
9. Remove the fan shroud, and move it back against the engine.
10. For Century Class Conventionals, attach chains and a lifting device to the hood strap attachment bolts on the top of the radiator.
11. Disconnect the struts from the radiator.
12. Remove the nuts from the radiator mounting bolts at the bottom of the radiator for Century Class Conventionals, or at the sides of the radiator for Argosy COEs.
13. For Argosy COEs, mark, then disconnect all the coolant hoses from the surge tank on top of the radiator. Disconnect the low coolant sensor wiring from the rear of the surge tank.
14. *For Century Class Conventionals,* use a lifting device and remove the radiator and charge air cooler from the vehicle.

    For Argosy COEs, use an assistant to help, and manually lift the radiator, the surge tank, and the charge air cooler from the vehicle.

Installation

1. *For Century Class Conventionals,* with a lifting device secured to the radiator and charge air cooler with chains, lift the radiator to position it in the vehicle.

   For Argosy COEs, attach the surge tank (if removed) to the top of the radiator and the charge air cooler inlet. Tighten the fasteners 26 lbf·ft (35 N·m).

   Put the radiator, charge air cooler, and surge tank assembly in place, making sure the mounting brackets on the side of the radiator line up with the mounts on the inside of the frame rails.

2. *For Century Class Conventionals,* install the nuts on the mounting bolts at the bottom of the radiator. Tighten the nuts 241 lbf·ft (327 N·m).

   For Argosy COEs, install the bolts, washers and nuts into the mounting brackets at both sides of the radiator and inside the frame rails. Tighten the nuts 136 lbf·ft (184 N·m).

3. If applicable, remove the lifting chains from the radiator.
4. Attach the struts to the radiator.

   For Century Class Conventionals, tighten the strut fasteners 68 lbf·ft (92 N·m).

   For Argosy COEs, tighten the strut fasteners 136 lbf·ft (184 N·m).

5. Install the fan shroud on the radiator. For instructions, refer to **Subject 120**.
6. Connect the coolant hoses to the radiator, and connect the hose clamps. Your hose clamps can be either T-bolt clamps (**Fig. 3**) or Breeze Constant-Torque clamps (**Fig. 4**).

   When working with T-bolt type hose clamps, tighten the clamps 55 lbf·in (620 N·cm). These clamps are now standard on hoses with an inside diameter greater than 2 inches (51 mm).

   When installing the Breeze Constant-Torque hose clamps, the clamps must be tightened to the correct torque. The screw tip of the clamp must extend about 1/4 inch (6 mm) from the clamp housing, and the belleville washer stacks must be collapsed almost flat. Use a torque wrench to install these hose clamps correctly. The correct installation torque for Breeze Constant-Torque hose clamps is as follows:

   For Breeze Constant-Torque hose clamps with a 5/16-inch tightening screw hex: 55 lbf·in (620 N·cm).

Radiator Removal and Installation

For Breeze Constant-Torque hose clamps with a 3/8-inch tightening screw hex: 90 lbf·in (1020 N·cm).

NOTE: All hose clamps will lose torque after installation due to "compression set." However, when correctly installed, Breeze Constant-Torque clamps will hold enough torque to automatically adjust and keep consistent sealing pressure. During vehicle operation and shutdown, the screw tip may adjust according to temperature and pressure changes. The torque may need to be adjusted for individual applications.

7. For Argosy COEs, connect the hoses to the surge tank, then connect the sensor wiring.

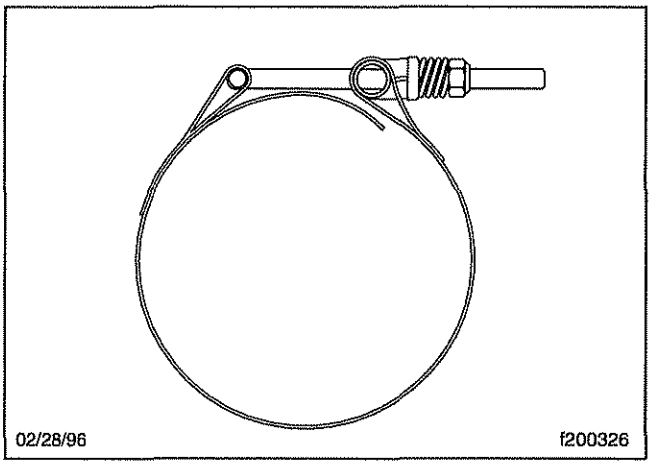
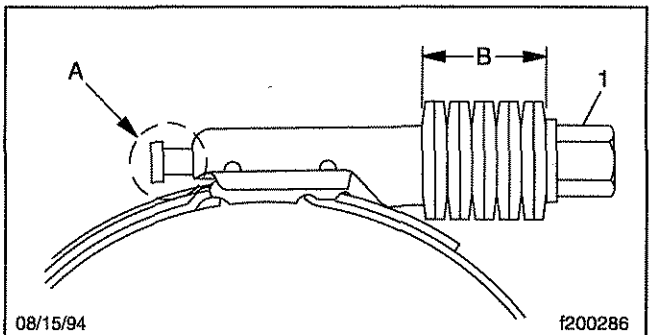


Fig. 3, T-Bolt Type Hose Clamp



A. The screw tip must extend about 1/4 inch (6 mm).
B. The belleville washer stacks must be collapsed almost flat.
1. Tightening Screw Hex

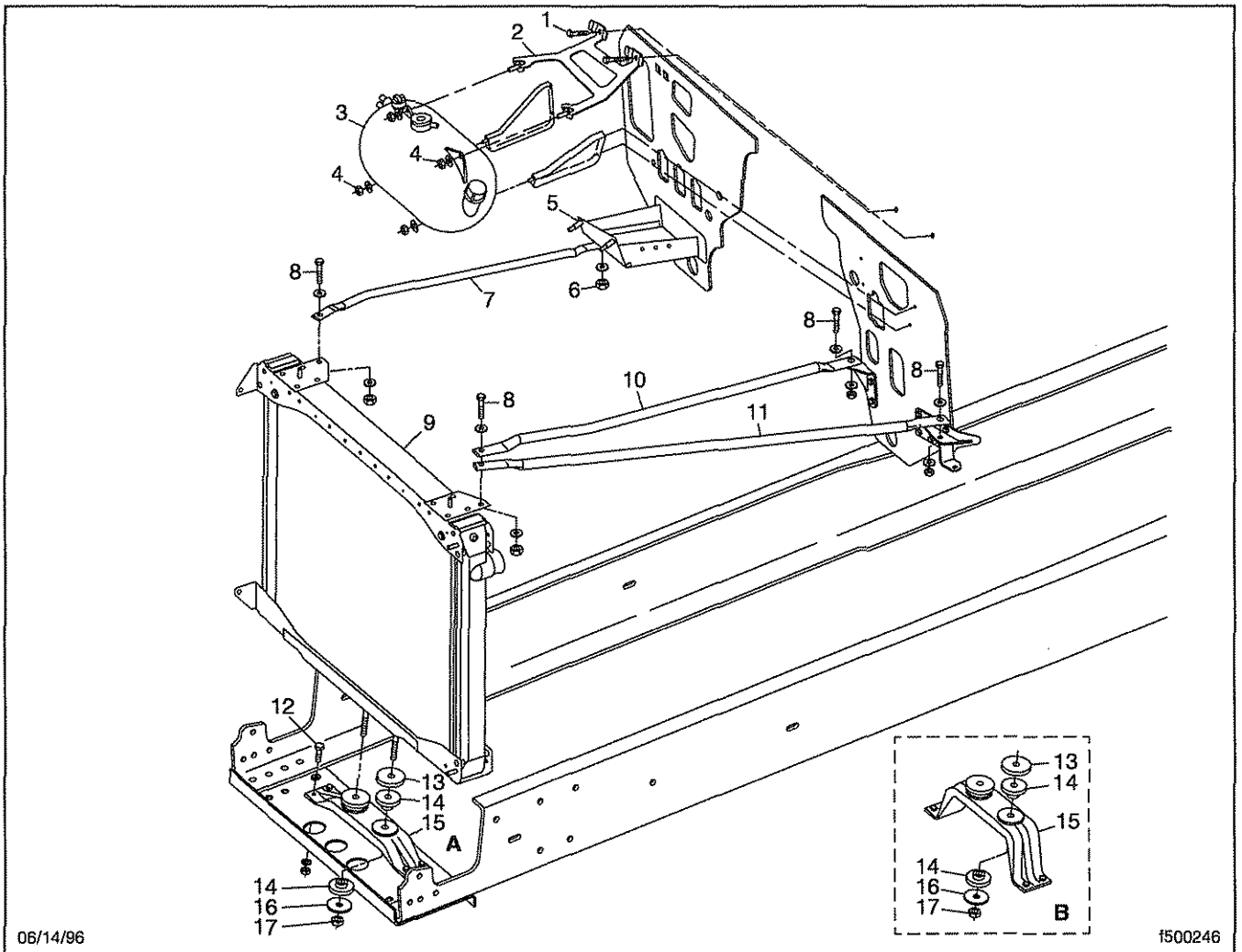
Fig. 4, Breeze Constant-Torque Hose Clamp Installation

8. Connect the hoses to the charge air cooler. For instructions, refer to **Group 09** in this manual.
9. Install the condensor. For instructions, refer to **Group 83** in this service manual.
10. Install the air recirculation shields, if so equipped.
11. Fill the coolant system. For instructions, refer to **Subject 100** in this service manual.
12. For Century Class Conventionals, install the hood straps. For instructions, refer to **Group 88** in this manual.
13. *For Century Class Conventionals,* close the hood, then install the grille. For instructions on installing the grille, refer to **Group 88** in this manual.

    For Argosy COEs, return the cab to the operating position. Install the upper and lower grilles. For instructions on lowering the cab and installing the upper and lower grilles, refer to **Group 60** in this manual.
14. Remove the chocks from the tires.

Radiator Mount Removal and Installation, Century Class Conventionals

Removal (See Fig. 1)



A. Support Bracket for a 1200-Square-Inch Radiator
B. Support Bracket for a 1000-Square-Inch Radiator

1. Machine Screw, 5/16-18 Stainless Steel
2. Upper Surge Tank Bracket
3. Surge Tank
4. Locknut, 3/8–16; Washer
5. Air Cleaner Mounting Bracket
6. Nut, 1/2–13, Grade 8; Washer
7. Right-Hand Radiator Strut Rod
8. Capscrew, 1/2–13x 2 Inches, Grade 8; Washer; Nut
9. Radiator
10. Left-hand Radiator Strut Rod, Inboard
11. Left-Hand Radiator Strut Rod, Outboard
12. Capscrew, 3/8–16, Grade 8; Washer; Nut
13. Spacer (used only with 11-inch frame rails)
14. Isolator
15. Radiator Support Bracket
16. Washer
17. Nut, 5/8–11, Grade 8

Fig. 1, Standard Radiator Installation, Century Class Conventionals

1. Remove the radiator. For instructions, refer to **Subject 130** in this workshop manual section.

Radiator Mount Removal and Installation, Century Class Conventionals

Remove the four bolts that hold the mounting bracket to the front closing crossmember.

2. Remove the mounting bracket from the vehicle.

Installation (See Fig. 1)

1. Position the radiator mounting bracket on the front closing crossmember.
2. Install the four bolts, nuts and washers, and tighten the nuts 28 lbf·ft (38 N·m).
3. Install the radiator. For instructions, refer to **Subject 130** in this workshop manual section.
4. Remove the chocks from the tires.

Pressure Testing

1. Remove the radiator from the vehicle. For instructions, refer to **Subject 130** in this manual section.
2. Pressure-test the radiator.

   2.1 Plug the inlet, outlet, and all other ports on the radiator assembly.

   CAUTION: Don't apply a higher amount of air pressure than specified below; too much pressure will damage the radiator core.

   2.2 Remove the radiator cap, and install a pressure regulator and gauge. Using a hand pump, apply 20 psi (138 kPa) air pressure through the filler neck.

   2.3 Submerge the radiator in a tank of water and check it for leaks. Remove the radiator from the water.

   2.4 Remove the plugs and the testing gauge, and install the radiator cap. Repair the radiator, if necessary.
3. Install the radiator in the vehicle. For instructions, refer to **Subject 130** in this manual section.

Surge Tank Removal and Installation

Removal (See Fig. 1)

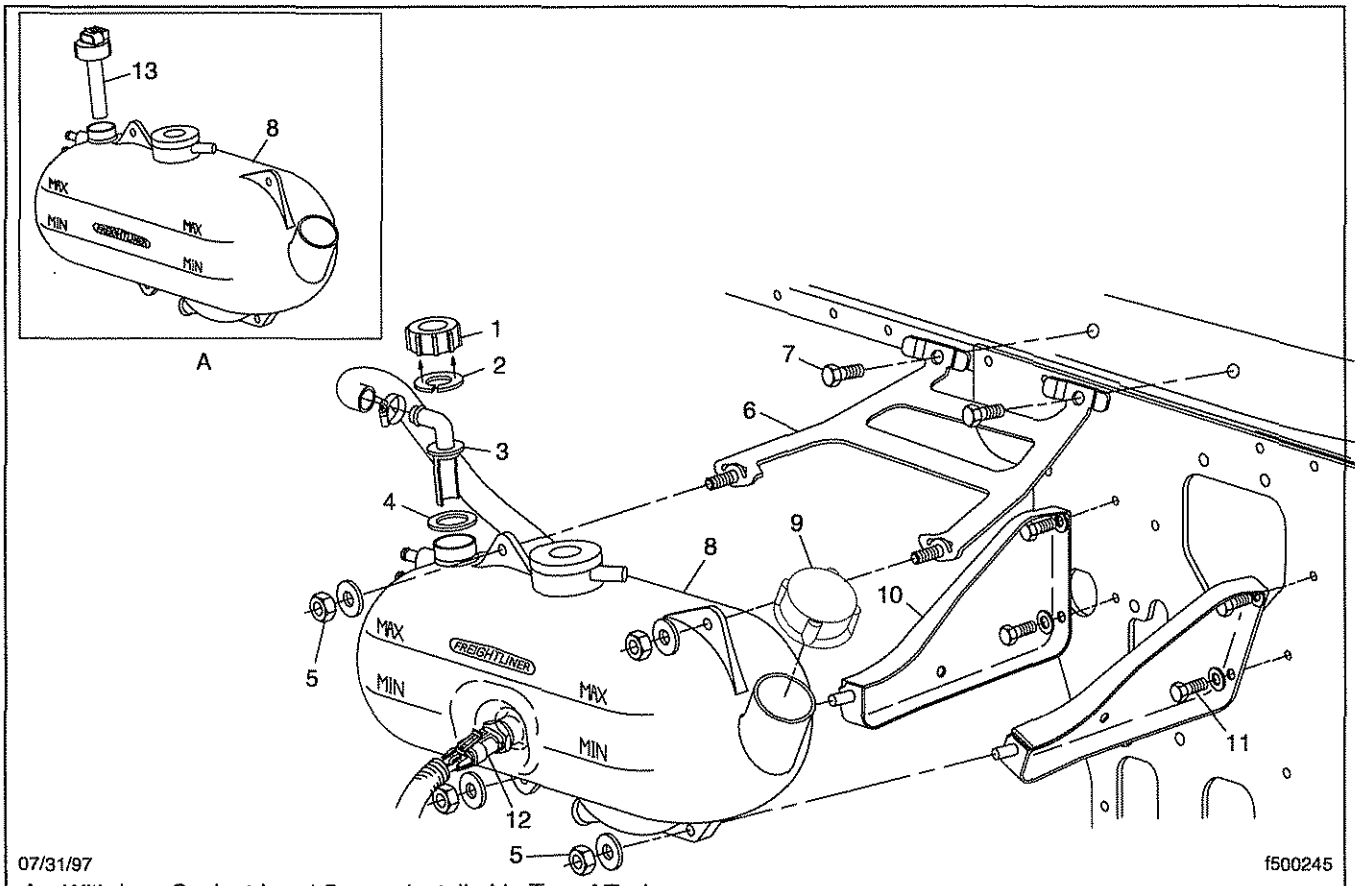
1. Drain coolant from the system until no coolant shows in the surge tank. For instructions, refer to **Subject 100**.

   Disconnect the hoses from the surge tank, but be careful to avoid spilling coolant from the hoses.

2. If the low coolant level sensor is installed in the top of the surge tank, remove it.

   If the low coolant level sensor is installed in the lower center of the surge tank, disconnect the wiring from it.

3. Remove the nuts that hold the tank to the upper and lower support brackets.



A. With Low Coolant Level Sensor Installed in Top of Tank

1. Breather Cap
2. Retaining Ring
3. Breather Assembly
4. Gasket
5. Locknut, 3/8–16; Washer
6. Upper Surge Tank Bracket
7. Machine Screw, 5/16–18, Stainless Steel
8. Surge Tank
9. Surge Tank Fill Cap
10. Lower Surge Tank Bracket
11. Capscrew, 5/16–18, Grade 5; Washer
12. Low Coolant Level Sensor, Installed in Lower Center of Tank
13. Low Coolant Level Sensor, Installed in the Top of Tank

Fig. 1, Standard Surge Tank Installation

Surge Tank Removal and Installation

Installation (See Fig. 1)

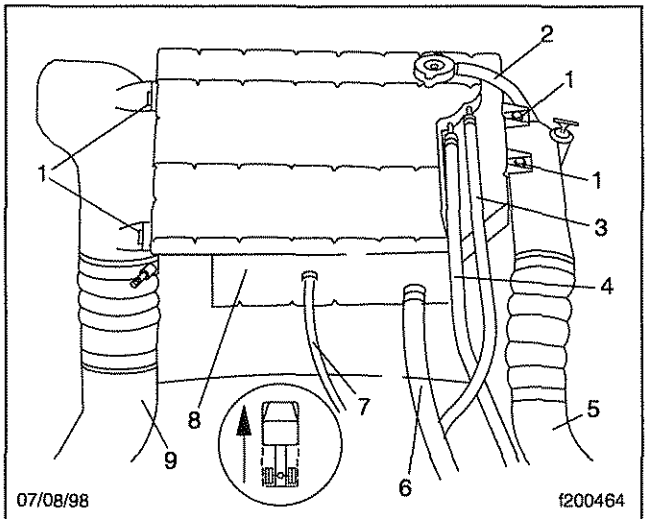
1. Position the surge tank on the upper and lower mounting brackets.
2. Install the four nuts and washers, and tighten the nuts 28 lbf·ft (38 N·m).
3. If the low coolant level sensor was removed from the top of the tank, install it.

   If the low coolant sensor is installed in the lower center of the tank, connect the wiring to it.
4. Connect the hoses to the tank
5. Fill the coolant system. For instructions, refer to **Subject 100** in this service manual section.

Surge Tank Removal and Installation, Argosy COEs

Removal

1. Park the vehicle, set the parking brakes, then chock the tires.
2. Tilt the cab. See **Group 60** for instructions.
3. Drain the coolant system enough to empty the surge tank. The surge tank is located on top of the radiator.
4. Mark, then disconnect the three coolant hoses from the surge tank. See **Fig. 1**.
5. Disconnect the the wiring from the low coolant level sensor at the rear of the surge tank.
6. Remove the fasteners holding the surge tank to the bracket on the right side of the radiator and the charge air cooler outlet.
7. Remove the surge tank.



1. Hexbolt, 3/8–16, Flatwashers, and Hexnut, 3/8–16, Grade 5
2. Overflow Hose
3. Coolant Hose to Radiator
4. Coolant Hose to Engine
5. Charge Air Cooler Inlet Hose
6. Coolant Hose to Water Pump
7. Low Coolant Sensor and Wiring
8. Surge Tank
9. Charge Air Cooler Outlet Hose

Fig. 1, Argosy Surge Tank Installation, Top View

Installation

1. Put the surge tank in place on top of the radiator.
2. Install the 3/8–16 fasteners. Tighten them 26 lbf·ft (35 N·m).
3. Connect the coolant hoses to the surge tank, as previously marked.
4. Connect the low coolant sensor wiring.
5. Fill the coolant system through the cap on top of the surge tank.
6. Return the cab to the operating position. See **Group 60** for instructions.
7. Remove the chocks from the tires.

Radiator Disassembly and Assembly

IMPORTANT: Disassembling and assembling radiators with nylon tanks requires the special tools listed in **Table 1**.

Description	Quantity
Plastech II® Tanking Machine With Five 2-Inch Cylinders	1
T-Bar	1
Hooked-End Bar	1
Wave Form Bar	1

Table 1, Disassembly Tools

Order these tools from:

RAD PAL
2381 17 St.
Detroit, MI 48216

Disassembly (See Fig. 1)

Before disassembling the radiator, pressure flush it and check the surge tank, following the instructions in the radiator group of the vehicle maintenance manual. Clean and check the exterior of the radiator, following the instructions in the vehicle driver's manual.

1. Remove the radiator from the vehicle; for instructions, refer to **Subject 130**.

⚠ CAUTION

Use care when handling or supporting the nylon tanks. Failure to do so could damage the tanks.

2. Remove the side channels from the radiator assembly.

   2.1 Remove the eight spring clips that hold the side channel mounting pins in position. **See Fig. 2.** Insert a screwdriver blade in the open end of each clip, and pry the clip open until it clears the edge of the mounting pin. Then, slip the clip off the pin.

   2.2 Use a rubber mallet and a punch to tap out the eight mounting pins. **See Fig. 3.**

   2.3 Slip the side channels off the radiator core and tank assembly. **See Fig. 4.**

3. Leak test the radiator core and tank assembly.

   3.1 Securely plug all tank ports.

⚠ CAUTION

Don't apply a higher amount of pressure than specified below; too much pressure will damage the radiator core.

   3.2 At one tank port, install a pressure regulator and gauge. Using a hand pump, apply 20 psi (138 kPa) air pressure through the port.

   3.3 Submerge the radiator in a tank of water and check it for leaks. Mark any leaks for repair. If a leak is between the radiator core header and a tank, remove the tank and inspect the tank flange, the header sealing surface, and the sealing gasket. If the leak is in the core, but within 7.5 cm (3 inches) of the tank, remove the tank before repairing the leak. If the leak is in the tank, replace the tank.

4. Remove the tanks.

   4.1 Place the radiator core and tank assembly in the disassembly/assembly fixture, and clamp the assembly securely in place. **See Fig. 5.**

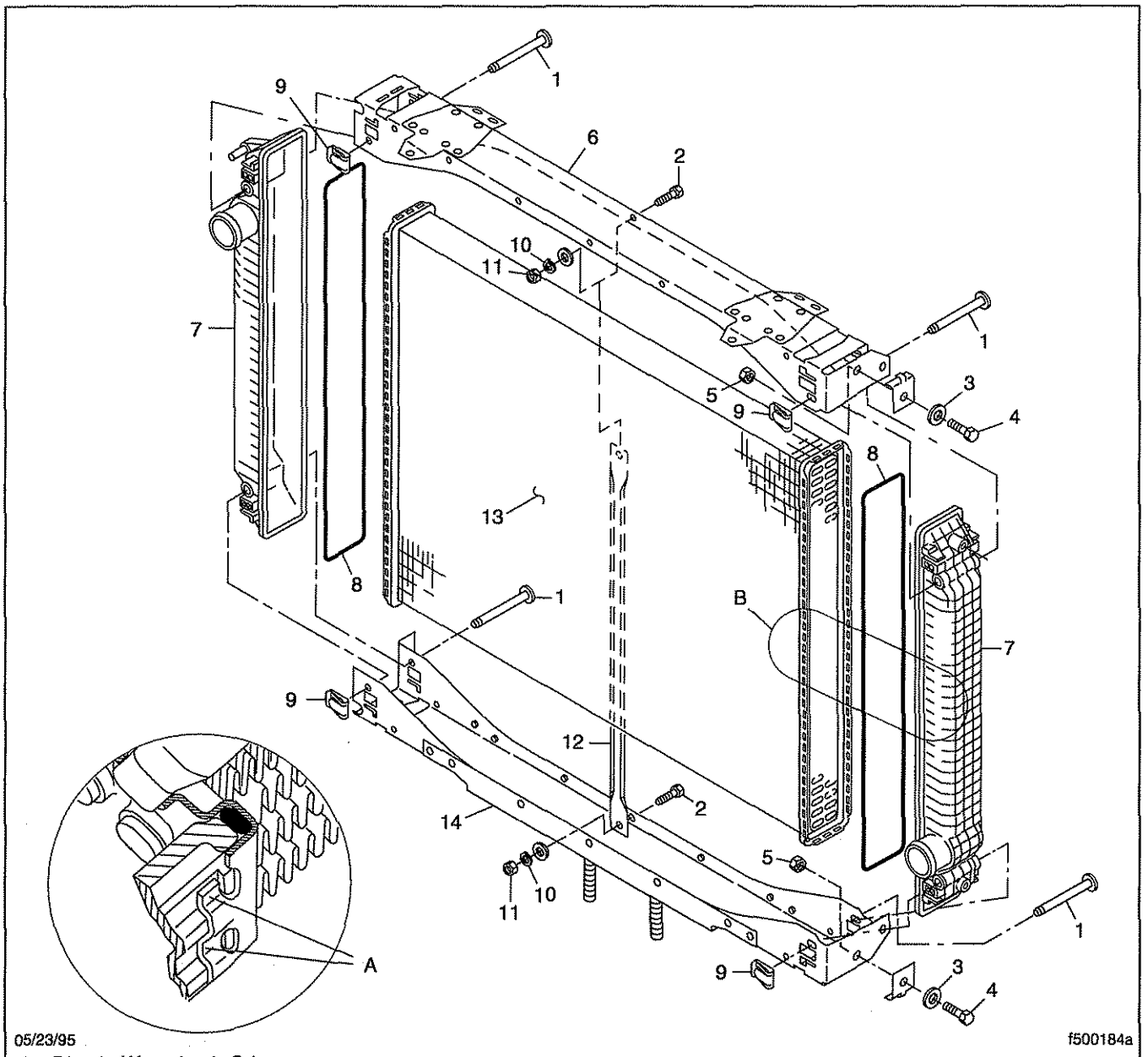
   4.2 Position the tank clamping cylinders evenly across the top of the tank. Make sure the cylinders' rubber plungers will not press against breakable fittings, such as vent tube ports.

⚠ CAUTION

Apply only enough pressure to compress the sealing gasket. Too much pressure will crack the nylon tank.

   4.3 Apply pressure evenly across the top of the tank until the tank-to-core sealing gasket is compressed enough to show a small gap between the bottom of the dimple wave lock crimp and the tank sealing flange.

Radiator Disassembly and Assembly

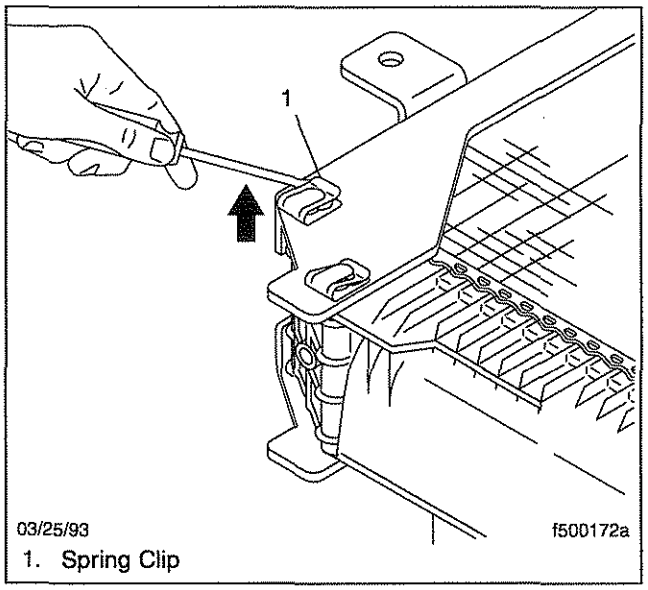


A. Dimple Wave Lock Crimp
B. See Detail

1. Channel Mounting Pin
2. Bolt
3. 3/8-Inch Flatwasher
4. 3/8-16 Bolt
5. 3/8-16 Nut
6. Side Channel (top)
7. End Tank
8. End Tank Gasket
9. Spring Clip
10. Lockwasher
11. Nut
12. Radiator Brace Rod
13. Radiator Core
14. Side Channel (bottom)

Fig. 1, Radiator With Plastic End Tanks, Century Class Conventional Shown

Radiator Disassembly and Assembly



1. Spring Clip

Fig. 2, Remove the Spring Clip

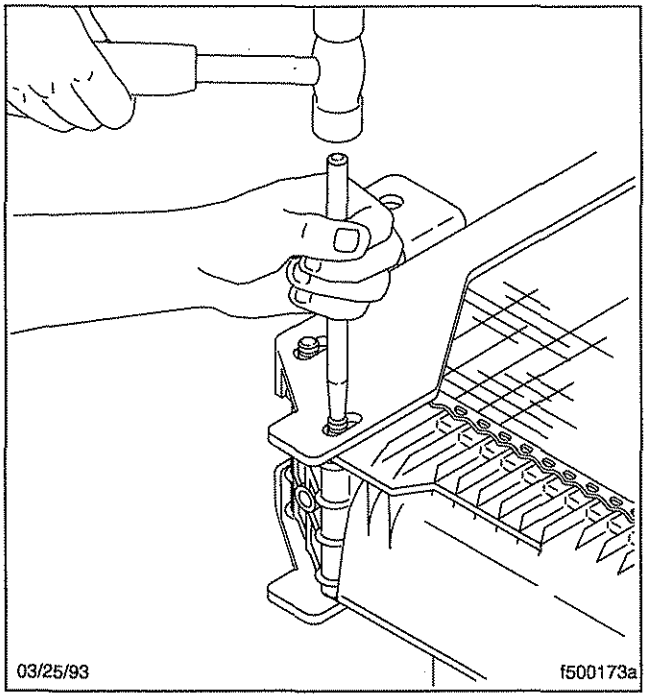
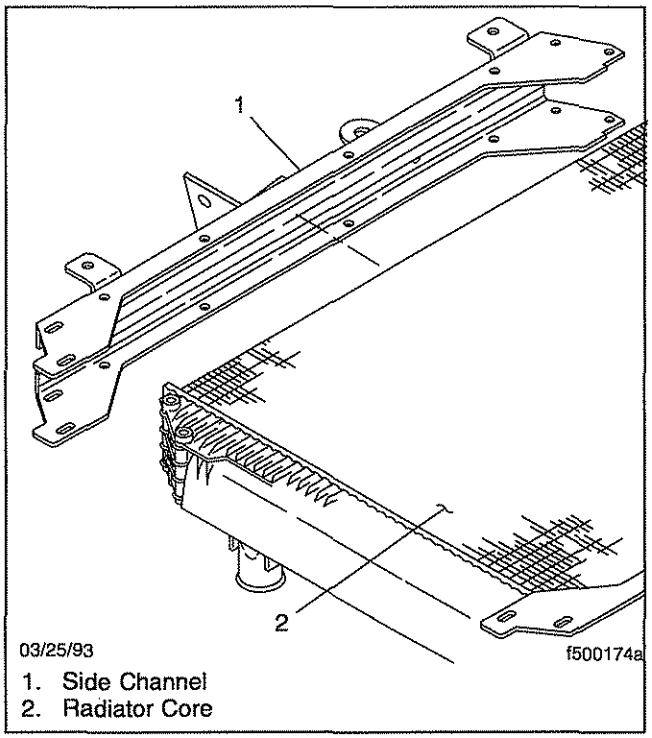


Fig. 3, Tap Out the Mounting Pins

⚠ CAUTION

In some places, especially around the tank ports, the wave lock crimps may have to be unlocked with a screwdriver. When using a screwdriver, use care not to crack or gouge the nylon tank.



1. Side Channel
2. Radiator Core

Fig. 4, Remove the Side Channels

4.4 Place the T-bar into the T-bar groove in the disassembly/assembly fixture. **See Fig. 6.**

4.5 Slide the hooked-end bar over the T-bar. Place the hook over the top of the wave crimp and pull the T-bar back to unlock the crimp. **See Fig. 6.**

4.6 Slide the hooked-end bar and the T-bar down the T-bar groove to the next wave crimp, and repeat the previous step until all the wave crimps are unlocked.

5. Once the wave crimps are unlocked, remove the tank.

5.1 Release the pressure from the tank, and move the clamping cylinders off the radiator core and tank assembly.

Radiator Disassembly and Assembly

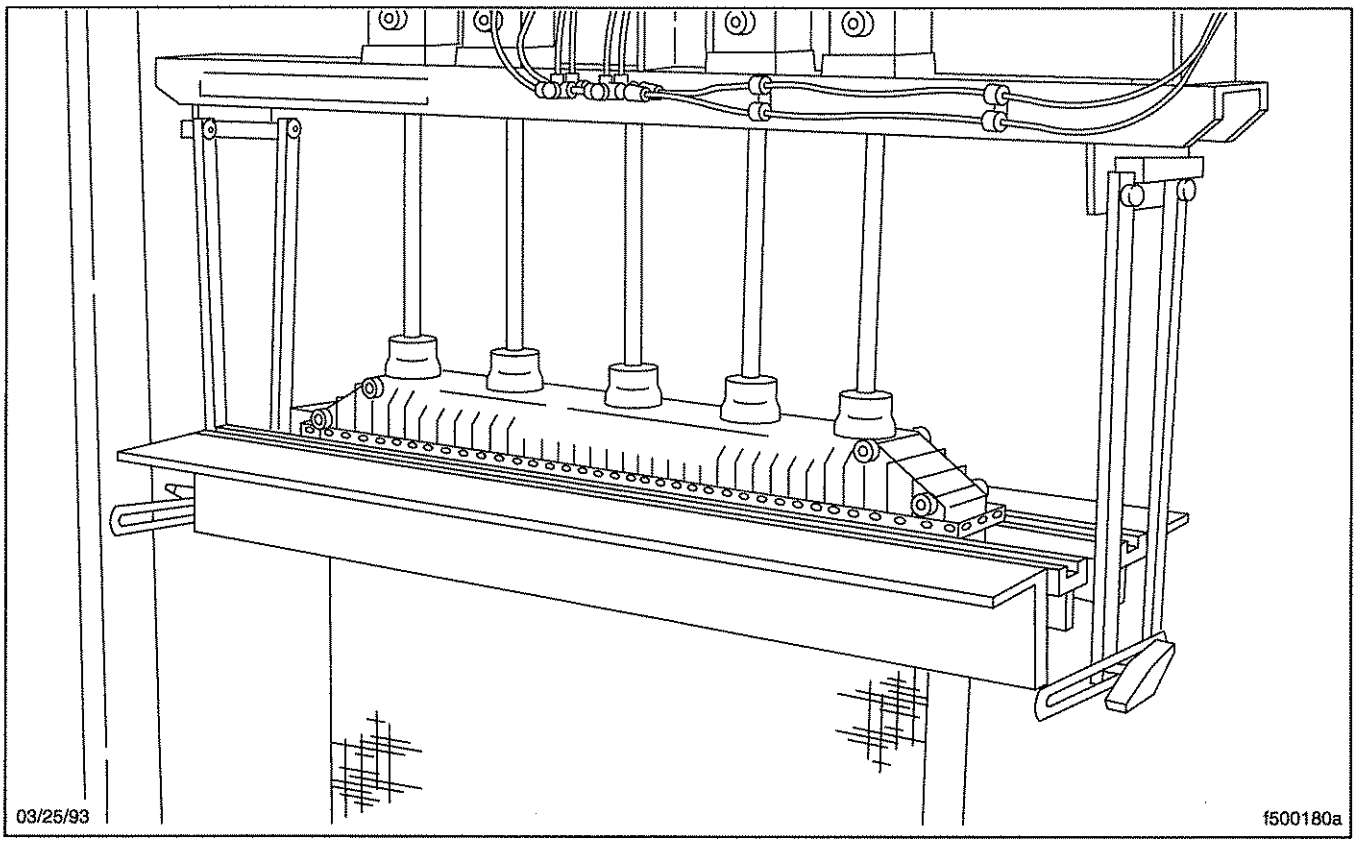


Fig. 5, Clamp the Radiator in the Disassembly/Assembly Fixture

⚠ CAUTION

If needed, use a rubber mallet or the heel of your hand and tap the side of the tank to loosen it. Do not use a screwdriver against the tank sealing flange. A screwdriver blade may damage the flange and prevent a good seal after the tank is installed.

5.2 Lift the tank from the forward side, the side opposite the tank ports. Remove the nylon tank from the radiator core. **See Fig. 7.**

5.3 Remove the sealing gasket from the sealing surface of the radiator core header. **See Fig. 8.**

5.4 Clean the sealing surface of the radiator core header.

5.5 Repair any leaks marked during leak testing.

5.6 Repeat the preceding steps to remove the opposite tank.

IMPORTANT: Check the tubes of the radiator core for scale deposits. If the radiator has been pressure-flushed, and the tubes are still clogged, the radiator should be rodded or boiled out with acid by an experienced radiator shop. Otherwise, replace the core.

Assembly

1. Install the nylon tanks on the radiator core.

1.1 With the radiator securely clamped in the disassembly/assembly fixture, header sealing surface up, make sure the bottom of the radiator core and tank assembly is completely supported, and that the header sealing surface is free of any dents, tool marks, or foreign particles.

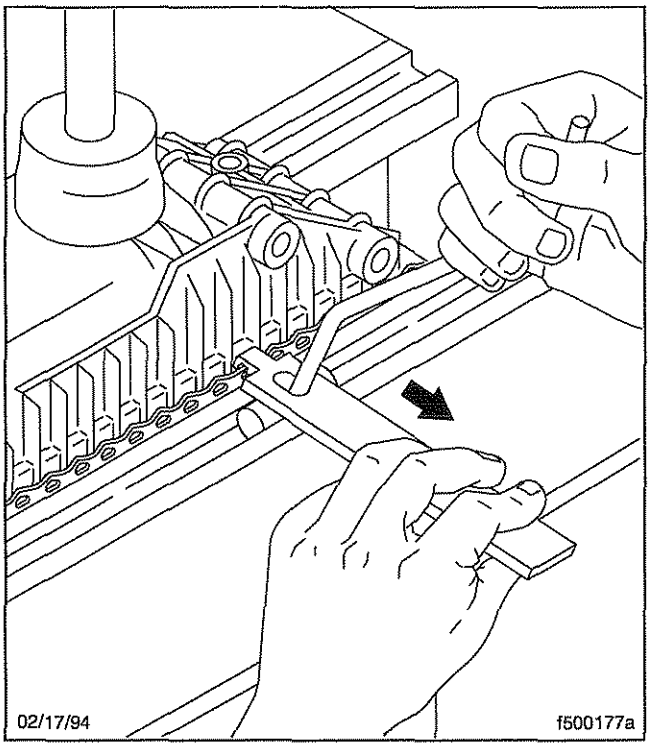


Fig. 6, Place the T-Bar

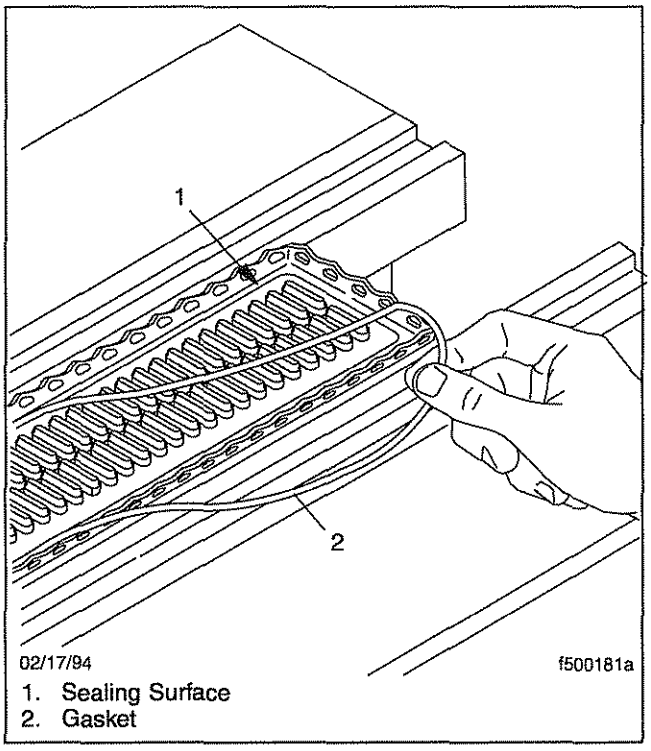


Fig. 8, Remove the Gasket

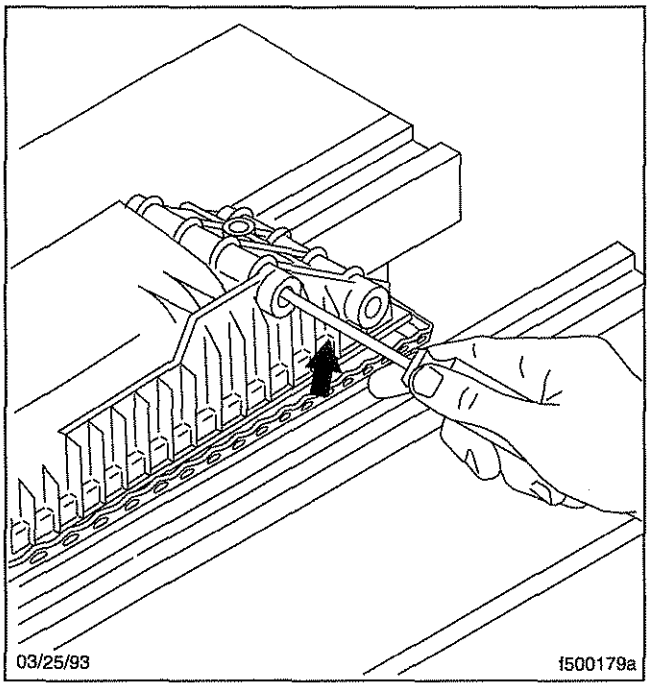


Fig. 7, Lift the Tank

1.2 Lubricate a new sealing gasket with a soap and water solution, and position the gasket on the header sealing surface. **See Fig. 8.** To make sure the gasket is not twisted, run a finger along the gasket as it lies on the sealing surface. The mold lines of the gasket should be on the outside and inside diameters of the gasket; if you can feel a mold line cross over the top of the gasket, the gasket is twisted.

1.3 Inspect the tank sealing flange. The flange must be clean and free of defects. If the sealing flange is damaged, replace the tank.

1.4 Place the tank on the gasket, and tap the tank with a rubber mallet or the heel of your hand to seat the tank. Make sure the tank ports are facing the correct direction.

1.5 Position the tank clamping cylinders evenly across the top of the tank. Make sure the cylinders' rubber plungers will not press against breakable fittings, such as vent tube ports. **See Fig. 5.**

Radiator Disassembly and Assembly

⚠ CAUTION

Apply only enough pressure to compress the sealing gasket. Too much pressure will crack the nylon tank.

1.6 Apply pressure evenly across the top of the tank until the tank-to-core sealing gasket is compressed enough to show a small gap between the bottom of the dimple wave lock crimp and the tank sealing flange.

1.7 Place the T-bar into the T-bar groove in the disassembly/assembly fixture.

1.8 Slide the wave form bar over the T-bar, and center the bar in front of the wave crimp slot.

⚠ CAUTION

Do not push the wave crimp until it touches the side of the nylon tank, or the tank may crack.

1.9 Push the T-bar forward to crimp the header's edge until it almost touches the tank's side. **See Fig. 9.**

1.10 Slide the tools down the T-bar groove to the next wave crimp slot, and repeat the previous steps until all the wave crimps are crimped.

⚠ CAUTION

In some places, especially around the tank ports, the wave crimps may have to be crimped with a screwdriver. When using a screwdriver, use care not to crack or gouge the nylon tank.

1.11 Release the pressure from the tank, and move the clamping cylinders off the radiator core and tank assembly.

1.12 Repeat the first step in this procedure to install the opposite tank.

2. Leak test the radiator core and tank assembly. For instructions, refer to "Disassembly."

3. Install the radiator side channels.

3.1 Slide the side channels onto the radiator core and tank assembly.

3.2 Using a rubber mallet and a punch, install the eight mounting pins through the side channel holes and tank bosses. **See Fig. 10.**

3.3 Install the eight spring clips to secure the mounting pins in position. **See Fig. 11.** To install each clip, place the clip over the end of the mounting pin, and slide the clip until it engages the groove in the pin and the open end of the clips snaps over the edge of the pin. If necessary, use a clamp to compress the side channel while installing the clips.

4. Install the radiator in the vehicle. For instructions, refer to **Subject 130.**

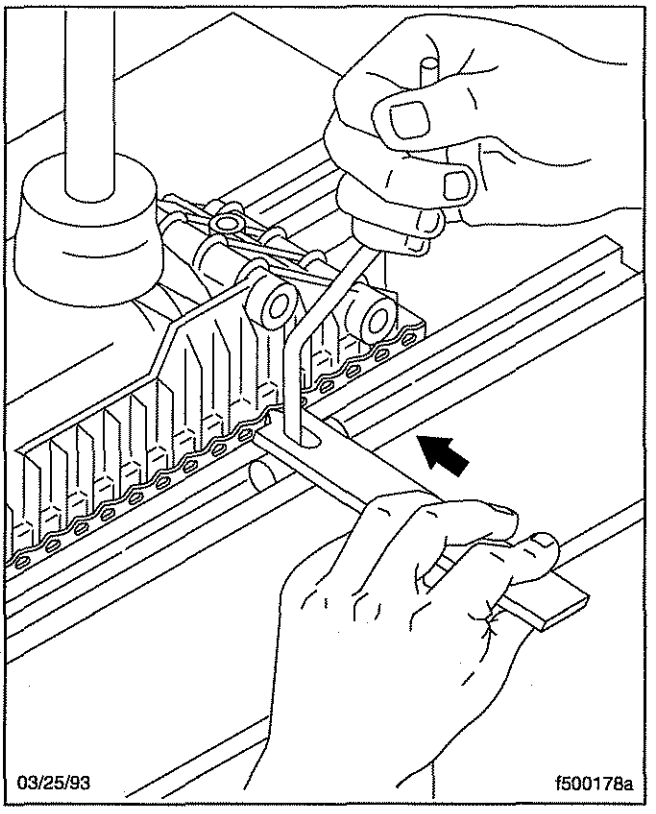


Fig. 9, Crimp the Header

Radiator Disassembly and Assembly

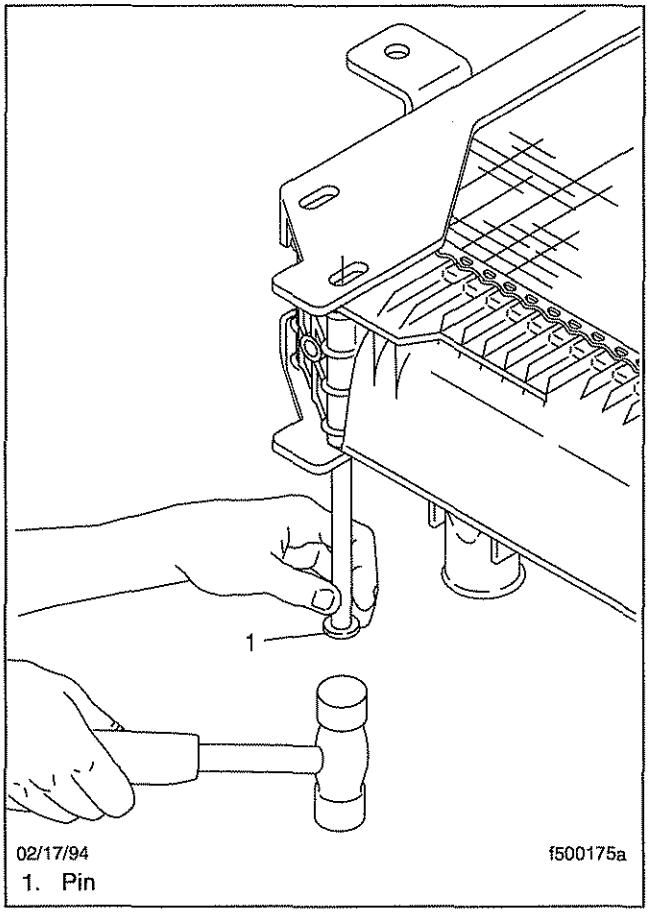


Fig. 10, Install the Mounting Pins

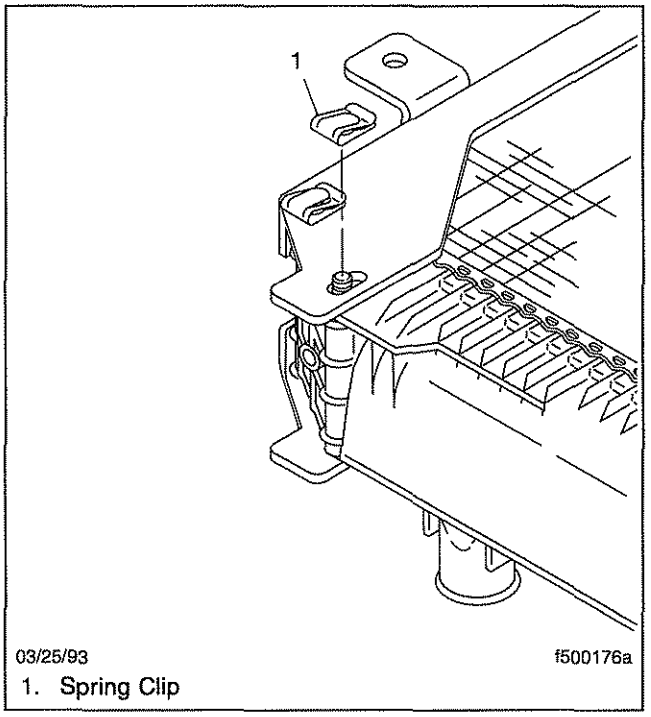


Fig. 11, Install the Spring Clips

Air Recirculation Shield Removal and Installation, Century Class Conventionals

Removal (See Fig. 1 or Fig. 2)

1. Park the vehicle, apply the parking brakes, and tilt the hood.
2. Remove the capscrews that hold the air recirculation shields to the charge air cooler and the radiator.
3. Remove the air recirculation shields.

Installation (See Fig. 1 or Fig. 2)

1. Position the air recirculation shields on the engine, and secure them with capscrews.
2. Tighten the capscrews firmly.

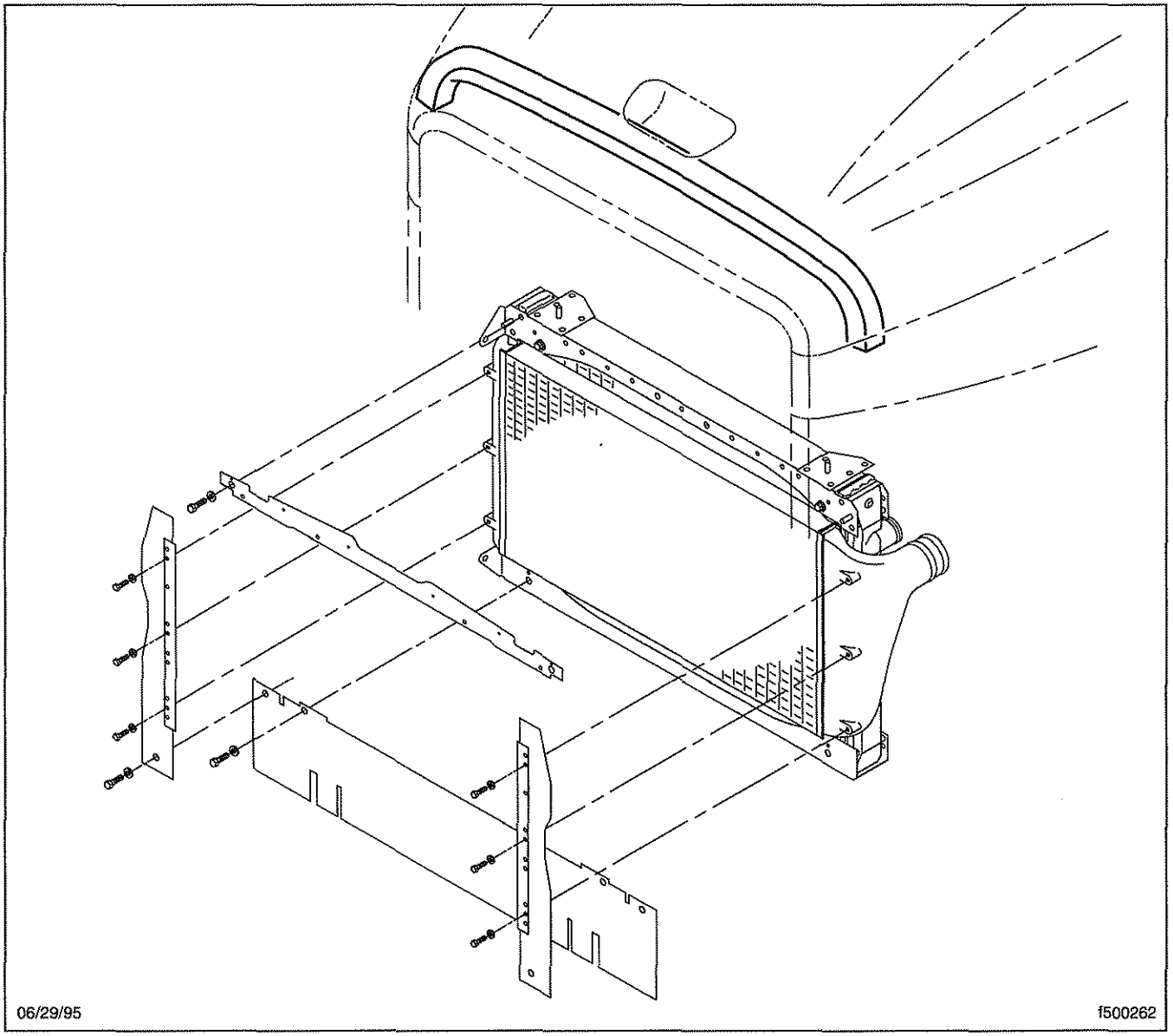


Fig. 1, Standard Air Recirculation Shield Installation, 1000-Square-Inch Radiator

Air Recirculation Shield Removal and Installation, Century Class Conventionals

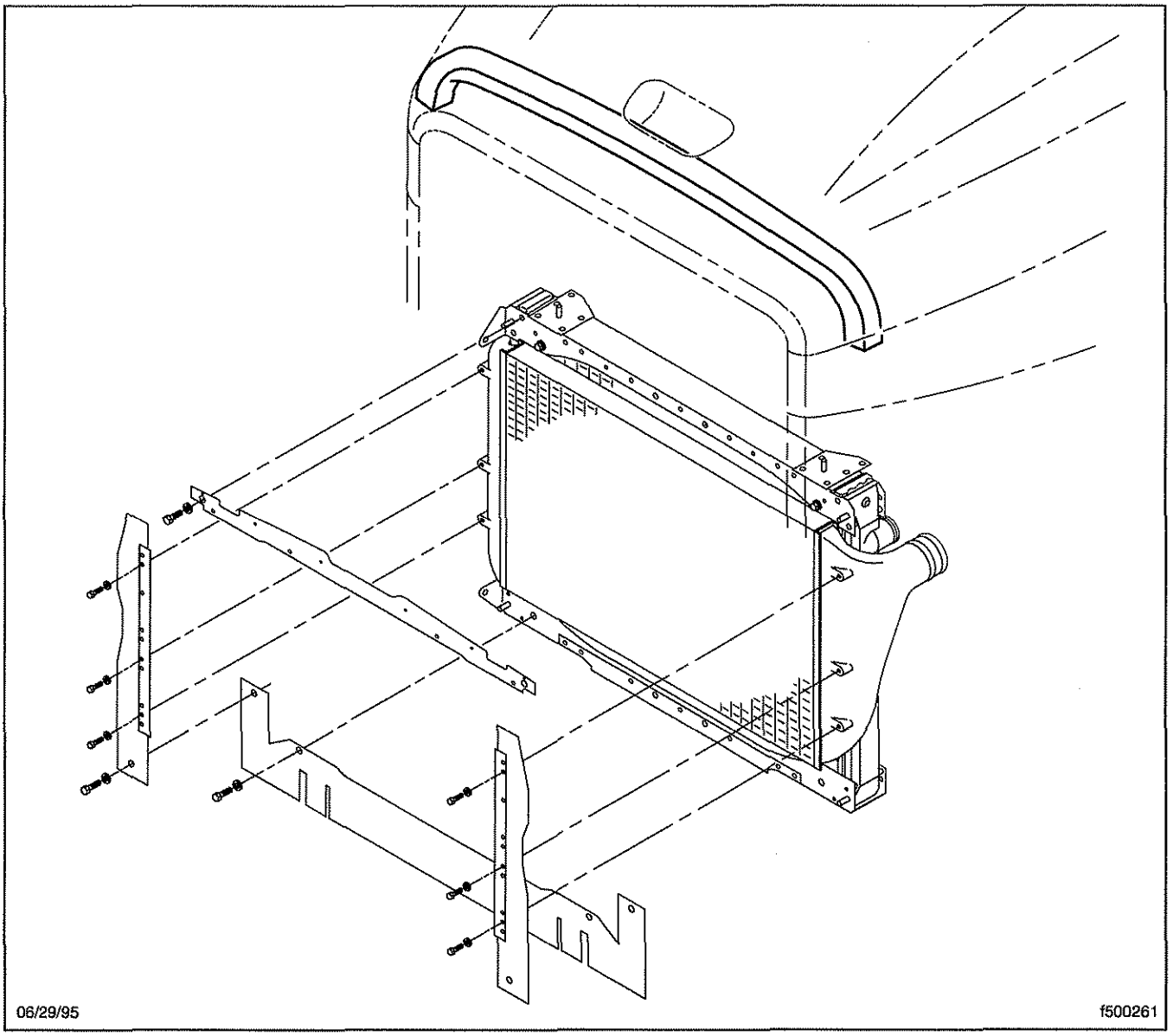


Fig. 2, Standard Air Recirculation Shield Installation, 1200-Square-Inch Radiator

3. Close the hood.

Radiator, 1350-Square-Inch, Removal and Installation

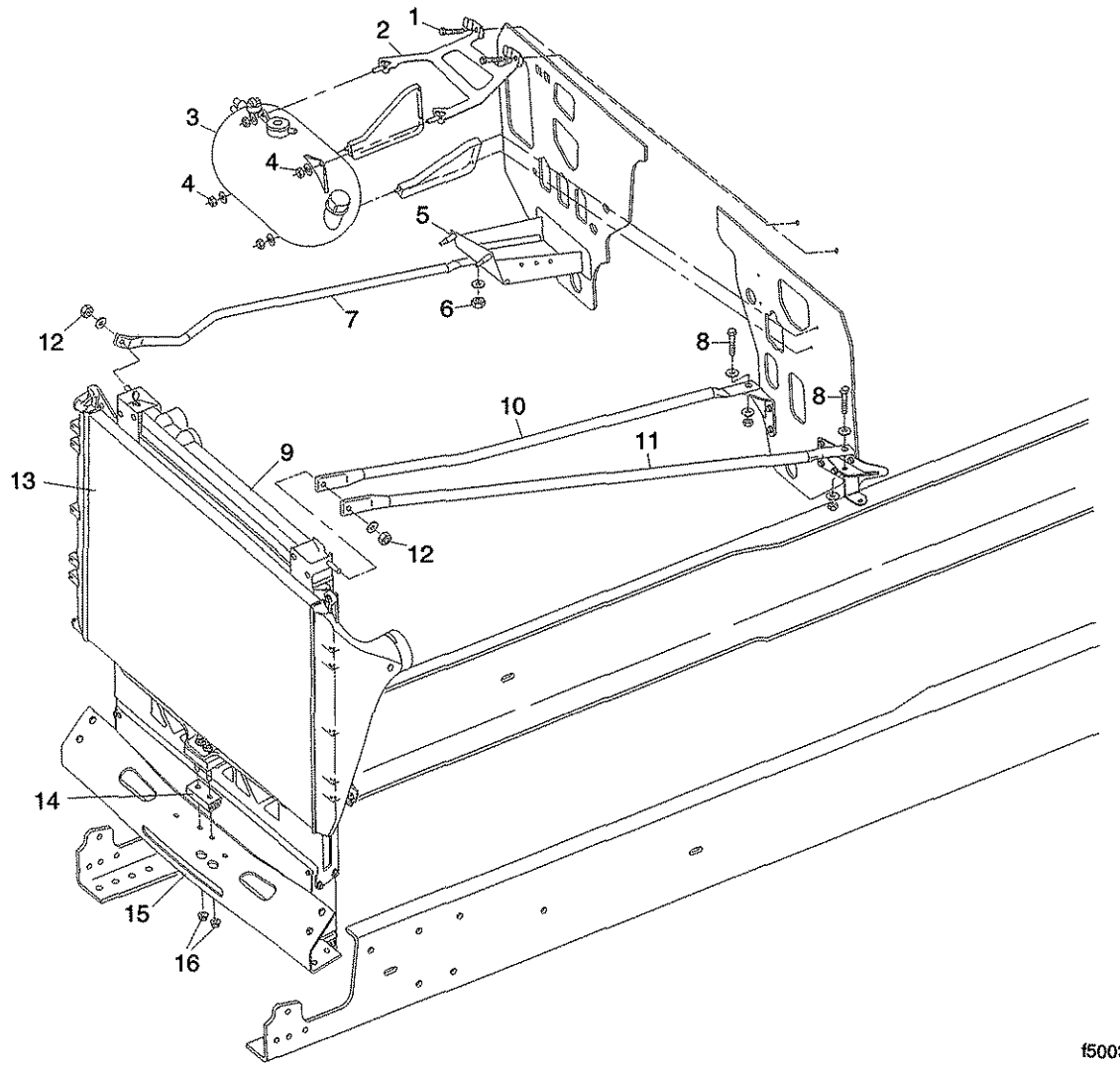
Removal

See **Fig 1** for removal and installation procedures.

1. Park the vehicle on a level surface, shut down the engine, set the parking brake, and chock the tires.

⚠ WARNING

Drain the coolant system only when engine/system is cool. Serious personal injury may result from contact with hot fluids.



1. Machine Screw, 5/16–18 Stainless Steel
2. Upper Surge Tank Bracket
3. Surge Tank
4. Locknut, 3/8–16; Washer
5. Air Cleaner Mounting Bracket
6. Nut, 1/2–13, Grade 8; Washer
7. Right-Hand Radiator Strut Rod
8. Capscrew, 1/2–13 x 2, Grade 8; Washer; Nut
9. Radiator Assembly
10. Left-Hand Radiator Strut Rod, Inboard
11. Left-Hand Radiator Strut Rod, Outboard
12. Nut, 1/2–13, Grade 8; Washer
13. Charge Air Cooler (CAC)
14. Spacer, Radiator Isolator
15. Crossmember, Frame
16. Nut, 1/2–13, Grade 8; Washer

Fig. 1, Radiator Installation, 1350-Square-Inch

Radiator, 1350-Square-Inch, Removal and Installation

2. Drain the radiator.
3. Open the hood.
4. Disconnect the hood support straps, and support the hood on a padded table.
5. Disconnect the hoses from the charge air cooler (CAC).
6. Without disconnecting the refrigerant lines, remove the A/C condenser from the front of the CAC. Cover the condenser with cardboard and secure it to the side and out of the way. Remove any stand-off brackets for the refrigerant hoses as needed.
7. Disconnect the upper and lower radiator hoses.
8. Remove the air recirculation shields from the radiator.
9. Disconnect the surge tank vent line from the top right side of the radiator.
10. Remove the fan.
11. Remove the fan shroud from the radiator (6 fasteners).
12. Disconnect the radiator struts from the top of the radiator (one on the right side; two on the left side).
13. Position a hoist over the radiator and attach lifting chains to the radiator strut studs on the top of the radiator. Use the same nuts that held the struts to the radiator.

NOTE: The studs protrude horizontally from the top of the radiator side channels.

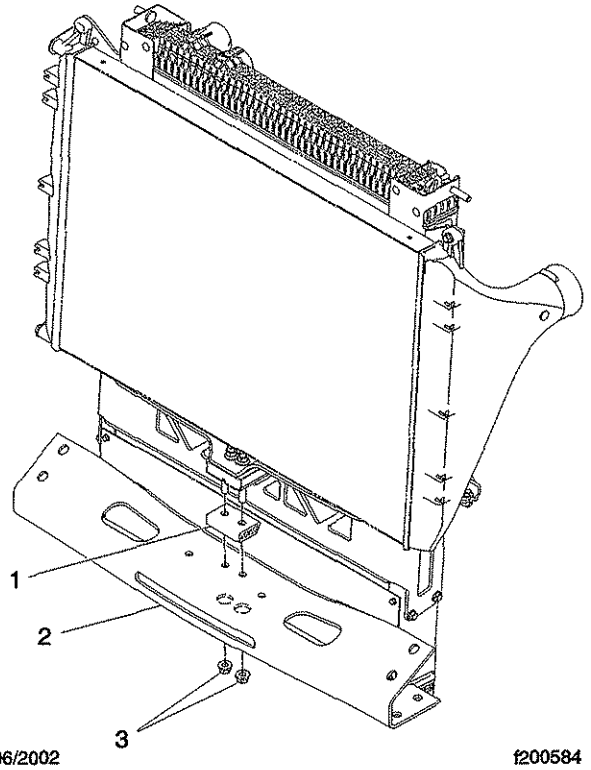
14. Remove the 1/2–13 nuts holding the radiator mounting bracket to the isolator and front crossmember. See **Fig. 2**.

NOTE: The isolator has two integral studs. There are hexnuts at the top and bottom of each stud. The top studs fasten the isolator to the radiator mounting bracket; the bottom ones fasten it to the front crossmember.

15. Lift the radiator up and remove it from the vehicle.
16. If applicable, remove the CAC from the radiator. See **Group 09** for instructions.

Installation

1. If it was removed, install the CAC onto the front of the radiator. See **Group 09** for instructions.
2. Using a hoist, put the radiator and CAC in place over the front crossmember.
3. Making sure the studs on the mounting bracket are aligned with the holes in the isolator and the front crossmember, lower the radiator onto the crossmember.
4. Install the 1/2–13 hexnuts and washers. Tighten to 95 lbf·ft (129 N·m).
5. Remove the lifting chains, then connect the radiator support struts.
6. Install the fan shroud.
7. Install the fan.



1. Spacer, Radiator Isolator
2. Crossmember
3. Nut, 1/2–13, Grade 8; Washer

Fig. 2, Isolator, 1350-Square-Inch Radiator

8. Install the air recirculation shields.
9. Connect the vent line from the surge tank to the top right side of the radiator.
10. Carefully release the A/C condenser from its position and install it onto the front of the CAC. Be careful not to kink the refrigerant lines. Install any stand-off brackets that were removed.
11. Connect the upper and lower radiator hoses.
12. Connect the CAC hoses to the CAC.
13. Lift the hood slightly and, with an assistant holding it, attach the hood support straps.
14. Fill the radiator with approved coolant. See the *Century Class Maintenance Manual* for coolant capacities.
15. Start the engine and check for leaks. If any are found, tighten the applicable connections.
16. Shut down the engine.
17. Remove the chocks from the tires.

Specifications

Description	Grade	Size	Torque	
			lbf·ft (N·m)	lbf·in (N·cm)
Radiator Mounting Bracket Capscrews	8	3/8–16	28 (38)	—
Fan Shroud Mounting Screws	—	1/4–20 x 3/4 Inch	—	108 (1220)
Radiator Mount Nuts	8	5/8–11	241 (327)	—
Radiator Strut Nuts	8	1/2–13	68 (92)	—

Table 1, Fastener Torques

Radiator Assembly 20.01

Contents

Subject	Subject Number
General Information	050
Service Operations	
Coolant Draining and Filling	100
Fan Removal and Installation	110
Fan Shroud Removal and Installation	120
Radiator Removal and Installation	130
Radiator Mount Removal and Installation, Century Class Conventionals	140
Radiator Pressure Testing	150
Surge Tank Removal and Installation, Century Class Conventionals	160
Surge Tank Removal and Installation, Argosy COEs	165
Radiator Disassembly and Assembly	170
Air Recirculation Shield Removal and Installation, Century Class Conventionals	180
Specifications	400

NOTE: For engine cooling system troubleshooting, refer to **Section 20.00** in this manual.

Removal

1. Partially remove the radiator. Do all the steps in **Subject 130** but *do not lift the radiator out of the vehicle*. Disconnect the radiator and charge air cooler, and have someone lean the components forward and hold them out of the way
2. Remove the fasteners that hold the fan to the fan clutch.
3. Remove the fan from the vehicle.

Installation

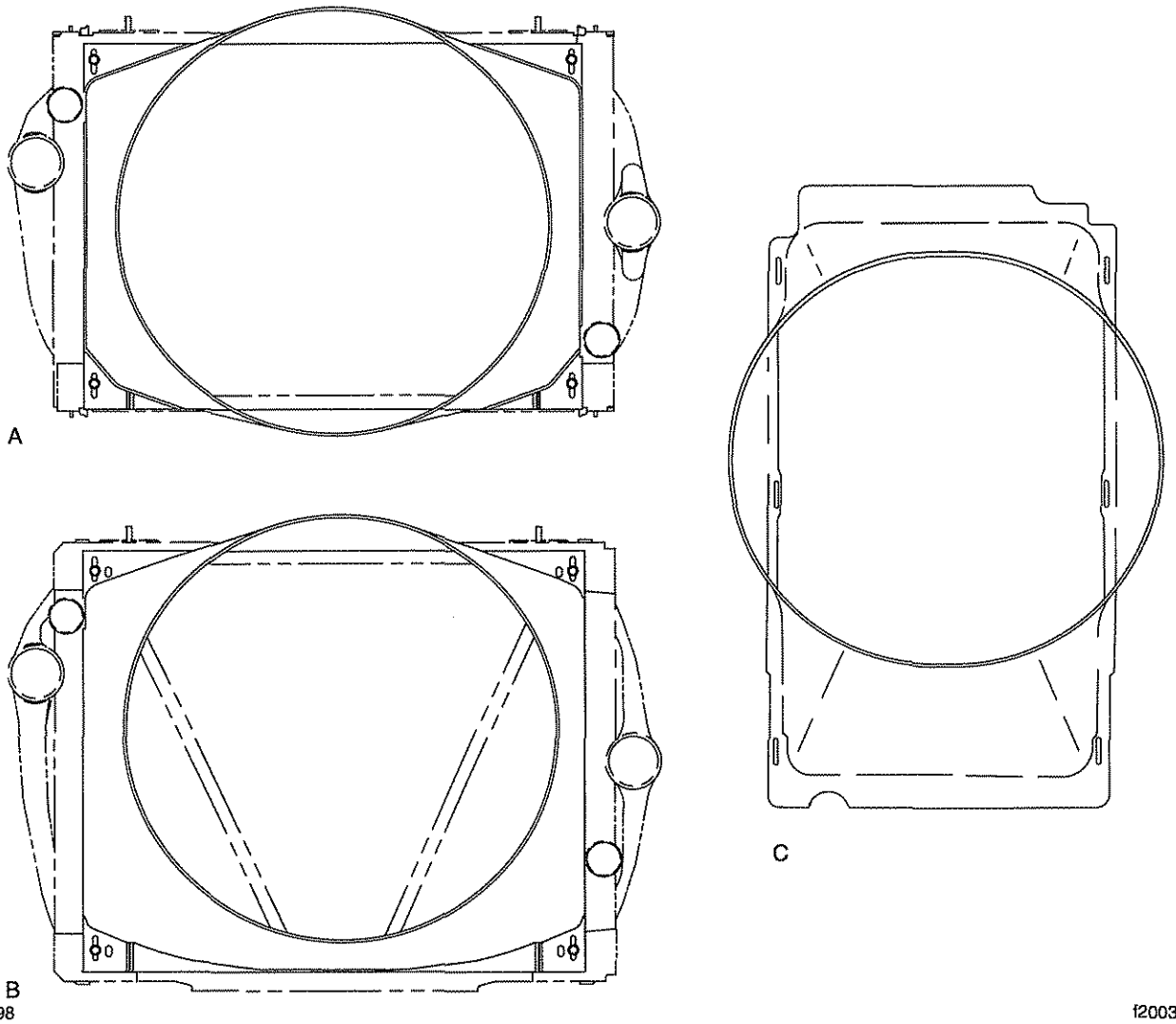
1. If not already done, disconnect the radiator according to the steps in **Subject 130** and have someone lean the components forward and hold them out of the way
2. Position the fan on the fan clutch, and tighten the fasteners 15 lbf·ft (20 N·m).
3. Install the radiator. For instructions, refer to **Subject 130** in this workshop manual section.
4. Remove the chocks from the tires.

Fan Shroud Removal and Installation

Removal (See Fig. 1)

1. Park the vehicle, apply the parking brakes, and chock the tires.
2. Remove the four screws and washers that hold the fan shroud to the radiator.
3. Remove the radiator. For instructions, refer to **Subject 130** in this workshop manual section.

   Remove the fan shroud from the vehicle.



A. Fan Shroud for a 1000-Square-Inch Radiator
B. Fan Shroud for a 1200-Square-Inch Radiator
C. Fan Shroud for a 1300-Square-Inch Radiator (Argosy COEs)

Fig. 1, Fan Shrouds

Fan Shroud Removal and Installation

Installation (See Fig. 1)

1. Place the fan shroud on the engine, and move it back as far as possible around the fan.
2. Install the radiator. For instructions, refer to **Subject 130** in this workshop manual section.
3. Install the fan shroud on the radiator.
   - 3.1 Adjust the vertical clearance between the top of the fan blade and the fan shroud opening. It should be equal within 1/8 inch (3 mm) to the clearance between the bottom of the blade and the shroud opening.
   - 3.2 Tighten the screws 108 lbf·in (1220 N·cm).
4. Remove the chocks from the tires.

Troubleshooting

Possible causes of hot or cold engine coolant temperatures are listed below. For repairs, refer to other sections of this manual or to the engine and component manufacturers' service publications.

Problem—Coolant Temperature Above Normal

Problem—Coolant Temperature Above Normal	
Possible Cause	**Remedy**
Coolant leakage (see possible sources below) is causing a low coolant level. External Leakage:hoses and hose connections, radiator seams, core, draincock and cap, block core and drain plugs, water pump thermostat housing(s), overflow and surge tank, heater hoses and core, temperature sending unit(s), cylinder head(s) mating (gasket) surfaces, coolant filter, oil cooler(s) Internal Leakage: cylinder head gasket, warped head or block surfaces, cracked cylinder head or block, cylinder head capscrews loose, missing, or tightened unevenly; oil cooler, air compressor cylinder head and gasket cylinder liners, liner seals aftercooler	Perform the repairs necessary to stop leakage. Fill to the bottom of the radiator fill neck with the correct mixture of antifreeze and water.
The temperature gauge is not working.	Check the gauge circuit wires, circuit breaker, and sending unit. If the gauge circuit is okay, replace the temperature gauge. If the gauge circuit is broken, repair it and then check temperature gauge operation
The radiator fins, the aftercooler, or the air conditioner condenser fins are clogged.	Clean the outside of the core, the aftercooler, and the condenser with compressed air directed from the fan side, or with water and a mild laundry soap. Straighten bent fins.
A radiator hose is collapsed or plugged.	Replace hoses.
A fan drive belt or the water pump belt is loose.	Adjust belt tension.
The cooling fan shroud is damaged.	Repair or replace the shroud.
The radiator cap is incorrect or malfunctioning.	Make sure the correct radiator cap is installed. If the cap does not hold the correct pressure, replace it.
The on-off fan clutch is not working.	Check the solenoid valve in the fan clutch air supply line, the sending unit for the valve, and the operating air pressure to the valve. If valve operation and air pressure are okay, repair or replace the fan clutch. If the valve doesn't work or if air pressure is low, make repairs and then check fan clutch operation.
The engine oil level is incorrect.	Fill to the high (H) mark on the dipstick.
There is too much antifreeze or coolant additive in the system.	Clean and flush the cooling system. Refill the system with the correct mixture of antifreeze and water, and install the correct additive and filter, or treatment filter.
One or both of the thermostats is incorrect or inoperative.	Make sure the correct thermostat is installed. Test the thermostat according to the engine manufacturer's instructions. Replace it if it does not operate correctly.
The water pump is not working correctly.	Repair or replace the water pump.

Troubleshooting

Problem—Coolant Temperature Above Normal	
Possible Cause	**Remedy**
The radiator core is internally plugged or damaged.	To check for blockages, warm the engine to normal operating temperature. Turn off the engine, and run your hand over the finned surface of the radiator. If there is a blockage in the radiator, it should cause an obvious temperature difference from one area of the core to another. An obvious difference between inlet and outlet temperature is normal. If blockage is suspected, clean and flush the cooling system. Repair or replace a damaged core.
Air or combustion gases are entering the cooling system.	Check the cylinder head(s), head gasket(s), cylinder liners, aftercooler, air compressor cylinder head, and fan/shutter air control valve (if applicable) for leaks. Repair or replace parts, as necessary.
The aftercooler is plugged or damaged.	Repair or replace the aftercooler.
The oil cooler is plugged or damaged.	Repair or replace the oil cooler.
The engine is receiving too much fuel.	Refer to the engine manufacturer's fuel delivery system adjustment procedures
The wrong fan (replacement unit) is installed.	Install the correct fan.
The wrong radiator (replacement unit) is installed.	Install the correct radiator.
There is exhaust blockage.	Repair the exhaust system.
There is frozen coolant in the radiator.	Use the proper antifreeze-to-water ratio needed for winter temperatures.

Problem—Coolant Temperature Below Normal

Problem—Coolant Temperature Below Normal	
Possible Cause	**Remedy**
The temperature gauge is not working.	Check the gauge circuit wires, circuit breaker, and sending unit. If the gauge circuit is okay, replace the temperature gauge. If the gauge circuit is broken, repair it and then check temperature gauge operation.
The on-off fan clutch operates continuously.	Check the solenoid valve in the fan clutch air supply line, the sending unit for the valve, and the operating air pressure to the valve. If valve operation and air pressure are okay, repair or replace the fan clutch. If the valve doesn't work or if air pressure is low, make repairs and then check fan clutch operation.
One or both thermostats are incorrect or inoperative.	Make sure the correct thermostat is installed. Test the thermostat according to the engine manufacturer's instructions. Replace it if it does not operate correctly.

3. Drain the coolant. For instructions, refer to **Subject 100** in this workshop manual section.
4. *For Century Class Conventionals and Coronados,* disconnect the hood straps. For instructions, refer to **Group 88.**
5. If so equipped, remove the air recirculation shields along the bottom and passenger side of the radiator for Century Class Conventionals. For instructions, see **Subject 180** in this workshop manual section. For Coronados, remove all the air recirculation shields.
6. Disconnect the condensor mounts and move the condensor aside without breaking the refrigerant lines. For instructions, refer to **Group 83.**
7. Disconnect the hoses from the radiator.
8. Disconnect the hoses from the charge air cooler.
9. Remove the fan shroud and move it back against the engine.

   For Coronados, remove the fasteners holding the fan shroud to the radiator, but leave the shroud in place.
10. For Century Class Conventionals and Coronados, attach chains and a lifting device to the hood strap attachment bolts on the top of the radiator.
11. Disconnect the struts from the radiator.
12. For Coronado vehicles, pull the fan shroud away from the rubber seal on the metal fan ring, then remove the fan shroud from the engine compartment.
13. Remove the nuts from the radiator mounting bolts at the bottom of the radiator for Century Class Conventionals and Coronados, or at the sides of the radiator for Argosy COEs.
14. For Argosy COEs, mark, then disconnect all the coolant hoses from the surge tank on top of the radiator. Disconnect the low coolant sensor wiring from the rear of the surge tank.
15. *For Century Class Conventionals and Coronados,* use a lifting device and remove the radiator and charge air cooler from the vehicle.

    For Argosy COEs, use an assistant to help, and manually lift the radiator, the surge tank, and the charge air cooler from the vehicle.

Installation

1. *For Century Class Conventionals and Coronados,* using a lifting device secured to the radiator and charge air cooler with chains, lift the radiator to position it in the vehicle.

   For Argosy COEs, attach the surge tank (if removed) to the top of the radiator and the charge air cooler inlet. Tighten the fasteners 26 lbf·ft (35 N·m).

   Put the radiator, charge air cooler, and surge tank assembly in place, making sure the mounting brackets on the side of the radiator line up with the mounts on the inside of the frame rails.
2. *For Century Class Conventionals and Coronados,* install the nuts on the mounting bolts at the bottom of the radiator. Tighten the nuts 241 lbf·ft (327 N·m).

   For Argosy COEs, install the bolts, washers and nuts into the mounting brackets at both sides of the radiator and inside the frame rails. Tighten the nuts 136 lbf·ft (184 N·m).
3. If applicable, remove the lifting chains from the radiator.
4. For Coronado vehicles, put the fan shroud in place in the engine compartment. Make sure the rubber seal on the metal fan ring fits correctly all the way around the shroud opening.
5. Attach the struts to the radiator.

   For Century Class Conventionals and Coronados, tighten the strut fasteners 68 lbf·ft (92 N·m).

   For Argosy COEs, tighten the strut fasteners 136 lbf·ft (184 N·m).
6. Install the fan shroud onto the radiator. For instructions, refer to **Subject 120.**
7. Connect the coolant hoses to the radiator, and connect the hose clamps. Your hose clamps can be either T-bolt clamps (**Fig. 3**) or Breeze Constant-Torque clamps (**Fig. 4**).

   When working with T-bolt type hose clamps, tighten the clamps 55 lbf·in (620 N·cm). These clamps are now standard on hoses with an inside diameter greater than 2 inches (51 mm).

Radiator Removal and Installation

When installing the Breeze Constant-Torque hose clamps, the clamps must be tightened to the correct torque. The screw tip of the clamp must extend about 1/4 inch (6 mm) from the clamp housing, and the belleville washer stacks must be collapsed almost flat. Use a torque wrench to install these hose clamps correctly. The correct installation torque for Breeze Constant-Torque hose clamps is as follows:

For Breeze Constant-Torque hose clamps with a 5/16-inch tightening screw hex: 55 lbf·in (620 N·cm).

For Breeze Constant-Torque hose clamps with a 3/8-inch tightening screw hex: 90 lbf·in (1020 N·cm).

NOTE: All hose clamps will lose torque after installation due to "compression set." However, when correctly installed, Breeze Constant-Torque clamps will hold enough torque to automatically adjust and keep consistent sealing pressure. During vehicle operation and shutdown, the screw tip may adjust according to temperature and pressure changes. The torque may need to be adjusted for individual applications.

8. For Argosy COEs, connect the hoses to the surge tank, then connect the sensor wiring.
9. Connect the hoses to the charge air cooler. For instructions, refer to **Group 09** in this manual.
10. Install the condensor. For instructions, refer to **Group 83** in this workshop manual.

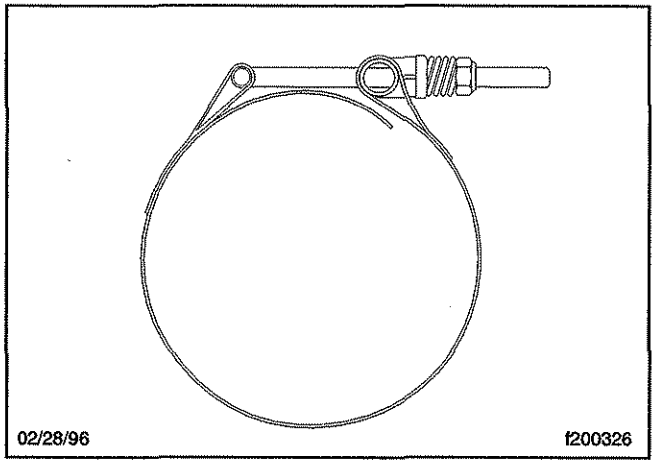
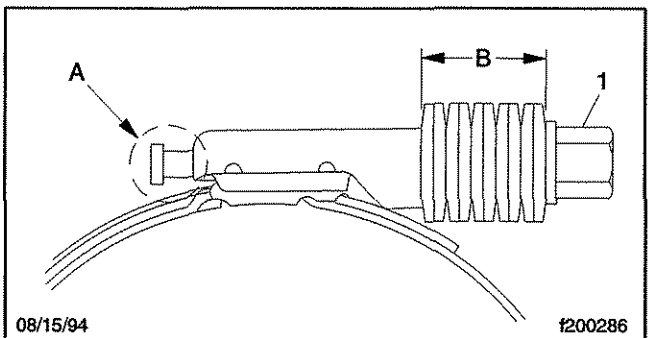


Fig. 3, T-Bolt Type Hose Clamp

11. Install the air recirculation shields, if so equipped. For instructions, see **Subject 180** in this workshop manual section.
12. Fill the coolant system. For instructions, refer to **Subject 100** in this workshop manual.
13. *For Century Class Conventionals and Coronados,* install the hood straps. For instructions, refer to **Group 88** in this manual.
14. *For Century Class Conventionals and Coronados,* close the hood, then install the grille. For instructions on installing the grille, refer to **Group 88** in this manual.

    For Argosy COEs, return the cab to the operating position. Install the upper and lower grilles. For instructions on lowering the cab and installing the upper and lower grilles, refer to **Group 60** in this manual.
15. Remove the chocks from the tires.



A. The screw tip must extend about 1/4 inch (6 mm).
B. The belleville washer stacks must be collapsed almost flat.
1. Tightening Screw Hex

Fig. 4, Breeze Constant-Torque Hose Clamp Installation

Fan Ring Assembly Removal and Installation, Coronado

Removal

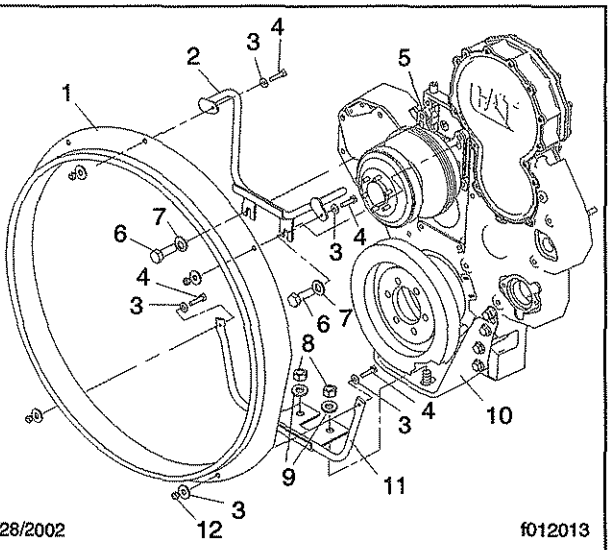
The fan ring assembly is installed on Coronado vehicles for improved fan efficiency and noise reduction. It consists of a metal ring that surrounds the fan and a rubber seal that ensures a tight fit with the fan shroud.

1. Park the vehicle on a level surface, shut down the engine, set the parking brake, and chock the tires.
2. Tilt the hood.
3. Roll the rubber seal on the fan ring away from the edge of the fan shroud.
4. Remove the four fasteners holding the fan shroud in place, then move the shroud to the side or remove it from the engine compartment.
5. Remove the fasteners holding the fan ring to the upper mounting bracket. See **Fig. 1**.
6. Remove the fasteners holding the fan ring to the lower mounting bracket. See **Fig. 1**.
7. Disconnect the radiator support struts from the radiator.
8. Slide the fan ring assembly forward and over the fan, then remove it from the vehicle.

Installation

1. With the fan shroud removed or moved to the side, put the fan ring in place over the fan.
2. Loosely install the hexbolts, washers and hexnuts holding the fan ring for the upper and lower mounting brackets. See **Fig. 1**.
3. Make sure the fan ring is centered over fan by spinning the fan. The blades should not contact the ring.
4. Adjust the fan ring as needed so that it is centered. Tighten the fasteners 28 lbf·ft (38 N·m).

   Check the fan clearance again. Adjust if needed.
5. Install the fan shroud. Tighten the fasteners snugly.
6. Unroll the rubber seal on the fan ring assembly and seat it all the way around the opening in the fan shroud.
7. Attach the fan struts to the radiator. Tighten the nuts 68 lbf·ft (92 N·m).
8. Start the engine and make sure the fan clears the fan ring.
9. Shut down the engine and return the hood to the operating position.
10. Remove the chocks from the tires.



NOTE: The upper and lower mounting brackets are shown removed from the engine.

1. Fan Ring Assembly
2. Upper Mounting Bracket
3. Flatwasher
4. Hexbolt, 3/8–16
5. Fan Clutch Mounting Bracket
6. Hexbolt, 1/2–13
7. Hardened Washer
8. Hexnut, 3/4–10
9. Hardened Washer
10. Forward Engine-Mount Bracket
11. Lower Mounting Bracket
12. Hexnut, 3/8–16

Fig. 1, Fan Ring Installation

Specifications

Description	Grade	Size	Torque	
			lbf·ft (N·m)	lbf·in (N·cm)
Radiator Mounting Bracket Capscrews	8	3/8–16	28 (38)	—
Fan Shroud Mounting Screws	—	1/4–20 x 3/4 inch	—	108 (1220)
Radiator Mount Nuts	8	5/8–11	241 (327)	—
Radiator Strut Nuts	8	1/2–13	68 (92)	—
Fan Ring Assembly Mounting-Bracket Fasteners	8	3/8–16	28 (38)	—

Table 1, Fastener Torques

Contents

Subject	Subject Number
General Information	050
Service Operations	
Fan Clutch Removal and Installation, Horton Advantage	100
Fan Clutch Removal and Installation, Kysor K22RA	110
Fan Clutch Major Rebuild, Horton Advantage	120
Fan Clutch Minor Rebuild, Kysor K22RA	130
Fan Clutch Relining, Kysor K22RA	140
Fan Clutch Minor Rebuild, Horton Advantage	150
Troubleshooting	300
Specifications	400

General Information

The fan drive is a temperature-controlled, air-operated clutch for the engine cooling fan. Its purpose is to maintain engine temperature by engaging or disengaging the fan. For the specific coolant temperatures that turn the engine fan on, refer to **Section 20.00** in this workshop manual.

Air pressure to the fan clutch is controlled by a solenoid valve; the solenoid valve is controlled by a temperature switch that is installed in the thermostat housing. **See Fig. 1.**

On vehicles with air conditioning, the fan clutch solenoid valve is connected to a fan cycling switch at the receiver-dryer. If the refrigerant pressure exceeds the setting of the fan cycling switch, the switch supplies power to the solenoid valve. **See Fig. 2.**

These vehicles use two types of fan clutches:

- Horton Advantage
- Kysor K22RA

Horton Advantage

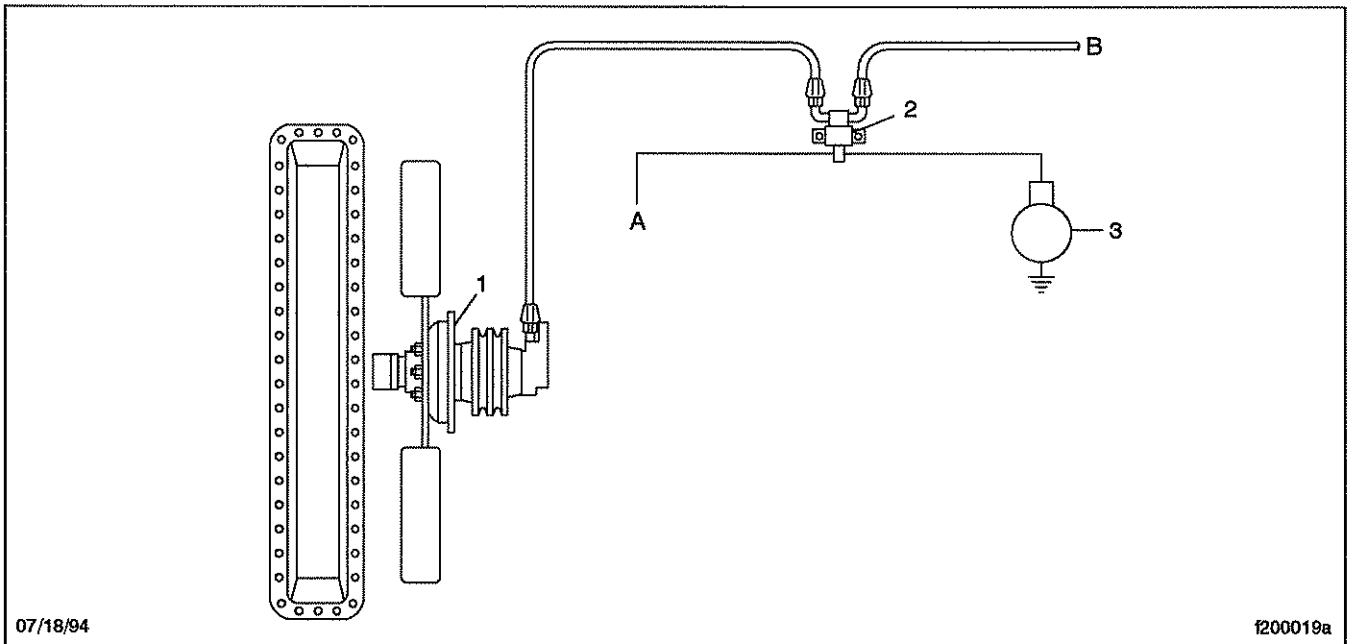
Internal spring pressure disengages the Horton fan clutch when the coolant temperature is below the specified temperature range; internal air pressure engages the fan clutch when the coolant temperature rises above that range.

With the Horton fan clutch, when you start a cold engine, the solenoid valve restricts air pressure to the cylinder, and the fan clutch remains disengaged. The fan does not turn.

When the coolant temperature rises to the temperature switch setting, the switch provides power to the solenoid valve, and the valve releases compressed air to engage the fan clutch.

When the coolant temperature drops to the temperature switch cutoff setting, the solenoid stops the compressed air, and the clutch disengages.

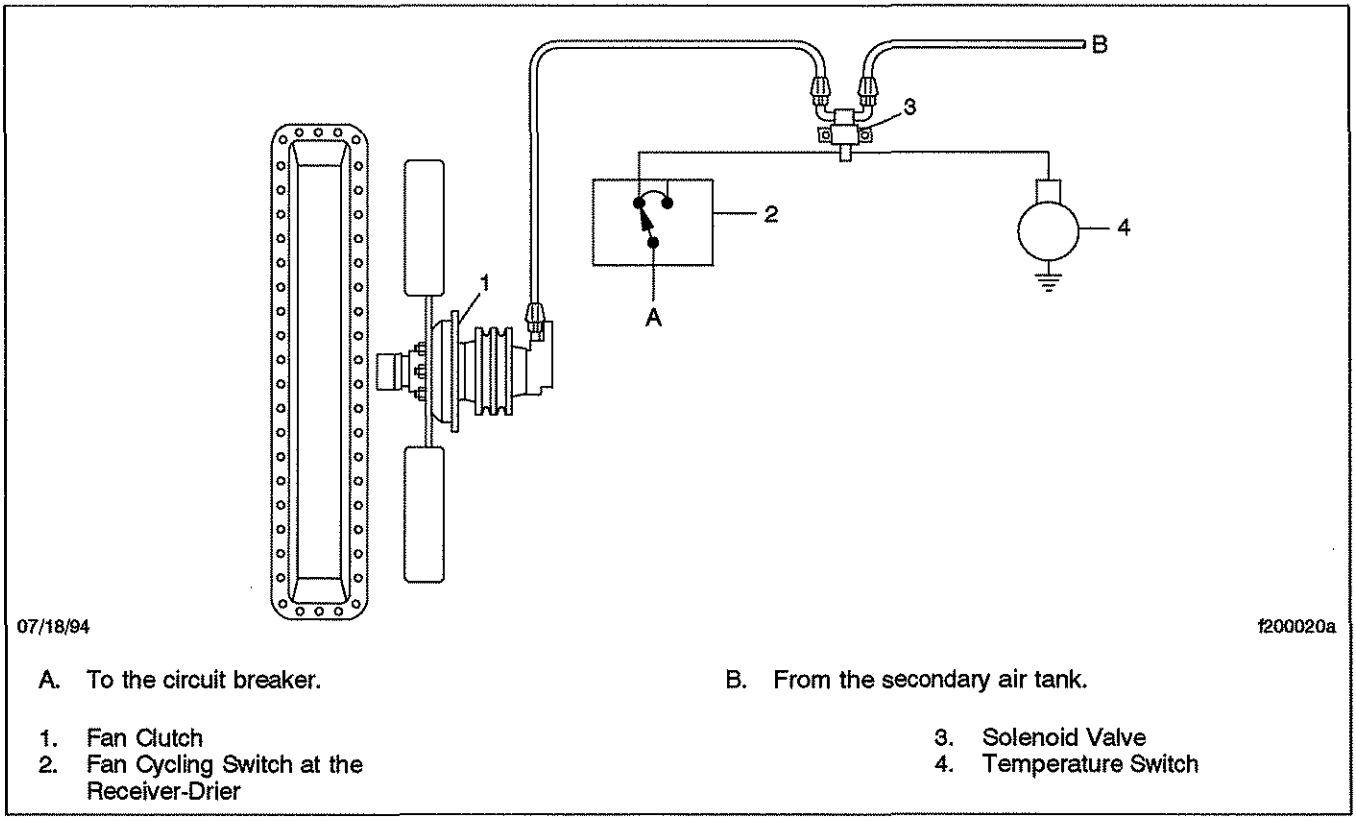
On vehicles with air conditioning, the fan clutch solenoid valve is connected to a fan cycling switch at the receiver-dryer. If the refrigerant pressure exceeds the setting of the fan cycling switch, the switch supplies



A. To the circuit breaker.
B. From the secondary air tank.
1. Fan Clutch
2. Solenoid Valve
3. Temperature Switch

Fig. 1, Fan Clutch Piping and Wiring, Vehicle Without Air Conditioning

General Information



A. To the circuit breaker.
B. From the secondary air tank.

1. Fan Clutch
2. Fan Cycling Switch at the Receiver-Drier
3. Solenoid Valve
4. Temperature Switch

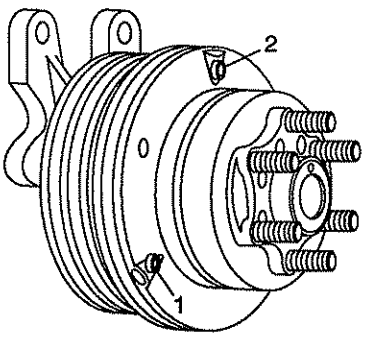
Fig. 2, Fan Clutch Piping and Wiring, Vehicle With Air Conditioning

power to the solenoid valve, which supplies air to engage the fan clutch.

Horton Advantage fan clutches include System Sentry™ fuses that protect the fan clutch from overheating. **See Fig. 3.** The System Sentry fuse is a brass fitting in the piston friction disc; the fitting uses lead alloy solder to hold a brass plug. If anything causes the fan clutch to slip excessively, heat from the slippage will melt the solder and release the plug. Air pressure inside the clutch will escape, and the clutch will release before heat build-up can damage the clutch bearings. The fuse is balanced by two counterweights.

If the fan clutch will not engage, check to see if the fuse is melted, and check to see what might be making the fan clutch slip excessively.

For the fan clutch model number and serial number, refer to the side of the air chamber. **See Fig. 4.**



1. System Sentry Fuse
2. Counterweight

Fig. 3, Horton Fan Clutch with System Sentry Fuse

Kysor K22RA

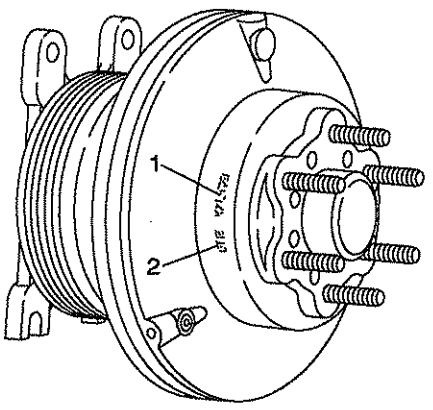
Internal spring pressure engages the Kysor fan clutch when the coolant temperature is above the specified temperature range; internal air pressure disengages the fan clutch when the coolant temperature drops below that range.

With the Kysor fan clutch, when you start a cold engine, the solenoid valve releases air pressure to the cylinder, and the fan clutch remains disengaged. The fan does not turn.

When the coolant temperature rises to the temperature switch setting, the switch provides power to the solenoid valve, and the valve stops the flow of compressed air to the fan clutch. A spring within the fan engages the clutch, and the fan turns.

When the coolant temperature drops to the temperature switch cutoff setting, the solenoid releases compressed air to the clutch, and the clutch disengages.

On vehicles with air conditioning, the fan clutch solenoid valve is connected to a fan cycling switch at the receiver-dryer. If the refrigerant pressure exceeds the setting of the fan cycling switch, the switch supplies power to the solenoid valve, which stops air flow and allows the internal spring to engage the fan clutch.



1. Model Number
2. Serial Number

Fig. 4, Fan Clutch Information, Horton

Fan Clutch Removal and Installation, Horton Advantage

Removal

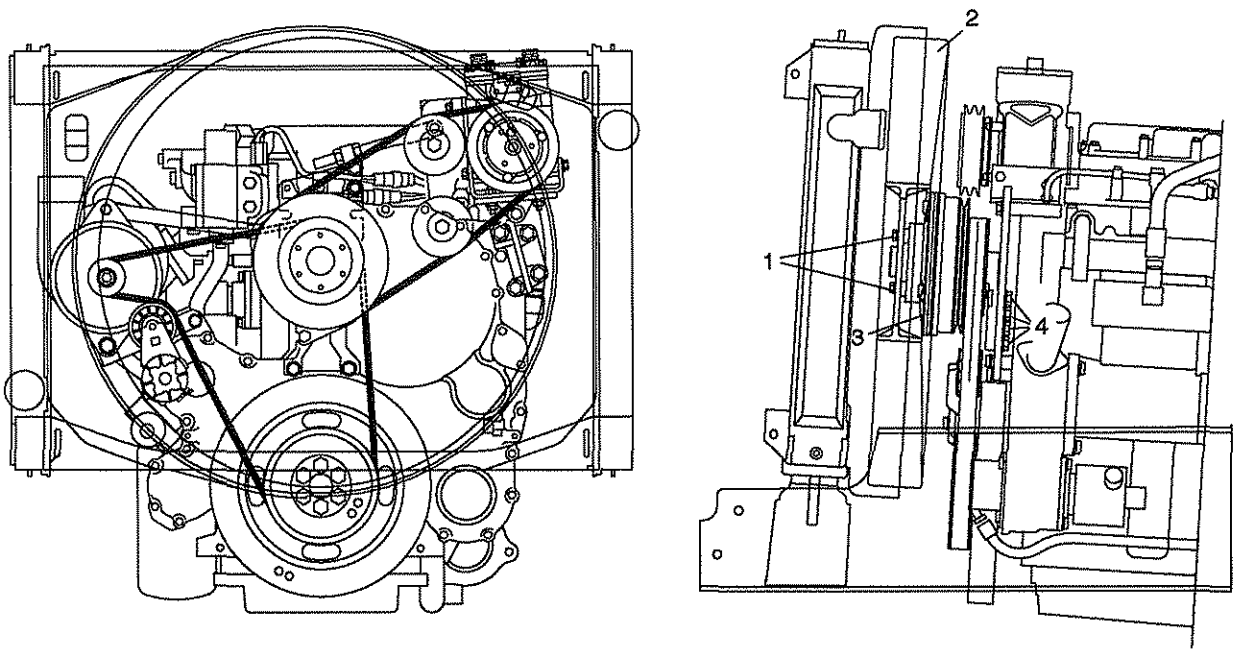
Refer to the following figures for the fan clutch installation for your engine:

- For Caterpillar 3176 engines, **see Fig. 1.**
- For Caterpillar 3406 engines, **see Fig. 2.**
- For Cummins M11 engines, **see Fig. 3.**
- For Cummins N14 engines, **see Fig. 4.**
- For Detroit Diesel Series 50 and 60 engines, **see Fig. 5.**
- For Detroit Diesel Series 55 engines, **see Fig. 6.**

1. Park the vehicle, apply the parking brakes, and chock the tires.

WARNING: Use care when loosening the air line fitting. The line could be under pressure and may have dirt or sludge in the air stream. If quickly disconnected, the line may whip, possibly causing eye injury or other bodily injury.

2. Disconnect the air line from the fan clutch.
3. Remove the fan shroud from the radiator, and move the shroud back against the engine. For instructions, refer to **Section 20.01** in this workshop manual.
4. Disconnect the radiator from all hose and mounts. For instructions, refer to **Section 20.01** in this workshop manual. With one person holding each side of the radiator, tilt the top of the radiator forward.



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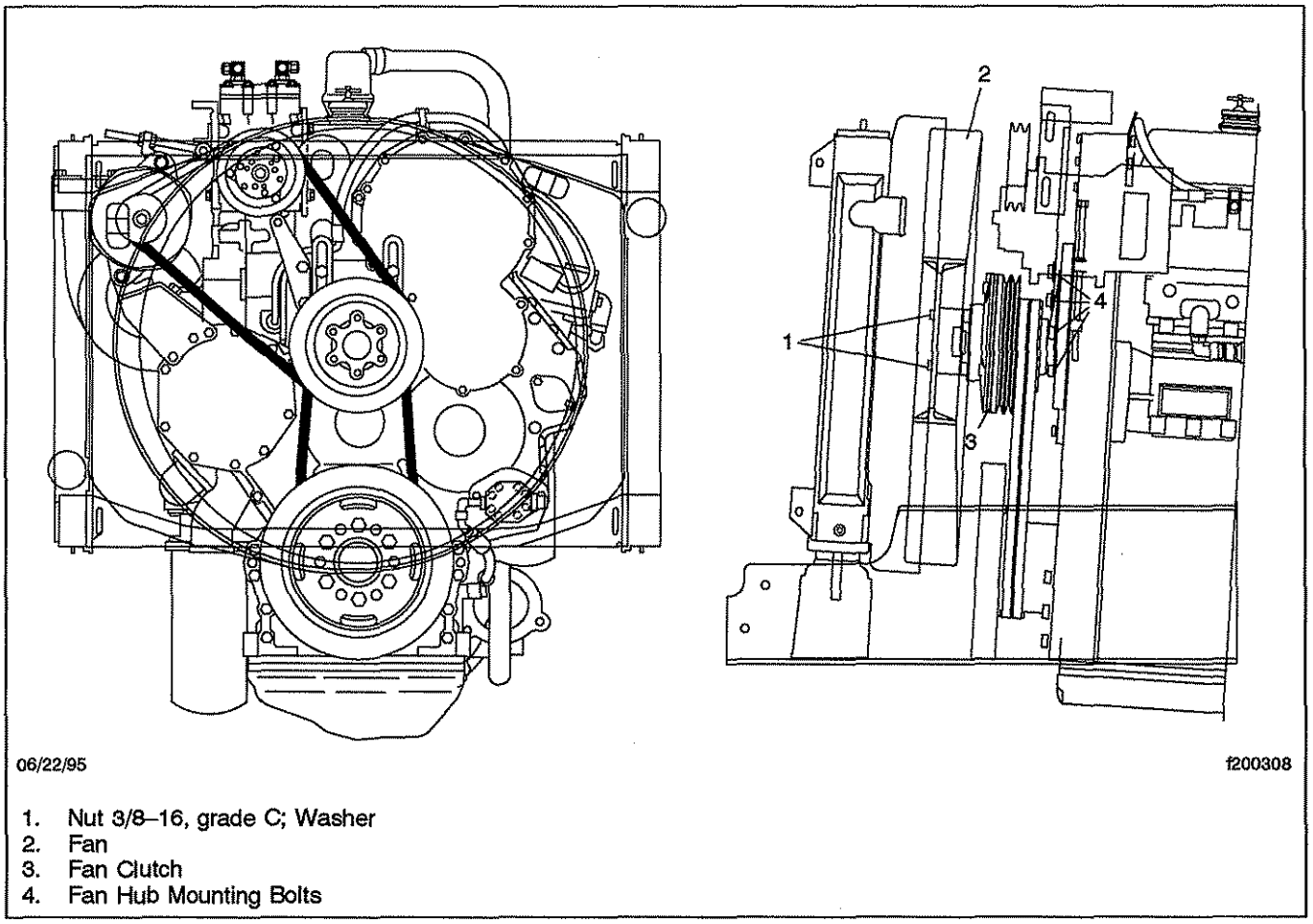
1. Capscrew 3/8–16 x 0.75 inch, grade 8; Lockwasher; Washer
2. Fan
3. Fan Clutch
4. Capscrew 1/2–13 x 1.25 inch, grade 8; Washer

Fig. 1, Caterpillar 3176 Engine, Horton Advantage Fan Clutch

Fan Clutch Removal and Installation, Horton Advantage



1. Nut 3/8–16, grade C; Washer
2. Fan
3. Fan Clutch
4. Fan Hub Mounting Bolts

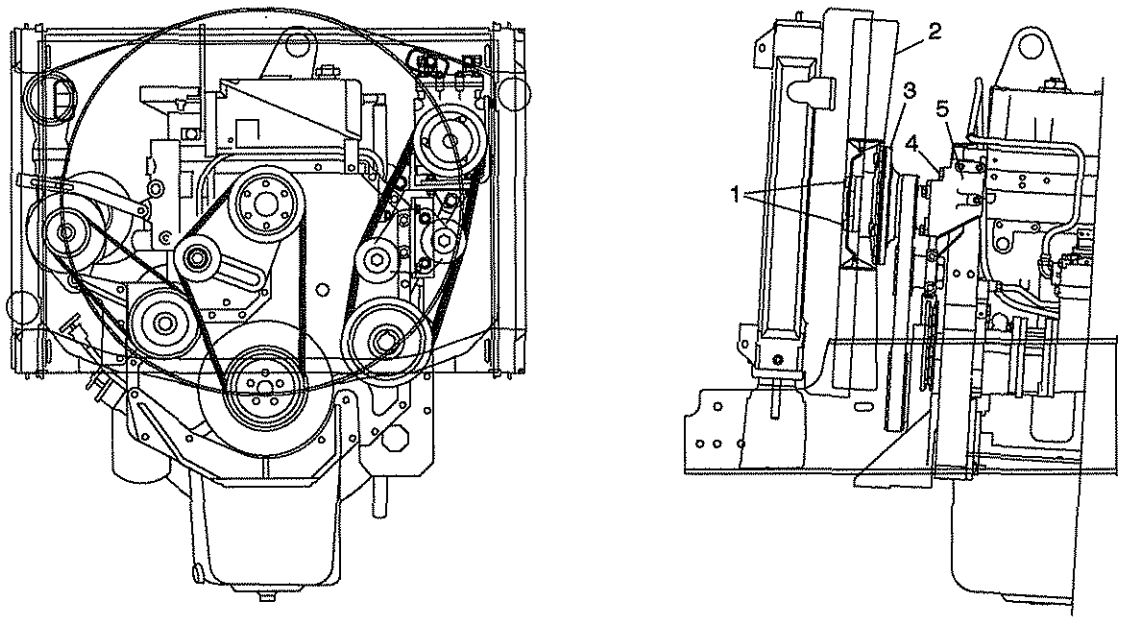
Fig. 2, Caterpillar 3406 Engine, Horton Advantage Fan Clutch

5. With the radiator tilted forward, remove the fan. For instructions, refer to **Section 20.01** in this workshop manual.
6. Remove the fan belts. For instructions, refer to the applicable engine section in **Group 01** of this workshop manual.
7. Remove the bolts (or nuts) and washers that attach the fan clutch and hub assembly to the engine. Remove the fan clutch and hub assembly.

Installation

1. Position the fan clutch and hub assembly on the engine and install the bolts (or nuts) and washers. Tighten the mounting fasteners just enough to hold the assembly in place, and allow for fan belt adjustment.
2. Install the fan belts. For instructions, refer to the applicable engine section in **Group 01** of this workshop manual.
3. Tighten the clutch and hub assembly mounting fasteners 85 lbf·ft (115 N·m).
4. Install the fan. For instructions, refer to **Section 20.01** in this workshop manual.
5. Install the radiator. For instructions, refer to **Section 20.01** in this workshop manual.
6. Install the fan shroud. For instructions, refer to **Section 20.01** in this workshop manual.
7. Connect the air line to the fan clutch.

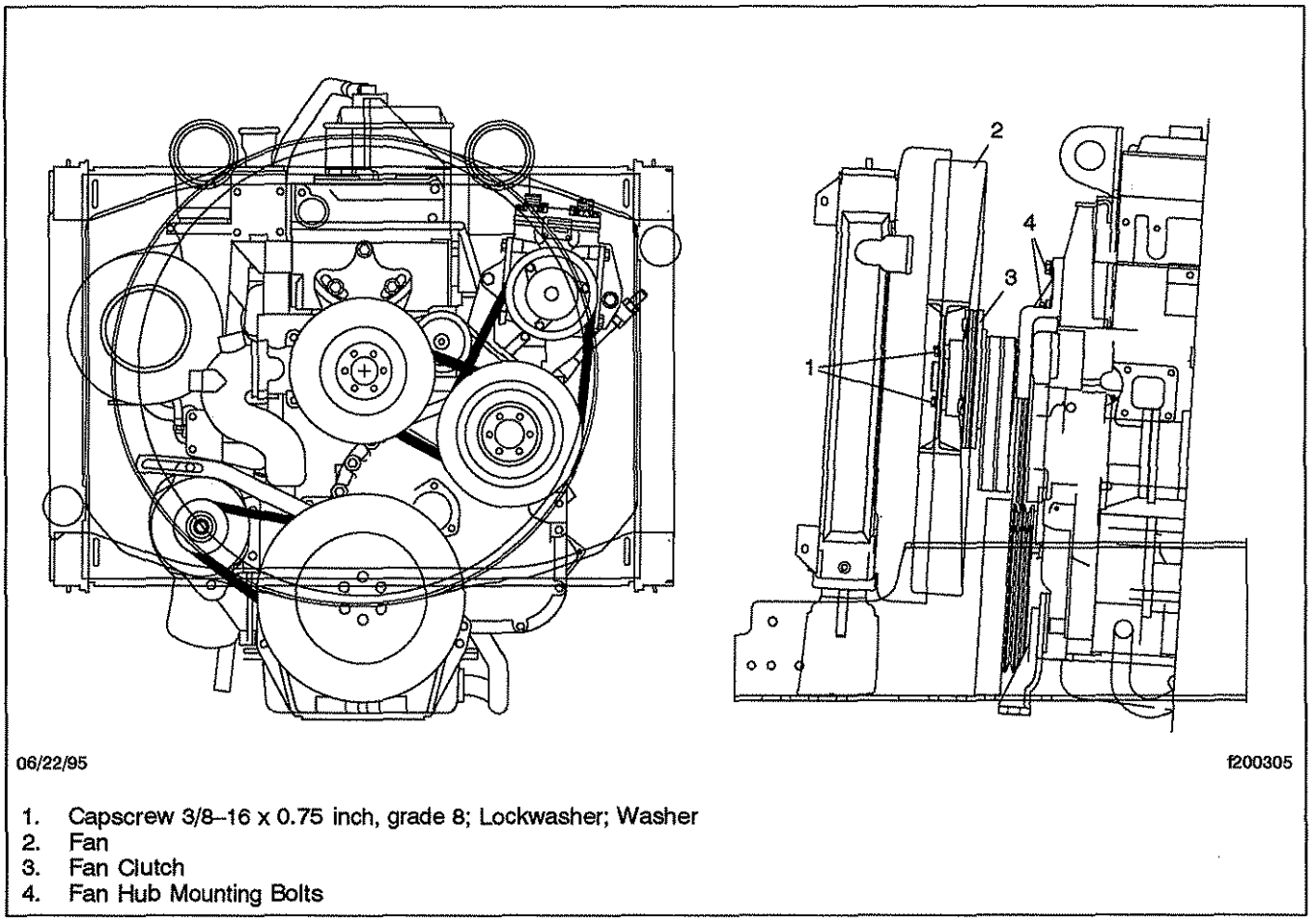
Fan Clutch Removal and Installation, Horton Advantage



1. Capscrew 3/8–16 x 1 inch, grade 8; Washer
2. Fan
3. Fan Clutch
4. Screw, M12 x 1.75 x 90
5. Fan Support Bracket

Fig. 3, Cummins M11 Engine, Horton Advantage Fan Clutch

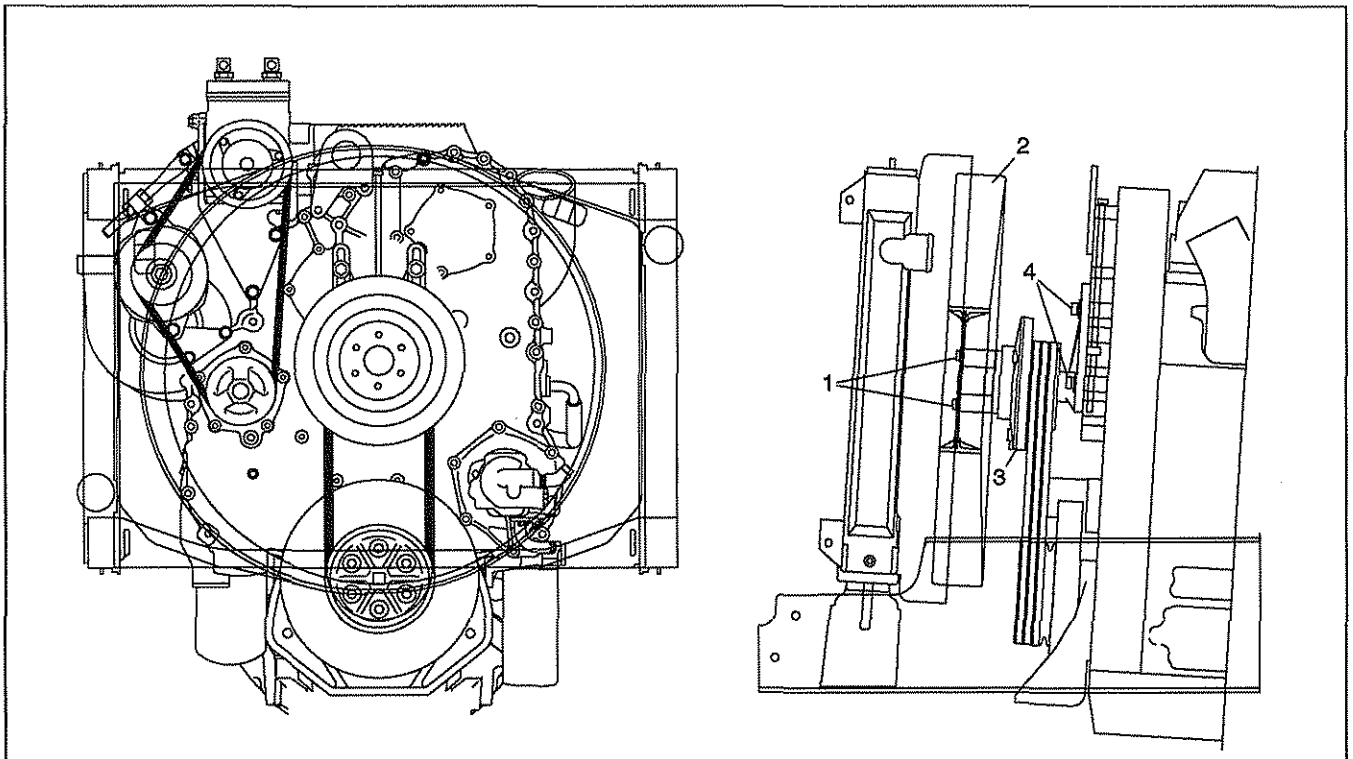
Fan Clutch Removal and Installation, Horton Advantage



1. Capscrew 3/8–16 x 0.75 inch, grade 8; Lockwasher; Washer
2. Fan
3. Fan Clutch
4. Fan Hub Mounting Bolts

Fig. 4, Cummins N14 Engine, Horton Advantage Fan Clutch

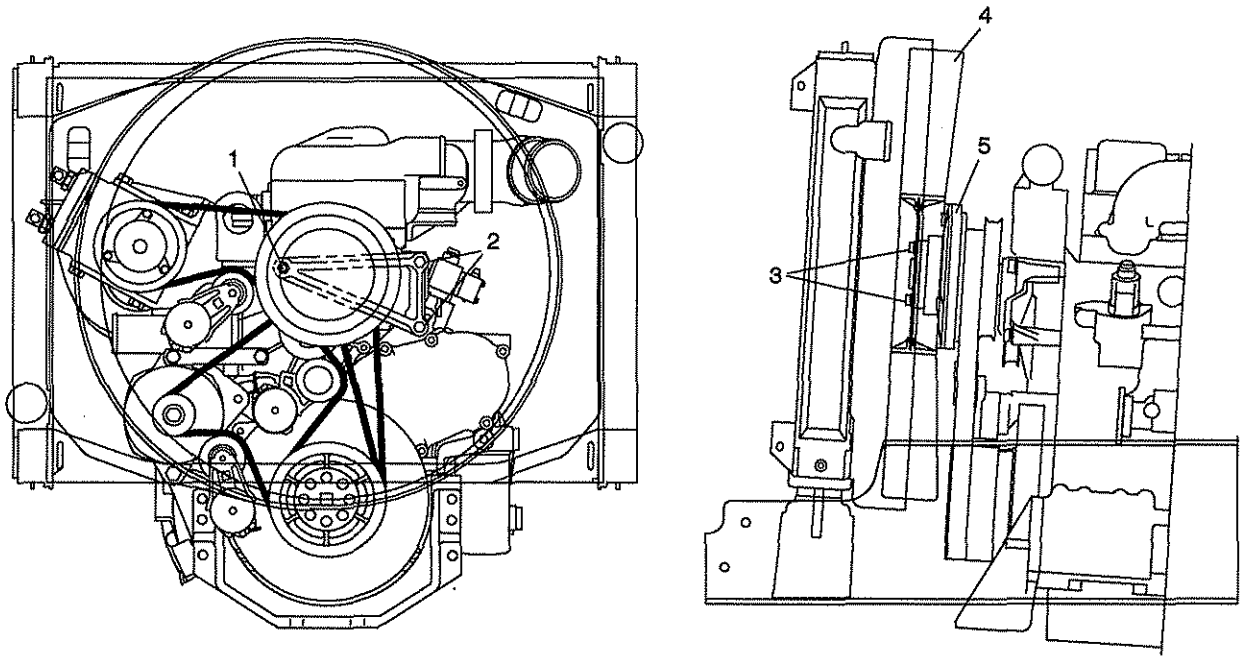
Fan Clutch Removal and Installation, Horton Advantage



1. Capscrew 3/8–16 x 3 inch, grade 8; Lockwasher; Washer
2. Fan
3. Fan Clutch
4. Flanged Bolt, M12 x 35 mm, grade 10.9; Washer

Fig. 5, Detroit Diesel Series 50 and 60 Engine, Horton Advantage Fan Clutch

Fan Clutch Removal and Installation, Horton Advantage



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1. Locknut M14
2. Flanged Bolt M12 x 100mm, grade 10.9
3. Nut 3/8–24; Washer
4. Fan
5. Fan Clutch

Fig. 6, Detroit Diesel Series 55 Engine, Horton Advantage Fan Clutch

Fan Clutch Removal and Installation, Kysor K22RA

Removal

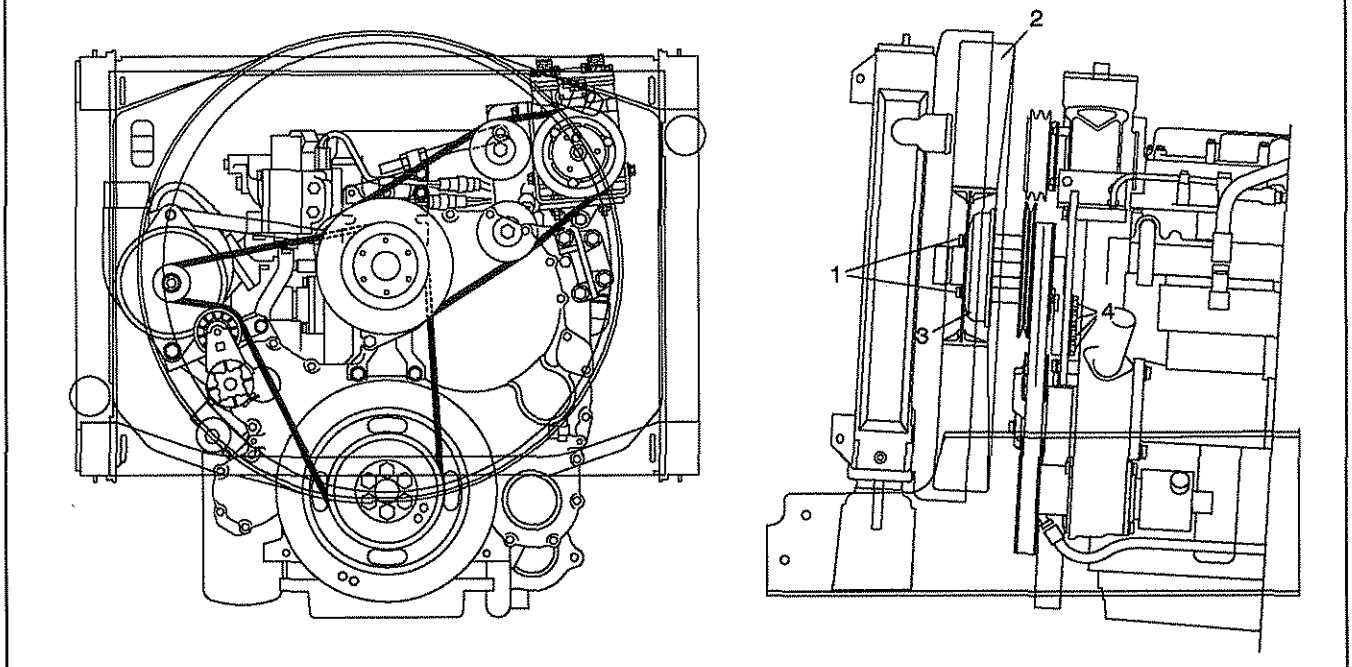
Refer to the following figures for the fan clutch installation for your engine:

- For Caterpillar 3176 engines, **see Fig. 1.**
- For Caterpillar 3406 engines, **see Fig. 2.**
- For Cummins M11 engines, **see Fig. 3.**
- For Cummins N14 engines, **see Fig. 4.**
- For Detroit Diesel Series 50 and 60 engines, **see Fig. 5.**
- For Detroit Diesel Series 55 engines, **see Fig. 6.**

1. Park the vehicle, apply the parking brakes, and chock the tires.

WARNING: Use care when loosening the air line fitting. The line could be under pressure and may have dirt or sludge in the air stream. If quickly disconnected, the line may whip, possibly causing eye injury or other bodily injury.

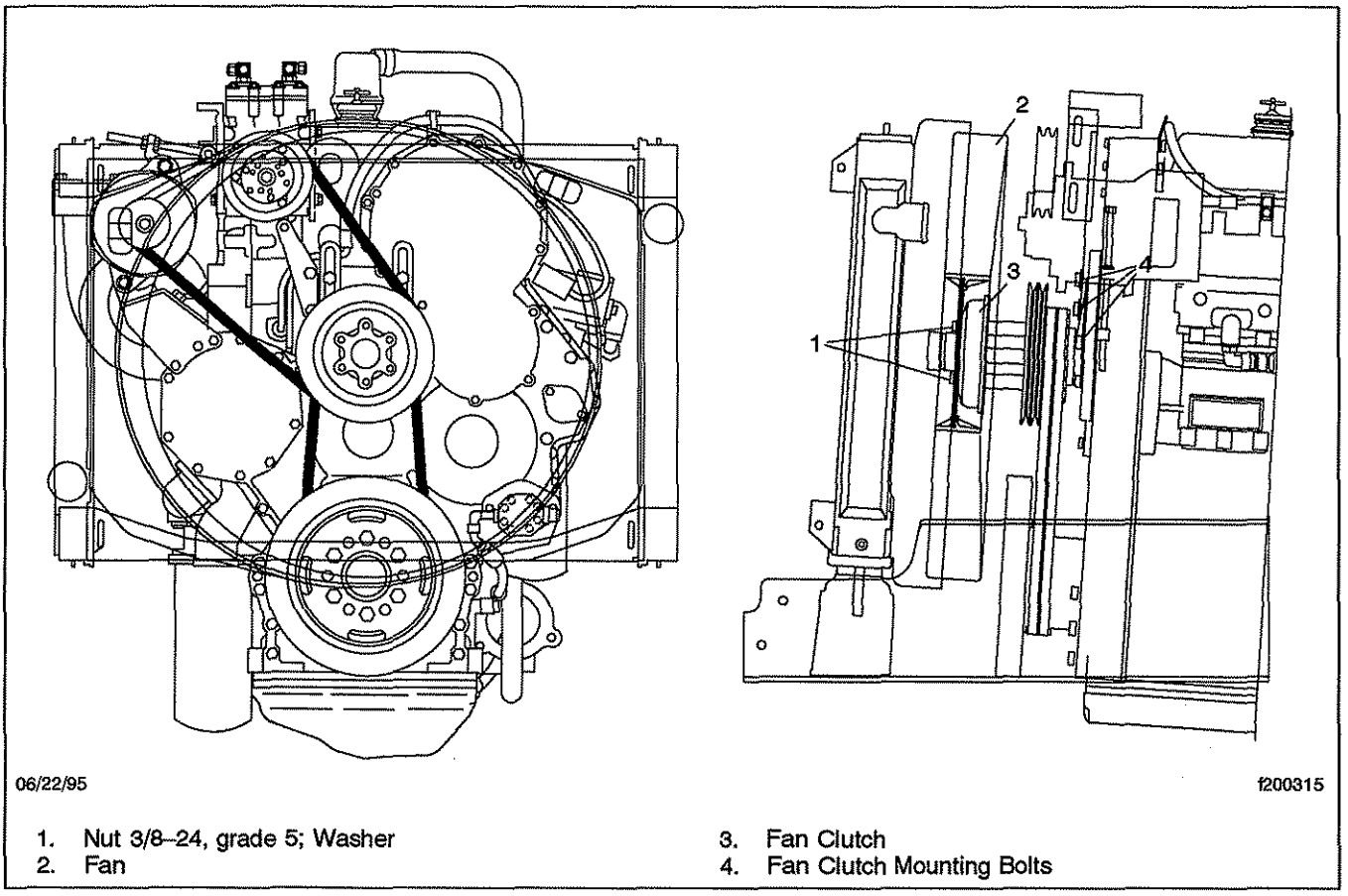
2. Disconnect the air line from the fan clutch.
3. Remove the fan shroud from the radiator, and move the shroud back against the engine. For instructions, refer to **Section 20.01** in this workshop manual.
4. Disconnect the radiator from all hoses and mounts. For instructions, refer to **Section 20.01** in this workshop manual. With one person holding each side of the radiator, tilt the top of the radiator forward.



1. Nut 3/8–24, grade 5; Washer
2. Fan
3. Fan Clutch
4. Capscrew M12 x 35 mm, grade 8.8; Washer

Fig. 1, Caterpillar 3176 Engine, Kysor Fan Clutch

Fan Clutch Removal and Installation, Kysor K22RA



1. Nut 3/8–24, grade 5; Washer
2. Fan
3. Fan Clutch
4. Fan Clutch Mounting Bolts

Fig. 2, Caterpillar 3406 Engine, Kysor Fan Clutch

5. With the radiator tilted forward, remove the fan. For instructions, refer to **Section 20.01** in this workshop manual.
6. Remove the fan belts. For instructions, refer to the applicable engine section in **Group 01** of this workshop manual.

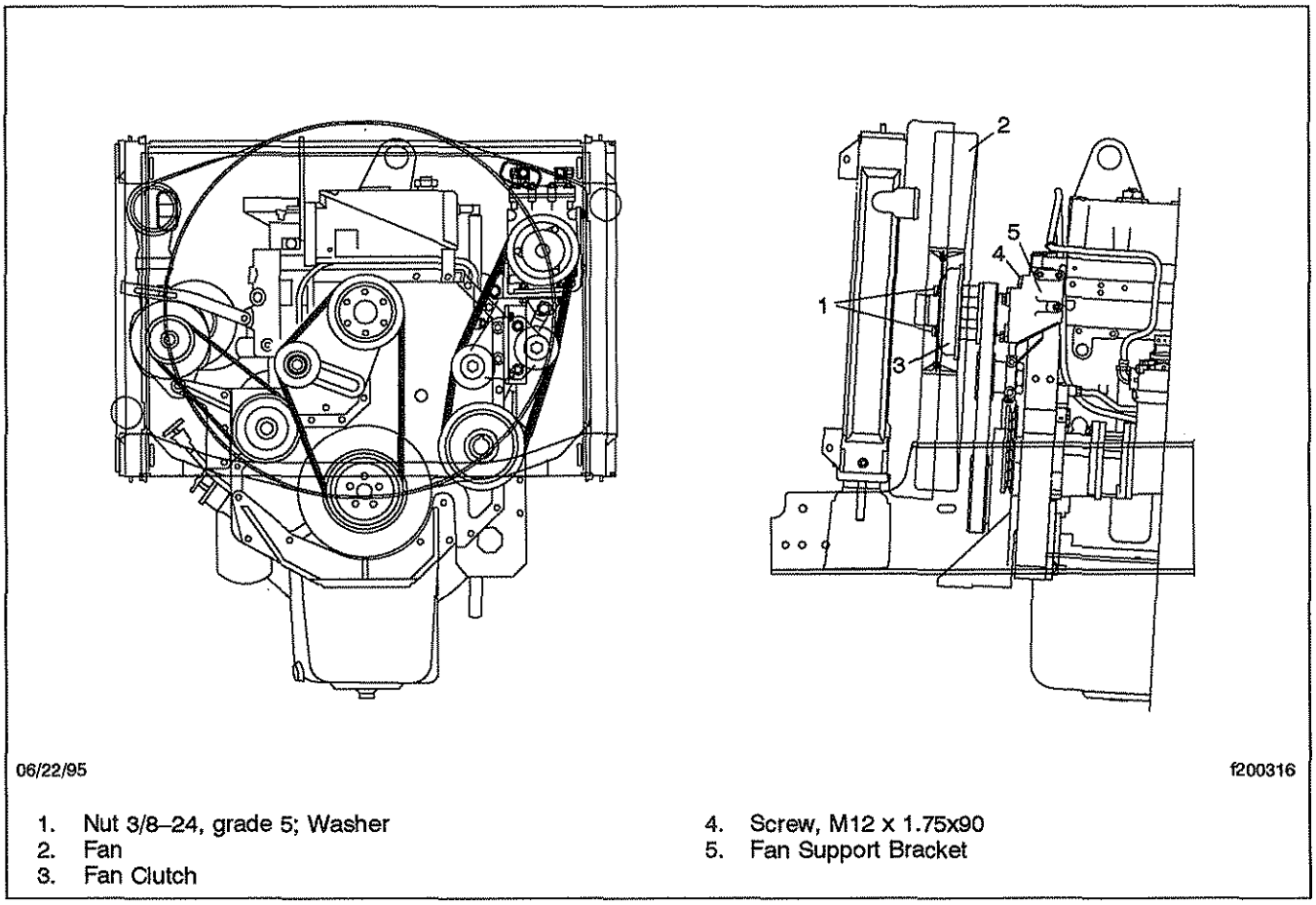
WARNING: If the fan clutch engages during this procedure, it could cause personal injury. Keep the fan clutch disengaged throughout this procedure by maintaining between 90 and 120 psi (6.1 and 8.2 bar) of air pressure.

7. Disengage the fan clutch and keep it disengaged throughout this procedure. To do this, apply between 90 and 120 psi (6.1 and 8.2 bar) of air pressure to the fan clutch to disengage the clutch.
8. Line up the access holes with the 5/16-inch allen screws. **See Fig. 7.**
9. Remove the air pressure from the fan clutch, and allow the fan to engage.
10. Remove the fan clutch from the fan clutch hub. It may be necessary to gently pry the clutch from the hub.

Installation

1. Position the fan clutch on the fan clutch hub, and line up the access holes in the clutch with the holes for the allen screws in the clutch hub.
2. Install the allen screws, and tighten them 44 lbf·ft (60 N·m).
3. Install the fan belts. For instructions, refer to the applicable engine section in **Group 01** of this workshop manual.

Fan Clutch Removal and Installation, Kysor K22RA

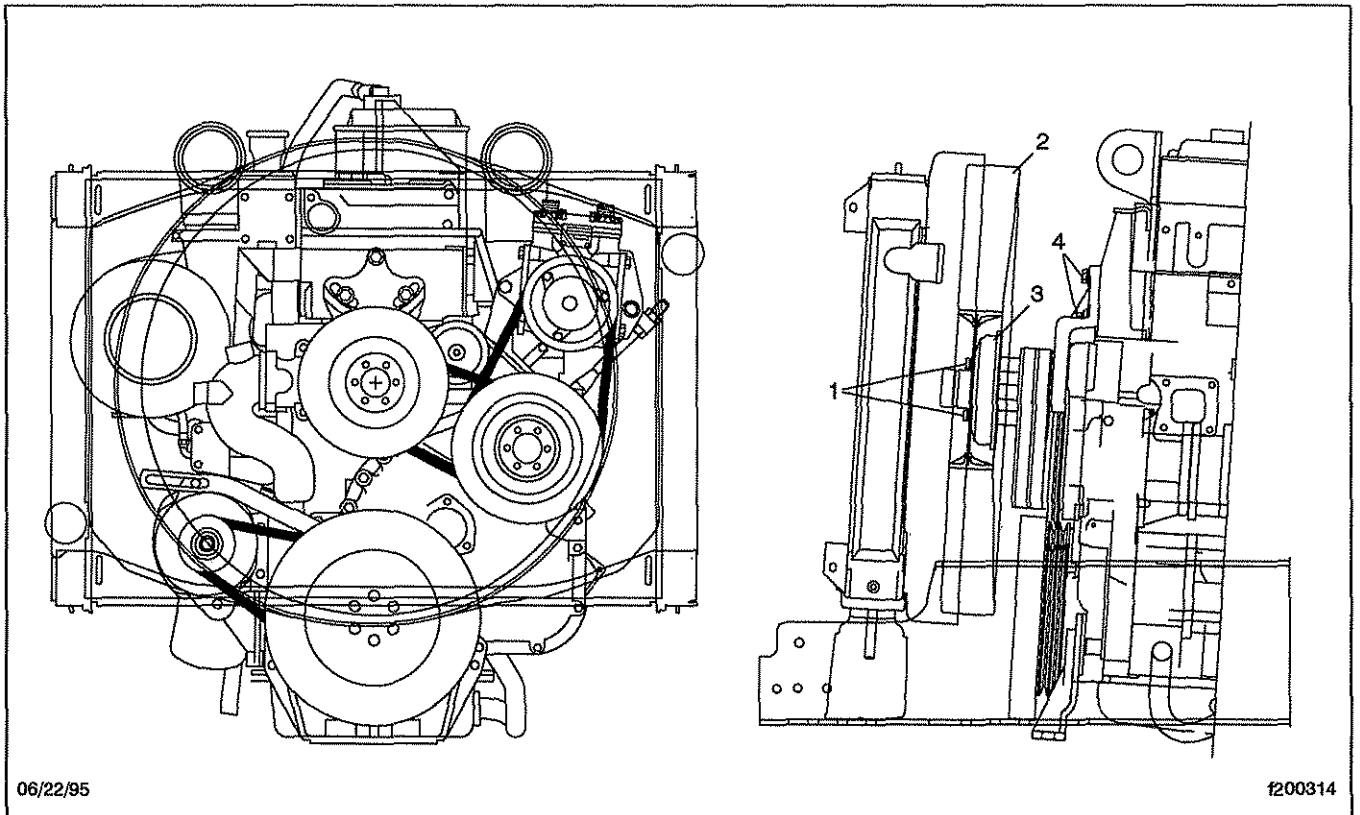


1. Nut 3/8–24, grade 5; Washer
2. Fan
3. Fan Clutch
4. Screw, M12 x 1.75x90
5. Fan Support Bracket

Fig. 3, Cummins M11 Engine, Kysor Fan Clutch

4. Install the fan. For instructions, refer to **Section 20.01**.
5. Install the radiator on the radiator mounts, and connect all radiator hoses For instructions, refer to **Section 20.01**.
6. Install the fan shroud. For instructions, refer to **Section 20.01**.
7. Connect the air line to the fan clutch.
8. Remove the chocks from the tires.

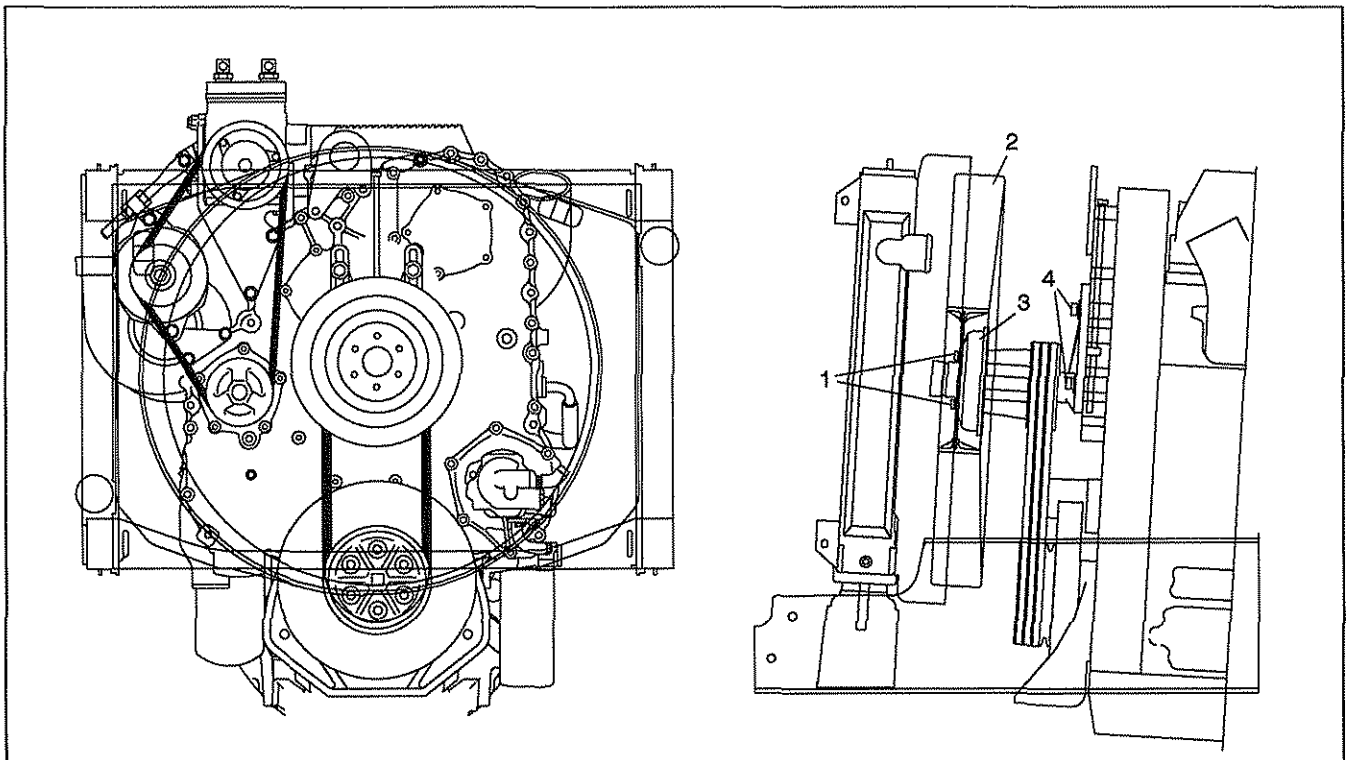
Fan Clutch Removal and Installation, Kysor K22RA



1. Nut 3/8–24, grade 5; Washer
2. Fan
3. Fan Clutch
4. Fan Clutch Mounting Bolts

Fig. 4, Cummins N14 Engine, Kysor Fan Clutch

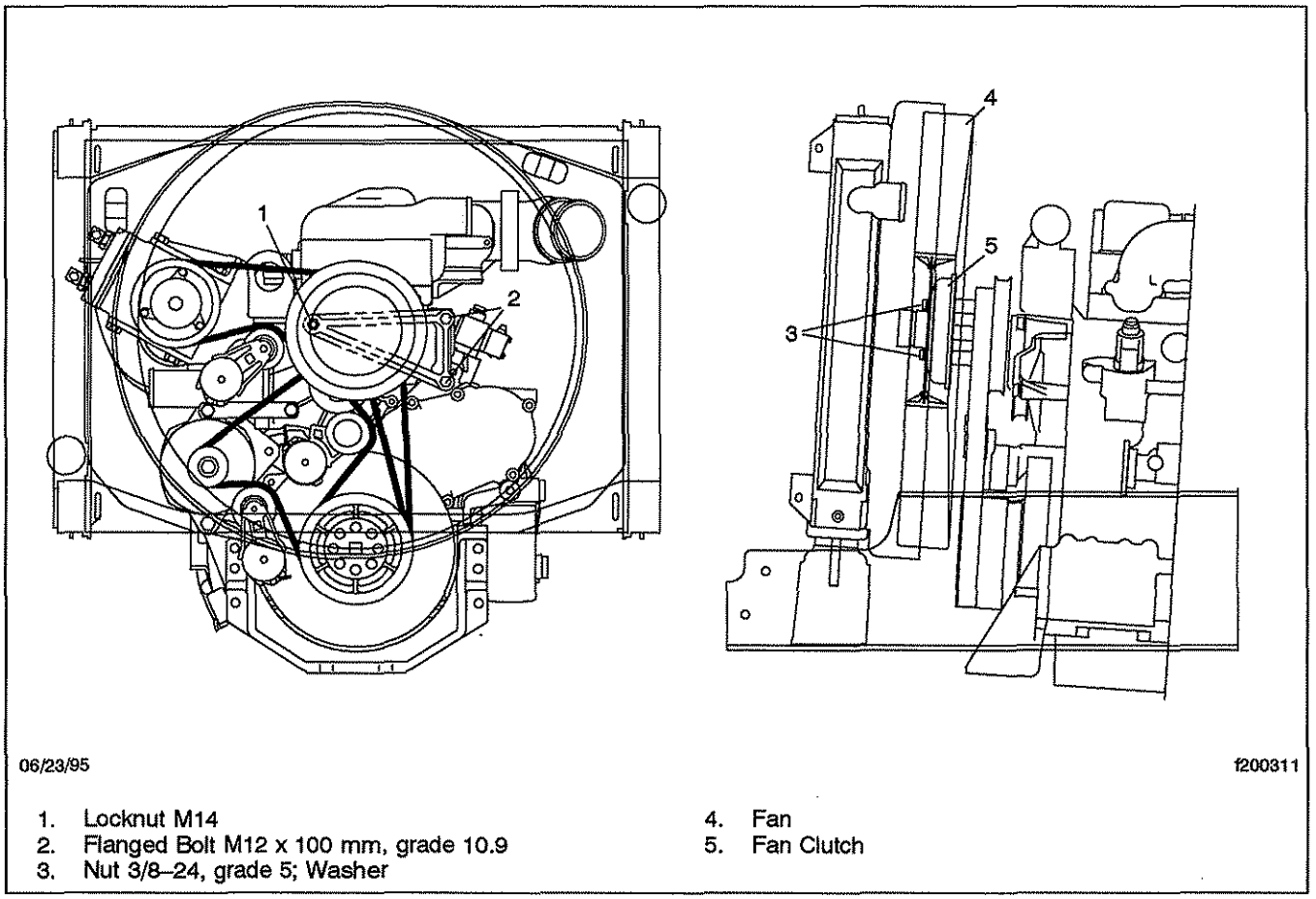
Fan Clutch Removal and Installation, Kysor K22RA



1. Nut 3/8–24, grade 5; Washer
2. Fan
3. Fan Clutch
4. Flanged Bolt, M12 x 35 mm, grade 10.9; Washer

Fig. 5, Detroit Diesel Series 50 and 60 Engine, Kysor Fan Clutch

Fan Clutch Removal and Installation, Kysor K22RA



1. Locknut M14
2. Flanged Bolt M12 x 100 mm, grade 10.9
3. Nut 3/8–24, grade 5; Washer
4. Fan
5. Fan Clutch

Fig. 6, Detroit Diesel Series 55 Engine, Kysor Fan Clutch

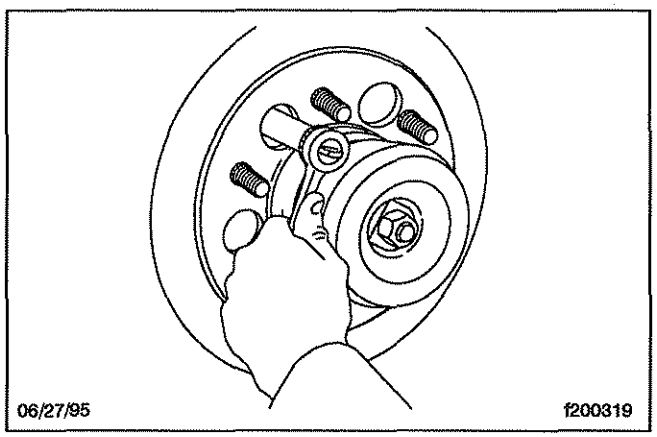


Fig. 7, Line Up the Access Holes

Fan Clutch Major Rebuild, Horton Advantage

Disassembly (See Fig. 1)

NOTE: This procedure involves a major rebuild of the Horton Advantage fan clutch, using parts from the manufacturer's Major or Super Kit. If you are replacing just the air cartridge, System Sentry® fuse, or the face seal, go to **Subject 150**.

1. Remove the fan and clutch assembly from the vehicle. For instructions, refer to **Subject 100**.
2. Clamp the fan clutch in a vise. See **Fig. 2**.
3. On some vehicles, the fan clutch has threaded studs on the air chamber and the fan is attached with nuts. On other vehicles, the fan is attached to the air chamber with hexbolts.

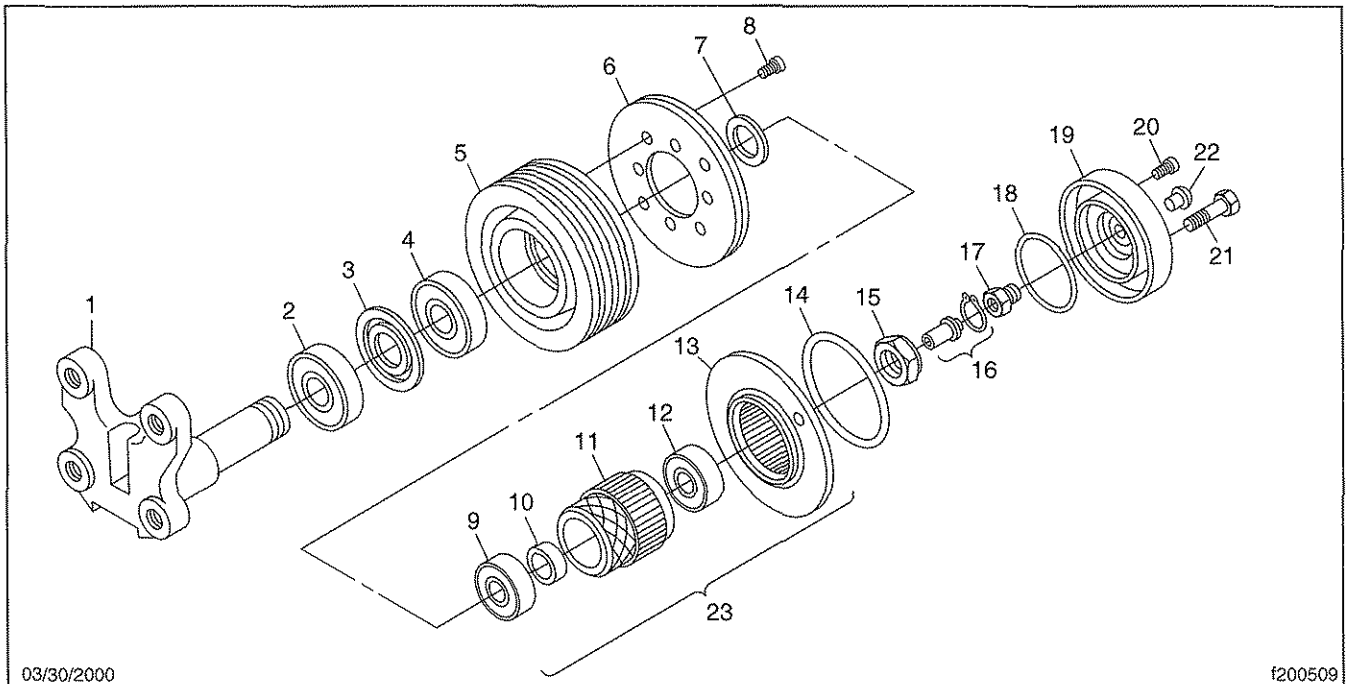
   If hexbolts were used to attach the fan, install two of the removed hexbolts in the air chamber so that a screwdriver can be used to keep the air chamber from rotating. See **Fig. 3**.

   Remove the socket-head capscrews from the air chamber.
4. If applicable, remove the two hexbolts previously installed.

⚠ WARNING

Apply air pressure slowly to the fan clutch. A sudden blast of air might blow the air chamber off the clutch, resulting in possible injury.

5. Connect a shop air hose to the cylinder inlet. See **Fig. 4**. Slowly apply air pressure, and remove the air chamber assembly.



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1. Mounting Bracket Assembly
2. Rear Sheave Bearing
3. Inner and Outer Bearing Spacers
4. Forward Sheave Bearing
5. Sheave
6. Friction Facing
7. Journal Spacer
8. Socket-Head Capscrew
9. Rear Hub Bearing
10. Bearing Spacer
11. Splined Hub
12. Forward Hub Bearing
13. Piston Friction Disc
14. Large O-Ring
15. Locknut
16. Air Cartridge Assembly
17. Face Seal
18. Small O-Ring
19. Air Chamber
20. Socket-Head Capscrew
21. Hexbolt (some vehicles equipped with studs)
22. Rubber Umbrella Valve
23. Disc and Piston Assembly

Fig. 1, Horton Advantage Fan Clutch

Fan Clutch Major Rebuild, Horton Advantage

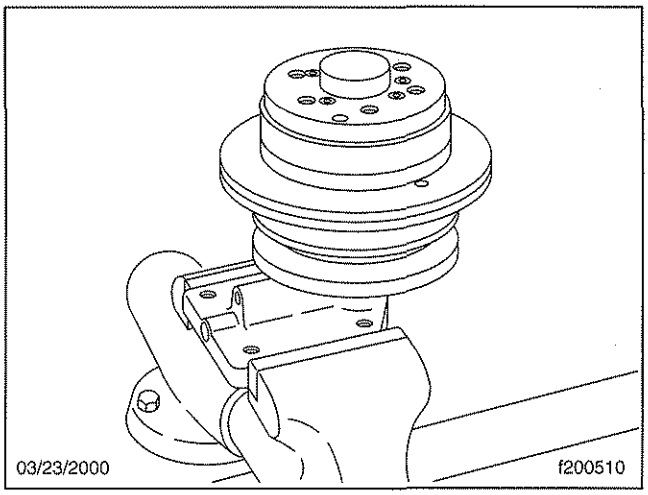
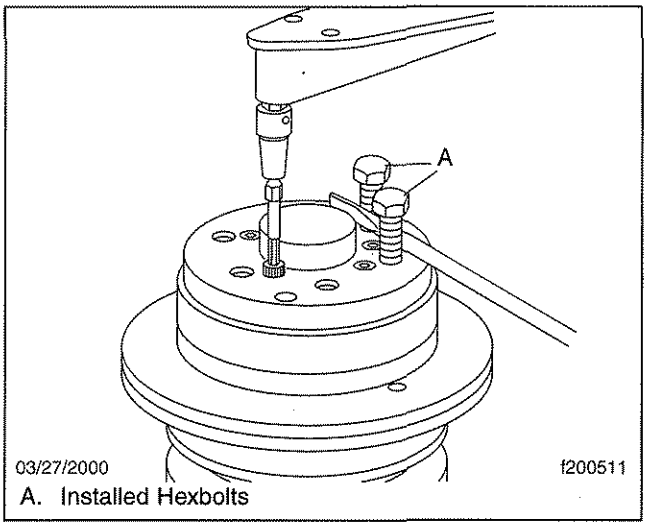


Fig. 2, Fan Clutch Placed in a Vise



A. Installed Hexbolts

Fig. 3, Remove the Socket-Head Capscrews

6. Remove and discard the O-rings from the air chamber and the piston friction disc. Clean the O-ring contact surfaces.
7. Remove the face seal from the air chamber.
8. Remove the System Sentry fuse from the piston friction disc. *Note that it is a left-hand thread.*
9. Remove the rubber umbrella valve from the air chamber.
10. Remove the adjusting nut. See **Fig. 5**.
11. Remove the disc and piston assembly, and the journal spacer. See **Fig. 6**.
12. Slide the sheave and bearings off the mounting bracket assembly. See **Fig. 7**.
13. Remove the socket-head capscrews from the friction facing. Remove the friction facing.

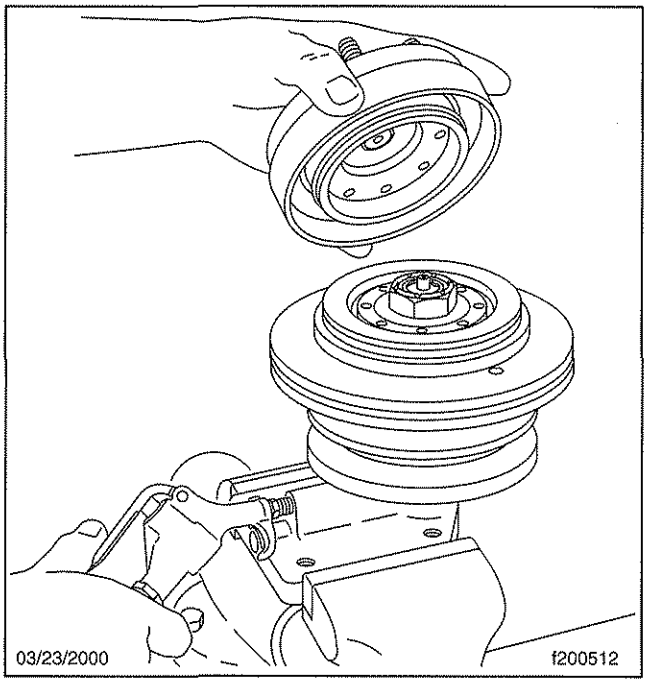


Fig. 4, Remove the Air Chamber

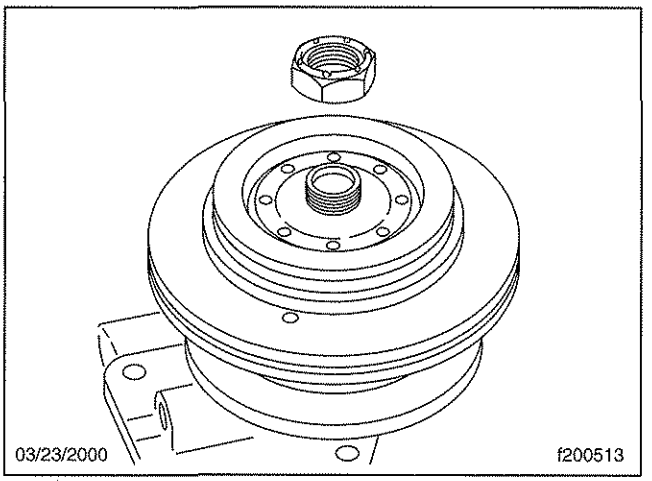


Fig. 5, Remove the Adjusting Nut

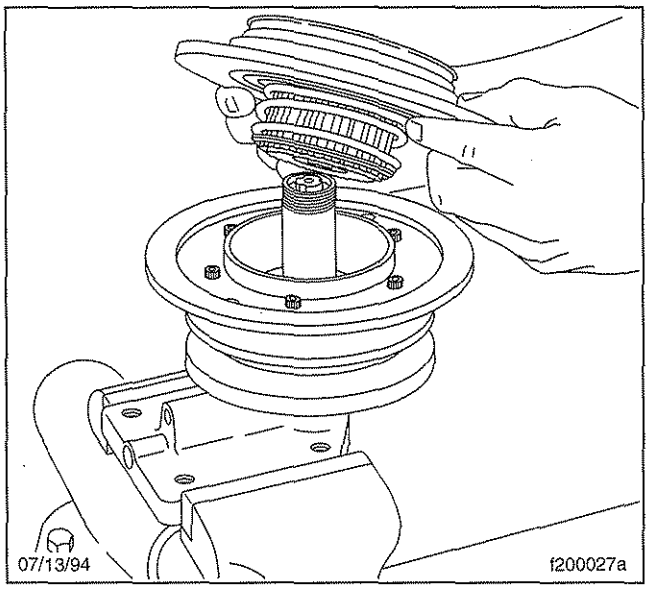


Fig. 6, Remove the Disc and Piston

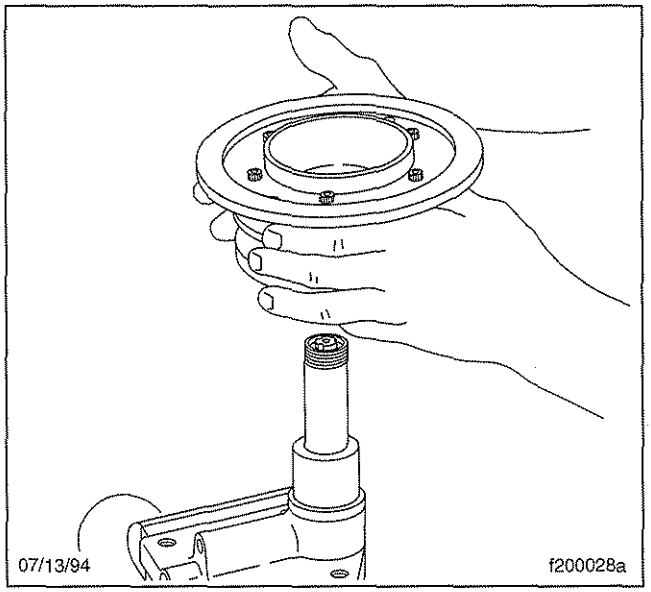


Fig. 7, Slide Off the Sheave and Bearings

14. Remove the retaining ring from the air cartridge assembly. See **Fig. 8**.

    Remove the cartridge assembly from the mounting bracket assembly. See **Fig. 9**.

15. Support the sheave and press out the bearings.

Assembly

1. Coat the new sheave bearings with grease and press them into the sheave.

NOTE: Some models have a spacer between the bearings. Install the spacer if equipped.

2. Install a new air cartridge assembly in the mounting bracket assembly. Note that the retaining ring is curved. Make sure the ring is

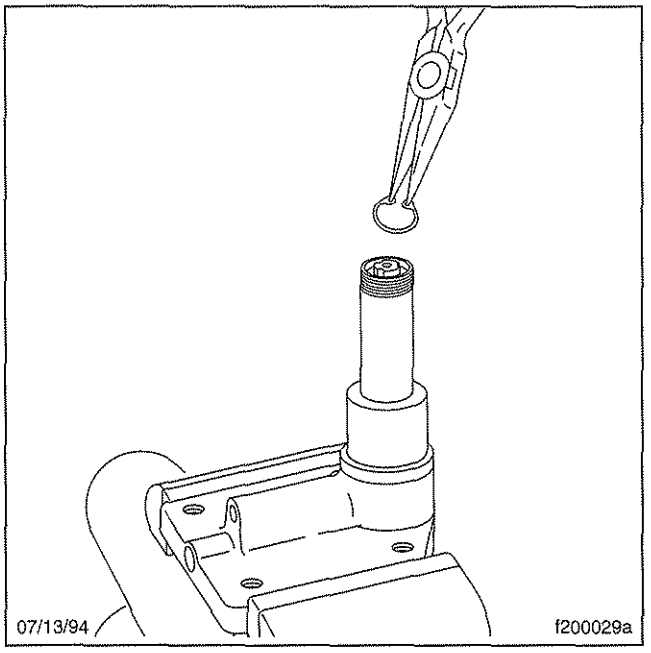


Fig. 8, Remove the Retaining Ring

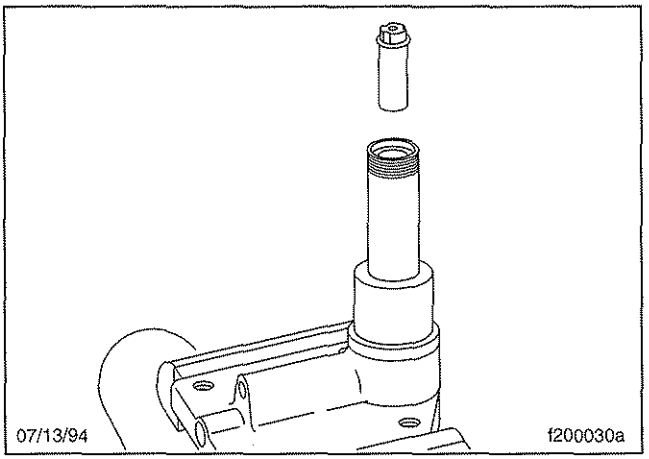


Fig. 9, Remove the Air Cartridge Assembly

Fan Clutch Major Rebuild, Horton Advantage

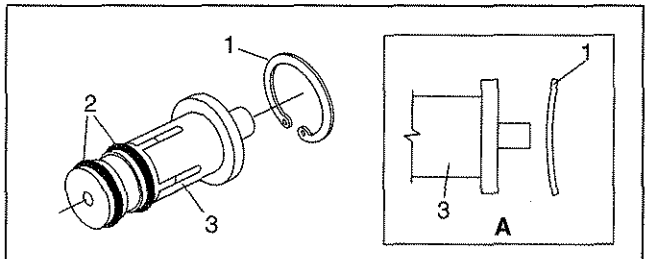
installed with the convex surface toward the air cartridge. See **Fig. 10**.

3. Slide the sheave and bearings onto the mounting bracket assembly.
4. Install a new friction facing onto the sheave. Following a star pattern, tighten the socket-head capscrews 60 lbf·in (680 N·cm).

⚠ CAUTION

Never fill more than one-third of the bearing void with grease. Too much grease can cause overheating and possible bearing damage.

5. Install the journal spacer, and the disc and piston assembly. Make sure that the lip on the journal spacer is facing up. See **Fig. 11**.
6. Install the adjusting nut. Tighten 150 lbf·ft (203 N·m).
7. Remove any dust and debris from the air chamber.
8. Coat the new O-rings with an approved lubricant and install them. See **Fig. 12**.
9. Install the new face seal in the air chamber. Tighten 50 lbf·in (565 N·cm).
10. Install the new rubber umbrella valve in the air chamber.
11. Install the new System Sentry fuse in the piston friction disc. *Note that it is a left-hand thread.*



A. Convex Surface of Retaining Ring Toward the Air Cartridge
1. Retaining Ring
2. O-Rings
3. Air Cartridge

Fig. 10, Air Cartridge Assembly

12. Slide the air chamber assembly onto the clutch. If applicable, install two of the hexbolts that hold the fan in place.
13. Using a screwdriver to keep the air chamber from rotating, install the socket-head capscrews. Following a star pattern, tighten 15 lbf·ft (20 N·m).
14. If applicable, remove the two hexbolts previously installed.
15. Install the fan and clutch assembly on the engine. For instructions, refer to **Subject 100**.

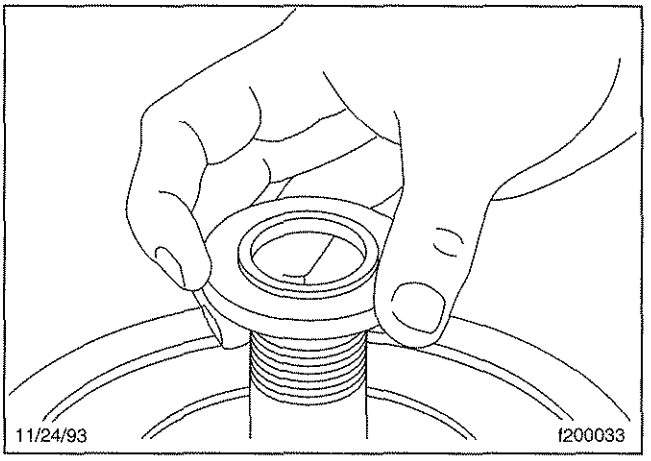


Fig. 11, Check the Journal Lip

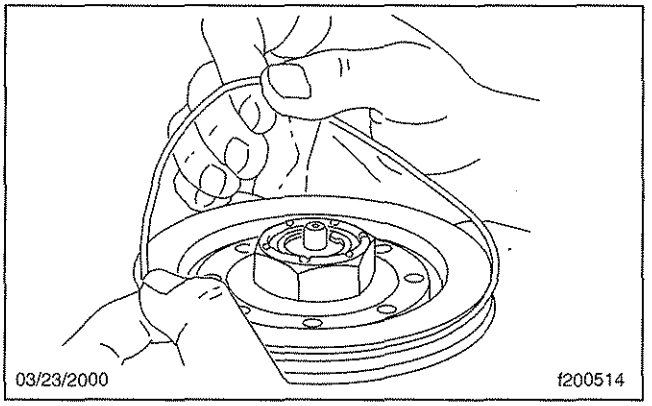


Fig. 12, Install New O-Rings

Fan Clutch Minor Rebuild, Kysor K22RA

Special Tools

IMPORTANT: Special tools are recommended, but not required for this procedure. See **Table 1** for the special tool set.

Special Tools		
Description	**Part Number**	**Order From**
Support and Compressor (see **Fig. 1**)	1090-00000-02	Wright Brothers Enterprises 8171 Hibma Marion, MI 49665 Telephone: 231-825-2939

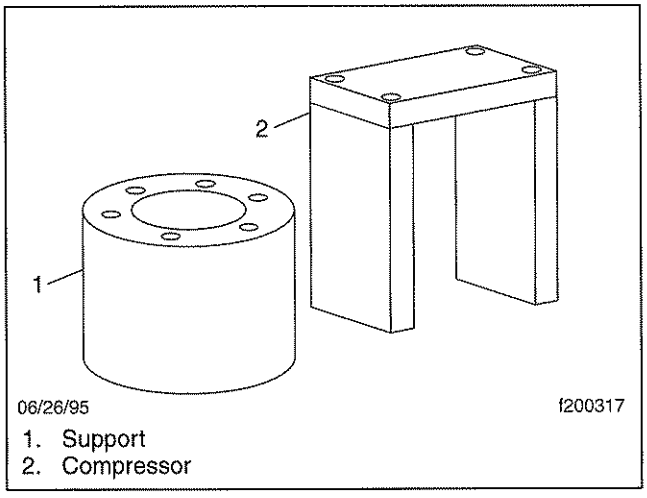
Table 1, Special Tools

Rebuild

1. Park the vehicle, apply the parking brakes, and chock the tires.
2. Remove the fan clutch from the vehicle. For instructions, refer to **Subject 110**.

⚠ CAUTION

When caging and compressing the engagement spring of the fan clutch, depress the clutch shaft only enough to relieve the pressure on the retaining plates (about 1/16-inch, or 1.5 mm). Applying additional force after the clutch shaft bottoms in the housing will damage the housing and render it unserviceable.



1. Support
2. Compressor

Fig. 1, Special Tools

NOTE: There are two methods of caging the engagement spring. One uses the special tools and a press. The other uses carriage bolts, washers, and wingnuts. Either method is effective.

3. Cage the engagement spring.

   If using the special support and compressor tools, place the fan clutch in a press to cage the engagement spring. See **Fig. 2**.

   If using the optional method of caging the engagement spring, do the following:

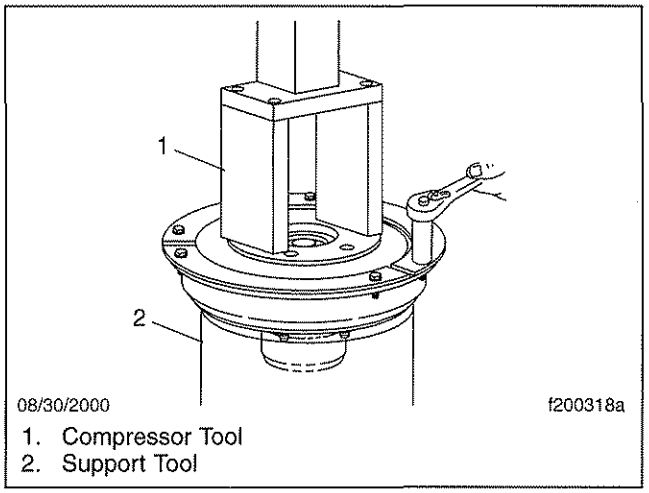
   3.1 With the access holes in the housing assembly aligned with those in the shaft assembly, install two 3-1/2-inch (89-mm) long carriage bolts and suitable washers on opposite sides of the clutch assembly.

   3.2 On the shaft assembly side, install about a 1/2-inch (13-mm) thickness of washers onto each carriage bolt.

   3.3 Install a wingnut on the end of each carriage bolt and tighten the wingnuts evenly until the engagement spring is caged.

4. Remove the lining retaining plates and the lining. See **Fig. 2** and **Fig. 3**.

Fan Clutch Minor Rebuild, Kysor K22RA



1. Compressor Tool
2. Support Tool

Fig. 2, Caging the Engagement Spring and Removing the Lining Retaining Plates

⚠ CAUTION

Do not press on the cylinder during this step, or the cylinder will be damaged. Use a 5/8-inch wrench as shown in Fig. 4 on the piston rod flats.

5. If applicable, turn the clutch over in the press, and use the special compressor tool to cage the engagement spring while removing the cylinder nut and cylinder. See **Fig. 4**.
6. Inspect the fan clutch. See **Fig. 3**
   - 6.1 Inspect the two surfaces where the lining rides.
   - 6.2 Inspect the needle bearing race on the shaft.
   - 6.3 Inspect the needle bearings inside the clutch housing.
   - 6.4 Inspect the piston bearing by rotating the piston.
7. If you find cracking or scoring on any surface, or if the bearings are rough, loose, or missing, replace the fan clutch.

NOTE: If you find metal particles in the existing grease, replace the fan clutch or contact Kysor for the training needed to perform a major fan clutch rebuild. Kysor will not provide parts for a major rebuild until the technician has completed rebuild training provided by Kysor.

IMPORTANT: Do not wash the clutch parts in solvent.

8. Using **Fig. 3** as a reference, lubricate the following rebuild parts with lubricant supplied with the rebuild kit (if the lubricant is unavailable, use one of the approved lubricants listed in **Specifications, 400)** :
   - The piston seal (pack the seal groove also)
   - The dust seal (pack the seal groove also)
   - The needle bearings inside the housing
   - The inside of the engagement spring
   - The outside of the piston rod assembly
   - The inside of the piston rod assembly
   - The inside of the cylinder assembly
   - Pack the lip of the grease seal

⚠ CAUTION

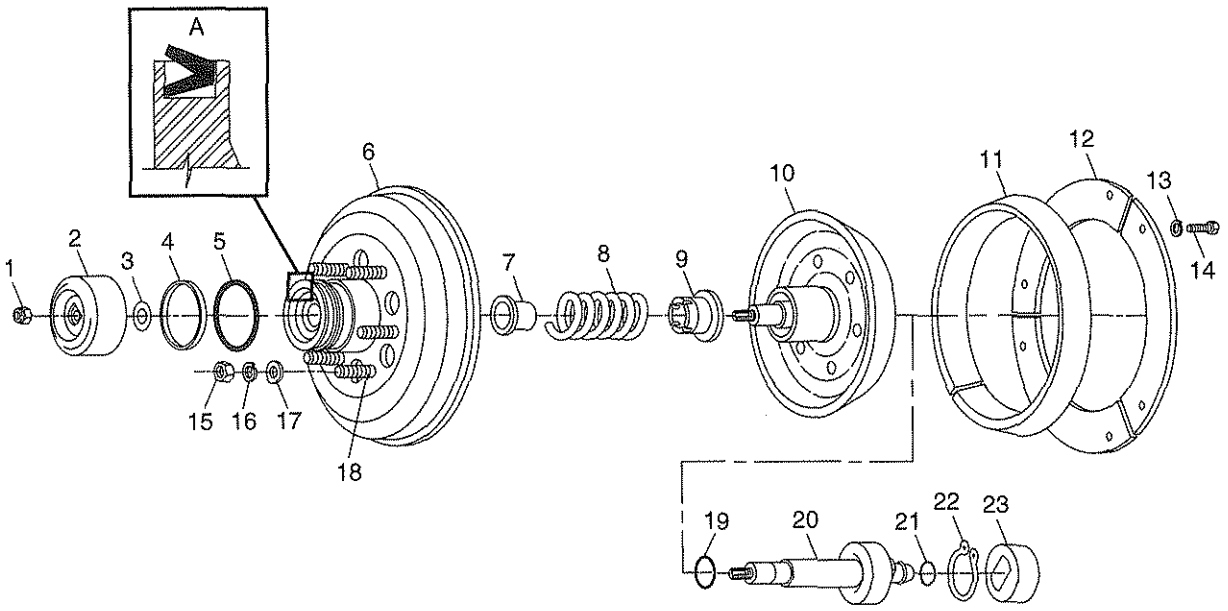
When caging the engagement spring, make sure the bottom edges of the housing assembly and the shaft assembly are flush and aligned all the way around. Failure to do so will cause the engagement spring pressure to affect the torque of the cylinder nut. This could result in the cylinder nut not being tight enough to effectively compress the piston seal washer, which could cause leakage and eventual fan clutch failure.

IMPORTANT: When caging the engagement spring, compress the clutch shaft only 1/16-inch (1.5 mm).

9. Assemble the fan clutch parts according to **Fig. 3**. Using either the special tools and a press, or carriage bolts, washers, and wingnuts, cage the engagement spring when installing the cylinder and lining. Be careful to depress the clutch shaft only 1/16-inch (1.5 mm).

   The piston rod seal washer is the last item to install before the cylinder goes on. See **Fig. 5**.
10. Tighten the cylinder nut 84 lbf·in (940 N·cm).
11. Tighten the lining screws 30 lbf·in (340 N·cm).
12. As applicable, remove the fan clutch from the press or remove the carriage bolts, washers, and wing nuts.

Fan Clutch Minor Rebuild, Kysor K22RA



A. If a lip seal is used, install it so that it faces away from the fan studs.

1. Cylinder Nut
2. Cylinder Assembly
3. Piston Rod Seal Washer
4. Lip Seal (may be O-Ring)
5. Dust Seal
6. Housing Assembly
7. Engagement Spring End Cap
8. Engagement Spring
9. Engagement Spring Carrier
10. Shaft Assembly
11. Lining
12. Lining Retaining Plates
13. Lockwasher
14. Screw
15. Fan Nut
16. Lockwasher
17. Flatwasher
18. Fan Stud
19. O-Ring
20. Piston Rod Assembly
21. O-Ring
22. Snap Ring
23. Coupling

Fig. 3, Kysor K22RA Fan Clutch (exploded view)

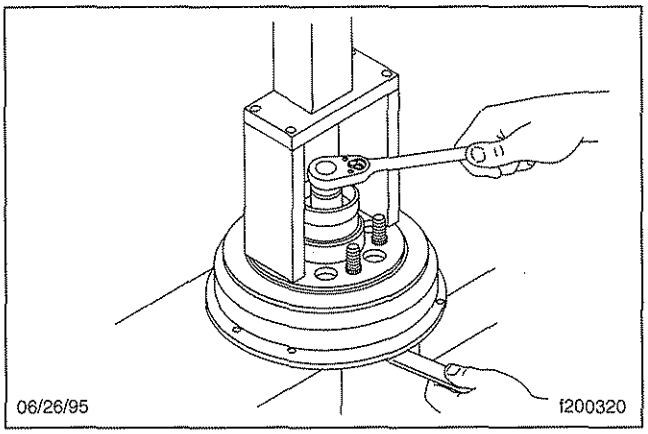


Fig. 4, Removing the Cylinder Nut and Cylinder

13. Check the front-to-rear travel of the fan clutch. For instructions, refer to **Group 20** in the *Century Class Trucks Maintenance Manual.*
14. Install the fan clutch on the engine. For instructions, refer to **Subject 110.**
15. Close the hood and remove the chocks from the tires.

Fan Clutch Minor Rebuild, Kysor K22RA

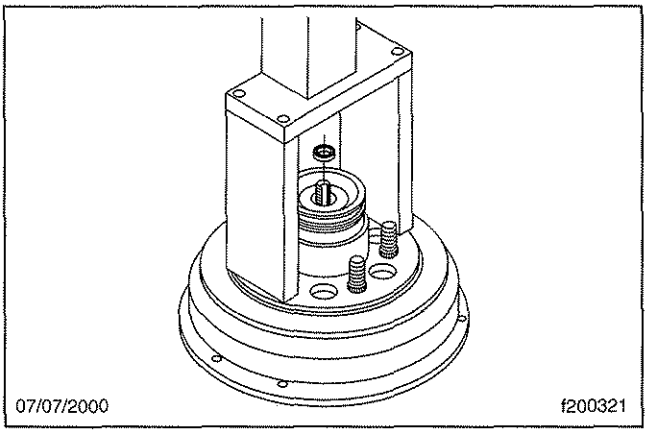


Fig. 5, Installing the Piston Rod Seal Washer

Fan Clutch Relining, Kysor K22RA

Relining (See Fig. 1)

IMPORTANT: Premature wearing of the fan clutch lining is due to either insufficient air pressure necessary to fully engage the clutch or a problem in the control circuit for the fan.

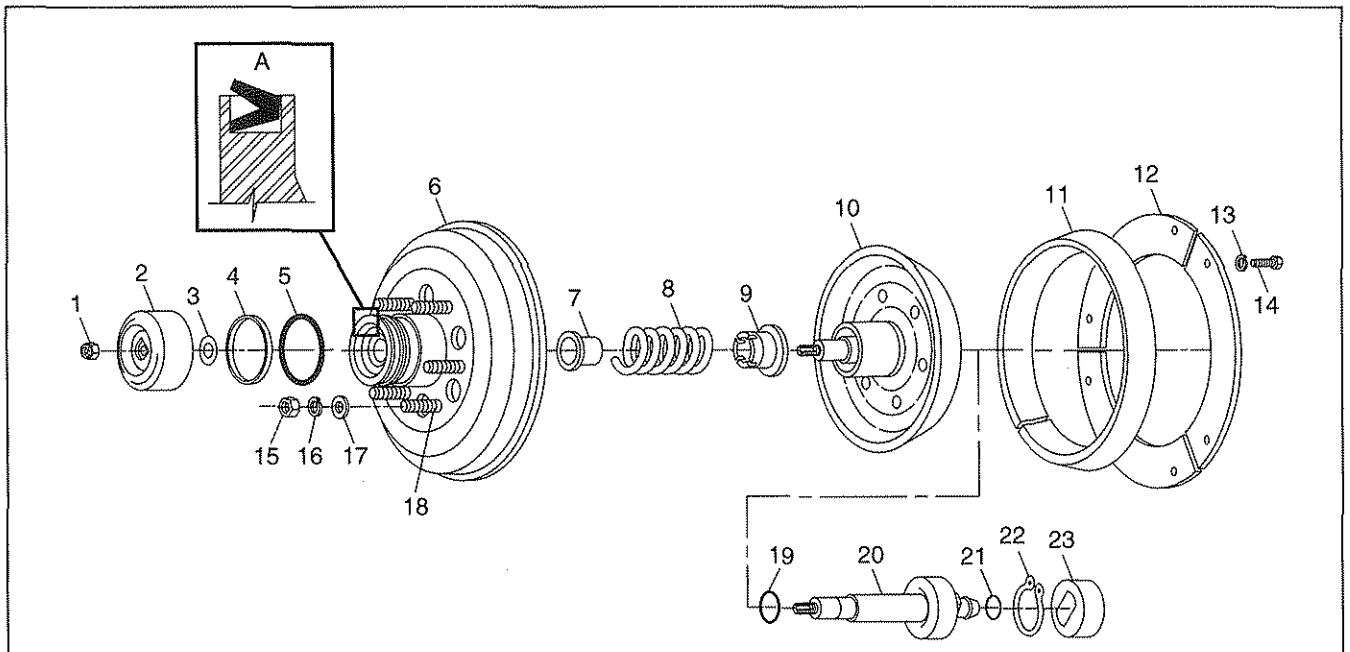
Before putting the fan clutch back in service, check the fan control and air supply systems and make any necessary repairs.

1. Park the vehicle, apply the parking brakes, and chock the tires.

⚠ WARNING

If the fan clutch engages during the next step, it could cause personal injury. Keep the fan clutch disengaged throughout this procedure by maintaining between 90 and 120 psi (620 and 827 kPa) of air pressure.

2. Remove the six lining plate screws, and remove the three lining plates. See **Fig. 2**.
3. Replace the lining.
4. Install the new lining plates, and tighten the screws 30 lbf·in (340 N·cm).
5. Remove the air pressure from the fan clutch, and allow the fan to engage.
6. Close the hood, and remove the chocks from the tires.



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A. If a lip seal is used, install it so that it faces away from the fan studs.

1. Cylinder Nut
2. Cylinder Assembly
3. Piston Rod Seal Washer
4. Lip Seal (may be O-Ring)
5. Dust Seal
6. Housing Assembly
7. Engagement Spring End Cap
8. Engagement Spring
9. Engagement Spring Carrier
10. Shaft Assembly
11. Lining
12. Lining Retaining Plates
13. Lockwasher
14. Screw
15. Fan Nut
16. Lockwasher
17. Flatwasher
18. Fan Stud
19. O-Ring
20. Piston Rod Assembly
21. O-Ring
22. Snap Ring
23. Coupling

Fig. 1, Kysor K22RA Fan Clutch (exploded view)

Fan Clutch Relining, Kysor K22RA

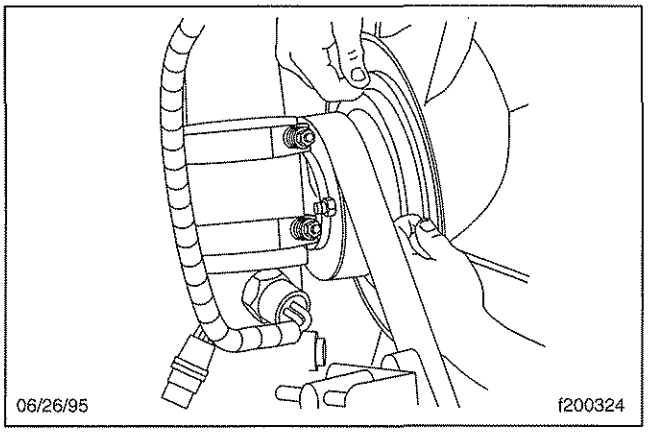


Fig. 2, Remove the Lining Plates

Fan Clutch Minor Rebuild, Horton Advantage

Disassembly

NOTE: This procedure involves replacing only the air cartridge, System Sentry® fuse, the face seal, and the O-rings, using parts from the manufacturer's Seal Kit. If doing a major rebuild, go to **Subject 120**.

1. Remove the fan and clutch assembly from the vehicle. For instructions, refer to **Subject 100**.
2. Clamp the fan clutch in a vise. See **Fig. 1**.
3. On some vehicles, the fan clutch has threaded studs on the air chamber and the fan is attached with nuts. On other vehicles, the fan is attached with hexbolts.

   If hexbolts were used to attach the fan, install two of the removed hexbolts in the air chamber so a screwdriver can be used to keep the air chamber from rotating. See **Fig. 2**.

   Remove the socket-head capscrews from the air chamber.
4. If applicable, remove the two hexbolts previously installed.

⚠ WARNING

Apply air pressure slowly to the fan clutch. A sudden blast of air might blow the air chamber off the clutch, resulting in possible injury.

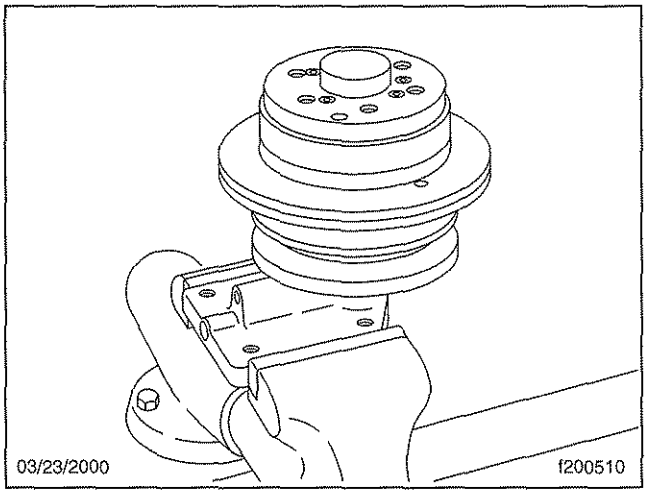


Fig. 1, Fan Clutch Placed in a Vise

5. Connect a shop air hose to the cylinder inlet. See **Fig. 3**. Slowly apply air pressure, and remove the air chamber assembly.
6. Remove and discard the O-rings from the air chamber and the piston friction disc. Clean the O-ring contact surfaces.
7. Remove the face seal from the air chamber. See **Fig. 3**.
8. Remove the System Sentry fuse from the piston friction disc. *Note that it is a left-hand thread.*
9. Remove the rubber umbrella valve from the air chamber.
10. Remove the adjusting nut. See **Fig. 4**.
11. Remove the retaining ring from the air cartridge assembly. See **Fig. 5**.

    Remove the cartridge assembly from the mounting bracket assembly. See **Fig. 6**.

Assembly

1. Install a new air cartridge assembly in the mounting bracket assembly. Note that the retaining ring is curved. Make sure the ring is installed with the convex surface toward the air cartridge. See **Fig. 7**.
2. Install the adjusting nut. Tighten 150 lbf·ft (203 N·m).

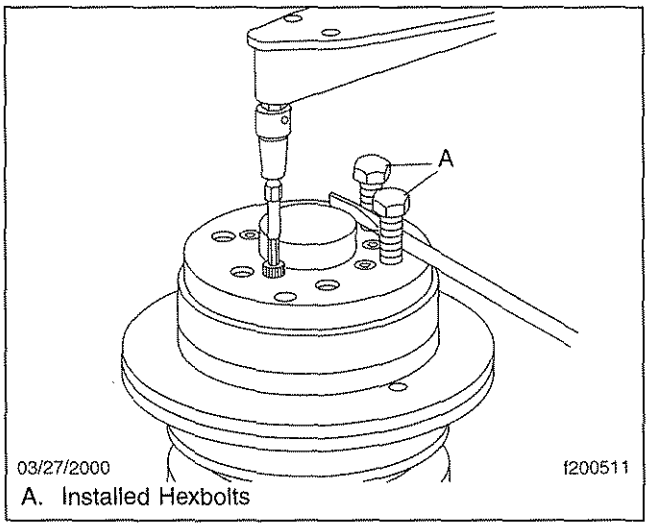
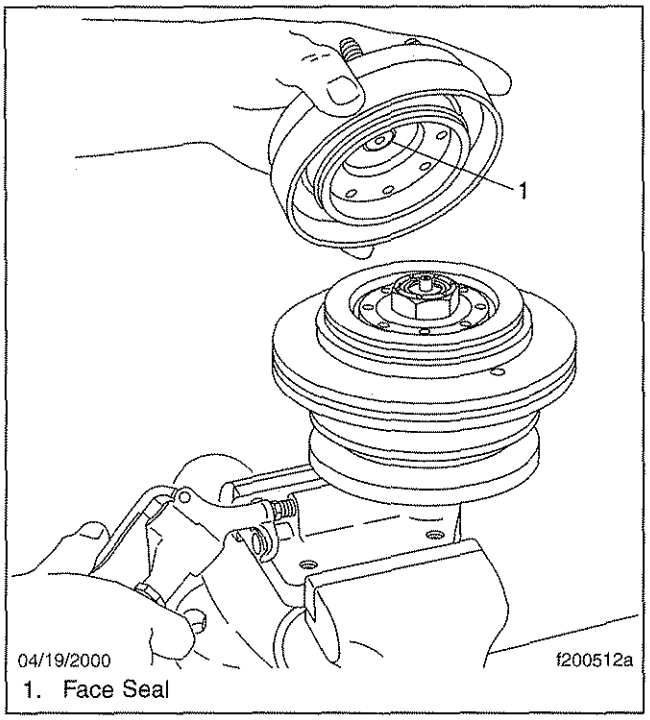


Fig. 2, Remove the Socket-Head Capscrews

Fan Clutch Minor Rebuild, Horton Advantage



1. Face Seal

Fig. 3, Remove the Air Chamber

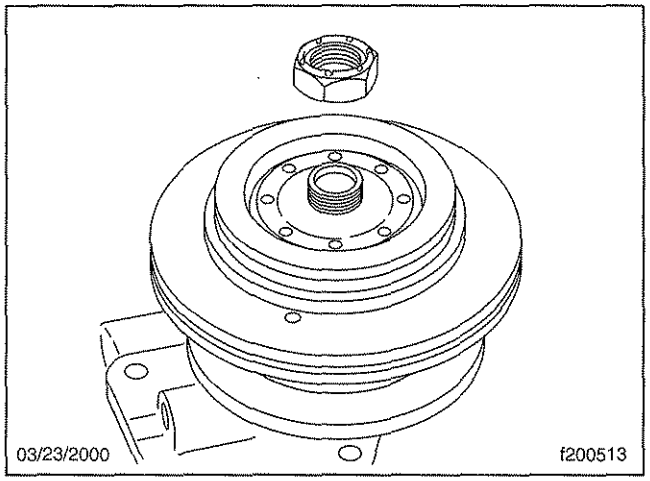


Fig. 4, Remove the Adjusting Nut

3. Remove any dust and debris from the air chamber.
4. Coat the new O-rings with an approved lubricant and install them. See **Fig. 8**.
5. Install the new face seal in the air chamber. Tighten 50 lbf·in (565 N·cm).

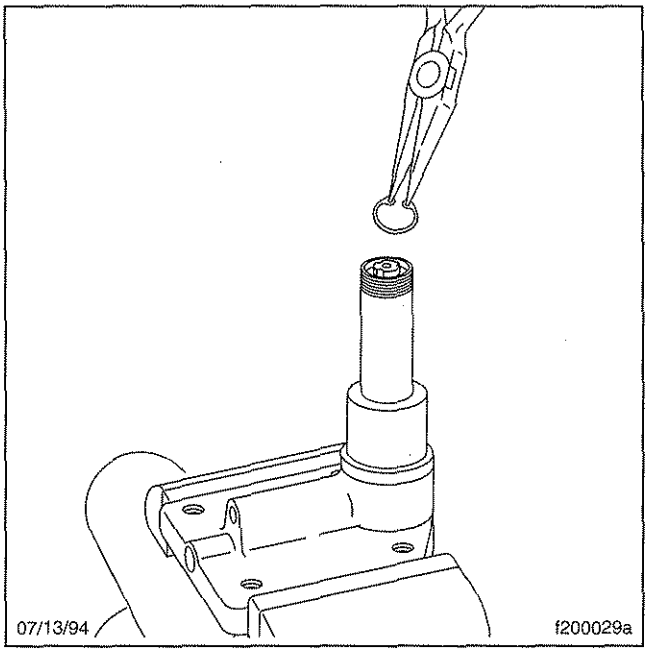


Fig. 5, Remove the Retaining Ring

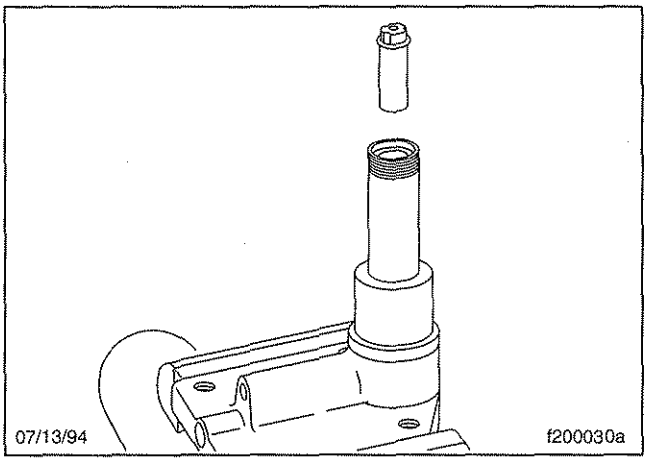
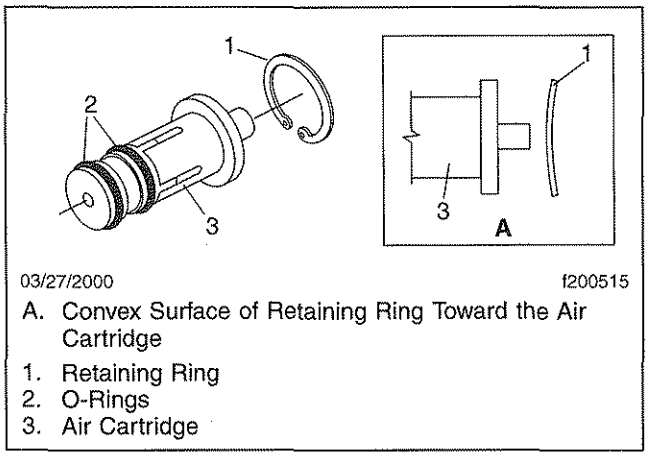


Fig. 6, Remove the Air Cartridge Assembly

6. Install the new rubber umbrella valve in the air chamber.
7. Install the new System Sentry fuse in the piston friction disc. *Note that it is a left-hand thread.*
8. Slide the air chamber assembly onto the clutch. If applicable, install two of the hexbolts that held the fan in place.



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A. Convex Surface of Retaining Ring Toward the Air Cartridge
1. Retaining Ring
2. O-Rings
3. Air Cartridge

Fig. 7, Air Cartridge Assembly

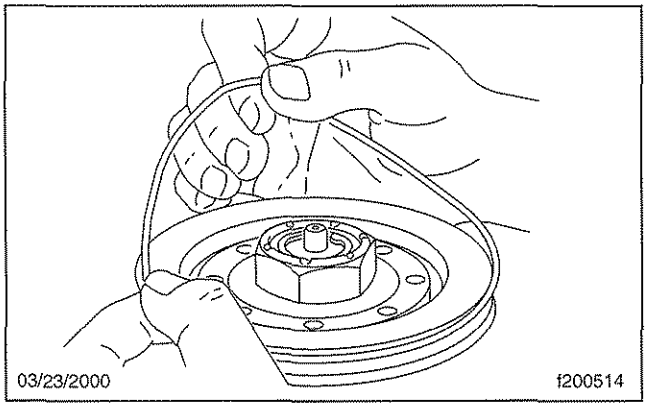


Fig. 8, Install New O-Rings

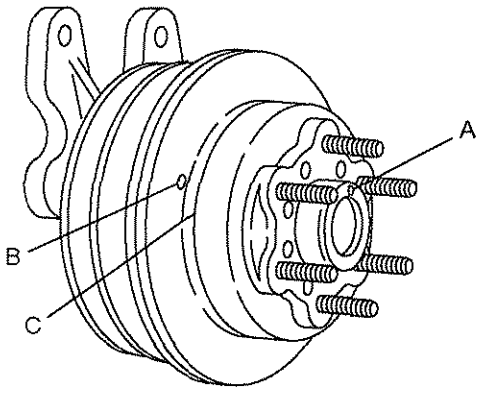
9. Using a screwdriver to keep the air chamber from rotating, install the socket-head capscrews. Following a star pattern, tighten 15 lbf·ft (20 N·m).
10. If applicable, remove the two hexbolts previously installed.
11. Install the fan and clutch assembly on the engine. For instructions, refer to **Subject 100**.

Problem—Air Is Leaking from the Fan Clutch

Possible Cause	Remedy
The face seal or air cartridge (**Fig. 1**) is bad, Horton Advantage	Install a new seal kit.
The O-ring seals (**Fig. 1**) are bad, Horton Advantage	Install a new seal kit.

Problem—The Fan Clutch Fails to Engage

Possible Cause	Remedy
There's no power to the fan clutch control circuit.	Check all electrical connections, and repair or replace wiring as needed. Check the circuit breaker for the engine fan and repair or replace as needed.
The engine temperature switch is damaged or an incorrect sensor has been installed.	For Horton fan clutches, make sure the switch is normally open, not normally closed. For Kysor fan clutches, make sure the switch is normally closed, not normally open. Replace the switch if it is damaged or if the switch is the wrong type.
The solenoid valve is malfunctioning.	Replace the solenoid valve.
The fan clutch is leaking.	Install a new seal kit.
The air supply to the fan clutch is restricted.	Make sure the fan clutch air lines are not leaking or pinched. Repair the lines as needed.



A. Face Seal or Air Cartridge Leak
B. O-Ring Seal Leak
C. O-Ring Seal Leak

Fig. 1, Possible Fan Clutch Air Leaks, Horton Advantage Fan Clutch

Troubleshooting

Problem—The Fan Clutch Does Not Disengage

Possible Cause	Remedy
The engine temperature switch is damaged or an incorrect sensor has been installed.	For Horton fan clutches, make sure the switch is normally open, not normally closed. For Kysor fan clutches, make sure the switch is normally closed, not normally open. Replace the switch if it is damaged or if the switch is the wrong type.
A restricted air line doesn't allow air to vent from the clutch.	Make sure the air lines are not pinched or plugged. Repair the air lines as needed.
The solenoid is not exhausting.	Make sure the solenoid exhaust port is not plugged.
The piston friction disc is seized due to contamination or worn splines.	Reline or replace the piston friction disc, and make sure the fan clutch air supply is clean.

Problem—The Fan Clutch Cycles Frequently

Possible Cause	Remedy
The fan clutch control circuit has a loose connection or is poorly grounded.	Check all wiring connections, and repair the circuit as needed. Check the circuit breaker for the engine fan and repair or replace as needed.
The temperature control settings are incorrect.	Check the fan clutch control setting of the temperature switch, according to the engine installed in the vehicle. Repair or replace the temperature switch as needed. For fan clutch control settings, refer to **Section 20.00**.
The fan cycling switch at the receiver-dryer is set too low.	Check the switch at the receiver-dryer, and if needed, replace the switch with a switch with a higher setting. Check the ACPU switch and unit.
There is an air restriction in front of the fan clutch.	Check for incorrect radiator shutter operation, winterfronts, or any other air restrictions.
The engine temperature is too high.	Check the programmable engine control parameters, and reprogram as needed.
The temperature switch is malfunctioning.	Replace the temperature switch.

Problem—The Fan Clutch Engages, But the Engine Still Overheats

Possible Cause	Remedy
There is an air restriction in front of the fan clutch.	Check for incorrect radiator shutter operation, winterfronts, or any other air restrictions.
There is a problem somewhere else in the cooling system.	Refer to the cooling system troubleshooting section, **Section 20.00**.

Specifications

If the lubricant that comes with the rebuild kit for the Kysor K22RA fan clutch is unavailable, use one of the following approved lubricants:

- Aeroshell 5
- Shell Alvania R3
- Chevron SR12
- Amoco Rykon Premium #2EP
- Texaco RB Premium

Kysor K22RA Fan Clutch Torques		
Description	**Torque**	
	lbf.ft (N.m)	**lbf.in (N.cm)**
Clutch-to-Hub Fasteners	45 (61)	—
Fan-to-Clutch Fasteners	26 (35)	—
Front Piston Nut	—	84 (950)
Lining Plate Screws	—	30 (340)

Table 1, Kysor K22RA Fan Clutch Torques

Engine Block Heaters

20.03

Contents

Subject	Subject Number
General Information	050
Service Operations	
Block Heater Element Replacement	100
Troubleshooting	300
Specifications	400

General Information

An engine block heater keeps the engine coolant about 27°C (80°F) warmer than the ambient air temperature. In cold weather, the heater helps engine starting and reduces wear on the piston walls.

When starting the engine, the diesel normally ignites on the compression stroke of each piston, when the compressed air within the cylinder reaches about 385°C (725°F). However, during cold weather starts, the heat of the compressed air dissipates into the surrounding engine block so the diesel may never reach the temperature it needs to ignite. Using the engine block heater, the engine block is already warm so heat is held in the cylinder to ignite the diesel. To reduce engine wear, the block heater warms the oil film on the piston walls and reduces piston drag caused by cold oil film.

The heater consists of an element that bolts into the side of the engine water jacket. **See Fig. 1.** A cord plugs into the outside end of the element, and the cord runs to a plug below the front bumper.

To turn on the heater, connect the heater cord to a power source. The element has no thermostat. Heat dissipating from the engine block prevents coolant overheating.

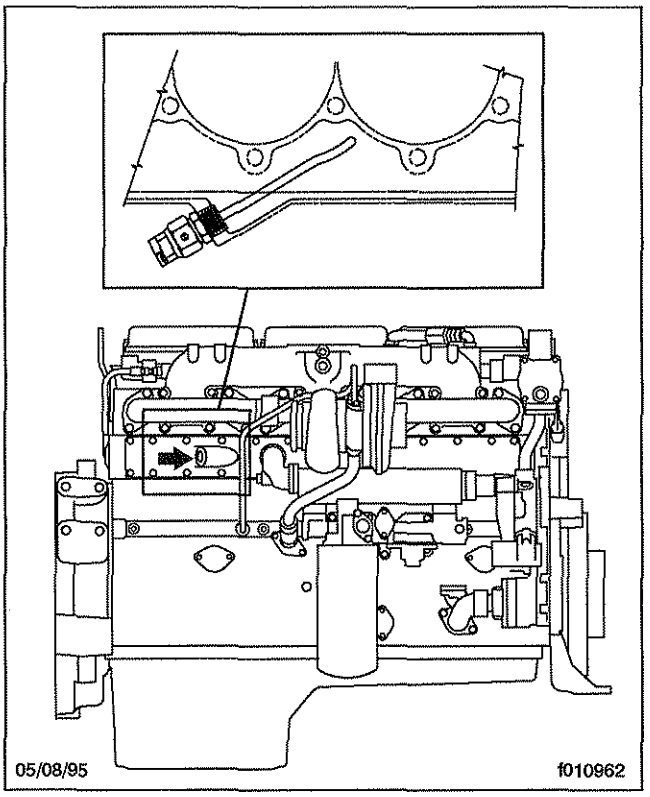


Fig. 1, Block Heater Element Installation, Caterpillar 3176 Engine

Block Heater Element Replacement

Removal

See the applicable figure for the block heater installation for your vehicle:

- For a Caterpillar 3176 engine, **see Fig. 1**
- For a Caterpillar 3406 engine, **see Fig. 2**
- For a Cummins L10 engine, **see Fig. 3**
- For a Cummins N14 engine, **see Fig. 4**
- For a Detroit Diesel Series 50 or 60 engine, **see Fig. 5**

1. Park the vehicle, apply the parking brakes, and chock the tires.
2. Tilt the hood.

WARNING: Drain the coolant only when the coolant and engine are cool. Draining it when these are hot could cause severe personal injury due to scalding.

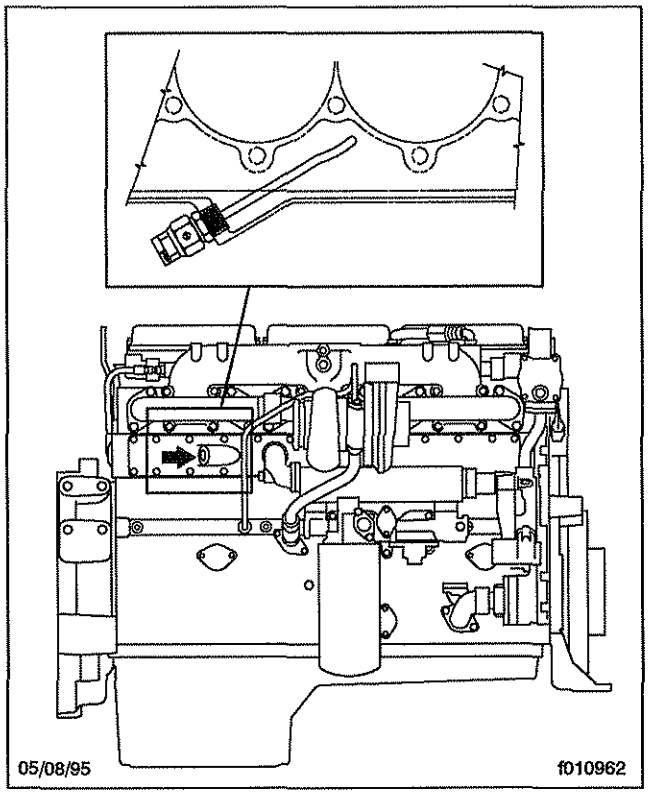


Fig. 1, Block Heater Element Installation, Caterpillar 3176

3. Drain the radiator. For instructions, refer to **Section 20.01**.
4. If applicable, unscrew the threaded cover that secures the cord to the element.
5. Pull the cord off the element.
6. Remove the element from the engine block:

   On all engines except the Cummins N14, loosen the jam nut (if applicable) and unscrew the element from the engine block.

   On Cummins N14 engines, remove the six capscrews that hold the element in the side of the engine block.

Installation

1. Position the heater element in the engine block.

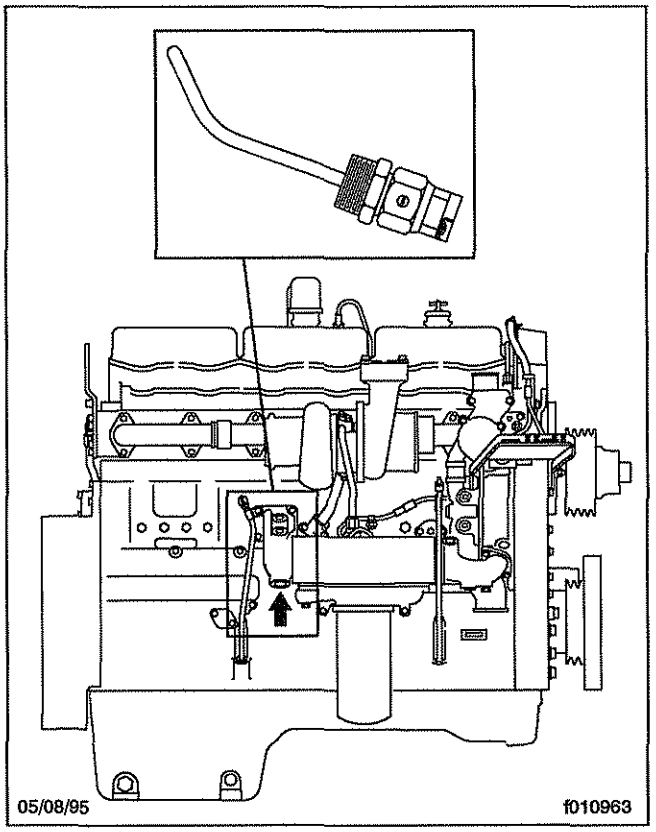


Fig. 2, Block Heater Element Installation, Caterpillar 3406

Block Heater Element Replacement

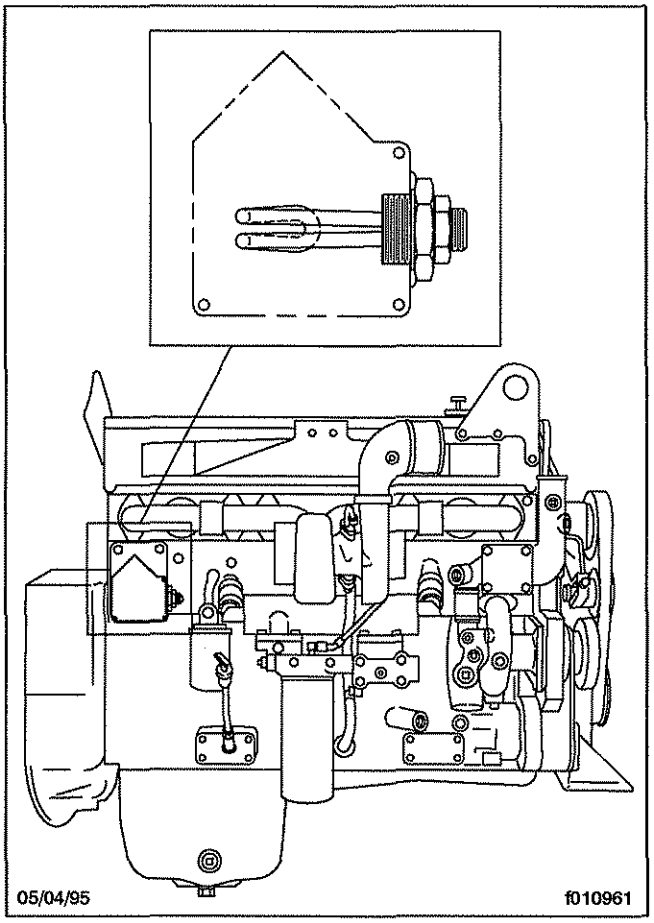


Fig. 3, Block Heater Element Installation, Cummins L10

On all engines except the Cummins N14, coat the threads of the element with a small amount of sealant. For the approved sealants, refer to **Specifications, 400.**

On Cummins N14 engines, make sure the gasket is in place between the element cover plate and the engine.

2. Secure the heater element in the engine block:

   On all engines except the Cummins N14, screw the element into the engine block hand tight, then use a wrench to turn the element 1-1/2 turns more.

   On Caterpillar 3406 engines, tighten the jam nut 50 to 60 lbf·ft (67 to 81 N·m).

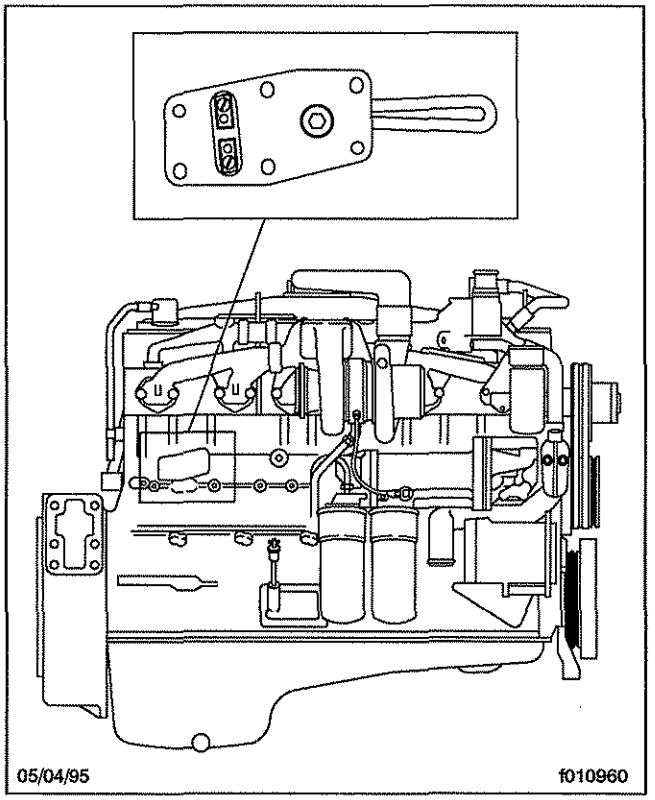


Fig. 4, Block Heater Element Installation, Cummins N14

On Cummins L10 engines, tighten the jam nut 20 to 30 lbf·ft (27 to 40 N·m).

On Cummins N14 engines, tighten the cover plate capscrews 60 to 84 lbf·in (680 to 940 N·cm).

3. Plug the cord into the element and (if applicable) secure it by screwing the threaded cord cover in place.

4. Fill the cooling system. For instructions, refer to **Section 20.01.**

5. Start the engine and check for leaks. Repair any leaks as necessary. Run the engine for half an hour to purge any air from the coolant system.

6. To test the heater, plug a wattmeter into a power source, and connect the heater cord to the meter. A reading on the meter will indicate the heater is working.

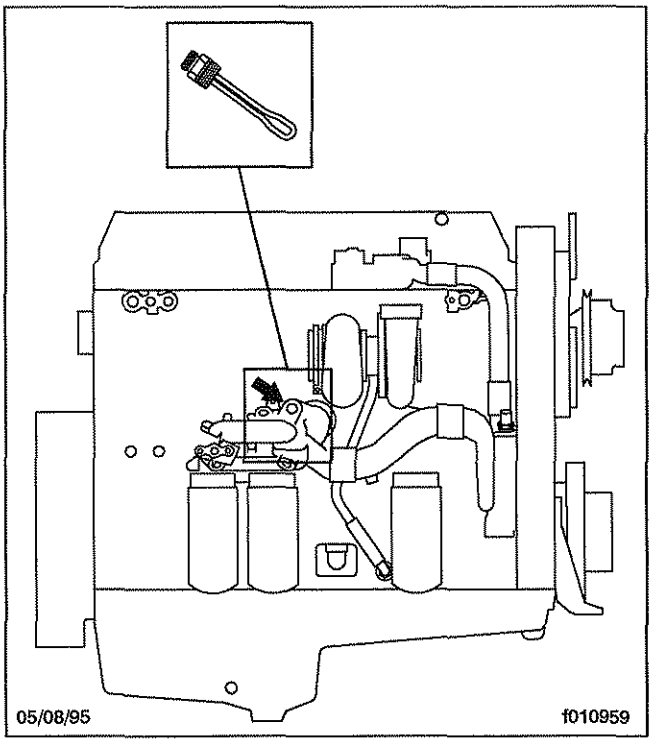


Fig. 5, Block Heater Element Installation, Detroit Diesel Series 50 and 60

Troubleshooting

Use the following procedures to check for the most common engine block heater problems.

WIRING PROBLEMS

1. Park the vehicle, apply the parking brakes, and chock the tires.
2. Tilt the hood.
3. Unscrew the threaded cover that secures the cord to the element. Pull the cord off the element.
4. Using an ohmmeter, check the continuity between the two poles of the element. The resistance should be very low, typically between 9 and 10 ohms. If there is no reading, the element has burned out, and if the reading is very high, the element is about to burn out.
5. If the element is good, check the cord. Plug the cord into the element and secure it by screwing the threaded cover in place.
6. Using an ohmmeter at the receptacle, check the continuity between the two power terminals. The resistance should be low, typically between 9 and 10 ohms. If there is no reading or a very high reading, the cord is damaged. Replace the cord.
7. Check the continuity between each power terminal and the ground terminal. There should be no ohmmeter reading. If there is a reading, replace the cord.
8. Check the ohmmeter reading between the ground terminal and a good vehicle ground. The reading should be zero. If not, replace the cord.

FOULED ELEMENT

1. Park the vehicle, apply the parking brakes, and chock the tires.
2. Tilt the hood.

WARNING: Drain the coolant only when the coolant and engine are cool. Draining it when these are hot could cause severe personal injury due to scalding.

3. Drain the radiator. For instructions, refer to **Section 20.01** in this manual.
4. Unscrew the threaded cover that secures the cord to the element. Pull the cord off the element.
5. Remove the element from the engine block. For instructions, refer to the **Subject 100** in this service manual section.
6. Inspect the element for residue deposits, discoloration, or damage.

   Greenish residue indicates the coolant solution contains too much antifreeze. Replace the element, and refer to the vehicle maintenance manual for the recommended antifreeze/water ratio.

   Gray or black residue indicates anti-leak coolant additives have been added to the system. Replace the element, and refer to the vehicle maintenance manual for the recommended coolant additives.

   Blue or black discoloration on the element indicates the coolant system needs more coolant. Replace the element, and fill the coolant system until coolant is visible in the surge tank sight glass.

   Holes in the element indicate the coolant solution contains too little antifreeze. The weak solution is boiling inside the engine block and causing pitting of the element and block. Replace the element, and refer to the vehicle maintenance manual for the recommended antifreeze to water concentrations.

   For element installation instructions, refer to **Subject 100** in this service manual section.

Specifications

APPROVED SEALANTS

- Loctite 567
- Henkel 790 Pipegrip
- Perma-Loc LH-150

Description	lbf·ft (N·m)
Element Jam Nut, Caterpillar 3406	50 to 60 (67 to 81)
Element Jam Nut, Cummins L10	20 to 30 (27 to 40)
Cover Plate Capscrews, Cummins N14	60 to 84 (680 to 940)

Table 1, Heater Element Torques

Contents

Subject	Subject Number
General Information	050
Service Operations	
Removal and Installation	100
Fan Clutch Major Rebuild	110
Fan Clutch Minor Rebuild	120
Troubleshooting	300
Specifications	400

General Information

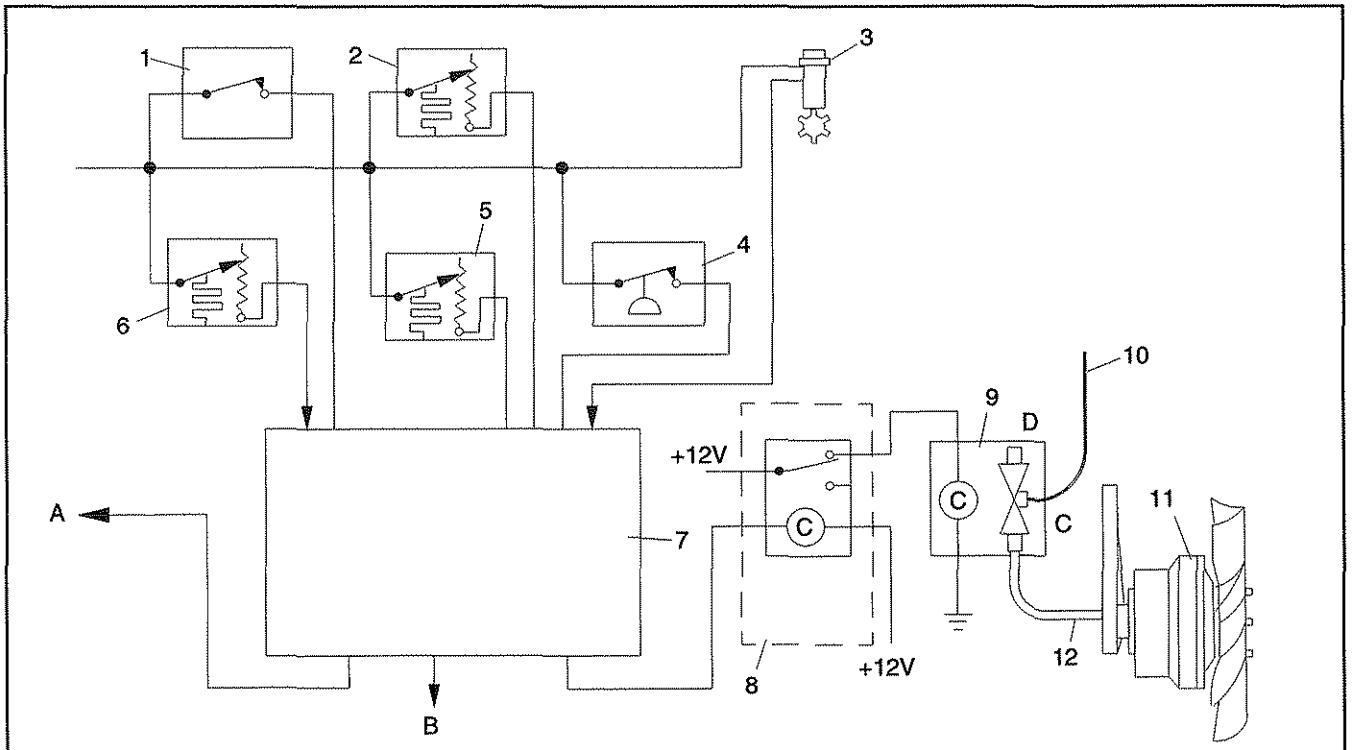
The Horton DriveMaster® fan clutch is a temperature-controlled, air-operated clutch for the engine cooling fan. It is spring engaged, and controls the engine temperature by engaging or disengaging the fan.

When the coolant temperature is below a specified range, air pressure keeps the fan disengaged to save engine power. When the coolant temperature rises above the specified range, air pressure to the fan clutch is cut off and internal spring pressure engages the fan.

Air pressure to the fan clutch is controlled by a solenoid valve; the solenoid valve is controlled by a temperature switch installed in the thermostat housing.

The temperature switch is connected to the engine ECM, which controls the solenoid valve. See **Fig. 1**. When you start a cold engine, the solenoid valve allows air pressure to the fan clutch and the clutch remains disengaged. When the coolant temperature rises to the temperature switch setting, the switch provides power to the solenoid valve and the valve cuts off compressed air to engage the fan.

On vehicles with air conditioning, the fan clutch solenoid valve is connected to a fan cycling switch at the receiver-dryer. If the refrigerant pressure exceeds the setting of the fan cycling switch, the switch supplies power to the solenoid valve, which cuts off air to the fan clutch, engaging the fan.



A. To Indicators and Gauges
B. To Electronic Injectors and Other Actuators
C. Normally Closed
D. Normally Open

1. Fan Override Switch
2. Air Temperature Sensor
3. Engine Speed Sensor
4. A/C Pressure Switch
5. Coolant Temperature Sensor
6. Foot Throttle
7. Engine ECM
8. Fan Relay (not present in all systems)
9. Solenoid Valve
10. Air Supply from Reservoir
11. Fan Clutch
12. Air Supply to Fan Clutch

Fig. 1, Fan Clutch Schematic (engine ECM controlled)

Removal

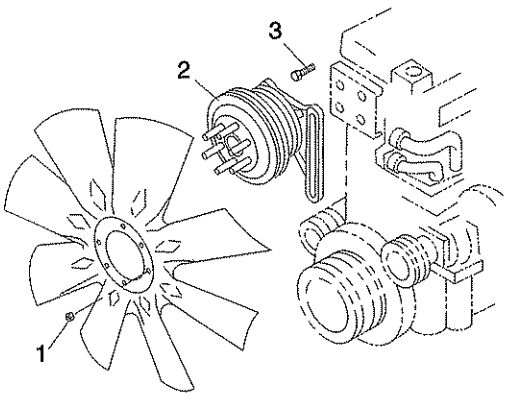
1. Park the vehicle on a level surface, shut down the engine, set the parking brakes, and chock the tires.

⚠ WARNING

Wear safety goggles when draining the air system or disconnecting an air line because dirt and sludge could fly out at high speeds. Don't direct the airstreams at anyone. Don't disconnected pressurized air lines, as they may whip as air escapes. Failure to take all necessary precautions could result in personal injury.

2. Drain the air tanks.
3. Tilt the hood.
4. Disconnect the left-side hose from the charge air cooler.
5. Remove the drive belts from the engine.
6. Disconnect the air line from the fan hub.
7. Remove the fan.
8. Remove the fan clutch assembly from the engine. See **Fig. 1**.

   8.1 If equipped with a metal fan ring, remove the two top fasteners holding the upper mounting bracket for the fan ring.



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1. Hexnut
2. Fan Clutch Assembly
3. Hexbolt,

Fig. 1, Fan Clutch Removal (typical)

   8.2 Remove the fasteners holding the fan clutch mounting bracket to the front of the engine.

⚠ WARNING

The fan clutch assembly may weigh up to 55 lbs. (25 kg). Be careful when lifting it. Use a helper or a hoist, if necessary. Failure to use care when lifting the fan clutch could cause the assembly to fall, which could result in injury or component damage.

   8.3 Remove the fan clutch assembly from the vehicle. If equipped with a metal fan ring, carefully push the ring forward to allow removal of the fan clutch assembly.

Installation

1. Using either a helper or a hoist, position the fan clutch assembly in place on the front of the engine, aligning the holes in the mounting bracket with those in the front of the engine.
2. Install the fasteners.

   If equipped with a metal fan ring, don't tighten the upper fan clutch fasteners completely.
3. Install the drive belts.
4. Connect the air line to the fan clutch.
5. Install the fan. Tighten the fan mounting nuts firmly.
6. Tighten the M8 fan-clutch mounting fasteners 15 lbf·ft (20 N·m).
7. Connect the left-side hose to the charge air cooler.
8. Lower the hood.
9. Remove the chocks from the tires.

Fan Clutch Major Rebuild

Disassembly

NOTE: This procedure involves a major rebuild of the Horton DriveMaster® fan clutch, using parts from the manufacturer's Super Kit. If you are replacing just the seals or the air cartridge, see **Subject 120** for the minor rebuild procedure.

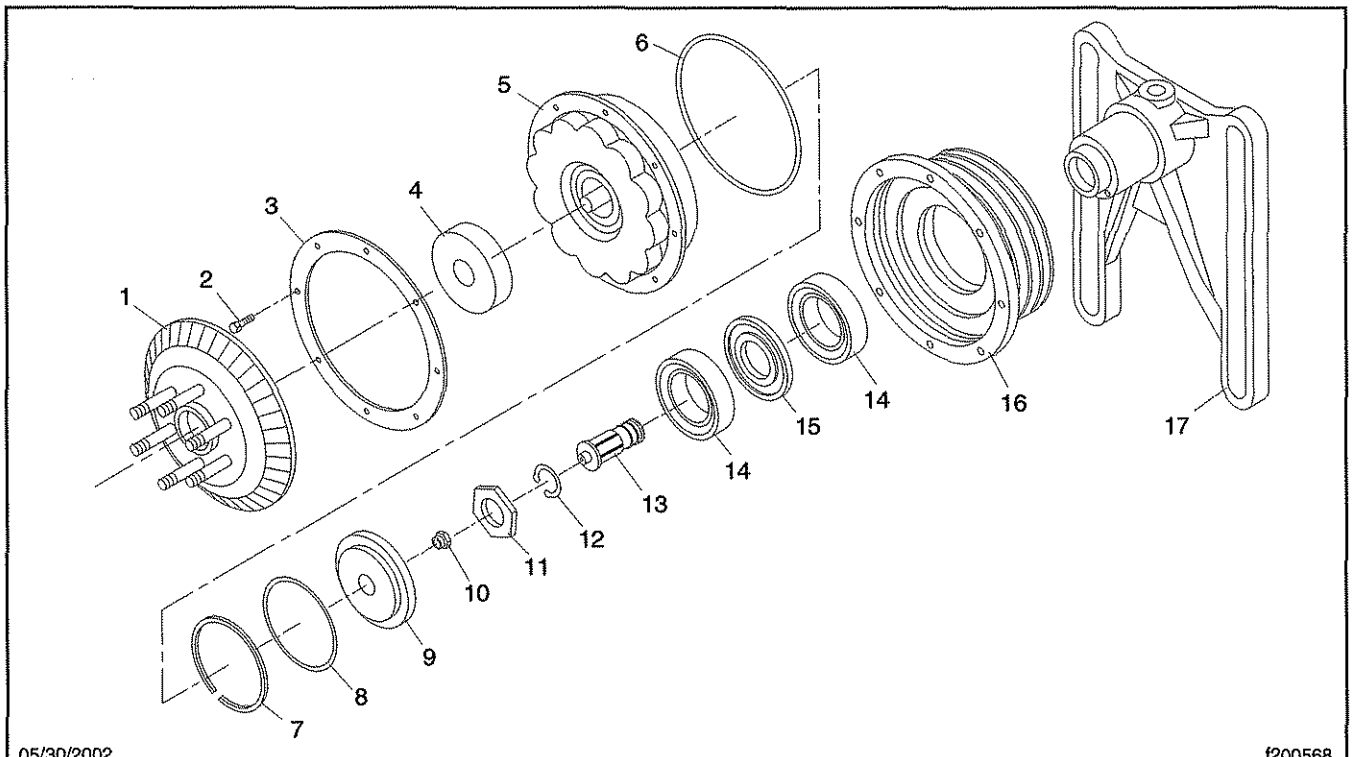
Refer to **Fig. 1** for this procedure.

1. Remove the fan clutch assembly from the vehicle. For instructions, see **Subject 100**.
2. Put the fan clutch assembly in a vise.
3. Connect a shop air hose to the fan clutch air inlet.
4. Apply 80 to 120 psi (552 to 827 kPa) to the fan clutch to lift the fan mounting disc off the spring housing/piston assembly.

⚠ CAUTION

Use care when placing the pry bar onto the fan mounting disc. Make sure it is secure and flat on the surface. Failure to do so make cause the pry bar to slip, which could result in damage to studs or the fan mounting disc.

5. Using a pry bar, wrench, and a T55 Torx® bit, loosen the jack bolt (left-hand thread) by turning it counterclockwise. See **Fig. 2**.



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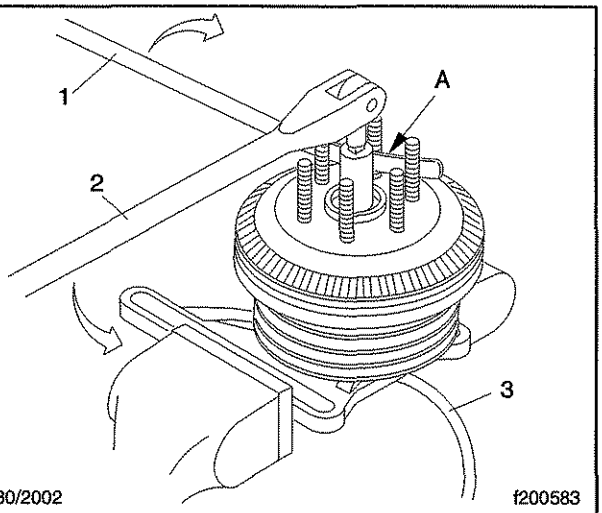
1. Fan Mounting Disc
2. Torx®-Head Screw (8 qty.)
3. Friction Lining
4. Cage Nut (supplied with repair kit)
5. Spring Housing/Piston Assembly
6. Air Chamber Seal
7. Air Chamber Cap Retaining Ring
8. O-Ring
9. Air Chamber Cap
10. Face Seal
11. Bearing Nut
12. Air Cartridge Retaining Ring
13. Air Cartridge Assembly
14. Sheave Bearings
15. Bearing Spacer
16. Sheave
17. Journal Bracket

Fig. 1, Horton DriveMaster Fan Clutch

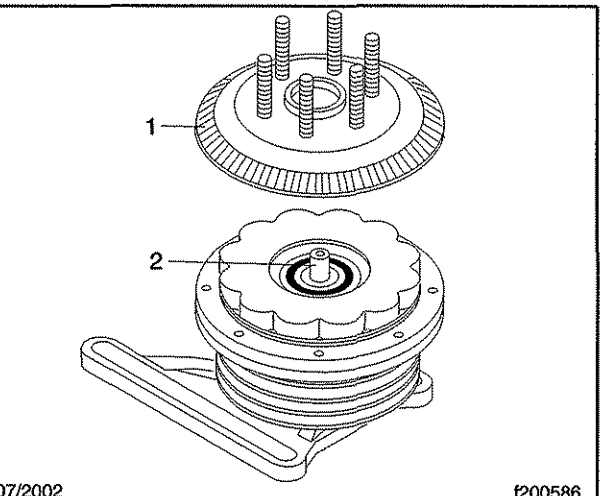
Fan Clutch Major Rebuild

6. Unscrew the fan mounting disc from the jack bolt. See **Fig. 3**
7. Inspect the fan mounting disc for wear or damage.



A. Place the pry bar here.
1. Pry Bar (push clockwise)
2. Torx Bit and Wrench (turn counterclockwise)
3. Shop Air Hose (connected to the inlet port)

Fig. 2, Loosening the Jack Bolt



1. Fan Mounting Disc
2. Jack Bolt (left-hand thread)

Fig. 3, Fan Mounting Disc Removal and Installation

⚠ WARNING

Do not disassemble the spring housing from the piston. The interior springs are very strong, and if released could eject the housing with considerable force, possibly resulting in serious injury. Always use the cage nut to hold the spring housing and the piston together.

8. Using a wrench and a T55 Torx bit to hold the jack bolt, install the cage nut from the kit onto the jack bolt (left-hand thread). Hand tighten it onto the spring housing.

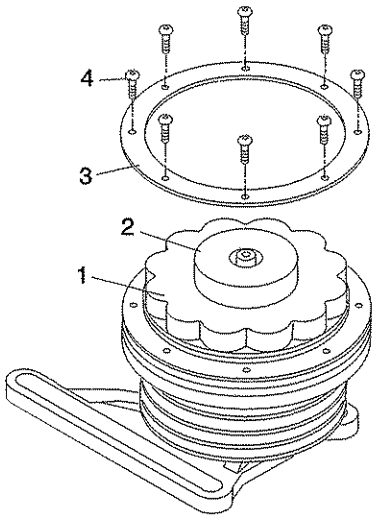
   The cage nut will keep the spring housing and piston together as an assembly. It will also maintain pressure on the internal springs after the Torx-head screws holding the friction lining in place are removed.

9. Release the air pressure from the fan clutch.

⚠ WARNING

Release the air pressure from the fan clutch before removing the friction lining Torx-head screws. Failure to release the air pressure could result in the spring housing/piston assembly being ejected with force, which could result in personal injury.

10. Using a T27 Torx bit, remove the eight Torx-head screws holding the friction lining in place.
11. Remove the friction lining. See **Fig. 4.**
12. *Keeping the cage nut installed and tightened,* remove the spring housing/piston assembly. See **Fig. 5.**
13. Remove the air chamber seal. See **Fig. 6.**
14. Examine the inside of the air chamber for signs of moisture and/or contaminants.
15. Remove the air chamber cap retaining ring. See **Fig. 6.**
16. Using two small screwdrivers placed 180 degrees apart, gently and evenly pry the air chamber cap out of the sheave.
17. Remove the O-ring seal from the air chamber cap. See **Fig. 6.**
18. Remove the face seal. See **Fig. 6.**



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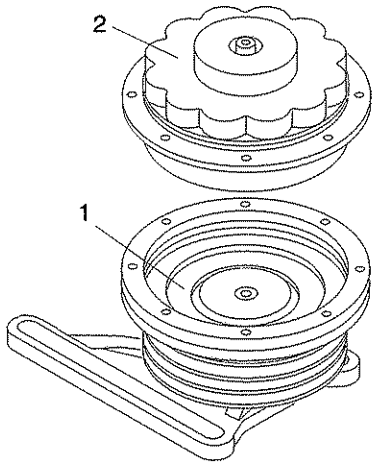
1. Spring Housing/Piston Assembly
2. Cage Nut
3. Friction Lining
4. Torx-Head Screws

Fig. 4, Friction Lining Removal and Installation



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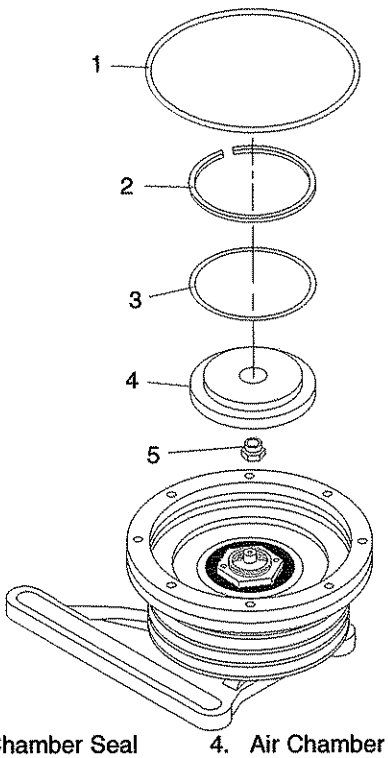
1. Air Chamber
2. Spring Housing/Piston Assembly (with cage nut installed)

Fig. 5, Spring Housing/Piston Assembly Removal and Installation

19. Inspect the face seal for signs of wear. Wear indicates that dirt may exist in the air system



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1. Air Chamber Seal
2. Retaining Ring
3. O-Ring Seal
4. Air Chamber Cap
5. Face Seal

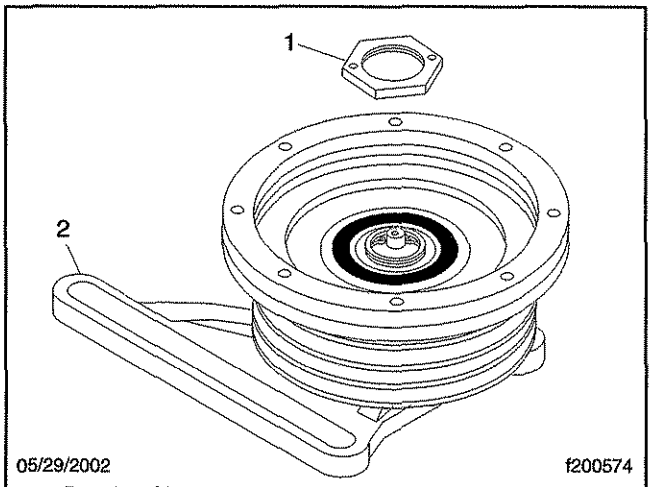
Fig. 6, Air Chamber Seal Removal and Installation

20. Remove the bearing nut from the mounting bracket. See **Fig. 7**.
21. Remove the sheave from the mounting bracket. See **Fig. 8**.
22. If replacing the bearings, support the sheave and press them out.
23. Clean and remove any dirt, debris, or corrosion that may be present.
24. Remove the air cartridge.
    - 24.1 Remove the retaining ring. See **Fig. 9**.
    - 24.2 Remove the air cartridge assembly. See **Fig. 10**.

Assembly

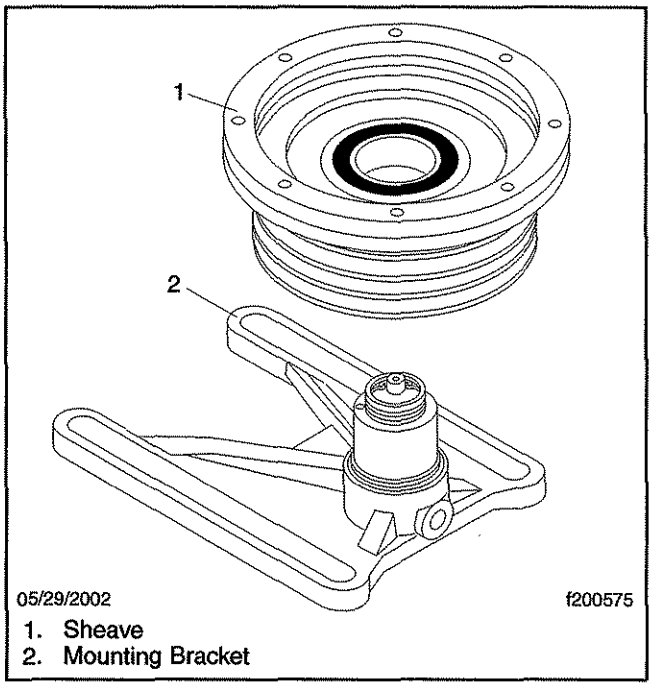
1. If necessary, clean the air cartridge bore in the mounting bracket.

Fan Clutch Major Rebuild



1. Bearing Nut
2. Mounting Bracket

Fig. 7, Bearing Nut Removal and Installation



1. Sheave
2. Mounting Bracket

Fig. 8, Removing the Sheave

NOTE: The sheave bearings do not require lubrication.

2. If replacing the sheave bearings, do the following:

   2.1 If equipped with two bearings, assemble the bearings so the markings on their edges line up to form an arrow. See **Fig. 11.** It doesn't matter which way the arrow faces when the bearings are installed.

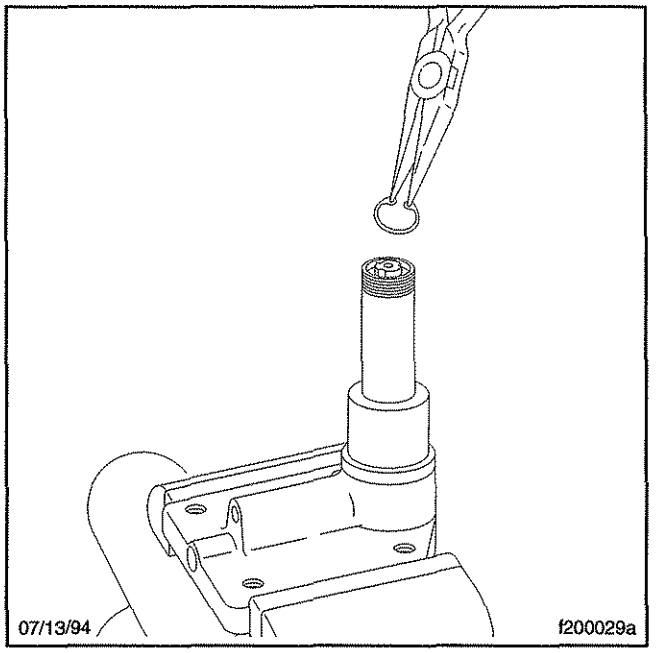
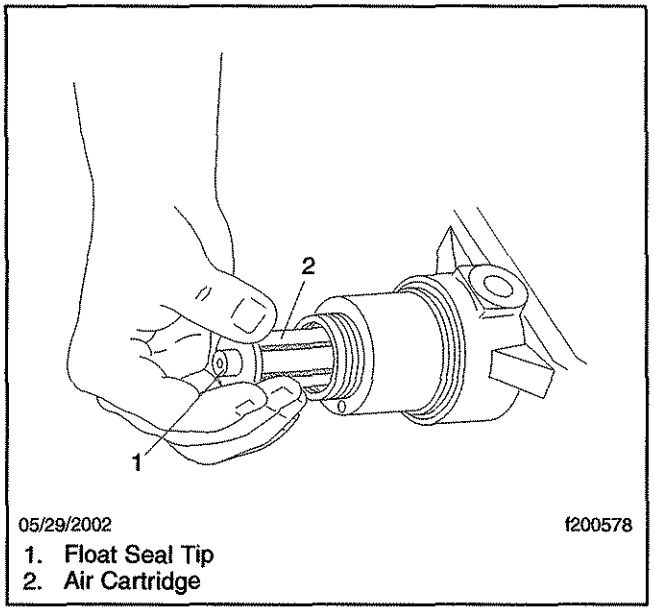


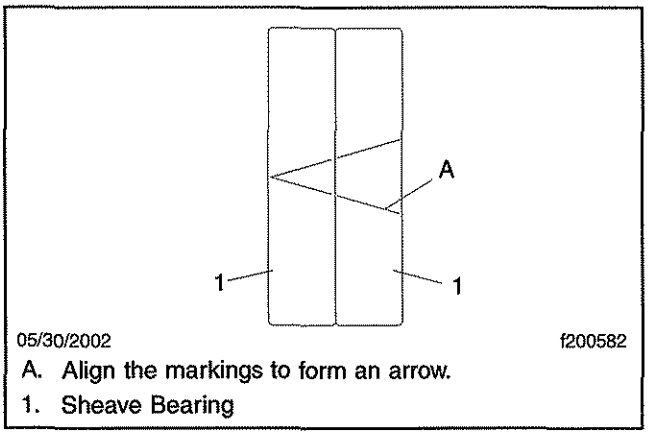
Fig. 9, Retaining Ring Removal and Installation



1. Float Seal Tip
2. Air Cartridge

Fig. 10, Removing the Air Cartridge

IMPORTANT: If the fan clutch uses spacers, be sure to install them between the bearings.



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A. Align the markings to form an arrow.
1. Sheave Bearing

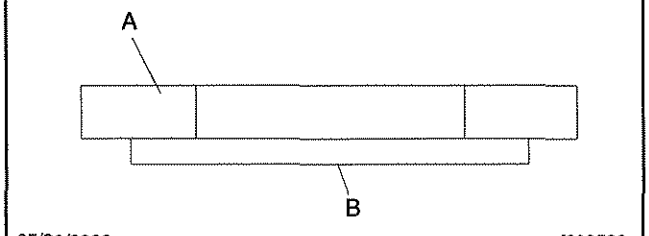
Fig. 11, Aligning the Bearings

2.2 Supporting the sheave, press the new sheave bearings — and spacers, if applicable — into place. Note the position of the lip inside the sheave.

2.3 Slide the sheave onto the mounting bracket. See **Fig. 8.**

2.4 Making sure that the bearing nut hex is facing up, install the bearing nut. See **Fig. 12.** Tighten 130 lbf·ft (176 N·m). See **Fig. 7.**

3. Apply O-ring lubricant from the kit to the outside O-rings of the new air cartridge assembly. See **Fig. 13.**
4. Install the new air cartridge assembly into the mounting bracket.
5. Install the retaining ring, making sure the convex surface of the ring is toward the air cartridge. See **Fig. 13.**



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A. Hex faces up.
B. Relief faces toward mounting bracket and bearings.

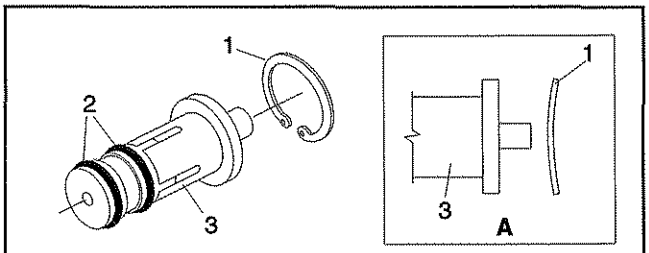
Fig. 12, Correct Bearing Nut Orientation

6. Using a clean, dry cloth, clean both the float seal tip of the air cartridge and the face seal of the air chamber cap.
7. Assemble the air chamber cap and face seal. See **Fig. 6.**

   Tighten the face seal 75 to 100 lbf·in (850 to 1130 N·cm).
8. Lubricate the O-ring seal with the fresh lubricant from the kit.
9. Install the O-ring seal on the air chamber cap. See **Fig. 6.**
10. Carefully set the air chamber cap into the sheave. See **Fig. 6.**
11. Install the retaining ring. See **Fig. 6.**
12. Install the air chamber seal into the sheave. Be sure the seal is evenly seated against the side and bottom of the groove surfaces, and the "V" of the seal is facing down. See **Fig. 14.**
13. Lubricate contact surfaces with the fresh lubricant from the kit.

⚠ WARNING

The new spring housing/piston assembly from the kit has a cage nut installed on it. Do not remove the cage nut. This will cause the spring housing to be forcibly ejected from the piston assembly, which could result in serious injury.



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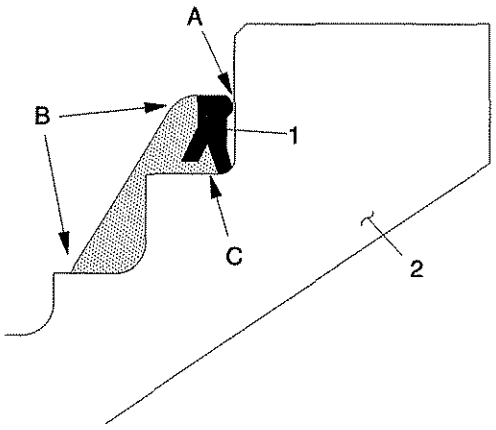
A. Convex surface of the retaining ring goes toward the air cartridge.
1. Retaining Ring
2. O-Rings
3. Air Cartridge

Fig. 13, Installing the Air Cartridge Retaining Ring

Fan Clutch Major Rebuild



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A. Seal is seated evenly against side and bottom of groove.
B. Apply grease only between these areas.
C. "V" of Seal Facing Down
1. Air Chamber Seal
2. Sheave

Fig. 14, Correct Installation of Air Chamber Seal (cross-section view)

14. Carefully set the new spring housing/piston assembly into position. See **Fig. 6**. Note that the new assembly has a cage nut installed on it.
15. Rotate the new spring housing/piston assembly to align the mounting holes with those of the sheave.

IMPORTANT: Handle the new friction liner by the edges to avoid contamination.

16. Set the new friction liner from the kit into place, being careful to touch only the edges.
17. Using a T27 Torx bit, install the eight Torx-head screws. See **Fig. 4**. Tighten alternately 80 lbf·in (900 N·cm).
18. Apply a minimum of 80 psi (552 kPa) of clean air to the air inlet.
19. Remove the cage nut from the spring housing/piston assembly.
20. Install the new fan mounting disc from kit.

⚠ CAUTION

Use care when placing the pry bar onto the fan mounting disc. Make sure it is secure and flat on the surface. Failure to do so make cause the pry bar to slip, which could result in damage to studs or the fan mounting disc.

21. Using a suitable wrench, a T55 Torx bit, and a pry bar, tighten the jack bolt (left-hand thread) 100 lbf·ft (136 N·m). Turn the wrench clockwise and push the pry bar counterclockwise.
22. Using shop air, actuate the fan clutch and check for correct engagement and disengagement of the fan mounting disc. If there is a problem, it must be corrected before installing the fan clutch onto the engine.
23. Check for air leaks at the bleed hole and around the spring housing/piston assembly.
24. Install the fan clutch assembly onto the engine. See **Subject 100** for instructions.

Disassembly

NOTE: This procedure involves a minor rebuild of the Horton DriveMaster® fan clutch, using parts from the manufacturer's Seal Kit. If a major rebuild of the fan clutch is needed, see **Subject 110.**

1. Remove the fan clutch assembly from the vehicle. For instructions, see **Subject 100.**
2. Put the fan clutch assembly in a vise.
3. Connect a shop air hose to the fan clutch air inlet.
4. Apply 80 to 120 psi (552 to 827 kPa) to the fan clutch to lift the fan mounting disc off the spring housing/piston assembly.

⚠ CAUTION

Use care when placing the pry bar onto the fan mounting disc. Make sure it is secure and flat on the surface. Failure to do so make cause the pry bar to slip, which could result in damage to studs or the fan mounting disc.

5. Using a pry bar, wrench, and a T55 Torx® bit, loosen the jack bolt (left-hand thread) by turning it counterclockwise. See **Fig. 1.**
6. Unscrew the fan mounting disc from the jack bolt. See **Fig. 2.**
7. Inspect the fan mounting disc for wear or damage.

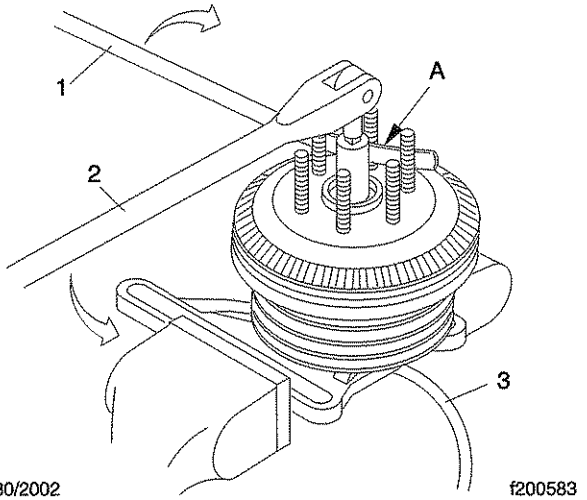
⚠ WARNING

Do not disassemble the spring housing from the piston. The interior springs are very strong, and if released could eject the housing with considerable force, possibly resulting in serious injury. Always use the cage nut to hold the spring housing and the piston together.

8. Using a wrench and T55 Torx bit to hold the jack bolt, install the cage nut from the kit onto the jack bolt (left-hand thread). Hand tighten it onto the spring housing.

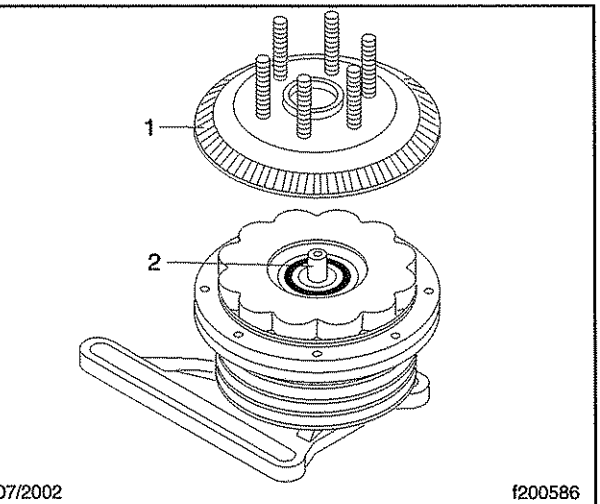
   The cage nut will keep the spring housing and piston together as an assembly. It will also maintain pressure on the internal springs after the Torx-head screws holding the friction lining in place are removed.

9. Release the air pressure from the fan clutch.



A. Place the pry bar here.
1. Pry Bar (push clockwise)
2. Torx Bit and Wrench (turn counterclockwise)
3. Shop Air Hose (connected to the inlet port)

Fig. 1, Loosening the Jack Bolt



1. Fan Mounting Disc
2. Jack Bolt (left-hand thread)

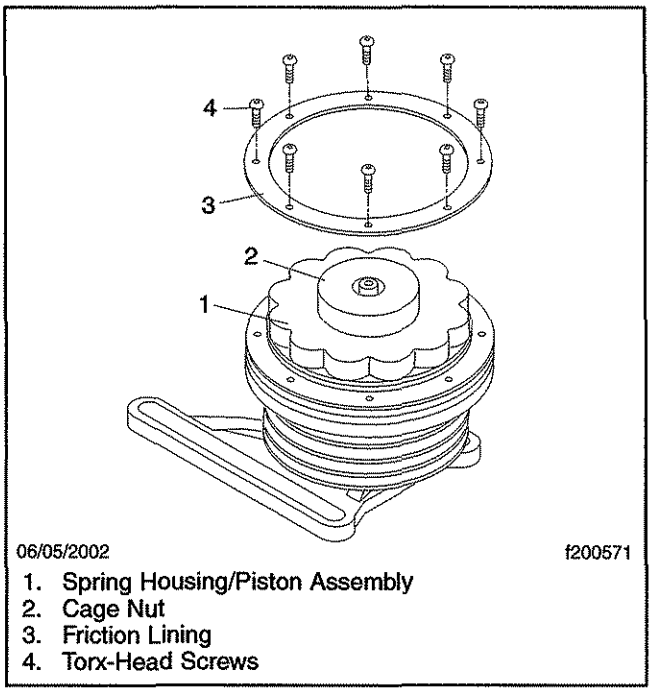
Fig. 2, Fan Mounting Disc Removal and Installation

Fan Clutch Minor Rebuild

⚠ WARNING

Release the air pressure from the fan clutch before removing the friction lining Torx-head screws. Failure to release the air pressure could result in the spring housing/piston assembly being ejected with force, which could result in personal injury.

10. Using a T27 Torx bit, remove the eight Torx-head screws holding the friction lining in place.
11. Remove the friction lining. See **Fig. 3.**
12. *Keeping the cage nut installed and tightened,* remove the spring housing/piston assembly. See **Fig. 4.**
13. Remove the air chamber seal. See **Fig. 5.**
14. Examine the inside of the air chamber for signs of moisture and/or contaminants.
15. Remove the air chamber cap retaining ring. See **Fig. 5.**
16. Using two small screwdrivers placed 180 degrees apart, gently and evenly pry the air chamber cap out of the sheave.
17. Remove the O-ring seal from the air chamber cap. See **Fig. 5.**
18. Remove the face seal. See **Fig. 5.**
19. Inspect the face seal for signs of wear. Wear indicates that dirt may exist in the air system.
20. Remove the air cartridge.
    - 20.1 Remove the retaining ring. See **Fig. 6.**
    - 20.2 Remove the air cartridge assembly. See **Fig. 7.**

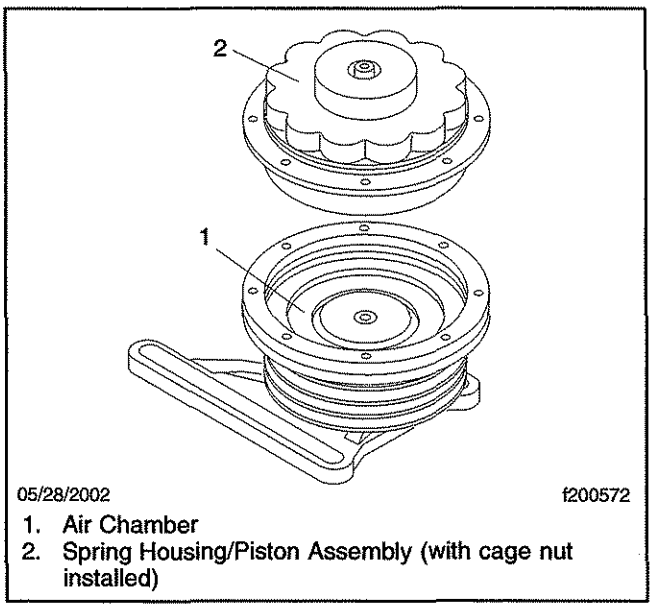


1. Spring Housing/Piston Assembly
2. Cage Nut
3. Friction Lining
4. Torx-Head Screws

Fig. 3, Friction Lining Removal and Installation

Assembly

1. Clean the mounting bracket bore if necessary.
2. Apply O-ring lubricant from the kit to the outside O-rings of the new air cartridge assembly. See **Fig. 8.**
3. Install the new air cartridge assembly into the mounting bracket.
4. Install the retaining ring, making sure the convex surface of the ring is toward the air cartridge. See **Fig. 8.**



1. Air Chamber
2. Spring Housing/Piston Assembly (with cage nut installed)

Fig. 4, Spring Housing/Piston Assembly Removal and Installation

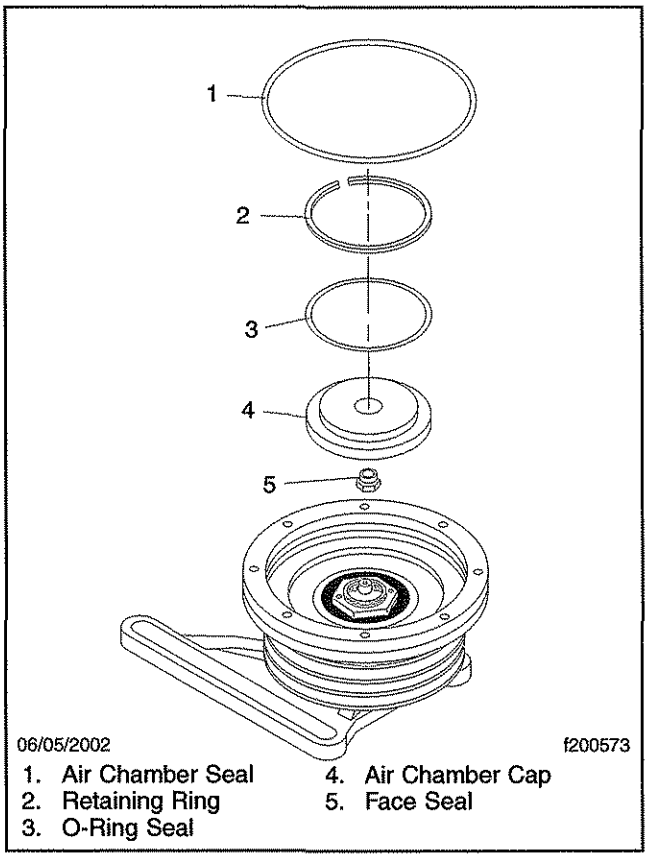


Fig. 5, Air Chamber Seal Removal and Installation

5. Using a clean, dry cloth, clean both the float seal tip of the air cartridge and the face seal of the air chamber cap.
6. Assemble the air chamber cap and face seal. See **Fig. 5**.

   Tighten the face seal 75 to 100 lbf·in (850 to 1130 N·cm).
7. Lubricate the O-ring seal with the fresh lubricant from the kit.
8. Install the O-ring seal on the air chamber cap. See **Fig. 5**.
9. Carefully set the air chamber cap into the sheave. See **Fig. 5**.
10. Install the retaining ring. See **Fig. 5**.
11. Install the air chamber seal into the sheave. Be sure the seal is evenly seated against the side and bottom of the groove surfaces, and the "V" of the seal is facing down. See **Fig. 9**.

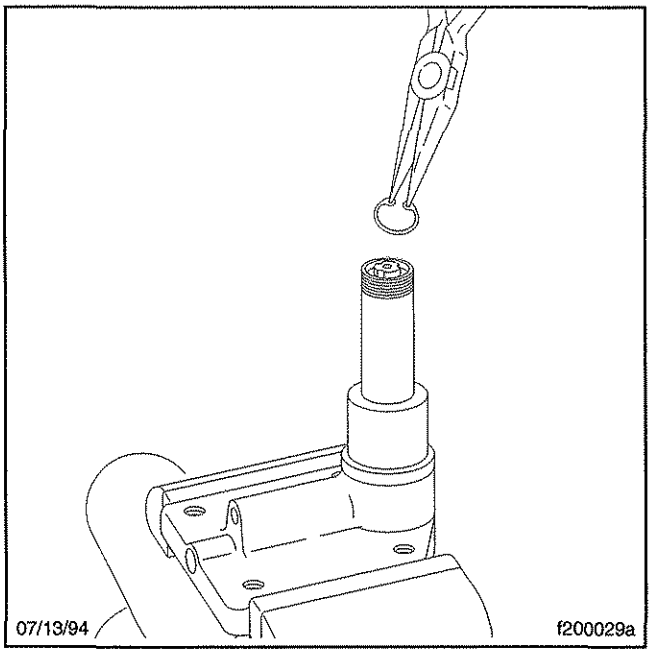


Fig. 6, Retaining Ring Removal and Installation (sheave not shown)

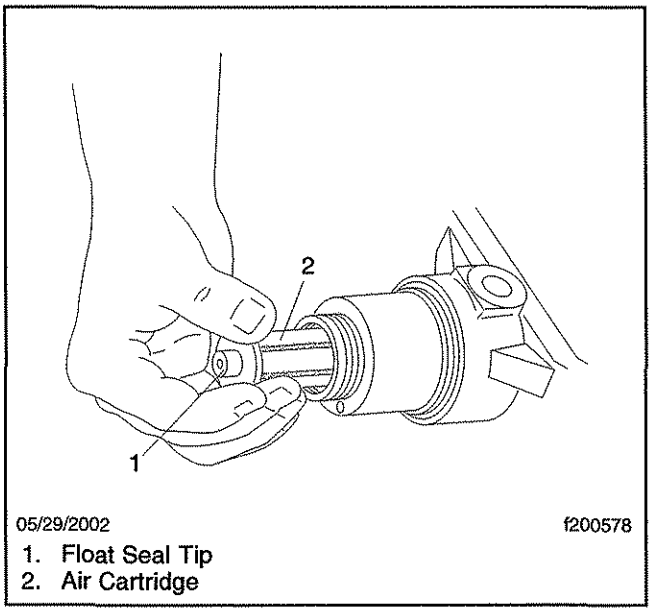
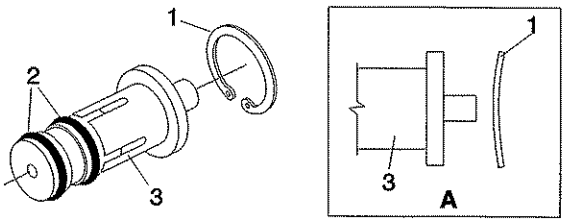


Fig. 7, Removing the Air Cartridge (sheave not shown)

Fan Clutch Minor Rebuild



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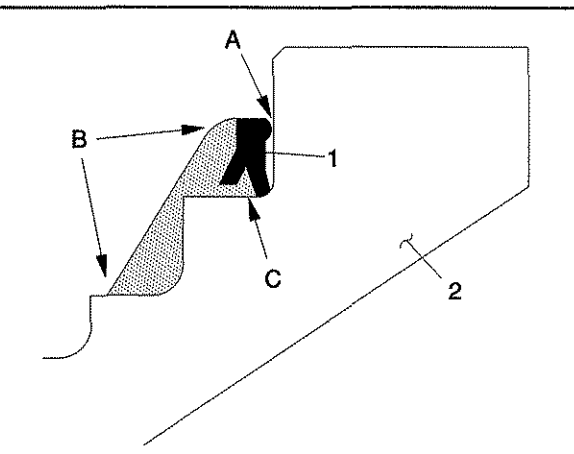
A. Convex surface of the retaining ring goes toward the air cartridge.
1. Retaining Ring
2. O-Rings
3. Air Cartridge

Fig. 8, Installing the Air Cartridge Retaining Ring

12. Lubricate contact surfaces with the fresh lubricant from the kit.

⚠ WARNING

The new spring housing/piston assembly from the kit has a cage nut installed on it. Do not remove the cage nut. This will cause the spring housing to be forcibly ejected from the piston assembly, which could result in serious injury.



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A. Seal is seated evenly against side and bottom of groove.
B. Apply grease only between these areas.
C. "V" of Seal Facing Down
1. Air Chamber Seal
2. Sheave

Fig. 9, Correct Installation of Air Chamber Seal (cross-section view)

13. Carefully set the new spring housing/piston assembly into position. See **Fig. 4**. Note that the new assembly has a cage nut installed on it.
14. Rotate the new spring housing/piston assembly to align the mounting holes with those of the sheave.
15. Set the friction liner from the kit into place, being careful to touch only the edges.
16. Using a T27 Torx bit, install the eight Torx-head screws. See **Fig. 3**. Tighten alternately 80 lbf·in (900 N·cm).
17. Apply a minimum of 80 psi (552 kPa) of clean air to the air inlet.
18. Remove the cage nut from the spring housing/piston assembly.

⚠ CAUTION

Use care when placing the pry bar onto the fan mounting disc. Make sure it is secure and flat on the surface. Failure to do so make cause the pry bar to slip, which could result in damage to studs or the fan mounting disc.

19. Using a suitable wrench, a T55 Torx bit, and a pry bar, tighten the jack bolt (left-hand thread) 100 lbf·ft (136 N·m). Turn the wrench clockwise and the pry bar counterclockwise.
20. Using shop air, actuate the fan clutch and check for correct engagement and disengagement of the fan mounting disc. If there is a problem, it must be corrected before installing the fan clutch onto the engine.
21. Check for air leaks at the bleed hole and around the spring housing/piston assembly.
22. Install the fan clutch assembly onto the engine. See **Subject 100** for instructions.

Troubleshooting Tables

Problem—Air Is Leaking from the Fan Clutch

Problem—Air Is Leaking from the Fan Clutch	
Possible Cause	**Remedy**
The face seal or air cartridge is damaged or worn.	Install a new seal kit.
The O-ring seals are damaged or worn.	Install a new seal kit.

Problem—The Fan Clutch Fails to Engage

Problem—The Fan Clutch Fails to Engage	
Possible Cause	**Remedy**
There's no power to the fan clutch control circuit.	Check all electrical connections, and repair or replace wiring as needed. Check the circuit breaker for the engine fan and repair or replace as needed.
The engine temperature switch is damaged or an incorrect sensor has been installed.	Make sure the switch is normally open, not normally closed. Replace the switch if it is damaged or if the switch is the wrong type.
The solenoid valve is malfunctioning.	Replace the solenoid valve.
The solenoid is not exhausting.	Make sure the solenoid exhaust port is not plugged.

Problem—The Fan Clutch Does Not Disengage

Problem—The Fan Clutch Does Not Disengage	
Possible Cause	**Remedy**
The engine temperature switch is damaged or an incorrect sensor has been installed.	Make sure the switch is normally open, not normally closed. Replace the switch if it is damaged or if the switch is the wrong type.
A restricted air line doesn't allow air supply to the clutch.	Make sure the air lines are not pinched or plugged. Repair the air lines as needed.
The fan clutch is leaking.	Install a new seal kit.
The air supply to the fan clutch is restricted.	Make sure the fan clutch air lines are not leaking or pinched. Repair the lines as needed.
The piston is seized due to contamination or dry seals.	Clean the air supply. Do a major rebuild.

Problem—The Fan Clutch Cycles Frequently

Problem—The Fan Clutch Cycles Frequently	
Possible Cause	**Remedy**
The fan clutch control circuit has a loose connection or is poorly grounded.	Check all wiring connections, and repair the circuit as needed. Check the circuit breaker for the engine fan and repair or replace as needed.
The temperature control settings are incorrect.	Check the fan clutch control setting of the temperature switch, according to the engine installed in the vehicle. Repair or replace the temperature switch as needed.
The fan cycling switch at the receiver-dryer is set too low.	Check the switch at the receiver-dryer, and if needed, replace the switch with a switch with a higher setting. Check the ACPU switch and unit.

Troubleshooting

Problem—The Fan Clutch Cycles Frequently	
Possible Cause	**Remedy**
There is an air restriction in front of the fan clutch.	Check for incorrect radiator shutter operation, winterfronts, or any other air restrictions.
The engine temperature is too high.	Check the programmable engine control parameters, and reprogram as needed.
The temperature switch is malfunctioning.	Replace the temperature switch.

Problem—The Fan Clutch Engages, But the Engine Still Overheats

Problem—The Fan Clutch Engages, But the Engine Still Overheats	
Possible Cause	**Remedy**
There is an air restriction in front of the fan clutch.	Check for incorrect radiator shutter operation, winterfronts, or any other air restrictions.
There is a problem somewhere else in the cooling system.	Refer to the cooling system troubleshooting section, **Section 20.00.**

Specifications

Horton DriveMaster® Repair Kits		
Kit Description*	**Part Number**	**When Used**
Super Kit	HOR994347	Fan Clutch Major Rebuild
Seal Kit	HOR994346	Replacing Seals and Air Cartridge
Friction Disc Kit	HOR994348	Replacing Fan Mounting Disc and Friction Lining
Friction Liner Kit	HOR994349	Replacing Friction Lining Only

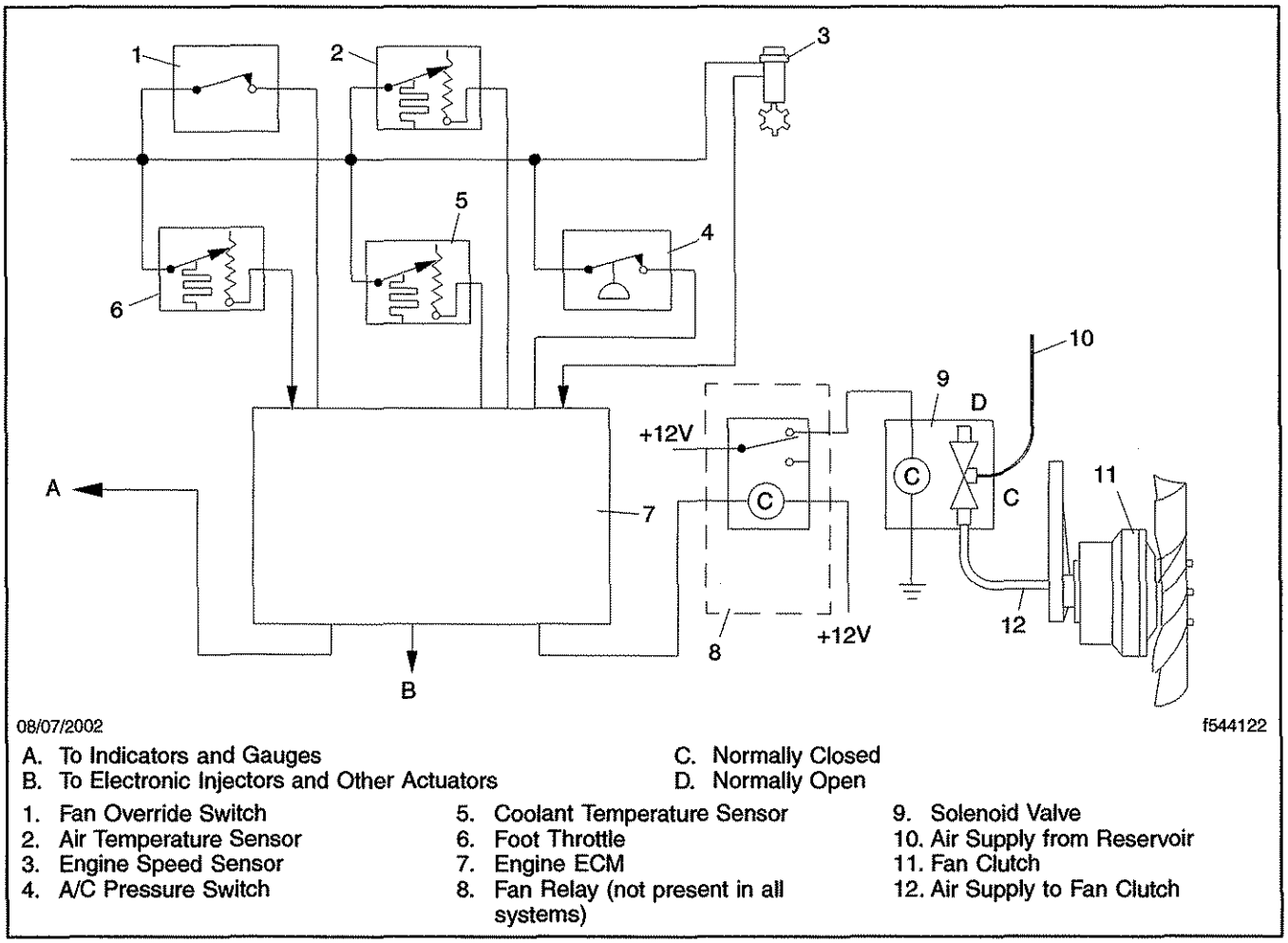
* All kits are available from the PDCs.

Table 1, Horton DriveMaster Repair Kits

Description	Torque	
	lbf.in (N.cm)	lbf.ft (N.m)
Friction Lining Screws	80 (900)	—
Face Seal	75 to 100 (850 to 1130)	—
Bearing Nut	—	130 (176)
Jack Bolt	—	100 (136)

Table 2, Torque Values

Specifications



A. To Indicators and Gauges
B. To Electronic Injectors and Other Actuators
C. Normally Closed
D. Normally Open

1. Fan Override Switch
2. Air Temperature Sensor
3. Engine Speed Sensor
4. A/C Pressure Switch
5. Coolant Temperature Sensor
6. Foot Throttle
7. Engine ECM
8. Fan Relay (not present in all systems)
9. Solenoid Valve
10. Air Supply from Reservoir
11. Fan Clutch
12. Air Supply to Fan Clutch

Fig. 1, Fan Clutch Schematic (engine ECM controlled)

Index, Alphabetical

Section **Section Number**

Clutch Brake 25.04
Clutch Linkage 25.03
Eaton Fuller Pull-Type Clutches 25.00
Rockwell® "Lite Pedal" 15-1/2 Inch Clutch 25.01
Valeo 16- and 17-Inch Clutches 25.02

Eaton Fuller Heavy-Duty Clutches 25.00

Contents

Subject	Subject Number
General Information	050
Service Operations	
Clutch Adjustments	100
Clutch Removal	110
Clutch Inspection and Pre-Installation Procedures	120
Clutch Installation	130
Troubleshooting	300
Specifications	400

General Description

Eaton® Fuller® clutches are pull-type clutches of a dry-disc design. They are available in 15.5-inch (394-mm) two-plate assemblies used in heavy-duty applications.

The intermediate plate separating the driven discs is carried on four lugs within the cover assembly, which is mounted on a flat flywheel. Four positive separator pins™ (roll pins) ensure an equal gap on all sides of the intermediate plate and increase the life of the clutch. Four return straps are attached to the cover assembly to retract the pressure plate when the clutch is disengaged.

Solo 15.5-Inch Clutch

Eaton Fuller Solo™ clutches are totally adjustment-free. See **Fig. 1**. As the clutch wears, its innovative wear-adjusting technology monitors clutch components and makes any necessary adjustments. The wear-adjusting technology comes from two sliding cams, which rotate to maintain the proper adjustment. Atop the upper cam, a wear indicating tab mirrors the cam's movement, letting you know when it's time to replace the clutch. See **Fig. 2**. This tab cannot be used as a mechanism for adjusting the clutch.

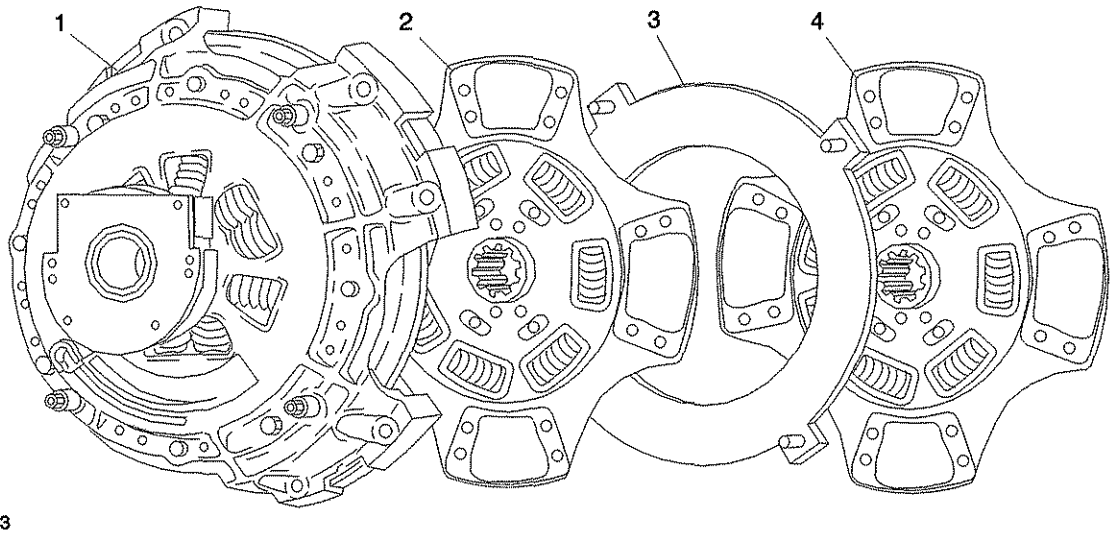
Heavy-duty Solo clutch discs are offered in two configurations, one standard on Century S/T and Argosy (see **Fig. 3**) and the other standard on Coronado (see **Fig. 4**):

- Seven spring dampers with four ceramic facings are standard on Century S/T and Argosy in the extended-lube (XL-100) version, and optional on the Coronado.
- Seven spring dampers with six ceramic facings and vibration control technology (VCT™plus) are standard in the extended-lube (XL-100) version on Coronado, and optional on the Century S/T and Argosy.

NOTE: An earlier version of vibration control technology (VCT™) had a disc with six spring dampers and six ceramic facings. This disc has now been replaced by VCT™plus.

Modern high-torque engines require higher performance from a clutch. The extended-lube (XL-100) clutches have a special roller yoke and a ribbed release bearing housing that reduces bearing wear and extends the service interval for lubrication.

On Century Class S/T or Argosy models, Solo clutches are only offered in the XL-100 version. On Coronado, the six-spring XL-100 version is standard, but clutches without the extended-lube feature are offered. XL-100 clutches are not available for Severe Service applications.



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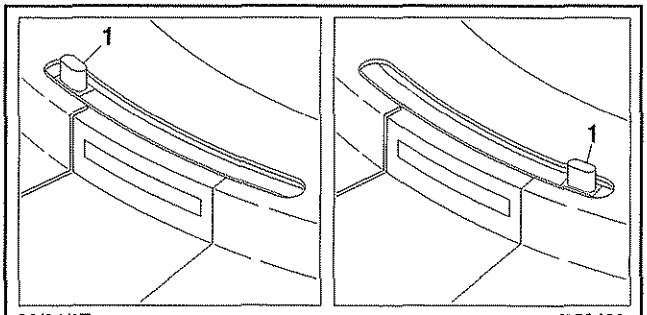
1. Clutch Cover
2. Rear Driven Disc
3. Intermediate Plate
4. Front Driven Disc

Fig. 1, Solo Heavy-Duty Clutch

General Information



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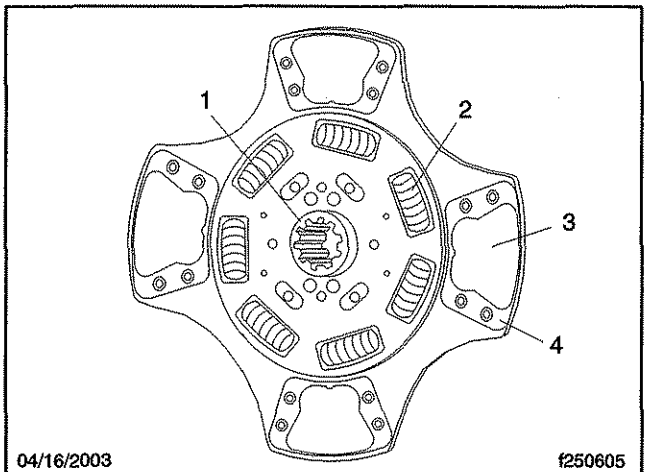
NOTE: "NEW" position on the left, "REPLACE" position on the right.

1. Wear Indicating Tab

Fig. 2, Wear Indicator



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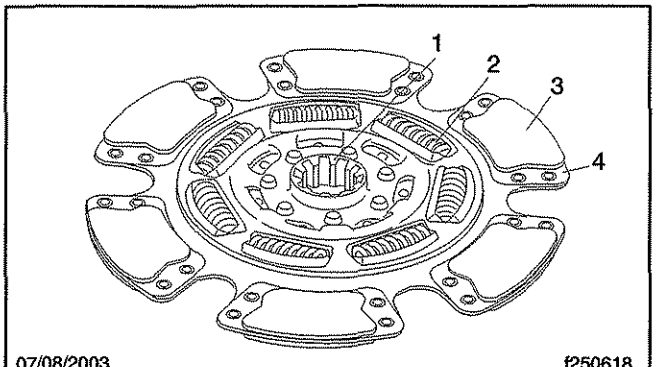
1. Hub
2. Damper
3. Facing
4. Paddle

Fig. 3, Driven Disc With Four Ceramic Facings

On older vehicles, clutch discs with eight, nine, or ten spring dampers may be installed. These older types of vibration dampers are not adequate for modern high-horsepower engines that operate at lower peak torques.

⚠ CAUTION

If your vehicle was originally equipped with six- or seven-spring discs, do not substitute eight- or ten-spring discs. This could cause excessive torsional vibration and component damage.



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1. Hub
2. Damper
3. Facing
4. Paddle

Fig. 4, Driven Disc With Six Ceramic Facings

For clutch capacities, see the appropriate clutch table in **Specifications, 400.**

Easy-Pedal 15.5-Inch Clutch

Eaton® Fuller® Easy-Pedal® clutches are easily adjustable using the Kwik-Adjust™ mechanism. See **Fig. 5.**

Easy-Pedal heavy-duty clutch discs are offered in two optional configurations on Coronado only:

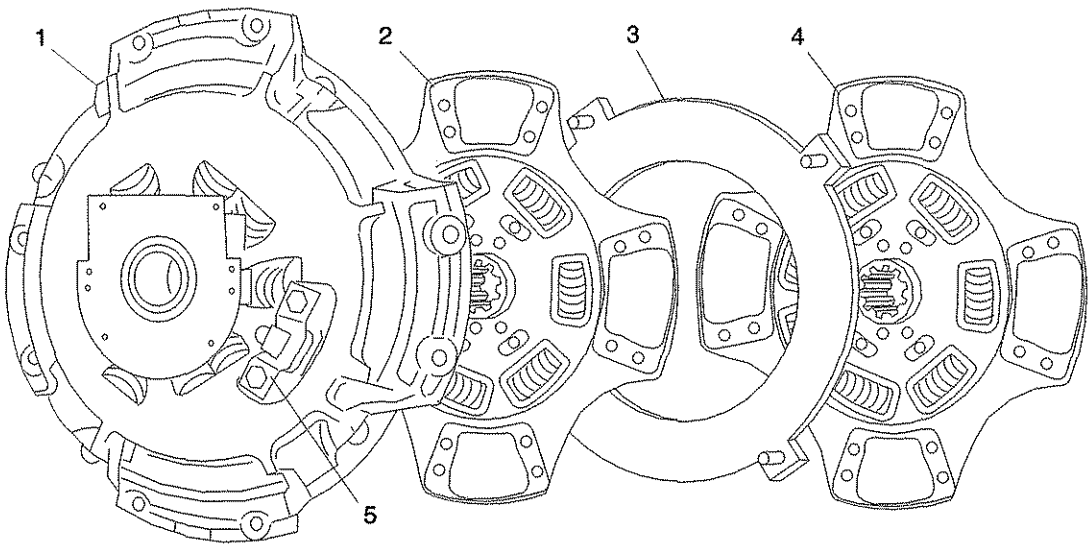
- Seven spring dampers with four ceramic facings. See **Fig. 3.**
- Seven spring dampers with six ceramic facings and vibration control technology (VCT™plus). See **Fig. 4.**

NOTE: An earlier version of vibration control technology (VCT™) had a disc with six spring dampers and six ceramic facings. This disc has now been replaced by VCT™plus.

On older vehicles, clutch discs with eight, nine, or ten spring dampers may be installed. These older types of vibration dampers are not adequate for modern high-horsepower engines that operate at lower peak torques.

⚠ CAUTION

If your vehicle was originally equipped with six- or seven-spring discs, do not substitute eight- or ten-spring discs. This could cause excessive torsional vibration and component damage.



1. Clutch Cover
2. Rear Driven Disc
3. Intermediate Plate
4. Front Driven Disc
5. Kwik-Adjust Mechanism

Fig. 5, Easy-Pedal Heavy-Duty Clutch

Clutch capacity is indicated by the color code of the pressure springs in the cover assembly. See the appropriate table for Easy-Pedal clutches in **Specifications, 400**.

Principles of Operation

The primary purpose of the clutch is to transfer the power of the engine from the engine flywheel to the transmission. At the point where clutch engagement begins (clutch pedal partially released), the transmission input shaft may be stationary, as when the vehicle is not moving, or it may be rotating at a different speed than the flywheel, as in the case of upshifting or downshifting. Once the clutch is fully engaged (clutch pedal fully released), both the engine flywheel and the transmission input shaft will be rotating at the same speed.

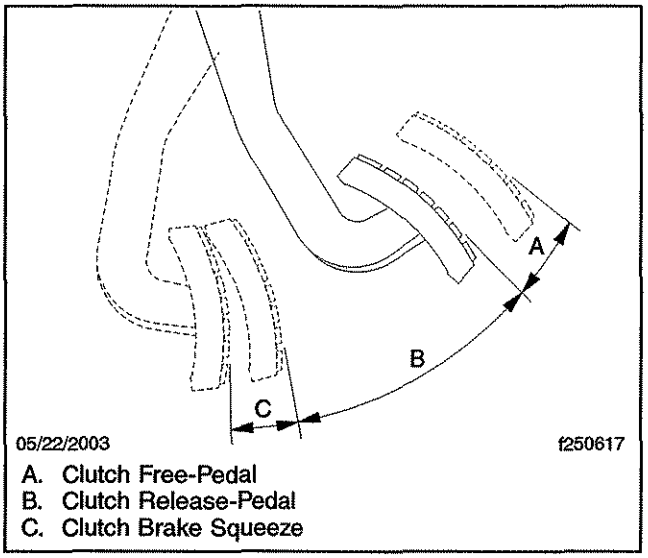
The secondary purpose of the clutch is to damp unwanted vibrations that normally exist in the driveline system. The springs within each driven disc provide a flexible link between the friction surfaces and the disc hubs. Damped clutch discs are specifically designed to prolong the life of drivetrain components by reducing vibrations from the engine, non-uniform U-joint angles, and road dips and bumps.

When the clutch pedal is first pressed down, the first 1/2-inch to 1-inch (12.7 to 25.4 mm) of pedal movement (clutch free-pedal) causes the release yoke fingers to move into contact with the wear pads of the release bearing (release yoke free-travel). See **Fig. 6**. The release yoke pulls the release bearing away from the pressure plate inside the clutch cover. This compresses the pressure springs, allowing the driven discs to slip freely, and at a different speed from the drive discs.

Further downward movement of the clutch pedal (clutch release-pedal), causes the release bearing to move into contact with the clutch brake (release bearing travel). The pressure springs force the pressure plate toward the engine flywheel, applying friction to the driven discs. Slippage occurs between the drive and driven discs because of the difference in their speeds.

In the last 1 inch to 1-1/4 inches (25 to 33 mm) of downward pedal movement, the clutch brake and the release bearing are pressed together (clutch brake squeeze). The friction between the discs increases, and the slippage and difference in speeds decreases. When the pedal is fully released, pressure and friction are sufficient to stop the discs from slipping. With no

General Information



A. Clutch Free-Pedal
B. Clutch Release-Pedal
C. Clutch Brake Squeeze

Fig. 6, Clutch Pedal Movement

slippage, the driving and driven members turn at the same speed.

When the vehicle is stationary, the clutch brake permits shifting into first gear or reverse gear without severe gear clash. The clutch brake is between the release bearing housing and the transmission bearing cap, and is engaged by tangs to the transmission input shaft. When the pedal is fully depressed, the clutch brake is squeezed between the release bearing housing and the transmission bearing cap, stopping the rotation of the main drive gear.

The clutch brake may be a disc type or a torque-limiting type. To prevent overloads to it, the torque-limiting clutch brake is designed to slip when loads of 20 to 25 lbf·ft (27 to 34 N·m) are reached. Clutch brakes are not designed for upshifting.

NOTE: The following procedures apply only to Eaton® Fuller® Easy-Pedal® clutches. Solo™ clutches are adjustment-free.

Release yoke free-travel is the distance between the release bearing wear pads and the release yoke. At the factory, the release yoke free-travel is set to 0.105 to 0.145 inch (2.7 to 3.7 mm). This setting produces approximately two inches (51 mm) of clutch free-pedal.

IMPORTANT: When clutch free pedal is less than about 3/4 inch (19 mm), adjust the clutch internally according to the procedures in this subject. Take care to do all procedures in the proper order.

Release bearing travel is the clearance between the aft end of the release bearing housing and the forward surface of the clutch brake disc. For the clutch to release properly, the release bearing travel measurement must be between 1/2 and 9/16 inch (12.7 to 14.3 mm).

As the clutch wears, the release bearing moves towards the engine flywheel, reducing release yoke free-travel and increasing release bearing travel. If internal clutch adjustments are not made, the release yoke fingers will eventually ride against the wear pads. This could cause the following problems:

- Worn bearing wear pads and release yoke
- Damaged release bearing and housing
- Eventual clutch slippage and burn-up

Release Bearing Travel

Measurement

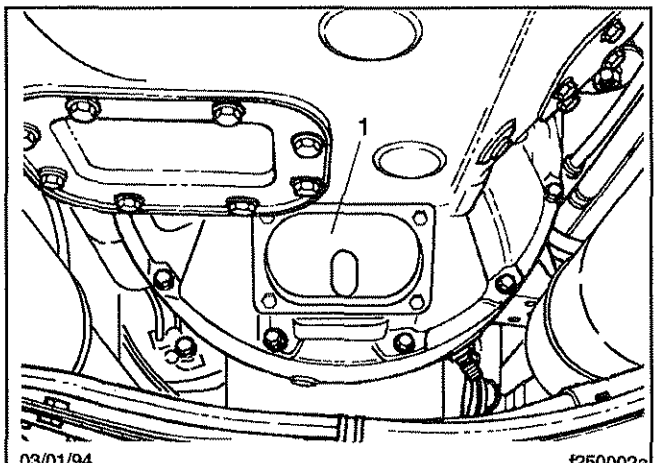
⚠ CAUTION

Make sure the internal adjustment is correct before making any linkage adjustments. Incorrect adjustments can cause transmission gear clash, slipping, and burning of clutch components.

1. Apply the parking brakes and chock all the tires.
2. Remove the clutch inspection cover from the bottom of the bell housing. See **Fig. 1.**
3. Slide the clutch brake (either the one-piece torque-limiting clutch brake, or the two-piece disc-type clutch brake with washer) tight against the transmission input-shaft bearing cap. See **Fig. 2.** Also, slide the release bearing as far as possible towards the transmission.

IMPORTANT: Release bearing travel tool A02–12419 is available through the PDCs. One end of the tool has green tape on it and is 0.50 inch (12.7 mm) in diameter; the other end has blue tape on it and is 0.56 inch (14.3 mm) in diameter.

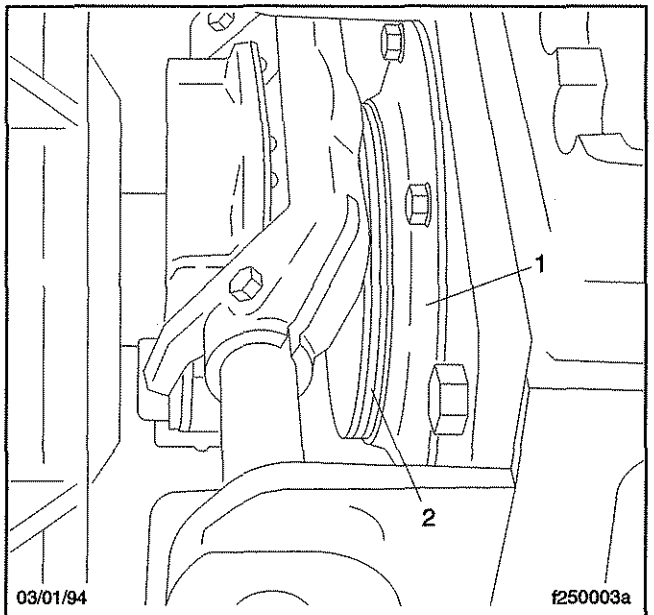
4. Measure the release bearing travel. See **Fig. 3** for the correct dimension to measure. Using both ends of the release bearing travel tool (**Fig. 4**), check this gap as follows:
   - 4.1 Position the tool so that the legs straddle the transmission input shaft.
   - 4.2 Insert the blue 0.56-inch (14.3-mm) end. If it fits loosely, the gap is too wide and adjustment is needed. See "Adjustment."
   - 4.3 If the blue 0.56-inch (14.3-mm) end can't be inserted in the gap, then try to insert the green 0.50-inch (12.7-mm) end. If the green end of the tool fits, snug or loose, then no adjustment is needed.
   - 4.4 If the green end of the tool can't be inserted in the gap, adjustment is needed. See "Adjustment."
5. If no internal clutch adjustment is necessary, go to "Release Yoke Free-Travel."



1. Clutch Inspection Cover

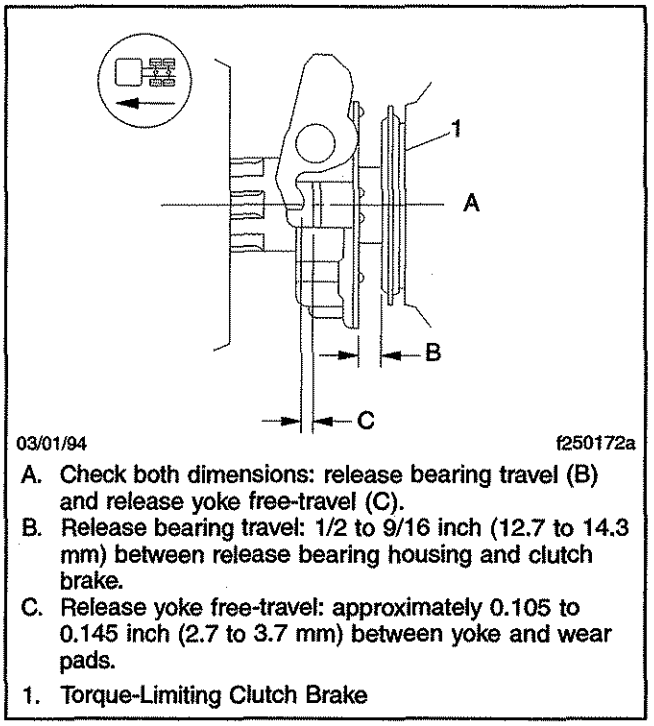
Fig. 1, Remove the Clutch Inspection Cover

Clutch Adjustments



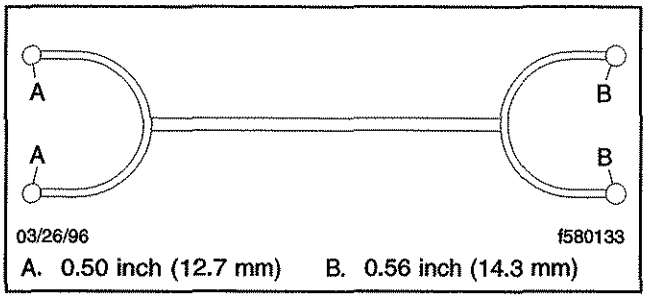
1. Transmission Input-Shaft Bearing Cap
2. Clutch Brake

Fig. 2, Position the Clutch Brake



A. Check both dimensions: release bearing travel (B) and release yoke free-travel (C).
B. Release bearing travel: 1/2 to 9/16 inch (12.7 to 14.3 mm) between release bearing housing and clutch brake.
C. Release yoke free-travel: approximately 0.105 to 0.145 inch (2.7 to 3.7 mm) between yoke and wear pads.
1. Torque-Limiting Clutch Brake

Fig. 3, Clutch Dimensions



A. 0.50 inch (12.7 mm) B. 0.56 inch (14.3 mm)

Fig. 4, Release Bearing Travel Tool A02-12419

Adjustment

To adjust Easy-Pedal clutches, use the Eaton Fuller Kwik-Adjust® mechanism (see **Fig. 5**).

1. Turn the engine flywheel until the lockstrap is aligned with the clutch inspection-cover opening. See **Fig. 1** and **Fig. 5**.
2. Release the clutch by depressing the pedal. Block the pedal in the released position, or have someone assist you by holding the pedal down during the adjustment procedure.

NOTE: An open-end wrench is not recommended for the following step.

3. Adjust the clutch, using a 5/8-inch box-end or socket wrench on the adjustment bolt.
   - 3.1 Insert the 5/8-inch box-end or socket wrench through the inspection cover opening.

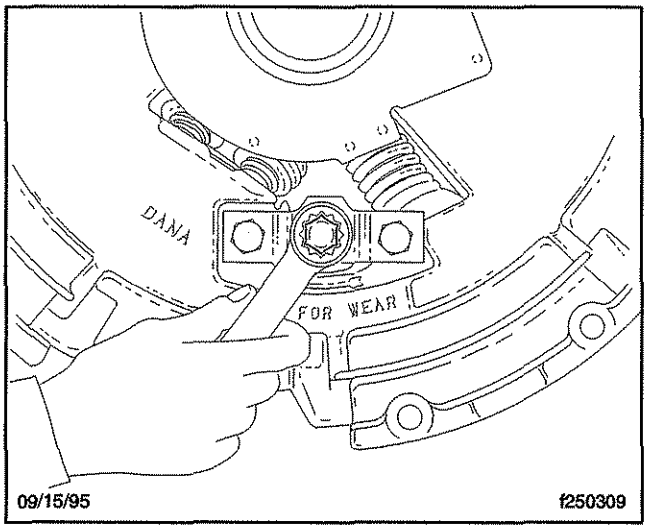


Fig. 5, Adjustment with Kwik-Adjust

3.2 To begin the adjustment, release the adjustment bolt by pressing down on the bolt head.

NOTE: Normal wear increases the gap between the release bearing and the transmission.

3.3 *To decrease the gap*: If clearance between the release bearing housing and the clutch brake is *more than* 9/16-inch (14.3 mm), turn the adjustment bolt clockwise (the release bearing moves toward the transmission).

To increase the gap: If clearance between the release bearing housing and the clutch brake is *less than* 1/2-inch (12.7 mm), turn the adjustment bolt counterclockwise (the release bearing moves toward the engine).

3.4 When the adjustment is complete, make sure the adjustment bolt is locked (pulled up flush with the mounting bolts).

NOTE: On Easy-Pedal 2000 clutches, each complete turn of the adjustment bolt represents about 1/8-inch (3.2 mm) of release bearing movement. On earlier Easy-Pedal models, each complete turn of the adjustment bolt represents about 0.02-inch (0.5 mm) of release bearing movement.

4. After adjusting, release the pedal and check the clearance between the release bearing housing and the clutch brake. When the clearance is 1/2 to 9/16 inch (12.7 to 14.3 mm), the adjustment is complete.

Release Yoke Free-Travel

IMPORTANT: Release yoke free-travel tool A02–12254 is available through the PDCs. The legs on one end of the tool have green tape on them and are 0.105 inch (2.7 mm) thick; the legs on the other end have blue tape on them and are 0.145 inch (3.7 mm) thick.

1. Measure the release yoke free-travel. See **Fig. 3** for the correct dimension to measure. Using both ends of the free-travel tool (**Fig. 6**), check the gap as follows:
2. Position the tool so that the legs straddle the release yoke.
3. Insert the blue 0.145-inch (3.7-mm) end. If it fits loosely, the gap is too wide and linkage adjustment is needed. See the appropriate subject in **Section 25.03**.
4. If the blue 0.145-inch (3.7-mm) end can't be inserted in the gap, then try to insert the green 0.105-inch (2.7-mm) end. If the green end of the tool fits, snug or loose, then no adjustment is needed.
5. If the green end of the tool can't be inserted in the gap, linkage adjustment is needed. See the appropriate subject in **Section 25.03**.

Clutch Brake Squeeze

NOTE: This procedure requires two persons: one under the vehicle with access to the release bearing, and the other in the vehicle to depress the clutch pedal and measure the pedal travel.

The distance the pedal moves (from the fully depressed position) to free the feeler gauge is the clutch brake squeeze measurement.

1. Apply the parking brakes and chock all the tires.
2. Remove the clutch inspection cover from the bottom of the bell housing. See **Fig. 1**.
3. Insert a 0.010 inch (0.25 mm) feeler gauge (a business card works well if a feeler gauge is not

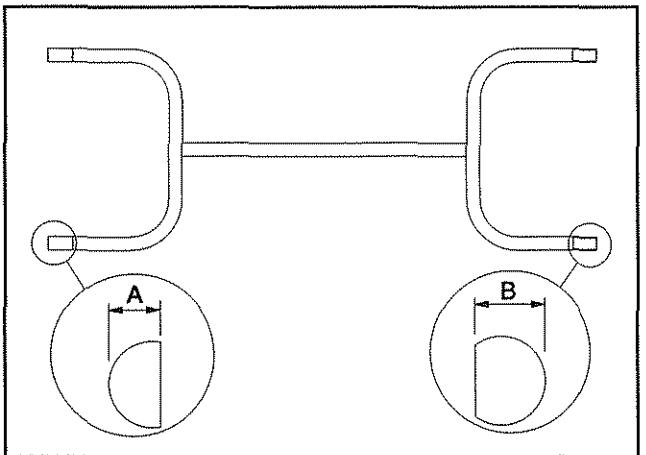


Fig. 6, Release Yoke Free-Travel Tool A02-12254

Clutch Adjustments

available) between the release bearing and clutch brake.

4. Depress the clutch pedal to the end of its stroke.
5. Slowly let the pedal up. Stop when the feeler gauge can be pulled out. The pedal should be 1/2 to 1 inch (12.7 to 25.4 mm) from the end of the stroke.
6. If necessary to obtain proper clutch brake squeeze, check the linkage for worn or damaged components. Repair or replace components as necessary. Adjust the linkage according to the procedures in the appropriate subject in **Section 25.03**.

Removal

Solo™ Heavy-Duty Clutch

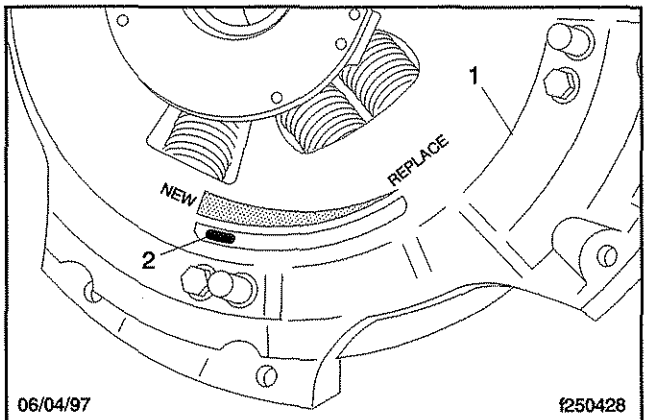
⚠ CAUTION

For proper installation of the Solo clutch, the wear indicating tab must be reset. Failure to reset this tab will prevent clutch release and result in possible clutch damage.

NOTE: This procedure requires two persons: one under the vehicle with access to the wear indicating tab, and the other in the vehicle to press the clutch pedal.

1. Reset the wear indicating tab with the clutch in the vehicle.
   - 1.1 From inside the cab, press the clutch pedal all the way down. Hold the clutch pedal down until the wear indicating tab is reset.
   - 1.2 Through the clutch inspection cover, slide the wear indicating tab to the left until it is at the "NEW" position on the indicator. See **Fig. 1**.

   IMPORTANT: Take note of the position of the wear indicating tab on the clutch cover. If the wear indicating tab is near the "REPLACE" position on the indicator, it is time to replace the clutch.



With the clutch pedal down, set the tab to the "NEW" position on the indicator.

1. Clutch Cover
2. Wear Indicating Tab

Fig. 1, Resetting the Wear Indicating Tab

   - 1.3 From inside the cab, release the clutch pedal. Check to be sure the wear indicating tab stays at the "NEW" position on the indicator.

NOTE: Before pulling the transmission from the bell housing, disconnect the external clutch linkage and rotate the release yoke so the yoke will clear the release bearing when it is removed.

2. Remove the transmission. See **Section 26.00**.

⚠ CAUTION

Do not let the rear of the transmission drop, and do not let the transmission hang unsupported in the splined hubs of the clutch discs. Taking these precautions will prevent bending and distortion of the clutch discs.

3. Remove the clutch brake from the transmission input shaft. See **Fig. 2**.
4. Install a spline aligning tool into the release bearing assembly, and through the driven discs. See **Fig. 3**. An old transmission input shaft may be used for this purpose.
5. Locate the four 7/16–14 x 1-3/4 shipping bolts (hexhead machine screws). These shipping bolts were installed on the clutch cover prior to installation.
6. Install the four 7/16–14 x 1-3/4 shipping bolts into the four clutch cover holes and fasten them finger-tight. See **Fig. 4**.
7. Remove the two top mounting capscrews from the cover assembly. Install two 7/16–14 x 5 guide studs in the open holes to help support the clutch assembly during removal. See **Fig. 5**.
8. Progressively loosen each of the mounting capscrews in the pattern shown in **Fig. 6**. This will prevent warping or bending within the clutch, and will ease removal of the clutch mounting capscrews.

⚠ WARNING

The clutch assembly is heavy. It should be removed and installed only with a lifting device. If the assembly is lifted incorrectly or dropped, it could cause serious personal injury.

Clutch Removal

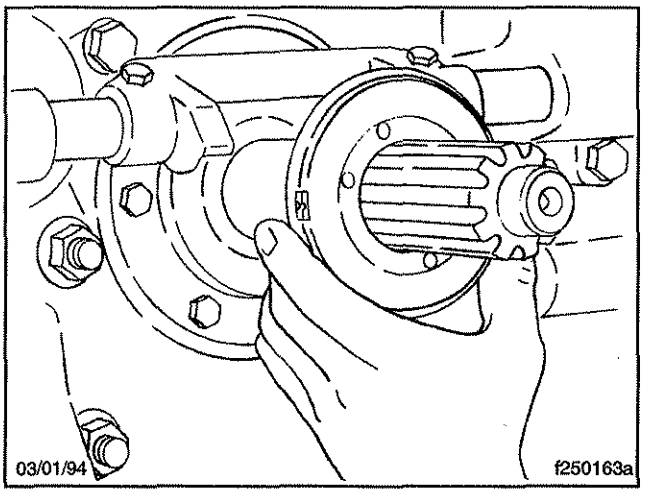


Fig. 2, Clutch Brake Removal

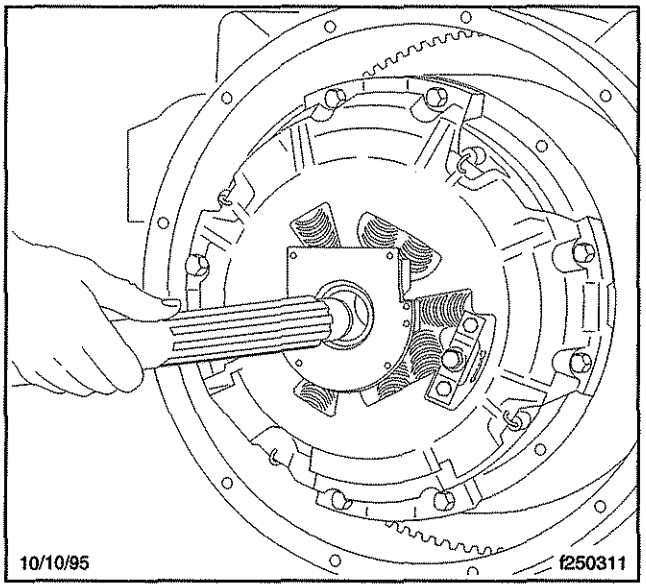


Fig. 3, Installing a Spline Aligning Tool

9. Remove the mounting capscrews, and carefully remove the clutch assembly together with the spline aligning tool.

NOTE: For installation, mark the proper position of the discs and intermediate plate adaptor ring.

10. Reset the pressure plate wear pins. See **Fig. 7.**

    10.1 Progressively tighten the four shipping bolts in a crisscross pattern.

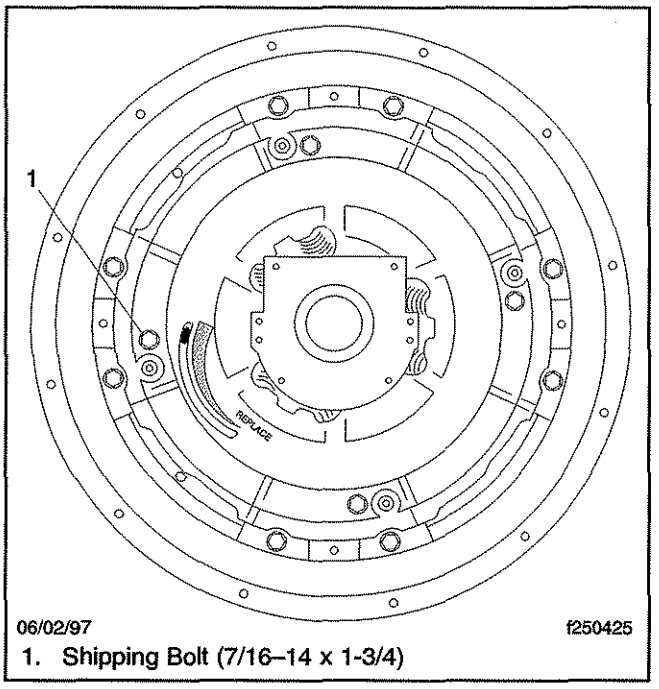


Fig. 4, Install the Shipping Bolts

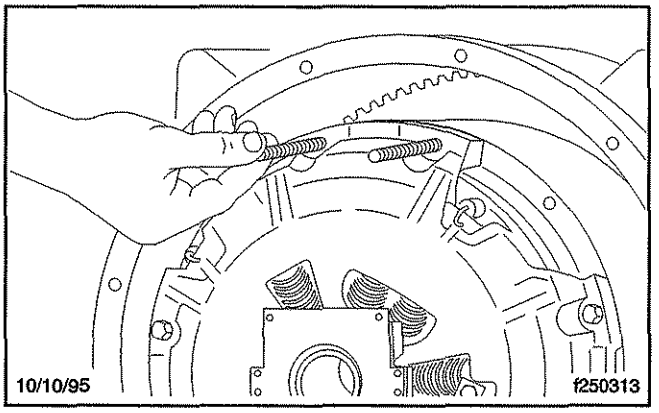


Fig. 5, Install the Guide Studs

    10.2 Measure the depth of the pressure plate. When the face of the pressure plate is 0.525 inches (13.3 mm) below the mounting surface, the wear pins are reset.

NOTE: Resetting the pressure plate wear pins will allow the clutch to release after installation.

11. Use an appropriate puller to remove the pilot bearing. Inspect the old pilot bearing for any unusual wear or damage. Discard the pilot bearing.

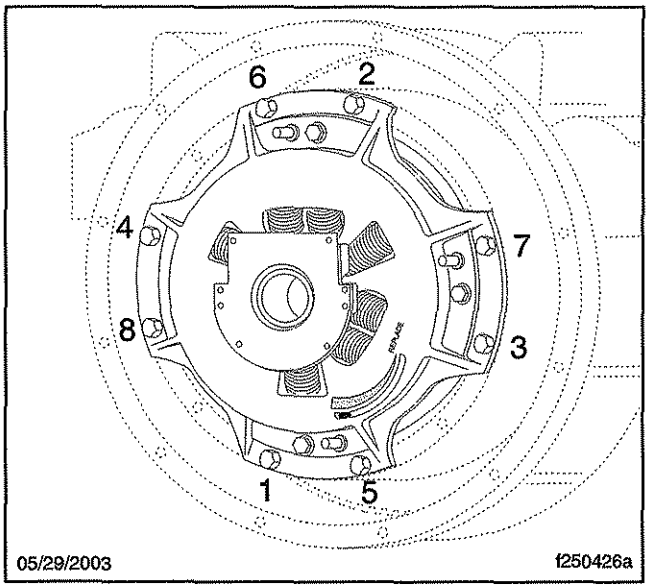
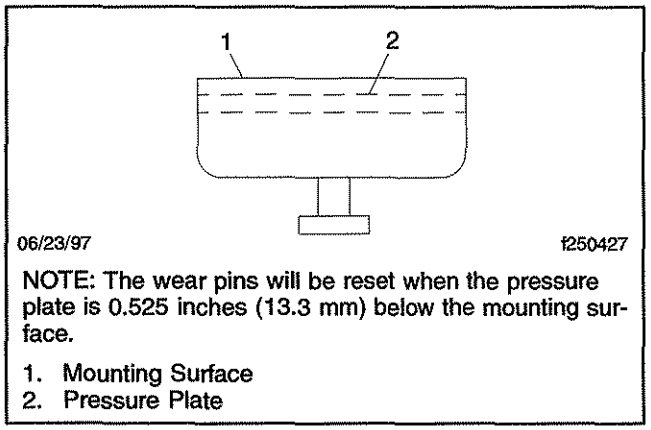


Fig. 6, Loosening Sequence, Solo



NOTE: The wear pins will be reset when the pressure plate is 0.525 inches (13.3 mm) below the mounting surface.

1. Mounting Surface
2. Pressure Plate

Fig. 7, Reset Wear Pins

Resetting the Wear Indicating Tab (clutch out of vehicle)

CAUTION

Use this procedure if the transmission and clutch were removed without resetting the wear indicating tab. Resetting the wear indicating tab allows the clutch to release and prevents possible clutch damage.

1. Remove the four shipping bolts (if installed).
2. Support the clutch cover in an arbor press with the release bearing facing down. When setting up the arbor press, allow at least 1 inch (25 mm) clearance for both movement of the release bearing and access to install shipping bolts. See **Fig. 8.**
3. Center the ram and press downward on the retainer until it comes to a stop. Lock the ram in position.
4. Slide the wear indicating tab to the left until it is at the new position of the indicator (**Fig. 1**) and hold it in position with a magnet.
5. Locate the four 7/16–14 x 1-3/4 shipping bolts.
6. Install the four 7/16–14 x 1-3/4 shipping bolts into the four clutch cover holes and fasten them finger-tight. See **Fig. 4.**

NOTE: You may need to temporarily install slightly longer bolts to allow access of the shipping bolts.

7. Reset the pressure plate wear pins. See **Fig. 7.**
   - 7.1 Progressively tighten the four shipping bolts in a crisscross pattern.
   - 7.2 Measure the depth of the pressure plate. When the face of the pressure plate is

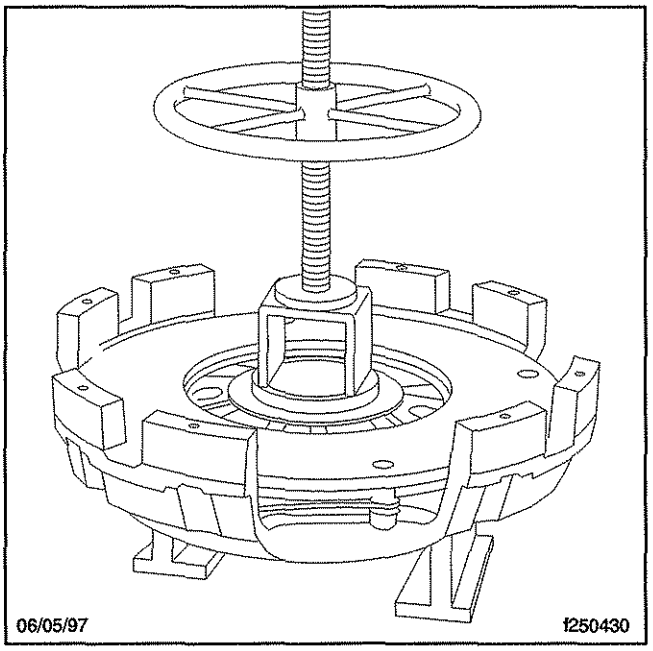


Fig. 8, Arbor Press Setup

Clutch Removal

0.525 inches (13.3 mm) below the mounting surface, the wear pins are reset.

NOTE: Resetting the pressure plate wear pins will allow the clutch to release after installation.

Easy-Pedal™ Clutch

NOTE: Before pulling the transmission from the bell housing, disconnect the external clutch linkage and rotate the release yoke so the yoke will clear the release bearing when it is removed.

1. Remove the transmission. See **Section 26.00**.

⚠ CAUTION

Do not let the rear of the transmission drop, and do not let the transmission hang unsupported in the splined hubs of the clutch discs. Taking these precautions will prevent bending and distortion of the clutch discs.

2. Remove the clutch brake from the transmission input shaft. See **Fig. 2**.
3. Install a spline aligning tool into the release bearing assembly, and through the driven discs. See **Fig. 3**. An old transmission input shaft may be used for this purpose.
4. Use a release tool and two 5/8-inch (16 mm) spacer blocks to pull the bearing back. See **Fig. 9**. The spacer blocks relieve the internal spring load in the clutch assembly, and facilitate clutch removal.
5. Remove the two top mounting bolts from the cover assembly. Install 7/16–14 x 5 guide studs in the open holes to help support the clutch assembly during removal. See **Fig. 5**.
6. Progressively loosen each of the mounting bolts in the pattern shown in **Fig. 10**. This will prevent warping or bending within the clutch, and will ease removal of the clutch mounting bolts.

⚠ WARNING

The clutch assembly is heavy. It should be removed and installed only with a lifting device. If the assembly is lifted incorrectly or dropped, it could cause serious personal injury.

7. Remove the mounting bolts, and carefully remove the clutch assembly.

   Be careful to keep the spline aligning tool in place to retain the discs and intermediate plate. Remove the spline aligning tool, the rear driven disc, the intermediate plate, and the front driven disc.

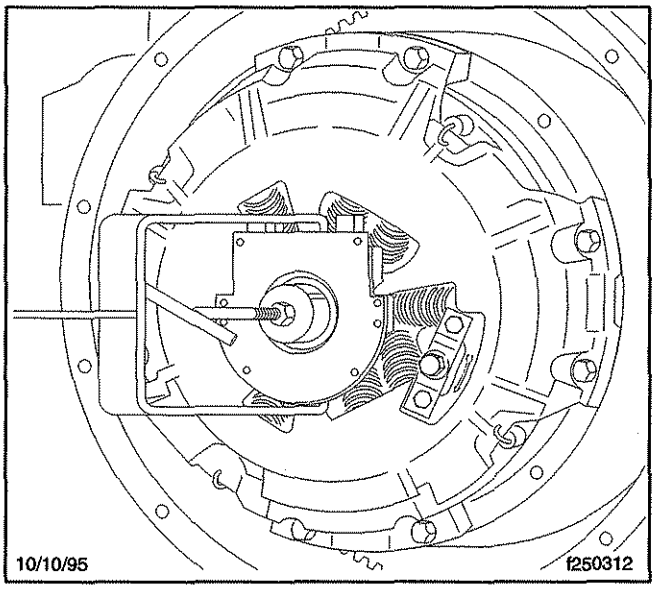


Fig. 9, Pulling the Bearing

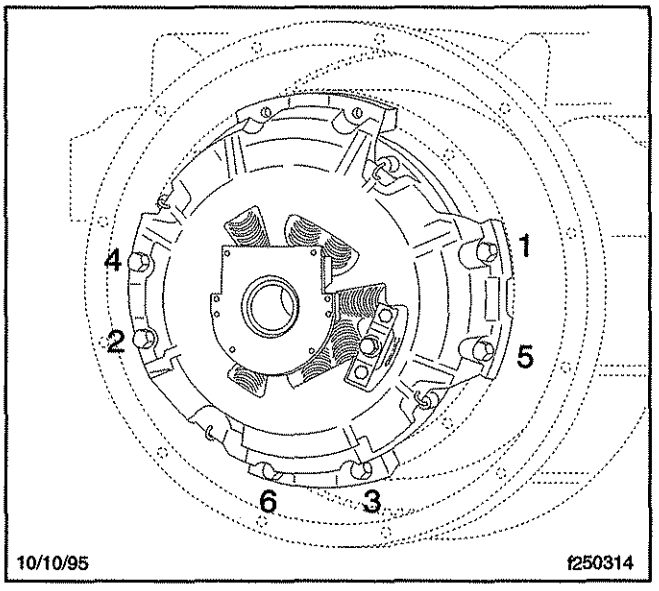


Fig. 10, Loosening Sequence, Easy-Pedal

8. Use an appropriate puller to remove the pilot bearing. Inspect the old pilot bearing. Correct the cause of any unusual wear or damage. Discard the bearing.

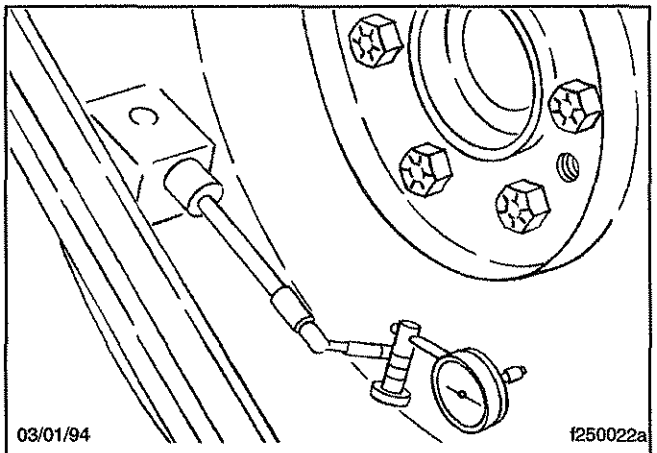
Clutch Inspection

⚠ CAUTION

Misalignment of any parts described in these procedures will cause premature wear of drivetrain components.

IMPORTANT: When taking the following readings, rotate the engine by hand; do not crank the engine with the starter. The engine may be rotated by the pulley nut at the front of the crankshaft, the flywheel mounting bolts, or the starter ring-gear on the flywheel.

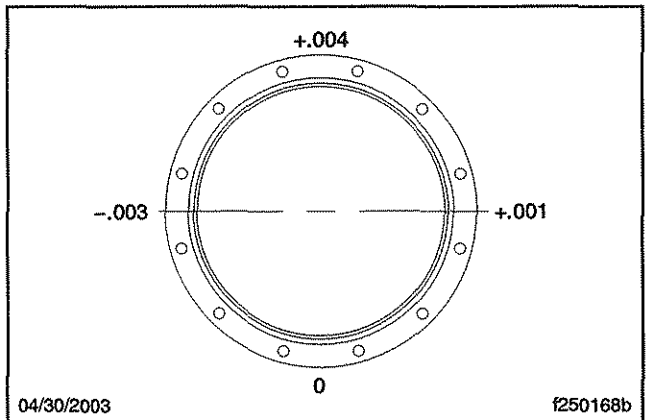
1. Clean the surfaces being measured to ensure accurate measurements.
2. Measure the runout of the flywheel face (friction surface). See **Fig. 1** for the correct set-up.
   - 2.1 Secure the dial indicator to the flywheel housing, with the gauge finger against the face of the flywheel near the outer edge.
   - 2.2 Turn the flywheel through one complete revolution. With chalk or soapstone, mark the high and low points on the flywheel face.
   - 2.3 The total runout will be the difference between the highest plus and minus readings. To calculate the runout, see **Fig. 2**.



Secure the dial indicator to the flywheel housing, with the gauge finger against the flywheel face, and near the outer edge.

Fig. 1, Measure the Flywheel Face

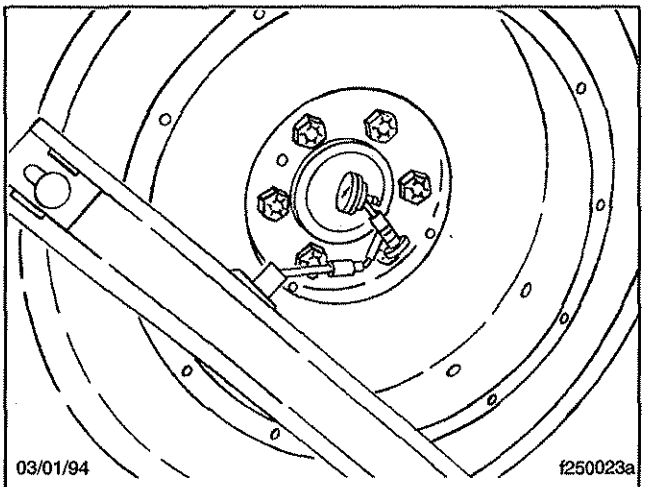
   Example: The highest reading is +0.004 at 12 o'clock. The lowest reading is –0.003 at 9 o'clock. Therefore the total runout is 0.007 inch.
   - 2.4 The SAE maximum total runout for the flywheel face is 0.008 inch (0.20 mm). If the readings are higher, see the engine manufacturer's manual for instructions.
3. Measure the runout of the pilot-bearing bore in the flywheel. See **Fig. 3** for the correct set-up.
   - 3.1 With the indicator still secured to the flywheel housing, move the gauge finger to contact the surface of the pilot-bearing bore.
   - 3.2 Turn the flywheel through one complete revolution. With chalk or soapstone, mark the high and low points on the bore of the pilot bearing.
   - 3.3 Calculate the runout as before.
   - 3.4 The SAE maximum total runout for the pilot-bearing bore is 0.005 inch (0.13 mm). If the readings are higher, see the engine manufacturer's manual for instructions.
4. Measure the runout of the flywheel housing bore. See **Fig. 4** for the correct set-up.



Take four readings, starting with zero at the 6 o'clock position, and going on to 9, 12, and 3 o'clock. Make sure the dial returns to zero at the original start position.

Fig. 2, Calculate the Runout

Clutch Inspection and Pre-Installation Procedures



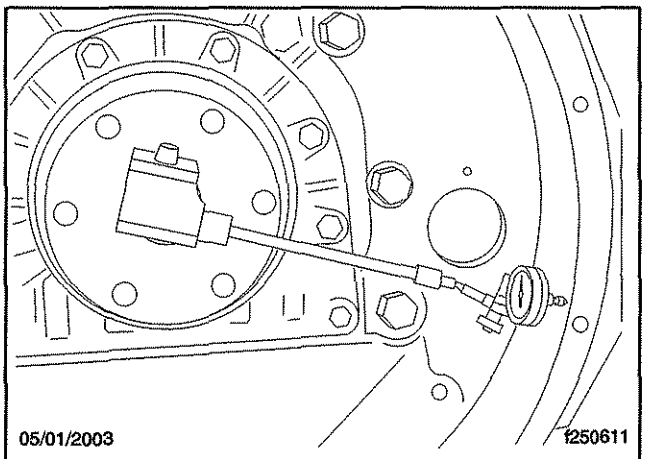
Secure the dial indicator to the flywheel housing, with the gauge finger on the surface of the pilot-bearing bore.

Fig. 3, Measure the Pilot-Bearing Bore

4.1 Secure the dial indicator to the crankshaft, with the gauge finger against the side of the flywheel housing.

4.2 Turn the flywheel through one complete revolution. With chalk or soapstone, mark the high and low points on the side of the flywheel housing.

4.3 Calculate the runout as before.



Secure the dial indicator to the crankshaft, with the gauge finger against the side of the flywheel housing.

Fig. 4, Measure the Flywheel Housing Bore

NOTE: Only if you have to reposition the flywheel housing is it necessary to mark the high and low runout readings in clock positions.

4.4 The SAE maximum total runout for the flywheel-housing bore is 0.008 inch (0.20 mm). If readings are higher, replace the flywheel housing. For instructions, see the engine manufacturer's manual.

5. Measure the runout of the face of the flywheel housing. See **Fig. 5** for the correct set-up.

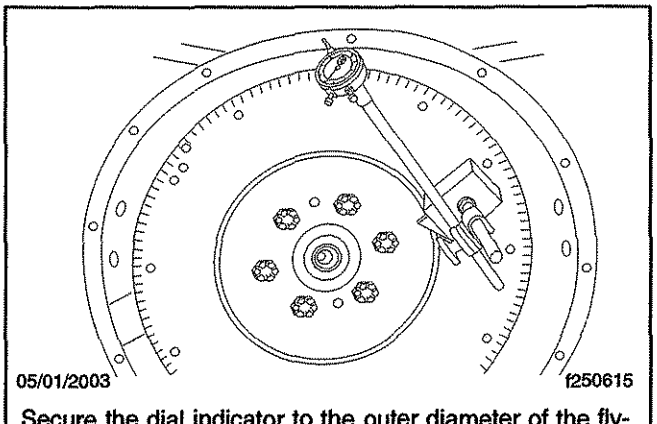
5.1 With the dial indicator secured to the outer diameter of the flywheel, move the gauge finger to contact the face of the flywheel housing.

5.2 Turn the flywheel through one complete revolution. With chalk or soapstone, mark the high and low points on the face of the flywheel housing.

5.3 Calculate the runout as before.

NOTE: Only if you have to reposition the flywheel housing is it necessary to mark the high and low runout readings in clock positions.

5.4 The SAE maximum total runout for the flywheel-housing face is 0.008 inch (0.20 mm). If the readings are higher, replace the housing. For instructions, see the engine manufacturer's manual.



Secure the dial indicator to the outer diameter of the flywheel, with the gauge finger against the face of the flywheel housing.

Fig. 5, Measure the Flywheel Housing Face

NOTE: Use a case-bore plug and shaft set to measure the bell-housing face and pilot. Case-bore plugs are tapped into the front and rear bores of the transmission case, and have very close tolerances. The shaft runs through the center of the plugs, and extends to the front far enough to secure a dial indicator and obtain a reading on the bell housing.

6. Measure the runout of the bell housing face and pilot.
   - 6.1 Secure the dial indicator to the case-bore shaft, with the gauge finger against the face of the bell housing.
   - 6.2 Turn the case-bore shaft through one complete revolution. With chalk or soapstone, mark the high and low points on the face of the bell housing.
   - 6.3 Calculate the runout as before.
   - 6.4 The SAE maximum total runout for the bell-housing face is 0.008 inch (0.20 mm). If the readings are higher, replace the bell housing. See the transmission manufacturer's service manual for instructions.
7. Remove the flywheel (see the engine manufacturer's manual), and measure the runout of the flywheel crankshaft face. See **Fig. 6.**
   - 7.1 Secure the dial indicator to the flywheel housing, with the gauge finger against the crankshaft face, and near the outer edge.
   - 7.2 Turn the crankshaft through one complete revolution. With chalk or soapstone, mark the high and low points on the face of the crankshaft.
   - 7.3 Calculate the runout as before.
   - 7.4 See the engine manufacturer's manual for maximum runout, corrective measures, and flywheel installation instructions.

Pre-Installation Procedures

Before installing a new, rebuilt, or used clutch, do the following procedures:

1. Install a new pilot bearing. Be sure that the pilot bearing has a press-fit in the flywheel.

⚠ CAUTION

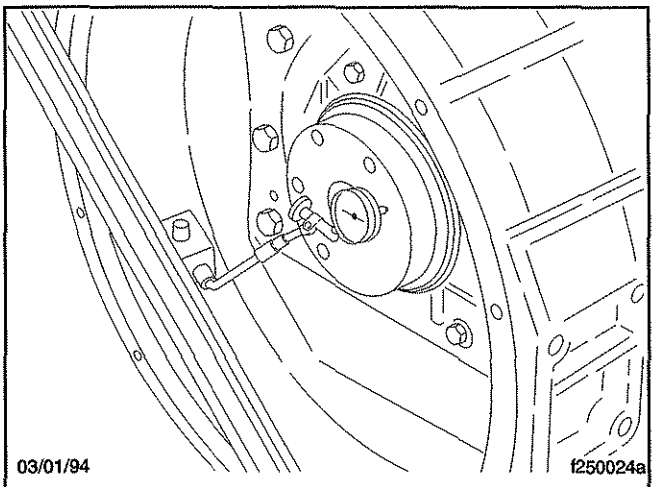
Tap on the outer race only. Tapping on the inner race could damage the pilot bearing.

NOTE: To discourage warranty claims for drag or clutch noise, use a premium grade C3/C4 pilot bearing. Due to increased operating temperatures and longer clutch life, the standard pilot bearings and grease are no longer acceptable.

2. Check for wear on the mating surfaces of the flywheel housing and the transmission bell housing. Any noticeable wear on either part causes misalignment. If worn, replace the part. See **Fig. 7.**
3. Check the flywheel for wear caused by the bell housing pilot (projecting lip of the bell housing). The correct dimension is 1/8-inch (3.2-mm). Wear is most likely to appear between the 3 o'clock and 8 o'clock positions. See **Fig. 8.**

NOTE: The pilot (lip) of the bell housing can wear into the flywheel housing. This can be caused by the transmission loosening up, or by road and engine vibration after high mileage.

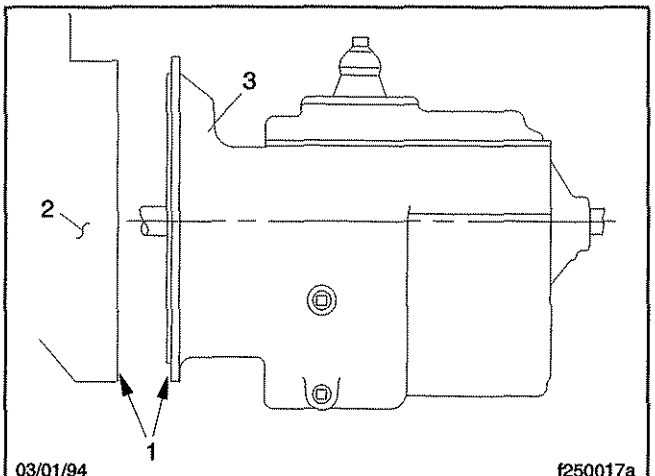
4. Inspect the flywheel. Replace or repair the flywheel if the wear is extreme.



Secure the dial indicator to the flywheel housing, with the gauge finger against the crankshaft face, and near the outer edge.

Fig. 6, Measure the Crankshaft Face Runout

Clutch Inspection and Pre-Installation Procedures



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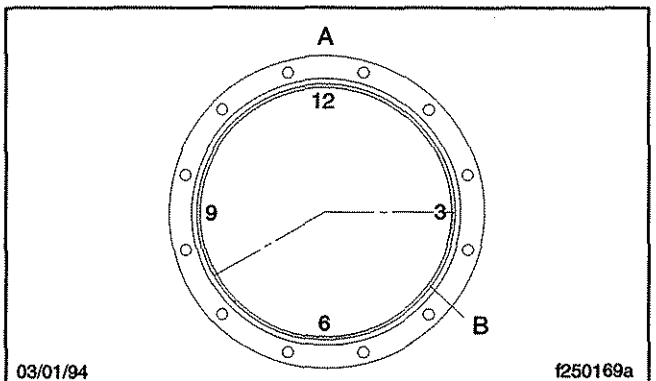
1. Mating Surfaces
2. Engine Flywheel Housing
3. Transmission Bell Housing

Fig. 7, Inspect the Mating Surfaces



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A. Top
B. The most common areas of wear are between the 3 o'clock and 8 o'clock positions.

Fig. 8, Check for Wear

4.1 Visually inspect the friction surface of the flywheel for heat checks and scoring.

4.2 Measure the friction surface wear with a straightedge and feeler gauge. For instructions, see the engine manufacturer's manual.

5. Inspect the input shaft, both the splined and the smooth area. See **Fig. 9**.

5.1 Check the fit of the splined hubs of the driven discs by sliding them along the splines of the input shaft. The hubs must slide freely so the clutch will release cleanly. If necessary, use a hand stone to dull the sharp edges of the splines.

5.2 If the input shaft splines are worn or notched, or if the hubs still do not slide freely, replace the input shaft. For instructions, see the transmission manufacturer's service manual.

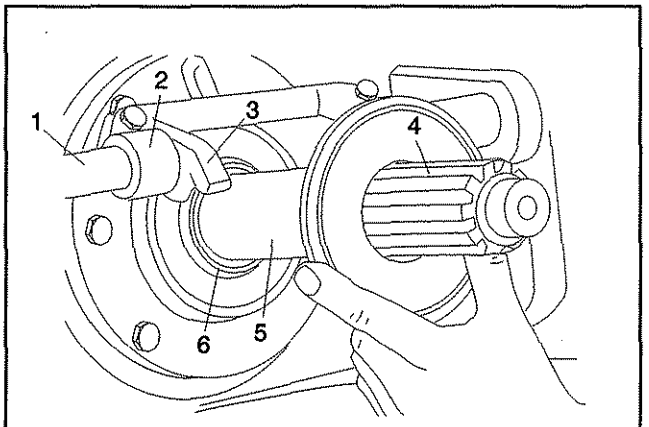
5.3 Inspect the smooth area of the input shaft for wear and/or rough spots. Replace the input shaft if necessary.

6. To prevent side-loading, inspect all pivot points of the clutch linkage for excessive wear and replace them if necessary. See **Fig. 9**. Pay special attention to the following points:

6.1 Check for excessive wear at the fingers of the release yoke where they contact release bearing wear pads.

6.2 Check the clutch cross-shaft and sleeve bushings for excessive wear. Check the sleeve bushings for walk-out.

7. To prevent clutch brake wear, check the input-shaft bearing cap and measure it as shown in **Fig. 10**.



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1. Cross-Shaft
2. Sleeve Bushing
3. Release Yoke Finger
4. Input Shaft (splined area)
5. Input Shaft (smooth area)
6. Bearing Cap

Fig. 9, Clutch Inspection Points

7.1 Visually check the bearing cap for excessive wear.

7.2 Measure the distance between the splined end of the input shaft and the bearing cap (dimension A). If dimension A is greater than 8.71 inches (221.5 mm), replace the bearing cap.

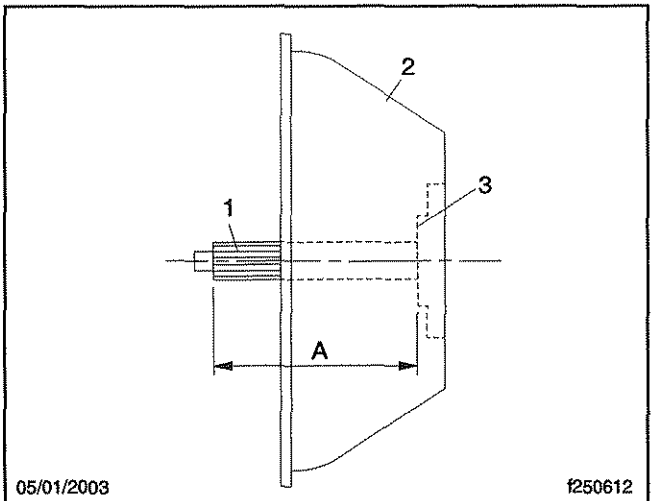
NOTE: Torque-limiting clutch brakes are a one-piece assembly with a large and a small face. When installing a torque-limiting clutch brake on an Eaton® Fuller® or Meritor™ transmission, install the smaller face toward the transmission.

8. Install a new clutch brake on the transmission input shaft, as shown in **Fig. 11**. Slide it tight against the input-shaft bearing cap.

9. Check the diameter of the flywheel bore opening (this is the recessed area for the flywheel bolt circle). See **Table 1** for minimum flywheel bore diameters for each disc type.

Minimum Flywheel Bores	
Disc Type	**Flywheel Bore in inch (mm)**
10-Spring	8.562 (217.48)
9-Spring	9.750 (247.65)
8-Spring	7.250 (184.15)
7-Spring	9.750 (247.65)
6-Spring	9.750 (247.65)

Table 1, Minimum Flywheel Bores



A. Length of Input Shaft, from the Splined End to the Bearing Cap
1. Input Shaft
2. Bell Housing
3. Bearing Cap

Fig. 10, Measure the Input Shaft

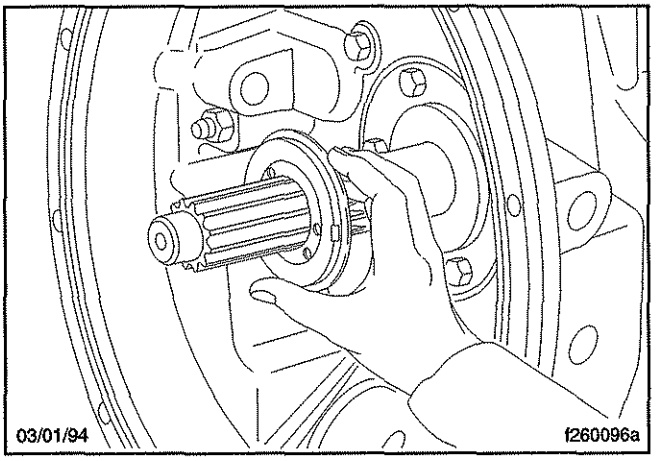


Fig. 11, Install the Clutch Brake

Installation

Solo™ Heavy-Duty Clutch

NOTE: Do the clutch inspection and pre-installation procedures in **Subject 120** before installing the clutch.

1. If not already installed, insert two 7/16–14 x 5 guide studs in the upper mounting holes of the flywheel. See **Fig. 1**. Rotate the flywheel to level the guide studs.
2. If installed (on new clutches), remove the protective coating from the pressure plate and the intermediate plate.
3. Set the clutch cover upright, and insert a spline aligning tool through the release bearing sleeve. See **Fig. 2**.

NOTE: Six-spring driven discs are identical, front and rear. Either disc can be installed first on the aligning tool.

4. Install the rear driven disc and intermediate plate.
   - 4.1 Install the rear driven disc on the aligning tool, with the side stamped *INTERMEDIATE PLATE SIDE* facing away from the clutch cover. See **Fig. 3**.
   - 4.2 Place the intermediate plate in the clutch cover. Align the drive lugs of the plate with the notches in the cover. See **Fig. 4**.
   - 4.3 Make sure the positive separator pins™ protrude toward the flywheel side. See **Fig. 4**. The pins should be flush on the pressure-plate side.
5. Install the front driven disc on the aligning tool, with the side stamped *INTERMEDIATE PLATE SIDE* facing the intermediate plate. See **Fig. 5**.

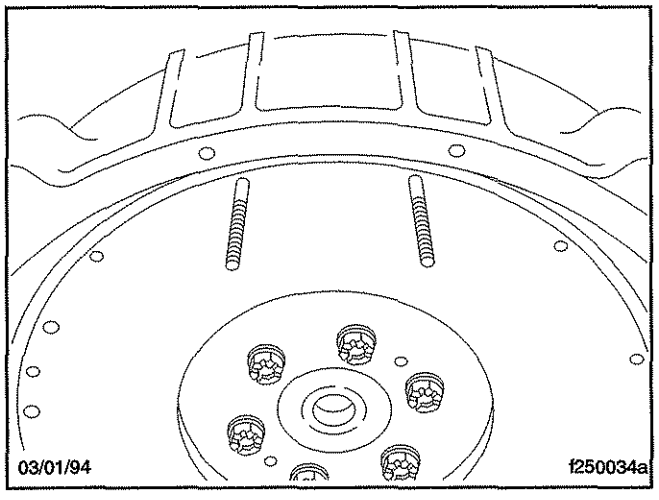


Fig. 1, Install the Guide Studs

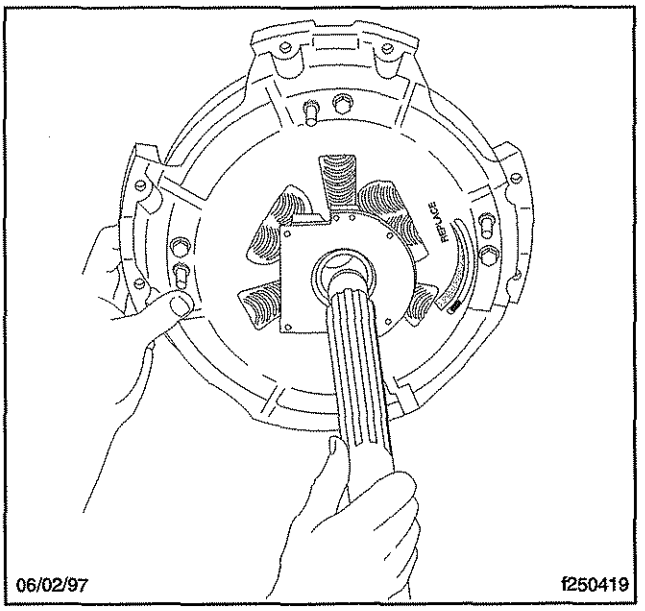


Fig. 2, Insert an Aligning Tool, Solo

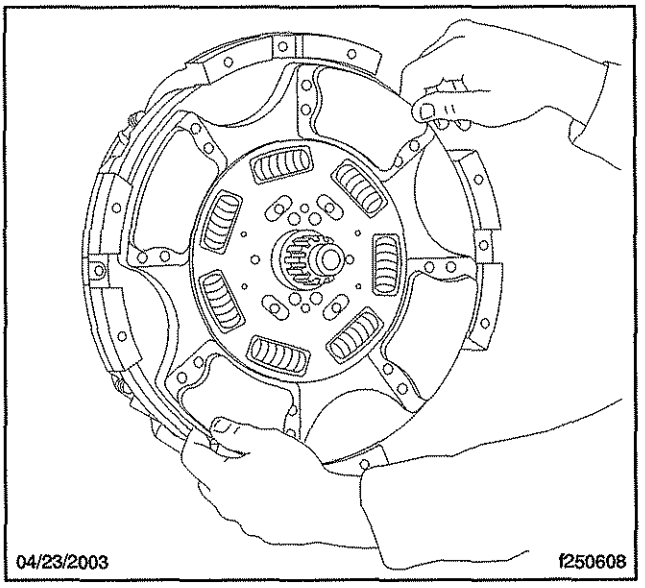
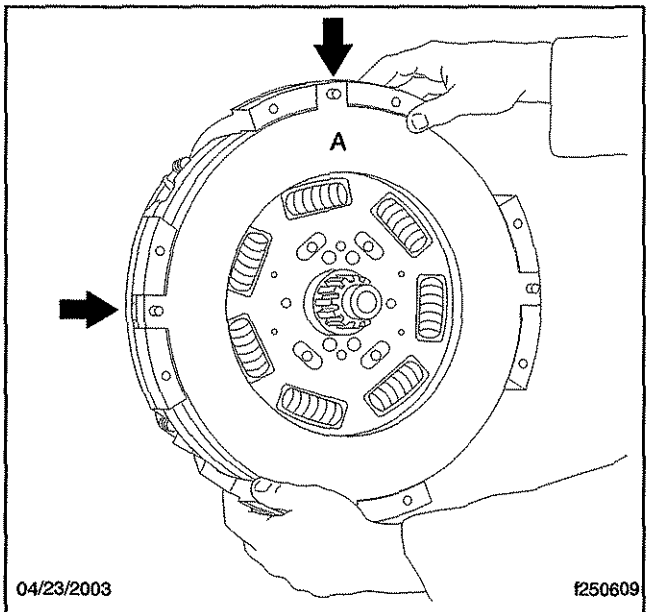


Fig. 3, Installing the Rear Driven Disc

Clutch Installation



The separator pins should protrude to the flywheel side.

A. Flywheel Side

Fig. 4, Positioning the Intermediate Plate

⚠ WARNING

The clutch assembly is heavy. It should be removed and installed only with a lifting device. If the assembly is lifted incorrectly or dropped, it could cause serious personal injury.

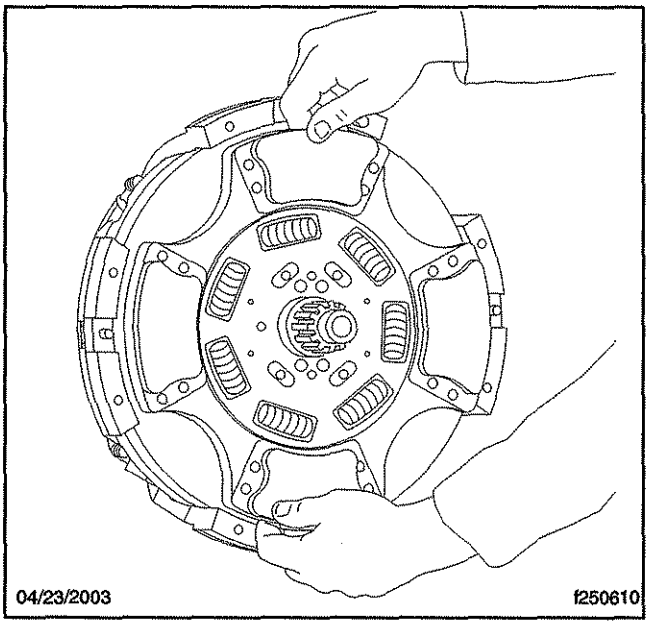


Fig. 5, Installing the Front Driven Disc

6. Position the clutch over the two guide studs, and slide the assembly forward until contact is made with the flywheel surface. See **Fig. 6**.
7. Install the mounting capscrews. See **Fig. 7**.
   - 7.1 Start six 7/16–14 x 2-1/4 (grade 5 or better) mounting capscrews with lockwashers, and fasten them finger-tight.
   - 7.2 Tap the aligning tool to make sure it is centered and seated in the pilot bearing.
   - 7.3 Remove the two guide studs and replace them with the two remaining 7/16–14 x 2-1/4 mounting capscrews and lockwashers.
8. Tighten the eight mounting capscrews progressively, in a crisscross pattern as shown in **Fig. 8**. The final torque is 40 to 50 lbf·ft (54 to 68 N·m).

IMPORTANT: Failure to tighten the bolts according to this procedure can have the following effects:

- prevent the clutch cover from centering into the pilot area of the flywheel;
- cause the clutch assembly to be out-of-balance with the flywheel;

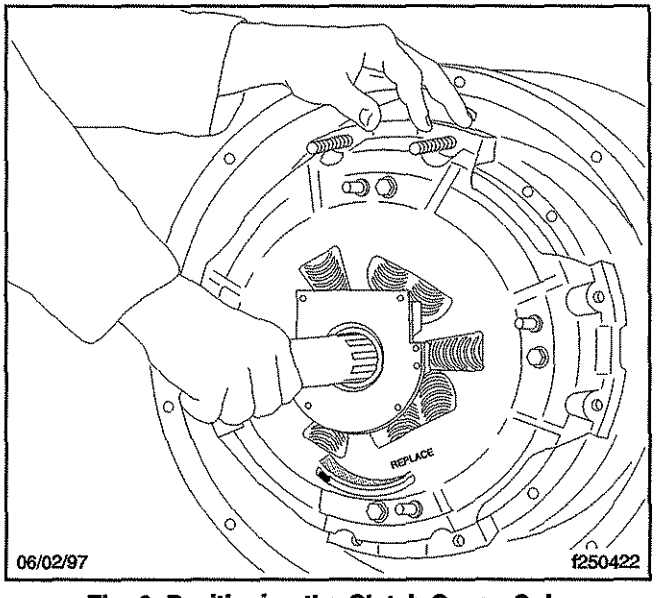


Fig. 6, Positioning the Clutch Cover, Solo

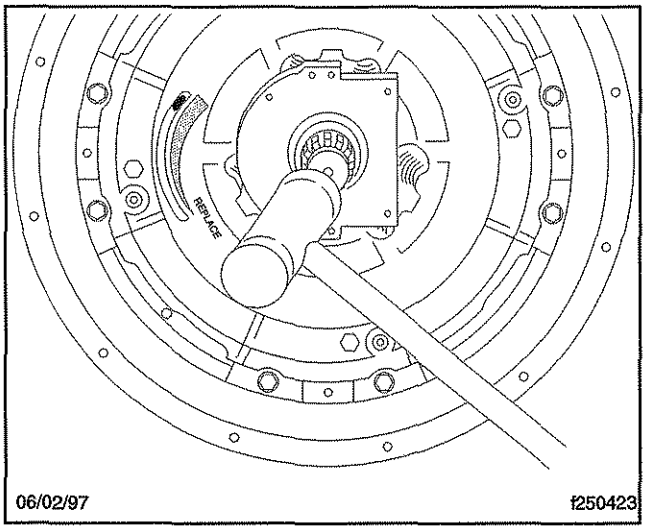


Fig. 7, Tap Aligning Tool

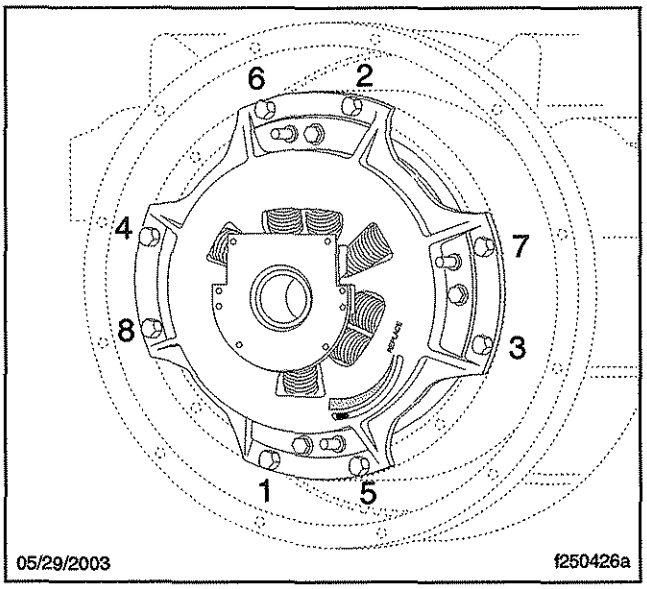


Fig. 8, Tightening Sequence, Solo

- cause permanent damage to the clutch cover.

9. Following a crisscross pattern, remove and retain the four yellow shipping bolts from the clutch cover. See **Fig. 9.**

NOTE: Retain these four shipping bolts. These bolts will be needed in the future to secure the clutch assembly during removal and installation.

10. Remove the aligning tool. On maintenance-free clutches only, remove the input shaft sleeve.

NOTE: Do not be concerned if the release bearing housing touches the clutch cover.

11. Set the positive separator pins.

    11.1 Locate the pin access holes. See **Fig. 10.**

⚠ WARNING

Wear safety goggles when tapping the pins. If any of the metal parts were to chip, flying pieces of metal could possibly cause eye injury.

    11.2 Using a 1/4-inch (6-mm) diameter flat nose punch, *lightly* tap each of the four positive separator pins toward the flywheel through the access holes. This step verifies that all the four pins are flush against the flywheel. See **Fig. 11.**

NOTE: Failure to perform this step properly may cause the clutch to drag (clutch does not release). If necessary, after the transmission has been installed, the four pins can be set through the inspection opening of the transmission bell housing.

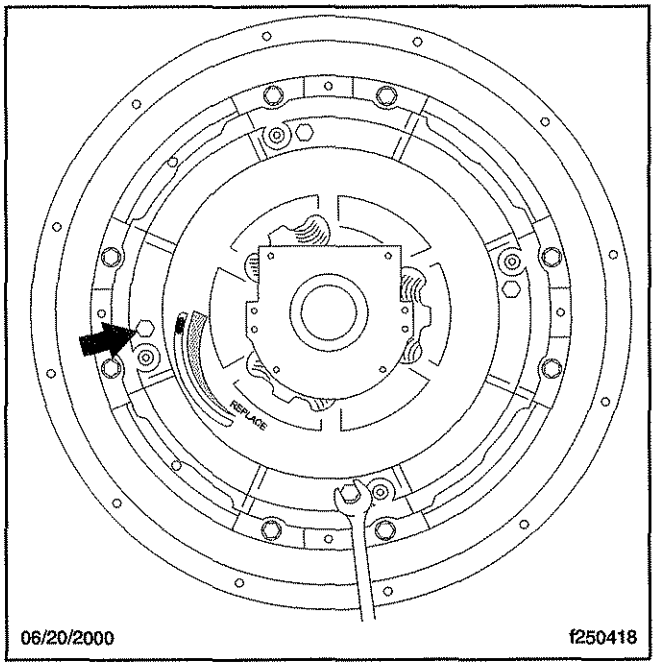


Fig. 9, Remove the Shipping Bolts

Clutch Installation

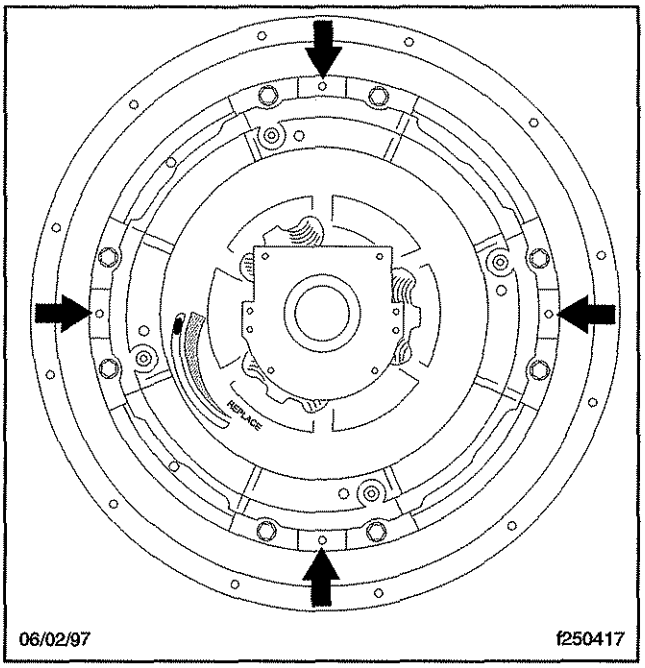
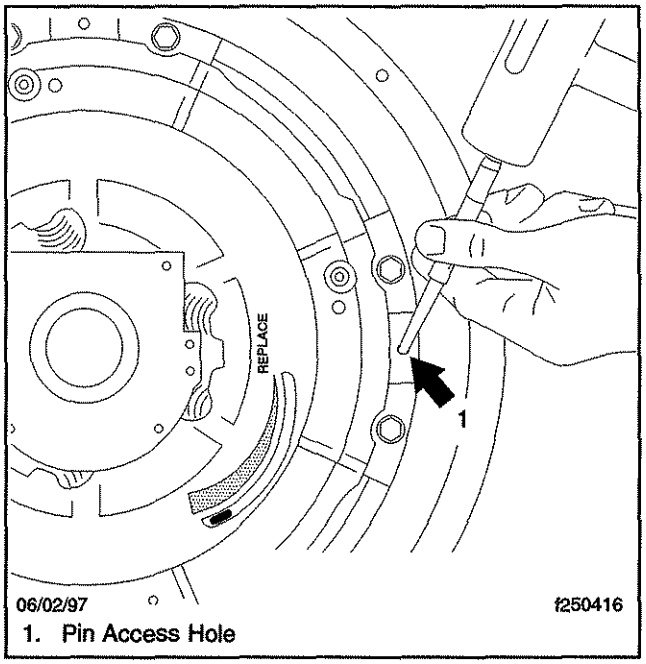


Fig. 10, Pin Access Holes, Solo



1. Pin Access Hole

Fig. 11, Tapping the Pin, Solo

12. Using a clean cloth, remove all grease from the input shaft.
13. Shift the transmission into gear so that during assembly the transmission input shaft can be rotated into line with the clutch driven-disc hub splines.
14. Install the transmission and attach the clutch linkage.

⚠ CAUTION

Avoid springing the driven discs when the transmission is being installed. Do not excessively force the transmission into the clutch assembly or engine housing. If it doesn't enter freely, investigate the cause of the problem and then make any necessary changes. Don't let the transmission drop or hang unsupported in the driven discs. If this should occur, the rear disc will become bent or distorted, causing the clutch to drag (not release).

IMPORTANT: Be sure the release yoke clears the bearing, and is rotated over the wear pads as the transmission is moved forward. See **Fig. 12**. Align the splines by turning the transmission output shaft.

15. Lubricate the release bearing and cross-shaft bushings. For instructions and recommended lubricants, see **Group 25** of the *Century Class Trucks Maintenance Manual.*

Easy-Pedal™ Clutch

NOTE: Do the clutch inspection and pre-installation procedures in **Subject 120** before installing the clutch.

1. If not already installed, insert two 7/16–14 x 5 guide studs in the upper mounting holes of the flywheel. See **Fig. 1**. Rotate the flywheel to level the guide studs.
2. If the clutch is new, remove the protective coating from the pressure plate and the intermediate plate.
3. Set the clutch cover upright, and insert a spline aligning tool through the release bearing sleeve. See **Fig. 13.**

NOTE: Six-spring driven discs are identical, front and rear. Either disc can be installed first on the aligning tool.

4. Install the rear driven disc and intermediate plate.
   4.1 Install the rear driven disc on the aligning tool, with the side stamped *INTERME-*

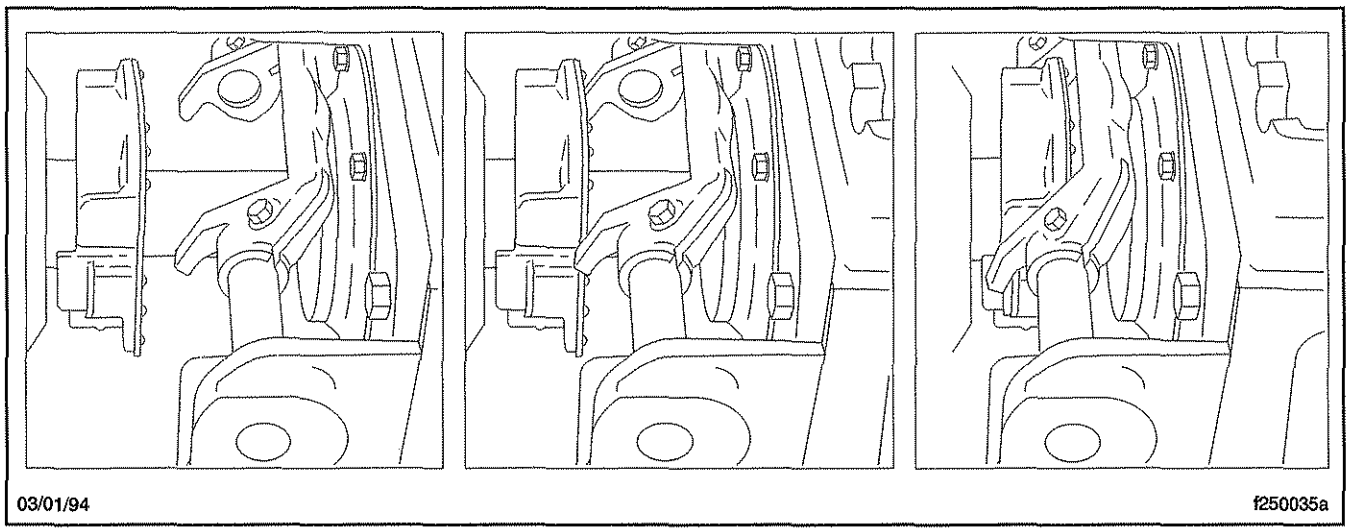


Fig. 12, Make Sure the Release Yoke Clears the Bearing

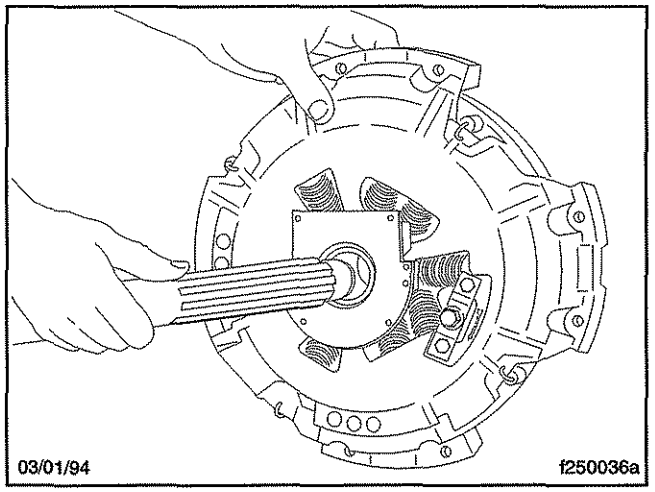


Fig. 13, Insert an Aligning Tool, Easy-Pedal

DIATE PLATE SIDE facing away from the clutch cover. See **Fig. 3.**

NOTE: On 8-, 9-, and 10-spring discs, this side will be stamped *FLYWHEEL SIDE.*

4.2 Place the intermediate plate in the clutch cover. Align the drive lugs of the plate with the notches in the cover. See **Fig. 4.**

4.3 Make sure the positive separator pins™ protrude toward the flywheel side. See **Fig. 4.** The pins should be flush on the pressure-plate side.

5. Install the front driven disc on the aligning tool, with the side stamped *INTERMEDIATE PLATE SIDE* facing the intermediate plate. See **Fig. 5.**

   Be sure that both driven discs are aligned as shown in **Fig. 14.**

NOTE: On 8-, 9-, and 10-spring discs, this side is stamped *FLYWHEEL SIDE.*

⚠ WARNING

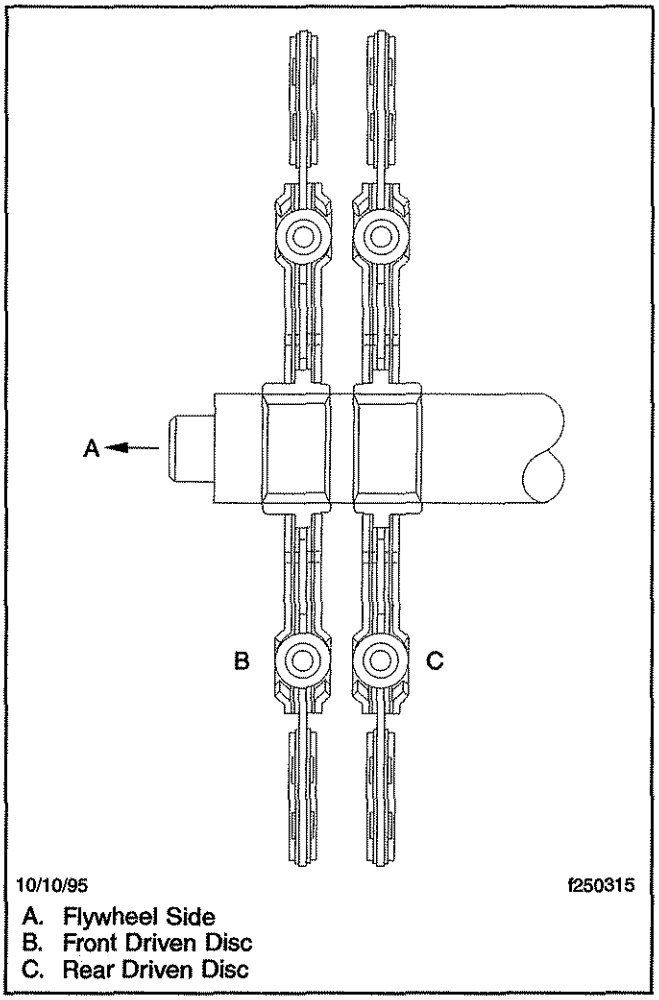
The clutch assembly is heavy. It should be removed and installed only with a lifting device. If the assembly is lifted incorrectly or dropped, it could cause serious personal injury.

6. Position the clutch over the two guide studs, and slide the assembly forward until it starts in the flywheel pilot. See **Fig. 15.**

7. Start six 7/16–14 x 2-1/4 (grade 5 or better) mounting bolts with lockwashers, and fasten them finger-tight. Tap the aligning tool to make sure it is centered and seated in the pilot bearing, then remove the two guide studs and replace them with 7/16–14 x 2-1/4 bolts and lockwashers.

8. Tighten the eight clutch mounting bolts progressively, in the sequence shown in **Fig. 16.** The final torque is 40 to 50 lbf·ft (54 to 68 N·m).

Clutch Installation



A. Flywheel Side
B. Front Driven Disc
C. Rear Driven Disc

Fig. 14, Checking Disc Alignment

⚠ CAUTION

If the bolts are not tightened in sequence, it may cause permanent damage to the clutch cover and create an out-of-balance condition.

9. As the capscrews are tightened, the release bearing spacers should fall free. If they don't, remove them. This may require light taps with a mallet on the end of the aligning tool.
10. Remove the aligning tool.
11. Set the positive separator pins.
    11.1 Locate the pin access holes. See **Fig. 17.**

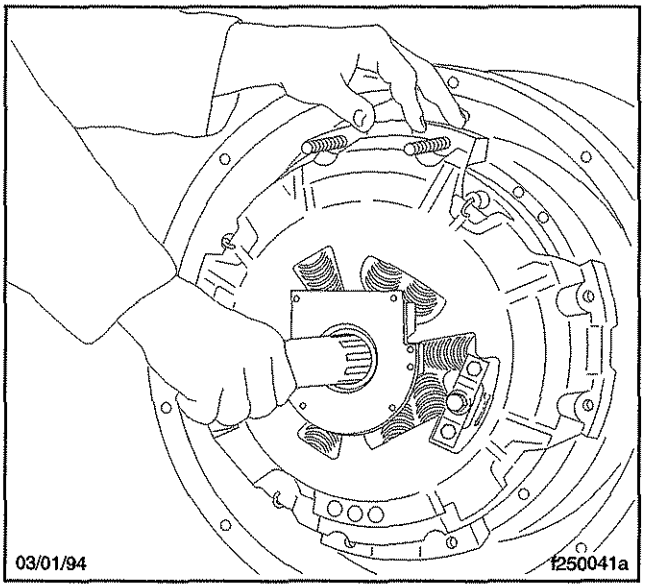


Fig. 15, Positioning the Clutch, Easy-Pedal

⚠ WARNING

Wear safety goggles when tapping the pins. If any of the metal parts were to chip, flying pieces of metal could possibly cause eye injury.

11.2 Using a 1/4-inch (6-mm) diameter flat nose punch, *lightly* tap each of the four positive separator pins toward the flywheel through

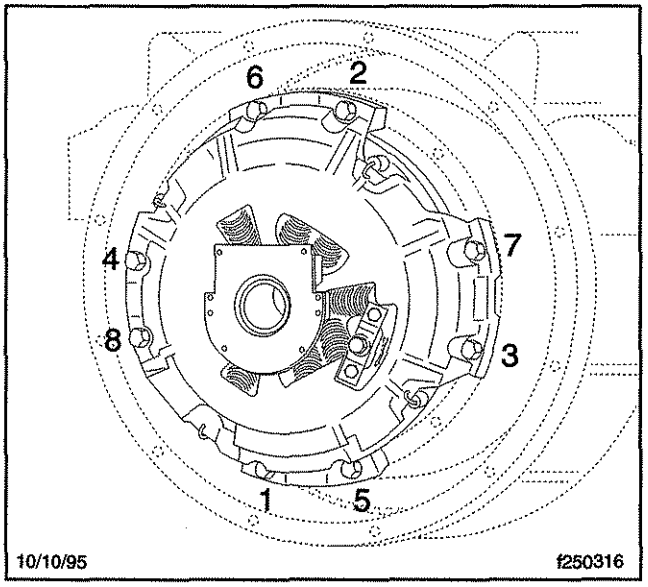


Fig. 16, Tightening Sequence, Easy-Pedal

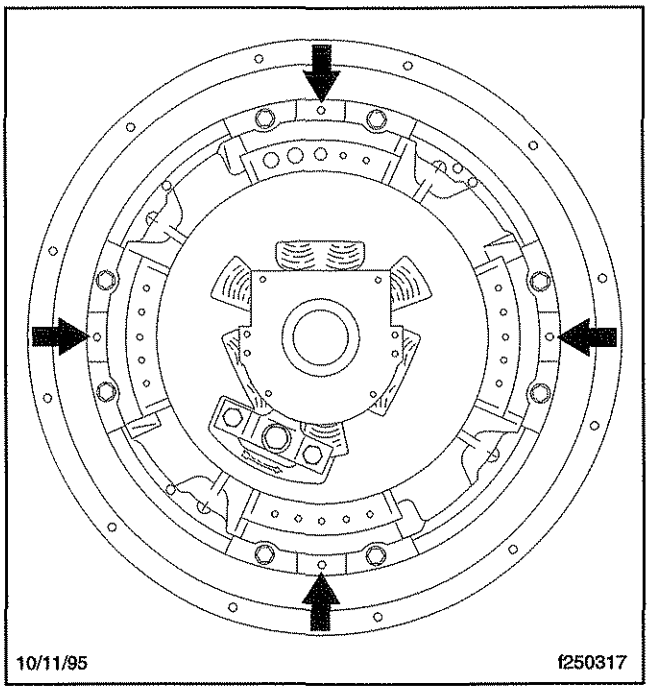


Fig. 17, Pin Access Holes, Easy-Pedal

the access holes. This step verifies that all the four pins are flush against the flywheel. See **Fig. 18.**

NOTE: Failure to perform this step properly may cause the clutch to drag (clutch does not release). If necessary, after the transmission has been installed, the four pins can be set through the inspection opening of the transmission bell housing.

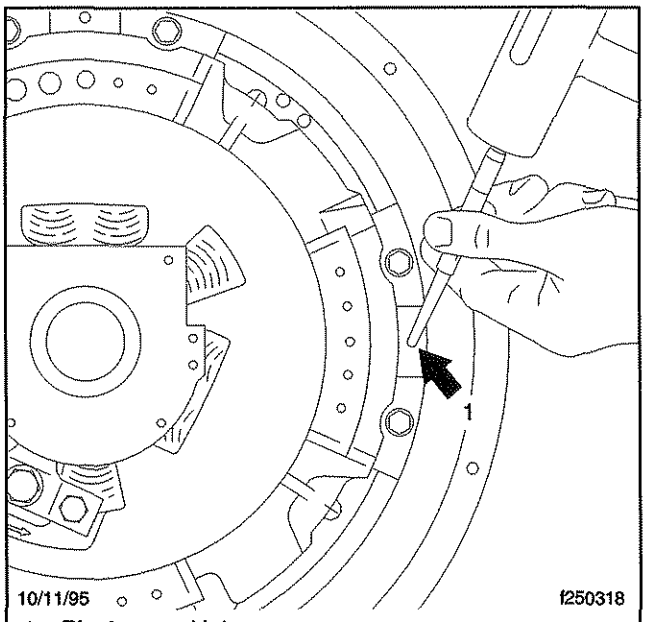
12. Using a clean cloth, remove all grease from the input shaft.
13. Shift the transmission into gear. Rotate the transmission input shaft to line up with the clutch driven-disc hub splines during assembly.
14. Install the transmission and attach the clutch linkage.

IMPORTANT: Be sure the release yoke clears the bearing, and is rotated over the wear pads as the transmission is moved forward. See **Fig. 12.** Align the splines by turning the transmission output shaft.

⚠ CAUTION

Avoid springing the driven discs when the transmission is being installed. Don't force the transmission into the clutch or flywheel housing if it doesn't enter freely. Don't let the transmission drop or hang unsupported in the driven discs. These practices can damage the clutch assembly.

15. Grease the release bearing and release shafts. For instructions and recommended lubricants, See **Group 25** of the *Century Class Trucks Maintenance Manual.*
16. Adjust the clutch according to the procedures in **Subject 100.**



1. Pin Access Hole

Fig. 18, Tapping the Pin, Easy-Pedal

Troubleshooting Tables

Problem—The Clutch Does Not Release Completely

Problem—The Clutch Does Not Release Completely	
Possible Cause	**Remedy**
The clutch pedal height is incorrect.	Adjust the clutch to obtain the following settings: • 1/2 to 9/16 inch (12.7 to 14.3 mm) release bearing travel; • 0.105 to 0.145 inch (2.7 to 3.7 mm) release yoke free-travel; and • 1/2 to 1 inch (12.7 to 25.4 mm) clutch brake squeeze.
The bushing in the release bearing sleeve assembly is damaged.	Replace the clutch cover.
The clutch cover assembly is not properly seated into the flywheel.	Re-seat the clutch cover assembly into the flywheel. Use a crisscross pattern when tightening the mounting bolts.
The intermediate plate and/or pressure plate is cracked or broken.	Replace any damaged parts.
The cross shafts protrude through the release yoke (a side-loading condition exists).	Check for protruding cross shafts. Repair or replace as necessary.
The release yoke fingers are bent or worn (a side-loading condition exists).	Install a new release yoke.
The engine housing and bell housing are misaligned (a side-loading condition exists).	Check for loose transmission mounting bolts. Tighten the transmission mounting bolts to the proper torque.
The clutch linkage is set up improperly (a side-loading condition exists).	Thoroughly examine the clutch linkage and adjust as necessary.
The driven discs are distorted or warped.	Replace any distorted or warped driven discs. If the transmission is allowed to hang unsupported during clutch installation, the driven discs may become distorted.
The driven discs are installed backwards, or the front and rear driven discs were switched with each other.	Install new driven discs. Also, check the clutch cover for any damage. Replace the clutch cover if damaged.
The input shaft spline is worn.	Replace the input shaft. Also, check the driven disc hubs for wear. Replace the driven discs if worn.
The input shaft spline is coated with grease, anti-seize compound, etc.	Clean and dry the input shaft spline before installation.
The input shaft splines are twisted.	Select a new driven disc and slide it along the full length of the splines. If the disc does not slide freely, replace the input shaft.
The input-shaft bearing cap is worn.	Replace the input-shaft bearing.
The flywheel pilot bearing fits either too tight or too loose in the flywheel and/or end of input shaft.	Check the pilot bearing for proper fit and replace it if worn.
The pilot bearing is dry or damaged.	Replace the pilot bearing.
The positive separator pins are bent, damaged or incorrectly set.	Be sure to use the proper tool when setting the positive separator pins. Also, take great care when handling the intermediate plate. For procedures, see **Subject 130**.

Troubleshooting

Problem—The Clutch Does Not Release Completely	
Possible Cause	**Remedy**
The clutch brake is damaged and/or not functioning.	Install a new clutch brake.
The driven disc faces are coated with oil or grease.	Replace the driven disc assemblies. Cleaning the old driven discs is not recommended.
There is foreign material (dirt, chaff, salt, etc.) inside the clutch cover.	Remove the foreign material and make sure the clutch inspection cover is installed.
The drive pins are cocked, causing the intermediate plate to stick on the drive lugs (Easy-Pedal only).	The drive pins must be ninety degrees square to the flywheel surface with a 0.006-inch (0.15-mm) minimum clearance between drive pins and intermediate plate slots. Repair or replace as necessary.
The pressure plate is not fully retracting (Easy-Pedal only).	Check the pressure plate return springs through the clutch inspection cover. If any are bent, stretched, or broken, replace them as necessary.
The release bearing travel is excessive and is causing the lever to contact the pressure plate (Easy-Pedal only).	Adjust the release bearing travel from 1/2 to 9/16 inch (12.7 to 14.3 mm).
The three anti-rattle springs were installed backwards (Easy-Pedal only).	Install the anti-rattle springs so the rounded sections are pointed toward the flywheel/engine.

Problem—The Clutch Rattles or Is Noisy

Problem—The Clutch Rattles or Is Noisy	
Possible Cause	**Remedy**
There is excessive flywheel runout.	Repair or replace the flywheel. For procedures, see the engine manufacturer's manual.
There is corrosion between the input shaft spline and the driven disc hubs.	Clean the mating parts between the input shaft and driven discs to ensure that the discs slide freely over the input shaft spline.
The engine idle is too fast.	Readjust engine idle to proper idling speed.
The clutch release bearing is dry or damaged.	Lubricate the clutch release bearing. If the noise persists, install a new clutch cover.
The flywheel pilot bearing is dry or damaged.	Replace the flywheel pilot bearing.
The bridge of the release yoke is hitting the clutch cover (an over-stroking condition exists).	Check for a worn, broken or missing clutch brake. Also, check the release yoke and input-shaft bearing cap for wear. Replace any worn parts.
The release yoke fingers are hitting the clutch cover.	Check if the release bearing, clutch cover, or release yoke fingers are worn or broken. Replace worn parts.
The clutch inspection cover is not installed.	Re-install the clutch inspection cover.
The sleeve bushings are worn.	Investigate for any side-loading conditions on the release bearing housing. If there is a side-loading condition, determine its cause. Also, before installing the new clutch, make sure that the side-loading condition has been corrected.
The clutch linkage is rattling excessively.	Clean, lubricate and reassemble or replace missing/worn parts.
An idle gear rattle is coming from the transmission.	Specify low-vibration driven discs. Check the engine for correct idle speed. For procedures, consult the engine manufacturer's manual.

Problem—The Clutch Rattles or Is Noisy	
Possible Cause	**Remedy**
The damper spring cover of the driven disc assembly is interfering with the flywheel.	Install the correct clutch assembly.
The rivets of the rear driven disc are interfering with the retainer assembly (Easy-Pedal only).	Adjust the clutch internally (via the adjustment bolt). For procedures, see **Subject 100.**

Problem—The Clutch Vibrates

Problem—The Clutch Vibrates	
Possible Cause	**Remedy**
The flywheel is loose.	Retighten the flywheel mounting bolts to the proper specifications.
The universal joints are worn.	Replace the worn parts.
The driveshaft is not properly phased.	Investigate and correct the phasing of the driveshaft.
The driveshaft is not balanced.	Balance and straighten the driveshaft.
The driveline angles are incorrect.	Shim the drivetrain components to equalize universal joint angles.
The flywheel is not balanced.	Balance the flywheel.
The pilot area of the clutch is not completely seated into the flywheel.	Ensure that no dirt, burrs, etc., are preventing the clutch cover from completely seating into the flywheel mounting surface.
The engine mounts are loose, damaged, or worn out.	Replace any worn or damaged parts. Retighten all bolts to proper specifications.
The engine is misfiring.	The engine is not in tune. To correct the problem, see the engine manufacturer's manual.
There is excessive flywheel runout.	Repair or replace the flywheel. For procedures, see the engine manufacturer's manual.
The rivets of the rear driven disc are interfering with the retainer assembly (Easy-Pedal only).	Adjust the clutch internally (via the adjustment bolt). For procedures, see **Subject 100.**

Problem—The Clutch Needs Frequent Adjustments

Problem—The Clutch Needs Frequent Adjustments	
Possible Cause	**Remedy**
The release yoke free-travel is insufficient.	After first adjusting the clutch for 1/2 to 9/16 inch (12.7 to 14.3 mm) release bearing travel, adjust the clutch linkage to obtain release yoke free-travel of 0.105 to 0.145 inch (2.7 to 3.7 mm).
The clutch specification is incorrect.	Check the clutch specifications in **Subject 400.** Install a new clutch with the proper specifications, if necessary.
The cross shafts and/or clutch linkage system is worn.	Investigate the entire clutch linkage system to determine if it is binding or operating sporadically and/or worn excessively.
The clutch driven discs are worn down to the rivets.	Install a new clutch. For procedures, see **Subject 130.**
The crankshaft has excessive end play.	Repair or replace the crankshaft. Consult the engine manufacturer's manual for procedures.

Troubleshooting

Problem—The Clutch Slips

Problem—The Clutch Slips	
Possible Cause	**Remedy**
The clutch pedal has no free travel.	Readjust the clutch.
The clutch is overloaded.	Verify that the proper clutch has been specified for the particular vehicle application.
The release mechanism is binding.	Free up the release mechanism and linkage. Also, check the clutch linkage adjustment.
The driven disc faces are coated with oil or grease.	Replace the driven disc assembly.
The driver is riding the clutch pedal.	Use correct driving procedures.
The input shaft spline is worn.	Replace the input shaft.

Problem—The Clutch Grabs or Chatters

Problem—The Clutch Grabs or Chatters	
Possible Cause	**Remedy**
The clutch is worn out.	Replace the clutch and all worn components.
The linkage system is not operating freely.	Check the clutch linkage for binding or excessive wear. Replace all worn parts.
The driven disc faces are coated with oil or grease.	Replace the driven disc assembly.
The engine mounts are loose.	Retighten the engine mounts to manufacturer's specifications.
The release yoke fingers and/or the release bearing wear pads are worn excessively.	Replace all the worn parts.

All Heavy-Duty Clutches

Clutch Torque Values in lbf·ft (N·m)				
Description	**Size**	**Grade**	**Easy-Pedal™**	**Solo™ Heavy-Duty**
Mounting Bolts, Clutch Cover to Flywheel	7/16–14 x 2-1/4	5	40–50 (54–68)	40–50 (54–68)

Table 1, Clutch Torque Values

Clutch Adjustments		
Dimension	**Definition**	**Specification in inch (mm)**
Release Bearing Travel (internal adjustment)	The distance between the release bearing and the clutch brake.	1/2–9/16 (12.7–14.3)
Release Yoke Free-Travel (linkage adjustment)	The distance between the release yoke fingers and the release bearing wear pads.	0.105–0.145 (2.7–3.7)
Clutch Brake Squeeze (pedal adjustment)	The movement of the clutch pedal from the time that the clutch brake contacts the release bearing until the pedal reaches the end of its stroke.	1/2–1 (12.7–25.4)

Table 2, Clutch Adjustments

Clutch Inspection Tolerances			
Measurement	**Dial Indicator at**	**Gauge Finger at**	**Maximum Runout in inch (mm)**
Flywheel Face Runout	Flywheel Housing	Flywheel Face	0.008 (0.20)
Pilot Bearing Bore Runout	Flywheel Housing	Pilot Bearing Bore	0.005 (0.13)
Flywheel Housing Bore Runout	Crankshaft	Flywheel Housing Bore	0.008 (0.20)
Flywheel Housing Face Runout	Flywheel Outer Diameter	Flywheel Housing Face	0.008 (0.20)

Table 3, Clutch Inspection Tolerances

Minimum Flywheel Bores	
Disc Type	**Minimum Flywheel Bore in inch (mm)**
10-Spring	8.562 (217.48)
9-Spring	9.750 (247.65)
8-Spring	7.250 (184.15)
7-Spring	9.750 (247.65)
6-Spring	9.750 (247.65)

Table 4, Minimum Flywheel Bores

Solo Heavy-Duty Clutches

Specifications

Solo Heavy-Duty Clutch Specifications					
Solo Part Number		Flywheel Bore in inch (mm)	Damper Style	No. of Springs	No. of Facings
Standard Yoke	Roller Yoke				
109701–81	N/A	7.0 (178)	Free Travel	8	4
109701–74	N/A	8.5 (216)	Free Travel	10	4
109701–82	109705–82Y	10.0 (254)	Low Rate	7	4
109701–20	109705–20Y	10.0 (254)	VCTplus	7	6
109701–25	109705–25Y	10.0 (254)	VCTplus	7	6
N/A	109706–32Y	10.0 (254)	VCTplus	7	6

Table 5, Solo Heavy-Duty Clutch Specifications

Solo Heavy-Duty Clutch Capacity				
Solo Part Number		Plate Load in lbf (N)	Torque in lbf.ft (N.m)*	Pressure Spring Color Code
Standard Yoke	Roller Yoke			
109701–81	N/A	3600 (16 000)	1400 (2000)	White
109701–74	N/A	3600 (16 000)	1650 (2235)	Plain
109701–82	109705–82Y	4000 (18 000)	1700 (2305)	Plain
109701–20	109705–20Y	4000 (18 000)	1860 (2520)	Red
109701–25	109705–25Y	4000 (18 000)	2050 (2780)	White
N/A	109706–32Y	4000 (18 000)	2250 (3050)	Green

* The clutch torque rating must equal or exceed the rated torque of the engine.

Table 6, Solo Heavy-Duty Clutch Capacity

Solo Clutch Pressure Plate Wear Pin Resetting	
Component	Depth in inch (mm)
Pressure Plate Face	0.525 (13.3)

Table 7, Solo Clutch Pressure Plate Wear Pin Resetting

Easy-Pedal Clutches

Easy-Pedal Clutch Specifications				
Easy-Pedal Part Number	Flywheel Bore in inch (mm)	Damper Style	No. of Springs	No. of Facings
108391–81	7.0 (178)	Free Travel	8	4
108391–74B	8.5 (216)	Free Travel	10	4
108925–82B	10.0 (254)	Low Rate	7	4
108925–20	10.0 (254)	VCTplus	7	6
108925–25	10.0 (254)	VCTplus	7	6

Table 8, Easy-Pedal Clutch Specifications

Specifications

Easy-Pedal Clutch Capacity			
Easy-Pedal Part Number	**Plate Load in lbf (N)**	**Torque in lbf.ft (N.m)***	**Pressure Spring Color Code**
108391–81B	3600 (16 000)	1400 (2000)	White
108391–74B	3600 (16 000)	1650 (2235)	Plain
108925–82B	4000 (18 000)	1700 (2305)	Plain
108925–20	4000 (18 000)	1860 (2520)	Red
108925–25	4000 (18 000)	2050 (2780)	White

* The clutch torque rating must equal or exceed the rated torque of the engine.

Table 9, Easy-Pedal 15-1/2 Inch Clutch Capacity

Easy-Pedal Clutch Component Dimensions		
Dimension	**Standard Duty in inch (mm)**	**Super Duty in inch (mm)**
Driven Disc Thickness (new)	0.450 (11.43)	0.360 (9.43)
Intermediate Plate Thickness (new)	0.580–0.630 (14.73–16.00)	0.750–0.810 (19.05–20.57)

Table 10, Easy-Pedal Clutch Component Dimensions

Rockwell® "Lite Pedal" 15-1/2 Inch Clutch 25.01

Contents

Subject	Subject Number
General Description and Principles of Operation	050
Service Operations	
Clutch Adjustments	100
Clutch Removal	110
Clutch Inspection	120
Clutch Installation	130
Troubleshooting	300
Specifications	400

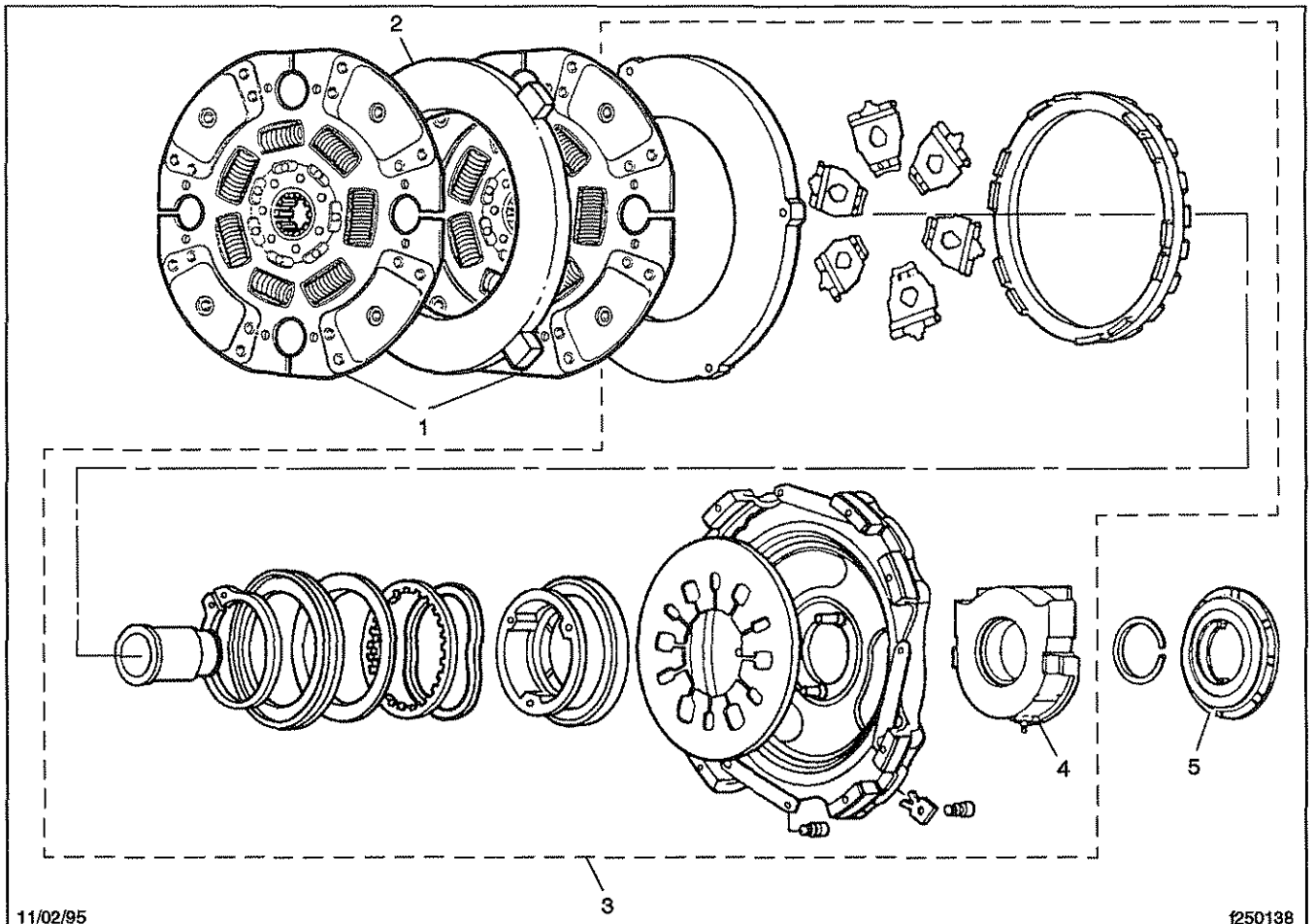
General Description and Principles of Operation

Rockwell clutches **(Fig. 1)** are available in 15-1/2 inch models in Freightliner trucks. An identification plate is located on the front cover. Rockwell clutches feature the following design characteristics:

- Two-plate
- Diaphragm-spring
- Pull-type
- Dry-disc
- Eight-hole installation pattern

Mounted directly on the flywheel, the clutch cover assembly houses most of the components, including the pressure plate. A diaphragm-type spring provides the force necessary to push the pressure plate forward and engage the clutch. The center plate, which separates the driven discs, has tabs that fit into slots on the clutch cover assembly.

A splined transmission input shaft projects through the cover assembly and driven discs and rests in a pilot bearing in the center of the flywheel. The splined hubs of the driven discs mesh with the splined input shaft



1. Ceramic Discs
2. Center Plate
3. Pressure Plate and Cover Assembly
4. Release Bearing
5. Clutch Brake

Fig. 1, Rockwell Two-Plate Clutch

General Description and Principles of Operation

to transmit power from the engine to the transmission. The rest of the clutch assembly can spin freely around the input shaft when the clutch pedal is depressed.

A clutch brake stops the transmission gears from rotating when the truck is stopped and when shifting into first or reverse gears. This lets the gears engage quickly without gear clash.

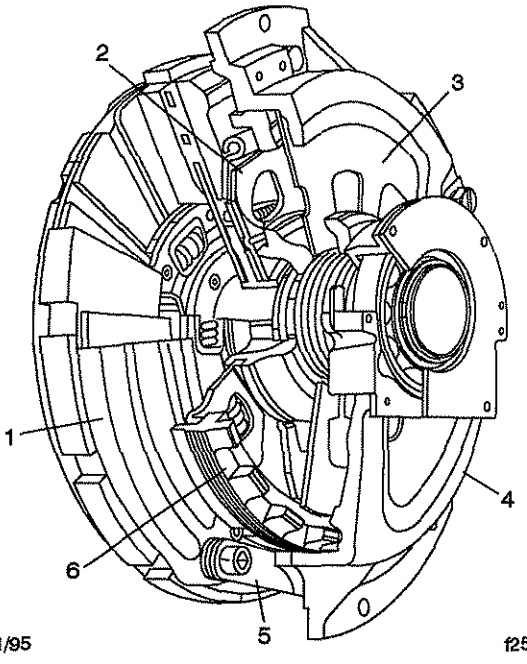
The release bearing assembly transfers the movement of the clutch linkage to engage or disengage the clutch. The release bearing assembly is available with a grease fitting or as a "lubed for life" assembly. Ball bearings permit the release bearing to rotate freely. A coil spring is installed on the sleeve between the release bearing and the hub. The coil spring holds the sleeve on the retainer in a "ball joint" arrangement. This prevents vibration and allows for minor misalignment that may occur between the transmission and the engine due to tolerances between the mounting surface dimensions.

The pressure plate and cover assembly apply the force necessary to engage the clutch. The following parts are in the pressure plate and cover assembly. **See Fig. 2.**

- The *cover* is the housing for the diaphragm spring, adjusting ring, levers, retainer, and the release bearing sleeve. Three holes in the cover provide air flow to remove heat from the clutch.
- The *diaphragm spring* is a one-piece unit that produces the pressure to lock the discs between the pressure plate, the center plate, and the flywheel. The spring is located and held in the cover by the retainer.
- Six *levers* connect the cover assembly to the release bearing sleeve. The levers multiply and transfer the force of the diaphragm spring from the retainer to the pressure plate.
- The *adjusting ring*, located inside the cover and in front of the pressure plate, controls the release bearing clearance. The clearance must be adjusted periodically to compensate for clutch lining wear.
- The *pressure plate* applies the force from the diaphragm spring and locks the clutch discs between the center plate and the flywheel.

The clutch discs are splined to allow movement along the transmission input shaft. Power is transmitted from the flywheel, pressure plate, and center plate through the discs to the transmission. Dampened ceramic clutch discs absorb vibration with spring washers, friction material, and co-axial torsion springs. Ceramic disc linings **(Fig. 3)**, are made from ceramic and bronze material. Rivets fasten the ceramic lining to the disc. The ceramic lining provides positive clutch engagement. The co-axial torsion springs also absorb torque shock during engagement.

The center plate increases the service life of the clutch by increasing the surface area for power transfer. The 15-1/2 inch clutch center plate is driven by tabs on the plate which fit into slots on the clutch cover.



1. Pressure Plate
2. Lever
3. Diaphragm Spring
4. Cover
5. Strap
6. Adjusting Ring

Fig. 2, Clutch Components

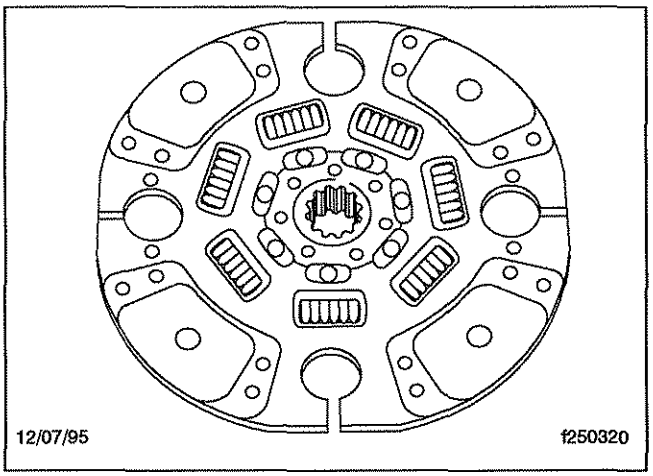


Fig. 3, Ceramic Disc

Clutch Adjustments

NOTE: Clutch linkage adjustment is required only after repair or replacement of the clutch or clutch linkage components. Refer to the clutch linkage section in this manual for procedures.

Internal clutch adjustments should be done whenever:

- the clutch is removed or installed
- any component of the clutch linkage is serviced
- the clutch free pedal is less than 1/2 inch (13 mm).

Make sure of the following before adjusting the clutch:

- The clutch system is in good condition.
- The linkage is tight but moves freely during operation.
- There is no "false" free pedal. Keep the clutch lever from moving and depress the clutch pedal. If the pedal moves more than 1/2 inch (13 mm), "false free pedal" is in the linkage. Inspect the linkage and all pivot points for wear or damage. Repair or replace worn or damaged parts.
- The release fork moves when the clutch pedal moves.

RELEASE-BEARING CLEARANCE CHECK

1. Remove the inspection hole cover on the clutch housing.
2. Measure the distance between the end of the release bearing and the clutch brake. **See Fig. 1.** This distance must be 1/2 to 9/16 inch (12.7 to 14.3 mm).

NOTE: While checking this dimension, pull the release bearing toward the transmission, using your hand or a screwdriver.

IMPORTANT: An inspection tool A02–12419 (available through the PDCs) can be used to check the distance between the release bearing and the clutch brake. **See Fig. 2.** One end of the tool has green tape on it and is 0.50 inch (12.7 mm) in diameter; the other end has blue tape on it and is 0.56 inch (14.3 mm) in diameter.

3. If using tool A02–12419 to check the distance between the release bearing and the clutch brake, position the tool so that the legs straddle the transmission input shaft. Check the gap with both ends of the tool as follows:

   3.1 Insert the blue 0.56-inch (14.3-mm) end. If it fits loosely the gap is too wide and adjustment is needed. Go to the next step.

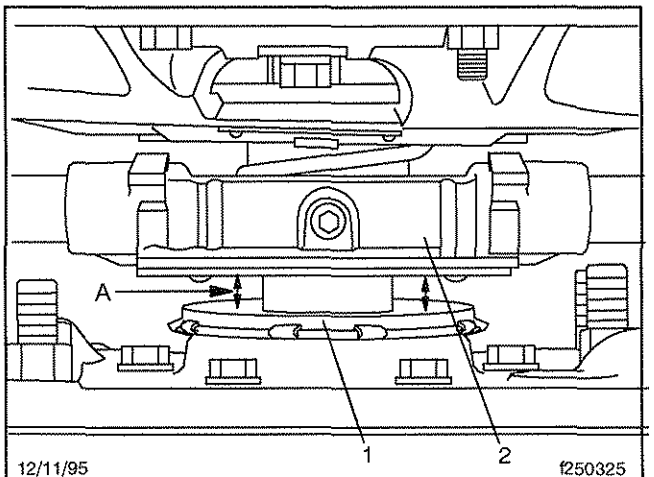
   3.2 If the blue 0.56-inch (14.3-mm) end can't be inserted in the gap, then try to insert the green 0.50-inch (12.7-mm) end. If the green end of the tool fits, snug or loose, then no adjustment is needed.

   3.3 If the green end of the tool can't be inserted in the gap, adjustment is needed. Go to the next step.

4. If the release bearing clearance is not correct, adjust the clutch.

   4.1 Turn the flywheel so that the lock plate is seen through the inspection cover. **See Fig. 3.**

   NOTE: Do not use the starter to move the flywheel. Turn the crankshaft with a socket wrench on the front pulley. If the front pulley is difficult to turn, use a spanner wrench on the teeth of the flywheel. See the engine manufacturer's manual for further information.

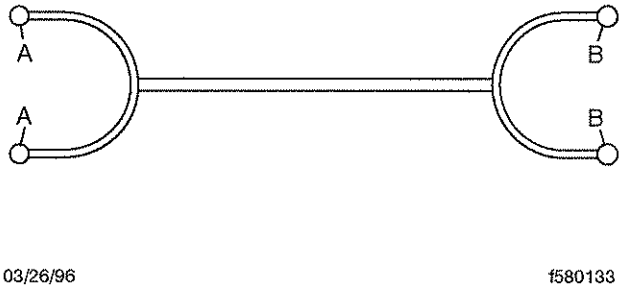


A = 1/2 to 9/16 inch (12.7 to 14.3 mm) Clearance

1. Clutch Brake
2. Release Bearing

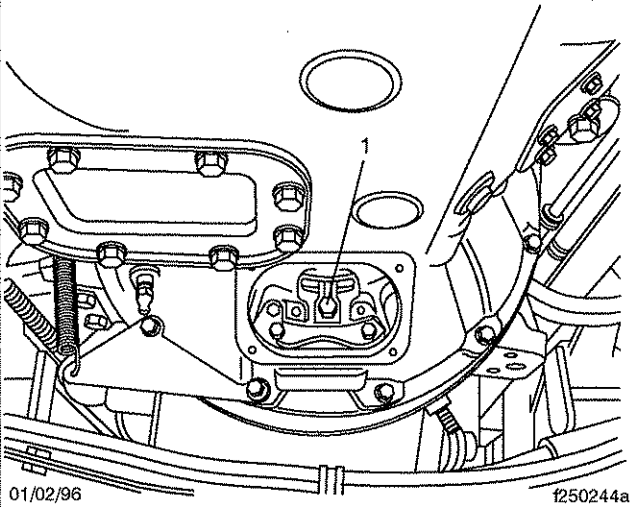
Fig. 1, Measuring the Release Bearing Clearance

Clutch Adjustments



A. 0.50 inch (12.7 mm)
B. 0.56 inch (14.3 mm)

Fig. 2, Inspection Tool A02-12419



1. Lock Plate

Fig. 3, Remove the Lock Plate

4.2 Push the clutch pedal to the bottom of its travel. Have another person hold the pedal at the bottom of its travel (or use a block of wood to hold the pedal).

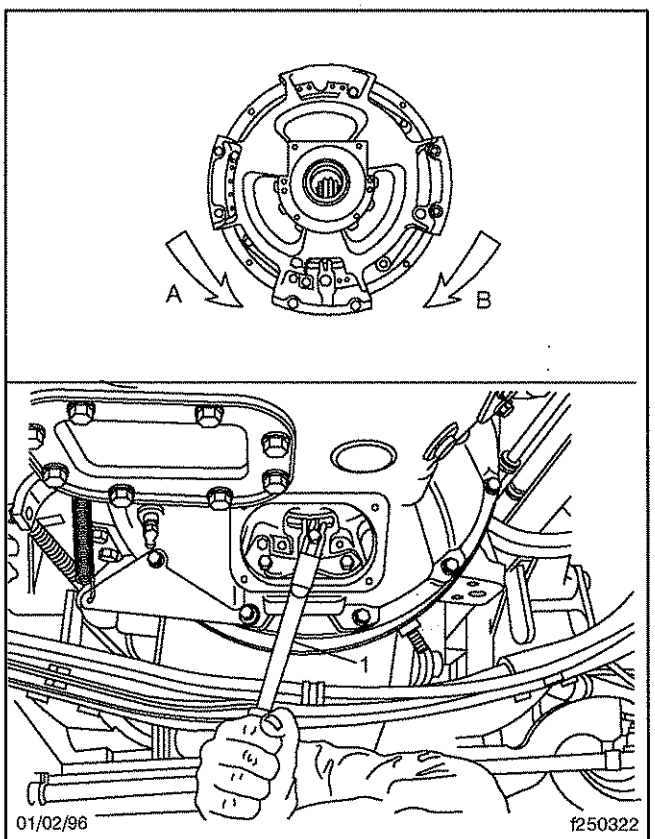
4.3 Remove the capscrew and lockwasher that fasten the lock plate to the clutch cover. **See Fig. 3.**

4.4 Turn the adjusting ring to obtain the specified release bearing clearance. Using a screwdriver or an adjusting tool as a lever against the notches in the ring, move the adjusting ring. **See Fig. 4.** When the adjusting ring is moved one notch, the release bearing will move 1/32 inch (about 0.5 mm).

NOTE: The adjusting tool is available from: Kent-Moore Tools, part number J 36216; Owatonna Tools, part number 7028; or, Snap-on Tools, part number GA454.

4.5 Install the lock plate. Install the capscrew that fastens the lock plate to the clutch cover. Tighten the capscrew 25 to 30 lbf·ft (34 to 40 N·m).

4.6 Release the clutch pedal.



A. Turn the adjusting ring in this direction to move the release bearing *toward* the clutch.
B. Turn the adjusting ring in this direction to move the release bearing *away from* the clutch.

1. Adjusting Ring Tool

Fig. 4, Turning the Adjusting Ring

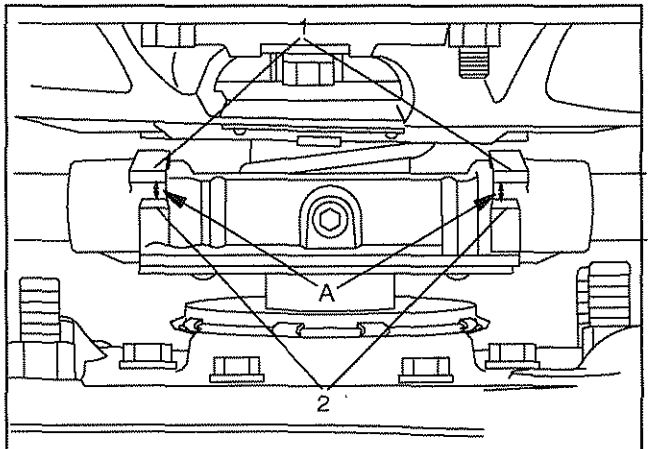
5. Check the clearance between the tips of the release fork and the bosses on the release bearing. The distance must be 0.105 to 0.145 inch (2.7 to 3.7 mm). **See Fig. 5.** If necessary, adjust the clutch linkage. For instructions, refer to the clutch linkage section in this group.

NOTE: The pedal must be released to check the release bearing clearance.

IMPORTANT: An inspection tool A02–12254 (available through the PDCs) can be used to check the distance between the bosses on the release bearing and the tips of the release fork (free travel). **See Fig. 6.**The legs on one end of the tool have green tape on them and are 0.105 inch (2.7 mm) thick; the legs on the other end have blue tape on them and are 0.145 inch (3.7 mm) thick.

6. If using tool A02–12254 to check the distance between the release bearing and the release fork, position the tool so it straddles the fork to ensure that there won't be any misalignment. Check the distance with both ends of the tool as follows:

   6.1 Insert the blue 0.145-inch (3.7-mm) end. If it fits loosely the gap is too wide and adjustment is needed. Go to the section on clutch linkage adjustment in this group.



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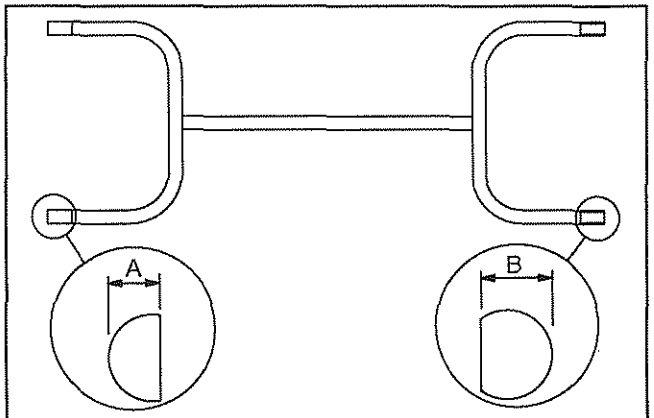
NOTE: A = 0.105 to 0.145 inch (2.7 to 3.7 mm) Clearance

1. Release Fork
2. Boss on Release Bearing

Fig. 5, Checking Clearance

   6.2 If the blue 0.145-inch (3.7-mm) end can't be inserted in the gap, then try to insert the green 0.105-inch (2.7-mm) end. If the green end of the tool fits, snug or loose, then no adjustment is needed.

   6.3 If the green end of the tool can't be inserted in the gap, adjustment is needed. Go to the section on clutch linkage adjustment in this group.



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A. 0.105 inch (2.7 mm)
B. 0.145 inch (3.7 mm)

Fig. 6, Inspection Tool A02-12254

Removal

1. Remove the transmission. Follow the procedures in **Group 26** of this manual.

CAUTION: Do not let the rear of the transmission drop, and do not let the transmission hang unsupported by the input shaft in the pilot bearing bore in the flywheel. Taking these precautions will prevent damage to the clutch assembly and the pilot bearing.

2. Remove the clutch brake assembly from the transmission input shaft. **See Fig. 1.**

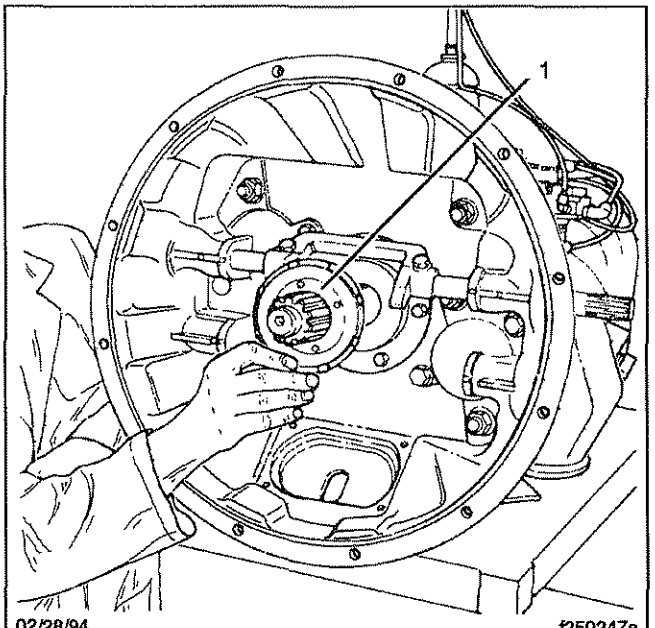
3. Install a clutch alignment tool through the clutch and into the flywheel pilot bearing to support the clutch assembly during removal. Use the correct tool so that the splines of the tool match the splines in the clutch. **See Fig. 2.**

NOTE: If an alignment tool is not available, use an input shaft from a manual transmission. Remove the gear from the the end of the input shaft. **See Fig. 3.**

4. Remove the top two bolts that fasten the pressure plate and cover assembly to the flywheel. Install two guide studs in the holes. **See Fig. 4.** The studs can be made by removing the head from two 7/16-inch capscrews.

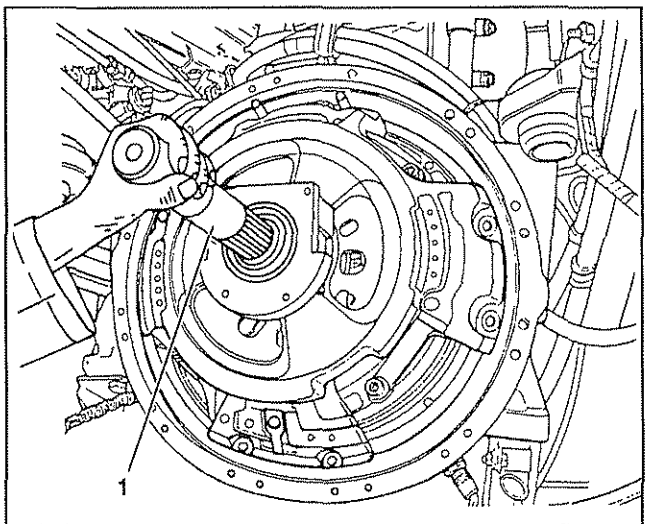
5. Make two wooden spacer blocks 1/2 to 5/8 inch (13 to 16 mm) thick. Insert them between the release bearing assembly and the clutch cover. The wooden spacer blocks ease removal and installation of the clutch. **See Fig. 5.**

WARNING: The pressure plate and cover assembly is heavy and should be removed only with a lifting device. If the assembly is lifted improperly or dropped, it could cause serious personal injury.



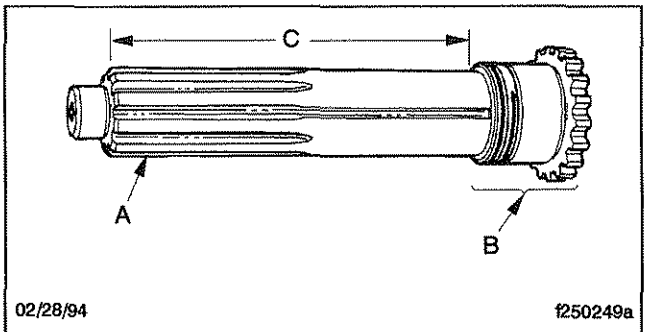
1. Clutch Brake

Fig. 1, Clutch Brake Assembly Removal



1. Alignment Tool

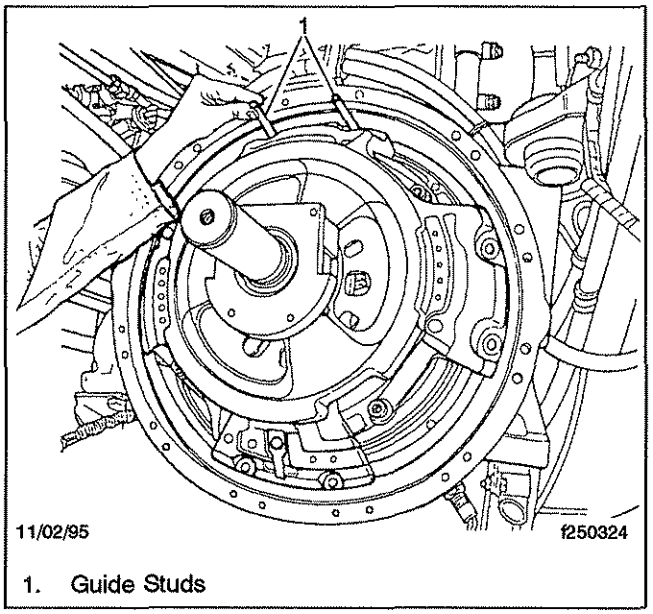
Fig. 2, Clutch Alignment Tool Installation



A. Make sure the splines are not damaged.
B. Remove the gear assembly from an input shaft.
C. 13 Inches (33 cm)

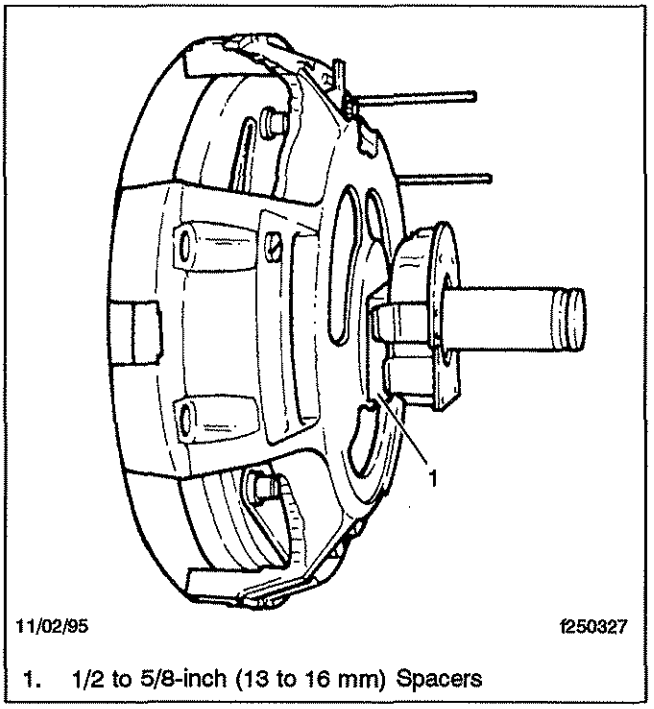
Fig. 3, Manual Transmission Input Shaft

Clutch Removal



1. Guide Studs

Fig. 4, Guide Stud Installation



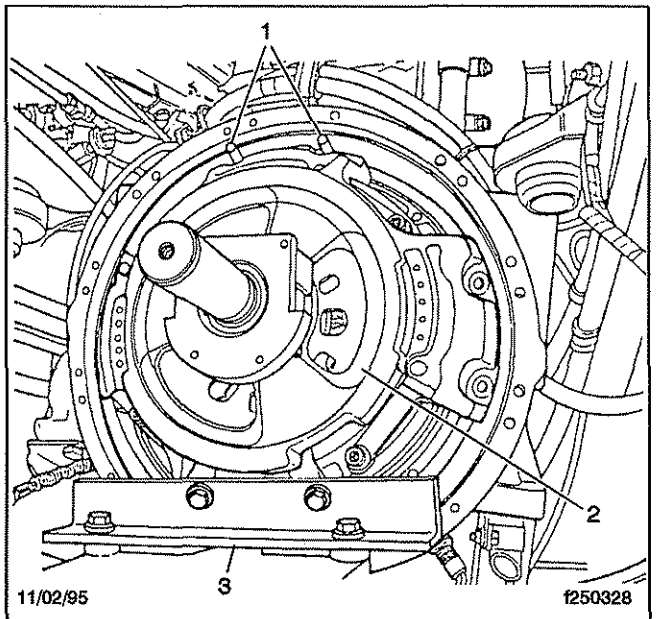
1. 1/2 to 5/8-inch (13 to 16 mm) Spacers

Fig. 5, Spacer Block Installation

6. Connect a lifting device to the pressure plate and cover assembly because of the weight. **See Fig. 6.**
7. Remove the remaining bolts that fasten the pressure plate and cover assembly to the flywheel.

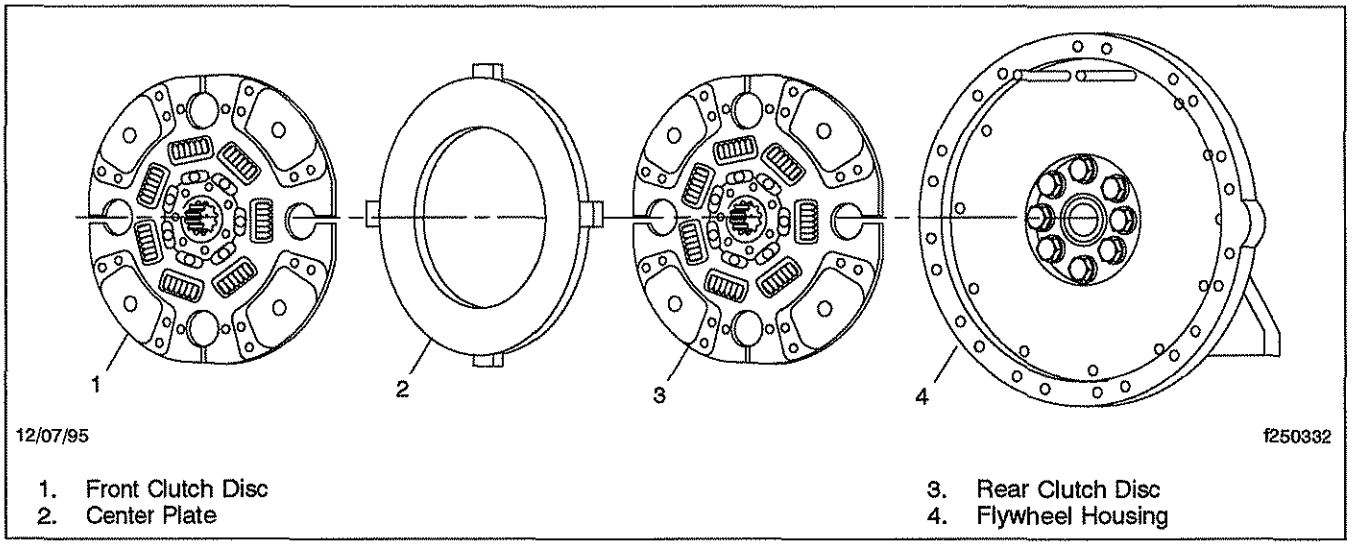
NOTE: When removing the clutch, the discs and the pressure plate can stay in the cover.

8. Remove the pressure plate and cover assembly over the alignment tool and off the flywheel.
9. Remove the alignment tool, the rear disc, the center plate, and the front disc. **See Fig. 7.**
10. Whenever the clutch assembly is serviced or the engine is removed, the pilot bearing in the flywheel should be removed and replaced. Use an appropriate internal puller to remove the pilot bearing. Discard the pilot bearing.



1. Guide Studs
2. 15-1/2 Inch Clutch Assembly
3. Lifting Device

Fig. 6, Connecting a Lifting Device



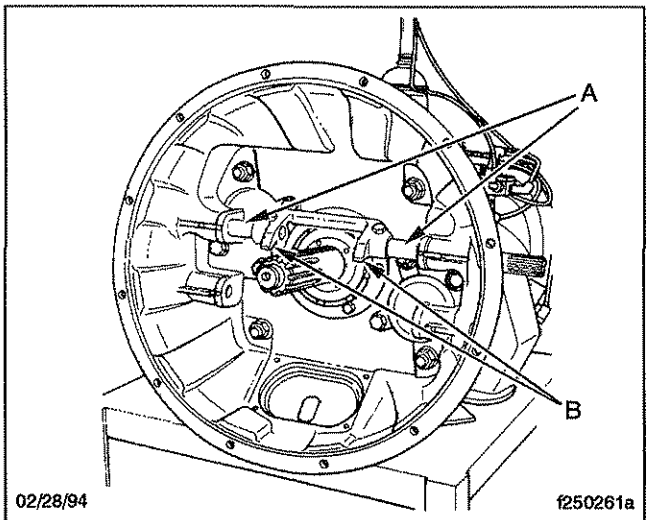
1. Front Clutch Disc
2. Center Plate
3. Rear Clutch Disc
4. Flywheel Housing

Fig. 7, Front Disc, Rear Disc, and Center Plate Removal

Inspection

1. Remove the clutch from the vehicle. Refer to **Subject 110** for instructions.
2. Inspect the release fork and the cross shaft. **See Fig. 1.** Make sure the release fork is straight and the tips of the fork are not worn or damaged. Replace forks that are worn or damaged.

   Make sure the cross shaft rotates freely and doesn't have any side-to-side movement in the transmission housing. If used, inspect the bushings for the shaft in the housing. Replace any parts that are worn or damaged. For instructions, refer to the clutch linkage section in this group.
3. Inspect the splines on the input shaft. **See Fig. 2.** Make sure the splines are not worn or damaged. Inspect the release bearing area of travel for damage. Using an emery cloth, remove small scratches from the input shaft. If the input shaft is worn or damaged, replace it. Any wear or damage on the input shaft causes the clutch to work incorrectly.
4. Remove dirt and contamination from the pressure plate and cover assembly with non-petroleum based cleaning solvents.



A. The cross shaft must rotate freely.
B. The tips on the fork must not be worn or damaged.

Fig. 1, Release Fork and Cross Shaft Inspection

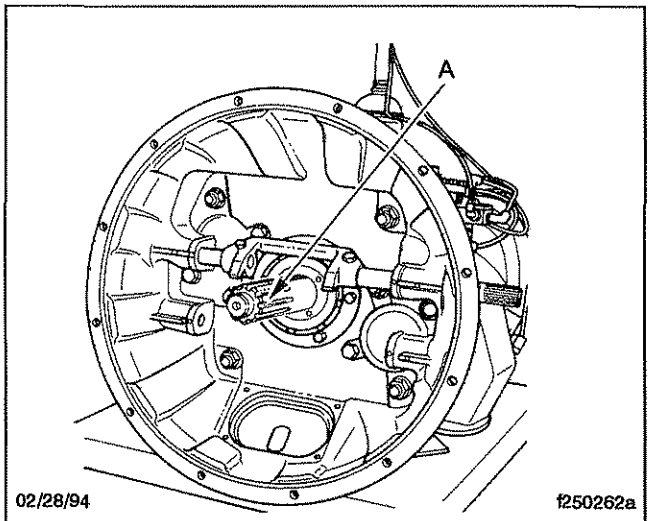
5. Inspect the cover for wear and damage. Make sure the diaphragm spring inside the cover is not broken. **See Fig. 3.** If the diaphragm spring is broken, the clutch cover must be disassembled to replace the spring.
6. Inspect the pressure plate.

   6.1 Visually check the pressure plate for wear or damage. **See Fig. 4.** If the plate is cracked, replace it. Heat marks are normal, and can usually be removed with an emery cloth. If the heat marks can't be removed, replace the pressure plate.

   6.2 Put the pressure plate and cover assembly on a bench with the plate facing up.

   6.3 Using a caliper, measure any scratches or scoring on the pressure plate. **See Fig. 5.** If the damage to the surface of the plate is more than 0.015 inch (0.38 mm), replace the pressure plate.

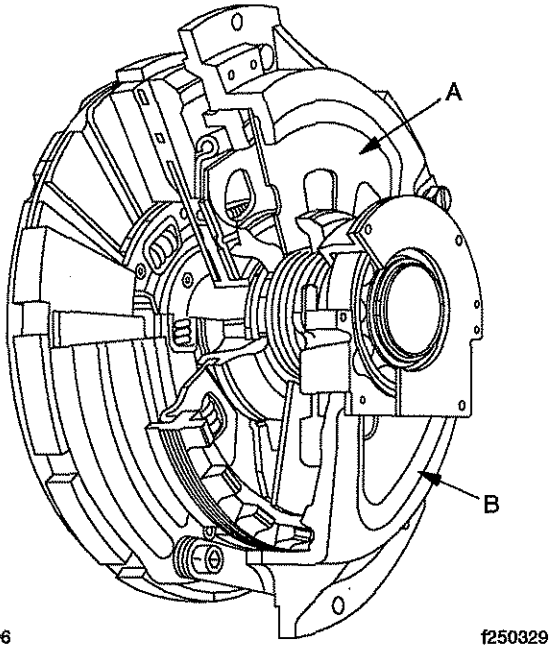
   6.4 Make sure the surface of the pressure plate is flat. Put a straightedge on the surface of the pressure plate, making sure it crosses the center of the plate. **See Fig. 6.** Using a feeler gauge, measure each gap that appears between the straightedge and the pressure plate. Rotate the straightedge through at



A. The splines must not be worn or damaged.

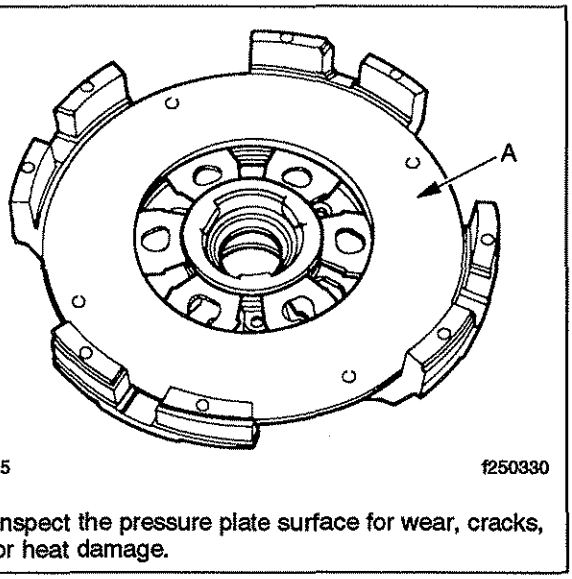
Fig. 2, Input Shaft Splines Inspection

Clutch Inspection



A. Make sure the diaphragm spring is not broken.
B. Make sure the cover is not worn or damaged.

Fig. 3, Diaphragm Spring and Cover Inspection



A. Inspect the pressure plate surface for wear, cracks, or heat damage.

Fig. 4, Pressure Plate Inspection

least four positions. If any gap is more than 0.004 inch (0.10 mm), replace the pressure plate.

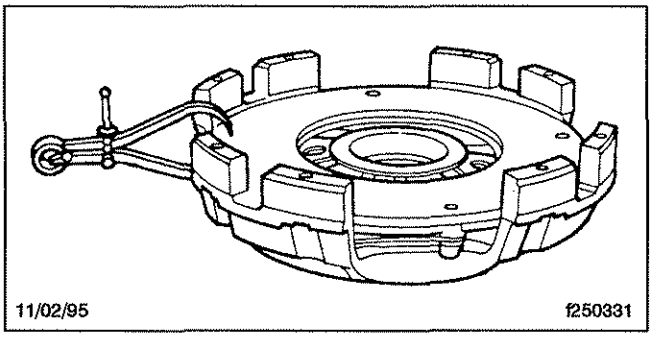
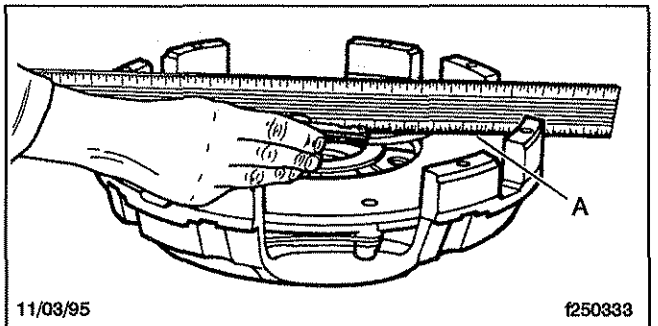


Fig. 5, Measuring Scratches or Scoring on the Pressure Plate

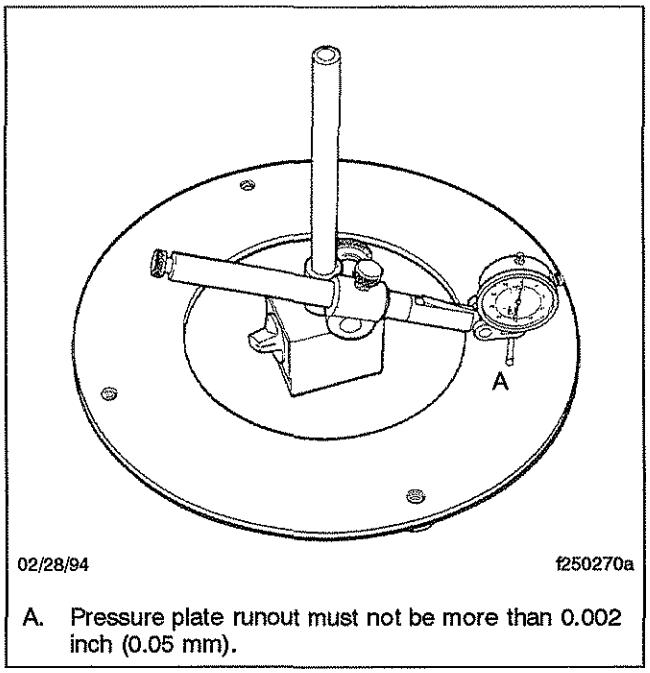
6.5 Measure the runout of the pressure plate to make sure the surfaces are parallel to each other. Put marks on a capscrew, strap, and pressure plate location to ensure that the pressure plate is installed in the original position on the cover. Remove the capscrews that fasten the pressure plate to the strap. Put the pressure plate on a bench so that the smooth surface is up. Put the base of a dial indicator inside the center of the plate. **See Fig. 7.** Put the tip of the dial indicator on the surface of the plate. Set the dial indicator to zero. Rotate the dial indicator one complete turn around the surface of the pressure plate. If the reading on the indicator is more than 0.002 inch (0.05 mm), replace the pressure plate.

7. Inspect the clutch discs.



A. Pressure plate flatness gap must not be more than 0.004 inch (0.10 mm).

Fig. 6, Checking the Pressure Plate Surface



A. Pressure plate runout must not be more than 0.002 inch (0.05 mm).

Fig. 7, Dial Indicator Mounting

7.1 Visually check for wear or damage. If any disc is worn, replace it.

7.2 Make sure the co-axial springs are not loose in the hub. **See Fig. 8.** Springs that rattle are not necessarily loose; springs that have any movement are. If any disc has loose springs, replace it.

7.3 Make sure the splines in the hub are not damaged. Make sure the hub is fastened to the disc. Replace any disc that is damaged.

7.4 Using a cleaning solvent with a non-petroleum base, remove grease and oil from the discs. If the grease and oil cannot be removed, replace the disc.

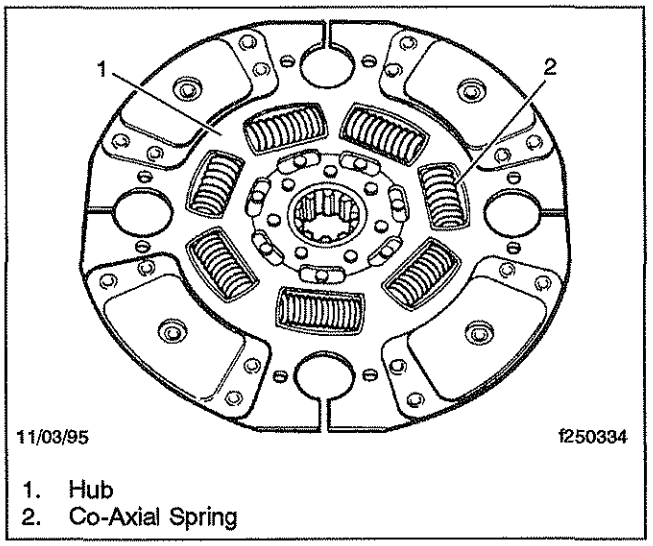
7.5 Ceramic linings are fastened to the disc with rivets. Replace the disc if the lining is loose, damaged, or worn to the top of the rivets. **See Fig. 9.**

8. Inspect the center plate.

8.1 Inspect the tabs on the outer edge of the center plate. **See Fig. 10.** If the tabs are worn or damaged, replace the center plate. If not, go on to the next step and inspect the center plate.

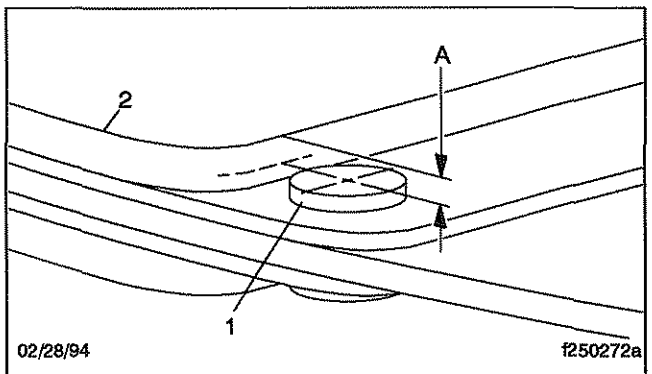
8.2 Inspect the center plate for wear or damage. If the plate is cracked, replace it. Heat marks are normal, and can usually be removed with an emery cloth. If the heat marks cannot be removed, replace the center plate.

8.3 Using a micrometer or a caliper, measure the thickness of the center plate. The



1. Hub
2. Co-Axial Spring

Fig. 8, Checking the Co-Axial Springs

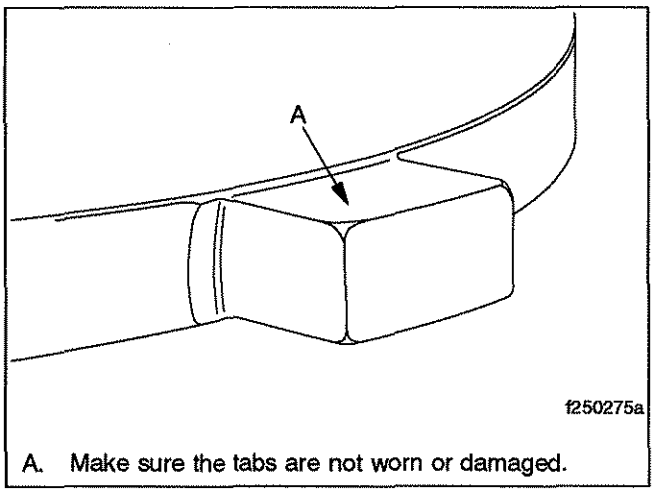


A. Replace the ceramic disc if the lining is even with or below the top of the rivet.

1. Rivet
2. Lining

Fig. 9, Checking the Ceramic Lining

Clutch Inspection



A. Make sure the tabs are not worn or damaged.

Fig. 10, Inspecting the Tabs on 15-1/2 Inch Clutches

minimum thickness should be 0.742 inch (18.84 mm). If the center plate measures less than the minimum thickness, replace it. **See Fig. 11.**

8.4 Make sure the surface of the center plate is flat. Put a straightedge on the surface of the center plate, making sure it crosses the center of the plate. **See Fig. 12.** Using a feeler gauge, measure each gap that appears between the straightedge and the pressure plate. Rotate the straightedge through at least four positions. If any gap is more than 0.002 inch (0.05 mm), grind a new surface on the center plate; if not, go on to the next step.

8.5 Measure the runout of the center plate to make sure the the surfaces are parallel to each other. **See Fig. 13.** Put the base of the dial indicator inside the center of the plate. Put the tip of the dial indicator on the surface of the plate. Set the dial indicator to zero. Rotate the dial indicator one complete turn around the surface of the center plate. If the reading on the indicator is more than 0.002 inch (0.05 mm), grind a new surface on the center plate; if not, go on to the next step.

8.6 If either the runout or the flatness of the center plate is more than 0.002 inch (0.05 mm), grind enough material so that the plate is flat, but do not go below the minimum thickness. Refer to the table in **Specifications, 400** for center plate minimum thickness. Re-check the flatness and runout of the center plate.

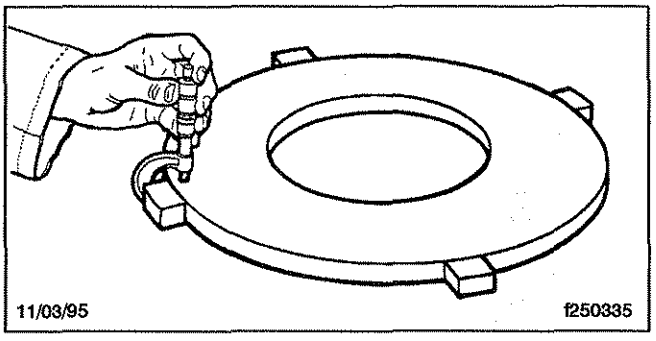
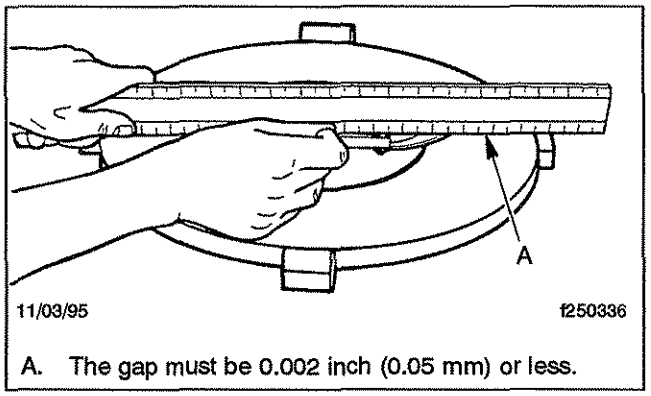
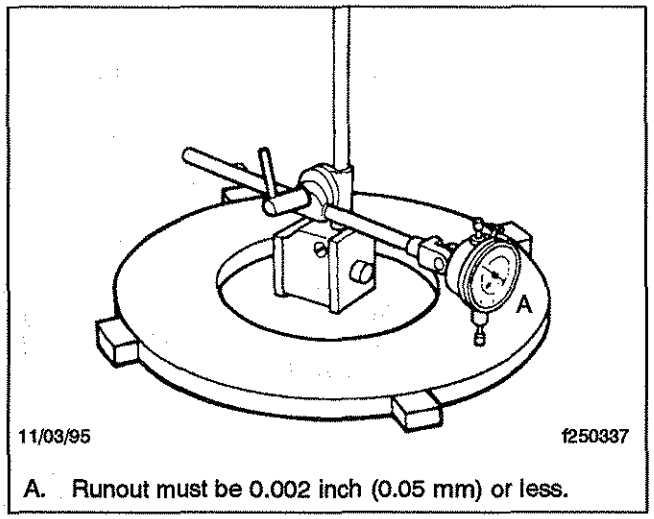


Fig. 11, Measuring Center Plate Thickness



A. The gap must be 0.002 inch (0.05 mm) or less.

Fig. 12, Checking the Center Plate Surface



A. Runout must be 0.002 inch (0.05 mm) or less.

Fig. 13, Measuring Center Plate Runout

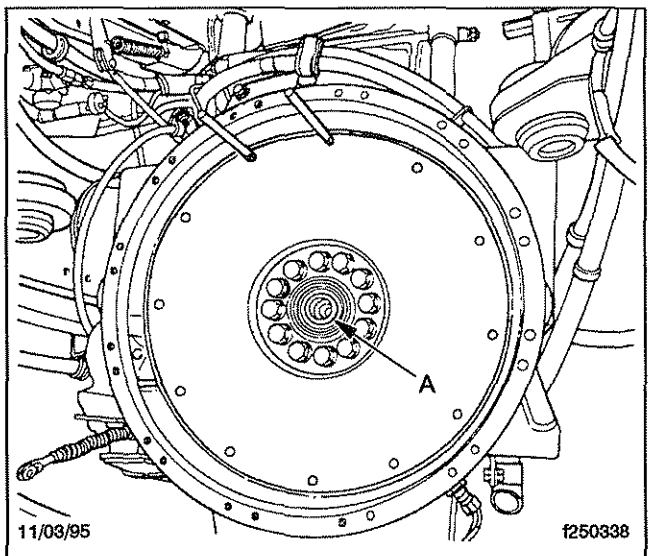
9. Although the pilot bearing must be replaced whenever the clutch is removed, inspect the old pilot bearing for wear or damage. **See Fig. 14.** If worn or damaged, correct the cause.

10. Inspect the surface of the flywheel for wear or damage. If the flywheel is cracked, replace it. Heat marks are normal, and can usually be removed with an emery cloth. Some wear or damage can be removed by grinding a new surface on the flywheel. If wear or damage on the surface of the flywheel cannot be removed, replace the flywheel.

    Refer to the engine manufacturer's service manual for flywheel service procedures.

IMPORTANT: If the flywheel surface is reground, make sure there is still adequate thickness for the capscrews to hold the clutch to the flywheel. The threads for these capscrews are below the surface of some flywheels, requiring the use of capscrews with a shoulder. If some of the flywheel surface is removed, the capscrews may not hold. Use new capscrews that are the correct length.

11. Inspect the ring gear teeth on the outer surface of the flywheel. If the teeth are worn or damaged, replace the ring gear or the flywheel. Refer to the engine manufacturer's service manual for instructions.



A. Make sure the pilot bearing is not worn or damaged.

Fig. 14, Inspecting the Old Pilot Bearing

    Check the tabs on the outer edge of the flywheel. Replace the flywheel if the tabs are worn or damaged.

12. The flywheel surface must be flat for correct clutch operation. Check the runout of the outer surface of the flywheel. Refer to the engine manufacturer's service manual for instructions.

NOTE: In general, maximum runout is 0.0005 inch times the flywheel diameter in inches.

13. Refer to the engine manufacturer's service manual for instructions and check the following:

    - pilot bearing bore runout
    - crankshaft end play
    - runout of the outer surface of the flywheel housing
    - runout of the inside of the flywheel housing

CAUTION: Do not clean ground or polished parts in a hot solution tank or with water, steam, or alkaline solutions. These solutions will cause the parts to corrode.

14. Clean the disassembled parts.

    14.1 Using a cleaning solvent or kerosene, clean all ground or polished parts or surfaces.

    14.2 Rough parts can be cleaned with the ground or polished parts. The rough parts can also be cleaned in hot solution tanks with a weak alkaline solution. The parts must remain in the tank until they are completely cleaned and heated.

    14.3 Dry the parts with clean paper, shop towels, or compressed air immediately after cleaning.

15. Apply lubricant to the cleaned and dried parts that are not damaged and are to be immediately assembled. *Do not* apply lubricant to the linings.

    If parts are to be stored, apply a special material that prevents corrosion and rust to all surfaces. *Do not* apply the material to the linings. Store the parts inside special paper or other material that prevents corrosion and rust.

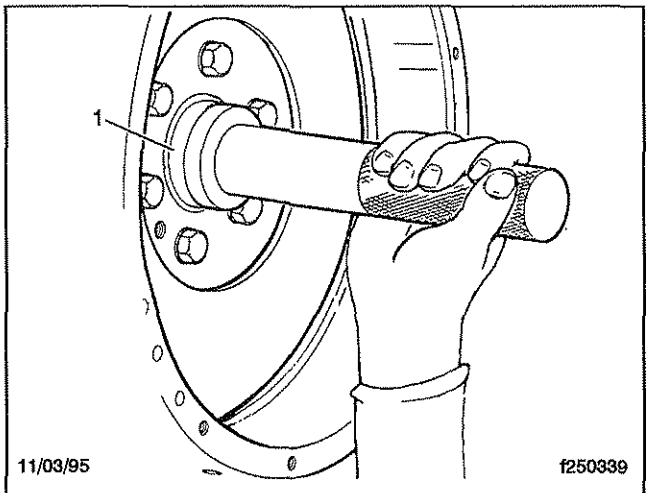
Installation

NOTE: During clutch removal, spacers or wooden blocks are installed between the release bearing and the clutch cover to facilitate removal. Do not remove the spacers or wooden blocks until after the clutch is installed. The spacers or blocks make installation of the clutch easier by holding the clutch components in position.

1. Lubricate the bore in the crankshaft for the pilot bearing with the specified lubricant. Do not use too much lubricant. Excess lubricant can contaminate the discs and cause the clutch to slip.
2. Use the correct size of driver to install the pilot bearing in the crankshaft bore. **See Fig. 1.** Refer to the engine manufacturer's service manual for instructions.
3. Install 3/8-inch guide studs in two of the upper mounting holes for the cover and pressure plate assembly. **See Fig. 2.**

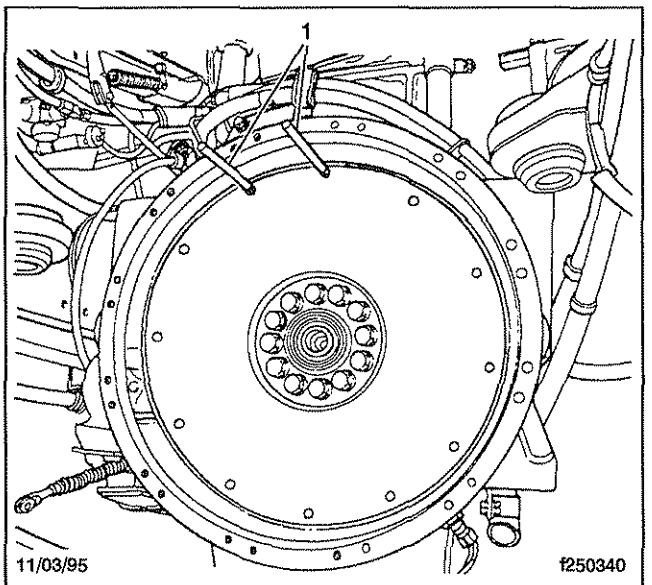
WARNING: The pressure plate and cover assembly is heavy and should be installed only with a lifting device. If the assembly is lifted improperly or dropped, it could cause serious personal injury.

4. Connect a lifting device to the pressure plate and clutch cover assembly. **See Fig. 3.**
5. Install the rear disc in the pressure plate and cover assembly. Make sure the words *PRESSURE PLATE SIDE* on the disc are toward the pressure plate. **See Fig. 4.**



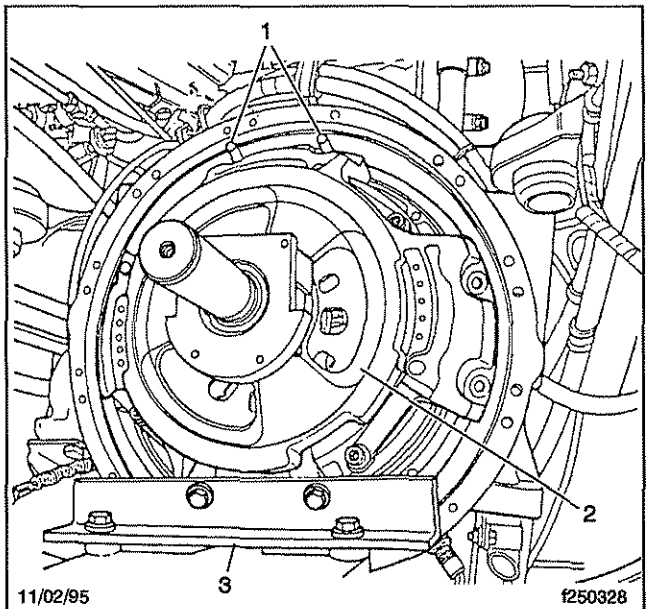
1. Pilot Bearing

Fig. 1, Pilot Bearing Installation



1. Guide Studs

Fig. 2, Guide Stud Installation



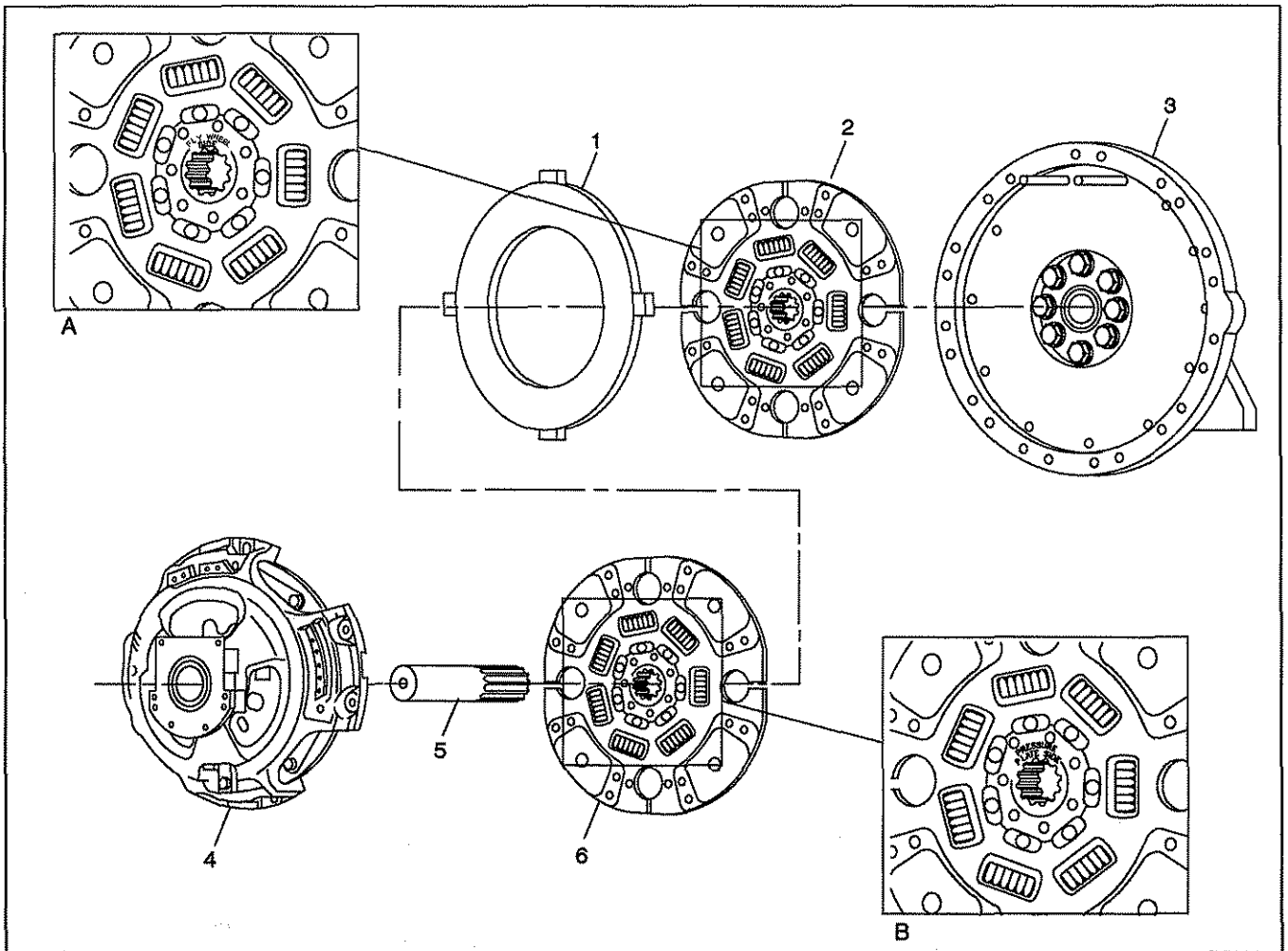
1. Guide Studs
2. 15-1/2 Inch Clutch Assembly
3. Lifting Device

Fig. 3, Lifting the Clutch Assembly

Clutch Installation

6. Install the center plate over the disc in the pressure plate and clutch cover assembly. Make sure the tabs on the plate are in the slots on the cover.
7. Install the front disc against the center plate. Make sure the words *FLYWHEEL SIDE* on the disc are toward the flywheel. **See Fig. 4.** Make sure the facings of ceramic clutches are aligned.
8. Install the alignment tool through the assembly. Rotate the discs so that the splines in the hub are aligned with the splines on the tool. **See Fig. 4.**

WARNING: Tilt the front of the alignment tool up when the clutch assembly is installed. If the tool is not tilted up, components will fall off the tool, causing personal injury and component damage.



A. Markings must be toward the flywheel.
B. Markings must be toward the pressure plate.

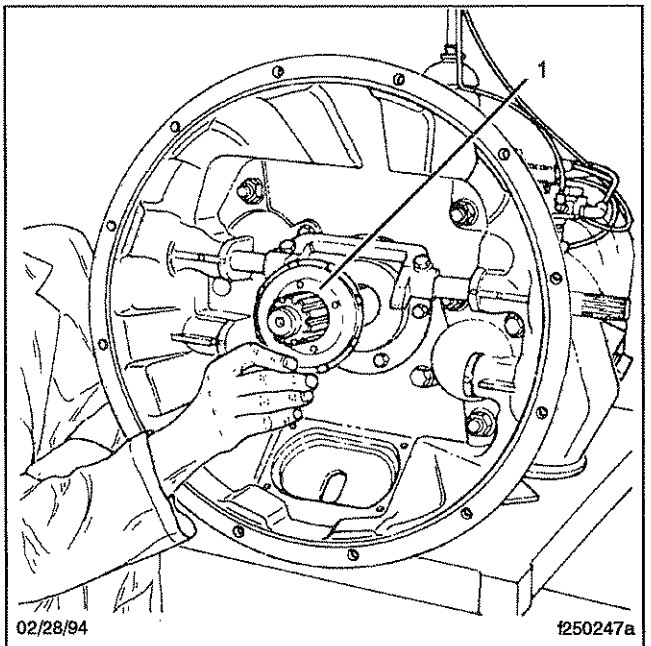
1. Center Plate
2. Rear Clutch Disc
3. Flywheel Housing
4. Cover
5. Alignment Tool
6. Front Clutch Disc

Fig. 4, Alignment Tool Installation

9. Using a lifting device, lift the clutch assembly onto the guide studs. **See Fig. 3.** Make sure the alignment tool is installed in the flywheel pilot bearing.
10. Install the clutch assembly against the flywheel. Remove the lifting device.
11. Install and hand-tighten the capscrews that fasten the clutch to the flywheel.
12. Remove the guide studs. Install and hand-tighten the remaining capscrews.

NOTE: When the capscrews are tightened, the wooden blocks or spacers will fall from between the release bearing and the cover.

13. Tighten the capscrews to the torque values in **Specifications, 400.**
14. Remove the alignment tool (or the input shaft used as an alignment tool).
15. If used, install the clutch brake on the transmission input shaft. Make sure the tabs on the clutch brake engage the slots on the input shaft. **See Fig. 5.**
16. Install the transmission. Follow the procedures in **Group 26** of this manual.



1. Clutch Brake

Fig. 5, Clutch Brake Installation

Troubleshooting Tables

TROUBLESHOOTING—FUNCTIONAL PROBLEMS

NOTE: Problem entries in the troubleshooting tables in this subject refer to functional or operational problems. Before troubleshooting the clutch, make sure that:

- the engine is operating correctly
- the engine mounts are in good condition
- the driveline angles of the engine, transmission, driveshaft, and rear axle are correct

Problem—The Clutch Does Not Disengage Completely

Problem—The Clutch Does Not Disengage Completely	
Possible Cause	**Remedy**
The clutch linkage and release bearing need adjustment.	Adjust the clutch linkage and release bearing.
The linkage is worn or damaged.	Lubricate the linkage. Make sure the linkage is not loose. If the condition persists, replace the linkage.
The release bearing is worn or damaged.	Lubricate (if applicable) the release bearing. If the condition persists, replace the release bearing.
The input shaft splines are worn or damaged.	Replace the input shaft.
The clutch housing is loose.	Tighten the fasteners to the specified torque. If necessary, replace the fasteners.
The pressure plate is worn or damaged.	Replace the pressure plate and cover assembly.
The center plate is worn or damaged.	Replace the center plate.
The center plate binds.	Inspect the tabs on the center plate and the slots in the cover. Service as needed.
Damaged clutch disc hub(s).	Replace the clutch discs.
The linings are worn beyond specification.	Replace the clutch discs.
The linings are damaged.	Replace the clutch.
Oil or grease on the linings.	Clean the linings. If the oil or grease cannot be removed, replace the clutch discs.
A clutch with incorrect lining for the vehicle application is installed.	Install a clutch with the correct type of lining.
The pilot bearing is damaged.	Replace the pilot bearing.

Problem—Clutch Pedal Hard to Operate

Problem—Clutch Pedal Hard to Operate	
Possible Cause	**Remedy**
Damaged bosses on the release bearing assembly.	Replace the bearing assembly. Make sure the clutch is adjusted correctly.
The clutch linkage is worn or damaged.	Lubricate the linkage. If the condition still exists, replace the linkage.

Troubleshooting

Problem—Clutch Pedal Hard to Operate	
Possible Cause	**Remedy**
The pressure plate and cover assembly components are worn or damaged.	Replace the pressure plate and cover assembly.
The clutch cross shaft binds.	Lubricate the cross shaft. If the condition persists, replace the cross shaft and bushings as required.

Problem—The Clutch Slips

Problem—The Clutch Slips	
Possible Cause	**Remedy**
The driver keeps his foot on the clutch pedal.	Use correct driving procedures.
The clutch linkage or release bearing needs adjustment.	Adjust the clutch linkage or release bearing.
Pressure plate and cover assembly components are worn or damaged.	Replace the pressure plate and cover assembly.
Linings are worn or damaged.	Replace the clutch discs.
Oil or grease on the linings.	Clean the linings. If the oil or grease cannot be removed, replace the clutch discs.
A clutch with incorrect lining for the vehicle application is installed.	Install a clutch with the correct type of lining.
The flywheel is worn or damaged.	Service the flywheel as needed. For instructions, refer to the engine manufacturer's service manual.

Problem—The Clutch Is Noisy

Problem—The Clutch Is Noisy	
Possible Cause	**Remedy**
The clutch linkage or release bearing needs adjustment.	Adjust the clutch linkage or release bearing.
The linkage is worn or damaged.	Lubricate the linkage. If the condition persists, replace the linkage.
The release bearing is worn or damaged.	Lubricate (if applicable) the release bearing. If the condition persists, replace the release bearing.
The clutch housing is worn or damaged.	Replace the clutch housing.
The clutch housing is loose.	Tighten the fasteners to the specified torque. If necessary, replace the fasteners.
The hub is damaged, or the co-axial spring(s) are broken in the clutch disc.	Replace the clutch discs.
Linings are worn below specified dimensions.	Replace the clutch discs.
Linings are damaged.	Replace the clutch discs.

Problem—The Clutch is Noisy	
Possible Cause	**Remedy**
Oil or grease on the linings.	Clean the linings. If the oil or grease cannot be removed, replace the clutch discs.
The pilot bearing is damaged.	Replace the pilot bearing.

Problem—The Clutch Vibrates

Problem—The Clutch Vibrates	
Possible Cause	**Remedy**
The input shaft splines are damaged.	Replace the input shaft.
The pressure plate and cover assembly are out of balance.	Remove the pressure plate and cover assembly. Check their balance and install them. If the problem persists, replace the pressure plate and cover assembly.
The splines are damaged in the clutch disc hub(s).	Replace the clutch discs.
The flywheel is loose.	Tighten the fasteners to the specified torque. If necessary, replace the fasteners. Check the flywheel mounting surface for damage. If necessary, replace the flywheel.

TROUBLESHOOTING—COMPONENT PROBLEMS

NOTE: Problem entries in the troubleshooting tables in this subject refer to damage to components.

Problem—Broken Tabs on the Clutch Brake

Problem—Broken Tabs on the Clutch Brake	
Possible Cause	**Remedy**
Vibration.	Inspect the clutch disc hubs; check the installation of the clutch. Make sure dampened discs are used.
The clutch linkage is incorrectly adjusted.	Adjust the clutch linkage. Also, check the installation of the clutch.
The driver used the clutch brake while the vehicle was moving.	Use correct driving technique.

Problem—Worn or Damaged Release Bearing Housing

Problem—Worn or Damaged Release Bearing Housing	
Possible Cause	**Remedy**
The driver keeps his foot on the pedal.	Use correct driving technique.
The clutch linkage is incorrectly adjusted.	Adjust the clutch linkage. Also, check the installation of the clutch.

Troubleshooting

Problem—Worn Bosses on the Release Bearing Housing

Problem—Worn Bosses on the Release Bearing Housing	
Possible Cause	**Remedy**
The linkage is damaged or out of adjustment.	Lubricate and adjust the linkage. Inspect the linkage for wear or damage.
The release yoke is binding.	Lubricate the release yoke shaft. If the yoke does not move freely, replace the shaft and yoke assembly.
The free pedal is out of adjustment.	Adjust the free pedal to specification.

Problem—Worn or Damaged Input Shaft Splines

Problem—Worn or Damaged Input Shaft Splines	
Possible Cause	**Remedy**
The transmission is not aligned.	Make sure the flywheel housing and the clutch housing are aligned to specification.
The transmission is not installed correctly.	Install the transmission correctly.
The clutch disc hubs are damaged.	Replace the clutch discs.
The pilot bearing is worn or damaged.	Replace the pilot bearing.
Engine vibration.	Make sure dampened discs are used.

Problem—Pressure Plate Cracked or Damaged by Heat

Problem—Pressure Plate Cracked or Damaged by Heat	
Possible Cause	**Remedy**
The driver engages the clutch while coasting.	Use correct driving techniques.
The driver uses the clutch as a brake.	Use correct driving techniques.
The clutch free pedal is not adjusted correctly.	Adjust the free pedal to specifications.
There is oil or grease on the clutch linings.	Clean the clutch discs. If the oil or grease cannot be removed, replace the clutch discs. Repair the cause of the grease or oil.
The diaphragm spring is worn or damaged.	Replace the pressure plate and the cover assembly.
The driver slips the clutch excessively during engagement.	Use correct driving techniques.

Problem—Grooves Worn in the Pressure Plate

Problem—Grooves Worn in the Pressure Plate	
Possible Cause	**Remedy**
The clutch discs are worn or damaged.	Replace the clutch discs. If damaged, replace the center plate and flywheel.

Problem—The Clutch Disc Hub is Warped

Problem—The Clutch Disc Hub is Warped	
Possible Cause	**Remedy**
The transmission was not installed correctly.	Replace the clutch discs. Install the transmission correctly.

Problem—The Hub Separates From the Clutch Disc

Problem—The Hub Separates From the Clutch Disc	
Possible Cause	**Remedy**
Excessive engine vibration.	Repair the engine.
The transmission was not installed correctly.	Install the transmission correctly.
The clutch housing is loose.	Tighten the clutch housing to the specified torque.
The driver engages the clutch while the vehicle is coasting.	Use correct driving techniques.
Shock loading.	Use correct driving techniques.

Problem—Heat Damage to the Clutch Disc

Problem—Heat Damage to the Clutch Disc	
Possible Cause	**Remedy**
The driver keeps his foot on the clutch pedal or slips the clutch.	Use correct driving techniques.
The clutch does not engage or disengage completely.	See "Troubleshooting—Functional Problems: Clutch Does Not Disengage Completely."
The free pedal is not adjusted correctly.	Adjust the free pedal.
The diaphragm spring is worn or damaged.	Replace the pressure plate and cover assembly.
There is oil or grease on the clutch linings.	Clean the clutch discs. If the oil or grease cannot be removed, replace the clutch discs. Repair the cause of the grease or oil.

Problem—The Linings Separate From the Disc

Problem—The Linings Separate From the Disc	
Possible Cause	**Remedy**
The linings are worn below the specified dimension.	Replace the clutch discs.
The driver allows the vehicle to coast downhill with the transmission in gear and the clutch engaged.	Use correct driving techniques.

Troubleshooting

Problem—Heat Damage to the Clutch Disc

Problem—Heat Damage to the Clutch Disc	
Possible Cause	**Remedy**
The driver does not start the vehicle in the correct gear.	Use correct driving techniques.
The driver engages the clutch while the vehicle is coasting.	Use correct driving techniques.
The tabs on the center plate are binding in the clutch cover.	Replace the pressure plate and cover assembly.
The clutch does not release.	See "Troubleshooting—Functional Problems: Clutch Does Not Disengage Completely."

Description	Specifications
Actuation Type	Pull
Minimum Clutch Housing Size for Mounting (SAE)	Number 2
Pressure Plate Actuation	Single Diaphragm Spring
Clamp Load	3600 lbf (16 013 N) 4000 lbf (17 793 N)
Adjustment	Manual
Facing Size	15.35 x 8.66 in (390 x 220 mm)
Lining Availability	Ceramic
Lining-to-Disc Fastener	Rivet

Table 1, General Specifications

Description	Clutch Diameter
Pressure Plate Runout	0.000 to 0.002 inch (0.00 to 0.05 mm)
Pressure Plate Flatness	0.002 to 0.004 inch (0.05 to 0.10 mm)
Maximum Allowable Wear	0.015 inch (0.38 mm)

Table 2, Pressure Plate Specifications

Description	Specifications
Center Plate Runout	0.000 to 0.002 inch (0.00 to 0.05 mm)
Center Plate Flatness	0.000 to 0.002 inch (0.00 to 0.05 mm)
Center Plate Minimum Thickness	0.742 inch (18.84 mm)
Center Plate Drive	Tabs on Center Plate in Clutch Cover

Table 3, Center Plate Specifications

Description	Specifications
Number of Splines on Disc	10
Spline Diameter	2.00 inch (51.0 mm)
Minimum Disc Thickness	To Top of Rivet

Table 4, Clutch Disc Specifications

Specifications

Description	Torque lbf·ft (N·m)
Adjusting Ring Lock Capscrew	25 to 30 lbf·ft (34 to 40 N·m)
Capscrew Between Cover Assembly and Flywheel	45 to 50 lbf·ft (62 to 67 N·m)

Table 5, Torque Values

Contents

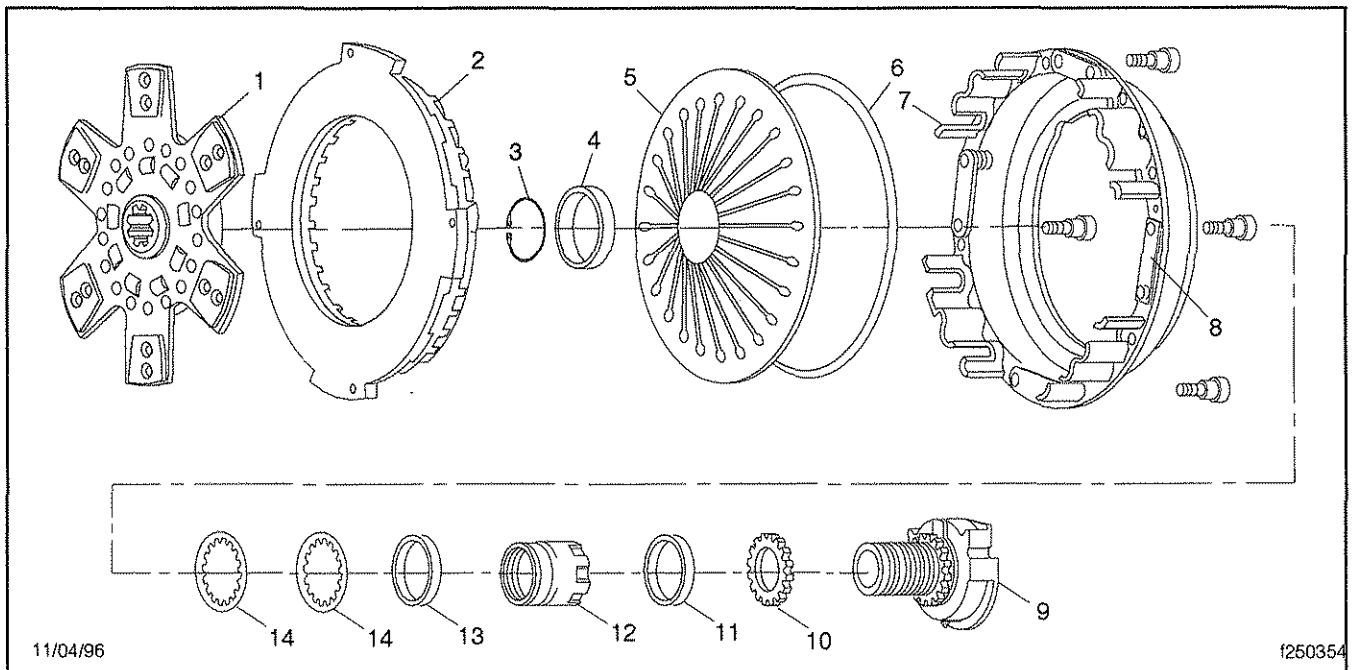
Subject	Subject Number
General Description	050
Service Operations	
Clutch Adjustments	100
Clutch Removal	110
Clutch Inspection	120
Clutch Installation	130
Troubleshooting	300
Specifications	400

General Description (See Fig. 1)

Valeo clutches installed in Freightliner heavy-duty vehicles are available in 16-inch and 17-inch models. They are single-disc, diaphragm spring, pull-type clutches. A dampened driven disc is standard. The lining is a "cerametallic" material.

Following is a description of each of the major clutch components.

- Clutch Disc—the clutch disc is the driven portion of the assembly that transmits power from the engine flywheel to the transmission input shaft. A typical disc has six paddle arms with cerametallic friction facings on the front and back sides of each arm. Power is transmitted through the friction facings to the splined hub that couples to the transmission input shaft. In the center portion of the clutch disc, between the friction facings and the splined hub, is the clutch damper unit. The damper unit is made up of several coil springs designed to absorb the torsional vibrations generated by the engine, reducing driveline noise and transmission input shaft spline wear.
- Pressure Plate—the pressure plate (**Fig. 2**) is a large cast iron disc machined on one side to press flat against the clutch disc. The pressure plate is attached to the flywheel through the clutch cover. Using spring pressure, it clamps the clutch disc to the engine flywheel allowing engine power to be transmitted to the transmission input shaft. The pressure plate casting is attached to the clutch cover by four sets of spring-steel drive straps (**Fig. 3**). These drive straps transmit engine power to the pressure plate through a flexible connection. This connection allows the pressure plate to



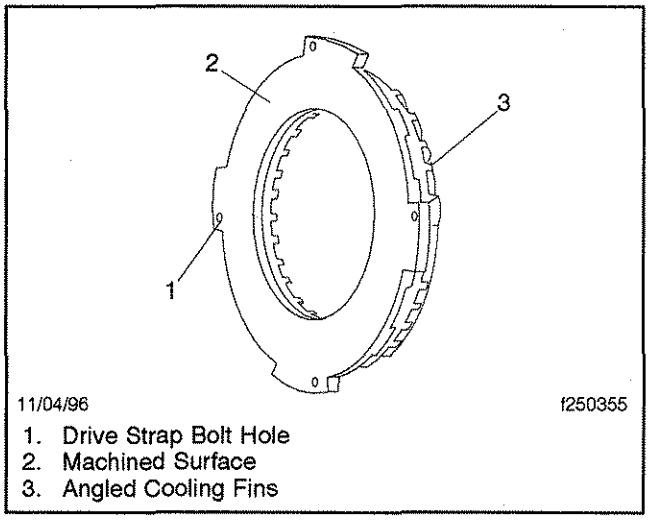
1. Clutch Disc
2. Pressure Plate
3. Snap Ring
4. Finger Contact Ring
5. Diaphragm Spring
6. Fulcrum Ring
7. Clutch Cover
8. Drive Strap
9. Release Bearing
10. Locknut
11. Separating Ring
12. Coupler
13. Shim Washer
14. Belleville Washers

Fig. 1, Valeo Clutch

General Description

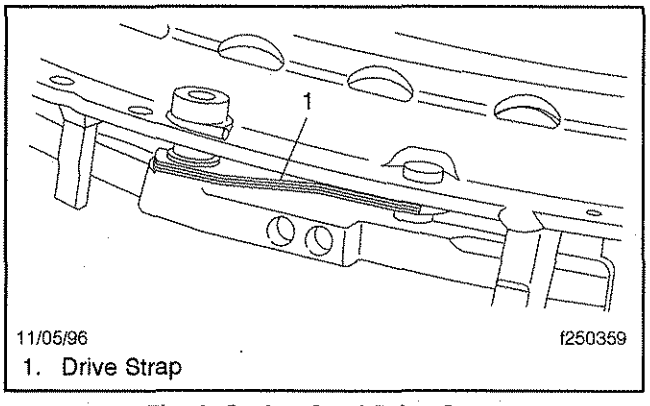
be moved toward or away from the engine. The drive straps act as springs to pull the pressure plate casting off the disc when the diaphragm spring clamping load is disengaged. This eliminates drag by mechanically retracting the pressure plate when the clutch pedal is depressed.

- Diaphragm Spring—the diaphragm spring (**Fig. 4**) is a circular disc. The spring portion contains several fingers that are moved back and forth to engage and disengage the clutch. The force created by the diaphragm spring provides the load necessary to clamp the clutch disc between the pressure plate casting and flywheel. The spring is placed inside the clutch cover between the fulcrum ring and a ridge on the pressure plate. The fingers of the diaphragm are attached to the coupler.
- Fulcrum Ring—the fulcrum ring is located within the clutch cover and provides a pivot surface for the diaphragm spring.
- Clutch Cover—the clutch cover (**Fig. 5**) is a lightweight steel stamping designed to provide strength and heat dissipation. It protects the vehicle from damage in case the pressure plate casting breaks. The cover completely covers the outside of the clutch and is attached to the flywheel. Four spring-steel drive straps attach the cover to the pressure plate.
- Release Bearing—the release bearing assembly is used to connect the clutch diaphragm spring to the clutch release linkage (**Fig. 6**). The assembly is attached to the diaphragm spring with a coupler and snap ring. The coupler, threaded sleeve and ball bearing inner race rotate at engine speed along with the clutch. The release bearing outer race remains fixed inside the bearing housing which is held stationary by the release yoke.



1. Drive Strap Bolt Hole
2. Machined Surface
3. Angled Cooling Fins

Fig. 2, Pressure Plate



1. Drive Strap

Fig. 3, Spring-Steel Drive Strap

Principles of Operation

The clutch is used to disconnect and reconnect driving (engine) and driven (transmission) members of the driveline. See **Fig. 7**. The clutch does the following:

- When engaged, the clutch allows the engine and driveline to rotate together as one solid member.

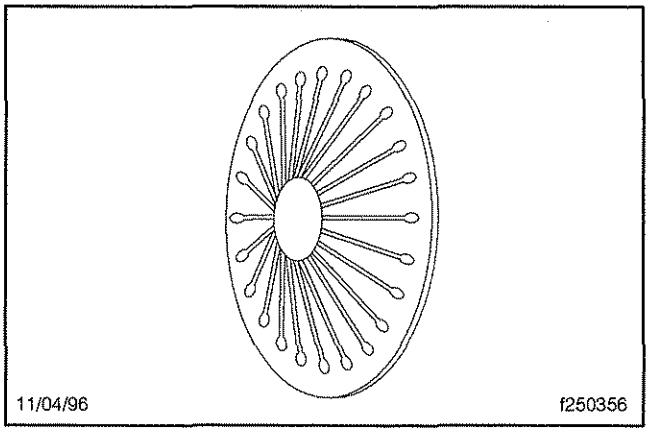
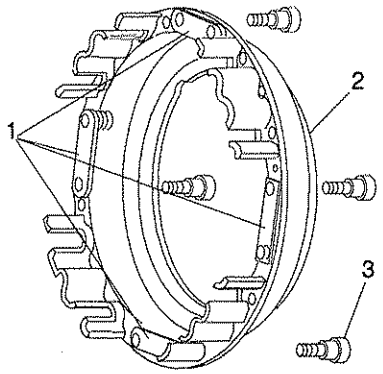


Fig. 4, Diaphragm Spring



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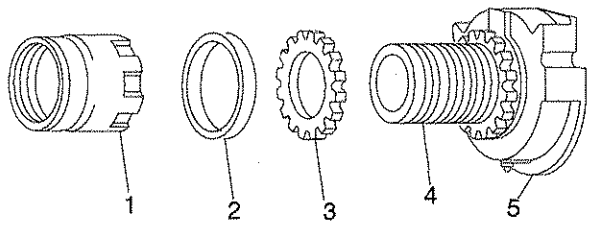
1. Spring Steel Drive Straps
2. Clutch Cover
3. Socket-Head Capscrew

Fig. 5, Clutch Cover



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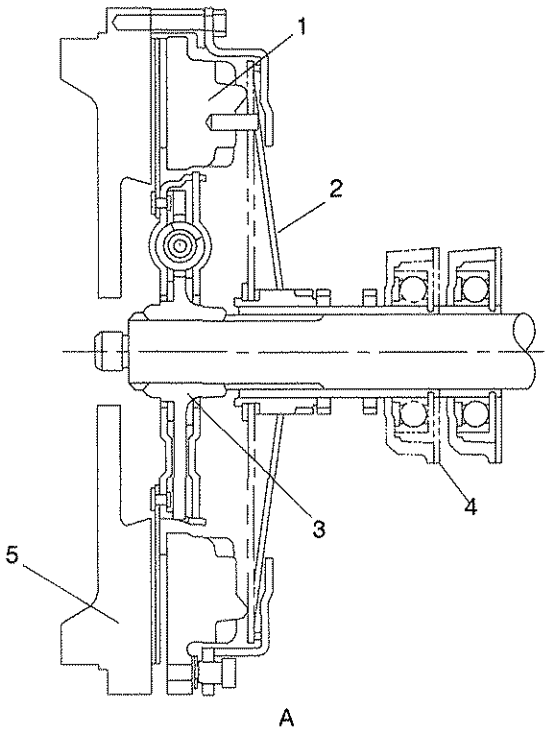
1. Coupler
2. Separating Ring
3. Locknut
4. Threaded Sleeve
5. Release Bearing

Fig. 6, Release Bearing

- When disengaged, the clutch disconnects the engine from the driveline allowing it to remain running while the vehicle is stopped.



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A. Disengaging the Clutch

B. Engaging the Clutch

1. Pressure Plate
2. Diaphragm Spring
3. Driven Disc
4. Release Bearing Assembly
5. Flywheel

Fig. 7, Clutch Engaging/Disengaging

General Description

- The clutch can be used to interrupt and reconnect the flow of engine power to allow the changing of transmission gears, or to engage or disengage a power takeoff unit.

The clutch pedal allows the driver to control the clutch. When the pedal is depressed, the release bearing is pulled rearward, toward the transmission. It pulls the diaphragm spring along with it, disengaging the clamp load on the driven disc. During clutch engagement, the release bearing moves toward the engine. This movement allows the diaphragm spring to clamp the clutch disc between the pressure plate and the engine flywheel, transmitting engine power to the transmission.

Special Tools

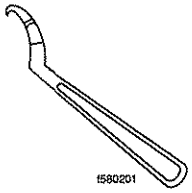
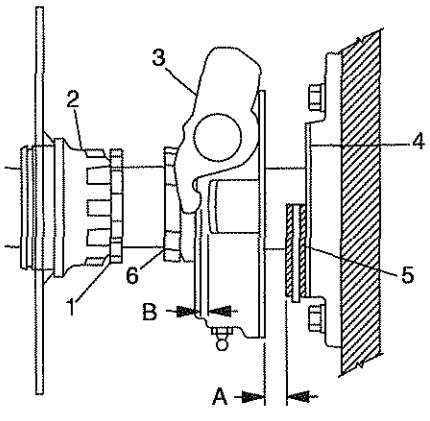
Special Tools				
Tool	**Description**	**Manufacturer**	**Part Number**	**Quantity Needed**
 f580201	Adjustable Hook Spanner Wrench	Kent-Moore	J4749	2

Table 1, Special Tools

Clutch Adjustments

Eaton Valeo clutches require two adjustments: release bearing clearance (this distance must be 1/2 to 9/16 inch (12.7 to 14.3 mm) and clutch free-travel (this distance must be 0.105 to 0.145 inch (2.7 to 3.7 mm). See **Fig. 1**.

IMPORTANT: An inspection tool A02–12419 (available through the PDCs) can be used to check the distance between the release bearing and the clutch brake. See **Fig. 2**. One end of the tool has green tape on it and is 0.50 inch (12.7 mm) in diameter; the other end has blue tape on it and is 0.56 inch (14.3 mm) in diameter.



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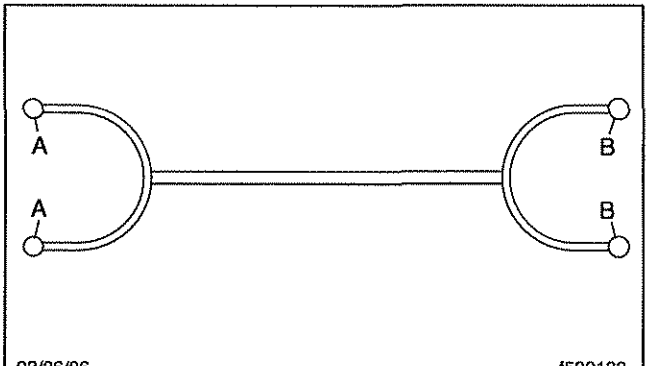
A. 1/2 to 9/16 inch (12.7 to 14.3 mm) With Clutch Brake
B. 0.105 to 0.145 inch (2.7 to 3.7 mm)

1. Locknut Ring
2. Release Bearing Coupler
3. Release Yoke
4. Bearing Cover
5. Bearing Pad
6. Adjuster Ring

Fig. 1, Clutch Adjustment Measurements

1. If using tool A02–12419 to check the distance between the release bearing and the clutch brake, position the tool so that the legs straddle the transmission input shaft. Check the gap with both ends of the tool as follows:
   - 1.1 Insert the blue 0.56-inch (14.3-mm) end. If it fits loosely the gap is too wide and adjustment is needed. Go to the next step.
   - 1.2 If the blue 0.56-inch (14.3-mm) end can't be inserted in the gap, then try to insert the green 0.50-inch (12.7-mm) end. If the green end of the tool fits, snug or loose, then no adjustment is needed.
   - 1.3 If the green end of the tool can't be inserted in the gap, adjustment is needed. Go to the next step.
2. Disconnect the external linkage to allow free movement of the release yoke.
3. Using two adjustable hook spanner wrenches (**Table 1**), loosen the release bearing locknut. Thread the locknut back toward the transmission a small distance to ensure that it will not interfere with the adjustment procedure.
4. Rotate the sleeve with the adjuster ring to the specified release bearing clearance.
5. Using the two spanner wrenches, place one on the notches of the release bearing coupler and the

Clutch Adjustments



A. 0.50 inch (12.7 mm)
B. 0.56 inch (14.3 mm)

Fig. 2, Inspection Tool A02-12419

other on the release bearing locknut. See **Fig. 3**. Use the first wrench to prevent the coupler from rotating while using the second wrench to tighten the locknut against the coupler.

Tighten the locknut ring against the release bearing coupler by placing the two wrenches in notches that will result in the two wrench handles slightly moving apart from one another. Then both handles can be grasped with one hand and squeezed closely together.

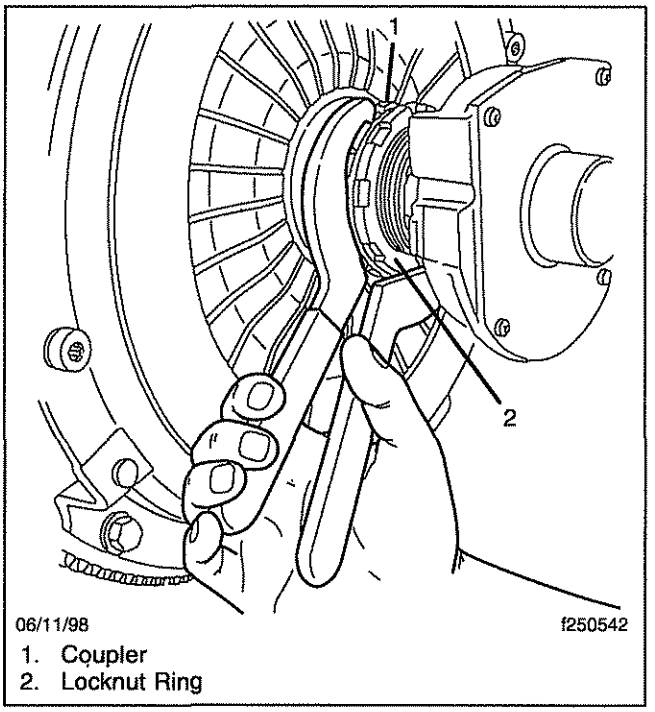
IMPORTANT: An inspection tool A02–12254 (available through the PDCs) can be used to check the distance between the release bearing and the release fork (free travel). See **Fig. 4**. The legs on one end of the tool have green tape on them and are 0.105 inch (2.7 mm) thick; the legs on the other end have blue tape on them and are 0.145 inch (3.7 mm) thick.

6. If using tool A02–12254 to check the distance between the release bearing and the release fork, position the tool so it straddles the fork to ensure that there won't be any misalignment. Check the distance with both ends of the tool as follows:

   6.1 Insert the blue 0.145-inch (3.7-mm) end. If it fits loosely the gap is too wide and adjustment is needed. Connect the external linkage, then go to the section on clutch linkage adjustment in this group.

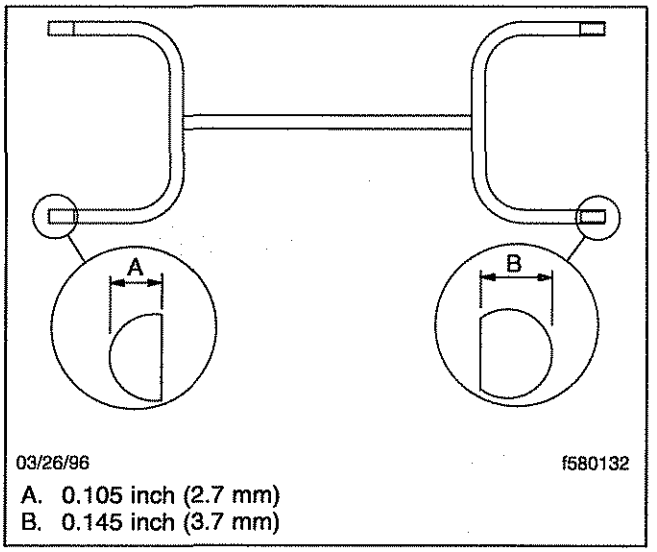
   6.2 If the blue 0.145-inch (3.7-mm) end can't be inserted in the gap, then try to insert the green 0.105-inch (2.7-mm) end. If the green end of the tool fits, snug or loose, then no adjustment is needed.

   6.3 If the green end of the tool can't be inserted in the gap, adjustment is needed. Connect



1. Coupler
2. Locknut Ring

Fig. 3, Tighten the Locknut Ring



A. 0.105 inch (2.7 mm)
B. 0.145 inch (3.7 mm)

Fig. 4, Inspection Tool A02-12254

the external linkage, then perform a clutch linkage adjustment. For instructions, see **Section 25.03**.

Clutch Removal

1. Remove the transmission. Follow the procedures in **Group 26** of this manual.

⚠ CAUTION

Do not let the transmission drop, and do not let the transmission hang unsupported by the input shaft in the pilot bearing. Taking these precautions will prevent damage to the clutch assembly and the pilot bearing.

2. To facilitate clutch removal and installation, Valeo clutches employ four shipping clips to hold the pressure plate toward the clutch. Install the four shipping clips. See **Fig. 1** and **Fig. 2.**

3. Install a clutch alignment tool through the clutch and into the flywheel pilot bearing to support the clutch assembly during removal.

NOTE: If an alignment tool is not available, use an input shaft from a manual transmission. Remove the gear from the end of the input shaft.

4. Remove the two capscrews (that are 180 degrees apart) from the pressure plate assembly as indicated in **Fig. 1** and **Fig. 2.** Install alignment pins in the two holes. If alignment pins are not available, they may be made by removing the heads from two capscrews.

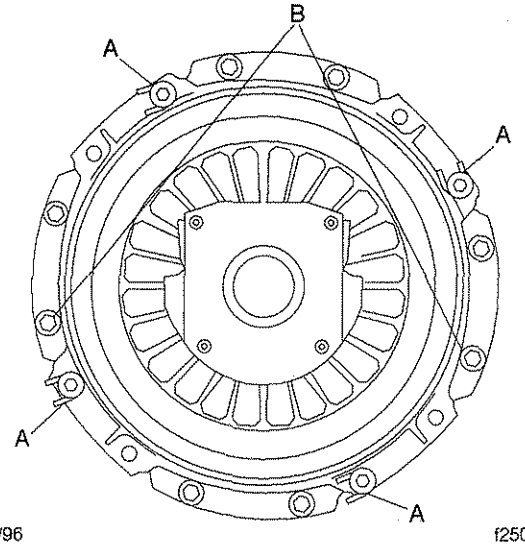
5. Remove the remaining capscrews which secure the cover assembly to the flywheel.

⚠ WARNING

The cover assembly is heavy and should be removed only with a lifting device. If the assembly is lifted improperly or dropped, it could cause serious personal injury.

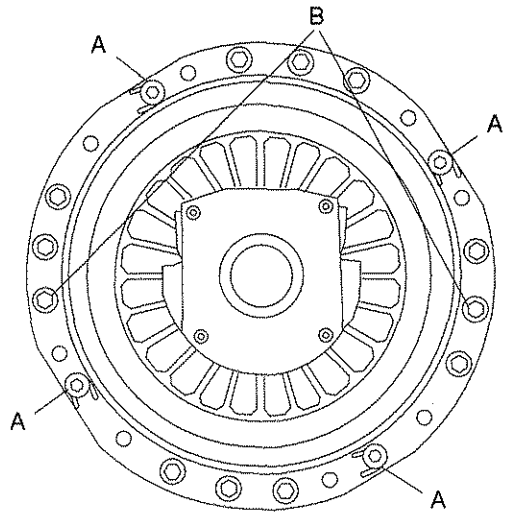
6. Lift the pressure plate, release bearing, and clutch assembly over the alignment tool and alignment pins.

7. Whenever the clutch assembly is serviced or the engine is removed, the pilot bearing in the flywheel should be removed and replaced. Use an appropriate internal puller and a slide hammer to remove the pilot bearing. Install the new pilot bearing with an appropriate driver.



A. Install shipping clips here.
B. Remove these two capscrews and install the alignment pins.

Fig. 1, 16-Inch Clutch



A. Install shipping clips here.
B. Remove these two capscrews and install the alignment pins.

Fig. 2, 17-Inch Clutch

Clutch Inspection

1. Remove the clutch from the vehicle. Refer to **Subject 110** for instructions.
2. Inspect the surface of the flywheel for wear or damage. If the flywheel is cracked, replace it. Heat marks are normal, and can usually be removed with an emery cloth. Some wear or damage can be removed by grinding a new surface on the flywheel. If wear or damage on the surface of the flywheel cannot be removed, replace the flywheel.

   Refer to the engine manufacturer's service manual for flywheel service procedures.

IMPORTANT: If the flywheel surface is reground, make sure there is still adequate thickness for the capscrews to hold the clutch to the flywheel. The threads for these capscrews are below the surface of some flywheels, requiring the use of capscrews with a shoulder. If some of the flywheel surface is removed, the capscrews may not hold. Use new capscrews that are the correct length.

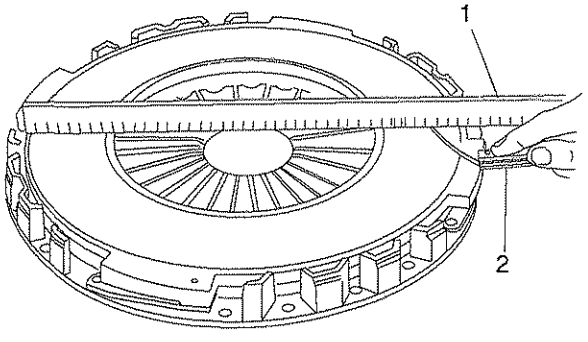
3. Inspect the ring gear teeth on the outer surface of the flywheel. If the teeth are worn or damaged, replace the ring gear or the flywheel. Refer to the engine manufacturer's service manual for instructions.

   Check the tabs on the outer edge of the flywheel. Replace the flywheel if the tabs are worn or damaged.
4. The flywheel surface must be flat for correct clutch operation. Check the runout of the outer surface of the flywheel. Refer to the engine manufacturer's service manual for instructions.
5. Refer to the engine manufacturer's service manual for instructions and check the following:
   - pilot bearing bore runout
   - crankshaft end play
   - runout of the outer surface of the flywheel housing
   - runout of the inside of the flywheel housing

⚠ CAUTION

Do not clean ground or polished parts in a hot solution tank or with water, steam, or alkaline solutions. These solutions will cause the parts to corrode.

6. Inspect the pilot bearing. Although the pilot bearing should be replaced whenever the clutch is removed, any excessive wear or damage to the pilot bearing could indicate other problems which should be remedied.
7. Check the locknut for adequate tightness against the release bearing coupler.
8. Inspect the pressure plate friction surface for wear by placing a straight edge across the width of the friction face. See **Fig. 1**. A gap in the worn area of 0.030 inch (0.75 mm) or more indicates the pressure plate and cover assembly should be replaced.
9. If reusing the pressure plate and cover assembly with a new disc, inspect the pressure plate for warpage or uneven wear by placing a straightedge across the entire diameter of the plate. If the gap at the inside wear diameter exceeds the gap at the outside wear edge by 0.008 inch (0.20 mm), there is excessive concave warpage and the pressure plate and cover assembly should be replaced. No measurable amount of convex warpage is allowed, so replacement of the assembly is required if the gap at the outside diameter exceeds the gap at the inside edge of the clutch wear area.



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1. Straight Edge 2. Feeler Gauge

Fig. 1, Checking the Pressure Plate for Wear and Warpage

Clutch Inspection

10. Inspect the pressure plate for heat damage such as discoloration, surface checking, or cracks. Slight discoloration or light checking is normal. Deep checking or cracks indicate that the pressure plate and cover assembly should be replaced.

11. Check the drivestrap assemblies for bends or kinks. Normal drivestrap units form a smooth, gently curving "S" shape when viewed from the edge, with all laminations fitting tightly together. See **Fig. 2.** Bent or kinked drivestraps will show an area of sharp bending next to the rivet or bolt attachments and/or noticeable gaps between laminations.

12. Do the following checks on the clutch disc.

    12.1 Inspect the friction material for signs of excessive wear or heat damage. Disc thickness should be checked with calipers or an outside micrometer. See **Fig. 3.** Minimum disc thickness is 0.295 inch (7.50 mm).

    12.2 Slide the clutch disc onto the transmission input shaft to look for evidence of sticking or binding splines. Clean and correct the source of interference or replace the clutch disc.

    12.3 Lay the clutch disc on a new pressure plate and cover assembly or flywheel to check for bent cerametallic paddle arms. Using a feeler gauge, check the gap between the friction material pads and the pressure plate and cover assembly or flywheel face. See **Fig. 4.** The gap must not exceed 0.030 inch (0.75 mm).

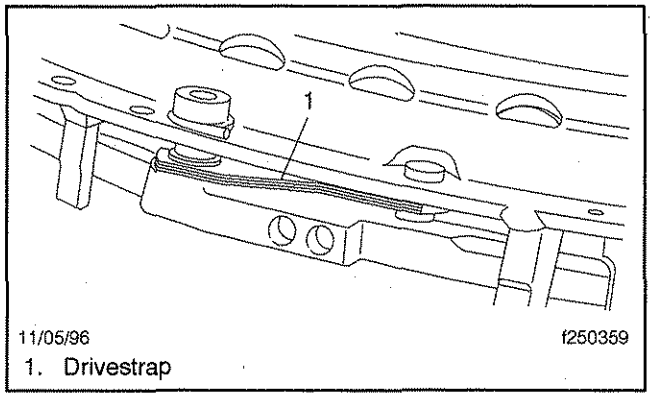


Fig. 2, Normal Drivestrap

    12.4 Examine the clutch disc for a bent hub by looking for unusually heavy and eneven friction material wear.

    12.5 Check for signs of driveline torsional vibration or shock loading damage like broken springs, cracked damper retainer plates, or damaged splines. See **Fig. 5.**

13. Inspect the clutch release yoke contact tips for excessive wear. Replace if needed. See **Fig. 6.**

14. Inspect the cross shafts for bushing wear, and check for end spline damage and wear. Replace as needed.

15. If a clutch brake is installed, inspect the clutch brake wear surface on the transmission. Replace the transmission front bearing cover if necessary.

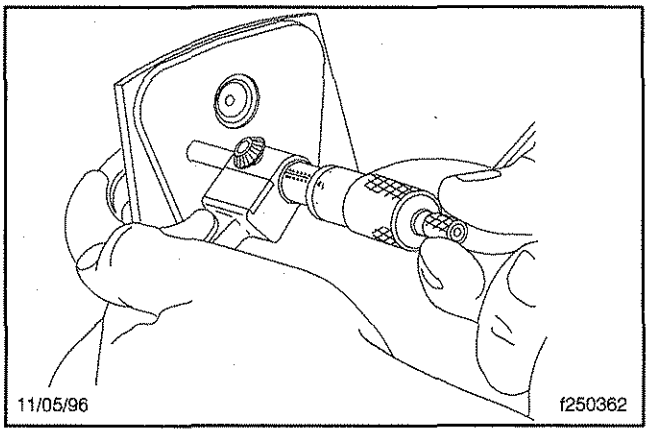


Fig. 3, Check the Clutch Disc Thickness

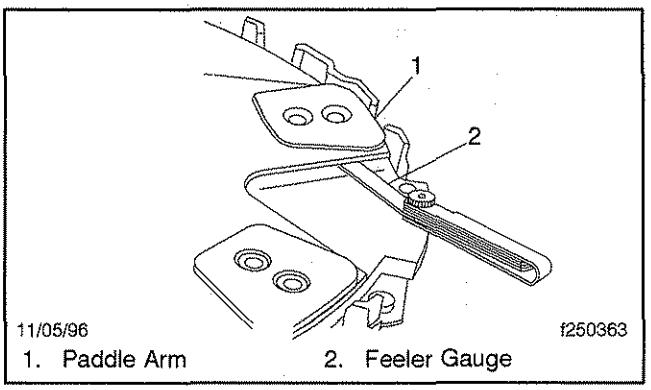
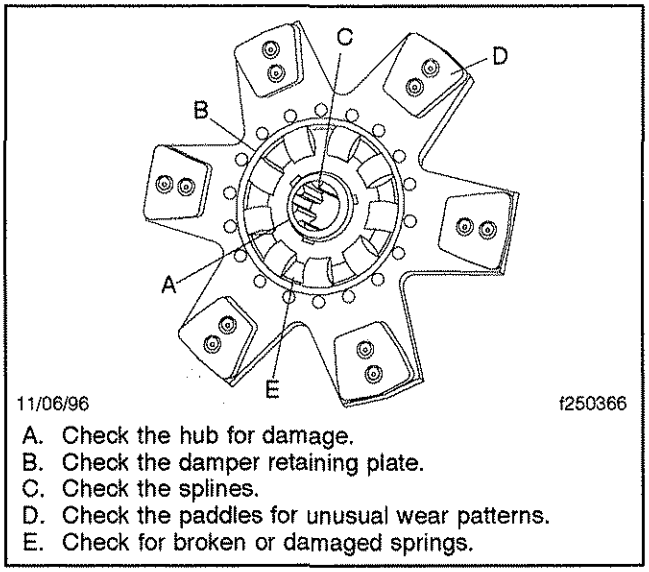
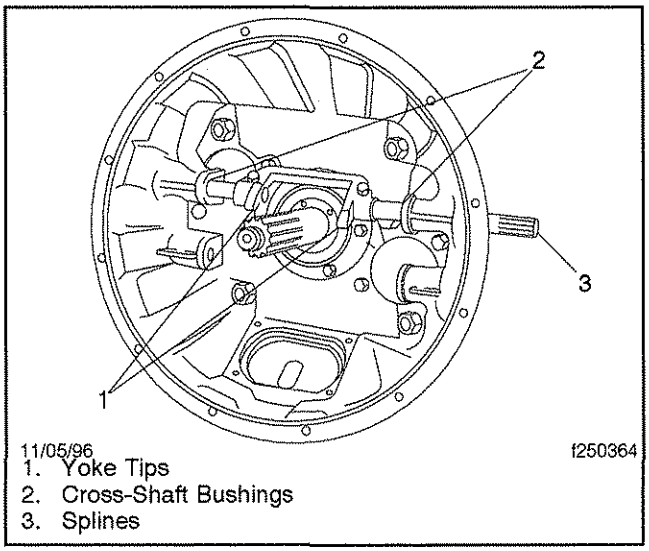


Fig. 4, Checking for Bent Paddle Arms



A. Check the hub for damage.
B. Check the damper retaining plate.
C. Check the splines.
D. Check the paddles for unusual wear patterns.
E. Check for broken or damaged springs.

Fig. 5, Inspect the Clutch Disc for Vibration or Shock Damage



1. Yoke Tips
2. Cross-Shaft Bushings
3. Splines

Fig. 6, Inspect the Clutch Release Yoke Contact Tips

Clutch Installation

NOTE: If you are installing components which have been in operation, do the steps in **Subject 120** before installing the clutch.

1. Lubricate the bore in the crankshaft for the pilot bearing with the specified lubricant. Do not over-lubricate. Excess lubricant can contaminate the disc and cause the clutch to slip.

   Using an appropriate driver, install the pilot bearing. Refer to the engine manufacturer's service manual for instructions.

2. If necessary, install the release bearing assembly on the pressure plate. See **Fig. 1** for assembly.

   2.1 Stand the coupler vertically on an arbor press working surface using the rear notched end face as a base.

   2.2 Place the specified size and number of shim washers on the coupler pilot.

   - 16-inch clutch: 0.031 inch (0.8 mm) shim
   - 17-inch clutch: 0.5 inch (0.020 mm) shim

   2.3 Place two toothed Belleville washers on the coupler pilot with the teeth pointing down toward the shim washers. See **Fig. 2.**

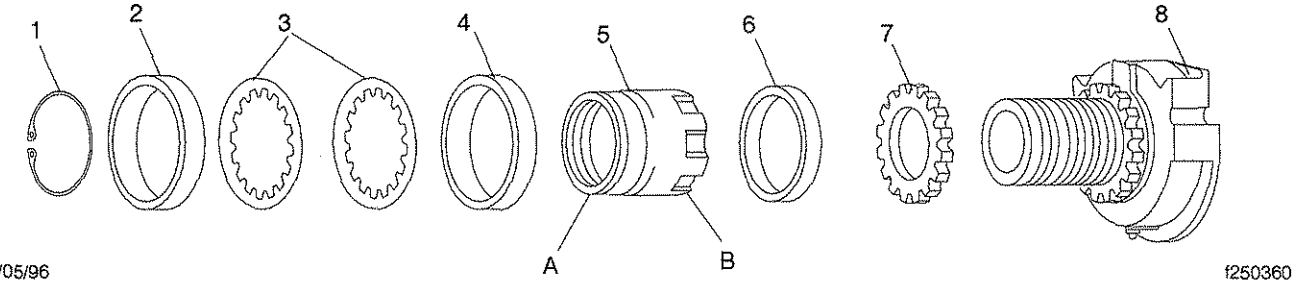
   2.4 Set the pressure plate and cover assembly on the coupler pilot end with the pressure plate side (engine side) facing up. The pressure plate and cover assembly should be positioned so that the diaphragm finger tips are resting on the solid edge of the Belleville washer.

NOTE: For ease of assembly, a shipping clip should be in place between each of the four drive-strap attaching screw heads and the pressure plate and cover assembly. If this is not the case, assemble the pressure plate and cover assembly over a disc onto a flywheel and evenly and slowly tighten each mounting screw in a crisscross pattern just enough to allow shipping clips, or an equivalent, to be installed. Then remove the pressure plate and cover assembly and continue with release bearing installation.

   2.5 Place the finger contact ring on the coupler pilot with the rounded face down contacting the diaphragm spring fingers. The flat face with the counter bore at the inside diameter will face up.

   2.6 Place the round wire snap ring on the exposed end of the coupler pilot. See **Fig. 3.**

   2.7 Using an arbor press ram, push down on the finger contact ring at one point enough to deflect the Belleville washers and start the open end of the round wire snap ring into its groove. Continue in this manner around the coupler until the snap ring is fully seated into its groove.

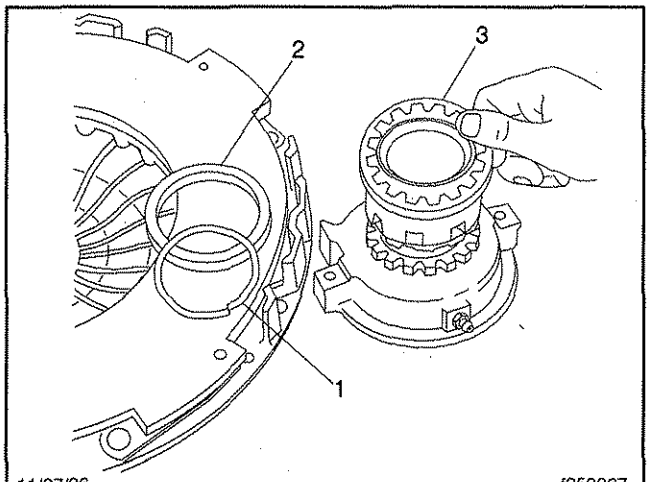


A. Pilot End
B. Notch End

1. Snap Ring
2. Finger Contact Ring
3. Belleville Washers
4. Shim Washer
5. Coupler
6. Separating Ring
7. Locknut
8. Release Bearing

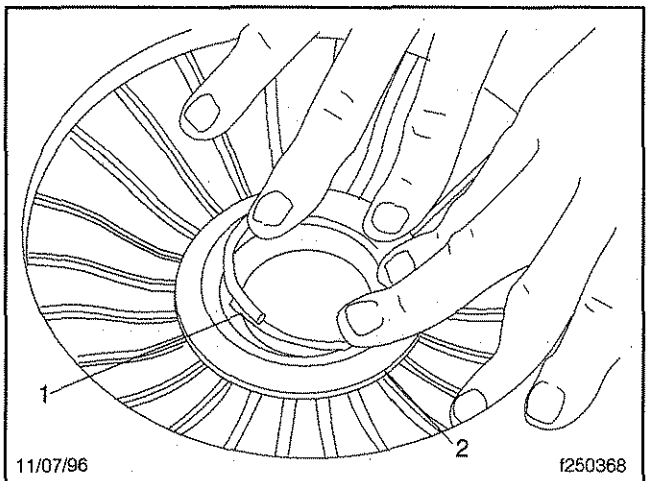
Fig. 1, Release Bearing Assembly Installation

Clutch Installation



1. Snap Ring
2. Finger Contact Ring
3. Belleville Washers

Fig. 2, Install the Belleville Washers



1. Snap Ring
2. Finger Contact Ring

Fig. 3, Install the Snap Ring

2.8 Thread the adjustment locknut on the release bearing barrel. Install a separating ring on the barrel.

2.9 Thread the release bearing assembly into the coupler deep enough so that it will not hit the transmission when it is installed.

3. Clean the friction surface of the pressure plate and cover assembly with a suitable brake surface cleaning solvent to remove all grease, oil, or protective film.

4. Install two alignment pins into two flywheel mounting holes that are 180 degrees apart. See **Fig. 4.**

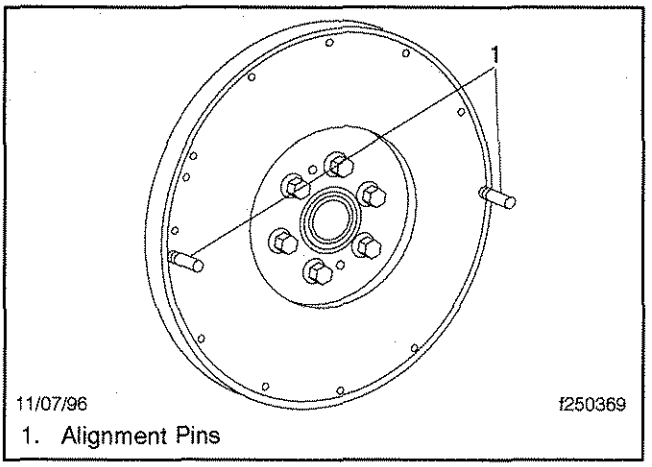
5. With the flatter side of the clutch disc pointing towards the flywheel, insert the clutch disc alignment tool through the splines on the disc. Next, insert the pilot arbor of the alignment tool into the flywheel pilot bearing and slide the clutch disc against the flywheel. See **Fig. 5.**

⚠ WARNING

WARNING: The cover assembly is heavy and should be installed only with a lifting device. If the assembly is lifted improperly or dropped, it could cause serious personal injury.

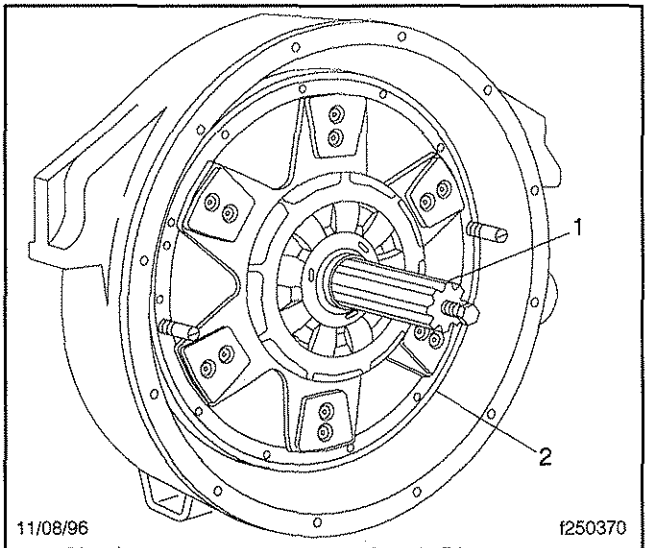
6. Install the pressure plate and cover assembly over the alignment tool and onto the alignment pins. See **Fig. 6.** Don't allow the weight of the pressure plate assembly to hang on the release bearing and clutch disc alignment tool.

NOTE: The 17-inch pot-type clutch is centered on the flywheel with two dowel pins located 180 degrees apart on the clutch mounting flanges. Be sure that the pressure plate assembly is correctly oriented so these dowel pins will enter the proper dowel pin holes in the clutch cover housing. See **Fig. 7.**



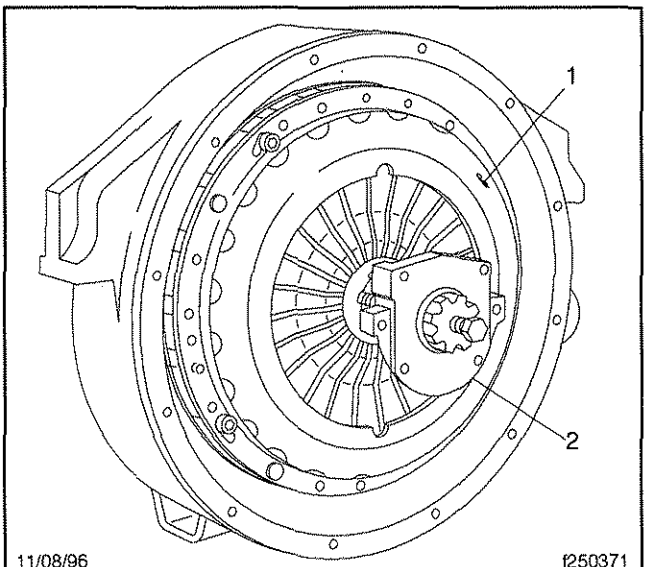
1. Alignment Pins

Fig. 4, Install the Alignment Pins



1. Clutch Alignment Tool
2. Clutch Disc

Fig. 5, Install the Clutch Disc



1. Pressure Plate and Cover Assembly
2. Release Bearing

Fig. 6, Install the Pressure Plate and Cover Assembly

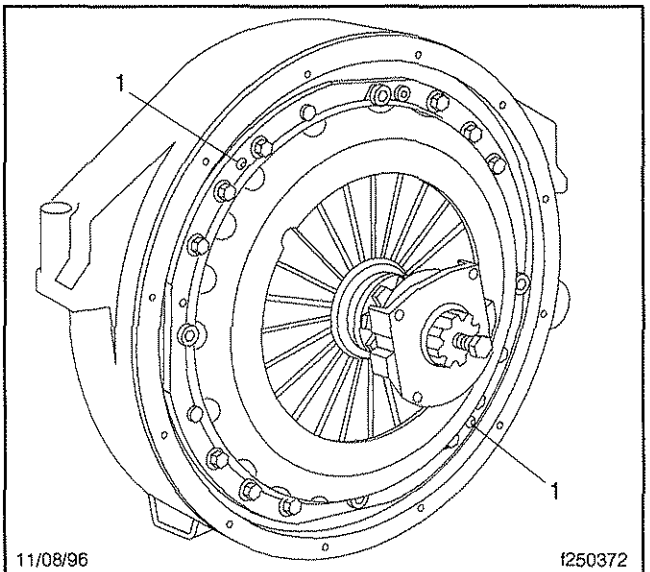
7. Place thick hardened flatwashers or lockwashers on each of the pressure plate assembly mounting capscrews.
8. Start each clutch mounting capscrew and washer assembly by hand and thread them in until the capscrews contact the clutch housing cover.
9. Remove the two alignment pins, and install the remaining two capscrew and washer assemblies.

IMPORTANT: Make sure that the pressure plate and cover assembly flange fully and evenly enters the pilot lip on the flywheel rim. See **Fig. 8.**

10. Tighten the capscrews as specified below. Follow the tightening sequence in **Fig. 9** and **Fig. 10**, tighten the capscrews 40 to 55 lbf·ft (54 to 75 N·m).
11. Remove the four wire shipping clips (**Fig. 11**).

⚠ CAUTION

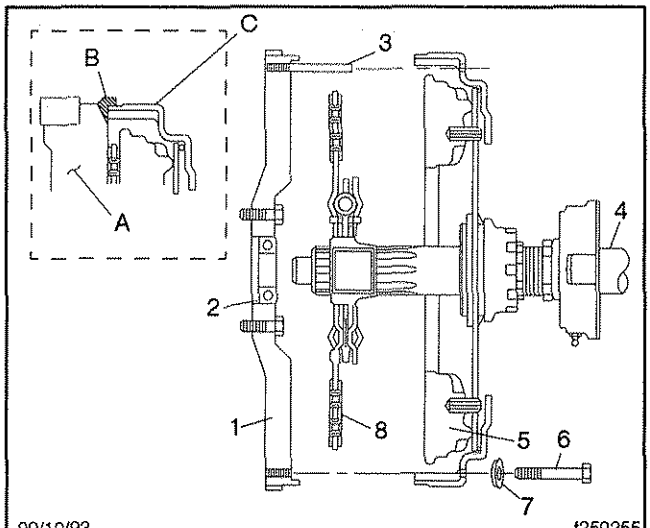
Do not let the transmission drop, and do not let the transmission hang unsupported by the input shaft in the pilot bearing bore in the flywheel. Taking these precautions will prevent damage to the clutch assembly and the pilot bearing. If excessive force is required to install the transmission into the flywheel housing, investigate the cause and make necessary corrections.



1. Dowel Pin

Fig. 7, 17-Inch Pot-Type Pressure Plate Assembly Installed on Dowel Pins

Clutch Installation



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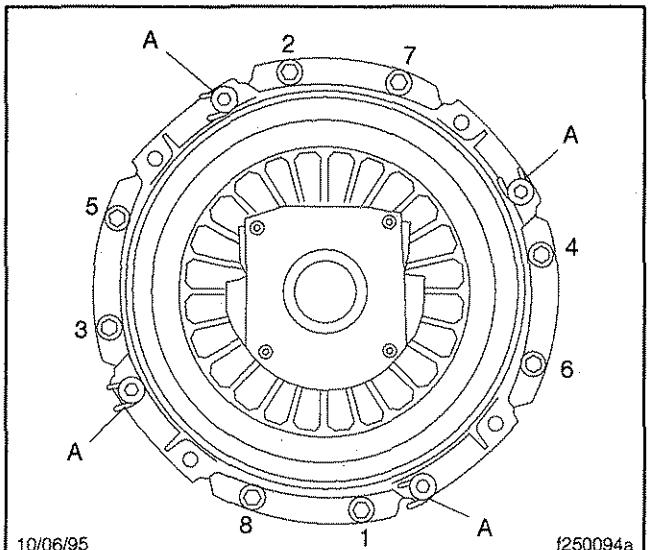
A. Flywheel
B. Raised Step
C. Pressure Plate Assembly

1. Flywheel
2. Pilot Bearing
3. Alignment Pin
4. Alignment Tool
5. Pressure Plate Assembly
6. Capscrew
7. Washer
8. Clutch Disc

Fig. 8, Clutch Assembly with Flat Flywheel



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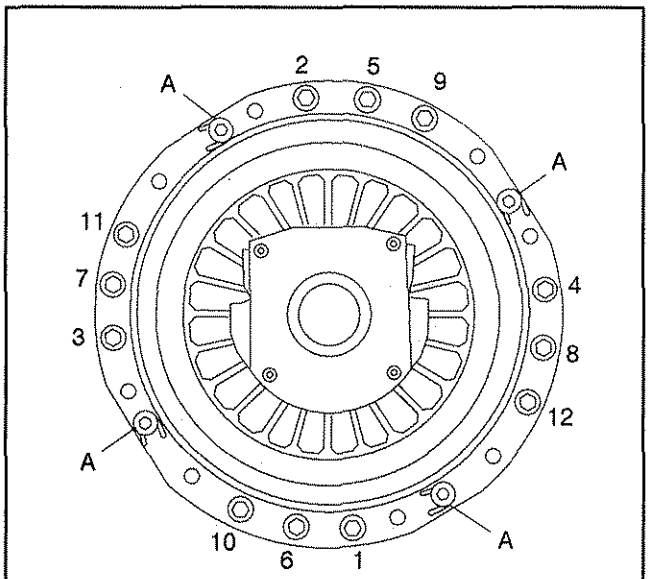
A. Shipping Clip

Fig. 9, 16-Inch Clutch Tightening Sequence



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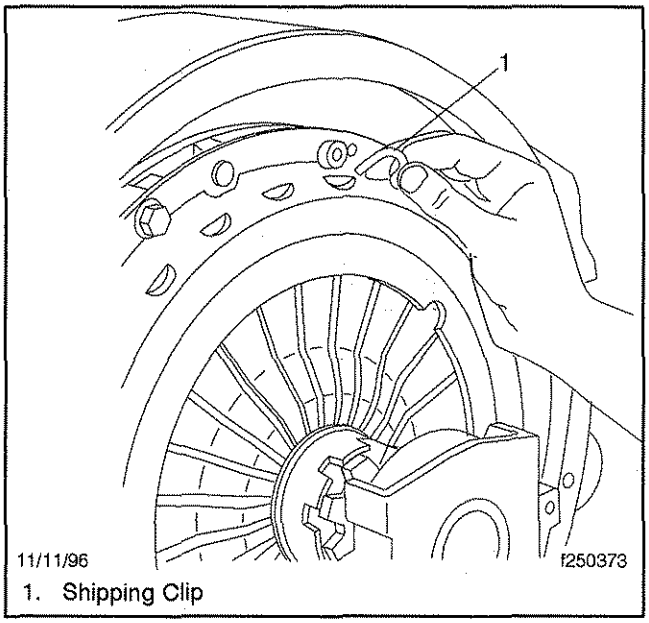
A. Shipping Clip

Fig. 10, 17-Inch Clutch Tightening Sequence



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1. Shipping Clip

Fig. 11, Remove the Shipping Clips

12. Install the transmission. Follow the procedures in **Group 26** of this manual.

Troubleshooting Tables

Troubleshooting—Functional Problems

NOTE: Problem entries in the troubleshooting tables that follow refer to functional or operational problems. Before troubleshooting the clutch, make sure that:

- the engine is operating correctly
- the engine mounts are in good condition
- the driveline angles of the engine, transmission, driveshaft, and rear axle are correct

Problem—The Clutch Does Not Disengage Completely

Problem—The Clutch Does Not Disengage Completely	
Possible Cause	**Remedy**
The clutch linkage and release bearing need adjustment.	Adjust the clutch linkage and release bearing.
The linkage is worn or damaged.	Lubricate the linkage. Make sure the linkage is not loose. If the condition persists, replace the linkage.
The release bearing is worn or damaged.	Lubricate (if applicable) the release bearing. If the condition persists, replace the release bearing.
The input shaft splines are worn or damaged.	Replace the input shaft.
The clutch housing is loose.	Tighten the fasteners to the specified torque. If necessary, replace the fasteners.
The pressure plate is worn or damaged.	Replace the clutch.
Damaged clutch disc hub.	Replace the clutch.
The clutch disc facings are worn beyond specification.	Replace the clutch.
Oil or grease on the clutch disc facings.	Clean the clutch disc facings. If the oil or grease cannot be removed, replace the clutch disc.
A clutch with incorrect clutch disc for the vehicle application is installed.	Install a clutch with the correct type of clutch disc.
The pilot bearing is damaged.	Replace the pilot bearing.
The clutch disc is bent or warped.	Replace the clutch.

Problem—Clutch Pedal Hard to Operate

Problem—Clutch Pedal Hard to Operate	
Possible Cause	**Remedy**
Damaged bosses on the release bearing assembly.	Replace the bearing assembly. Make sure the clutch is adjusted correctly.
The clutch linkage is worn or damaged.	Lubricate the linkage. If the condition still exists, replace the linkage.
The pressure plate and cover assembly components are worn or damaged.	Replace the clutch.
The clutch cross shaft binds.	Lubricate the cross shaft. If the condition persists, replace the cross shaft and bushings as required.

Troubleshooting

Problem—Clutch Pedal Hard to Operate	
Possible Cause	**Remedy**
The release bearing bushing is worn or damaged.	Replace the bearing assembly. Look for input shaft wear or damage. Make sure the clutch is adjusted correctly.
The input shaft is worn or damaged.	Replace the input shaft. Look for release bearing bushing wear or damage. Make sure the clutch is adjusted correctly.

Problem—The Clutch Slips

Problem—The Clutch Slips	
Possible Cause	**Remedy**
The driver keeps his foot on the clutch pedal.	Use correct driving procedures. Look for clutch wear or damage.
The clutch linkage or release bearing needs adjustment.	Adjust the clutch linkage or release bearing.
Pressure plate and cover assembly components are worn or damaged.	Replace the clutch.
Clutch disc facings are worn or damaged.	Replace the clutch.
Oil or grease on the clutch disc facings.	Clean the clutch disc facings. If the oil or grease cannot be removed, replace the clutch.
A clutch with incorrect clutch disc for the vehicle application is installed.	Install a clutch with the correct type of disc.
The flywheel is worn or damaged.	Service the flywheel as needed. For instructions, refer to the engine manufacturer's service manual.
The release bearing locknut is loose.	Adjust the release bearing length and tighten the locknut.

Problem—The Clutch is Noisy

Problem—The Clutch is Noisy	
Possible Cause	**Remedy**
The clutch linkage or release bearing needs adjustment.	Adjust the clutch linkage or release bearing.
The linkage is worn or damaged.	Lubricate the linkage. If the condition persists, replace the linkage.
The release bearing is worn or damaged.	Lubricate (if applicable) the release bearing. If the condition persists, replace the release bearing.
The clutch housing is worn or damaged.	Replace the clutch housing.
The clutch housing is loose.	Tighten the fasteners to the specified torque. If necessary, replace the fasteners.
Clutch brake rattle.	Replace with a different style of clutch brake.
Clutch disc facings are worn beyond specified dimensions.	Replace the clutch.
Clutch disc damper is worn or damaged.	Replace the clutch.

Problem—The Clutch is Noisy	
Possible Cause	**Remedy**
Clutch incorrectly installed.	Remove the clutch and install correctly.
The pilot bearing is damaged.	Replace the pilot bearing.
If noisy only at idle, the clutch disc may lack the idle noise damper option.	Replace with dual damper style clutch assembly.

Problem—The Clutch Vibrates

Problem—The Clutch Vibrates	
Possible Cause	**Remedy**
The input shaft splines are damaged.	Replace the input shaft.
Pilot bearing worn or damaged.	Replace the pilot bearing and input shaft if needed.
The clutch disc facings are damaged.	Replace the clutch.
The flywheel is loose.	Tighten the fasteners to the specified torque. If necessary, replace the fasteners. Check the flywheel mounting surface for damage. If necessary, replace the flywheel.
Clutch is out of balance.	Replace the clutch.
Clutch is installed incorrectly.	Remove the clutch and install correctly.
Release bearing worn or damaged.	Replace the release bearing.
Excessive driveline torsional activity (poorly phased driveshaft u-joints, incorrect driveline angles, incorrect air ride height adjustment, excessive driveshaft imbalance, incomplete ignition, etc.)	Find and correct cause of excessive driveline torsional activity.

Troubleshooting—Component Problems

NOTE: Problem entries in the troubleshooting tables that follow refer to damage to components.

Problem—Broken Tabs on the Clutch Brake

Problem—Broken Tabs on the Clutch Brake	
Possible Cause	**Remedy**
Vibration.	Inspect the clutch disc hub; check the installation of the clutch. Replace the clutch disc hub or install the clutch correctly.
The clutch linkage is incorrectly adjusted.	Adjust the clutch linkage. Also, check the installation of the clutch.
The driver used the clutch brake while the vehicle was moving.	Use correct driving technique.
The driver used the clutch to hold the vehicle on a hill when stopped.	Use correct driving technique.

Troubleshooting

Problem—Worn or Damaged Release Bearing Housing

Problem—Worn or Damaged Release Bearing Housing	
Possible Cause	**Remedy**
The driver keeps his foot on the pedal.	Use correct driving technique.
The clutch linkage is incorrectly adjusted.	Adjust the clutch linkage. Also, check the installation of the clutch; install correctly if needed.
The release bearing has been greased with incorrect thick grease or dirt contaminated grease.	Use approved lubricant and schedule lube change.

Problem—Worn Bosses on the Release Bearing Housing

Problem—Worn Bosses on the Release Bearing Housing	
Possible Cause	**Remedy**
The linkage is damaged or out of adjustment.	Lubricate and adjust the linkage. Inspect the linkage for wear or damage; replace linkage if necessary.
The release yoke is binding.	Lubricate the release yoke shaft. If the yoke does not move freely, replace the shaft and yoke assembly.
The free pedal is out of adjustment.	Adjust the free pedal to specification.

Problem—Worn or Damaged Input Shaft Splines

Problem—Worn or Damaged Input Shaft Splines	
Possible Cause	**Remedy**
The transmission is not aligned.	Make sure the flywheel housing and the clutch housing are aligned to specification.
The transmission is not installed correctly.	Install the transmission correctly.
The clutch disc hub is damaged.	Replace the clutch.
The pilot bearing is worn or damaged.	Replace the pilot bearing.
The clutch is out of adjustment.	Adjust the clutch and linkage to specifications.

Problem—Pressure Plate Cracked or Damaged by Heat

Problem—Pressure Plate Cracked or Damaged by Heat	
Possible Cause	**Remedy**
The driver engages the clutch while coasting.	Use correct driving techniques.
The driver uses the clutch as a brake.	Use correct driving techniques.
The clutch free pedal is not adjusted correctly.	Adjust the free pedal to specifications.

Problem—Pressure Plate Cracked or Damaged by Heat	
Possible Cause	**Remedy**
There is oil or grease on the clutch disc facings.	Clean the clutch disc. If the oil or grease cannot be removed, replace the clutch disc. Repair the cause of the grease or oil.
The driver slips the clutch excessively during engagement.	Use correct driving techniques.
The driver starts the truck in too high of a transmission gear.	Use correct driving techniques.

Problem—Grooves Worn in the Pressure Plate

Problem—Grooves Worn in the Pressure Plate	
Possible Cause	**Remedy**
The clutch disc is worn or damaged.	Replace the clutch disc.

Problem—The Clutch Disc Hub is Warped

Problem—The Clutch Disc Hub is Warped	
Possible Cause	**Remedy**
The transmission was not installed correctly.	Replace the clutch disc. Install the transmission correctly.

Problem—The Hub Separates From the Clutch Disc

Problem—The Hub Separates From the Clutch Disc	
Possible Cause	**Remedy**
Excessive engine vibration.	Repair the engine.
The transmission was not installed correctly.	Install the transmission correctly.
The clutch housing is loose.	Tighten the clutch housing to the specified torque.
The driver engages the clutch while the vehicle is coasting.	Use correct driving techniques.
Shock loading.	Use correct driving techniques.

Troubleshooting

Problem—Heat Damage to the Clutch Disc

Problem—Heat Damage to the Clutch Disc	
Possible Cause	**Remedy**
The driver keeps his foot on the clutch pedal or slips the clutch.	Use correct driving techniques.
The clutch does not engage or disengage completely.	See "Troubleshooting—Functional Problems: Clutch Does Not Disengage Completely."
The free pedal is not adjusted correctly.	Adjust the free pedal.
There is oil or grease on the clutch disc facings.	Clean the clutch disc. If the oil or grease cannot be removed, replace the clutch disc. Repair the cause of the grease or oil.
The driver does not start the vehicle in the correct gear.	Use correct driving techniques.
The driver engages the clutch while the vehicle is coasting.	Use correct driving techniques.
The clutch does not release.	See "Troubleshooting—Functional Problems: Clutch Does Not Disengage Completely."

Problem—The Facings Separate From the Disc

Problem—The Facings Separate From the Disc	
Possible Cause	**Remedy**
The clutch disc facings are worn below the specified dimension.	Replace the clutch.
The driver allows the vehicle to coast downhill with the transmission in neutral and the clutch engaged.	Use correct driving techniques.

Specifications

Designation	Definition
EV	Valeo
145	x 10 = Maximum torque capacity in lbf.ft
17	Clutch size in inches

Table 1, Model Number Breakdown (example: EV14517)

Torque Values				
Model	**Total Weight lbs (kg)**	**Torque Rating lbf.ft (N.m)**	**Housing**	**Flywheel**
EV12516	91 (41)	1250 (1695)	SAE #2	16-Inch Flat
EV14016	91 (41)	1400 (1898)		
EV14517	104 (47)	1450 (1966)	SAE #1	17-Inch Flat
EV16517	105 (48)	1650 (2237)		
EV18517	113 (51)	1850 (2508)		

Table 2, Torque Values

Description	Clutch	Torque: lbf.ft (N.m)
Cover Assembly Capscrews (grade 8)	16- and 17-Inch	40–55 (54–75)

Table 3, Cover Assembly Torque Values

Adjustment Values	
Description	**Adjustment inches (mm)**
Release Yoke Finger to Bearing Pad Clearance	0.105 to 0.145 (2.7 to 3.7)
Clutch Free Pedal (minimum)	3/4 (19)
Release Travel Clearance: Non-Synchronized Transmission With Clutch Brake	1/2 to 9/16 (12.7 to 14.3)

Table 4, Adjustment Values

Specifications

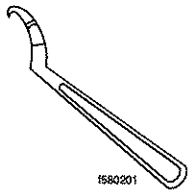
Special Tools			
Tool	**Description**	**Manufacturer**	**Part Number**
	Adjustable Hook Spanner Wrench	Kent-Moore	J4749

Table 5, Special Tools

Clutch Linkage 25.03

Contents

Subject	Subject Number
General Description	050
Service Operations	
Clutch Linkage Adjustment, Century Class Conventional	100
Clutch Release Shaft Replacement	110
Clutch Linkage Adjustment, Argosy COE	120
Specifications	400

General Description

The clutch linkage transfers the motion of the clutch pedal to the clutch release bearing. The clutch linkage may be adjusted to maintain clutch free pedal, but only after internal clutch adjustments are made.

Clutch free pedal is required to ensure that the release bearing does not run against the fingers of the release yoke. There should not be any play or looseness in the connections and joints of the clutch linkage.

IMPORTANT: Release bearing and release fork clearance are internal clutch adjustments, and *can not be adjusted* by adjusting the clutch linkage. Refer elsewhere in this group for internal clutch adjustments, or to the clutch manufacturer's service literature.

Clutch Linkage Adjustment, Century Class Conventional

Clutch Linkage Adjustment

IMPORTANT: Observe the following points before beginning clutch linkage adjustment:

- Be sure internal clutch adjustments are correct before making adjustments to the clutch linkage. Refer to the appropriate section in this manual.
- Adjust clutch linkage only after repair or replacement of the clutch or clutch linkage components.
- Do not attempt to adjust the linkage to compensate for component wear.
- If equipped with cab air-suspension, be sure the air bags are properly inflated. If the air bags are not inflated, the clutch linkage can't be adjusted correctly. For instructions, see **Group 60** in this manual.

IMPORTANT: A special tool is used to adjust the clutch linkage. The special tool is a 3/4-inch (19-mm) spacer and may be ordered from the PDCs under part number 02–12282–000.

1. Tilt the hood.
2. Be sure the clutch pedal is all the way up, against the upper stop.
3. Remove the clutch inspection cover from the bottom of the bell housing.
4. Measure the distance between the release yoke and the release bearing. If this measurement is 0.105 to 0.145 inch (2.7 to 3.7 mm), no further work is needed. If the measurement is incorrect, do all of the remaining steps.
5. Loosen the rod-end jam nuts at the upper end of the threaded adjusting rod.
6. Disconnect the clutch rod from the lower end of the pedal shaft. See **Fig. 1**.
7. Place the special tool (part number 02–12282–000) between the clutch pedal stop bracket and the clutch pedal. See **Fig. 2**.
8. Without applying excessive force, pull the clutch rod forward until it stops (release yoke contacts the release bearing).
9. To obtain a free travel measurement of 0.105 to 0.145 inch (2.7 to 3.7 mm) between the release yoke and the release bearing, turn the clutch rod end until the center of the rod-end hole is aligned with the center of the hole in the upper clutch lever.

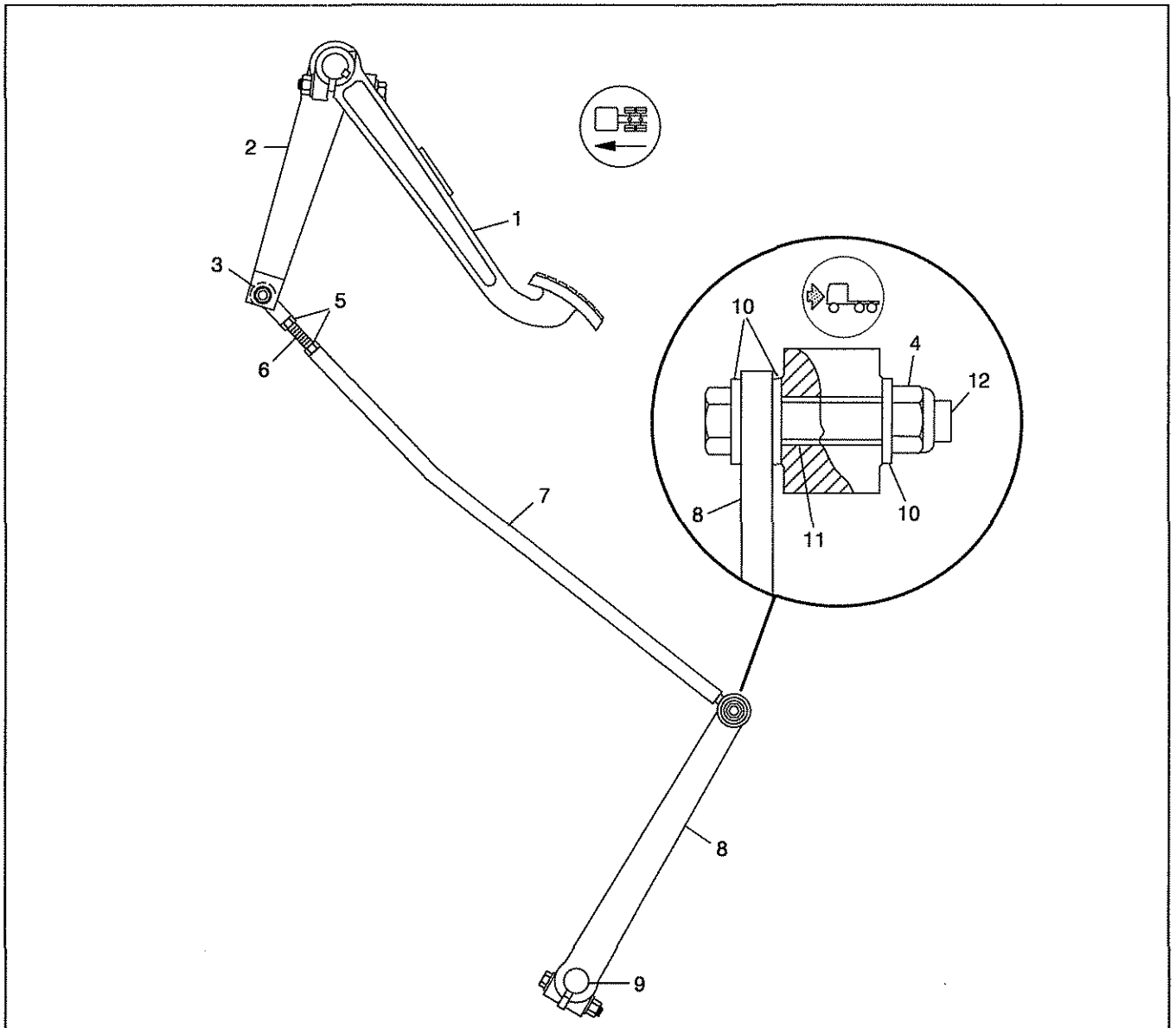
NOTE: Each complete turn of the rod end (or rod) equals about 1/32 inch (1 mm) movement. After lengthening the linkage, at least 3/8 inch (9.5 mm) of thread must remain engaged in each end of the rod.

10. After adjusting the length, connect the clutch rod to the pedal shaft. Install the rod end and nut. Tighten the nut 30 lbf·ft (41 N·m). See **Fig. 3**.

    Tighten both rod-end jam nuts 12 to 15 lbf·ft (16 to 20 N·m).

    Remove the special tool from the clutch pedal stop bracket.
11. Install the inspection cover on the bottom of the bell housing.

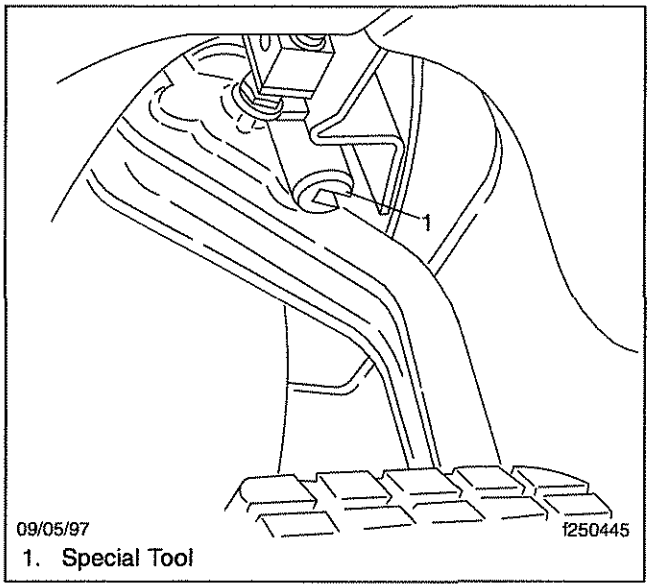
Clutch Linkage Adjustment, Century Class Conventional



1. Clutch Pedal
2. Clutch Pedal Shaft
3. Rod End
4. Locknut
5. Rod-End Jam Nut
6. Threaded Adjusting Rod
7. Clutch Rod
8. Clutch Release Lever
9. Clutch Release Shaft
10. Flatwasher
11. Spacer
12. Capscrew

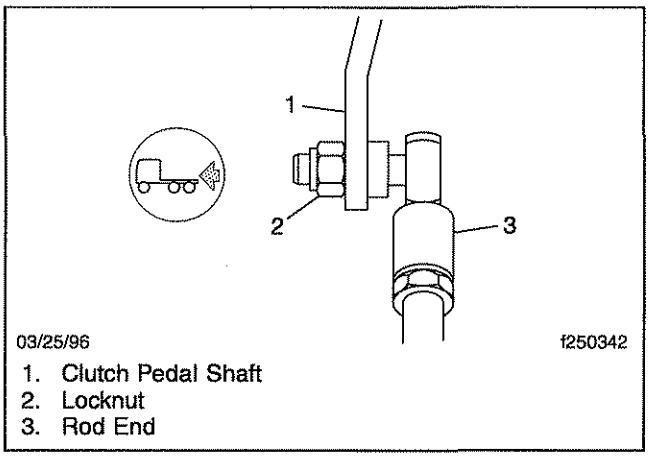
Fig. 1, Clutch Linkage

Clutch Linkage Adjustment, Century Class Conventional



1. Special Tool

Fig. 2, Insert the Special Tool



1. Clutch Pedal Shaft
2. Locknut
3. Rod End

Fig. 3, Connect the Clutch Rod to the Pedal Shaft

Clutch Release Shaft Replacement

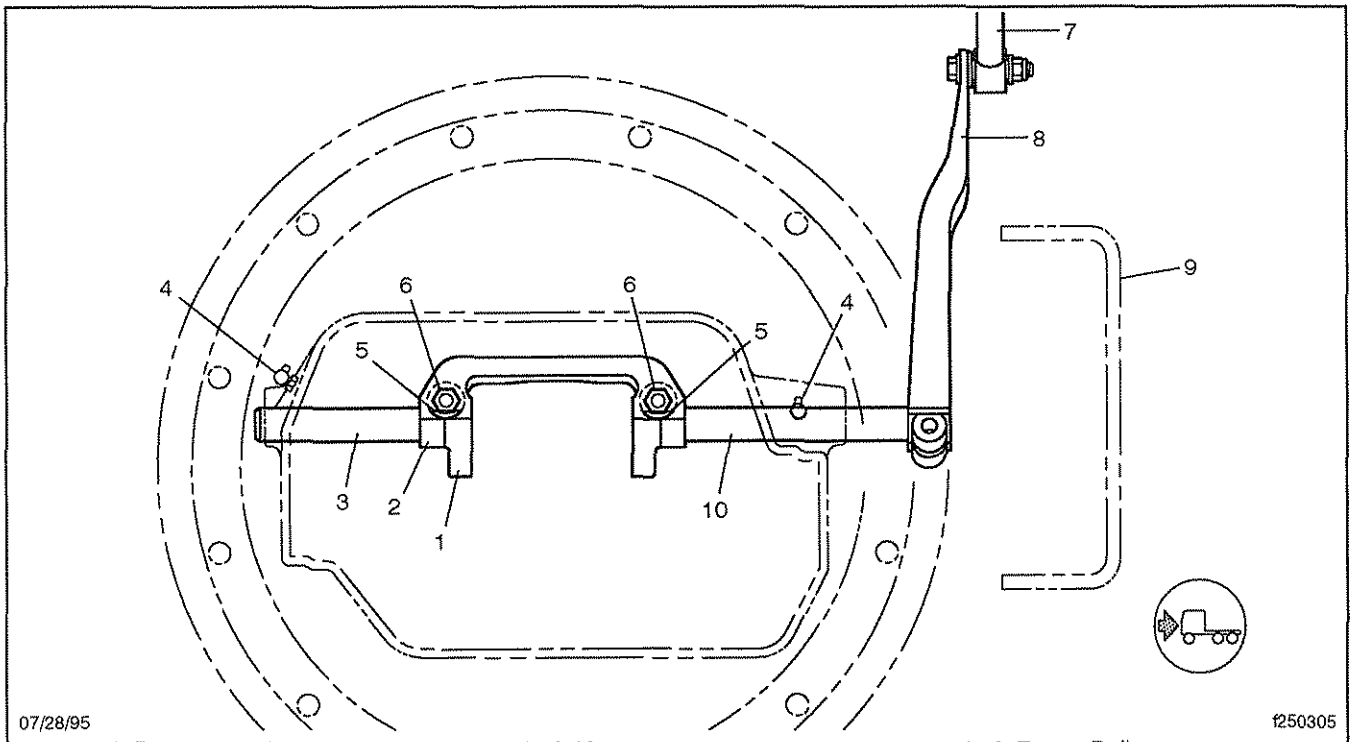
Replacement (See Fig. 1)

NOTE: If the clutch release shaft assembly is damaged, use the following replacement instructions.

1. Remove the transmission from the vehicle. For instructions, refer to **Group 26** in this manual.
2. Remove the capscrew and shaft key from the right (passenger side) clutch release shaft. Remove the shaft from the mounting holes on the transmission and the clutch release yoke.
3. Remove the capscrew and shaft key from the left (driver's side) clutch release shaft. Remove the shaft from the mounting holes on the transmission and the clutch release yoke.
4. Insert the right (passenger side) clutch release shaft into the mounting holes on the transmission and the clutch release yoke. Line up the release yoke with the slot in the release shaft. Install the shaft key and the capscrew. Tighten the capscrew finger-tight.

NOTE: Make sure the release shaft does not extend through the release fork.

5. Repeat the previous step and install the left (driver's side) clutch release shaft.
6. Tighten the capscrews 35 to 45 lbf·ft (47 to 61 N·m).
7. Install the transmission. For instructions, refer to **Group 26** in this manual.
8. Wipe dirt from the grease fittings. Using a pressure gun, lubricate the clutch release shaft with multi-purpose chassis grease.
9. Check for binding; the clutch release shaft assembly should rotate smoothly.



1. Clutch Release Fork
2. Clutch Release Yoke
3. Right Clutch Release Shaft
4. Grease Fitting
5. Shaft Key
6. Capscrew
7. Lower Clutch Rod
8. Clutch Release Lever
9. Left Frame Rail
10. Left Clutch Release Shaft

Fig. 1, Clutch Release Shaft (pull-type clutch shown)

Clutch Release Shaft Replacement

10. Check that the clutch engages and disengages smoothly. If needed, adjust the clutch at the linkage. For instructions, refer to **Subject 100**.

Clutch Linkage Adjustment, Argosy COE

Clutch Linkage Adjustment

1. Shut down the vehicle, apply the parking brake, and chock the tires.

IMPORTANT: Observe the following points before beginning clutch linkage adjustment:

- Be sure internal clutch adjustments are correct before making adjustments to the clutch linkage. Refer to the appropriate section in this manual.
- Adjust clutch linkage only after repair or replacement of the clutch or clutch linkage components.
- Do not attempt to adjust the linkage to compensate for component wear.
- If equipped with cab air-suspension, be sure the air bags are properly inflated. If the air bags are not inflated, the clutch linkage can't be adjusted correctly. For instructions, see **Group 60** in this manual.

2. Be sure the clutch pedal is all the way up, against the upper stop.
3. Measure the distance between the release yoke and the release bearing using the clutch inspection tool (part number A02–12254). If this measurement is 0.105 to 0.145 inch (2.7 to 3.7 mm), no further work is needed. If the measurement is incorrect, do all of the remaining steps.

IMPORTANT: A special tool is used to adjust the clutch linkage. The special tool may be ordered from Kent Moore (part number J–43837).

⚠ WARNING

Before tilting the cab, read the instructions and the Danger and Warning notices in Section 60.15 of this manual. Failure to follow these instructions could cause the cab to hit or crush a person, possibly resulting in serious injury or death.

4. Tilt the cab. For instructions, see **Group 60**.
   - 4.1 Tilt the cab so the safety stop can be lowered onto the tilt ram.
   - 4.2 Lower the safety stop onto the tilt ram.

   IMPORTANT: The clutch adjustment will be inaccurate if the cab is not lowered against the safety stop.
   - 4.3 Return the cab until it rests against the safety stop.
5. Remove the clutch inspection cover from the bottom of the bell housing.
6. Loosen the rod-end jam nuts at the end of the threaded adjusting rod.
7. Disconnect the clutch rod from the clutch release lever. See **Fig. 1**.
8. Without applying excessive force, pull the clutch release lever toward the front of the vehicle until it stops.

NOTE: Each complete turn of the rod end (or rod) equals about 1/24 inch (0.8 mm) movement. After lengthening the linkage, at least 3/8 inch (9.5 mm) of thread must remain engaged in each end of the rod.

9. Insert the clutch adjustment tool (Kent Moore part number J–43837) short dowel into the hole in the end of the clutch release lever. If the adjustable end does not slide onto the long dowel while the tool is held in a parallel plain position with the frame rail, loosen the jam nut and adjust the rod end until it slides over the dowel. See **Fig. 2**. Tighten the jam nut.
10. After adjusting the length, connect the clutch rod to the clutch release lever. Install the rod end and nut. Tighten the nut 30 lbf·ft (41 N·m). See **Fig. 3**.

    Tighten the rod-end jam nut 12 to 15 lbf·ft (16 to 20 N·m).

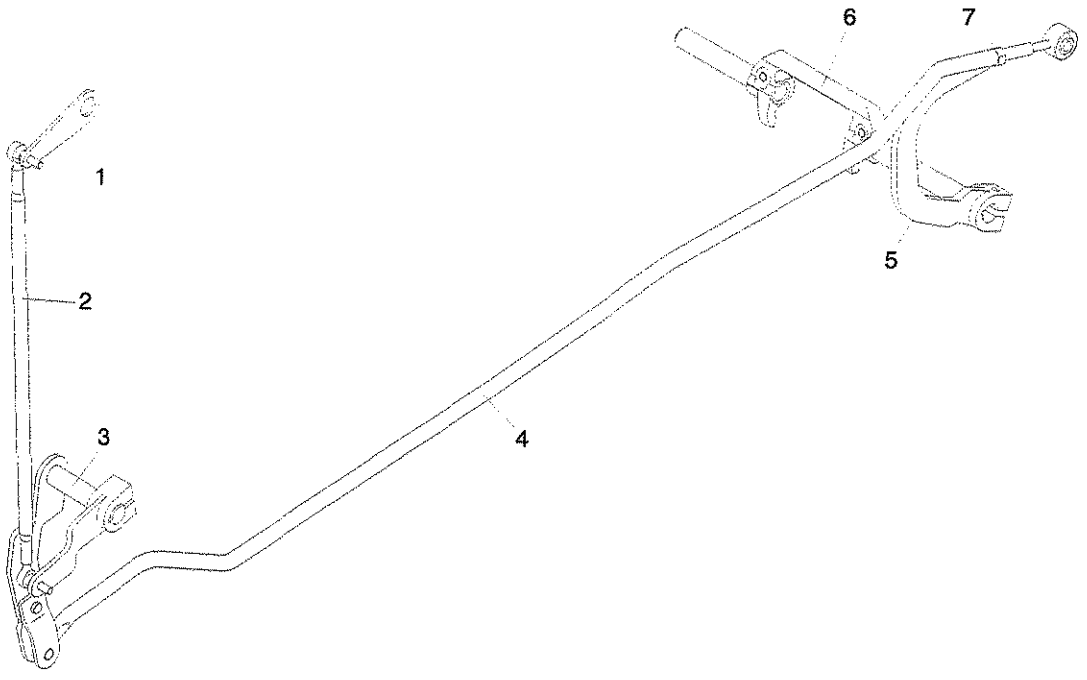
⚠ DANGER

Before returning the cab to the normal operating position, read the instructions and Danger and Warning notices in Section 60.15 of this manual. Failure to follow these instructions could cause the cab to hit or crush a person, possibly resulting in serious injury or death.

11. Return the cab and measure the distance between the release yoke and the release bearing using the clutch inspection tool (part number A02–12254). If this measurement is 0.105 to 0.145 inch (2.7 to 3.7 mm), no further work is needed. If the measurement is incorrect, repeat the above steps.
12. Install the inspection cover on the bottom of the bell housing.

Clutch Linkage Adjustment, Argosy COE

13. Remove the chocks from the tires.



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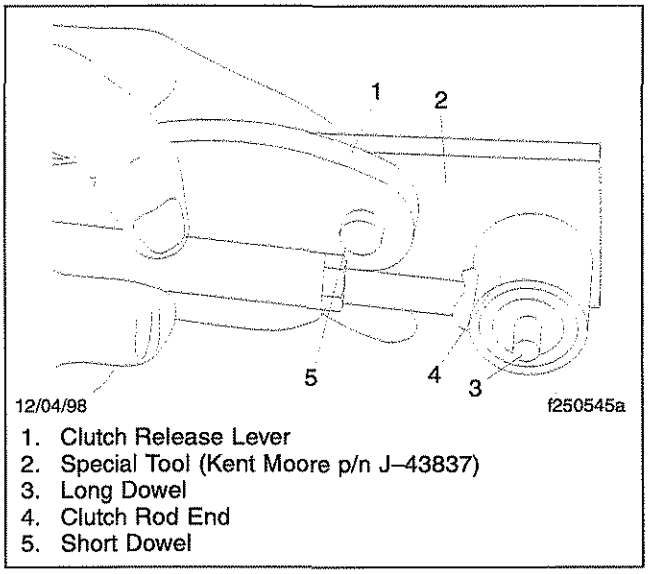
1. Clutch Pedal Shaft
2. Clutch Rod
3. Clutch Rod Relay
4. Clutch Rod
5. Clutch Release Lever
6. Clutch Release Yoke
7. Rod-End Jam Nut

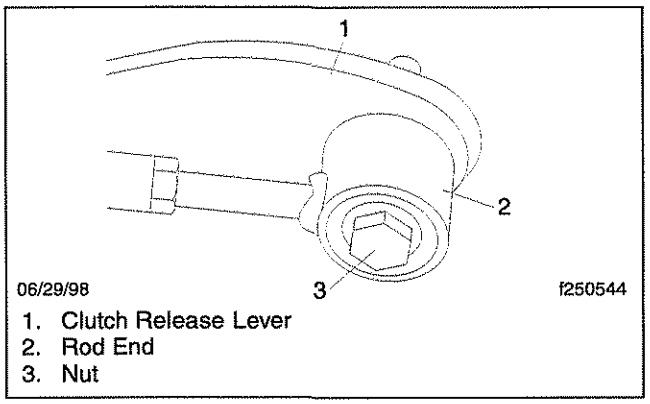
Fig. 1, Clutch Linkage

Clutch Linkage Adjustment, Argosy COE



1. Clutch Release Lever
2. Special Tool (Kent Moore p/n J–43837)
3. Long Dowel
4. Clutch Rod End
5. Short Dowel

Fig. 2, Insert the Special Tool



1. Clutch Release Lever
2. Rod End
3. Nut

Fig. 3, Connect the Clutch Rod to the Release Lever

Specifications

Description	Torque
Clutch Linkage Jam Nuts	12–15 lbf·ft (16–20 N·m)
Clutch Rod-to-Pedal Shaft	30 lbf·ft (41 N·m)

Table 1, Clutch Linkage Torque Values

Contents

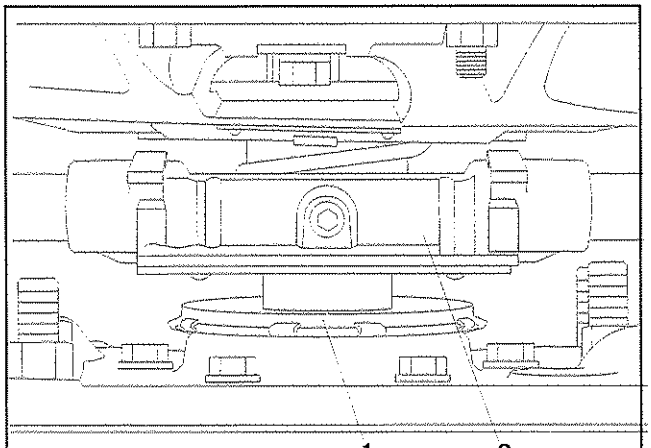
Subject	Subject Number
General Information	050
Service Operations	
One-Piece Clutch Brake Replacement	100
Replacement of a One-Piece Clutch Brake with a Two-Piece Clutch Brake	110
Two-Piece Clutch Brake Replacement	120
Troubleshooting	300

General Description

When the vehicle is stationary, a clutch brake permits shifting into first gear or reverse gear without severe gear clash.

Clutch brake engagement occurs approximately during the last 1 to 1-1/4 inches (25 to 33 mm) of downward pedal travel. The clutch brake is between the release-bearing housing (see **Fig. 1**) and the transmission bearing cap, and is engaged by tangs to the transmission input shaft. When the pedal is fully depressed, the clutch brake is squeezed between the release-bearing housing and the transmission bearing cap (see **Fig. 2**), stopping the rotation of the main drive gear.

The clutch brake may be a disc-type or a torque-limiting type. In addition, the clutch brake may be either a one-piece or two-piece design. To prevent overloads to it, the torque-limiting clutch brake is designed to slip when loads of 20 to 25 lbf·ft (27 to 34 N·m) are reached. Clutch brakes are not designed for upshifting.



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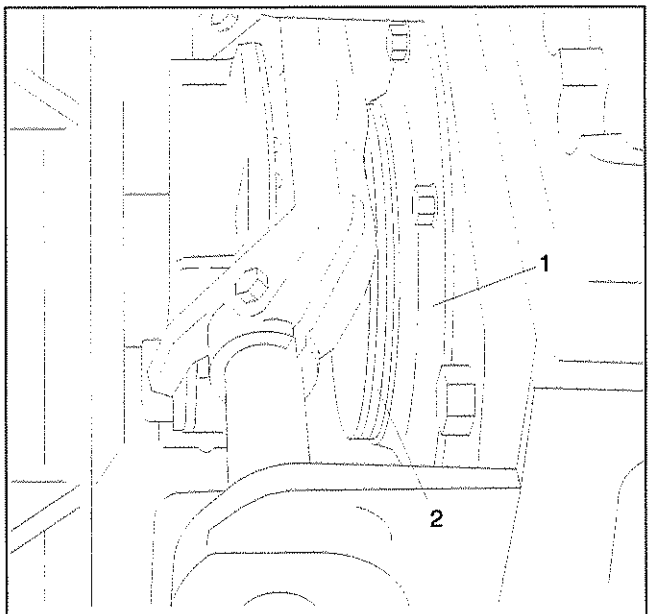
1. Clutch Brake
2. Release Bearing

Fig. 1, Clutch Brake and Release Bearing



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1. Transmission Input Shaft Bearing Cap
2. Clutch Brake Discs and Washer

Fig. 2, Clutch Brake and Bearing Cap

One-Piece Clutch Brake Replacement

Replacement

1. Shut down the engine, set the parking brake, and chock the tires.
2. Tilt the hood.
3. Drain the air tanks.
4. Disconnect the batteries.
5. Place the transmission in gear.
6. Remove the shift tower from the top of the transmission. See **Group 26** in this manual for instructions.
7. Disconnect the driveline from the rear of the transmission. See **Group 41** in this manual for instructions.
8. Disconnect the midship bearing. See **Group 41** in this manual for instructions. Pull the driveshaft aside and position it out of the way.
9. Remove the fuel tank compression brace. See **Group 47** in this manual for instructions.
10. Disconnect the clutch rod from the clutch release lever. See **Section 25.03** in this group for instructions.
11. Disconnect the transmission wiring.
12. Disconnect the transmission air lines.
13. Remove the auxiliary air tank, if so equipped.
14. Remove the transmission oil cooler and set it aside, out of the way.

IMPORTANT: Do not disconnect the oil cooler lines.

15. Place a transmission jack in position below the transmission. Adjust the jack to support the transmission.
16. Secure the transmission to the jack.
17. Remove the flywheel housing-to-clutch housing bolts. See **Group 26** in this manual for instructions.

⚠ CAUTION

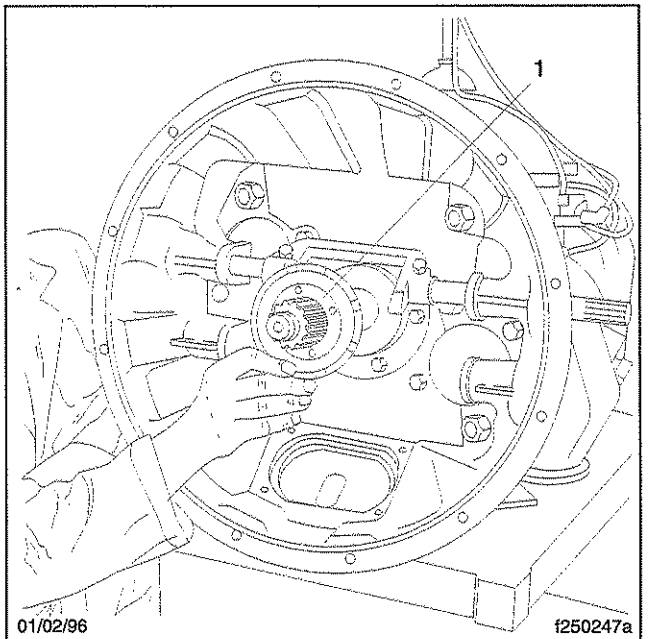
Do not let the rear of the transmission drop, and do not let the transmission hang unsupported in the splined hubs of the clutch discs. Taking these precautions will prevent bending and distortion of the clutch discs.

18. Pull the transmission back until the input shaft clears the flywheel.
19. Remove the old clutch brake from the transmission input shaft. See **Fig. 1**.
20. Align the tangs of the new clutch brake with the grooves on the input shaft and slide the clutch brake into position. See **Fig. 2**.

⚠ CAUTION

Use care to avoid springing the drive discs when the transmission is being installed. Do not force the transmission into the clutch or flywheel housing if it does not enter freely. Do not let the transmission drop or hang unsupported in the driven discs. These practices can damage the clutch assembly.

21. Install the transmission. See **Group 26** in this manual for instructions.
22. Remove the transmission jack.
23. Connect the air lines and the transmission wiring.



1. Clutch Brake

Fig. 1, Clutch Brake Removal

One-Piece Clutch Brake Replacement

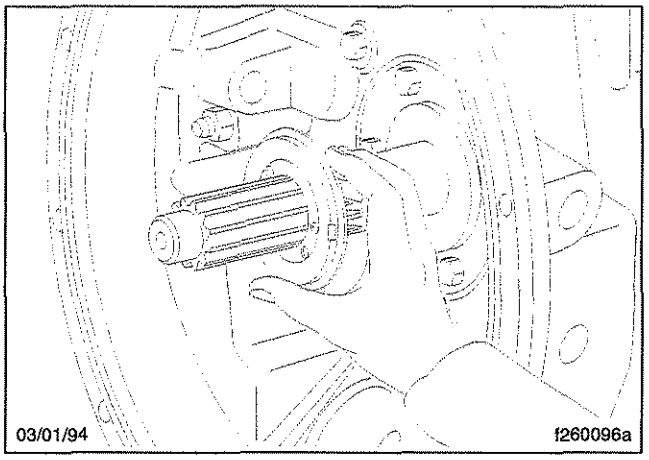


Fig. 2, Clutch Brake Installation

24. Install the fuel tank compression brace. See **Group 47** in this manual for instructions.
25. Install the auxiliary air tank, if so equipped.
26. Install the transmission oil cooler.
27. Install the shift tower on the top of the transmission. See **Group 26** in this manual for instructions.
28. Connect the clutch rod to the clutch release lever. See **Section 25.03** in this group for instructions.
29. Connect the driveline at the rear of the transmission. See **Group 41** in this manual for instructions.
30. Connect the midship bearing. See **Group 41** in this manual for instructions.
31. Ensure that the transmission is out of gear and adjust the clutch. See **Group 25** in this manual for instructions.
32. Connect the batteries.
33. Lower the hood and remove the chocks from the tires.
34. Test drive the vehicle and ensure that the clutch brake and clutch operate properly.

Replacement of a One-Piece Clutch Brake with a Two-Piece Clutch Brake

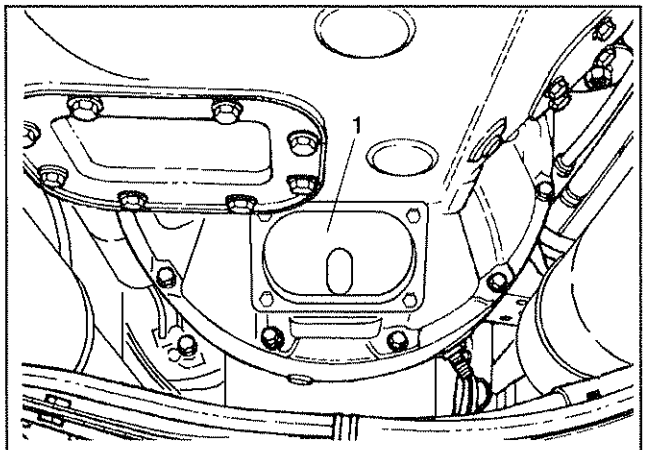
Replacement

1. Shut down the engine, set the parking brake, and chock the tires.
2. Tilt the hood.
3. Remove the four fasteners and the clutch inspection cover. See **Fig. 1**.

⚠ WARNING

Wear safety goggles when cutting off the old clutch brake. If any of the metal parts were to chip, flying pieces of metal could cause eye injury.

4. Using an air chisel, carefully cut off the old clutch brake.
5. Check the orientation and fit of the new two-piece clutch brake halves.
6. Place one half of the new two-piece clutch brake onto the input shaft and rotate it to the top side of the shaft. See **Fig. 2**.
7. Align the lower half with the upper half at the connecting points.
8. Hold both halves together and start the fasteners on both sides.
9. Align the fasteners with the grooves on the input shaft.



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1. Inspection Cover

Fig. 1, Clutch Inspection Cover

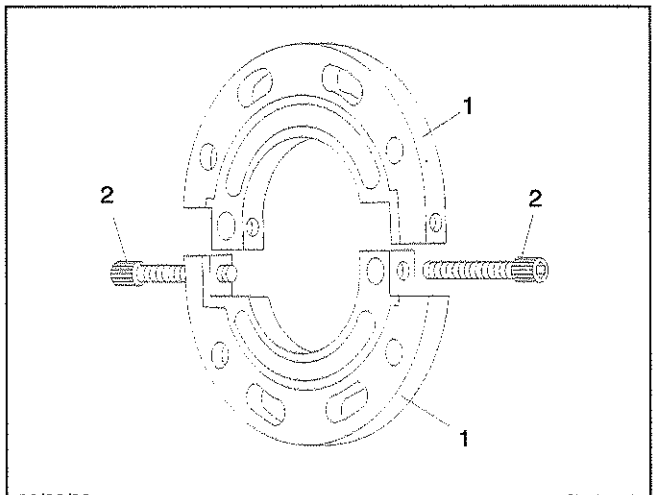
10. Tighten Allen-head fasteners 60 lbf·in (675 N·cm).

NOTE: Other types of two-piece clutch brakes use roll pins for fasteners.

⚠ WARNING

Wear safety goggles when driving in roll pins. If any of the metal parts were to chip, flying pieces of metal could cause eye injury.

11. If the replacement clutch brake uses roll pins, carefully drive in the roll pins equally with a punch and mallet, securing the halves to each other.
12. Install the clutch inspection cover and the four fasteners. Tighten the fasteners securely.
13. Adjust the clutch. See **Group 25** in this manual for instructions.
14. Lower the hood and remove the chocks from the tires.
15. Test drive the vehicle and ensure that the clutch brake and clutch operate properly.



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1. Clutch Brake Half
2. Allen-Head Fastener

Fig. 2, Two-Piece Clutch Brake (Spicer shown)

Two-Piece Clutch Brake Replacement

Replacement

1. Shut down the engine, set the parking brake, and chock the tires.
2. Tilt the hood.
3. Remove the four fasteners and the clutch inspection cover. See **Fig. 1**.

NOTE: Some types of two-piece clutch brakes use roll pins for fasteners.

4. Rotate the input shaft until the Allen-head fasteners or roll pins securing the two clutch brake halves are visible.
5. If the old clutch brake uses Allen-head fasteners, remove the fasteners and remove the two brake halves from the input shaft.

⚠ WARNING

Wear safety goggles when driving out roll pins. If any of the metal parts were to chip, flying pieces of metal could cause eye injury.

6. If the old clutch brake uses roll pins, carefully drive out the pins with a punch and mallet and remove the two brake halves from the input shaft.
7. Check the orientation and fit of the new two-piece clutch brake halves.

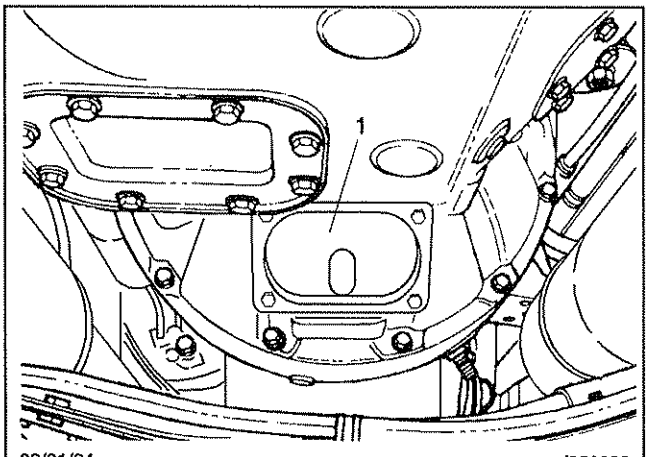


Fig. 1, Clutch Inspection Cover

8. Place one half of the new two-piece clutch brake onto the input shaft and rotate it to the top side of the shaft. See **Fig. 2**.
9. Align the lower half with the upper half at the connecting points.
10. Hold both halves together and start the fasteners on both sides.
11. Align the fasteners with the grooves on the input shaft.
12. Tighten Allen-head fasteners 60 lbf·in (675 N·cm).

⚠ WARNING

Wear safety goggles when driving in roll pins. If any of the metal parts were to chip, flying pieces of metal could cause eye injury.

13. If the replacement clutch brake uses roll pins, carefully drive in the roll pins equally with a punch and mallet, securing the halves to each other.
14. Install the clutch inspection cover and the four fasteners. Tighten the fasteners securely.
15. Adjust the clutch. See **Group 25** in this manual for instructions.
16. Lower the hood and remove the chocks from the tires.

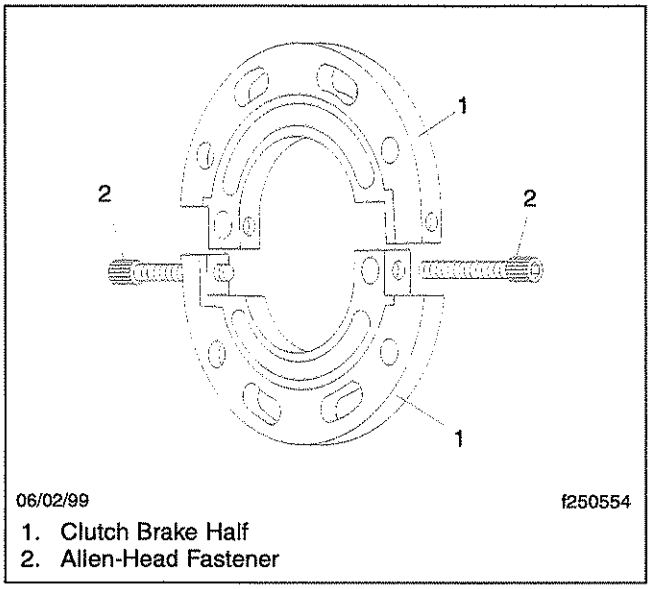


Fig. 2, Two-Piece Clutch Brake (Spicer shown)

Two-Piece Clutch Brake Replacement

17. Test drive the vehicle and ensure that the clutch brake and clutch operate properly.

Troubleshooting Tables

Problem—Broken Tabs on the Clutch Brake

Problem—Broken Tabs on the Clutch Brake	
Possible Cause	**Remedy**
Vibration.	Inspect the clutch disc hubs; check the installation of the clutch. Make sure dampened discs are used.
The clutch linkage is incorrectly adjusted.	Adjust the clutch linkage. Also, check the installation of the clutch.
The driver used the clutch brake while the vehicle was moving.	Use correct driving technique.
The driver used the clutch to hold the vehicle on a hill when stopped.	Use correct driving technique.

Problem—Poor Clutch Release

Problem—Poor Clutch Release	
Possible Cause	**Remedy**
The clutch brake is damaged and/or not functioning.	Install a new clutch brake.

Group Index, Alphabetical

Section	Section Number
Freightliner SmartShift™ Transmission Shift Control	26.01
Manual Transmission	26.00
Transmission Shift Cables, Argosy COE	26.02

Contents

Subject	Subject Number
General Information	050
Service Operations	
Shift Control Lever Replacement	100

Contents

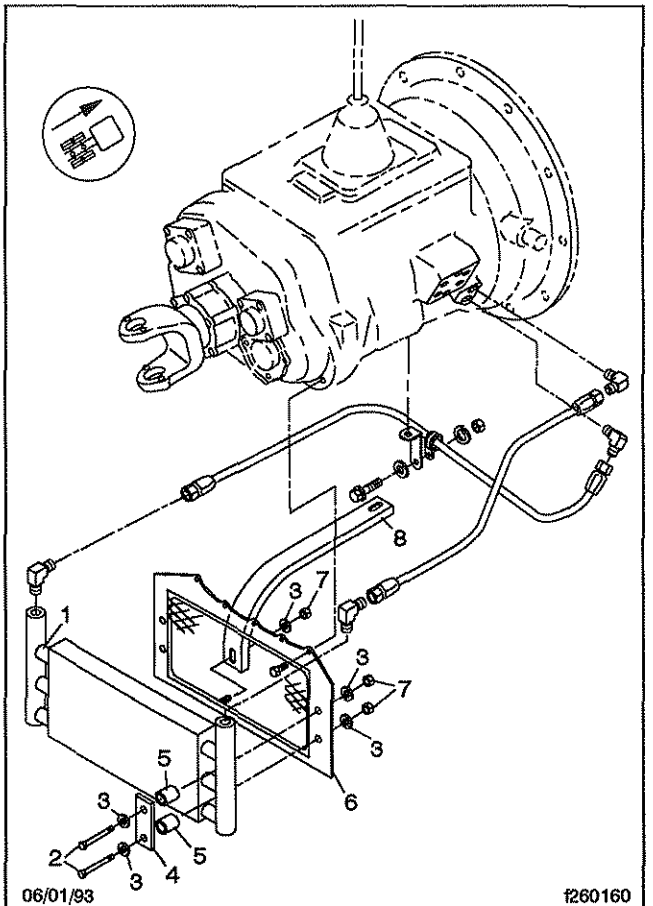
Subject	Subject Number
Service Operations	
Manual Transmission Removal and Installation, Century Class Conventional	100
Manual Transmission Removal and Installation, Argosy COE	110

Manual Transmission Removal and Installation

Removal

1. Apply the parking brakes, chock the tires, put the transmission into high gear, and tilt the hood.
2. Disconnect the batteries.
3. Remove the air reservoirs. For instructions, refer to **Group 42**.
4. If installed, remove the transmission fluid cooler and the plug fittings in the cooler and transmission. **See Fig. 1.**
5. Disconnect the driveline from the transmission output yoke. For instructions, refer to **Group 41**.
6. Disconnect the driveline midship bearing from the midship bearing bracket, and pull the driveline off to one side, out of the way. For instructions, refer to **Group 41**.
7. Disconnect the EquiFlo bracket from the top of the transmission.
8. Remove or disconnect the shift linkage. **See Fig. 2.**
   - 8.1 Remove the shift tower boot and air lines.
   - 8.2 Remove the shift tower from inside the cab, and cover the shift tower hole in the top of the transmission to prevent dirt from entering the transmission.
   - 8.3 Disconnect the electrical connectors from the top of the transmission.
9. Disconnect the clutch rod from the clutch release lever. Rotate the clutch release yoke so that it will clear the clutch release bearing.
10. Disconnect all wiring at the transmission, including the speedometer sensor at the output yoke, the neutral start switch, and the back-up alarm as applicable. Mark all wires for reassembly.
11. Disconnect all air lines from the transmission, and mark those lines for reassembly. Plug all air lines, and cap all transmission air fittings.
12. Position a transmission jack under the transmission, and raise its support plate against the bottom of the transmission. Adjust the support plate to the same angle as the bottom of the transmission.
13. Raise the transmission jack until it fits securely against the bottom of the transmission, then secure the transmission to the jack with a chain.
14. Remove the flywheel-housing-to-clutch-housing attachment bolts. Keep the flange of the clutch housing parallel (all the way around) to the flange of the flywheel housing, until the input shaft is clear of the clutch.

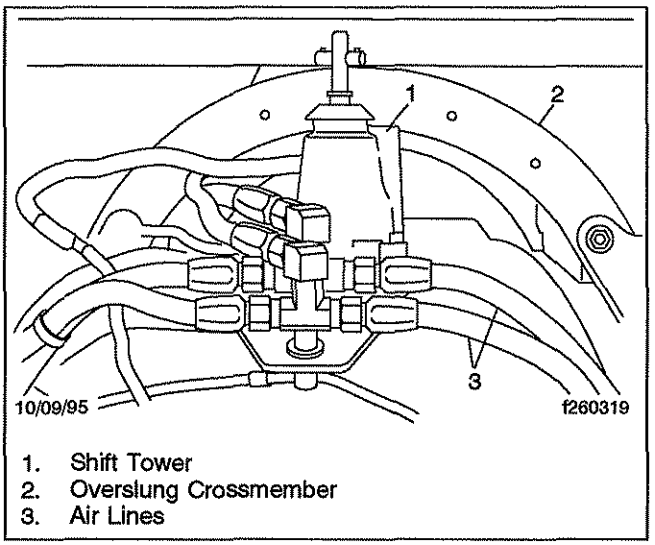
CAUTION: Do not let the rear of the transmission drop, and do not let the transmission hang unsupported in the splined hubs of the clutch discs. Taking these precautions will prevent damage to the clutch discs.



1. Transmission Fluid Cooler
2. Capscrew, 5/16-18
3. Washer, 5/16-inch
4. Retaining Plate
5. Biscuits
6. Mounting Bracket
7. Locknut, 5/16-18
8. Support Strut

Fig. 1, Transmission Fluid Cooler Mounting

Manual Transmission Removal and Installation



1. Shift Tower
2. Overslung Crossmember
3. Air Lines

Fig. 2, Shift Linkage Removal

15. Pull the transmission and jack straight back, until the transmission input shaft is clear of the clutch and the engine flywheel housing. Lower the transmission. **See Fig. 3.**

WARNING: After lifting the front end of the vehicle, do not get under the vehicle until it is securely supported by vehicle stands. If the vehicle is supported only by an axle jack, the vehicle can fall, resulting in personal injury or property damage.

16. Raise the front axle of the vehicle high enough that you can remove the transmission by rolling it out behind the front tire.

Installation

1. If not already done, apply the parking brakes, chock the tires, and tilt the hood.
2. If the clutch brake was removed, install the clutch brake on the transmission input shaft. **See Fig. 4.** Slide it tight against the input shaft bearing cap.

NOTE: Torque-limiting clutch brakes are a one-piece assembly with a larger and a smaller face. When installing a torque-limiting clutch brake on a Fuller® or Rockwell transmission, install the *smaller* face toward the transmission.

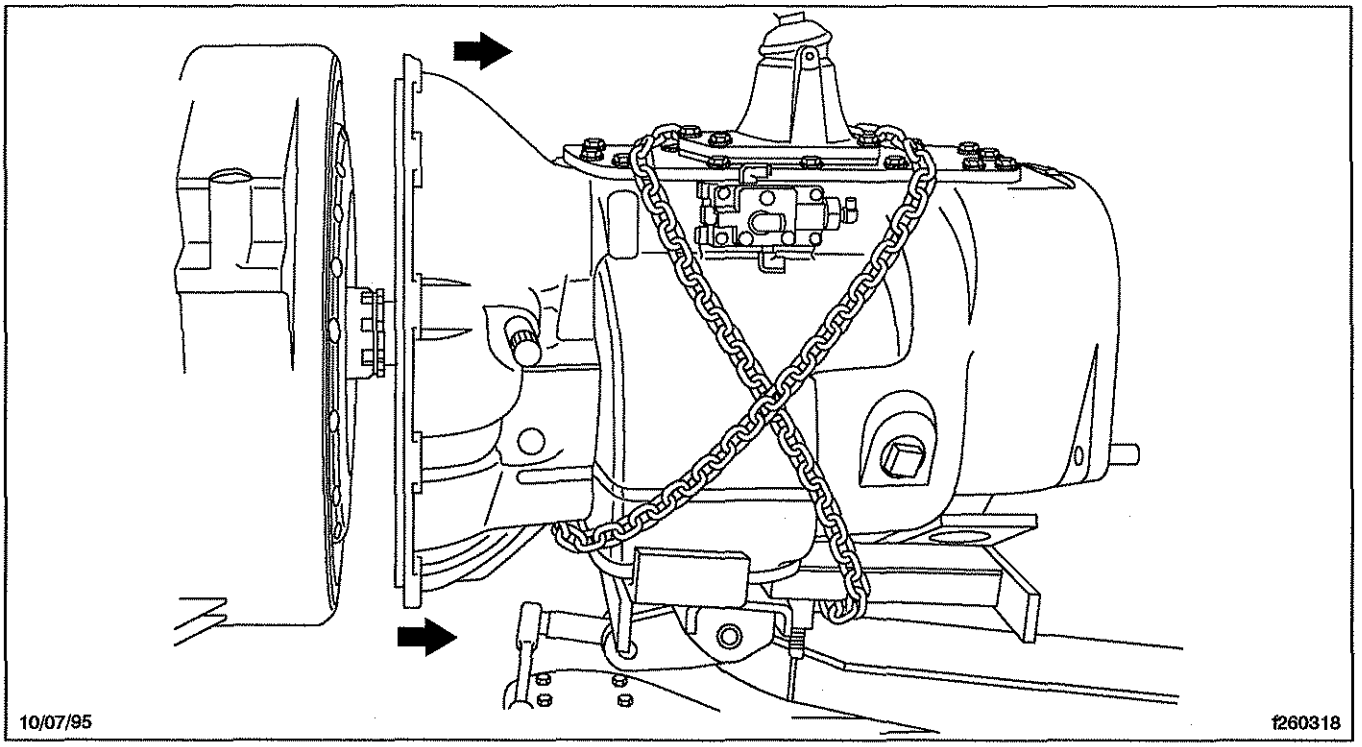


Fig. 3, Transmission Removal

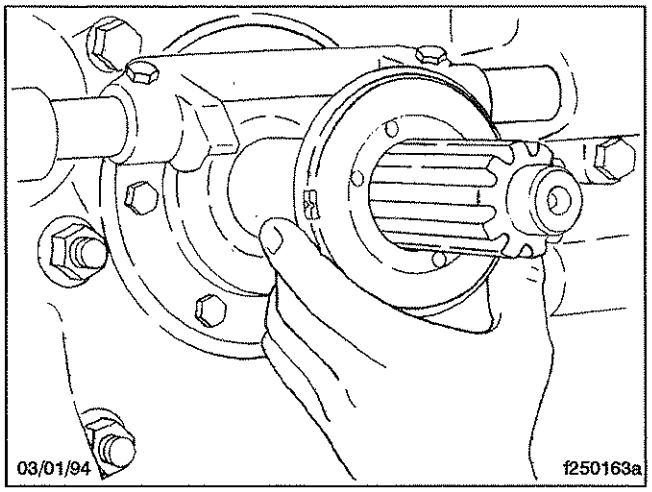


Fig. 4, Clutch Brake Installation

3. Check for wear on the fingers of the clutch release yoke, release shafts, and the release shaft bushings. Replace any worn parts as necessary.
4. Shift the transmission into gear, so that the transmission input shaft can be rotated during assembly, to line it up with the clutch driven-disc hub splines.

WARNING: After lifting the front end of the vehicle, do not get under the vehicle until it is securely supported by vehicle stands. If the vehicle is supported only by an axle jack, the vehicle can fall, resulting in personal injury or property damage.

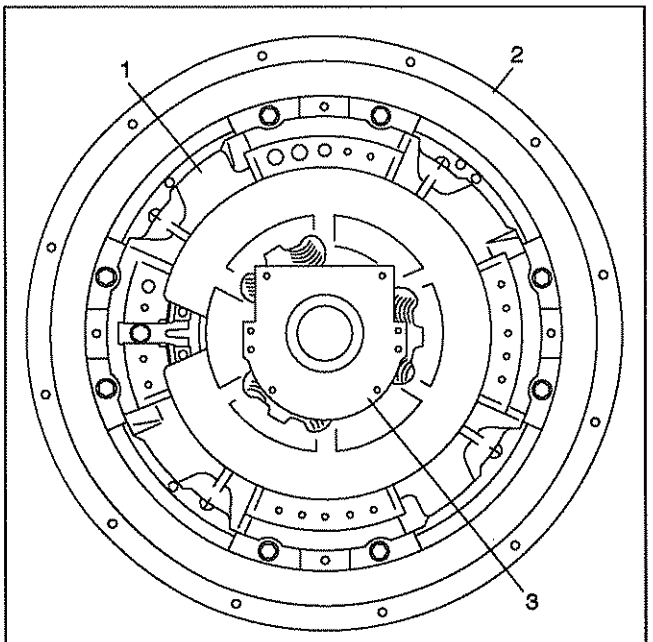
5. If the vehicle is not already raised and supported on stands, raise the front of the vehicle high enough that you can move the transmission into position by rolling it in from behind the front tire.
6. Raise the vehicle enough to remove the vehicle stands. Remove the stands, and lower the vehicle to the ground.
7. Roll the transmission and jack into alignment behind the engine. Raise the transmission jack support plate until the flange of the clutch housing is parallel (all the way around) to the flange of the flywheel housing. Align the transmission input shaft with the hole in the release bearing sleeve. **See Fig. 5.**

NOTE: If necessary, wipe the input shaft clean with a clean, dry cloth. It is not necessary to lubricate the input shaft.

8. Push the transmission and jack straight forward, while making sure the flanges remain parallel, until the transmission input shaft begins to enter the clutch release bearing.
9. Rotate the top of the clutch release yoke rearward, and rotate the release bearing until the flat portion is at the top. Roll the transmission slowly forward. Raise or lower the transmission as required to maintain alignment.

IMPORTANT: Be sure that the release yoke clears the release bearing, and is rotated over the wear pads as the transmission is moved forward. **See Fig. 6.** Align the input shaft splines with the clutch disc splines by turning the transmission output shaft.

CAUTION: Use care to avoid springing the drive discs when the transmission is being installed. Do not force the transmission into the clutch or flywheel housing if it does not enter freely. Do not let the transmission drop or hang unsupported in the driven discs. These practices can damage the clutch assembly.



1. Clutch
2. Flywheel Housing
3. Release Bearing

Fig. 5, Aligning the Transmission and Release Bearing

Manual Transmission Removal and Installation

10. Push the transmission forward until the clutch housing pilot flange enters the flywheel housing pilot bore. Install the flywheel-housing-to-clutch-housing attachment bolts, and tighten them finger-tight. Using a crisscross pattern, tighten the bolts 20 lbf·ft (27 N·m). Then, using the same crisscross pattern, tighten the bolts 50 to 55 lbf·ft (68 to 75 N·m).
11. Remove the chain that secures the transmission to the jack, and remove the jack from under the vehicle.
12. Install or connect the shift linkage.
    - 12.1 Install the shift tower inside the cab.
    - 12.2 Install the air lines and shift boot.
    - 12.3 Install the electrical connectors on the top of the transmission.
13. Connect the air lines and wiring to the transmission as previously marked.
14. Connect the clutch rod to the clutch release lever. For instructions, refer to **Group 25.**
15. Connect the driveline to the transmission output yoke. For instructions, refer to **Group 41.**
16. Connect the midship bearing to the midship bearing bracket. For instructions, refer to **Group 41.**
17. Connect the EquiFlo bracket to the top of the transmission. Open the fuel shut-off valves or fill the fuel tanks as applicable.
18. Install the transmission fluid cooler and all the plug fittings in the cooler and transmission. **See Fig. 1.**
19. Install the air reservoirs on the vehicle. For instructions, refer to **Group 42.**
20. Connect the batteries.
21. Grease the clutch release bearing and the release shafts. For instructions, refer to the **vehicle maintenance manual.**
22. Check the clutch and clutch linkage for proper clutch pedal free-travel and clutch brake operation. For instructions, refer to the vehicle driver's manual.

    To adjust the clutch, refer to **Group 25.**
23. Start the engine and run it long enough to pressurize the air system to at least 80 psi (550 kPa). Lower the hood, and remove the chocks from the tires.

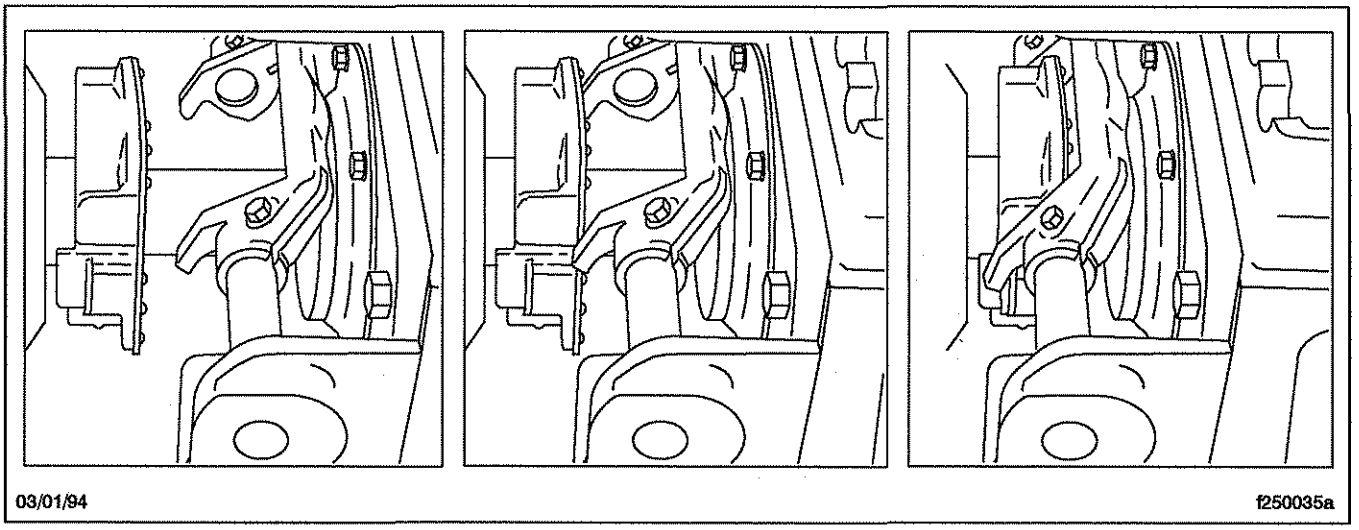
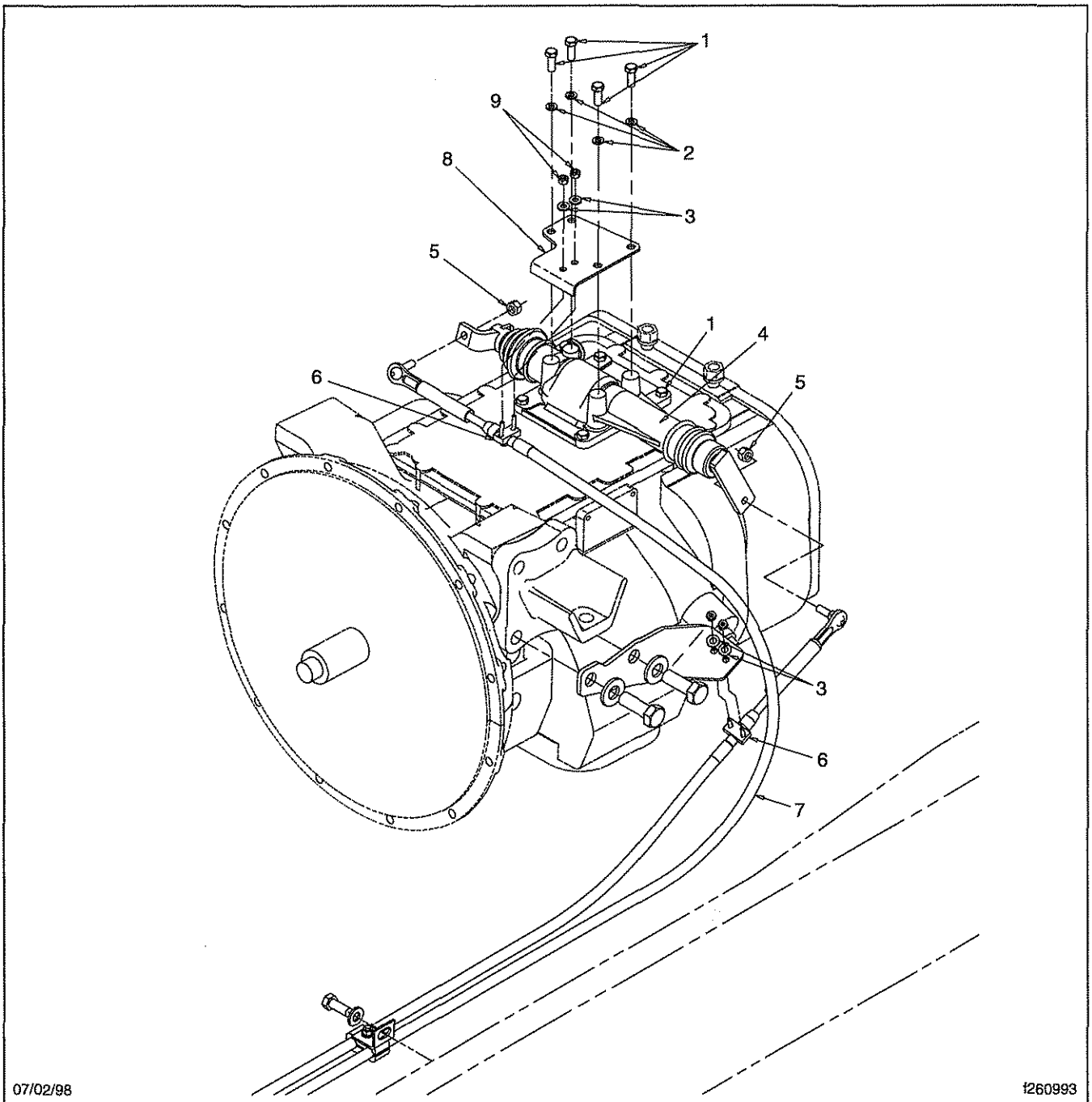


Fig. 6, Release Yoke Clearing the Release Bearing

Manual Transmission Removal and Installation, Argosy COE

Removal (See Fig. 1)



1. Capscrew, 3/8–24 x 1
2. Lockwasher
3. Hardened Washer
4. Remote Shift Mechanism
5. Hexnut, 3/8–24
6. Spacer
7. Shift Cables
8. Select Cable Bracket
9. Hexnut, 5/16–24

Fig. 1, Manual Transmission, Argosy COE Installation

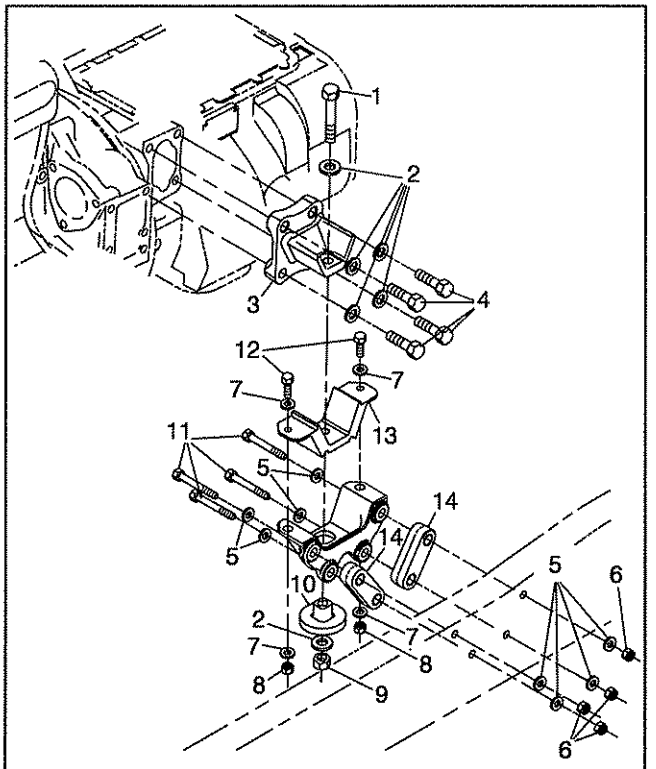
Manual Transmission Removal and Installation, Argosy COE

1. Apply the parking brakes, chock the tires, put the transmission into high gear.

⚠ WARNING

Before tilting the cab, read the instructions and the Danger and Warning notices in Group 60 of this workshop manual. Failure to follow these instructions could cause the cab to hit or crush a person, possibly resulting in serious injury or death.

2. Tilt the cab.
3. Disconnect the batteries, and remove the battery box. Refer to **Group 54** for instructions.
4. If installed, remove the transmission fluid cooler and the plug fittings in the cooler and transmission.
5. Disconnect the cab air suspension assembly. Refer to **Group 60** for instructions.
6. Remove the overslung crossmember. Refer to **Group 31** for instructions.
7. Disconnect the driveline from the transmission output yoke. For instructions, refer to **Group 41**.
8. Disconnect the driveline midship bearing from the midship bearing bracket, and pull the driveline off to one side, out of the way. For instructions, refer to **Group 41**.
9. Disconnect the EquiFlo bracket from the top of the transmission.
10. Disconnect the two shift cables from the transmission.
11. Disconnect the clutch rod from the clutch release lever. Rotate the clutch release yoke so that it will clear the clutch release bearing.
12. Disconnect all wiring at the transmission, including the speedometer sensor at the output yoke, the neutral start switch, and the back-up alarm as applicable. Mark all wires for reassembly.
13. Disconnect all air lines from the transmission, and mark those lines for reassembly. Plug all air lines, and cap all transmission air fittings.
14. Remove the rear engine mounts. See **Fig. 2**.
    - 14.1 Remove the centerbolt from the engine mount (Ref. 1).
    - 14.2 Loosen bolts on the front engine mount.
    - 14.3 Attach an overhead crane to the transmission, and lift the transmission.
    - 14.4 Position a jack stand under the engine flywheel housing.



07/15/98 f260994

1. Bolt, 3/4–10 x 4.5, Grade 8
2. Hardened Washer, 0.81 x 1.47 x .177
3. Engine Support Bracket
4. Capscrew, 3/4–10 x 3, Grade 8
5. Hardened Washer, 0.69 x 1.31 x .177
6. Nut, 5/8–11
7. Bearing Washer, 1/2 x 1.06 x .14
8. Hexnut, 1/2–13
9. Hexnut, 3/4–10
10. Upper Isolator, Engine Support
11. Bolt, 5/8–11 x 4, Grade 8
12. Bolt, 1/2–13 x 1.25
13. Lower Isolator, Engine Support
14. Spacer, Engine Support

Fig. 2, Engine Mount Assembly

14.5 Lower the engine on the jack stand, and remove the overhead crane.

14.6 Remove the four bolts from the frame rail (Ref. 11).

14.7 Remove the two bolts from the rear engine mount assembly (Ref. 12).

14.8 Remove the engine mount assembly.

15. Position a transmission jack under the transmission, and raise its support plate against the bottom of the transmission. Adjust the support plate to the same angle as the bottom of the transmission.

16. Raise the transmission jack until it fits securely against the bottom of the transmission, then secure the transmission to the jack with a chain.

17. Remove the flywheel-housing-to-clutch-housing attachment bolts. Keep the flange of the clutch housing parallel (all the way around) to the flange of the flywheel housing, until the input shaft is clear of the clutch.

⚠ CAUTION

Do not let the rear of the transmission drop, and do not let the transmission hang unsupported in the splined hubs of the clutch discs. Taking these precautions will prevent damage to the clutch discs.

18. Pull the transmission and jack straight back, until the transmission input shaft is clear of the clutch and the engine flywheel housing. Lift the transmission up and out of the vehicle.

19. Remove the transmission from the vehicle.

Installation

1. If not already done, apply the parking brakes, chock the tires, and tilt the cab. For cab tilting instructions, refer to **Group 60** of this workshop manual.

2. If the clutch brake was removed, install the clutch brake on the transmission input shaft. Slide it tight against the input shaft bearing cap. See **Fig. 3**.

NOTE: Torque-limiting clutch brakes are a one-piece assembly with a larger and a smaller face. When installing a torque-limiting clutch brake on a Fuller® or Meritor transmission, install the *smaller* face toward the transmission.

3. Check for wear on the fingers of the clutch release yoke, release shafts, and the release shaft bushings. Replace any worn parts as necessary.

4. Attach the rear engine mounts.

   4.1 Position the rear engine mount on the engine flywheel housing. Replace the two bolts, and tighten them 68 lbf·ft (92 N·m).

   4.2 Attach the four bolts to the frame rail, and tighten them 136 lbf·ft (184 N·m).

5. Shift the transmission into gear, so that the transmission input shaft can be rotated during assembly, to line it up with the clutch driven-disc hub splines.

6. Lower the transmission in to the vehicle.

7. Roll the transmission and jack into alignment behind the engine. Raise the transmission jack support plate until the flange of the clutch housing is parallel (all the way around) to the flange of the flywheel housing. Align the transmission input shaft with the hole in the release bearing sleeve. See **Fig. 4**.

NOTE: If necessary, wipe the input shaft clean with a clean, dry cloth. It is not necessary to lubricate the input shaft.

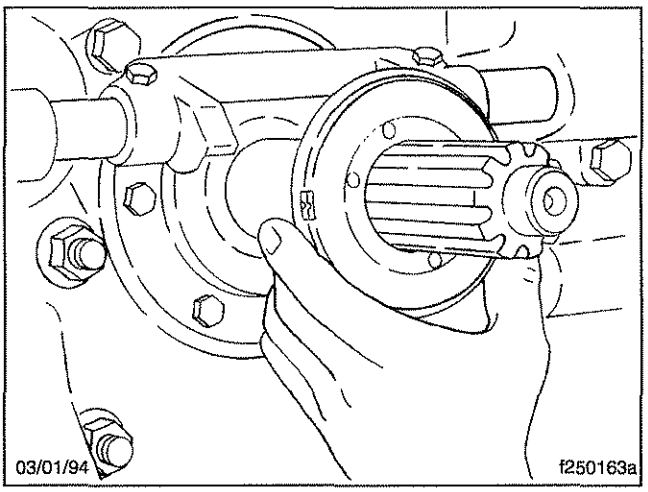


Fig. 3, Clutch Brake Installation

Manual Transmission Removal and Installation, Argosy COE

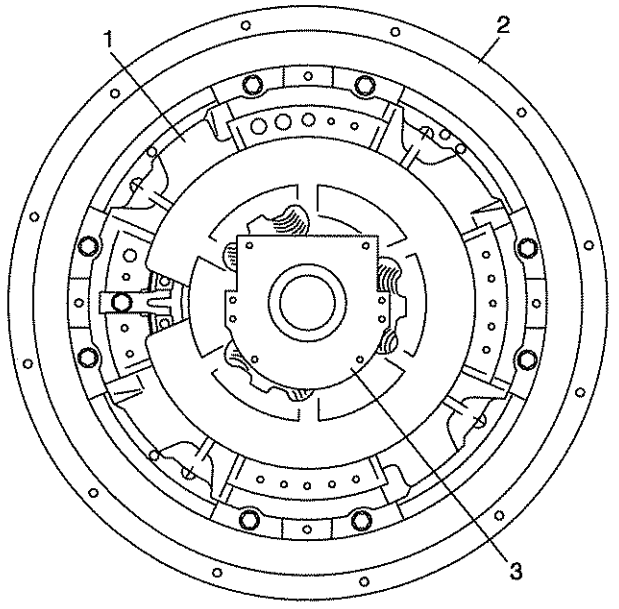


Fig. 4, Aligning the Transmission and Release Bearing

8. Push the transmission and jack straight forward, while making sure the flanges remain parallel, until the transmission input shaft begins to enter the clutch release bearing.

9. Rotate the top of the clutch release yoke rearward, and rotate the release bearing until the flat portion is at the top. Roll the transmission slowly forward. Raise or lower the transmission as required to maintain alignment.

IMPORTANT: Be sure that the release yoke clears the release bearing, and is rotated over the wear pads as the transmission is moved forward. See **Fig. 5**. Align the input shaft splines with the clutch disc splines by turning the transmission output shaft.

⚠ CAUTION

Use care to avoid springing the drive discs when the transmission is being installed. Do not force the transmission into the clutch or flywheel housing if it does not enter freely. Do not let the transmission drop or hang unsupported in the driven discs. These practices can damage the clutch assembly.

10. Push the transmission forward until the clutch housing pilot flange enters the flywheel housing pilot bore. Install the flywheel-housing-to-clutch-housing attachment bolts, and tighten them finger-tight. Using a crisscross pattern, tighten the bolts 20 lbf·ft (27 N·m). Then, using the same crisscross pattern, tighten the bolts 50 to 55 lbf·ft (68 to 75 N·m).

11. Replace the centerbolt in the rear engine mount, and tighten 241 lbf·ft (327 N·m).

12. Tighten the bolts on the forward engine mount, and tighten them 241 lbf·ft (327 N·m).

13. Remove the chain that secures the transmission to the jack, and remove the jack from under the vehicle.

14. Connect the two shift cables to the transmission and tighten the bolts securely.

15. Connect the air lines and wiring to the transmission as previously marked.

16. Connect the clutch rod to the clutch release lever. For instructions, refer to **Group 25.**

17. Connect the driveline to the transmission output yoke. For instructions, refer to **Group 41.**

18. Connect the midship bearing to the midship bearing bracket. For instructions, refer to **Group 41.**

19. Connect the EquiFlo bracket to the top of the transmission. Open the fuel shut-off valves or fill the fuel tanks as applicable.

20. Install the transmission fluid cooler and all the plug fittings in the cooler and transmission.

21. Install the air reservoirs on the vehicle. For instructions, refer to **Group 42.**

22. Install the overslung crossmember. Refer to **Group 31** for instructions.

23. Install the cab air suspension assembly. Refer to **Group 60** for instructions.

24. Replace the battery box and connect the batteries. Refer to **Group 54** for instructions.

Manual Transmission Removal and Installation, Argosy COE

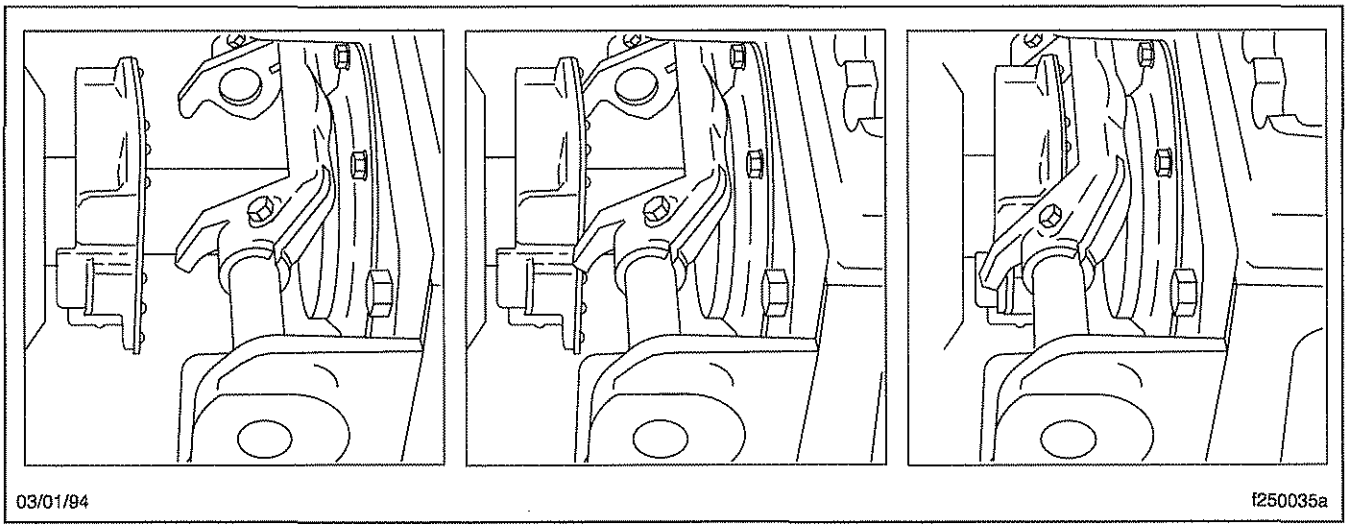


Fig. 5, Release Yoke Clearing the Release Bearing

25. Grease the clutch release bearing and the release shafts. For instructions, refer to **Group 25** in the *Vehicle Maintenance Manual*.

26. Check the clutch and clutch linkage for proper clutch pedal free-travel and clutch brake operation. For instructions, refer to the vehicle driver's manual.

    To adjust the clutch, refer to **Group 25**.

27. Start the engine and run it long enough to pressurize the air system to at least 80 psi (550 kPa).

⚠ DANGER

Before returning the cab to the normal operating position, read the instructions and Danger and Warning notices in Group 60 of this workshop manual. Failure to follow these instructions could cause the cab to hit or crush a person, possibly resulting in serious injury or death.

28. Return the cab to the operating position.

29. Remove the chocks from the tires.

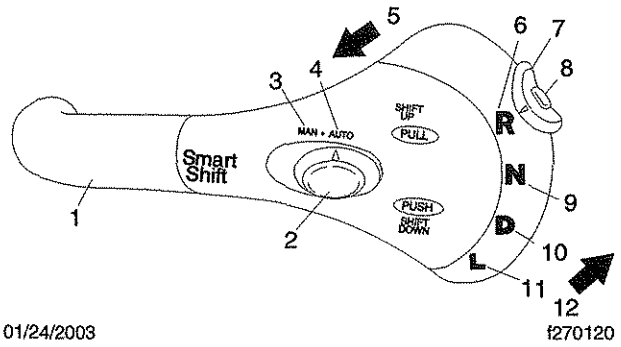
General Information

The SmartShift™ transmission shift control is an electronic transmission control device. It is applicable to automated mechanical transmissions and is required with the Eaton® Fuller® AutoShift, ZF Meritor™ FreedomLine™, and Meritor™ SureShift™ transmission. It replaces either the typical floor-mounted shift lever or dash-mounted pushbutton control.

The SmartShift control mounts to the right-hand side of the steering column and is operated by the driver's right hand. There are three versions of the control:

- See **Fig. 1** for the AutoShift control.
- See **Fig. 2** for the FreedomLine control.
- See **Fig. 3** for the SureShift control.

SmartShift accepts driver requests for transmission functions and transmits them through hard wiring to the transmission control unit (TCU). SmartShift is a true shift-by-wire system.



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To upshift manually, pull the control up (towards you). To downshift manually, push the control down (away from you).

1. SmartShift Control
2. Slide Switch (forward driving mode switch)
3. MAN Position (on slide switch)
4. AUTO Position (on slide switch)
5. Upshift Direction
6. Reverse Position (on selector switch)
7. Selector Switch
8. Safety Release
9. Neutral Position (on selector switch)
10. Drive Position (on selector switch)
11. Low Position (on selector switch)
12. Downshift Direction

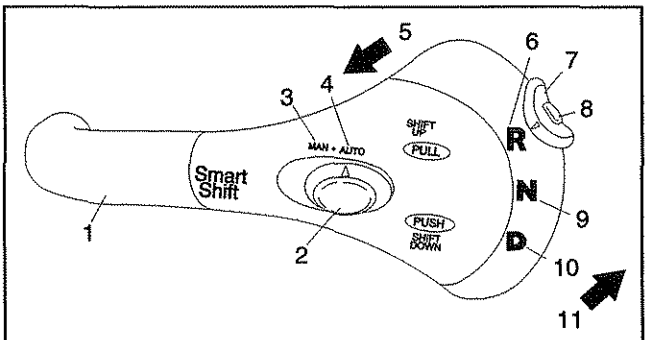
Fig. 1, SmartShift Control (with Eaton Fuller Autoshift)

SmartShift offers two main advantages over conventional transmission control devices. Usable cab space is increased and access to the sleeper is improved by removing the shift lever from the floor. Because of the steering column mounting, the transmission control is within fingertip reach of the steering wheel, which enhances safety.

In automatic drive mode, forward drive gears are shifted automatically, without driver interaction. On SmartShift as designed for AutoShift and FreedomLine, a slide switch allows the driver to choose between automatic and manual forward driving modes. In manual mode the driver has direct control over gear shifts.

NOTE: With SureShift, there is no slide switch.

Manual gear shifts (all SureShift shifts; AutoShift or FreedomLine when in manual mode) are accomplished by a momentary pull or push on the control in the plane perpendicular to the steering wheel. See **Fig. 4.** All shifts into reverse (R) are done manually.



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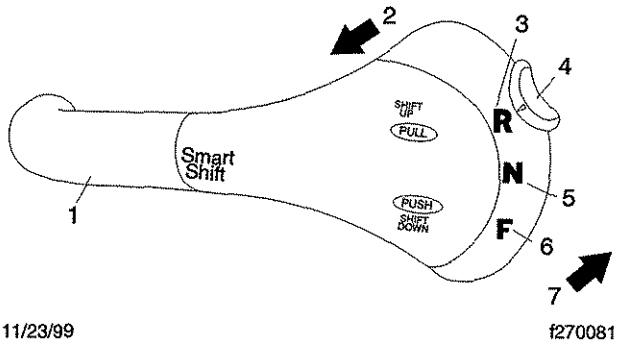
To upshift manually, pull the control up (towards you). To downshift manually, push the control down (away from you).

1. SmartShift Control
2. Slide Switch (forward driving mode switch)
3. MAN Position (on slide switch)
4. AUTO Position (on slide switch)
5. Upshift Direction
6. Reverse Position (on selector switch)
7. Selector Switch
8. Safety Release
9. Neutral Position (on selector switch)
10. Drive Position (on selector switch)
11. Downshift Direction

Fig. 2, SmartShift Control (with ZF Meritor FreedomLine)

26.01 Freightliner SmartShift™ Transmission Shift Control

General Information



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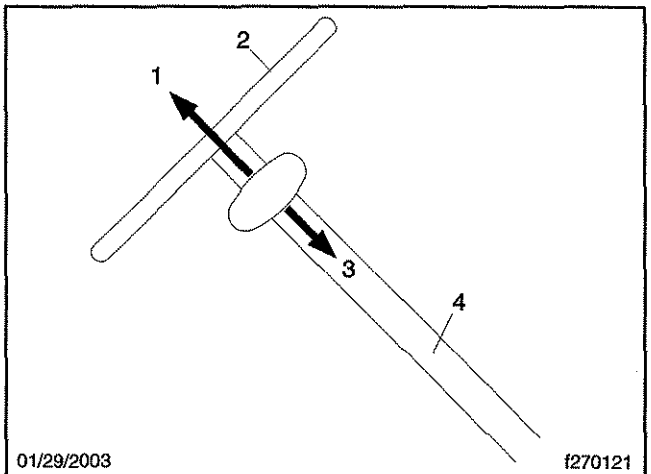
To upshift manually, pull the control up (towards you). To downshift manually, push the control down (away from you).

NOTE: Shown without safety release.

1. SmartShift Control
2. Upshift Direction
3. Reverse Position (on selector switch)
4. Selector Switch
5. Neutral Position (on selector switch)
6. Forward Position (on selector switch)
7. Downshift Direction

Fig. 3, SmartShift Control (with Meritor SureShift)

Pull upward (toward you) on the control to upshift and push downward (away from you) to downshift. The control is spring-loaded and returns to mid-position when released after an upshift or downshift.



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1. Upshift (in manual mode, pull upward)
2. Steering Wheel
3. Downshift (in manual mode, push downward)
4. Steering Column

Fig. 4, SmartShift Control Operation

The selector switch is located at the end of the control. There are three different versions:

- With AutoShift, the selector switch has four positions (R, N, D, L). See **Fig. 1**.
- With FreedomLine, the selector switch has three positions (R, N, D). See **Fig. 2**.
- With SureShift, the selector switch has three positions (R, N, F) and there is no slide switch. See **Fig. 3**.

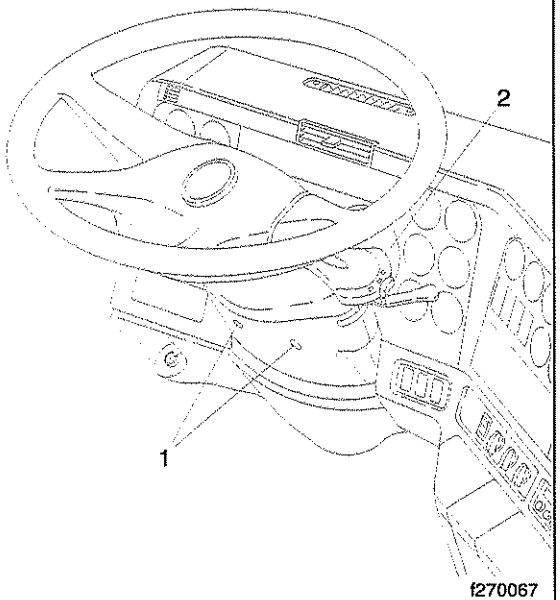
On FreedomLine, all selector switches have a safety release which must be pressed to move the switch. On AutoShift and SureShift, all models built after November 2002 have the safety release. In appearance, the safety release is a small yellow button embedded in the switch.

IMPORTANT: The safety release prevents accidental movement of the switch.

Shift Control Lever Replacement

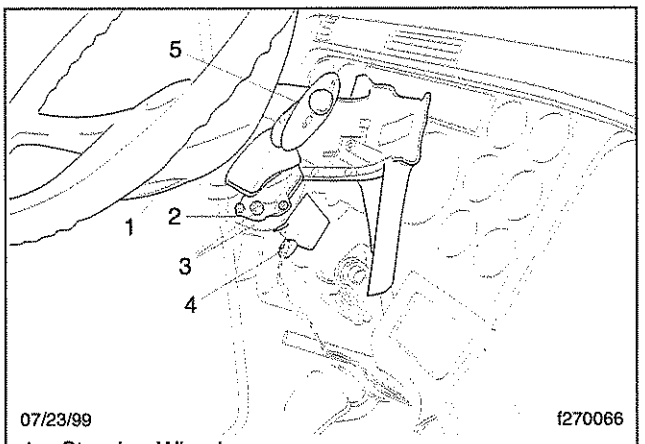
Replacement

1. Shut down the engine, apply the parking brakes and chock the tires.
2. Remove the shift column dash panel.
   - 2.1 Remove the two screws securing the panel. See **Fig. 1**.
   - 2.2 Seperate the upper and lower panels, accessing the shift lever.
3. Disconnect the electrical connector from the lever. See **Fig. 2**.
4. Remove the three bolts securing the shift lever to the bracket on the column.
5. Remove the shift lever.
6. Place the new lever into position and secure it using the nuts and bolts previously removed.
7. Connect the electrical connector to the shift lever.
8. Using the screws previously removed, fasten the upper and lower column cover.
9. Remove the chocks from the tires.



1. Steering Column Panel Capscrews
2. SmartShift Lever

Fig. 1, Shift Column



1. Steering Wheel
2. Shift Lever Bracket
3. Nuts and Bolts
4. Electrical Connector
5. Shift Lever

Fig. 2, SmartShift Lever Replacement

Transmission Shift Cables, Argosy COE 26.02

Contents

Subject	Subject Number
Service Operations	
Transmission Shift Cable Removal and Installation	100

Transmission Shift Cable Removal and Installation

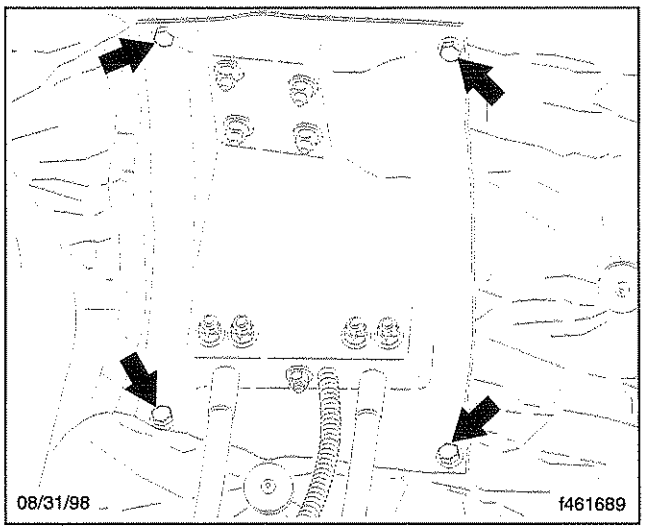


Fig. 3, Tunnel Mount Bracket Installation Capscrews

the transmission's remote shift mechanism. The uncovered rod end is installed on the tunnel mount bracket.

2. Install the cables on the tunnel mount bracket.

   2.1 Insert the shift cable (shorter cable) in the bracket as shown in **Fig. 4**.

   2.2 Insert the cable-assembly capscrew in the arm of the bracket and secure with a 3/8–24 hexnut.

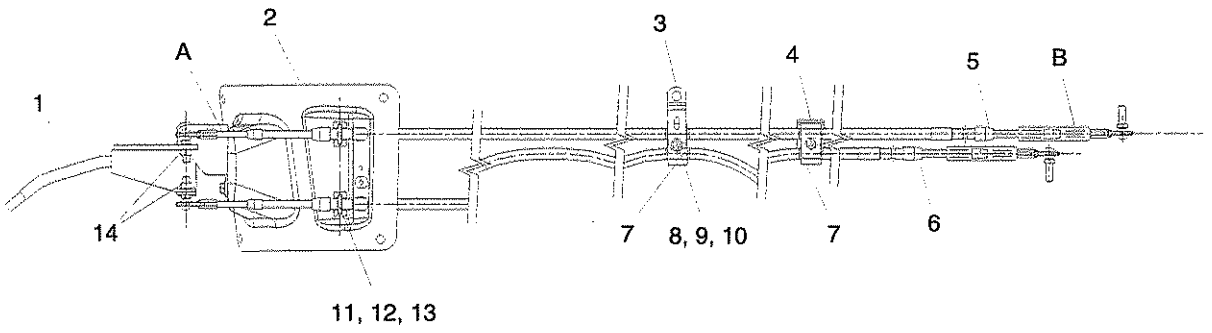
   2.3 Place a saddle spacer between the cable and the tunnel mount bracket, aligning the bolt holes. Insert a 5/16–24 U-bolt over the cable and through the bolt holes in the spacer and bracket. See the insert in **Fig. 5**.

   2.4 On the back of the bracket, install washers and hexnuts on the U-bolt.

   2.5 Repeat the above steps to install the select cable (longer cable) on the other side of the bracket.

3. Feed the sleeved end of the cables through the right front corner of the cab, and along the channel of the driver-side frame rail to the transmission assembly.

4. Connect the shift cable to the transmission assembly.



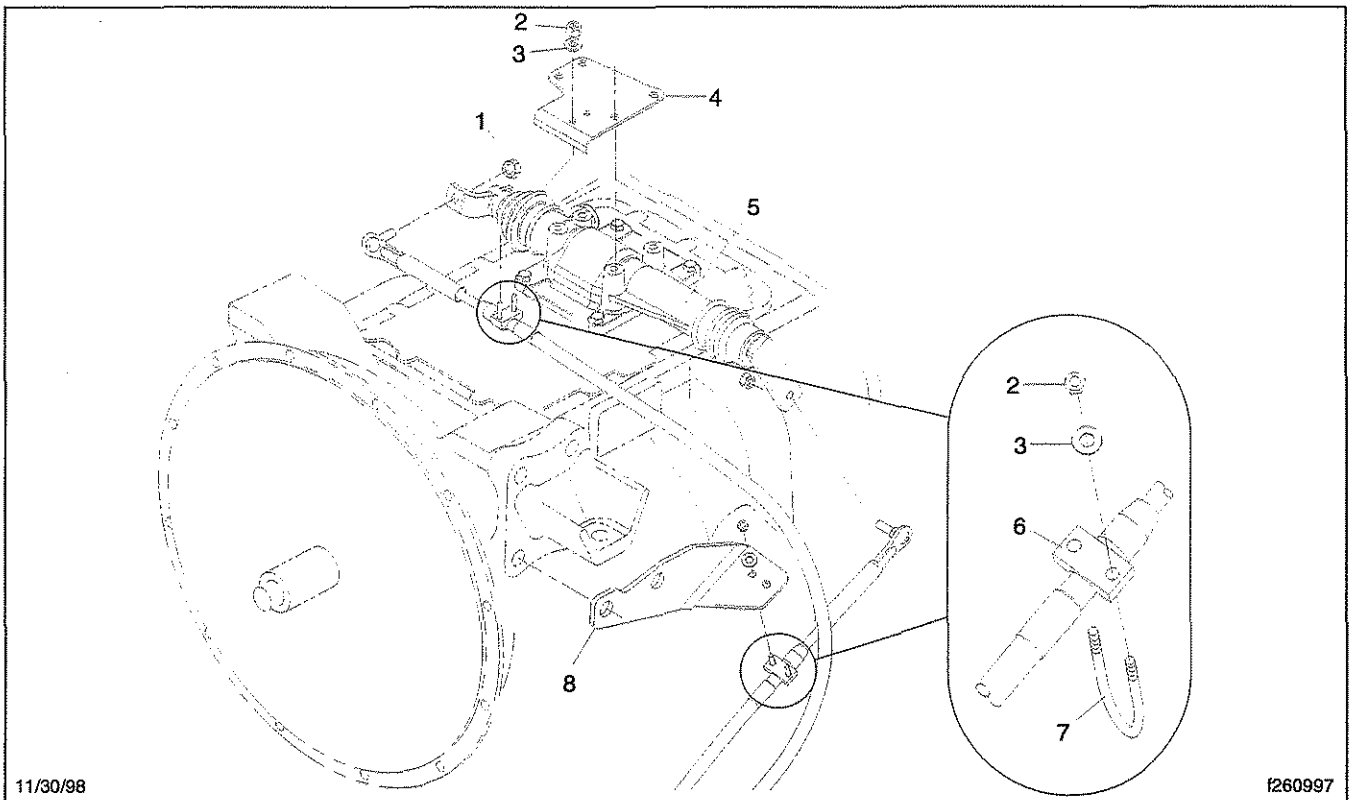
NOTE: Do not adjust the rod-end jam nuts on the cables.

A. Uncovered rod end of the cable is installed on the tunnel mount bracket.
B. Sleeved end of the cable is installed on the transmission assembly.

1. Shift Column
2. Tunnel Mount Bracket
3. Standoff Bracket
4. Frame Mount Bracket
5. Select Cable
6. Shift Cable
7. Cable Retainer
8. Hex Capscrew, 5/16–18 x 1-1/2"
9. Washer (zinc-plated steel)
10. Hexnut, 5/16–18
11. Saddle Spacer
12. U-Bolt, 5/16–24
13. Hexnut, 5/16–24
14. Hexnut, 3/8–24

Fig. 4, Shift Cable Assembly

Transmission Shift Cable Removal and Installation



1. Hexnut, 3/8–24
2. Hexnut, 5/16–24
3. Washer (hardened)
4. Select-Cable Rail Bracket
5. Remote Shift Mechanism
6. Saddle Spacer
7. U-Bolt, 5/16–24, 1" STR, 0.312R
8. Shift-Cable Mount Bracket

Fig. 5, Cable Installation on Transmission Assembly

4.1 Insert the shift cable's capscrew into the end bracket on the driver side of the remote shift mechanism. See **Fig. 5**. Install a 3/8–24 hexnut on the capscrew and tighten, using two wrenches.

4.2 Place a saddle spacer under the shift-cable mount bracket and align the bolt holes. Insert a 5/16–24 U-bolt under the cable and through the bolt holes in the saddle spacer and bracket. On the top side of the bracket, install washers and hexnuts on the U-bolt. Tighten the hexnuts 16 lbf·ft (22 N·m).

5. Connect the select cable to the transmission assembly.

5.1 Insert the select cable's capscrew into the end bracket on the passenger side of the remote shift mechanism. Install a 3/8–24 hexnut on the capscrew and tighten, using a single wrench.

5.2 Place a saddle spacer under the select-cable rail bracket and align the bolt holes. Insert a 5/16–24 U-bolt under the cable and through the saddle spacer and bracket. On the top side of the bracket, install washers and hexnuts on the U-bolt. Tighten the hexnuts 16 lbf·ft (22 N·m).

6. On the front of the cab, insert the shift column assembly up through the opening in the tunnel.

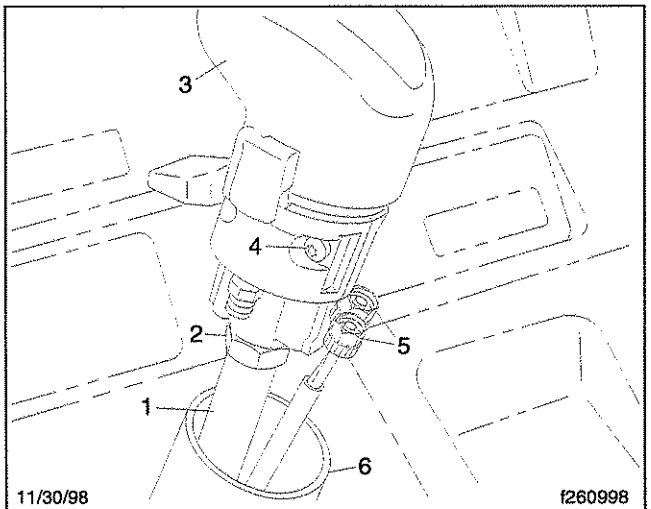
7. Fasten the tunnel mount bracket to the tunnel with a washer and 5/16–18 hexhead capscrew in each corner of the bracket. See **Fig. 2**. Tighten the capscrews 15 lbf·ft (20 N·m).

8. Install the cable guide and hexnut on the bracket on the front of the cab.

Transmission Shift Cable Removal and Installation

Removal

1. Park the vehicle on a level surface. Shut down the engine. Set the parking brake and chock the front and rear tires.
2. Drain the air reservoirs.
3. Remove the two screws from the shift-knob sleeve and slide the sleeve down. See **Fig. 1**.
4. Disconnect the three air lines from the shift knob.
   - Eaton model: Use a wrench to loosen the fittings.
   - Meritor model: Press the quick-disconnect fittings with a blunt tool such as a screwdriver.
5. Remove the two Torx®-head capscrews on the shift knob to release the clamping pressure on the shift column.
6. Loosen the jam nut on the shift column, using a 3/4-inch wrench. Remove the shift knob.
7. On the front of the cab, remove the lower grille panel.
8. Raise the cab front access panel. See **Chapter 3** of the *Argosy COE Driver's Manual* for instructions.



1. Shift Column
2. Jam Nut, 1/2–13
3. Shift Knob
4. Torx-head Capscrew
5. Air Line Fittings
6. Sleeve

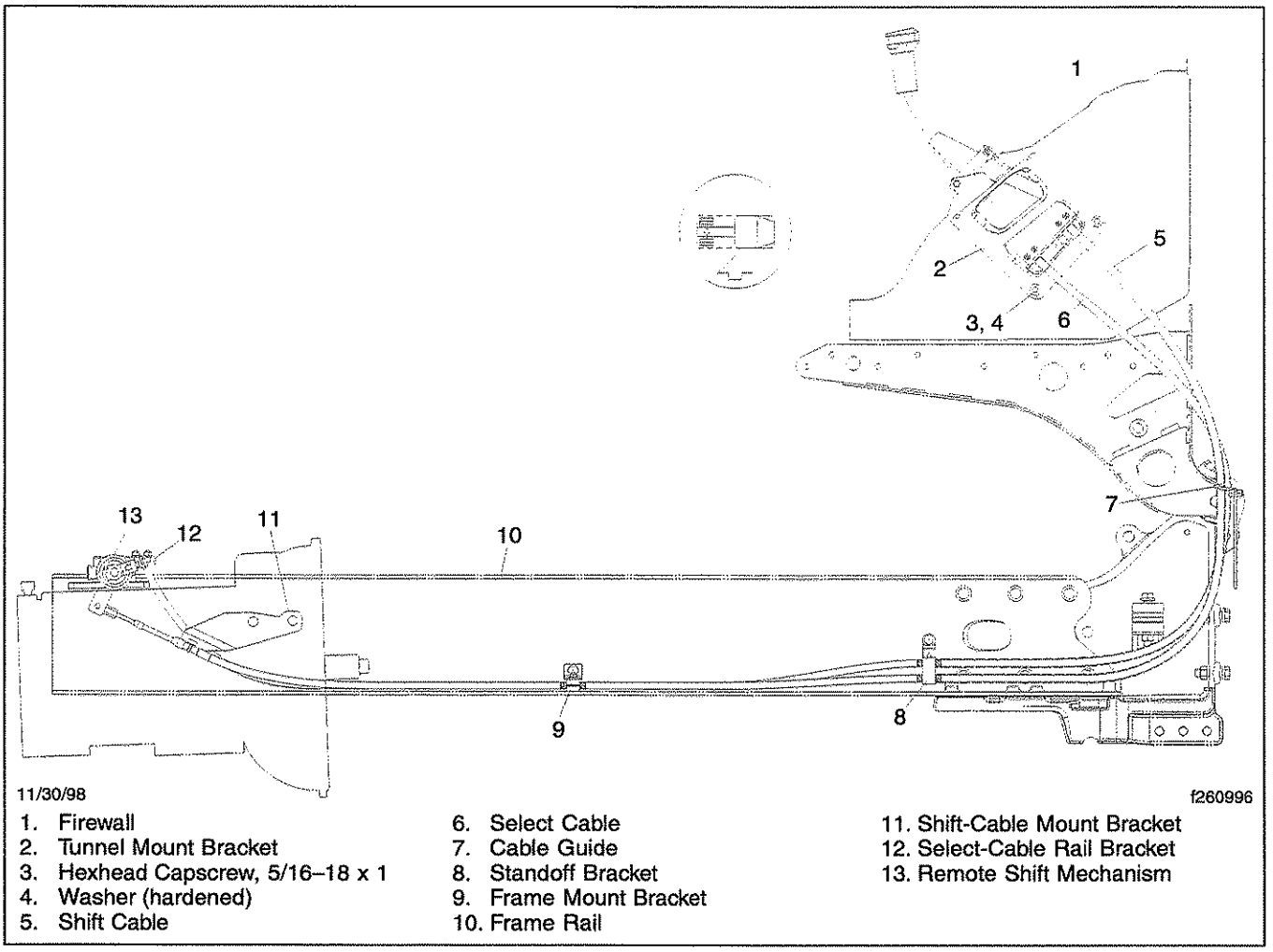
Fig. 1, Shift Knob Removal

⚠ WARNING

Before tilting the cab, read the instructions and safety hazard alerts in Section 60.15 of this workshop manual. Failure to follow these instructions could cause serious personal injury or death.

9. Tilt the cab until the tunnel mount bracket is exposed on the tunnel. See **Fig. 2**.
10. Remove four 5/16–18 hexhead capscrews and washers from the corners of the tunnel mount bracket. See **Fig. 3**.
11. Pull the shift column assembly down through the tunnel.
12. Using two wrenches, remove the hexnuts securing the ends of the cables to the tunnel mount bracket. See **Fig. 4**.
13. On the back of the tunnel mount bracket, remove the hexnuts and washers securing the two U-bolts to the bracket. Remove the U-bolts and saddle spacers.
14. Remove the cables from the bracket.
15. Remove the hexnut and cable guide from the bracket on the front of the cab. See **Fig. 2**.
16. Disconnect the select cable from the transmission assembly.
    - 16.1 Using a wrench on the hexnut, remove the capscrew securing the select cable to the rail bracket (passenger side of the transmission). See **Fig. 5**.
    - 16.2 Remove the hexnuts and washers on the U-bolt securing the cable to the rail bracket (about 6 inches [150 mm] from the end of the cable). Remove the U-bolt and saddle spacer.
17. Disconnect the shift cable from the transmission assembly.
    - 17.1 Using two wrenches, remove the hexnut securing the shift cable to the mount bracket (driver side of the transmission).
    - 17.2 Remove the hexnuts and washers on the U-bolt securing the cable to the mount bracket. Remove the U-bolt and saddle spacer.

Transmission Shift Cable Removal and Installation



1. Firewall
2. Tunnel Mount Bracket
3. Hexhead Capscrew, 5/16–18 x 1
4. Washer (hardened)
5. Shift Cable
6. Select Cable
7. Cable Guide
8. Standoff Bracket
9. Frame Mount Bracket
10. Frame Rail
11. Shift-Cable Mount Bracket
12. Select-Cable Rail Bracket
13. Remote Shift Mechanism

Fig. 2, Shift Cable Assembly Installation

18. Remove the cables from the brackets on the driver-side frame rail. See **Fig. 2.**

    18.1 Remove the 1/2–20 hexnuts and washers securing the frame mount and standoff brackets to the frame rail.

    18.2 On the standoff bracket, remove the 5/16–18 hexnut that clamps the two parts of the cable retainer together. Remove the cables.

    18.3 On the frame mount bracket, remove the 5/16–18 hexnut that clamps the two parts of the cable retainer together. Remove the cables.

19. From the front of the cab, carefully pull the cables out of the vehicle.

Installation

⚠ CAUTION

Do not adjust the rod-end jam nuts near the ends of the new cables. These nuts are factory set to the precise specification for each engine configuration. Adjusting the nuts will cause the shift mechanism to malfunction. If the new cables do not fit exactly, verify that you have the correct part number for your model.

1. Lay out the tunnel mount bracket and cables as shown in **Fig. 4**. Each cable has a sleeve about 4 inches (100 mm) long covering the seal at one end. The sleeved end of each cable is installed on

9. Install the cables in the brackets on the driver-side frame rail.

   9.1 Place both cables between the two parts of the cable retainer on the standoff bracket. Install a 5/16–18 hexhead capscrew, washer, and hexnut in the cable retainer to clamp it together.

   9.2 Mount the standoff bracket on the inside of the frame rail. Insert a 1/2–20 x 1-1/4 hexhead capscrew through a washer (1/2 x 1.06 x 0.14) and the frame rail. Secure with another washer and a 1/2–20 hexnut on the outside of the frame rail.

   9.3 Repeat the above steps for the frame mount bracket.

⚠ WARNING

Before returning the cab to the normal operating position, read the instructions and Danger and Warning notices in Section 60.17 of this workshop manual. Failure to follow these instructions could cause serious injury or death.

10. Return the cab to the operating position.
11. Inside the cab, place the shift knob on the shift column.
12. Tighten the jam nut on the shift column 10 to 15 lbf·ft (14 to 20 N·m), using a 3/4-inch wrench.
13. Install two Torx-head capscrews on the shift knob and tighten.
14. Connect the three air lines to the shift knob. The knob is marked B (black), R (red), and G (green) to identify the connector for each of the color-coded hoses.
15. Slide the shift-knob sleeve back up into position on the shift knob. Install two screws in the lower part of the sleeve to secure it in place.
16. Lower the cab front access panel.
17. Replace the lower grille panel.
18. Start the engine and run it long enough to pressurize the air system to at least 80 psi (550 kPa).
19. Shut down the engine and remove the chocks from the tires.

Group Index, Alphabetical

Section	Section Number
Electronic Throttle Pedal	30.00

Electronic Throttle Pedal 30.00

Contents

Subject	Subject Number
General Information	050
Service Operations	
Throttle Pedal Removal and Installation	100
Throttle Pedal Sensor Replacement	110
Troubleshooting	300

General Information

Throttle Pedal Assembly (See Fig. 1 and Fig. 2)

Freightliner uses a single model of Williams electronic throttle pedal, and two types of throttle pedal sensors depending on the engine. Vehicles with a Cummins or Detroit Diesel engine have a throttle pedal sensor designed for those engines. Vehicles with a Caterpillar engine have a throttle pedal sensor designed for that engine. See **Fig. 3.**

The suspended pedal assembly mounts to the inside of the cab bulkhead, and communicates with the engine through a wiring harness.

As the driver presses the pedal, the drive lever is forced downward, rotating the pinion gear which meshes with the pedal sensor (sometimes called the "potentiometer"). As the drive lever moves down and rotates the pinion gear, the sensor, attached to the outboard side of the assembly, monitors how far the pinion gear rotates. Depending on how much the driver presses the pedal—and the pedal rotates the pinion gear—the sensor tells the electronic engine control how much fuel to deliver to the engine.

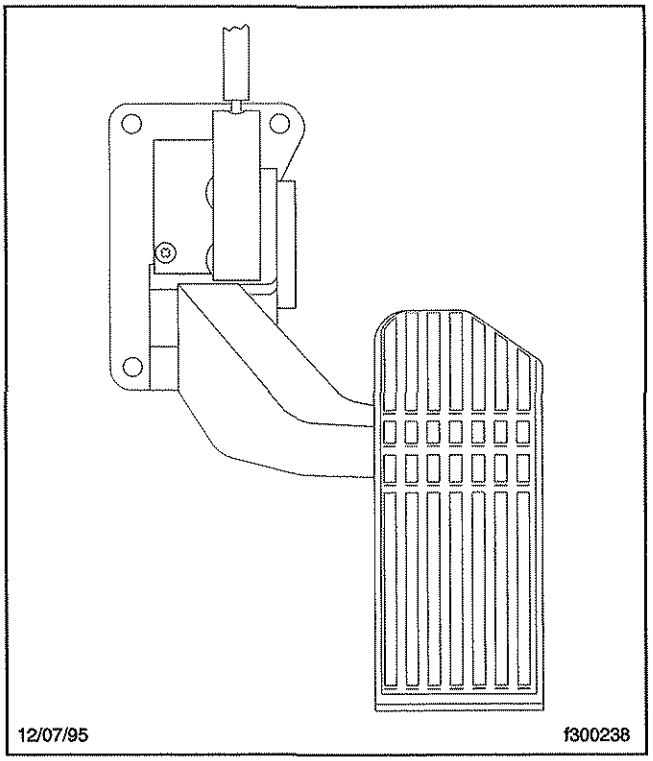


Fig. 1, Williams Suspended Throttle Pedal

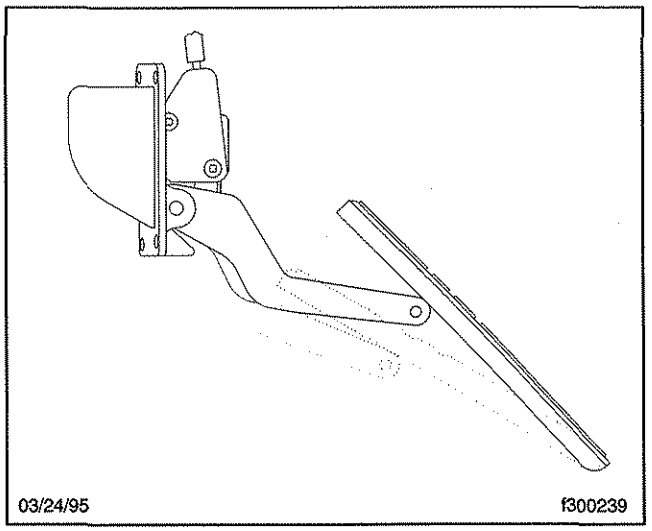
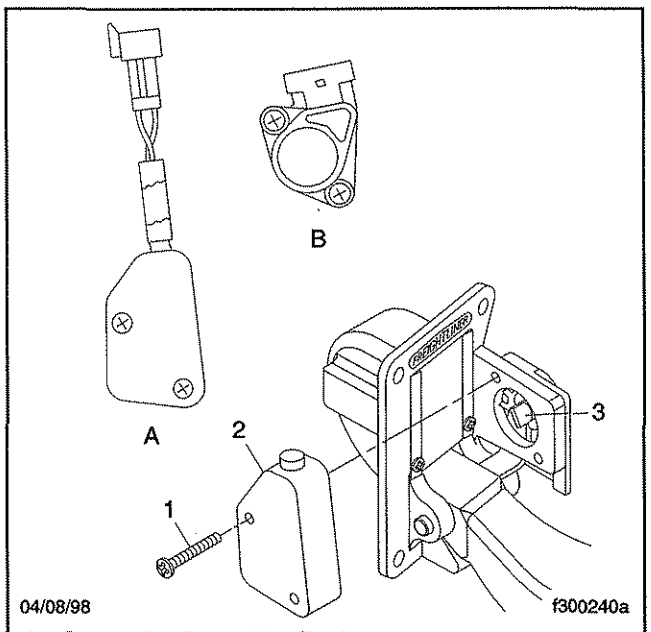


Fig. 2, Williams Throttle Pedal, Range of Motion



A. Sensor for Caterpillar Engines
B. Sensor For Detroit Diesel and Cummins Engines
1. Sensor Mounting Screw, M10–32 x 1.5, Pan Head
2. Sensor (Caterpillar sensor shown)
3. Pinion Gear

Fig. 3, Sensors Used With the Williams Throttle Pedal

General Information

When the driver stops pressing the pedal, return springs within the pedal assembly lift the pedal back to the original idle position.

The pedal sensor and the pedal assembly are both replaceable.

Throttle Position Sensor (TPS)

The throttle position sensor (TPS) is an electro-mechanical device that converts the mechanical input from the throttle pedal assembly into an electrical signal proportional to the input of the pedal. This electrical signal is fed to the engine ECU, which uses the signal to manage engine and engine accessory operations.

Two types of throttle position sensors are used on electronic engines:

- The first type is a ratiometric sensor that produces a linear voltage output in proportion to pedal input. The engine ECU uses a converter circuit to turn the analog voltage into a digital "count."
- The second type is a pulse-width modulated (PWM) sensor that generates a series of discrete voltage pulses. The width of the pulses is proportional to the pedal position. A narrower pulse width indicates a smaller throttle pedal request and a wider pulse width indicates a larger pedal request. The pulse width is termed the "duty cycle" of the TPS.

The linear-type sensor is used on Cummins and Detroit Diesel engines. The PWM sensor is used on Caterpillar engines.

The TPS can also provide an idle validation signal (IVS). At present, an IVS is only available on vehicles equipped with Cummins electronic engines. The IVS is a single-pole, dual-throw switch integral with the TPS. When the throttle pedal returns to idle, the IVS moves to the "idle" position to tell the engine ECU that the pedal has returned to idle. When the throttle pedal is moved off of idle, the IVS moves to an "off idle" position to tell the engine ECU that the pedal is no longer in the idle position. Unlike a switch, there is a transition point on the TPS where a high resistance between the IVS common lead and either of the output leads may appear.

When properly installed, the TPS does not operate in either the lower or the upper 10 to 15 percent of the full range of travel. The output signal from the TPS can never be zero volts or equal the supply voltage from the engine. If such a condition should occur, the engine ECU will report a TPS problem.

The input signal from the TPS to the engine ECU is converted to binary data for engine management requirements. Detroit Diesel engines report the input voltage as "counts," one "count" being equal to about 0.005 volt. Caterpillar and Cummins engines convert the actual TPS position to a percentage TPS value. The percentage TPS value is scaled so that the values represent the sensor position in the allowed range of travel. A 0 percent value (3 percent for Caterpillar engines) corresponds to idle. A 100 percent value corresponds to full throttle. Raw data may be available for diagnosis, but the percentage TPS values are displayed by the diagnostic tools and appear in troubleshooting manuals.

Troubleshooting

⚠ CAUTION

The throttle pedal assembly is designed so that the throttle position sensor (TPS) will not reach the internal stop points when it is mounted to the pedal assembly. Very little sensor rotational adjustment is available once the TPS is installed. Attempting to modify the TPS, in an effort to gain adjustment range, or forcing the TPS shaft beyond the internal stop points will result in severe damage to the TPS.

The TPS used with Caterpillar engines is a pulse-width modulated (PWM) sensor. It cannot be properly diagnosed with a digital multimeter set to measure voltage, resistance, or continuity. A multimeter capable of measuring "duty cycle" can be used to view the TPS output. Caterpillar engine diagnostic tools are recommended for viewing the percentage TPS reported by the engine ECU. Attempting to diagnose a PWM sensor assembly without the proper tools will result in damage to the TPS.

NOTE: Century Class vehicles with Detroit Diesel engines have used two different TPS designs in production. Vehicles built before February 1998, have a three-pin TPS electrical connector. Vehicles built from February 1998, have a six-pin TPS electrical connector. When troubleshooting, verify which sensor is present.

Common Problems and Indications

A number of symptoms may be reported which can indicate a problem with the throttle pedal, TPS, or wiring to the electronic engine, including:

- Low power or poor acceleration
- The vehicle will not reach programmed top speed
- The engine is stuck at idle
- The engine brake or engine retarder does not function
- Slow deceleration
- The check engine light comes on
- An engine fault code indicating a TPS problem appears

These symptoms do not always indicate a throttle pedal, TPS, or wiring problem. Symptoms can disappear when the TPS is replaced, however, the TPS may not be faulty. A thorough diagnosis of the entire TPS system must be performed to ensure that a TPS is faulty.

Preliminary Checks

1. Verify, by testing with the particular engine manufacturer's diagnostic software and tools, that the TPS is operating properly. For Cummins engines, also verify idle validation signal (IVS) inputs. See **Table 1**.

IMPORTANT: **Table 1** is a guide for common engine installations. It is necessary to verify the correct information for the specific engine installed in the vehicle.

2. If the engine manufacturer's diagnostic software and tools produce the readings shown in **Table 1**, the TPS is not at fault. If you are unable to produce the readings shown in **Table 1**, go to the next step.
3. Verify that the TPS is wired properly. See **Table 2**.

IMPORTANT: Reversing the TPS signal line and the ground line can result in a percentage TPS reading that does not change, and may also produce a fault code at the engine ECU. Reversing the TPS signal line and the +v supply line can prevent the TPS signal from reaching 100 percent. Reversing the +v supply line and the common line will result in the TPS providing "inverted" pedal information, or not working at all. Verify circuit positions and circuit designations in the engine ECU connector using the engine manufacturer's troubleshooting documentation.

NOTE: On Caterpillar engines, swapping any circuits may cause the TPS not to operate.

4. Check the voltage to the TPS. See **Table 3** for TPS connector pin locations.

IMPORTANT: The ignition key must be in the ON position. For Cummins and Detroit Diesel engines, disconnect the TPS connector at the TPS. For Caterpillar engines, use or fabricate a breakout harness. After diagnosis, clear any historical TPS fault codes to prevent mis-diagnosis in the future.

NOTE: It is normal for the engine to report fault codes when the TPS connector is disconnected.

Troubleshooting

⚠ CAUTION

Do not perform the tests in steps 5, 6, and 7 on the PWM sensor used with Caterpillar engines. Doing so may result in serious damage to the TPS.

5. If you do not read the voltages shown in **Table 3**, test resistance on the +v supply and common circuits between the TPS and the engine connectors. Disconnect the OEM harness connector at the engine ECU.

IMPORTANT: For Caterpillar engines, also disconnect the TPS connector from the TPS. Ensure that the ignition key is in the OFF position before making any tests.

6. If a resistance greater than 10 ohms is read, there is a potential wiring problem. Correct any wiring problem before attempting further tests. If a wiring problem is discovered and repaired, go back and repeat step 1 to determine if this was the only problem.

NOTE: If circuit resistance is 10 ohms or less but the voltage is below that listed in **Table 3**, the engine ECU is probably faulty. If both voltage and circuit resistance are within spec, go to the next step.

7. For Cummins and Detroit Diesel TPS, check the resistance of the TPS at the OEM harness connector with a digital multimeter. Before making measurements, reconnect the TPS connector to the TPS. Leave the OEM harness connector disconnected. See **Table 4** for acceptable readings.

8. Inspect and ensure that all connector pins at the TPS sensor, frontwall, and engine ECU are free of corrosion and are not bent or damaged. Inspect and ensure that the connections between the pins and the wires are secure and also free of corrosion.

NOTE: If the TPS does not return to idle, one of two conditions exists. Either the IVS is faulty or the TPS signal voltage or PWM duty cycle, recorded by the engine ECU, is dropping significantly after the engine has calibrated the idle position.

9. On Cummins engines only, check and ensure that the IVS is working properly. If a problem is found with the IVS, replace the TPS with a new unit or one known to be good and continue testing. If no problem is found, go to the next step.

10. Remove the pedal assembly from the floor. Loosen (but do not remove) the TPS mounting screws. By hand, rotate the TPS sensor assembly as far as possible. Then, tighten the mounting screws securely. Check the operation of the TPS again.

NOTE: In some cases, it may be necessary to exchange the existing TPS with another because the TPS and pedal assembly tolerances result in an idle position too close to the edge of acceptable operation. In this situation, the TPS is probably not faulty and may perform acceptably in another pedal.

11. If the engine will not reach rated speed or recognize full throttle, the cause is something other than the TPS. Check the engine ECU parameters and reset them if necessary. Check and ensure that the TPS is wired correctly. Remove the TPS from the pedal assembly and move the pedal through the full range of operation. Watch the operation of the TPS actuator tab. Ensure that no parts are binding or broken.

12. If the TPS does not leave idle, check IVS operation (if so equipped) and ensure that the switch transitions from the idle to the off-idle state. Also, check for a signal on the appropriate wires at the engine ECU for both idle and off-idle states. On vehicles not equipped with an IVS, check and ensure that the TPS is connected correctly to the engine.

13. If the problem has still not been resolved, the problem is not with the TPS. See the engine manufacturer's service literature for further guidance.

Diagnostic Software/Tool Readings		
Engine	**Pedal Position**	**Reading**
Caterpillar*	Idle	3% TPS
	Full throttle	100% TPS
	Between idle/full throttle	Varies smoothly between 3% and 100%

Diagnostic Software/Tool Readings		
Engine	**Pedal Position**	**Reading**
Cummins*	Idle	0% TPS, IVS on-idle
	Full throttle	100% TPS, IVS off-idle
	Between idle/full throttle	Varies smoothly between 0% and 100%, IVS transitions between on-idle and off-idle at or before 15% TPS
Detroit Diesel	Idle	64 to 205 counts, (0% TPS)
	Full throttle	Less than 968 counts (100% TPS)
	Between idle/full throttle	Varies smoothly between idle and full throttle values

* The ECM converts raw TPS data to % TPS.

Table 1, Diagnostic Software/Tool Readings

Throttle Position Sensor (TPS) Wiring			
Engine	**Engine Mfr. Circuit**	**TPS Connector Pin**	**Engine ECU Connector and Pin**
Caterpillar	C985 (+v supply)	Pin A	Connector P1, pin 35
	C795 (common)	Pin B	Connector P1, pin 29
	C986 (TPS signal)	Pin C	Connector P1, pin 37
Cummins	N18 (+v supply)	Pin C	OEM harness connector, pin 18
	N19 (common)	Pin B	OEM harness connector, pin 19
	N11 (TPS signal)	Pin A	OEM harness connector, pin 11
Detroit Diesel	D916 (+v supply)	Pin A, 3-pin TPS Pin C, 6-pin TPS	OEM harness connector, pin A3
	D952 (common)	Pin C, 3-pin TPS Pin B, 6-pin TPS	OEM harness connector, pin C3
	D417 (TPS signal)	Pin B, 3-pin TPS Pin A, 6-pin TPS	OEM harness connector, pin D2

Table 2, Throttle Position Sensor (TPS) Wiring

TPS Connector Pin Locations			
Engine	**TPS +V Supply**	**TPS Common (Ground)**	**Voltage**
Caterpillar	Pin A	Pin B	+8v ± 0.5v
Cummins	Pin C	Pin B	+5v ± 0.5v
Detroit Diesel	Pin A (3-pin TPS) Pin C (6-pin TPS)	Pin C (3-pin TPS) Pin B (6-pin TPS)	+5v ± 0.5v

Table 3, TPS Connector Pin Locations

Troubleshooting

TPS Resistance at OEM Connector Harness (Cummins and Detroit Diesel engines only)			
Measurement	**From**	**To**	**Value**
TPS total resistance	+V supply	Common	2000 to 3000 ohms
TPS signal to common at idle	TPS signal	Common	200 to 500 ohms (13% ± 2% of TPS total resistance)
TPS signal to +v supply at idle	TPS signal	+V supply	1800 to 2500 ohms and less than TPS total resistance
TPS signal over pedal travel range	TPS signal	+V supply	Should change smoothly from high to low resistance values as the pedal moves from idle to wide-open throttle
	TPS signal	Common	Should change smoothly from low to high resistance values as the pedal moves from idle to wide-open throttle

Table 4, TPS Resistance at OEM Connector Harness (Cummins and Detroit Diesel engines only)

Index, Alphabetical

Section	Section Number
Aerodynamic Bumper	31.03
Chassis Side Fairing	31.04
Fifth Wheel, Fontaine H5092 Series	31.07
Fifth Wheel, Fontaine 6000 and 7000 No-Slack II Series	31.15
Fifth Wheel, Holland 3500 Series	31.05
Fifth Wheel Mount, Sliding, Holland FW35/FW2535	31.06
Fifth Wheel Mount, Sliding Fontaine® 5AWB and 5MWS Models	31.08
Fifth Wheels, ASF Castloc II® and Simplex® Series	31.02
Frame Assembly	31.01
Frame Fasteners	31.00
Non-Aerodynamic Bumper	31.12
Rear Fender	31.13
Tool Box	31.14
Trailer Coupling, Holland PH–T–60–AL	31.11
Trailer Coupling, Premier 260 and 460	31.09
Trailer Coupling, Premier 690	31.10

Frame Fasteners 31.00

Contents

Subject	Subject Number
General Information	050

General Information

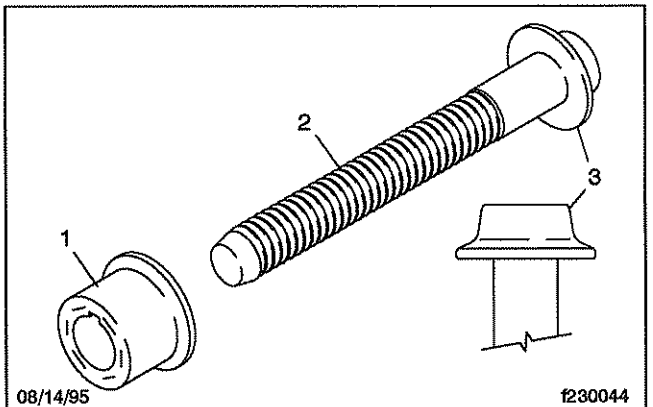
Either Huck® fasteners or grade 8 hexhead bolts and grade C prevailing torque locknuts are used for frame attachments. **See Fig. 1 and Fig. 2.** For attachments where clearance is minimal, low-profile hexhead bolts and grade C prevailing torque locknuts are used. Prevailing torque locknuts of both bolt types have distorted sections of threads to provide torque retention.

When hexhead bolts and locknuts are used on an attached part, a hardened flatwasher is required to prevent the bolt head or nut from embedding in the part. In general, hardened washers are used to distribute the load, and to prevent localized overstressing of the frame rails, brackets, and other parts. They are placed directly against the part, under the nut or bolt head. These special hardened washers are used on the frame rails and for the engine rear supports, rear suspension brackets, and fifth wheel mountings. They are cadmium-or zinc-plated, and have a hardness rating of 38 to 45 HRC.

HEXHEAD BOLT REPLACEMENT

Replace hexhead bolts with identical fasteners. Refer to the Freightliner Parts Book for fastener specifications.

Apply Alumilastic® compound, or an equivalent, to all surfaces where steel and aluminum parts contact each other.

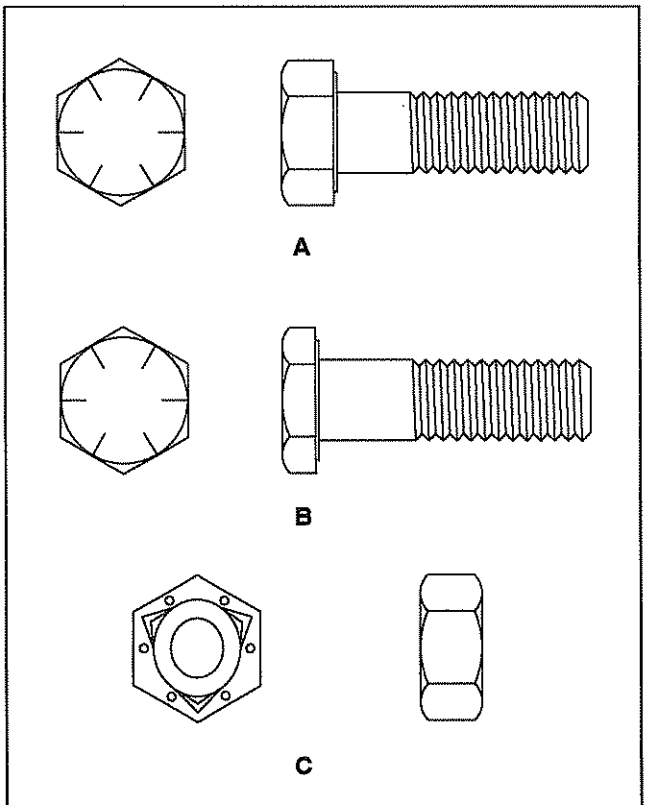


1. Spin Collar
2. Lock Pin
3. Round Head

Fig. 1, Huck Fastener

CAUTION: Failure to apply Alumilastic compound, or an equivalent, to areas where aluminum and steel parts contact each other, could lead to corrosion of the metals, resulting in damage to the frame or parts.

Never hammer or screw bolts into place. Align the holes of the frame and the part being attached to it, so that the nut and bolt surfaces are flush against the frame and the part. For bolts 4 inches (102 mm) or less in length, make sure that at least 1-1/2 threads and no more than 5/8-inch (16-mm) bolt length extend through the self-locking nut after it has been tightened. For bolts longer than four inches (102 mm), allow a minimum of 3 threads and a maximum of 3/4-inch (19-mm) bolt length.



A. Grade 8 Hexhead Bolt
B. Grade 8 Low-Profile Hexhead Bolt
C. Grade C Prevailing Torque Locknut

Fig. 2, Hexhead Fasteners

HUCK FASTENER REMOVAL

The collar for Huck fasteners is spun on when they are installed, but it cannot be unscrewed. Use the Huck Collar Cutter to remove Huck fasteners. If the Collar Cutter isn't available, split the collar with an air chisel while supporting the opposite side of the collar with an anvil. **See Fig. 3.** Then, drive out the lock pin with a punch. Discard the fastener after removing it. Replace Huck fasteners with standard grade 8 threaded fasteners.

CAUTION: Never attempt to reuse any Huck fastener that has been removed. Reusing any Huck frame fastener can result in damage to the vehicle frame or components attached to the frame.

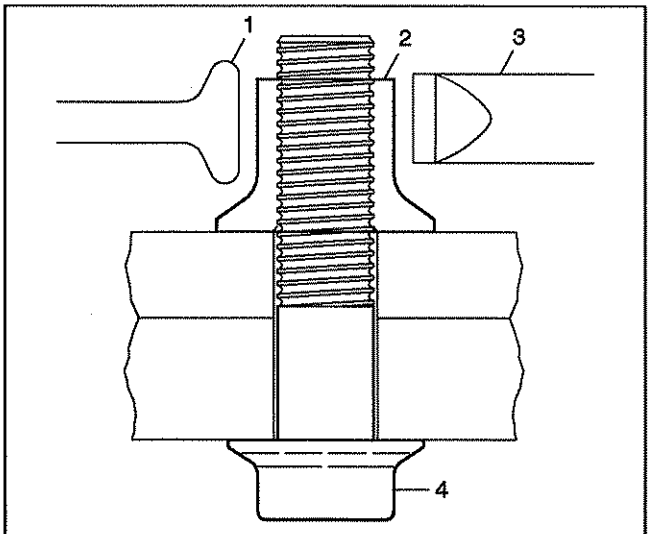
FRAME FASTENER TIGHTENING

CAUTION: Tighten standard frame fasteners periodically. Continued vehicle operation with loose fasteners could result in component, bracket, and frame damage.

Tighten hexhead bolts and locknuts periodically to offset the effects of "bedding in" (seating). Refer to the Maintenance Schedule and the frame section in the vehicle maintenance manual for intervals.

When tightening the fasteners, tighten the nut, not the bolt head. This will give a true torque reading by eliminating bolt body friction. For torque specifications, refer to the general information section in the vehicle maintenance manual.

NOTE: Huck fasteners do not require periodic tightening.



1. Anvil
2. Spin Collar
3. Chisel
4. Lock Pin

Fig. 3, Huck Fastener Removal

Contents

Subject	Subject Number
General Description and Handling	050
Service Operations	
Repairing Frame Rail Cracks, Filling Unused Holes, and Drilling Holes	100
Welding Frame Rails	110
Lengthening Frame Rails	120
Frame Crossmember Removal and Installation	130
Frame Rail Alignment	140
Frame Shaping	150
Specifications	400

General Description

IMPORTANT: This workshop manual *does not cover* the procedures and calculations necessary to do frame modifications. Before doing any modification to the frame rails, consult with the Freightliner Engineering Department.

The main body of the frame consists of two frame rails connected by a series of crossmembers. See **Fig. 1** and **Fig. 2**. The frame supports the rest of the chassis and body.

The frame rails are made of steel, and both have identical specifications. Each rail has an upper flange, lower flange, and web (the surface area between the flanges). The inside area of the frame rail is called the channel. See **Fig. 3**.

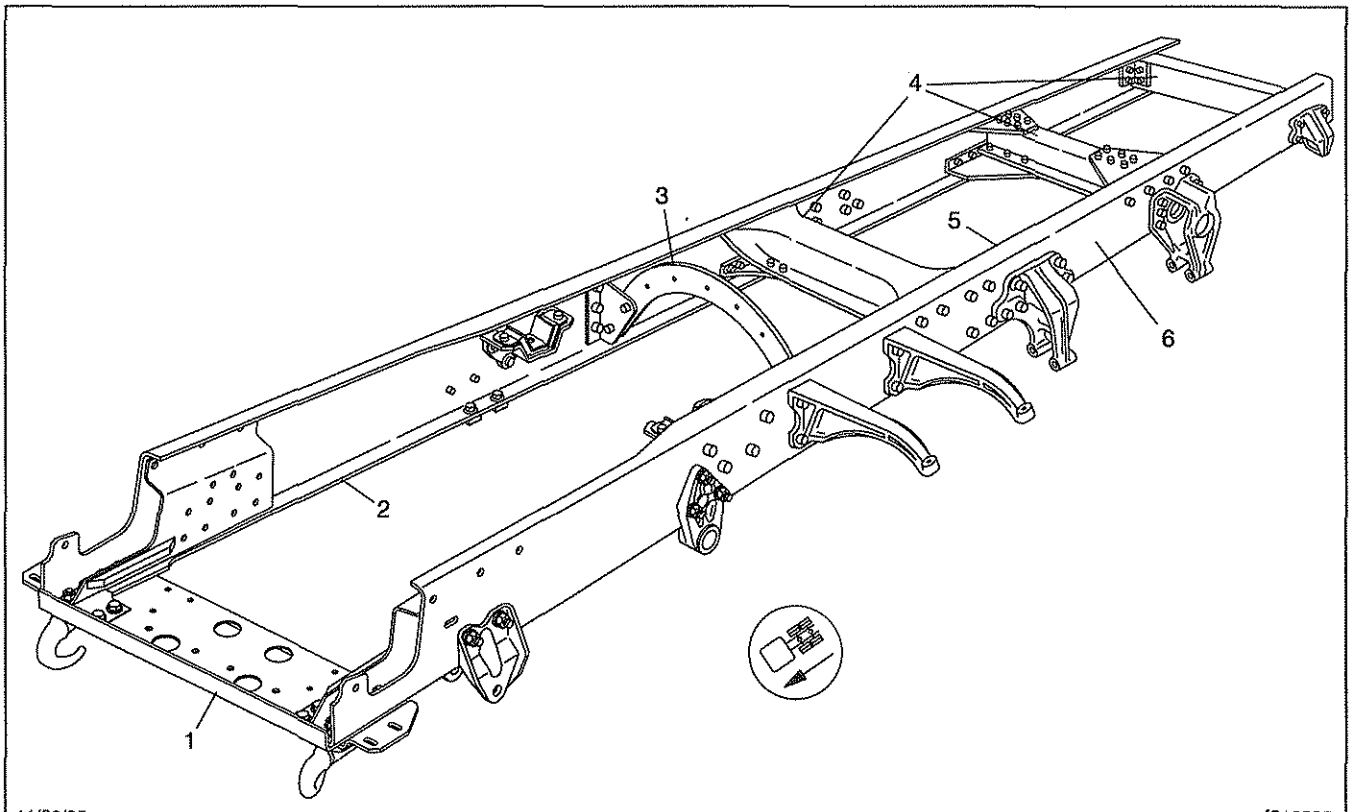
The crossmembers control axial rotation and longitudinal motion of the rails, and reduce torsional stress transmitted from one rail to the other. Crossmembers are also used for vehicle component mounting, and protecting the wires and tubing that are routed from one side of the vehicle to the other.

Follow the guidelines in this section when servicing the frame. For information on installation of specialized equipment on the frame, refer elsewhere in this section.

FRAME STATIONS

Century Class Conventionals

A frame station is a reference point on the frame rail from which the location of each component (mounted on the frame rail) is measured. There are two frame



1. Front Crossmember
2. Lower Flange
3. Overslung Crossmember
4. Frame Crossmembers
5. Upper Flange
6. Frame Rail Web

Fig. 1, Frame Assembly, Century Class Conventional

General Description

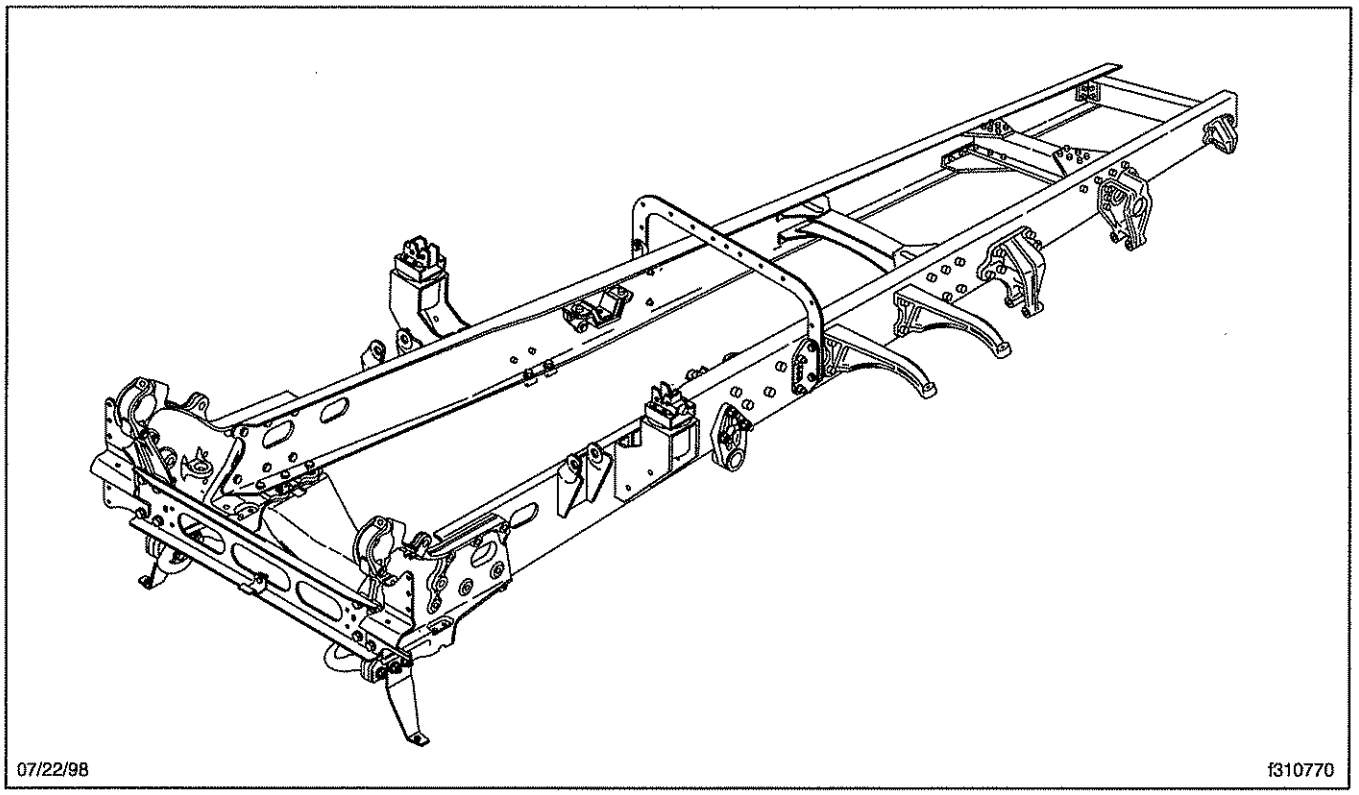


Fig. 2, Frame Assembly, Argosy COE

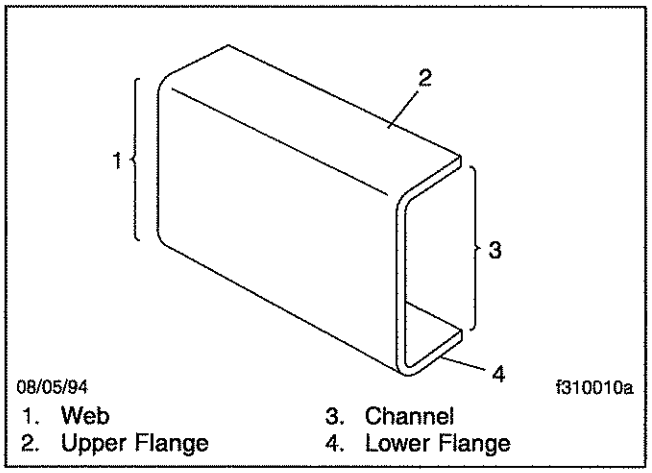


Fig. 3, Frame Terminology

stations on the frame rails: station zero (usually written as 0.00"); and station 1150. See **Fig. 4**.

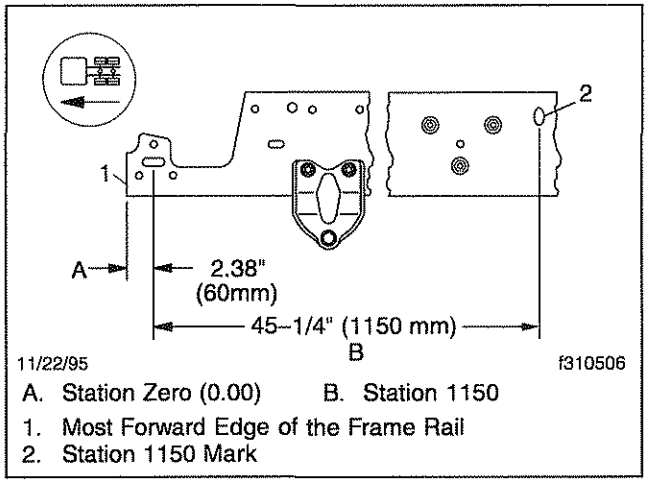
There is no identifying mark for station zero. It is located 2-3/8 inches (60 mm) to the rear of the most forward edge of the frame rail. See **Fig. 4**.

Station 1150 is located 45-1/4 inches (1150 mm) to the rear of station zero. Station 1150 is used when station zero is not accessible because of vehicle assembly. Station 1150 is identified by a 1/2-inch (13-mm) high oval stamped near the top part of the frame rail web.

The vehicle's frame drilling chart lists the location of each frame rail component. For example: if a component is given a location of 2500, then that component is installed on the frame rail 98-7/16 inches (2500 mm) aft of station zero, or 53-3/16 inches (1350 mm) aft of station 1150.

Argosy COE

A frame station is a reference point on the frame rail from which the location of each component (mounted on the frame rail) is measured. There are two frame



A. Station Zero (0.00) B. Station 1150
1. Most Forward Edge of the Frame Rail
2. Station 1150 Mark

Fig. 4, Frame Rail Stations, Century Class Conventional

stations on the frame rails: station zero (usually written as 0.00"); and station 1300. See **Fig. 5**.

There is no identifying mark for station zero. It is located 8-7/8 inches (225 mm) forward of the most forward edge of the frame rail. See **Fig. 5**.

Station 1300 is located 51-3/16 inches (1300 mm) to the rear of station zero. Station 1300 is used when station zero is not accessible because of vehicle assembly. Station 1300 is identified by three vertical indentations near the top part of the frame rail web.

The vehicle's frame drilling chart lists the location of each frame rail component. For example: if a component is given a location of 2500, then that component is installed on the frame rail 98-7/16 inches (2500 mm) aft of station zero, or 47-1/4 inches (1200 mm) aft of station 1300.

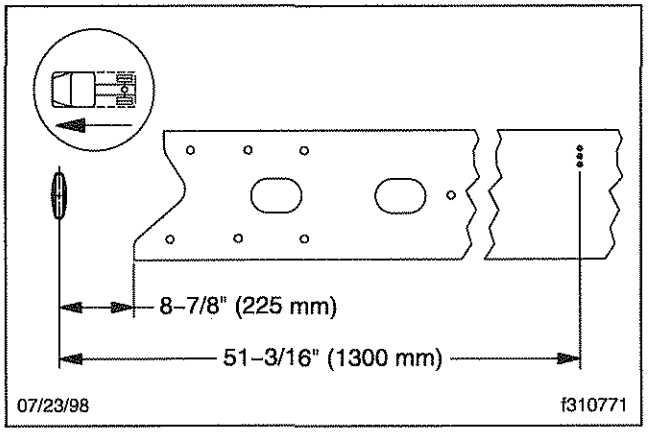


Fig. 5, Frame Rail Stations, Argosy COE

Handling

Whenever the frame rails are lifted or moved, take care to avoid anything that may scratch, cut, or damage the exposed frame assembly. Cushion all chain hoists or cable slings with a section of heavy hose. If the frame rail is raised with a jack, place a block of wood between the jack and the frame rail.

Never heat the frame rails for straightening purposes. Such work should be done cold, as the frame rails have been heat-treated.

⚠ CAUTION

Heating the frame rail for straightening purposes will reduce the strength of the rail in localized areas, which can result in structural failure of the frame rail.

Use pencil lines or soapstone marking for any work that requires marking of the frame rail. High visibility can be obtained by first chalking the surface of the frame rail, then making the pencil marks.

Repairing Cracks, Filling Unused Holes, and Drilling Holes

Repairing Cracks

IMPORTANT: Freightliner LLC recommends that cracked or damaged frame rails be replaced. In some cases it may be necessary to repair minor damage; before attempting any repairs, contact your regional service representative for approval.

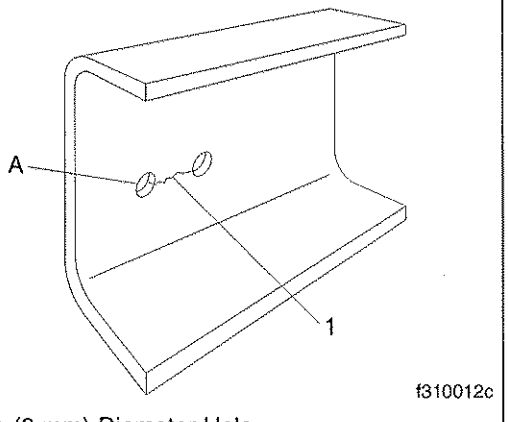
⚠ CAUTION

Before performing any electric welding on a vehicle, read and understand the welding precautions in Subject 110. Disconnect the battery power and ground cables and any electronic control units (ECUs) installed on the vehicle. Electric currents produced during electric welding can damage various electrical components on the vehicle, such as alternator diodes and ECUs.

Freightliner vehicle components that typically use ECUs include electronic engine, electronic automatic transmission, and ABS (antilock braking system).

For any ECU with a battery power harness, disconnect its ground terminal from the chassis ground, and disconnect its power terminal from the battery positive post, or disconnect the main connection at the ECU.

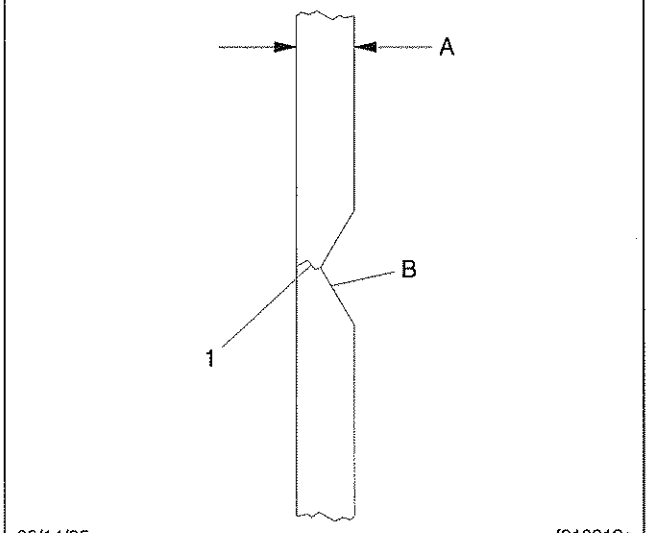
1. Drill a 1/8-inch (3-mm) diameter hole at each end of the crack to prevent further spreading of the crack. See **Fig. 1**.



1. 1/8-inch (3-mm) Diameter Hole
2. Crack

Fig. 1, Preventing Cracks from Spreading

2. Vee out the crack to a depth of two thirds of the stock thickness. See **Fig. 2**.



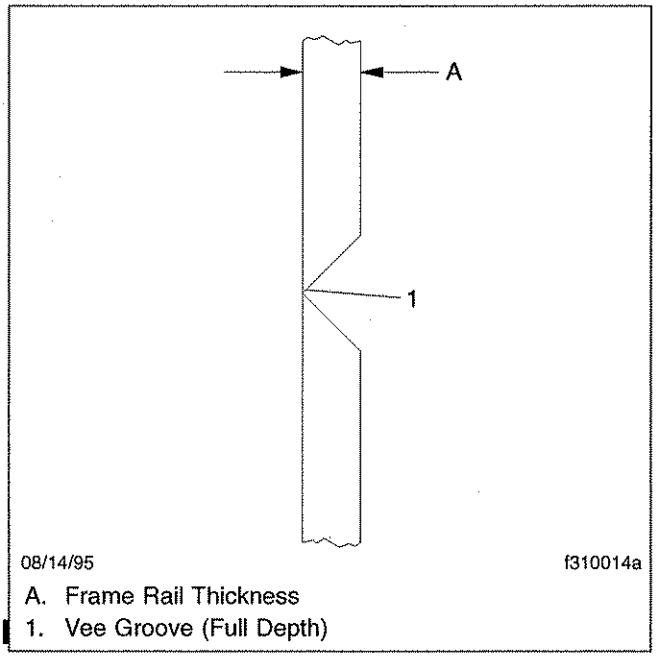
A. Frame Rail Thickness
B. Grind a vee groove two thirds the depth of the stock thickness.
1. Crack

Fig. 2, Cross-Section View

NOTE: If it will not be possible to grind both sides of the frame rail, then grind the vee groove on one side to the full depth of the stock thickness. See **Fig. 3**.

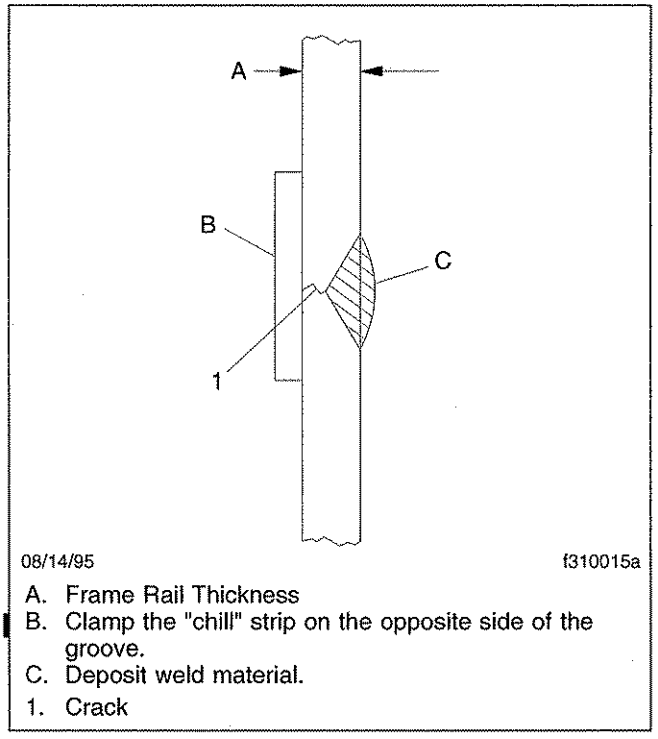
3. Clamp a copper or aluminum bar on the opposite side of the groove. The bar will act as a "chill" strip, keeping the heat from spreading to the surrounding area of the frame rail. See **Fig. 4**. Deposit the weld material using the applicable welding method described in this section.
4. Grind the weld flush with the frame rail. See **Fig. 5**.
5. Cut a deep enough vee groove on the opposite side of the frame rail to reach the weld metal. See **Fig. 6**.
6. Clamp the "chill" strip on the opposite side of the groove. See **Fig. 7**. Weld the vee groove, as instructed above. Make full penetration of the weld.
7. Grind the weld flush with the frame rail. See **Fig. 8**.

Repairing Cracks, Filling Unused Holes, and Drilling Holes



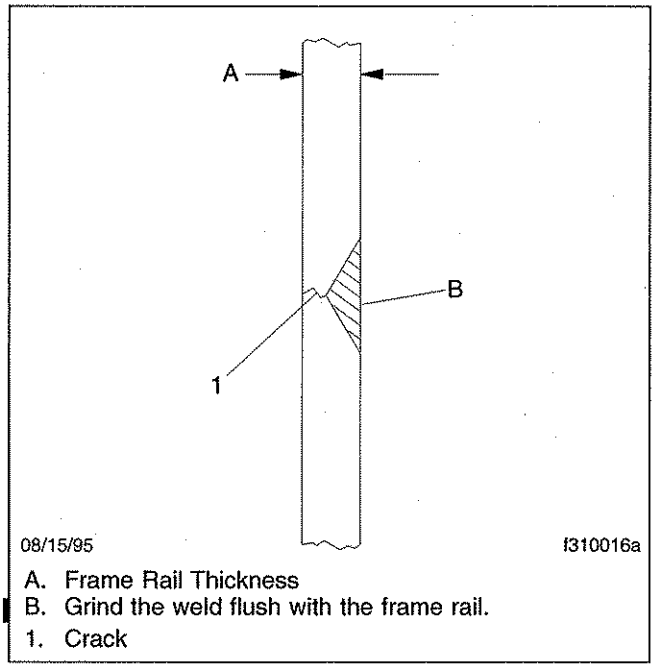
A. Frame Rail Thickness
1. Vee Groove (Full Depth)

Fig. 3, Full Depth Groove



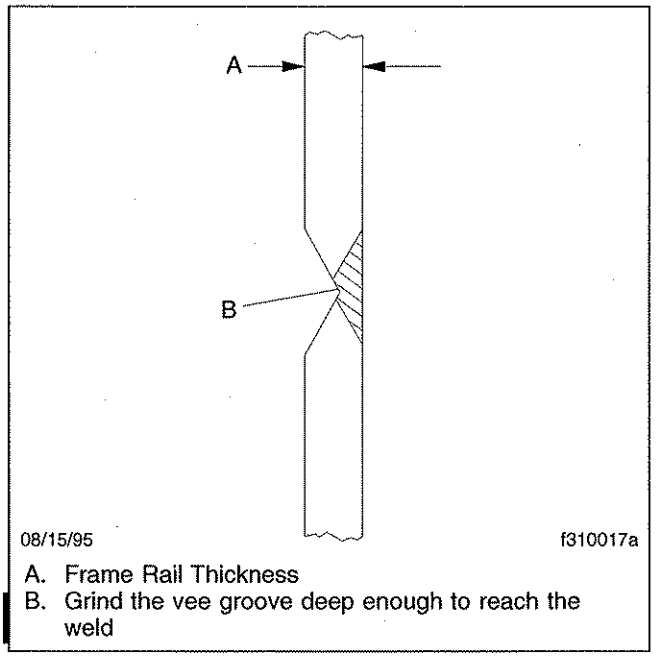
A. Frame Rail Thickness
B. Clamp the "chill" strip on the opposite side of the groove.
C. Deposit weld material.
1. Crack

Fig. 4, Using a Chill Strip



A. Frame Rail Thickness
B. Grind the weld flush with the frame rail.
1. Crack

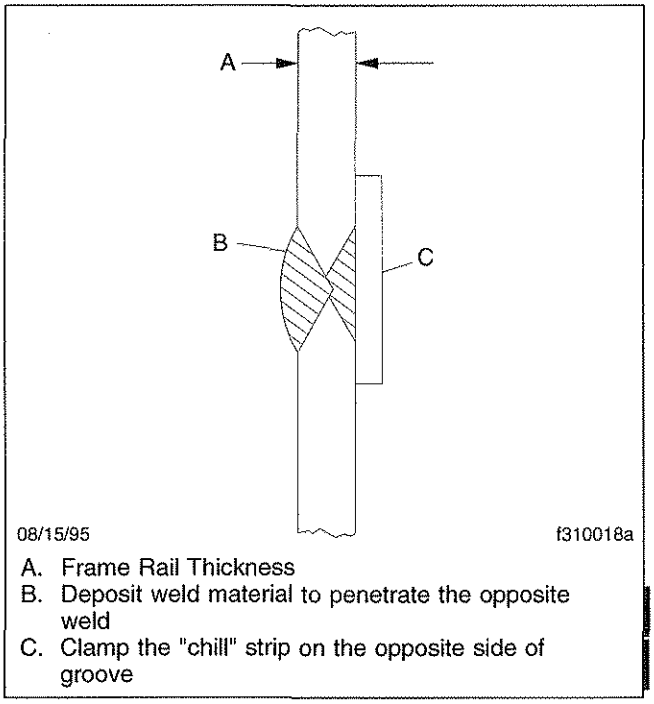
Fig. 5, Weld Ground Flush



A. Frame Rail Thickness
B. Grind the vee groove deep enough to reach the weld

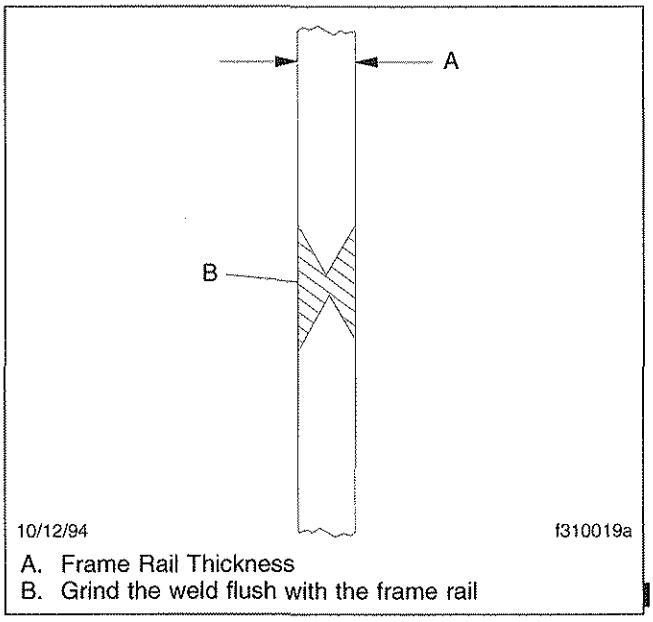
Fig. 6, Cross-Section View

Repairing Cracks, Filling Unused Holes, and Drilling Holes



A. Frame Rail Thickness
B. Deposit weld material to penetrate the opposite weld
C. Clamp the "chill" strip on the opposite side of groove

Fig. 7, Second Weld



A. Frame Rail Thickness
B. Grind the weld flush with the frame rail

Fig. 8, Second Weld Ground Flush

Filling Unused Holes

1. Fill all unused holes in the frame assembly with the applicable nut, washer, and bolt combination.
2. If the diameter of a hole is less than 3/8 inch (9.5 mm), enlarge it to 3/8 inch (9.5 mm), and fill it with the applicable nut, washer, and bolt combination.
3. Tighten the fasteners to the applicable torque value. For proper frame fastening instructions, refer elsewhere in this group.

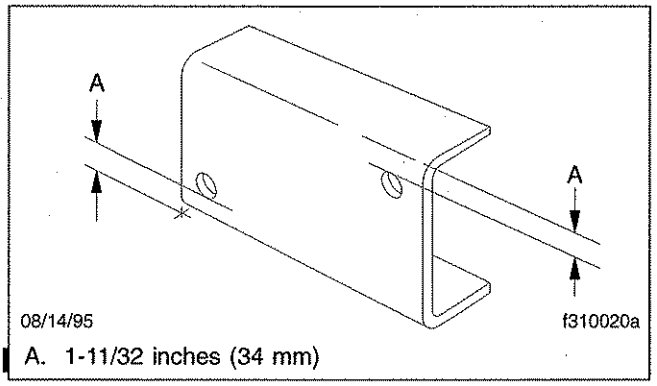
Drilling Holes

During vehicle manufacture, holes are drilled or punched in the frame rail only as specified on the vehicle frame drilling chart. If any additional holes need to be drilled, contact your regional service representative for approval.

A single exception to this rule is that holes may be drilled for tubing clips and the like through the web portion of the channel only, with the following restrictions:

- The *edge* (not the center) of the hole must be no closer than 1-11/32 inches (34 mm) from the outer face of the flange. See **Fig. 9** for the minimum distance to the flanges that holes can be placed on the web.
- Material between the centerline of the hole and the outside of the upper or lower flange must be at least 2-13/32 inches (60 mm).
- Minimum material between hole centerlines must be 2 inches (50 mm).
- All attaching fasteners must be Grade 8. Flat washers must be made with high strength steel.
- The minimum material between the rear suspension bracket and the end of the frame must be at least 2 inches (50 mm).
- Holes between the front axle centerline and the rear axle centerline cannot exceed 3/4 inches (19 mm).

Repairing Cracks, Filling Unused Holes, and Drilling Holes



A. 1-11/32 inches (34 mm)

Fig. 9, Minimum Distance for Drilling Holes

Welding Frame Rails

Safety Precautions

⚠ CAUTION

Before performing any electric welding on a vehicle, disconnect the battery power and ground cable, and any electronic control units or similar devices installed on the vehicle. Electric currents produced during electric welding can damage various electrical components on the vehicle, which could result in malfunction of the components.

1. Park the vehicle on a level surface. Shut down the engine. Set the parking brake, and chock the front and rear tires.
2. Tilt the hood.
3. Disconnect the batteries. Attach the welding ground strap as close to the work being done as safely possible.
4. Disconnect the following ECUs and other electronic devices:

ENGINE ELECTRONIC CONTROL UNIT (ECU)

The location of the engine ECU differs with the engine manufacturer. See **Fig. 1**, **Fig. 2**, **Fig. 3**, and **Fig. 4**.

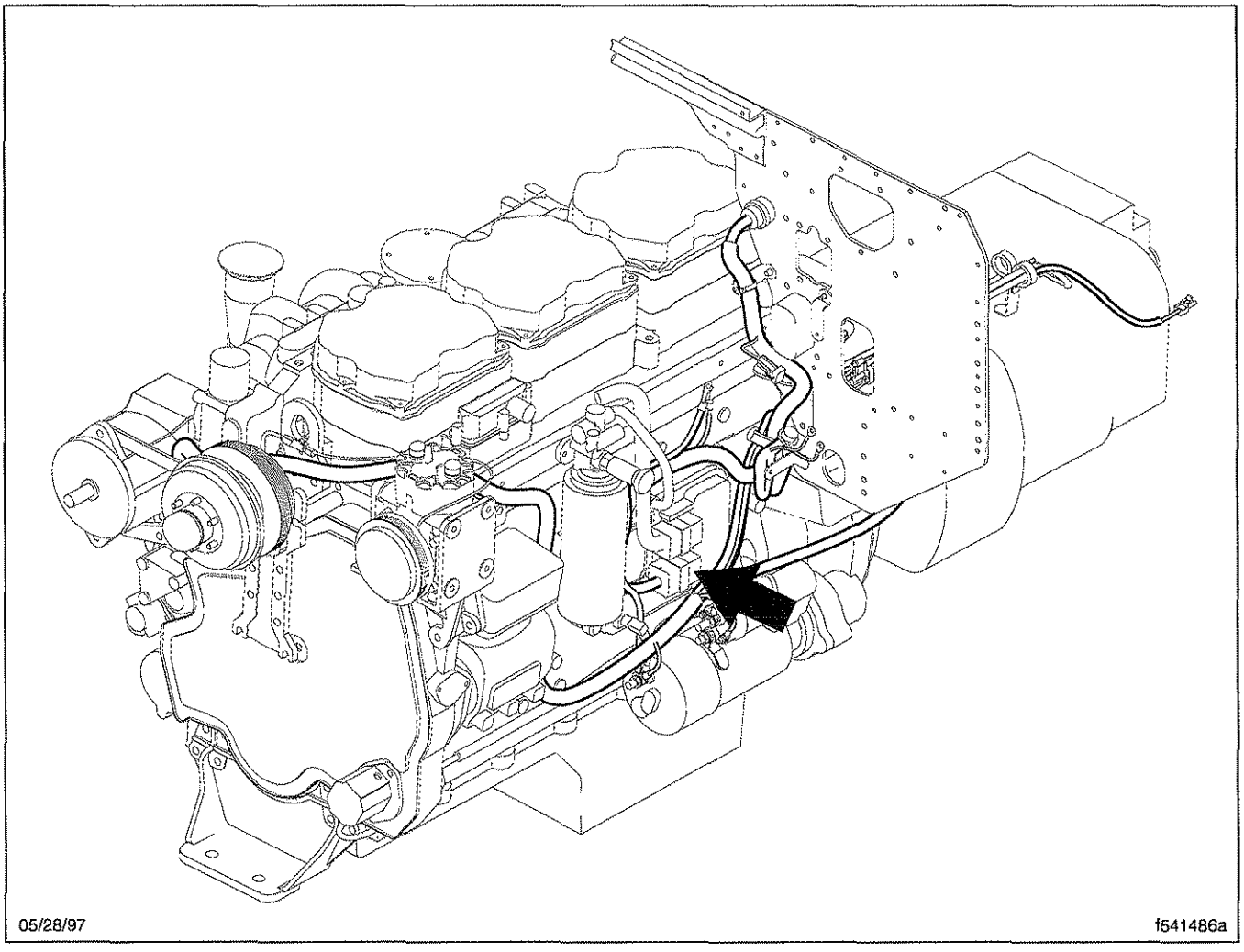


Fig. 1, Caterpillar C-10/C-12/3176 Engine ECU Location

Welding Frame Rails

INSTRUMENT CLUSTER UNIT (ICU)

The ICU includes the driver's instrument panel, the ICU housing, and the dash message center (all installed as one unit). To disconnect the ICU, see **Section 54.03** in this manual.

DATA LOGGING UNIT (DLU)

The DLU is one of several electronic modules mounted inside a compartment on the lefthand B-pillar, behind the driver's seat. See **Fig. 5**. The data logging unit is the top unit, and is mounted above the auxiliary power distribution module. Disconnect the electrical connector from the bottom of the unit.

AIR CONDITIONING PROTECTION UNIT (ACPU)

The ACPU connector is located near the bottom of the righthand side of the firewall in the engine compartment.

ANTILOCK BRAKE SYSTEM (ABS)

The ABS ECU is mounted in the B-pillar compartment. See **Fig. 5**.

AUXILIARY POWER DISTRIBUTION MODULE (APD)

The APD module is mounted in the B-pillar compartment. See **Fig. 5**.

VORAD SYSTEM

The ECU for the VORAD system is mounted in a small compartment on the righthand B-pillar, behind the driver's seat.

DAYTIME RUNNING LIGHTS

The ECU for the Daytime Running Lights is located in a small compartment on the righthand B-pillar, behind the driver's seat.

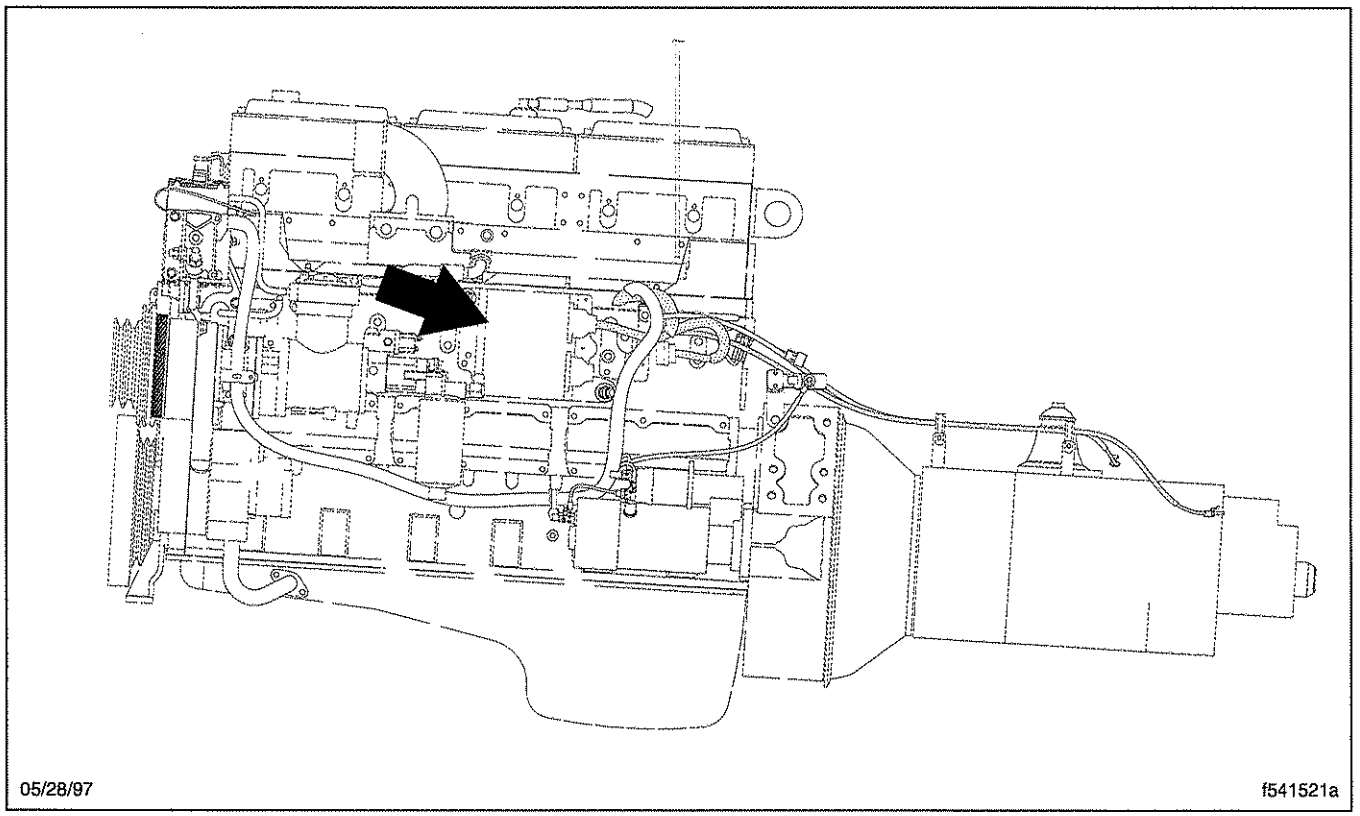


Fig. 2, Cummins N14 Engine ECU Location

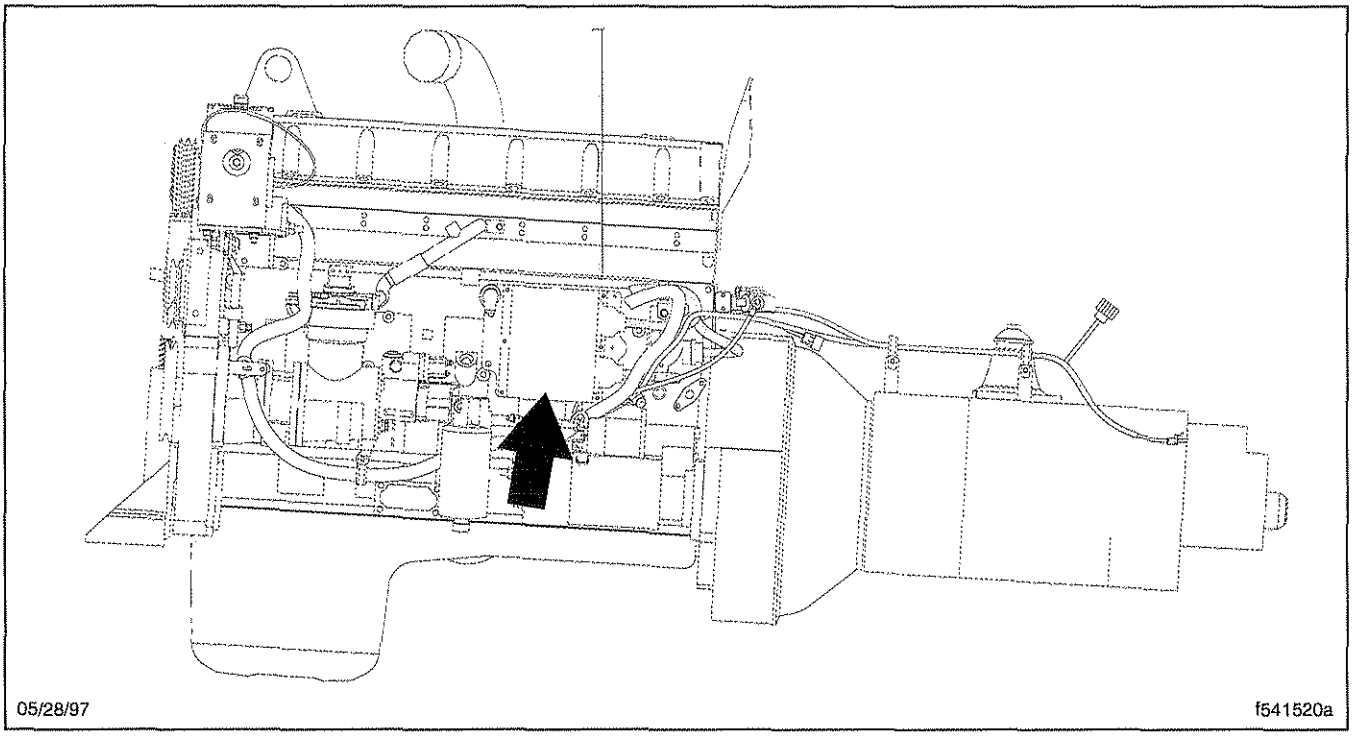


Fig. 3, Cummins M11 Engine ECU Location

RADIO

Disconnect the electrical connection to the radio.

ALTERNATOR

Disconnect the ground strap, as previously mentioned, and this should serve to remove any chance for damage to the alternator.

WINDOW EXPRESS MODULE

The Window Express module is located beneath the driver's step threshold plate. Remove the plate to disconnect the module connection.

VEHICLE SECURITY SYSTEM

The vehicle's security system ECU is mounted in the righthand B-pillar compartment.

SPACE SYSTEM

If the vehicle is so equipped, the SPACE system's ECU is disconnected by unplugging the wiring attached to the SPACE device mounted behind the operator's seat.

Welding Frame Rails

IMPORTANT: There are very few cases in which welding a heat-treated frame rail is allowable. If possible, avoid direct welding of the frame rail web. Before any welding is done, contact your regional service representative for approval.

⚠ CAUTION

Weld only as instructed in this section; all precautions and methods must be strictly followed. Failure to do so can reduce the structural strength in the welded area of the frame rail.

⚠ WARNING

Wear protective welding masks and gloves when welding. Failure to do so could result in personal injury, due to the intensity of heat, sparks, and flying debris.

Welding Frame Rails

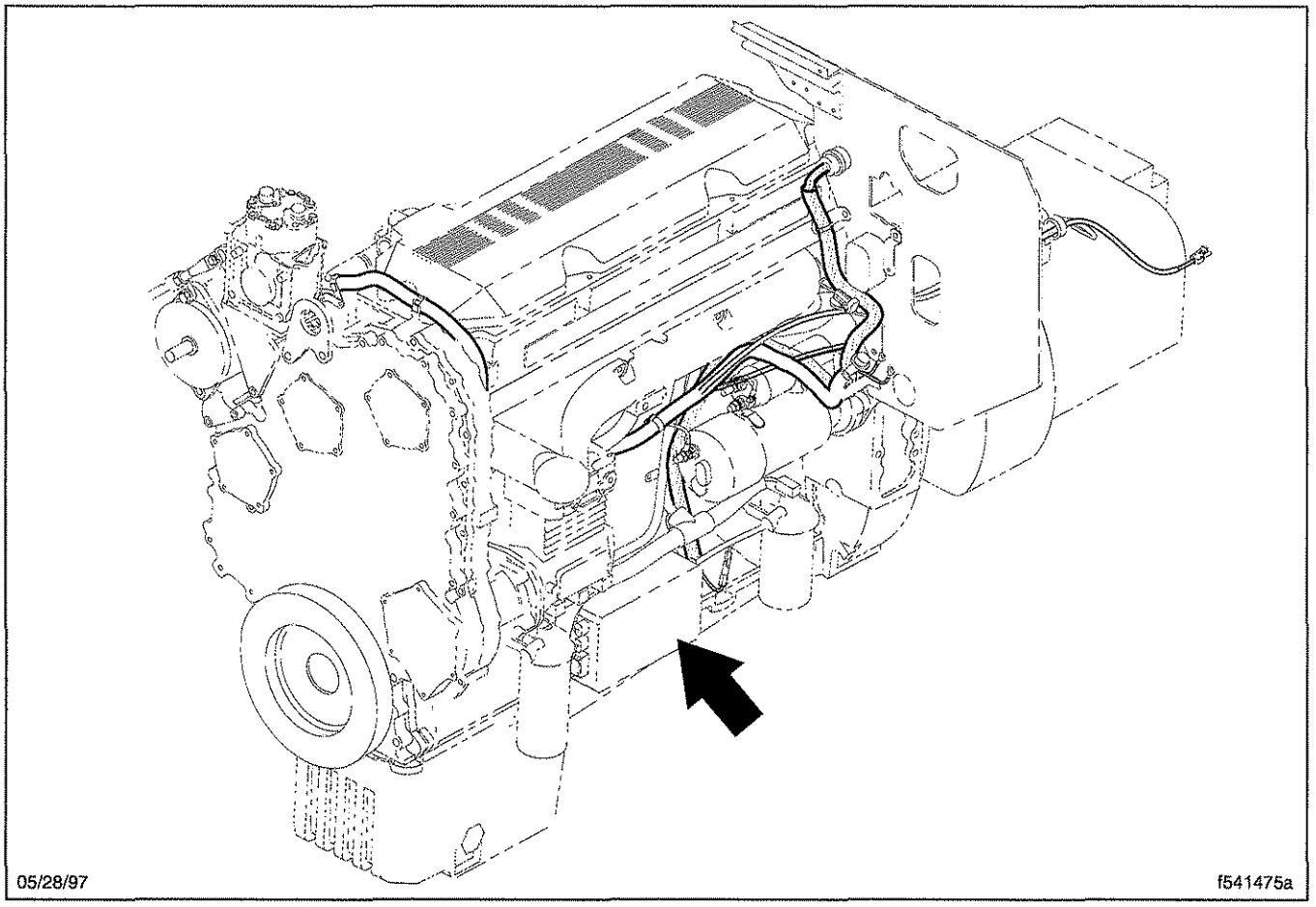


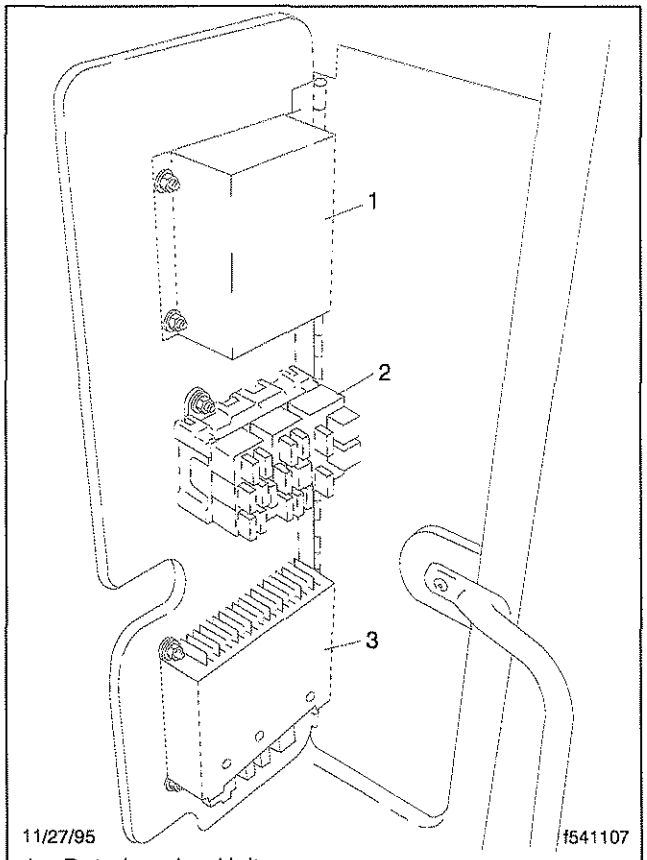
Fig. 4, Detroit Diesel Series 60 Engine ECU Location

1. Do not weld attachments to the frame rail. For guidelines on the attachment of equipment on the frame rails, refer elsewhere in this group.
2. Use only the applicable welding method under "Welding Methods."
3. Before welding, clean off any oil, grease, paint, scale, and other contaminants. Wipe dry with a clean cloth.
4. Do not weld in an area that allows drafts from any source such as windows, engines, or fans, as it will affect the soft flow of gas from the welding gun.
5. Do not weld into the radius of the frame rail flanges or along the edge of the flange.
6. Do not weld square with the frame side rail. Make all reinforcing welds at least 30 degrees from square. This will distribute the weld stresses over a larger area.
7. Do not notch, undercut, or leave craters during the welding process.
8. Keep as close to the weld centerline as possible.

WELDING METHODS

Gas-metal arc welding is the recommended method. If gas-metal arc welding is not available, coated-electrode arc welding can be used. For both gas-metal arc welding and coated-electrode arc welding, direct current reverse polarity is recommended, however, alternating current can be used. Use either a short arc beading technique or a narrow weave technique.

1. Review the information under "Precautions." Then, if using the gas-metal arc weld method, proceed



1. Data Logging Unit
2. Auxiliary Power Distribution Module
3. ABS ECU

Fig. 5, Lefthand B-Pillar Electrical Compartment

to the next step. If using the coated-electrode arc weld method, go to the step after the next, below.

2. For the gas-metal arc welding method, use the following requirements and specifications:

   2.1 Use weld wire that meets American Welding Society (AWS) specification A 5.28, Class E110S.

   2.2 Use Linde M-5 gas or an equivalent argon-oxygen mixture of 5 percent oxygen.

   2.3 For machine settings, refer to the applicable table under **Specifications, 400**.

3. For the coated-electrode arc welding method, use 1/8-inch-thick AWS-E-11018 type weld rod. For amperage and voltage settings of each weld position, refer to the applicable table under **Specifications, 400**.

IMPORTANT: Always keep the weld rod free of moisture. The welding rod being used should come directly from a hermetically sealed container, or be dried at least one hour in a 700° to 800°F (371° to 427°C) oven. Immediately after removal from a sealed container or after drying, store the welding rod in an oven at 250°F (121°C). A welding rod that has been exposed to the atmosphere longer than one-half hour must be dried before use.

NOTE: On 1/4-inch-thick frame rails only, AWS-E-9018 type weld rod can be used, however, AWS-E-11018 type weld rod is recommended.

Lengthening Frame Rails

Steel frame rails can be lengthened by welding a frame rail extension onto the rear of the frame rail. The frame rail end and the extension piece are cut so that they overlap each other. Obtain approval from your regional service representative before welding and lengthening the frame rail.

⚠ CAUTION

Before performing any electric welding on a vehicle, read and understand the welding precautions in Subject 110. Disconnect the battery power and ground cables and any electronic control units (ECUs) installed on the vehicle. Electric currents produced during electric welding can damage various electrical components on the vehicle, such as alternator diodes and ECUs.

Freightliner vehicle components that typically use ECUs include electronic engine, electronic automatic transmission, and ABS (antilock braking system).

For any ECU with a battery power harness, disconnect its ground terminal from the chassis ground, and disconnect its power terminal from the battery positive post. Or else disconnect the main connection at the ECU.

1. Cut the frame rail end and extension to the applicable dimensions. See **Fig. 1** for truck vehicles; see **Fig. 2** for tractor vehicles. Refer only to the figure that relates to the vehicle being modified.

NOTE: If the length of the extension is to be 6 inches (152 mm) or less, then straight-cut the frame rail end and extension.

2. Grind the cut ends of the frame rail and extension to the dimensions in **Fig. 3**.

3. Align the cut ends of the extension piece with the cut ends of the frame rail so that there is a 1/16- to 1/8-inch (1.6 to 3.2 mm) gap between them. See **Fig. 3**. Using a torch, heat the cut ends to 70°F (21°C), if necessary, before welding.

NOTE: A 1/16-inch (1.6 mm) gap is recommended. The ends must not contact each other. Maintain the joint spacing by placing a short piece of clean, 1/16-inch (1.6 mm) diameter bare steel wire between the extension and frame rail. The wire sections must be short enough to be completely fused by the welding process.

4. Using one of the methods in **Subject 110**, weld the extension to the frame rail, making full penetration. See **Fig. 4**. Remove any slag between passes, and back-gouge the root of the first vee before welding the other side.

⚠ CAUTION

Residual stresses will occur in the weld if the web area is not welded first, or if the flanges contact each other when welding the web.

IMPORTANT: Weld the web area first, then the flange, working from the inside of the channel. When welding the web, make sure that the flanges do not contact each other.

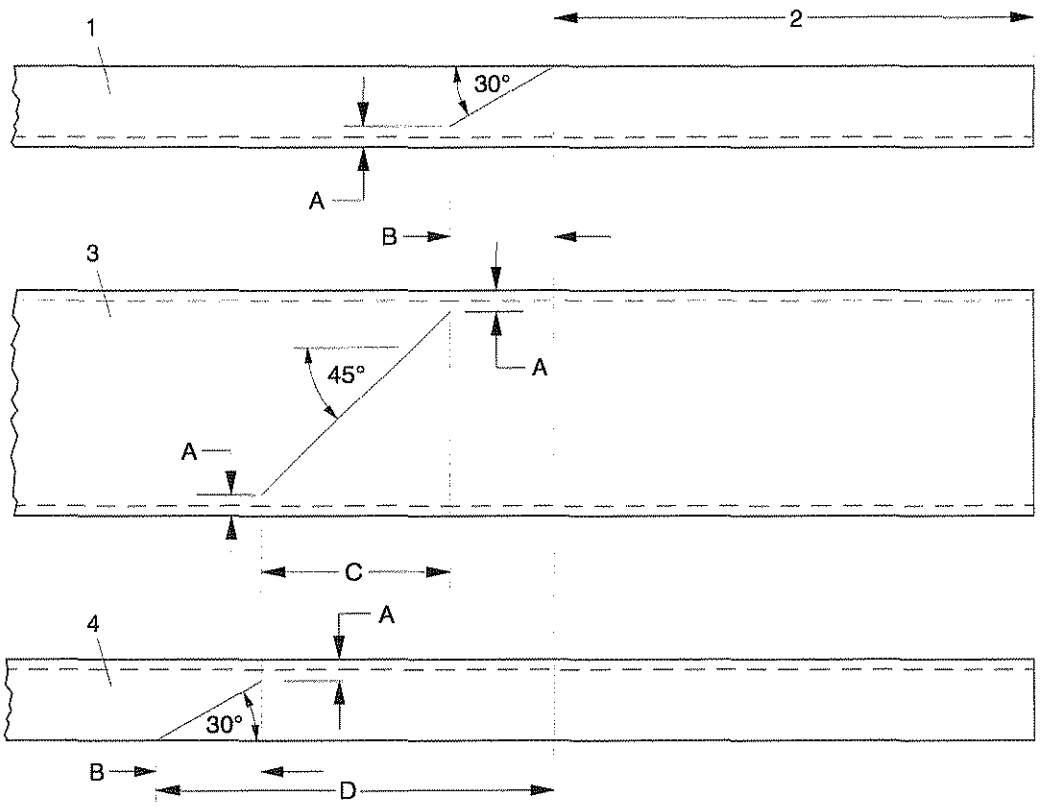
5. When finished welding, sand the joint for appearance. Hold the sander so that the grind runs parallel with the length of the frame rail.

Lengthening Frame Rails

⚠ CAUTION

Do not "hollow grind" the weld. Small depressions from improper grinding of the weld will reduce the strength of the frame rail.

Lengthening Frame Rails



NOTE: Left rail shown; right rail will be opposite dimensions.

FRAME RAIL SIZE inches	DIMENSION			
	A inches (mm)	B inches (mm)	C inches (mm)	D inches (mm)
10.06	0.69 (17.5)	5.00 (127.0)	8.75 (222.2)	18.75 (476.2)
10.12	0.69 (17.5)	5.00 (127.0)	8.75 (222.2)	18.75 (476.2)

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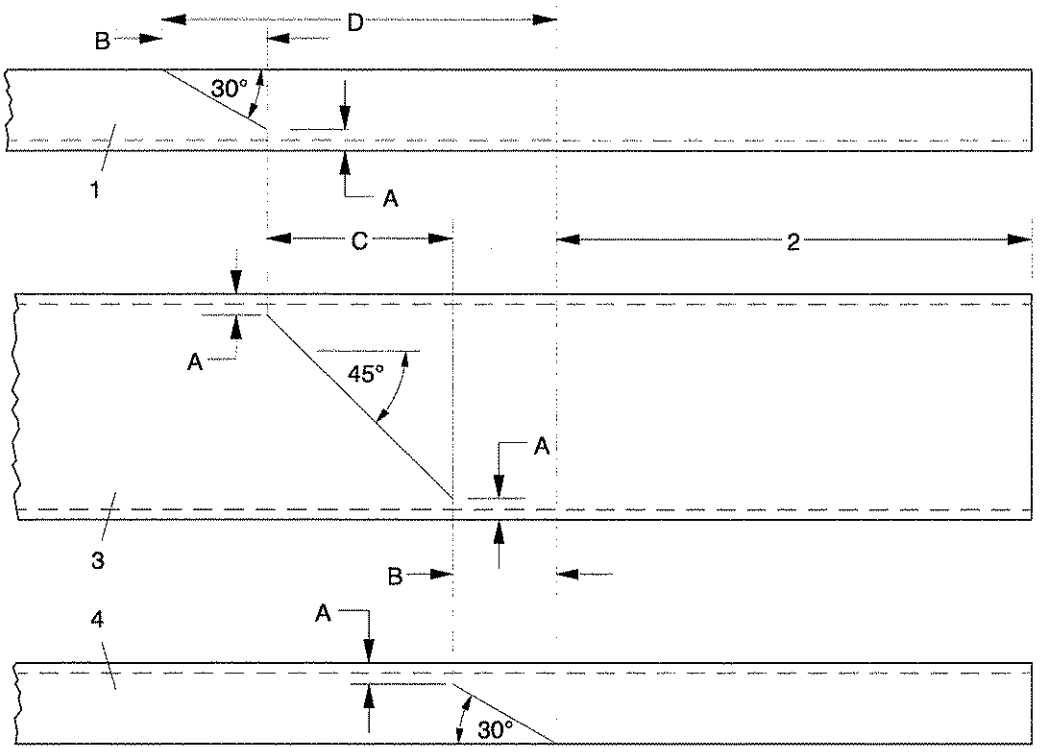
1. Upper Flange
2. Extension Length
3. Web
4. Lower Flange

Fig. 1, Frame Rail and Extension Cutting Dimensions for Truck Vehicles

Lengthening Frame Rails



NOTE: Left rail shown; right rail will be opposite dimensions.

FRAME RAIL SIZE inches	DIMENSION			
	A inches (mm)	B inches (mm)	C inches (mm)	D inches (mm)
10.06	0.69 (17.5)	5.00 (127.0)	8.75 (222.2)	18.75 (476.2)
10.12	0.69 (17.5)	5.00 (127.0)	8.75 (222.2)	18.75 (476.2)

11/22/95 f310508

1. Upper Flange
2. Extension Length
3. Web
4. Lower Flange

Fig. 2, Frame Rail and Extension Cutting Dimensions for Tractor Vehicles

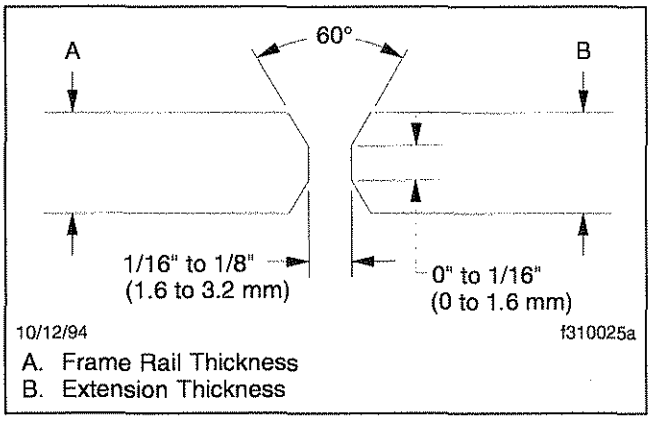


Fig. 3, Grinding Dimensions

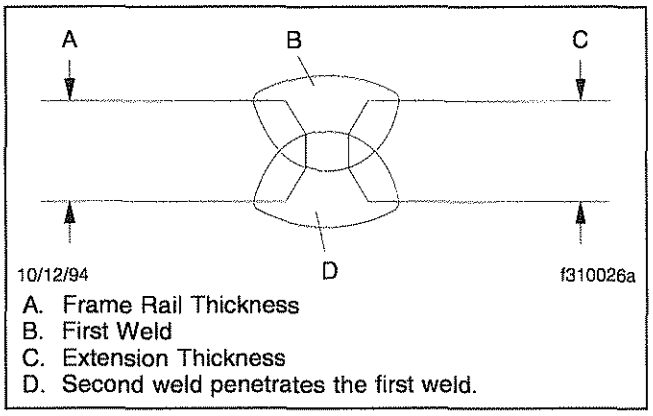


Fig. 4, Correct Weld Penetration

Frame Crossmember Removal and Installation

Removal

The placement of crossmembers affects the overall stability of the frame. If a crossmember is being eliminated, added, or relocated, contact your regional service representative for instructions and approval.

REAR-CLOSING CROSSMEMBER

1. Chock the tires.
2. Remove the taillights from the rear-closing crossmember. If so equipped, remove the backup alarm.
3. If the relay valve or quick-release valve is attached to the rear-closing crossmember, drain the air reservoirs, then remove the valve(s) from the crossmember.

   Remove any clamps that attach air lines or wiring to the crossmember.
4. Remove the rear mud flap brackets and fasteners.
5. Remove the fasteners that attach the crossmember to the angle brackets.
6. Remove the fasteners that attach the rearmost angle brackets to each frame rail, and remove the rearmost angle brackets. For assembly reference, note the direction that the bolts are installed.
7. Tip the top of the rear-closing crossmember to the rear and down, then slide it out the rear of the frame rails.
8. If needed, remove the forwardmost angle brackets and their fasteners. If the rear spring brackets are attached to the frame rails with the same fasteners that attach the angle brackets, before removing the fasteners, support the rear of the frame at its normal ride height, using safety stands. After removing the fasteners, remove the rear spring brackets from the springs.

CHANNEL CROSSMEMBER

NOTE: If the vehicle is equipped with a fifth wheel, remove it if it interferes with removal of the channel crossmember. Refer to the applicable fifth wheel section in this manual for removal instructions.

1. Disconnect any suspension torque rod bracket(s) that are attached to the crossmember. Note the number and location of any spacers.
2. If the relay valve or quick-release valve is attached to the channel crossmember, drain the air reservoirs, then remove the valve(s) from the crossmember.

   Remove any clamps that attach air lines or wiring to the crossmember.
3. Remove all fasteners that attach the channel crossmember to the upper and lower gussets. Work the crossmember out of the gussets, then work it out of the top or bottom of the frame rails.
4. If removal of the gussets is needed, and if they attach to the frame with the same fasteners as the suspension brackets, chock the tires, and use safety stands to support the frame at its normal unloaded ride height. Remove the fasteners that attach the gussets and frame brackets to the frame rails. For assembly reference, note the direction that the bolts are installed. Remove the gussets and (if equipped) frame spacers.

ALLIGATOR CROSSMEMBER

1. Using the above instructions, remove the rear-closing crossmember and angle brackets, and remove the channel crossmember, gussets, and (if equipped) frame spacers.
2. If air reservoirs are mounted inside the frame rails, remove any air reservoirs that are mounted rearward of the alligator crossmember that must be replaced. Use the air reservoir removal instructions in the applicable brake section in this manual.
3. Remove the alligator crossmember that must be replaced, and any alligator crossmembers mounted rearward of it, as follows:

   3.1 Remove the fasteners that attach the crossmember lower struts to the crossmember, and to the frame rails. For assembly reference, note the direction that the bolts are installed. Remove the lower struts.

   3.2 If removing a midship bearing crossmember, support the driveline on a safety stand, then remove the fasteners that attach the midship bearing bracket to the crossmember.

   3.3 If removing the rear cab-mount crossmember, support the fuel tanks, then remove the fasteners from the fuel tank brackets. Using an overhead hoist, support the rear of

Frame Crossmember Removal and Installation

the cab, then remove the cab suspension bracket from the cab and the crossmember.

3.4 From the weld studs in the frame rails, remove the clamps that attach any wiring or air lines that might interfere with crossmember removal.

3.5 Unbolt the crossmember, then (if equipped) remove the frame spacer from each frame rail. For assembly reference, note the direction that the bolts are installed. Slide the crossmember out the rear of the frame rails, lifting it or lowering it as needed to clear the weld studs.

FIVE-PIECE WELDED CROSSMEMBER

NOTE: If the vehicle is equipped with a fifth wheel, and it interferes with removal of the crossmember, refer to the applicable fifth wheel section in this manual for fifth wheel removal instructions.

1. Apply the parking brakes and chock the tires on both the front and rear axles.
2. If any air brake valve is attached to the crossmember, drain the air reservoirs, then remove the valve(s) from the crossmember.

   Remove any clamps that attach air lines or wiring to the crossmember, and secure the lines or wiring away from the crossmember.
3. If rear suspension brackets are attached to the frame rails with the same fasteners that attach the crossmember, use safety stands to support the rear of the frame at its normal ride height.
4. If removing a midship bearing crossmember, support the driveline on a safety stand, then remove the fasteners that attach the midship bearing bracket to the crossmember.
5. If removing the rear cab-mount crossmember, support the fuel tanks, then remove the fasteners from the fuel tank brackets. Using an overhead hoist, support the rear of the cab, then remove the cab suspension bracket from the cab and the crossmember.
6. Take note of whether the crossmember open channel faces the front or rear of the vehicle.
7. Using a cutting torch, cut the crossmember channel in two. A slightly diagonal cut will make removal of the crossmember pieces easier.
8. Remove the fasteners that attach the crossmember halves to the frame rails, and remove the crossmember. If threaded fasteners are used, save them to use with the new crossmember. If Huckbolts are used, refer to "Frame Fasteners" in this manual for removal (and installation) information.

OVERSLUNG CROSSMEMBER, CENTURY CLASS CONVENTIONAL

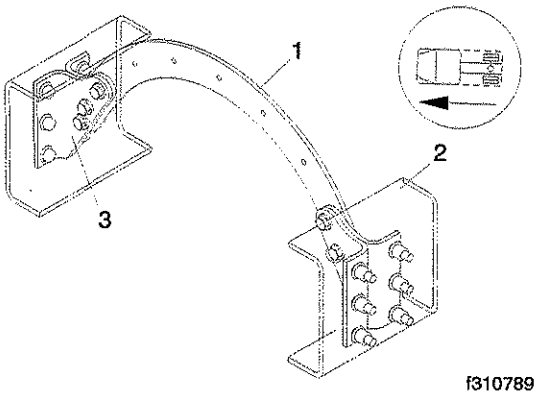
1. Apply the parking brakes and chock the tires on both the front and rear axles.

IMPORTANT: To improve access while removing the top crossmember bolt on the left-hand side of the vehicle, have an assistant hold the clutch pedal to the floor.

2. From underneath the chassis, remove the 5/8–11 bolts and nuts that hold each side of the crossmember to the mounting brackets. See **Fig. 1**.
3. Remove the overslung crossmember by rotating it down and outward on the right-hand side of the vehicle.

OVERSLUNG CROSSMEMBER, ARGOSY COE

1. Park the vehicle, apply the parking brakes, and chock the tires.
2. Tilt and support the cab as described in Section 60.15, **Subject 060** in this manual.



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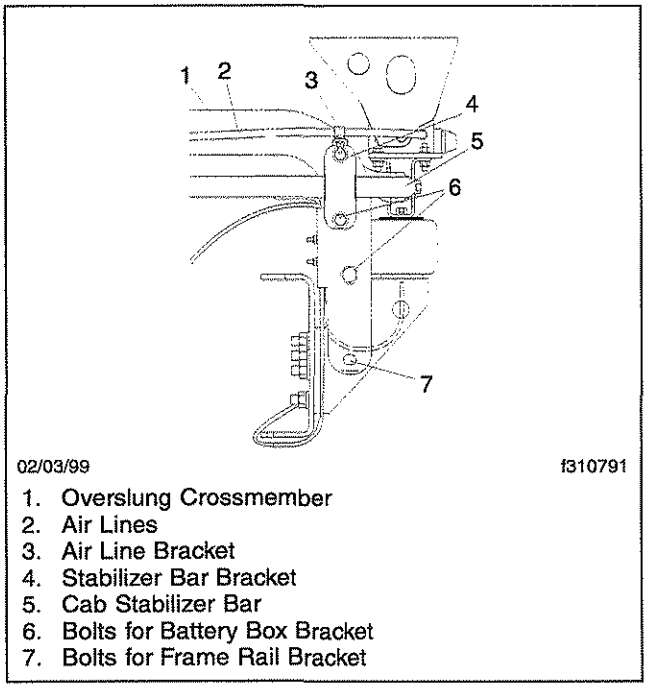
1. Overslung Crossmember
2. Frame Rail
3. Frame Rail Bracket

Fig. 1, Overslung Crossmember, Century Class

3. Remove the bolts, washers and nuts that hold the air cleaner assembly and the center air line bracket to the overslung crossmember.
4. Remove the 1/2-inch bolts, washers and nuts that hold the bracket for the cab stabilizer bar to each side of the crossmember. See **Fig. 2**. Keep the brackets and bushings on the stabilizer bar. Move the air lines and support brackets out of the way.
5. Put blocks of wood between the battery box and both frame rails to support the box when the front battery box mounting brackets are removed in the next step.
6. Support the crossmember and remove the four 5/8-inch bolts, washers and nuts that hold the overslung crossmember to the bracket on each frame rail. See **Fig. 3**. Note that the upper two fasteners also support the front brackets for the battery box.
7. Keep the air lines out of the way and slide the overslung crossmember up from between the frame brackets and the battery box brackets. Remove the overslung crossmember from the vehicle.

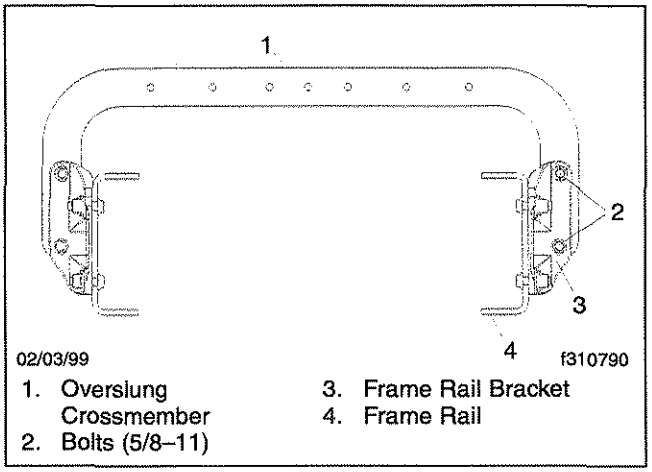


1. Overslung Crossmember
2. Air Lines
3. Air Line Bracket
4. Stabilizer Bar Bracket
5. Cab Stabilizer Bar
6. Bolts for Battery Box Bracket
7. Bolts for Frame Rail Bracket

Fig. 2, Overslung Crossmember Assembly, Argosy

FRONT CROSSMEMBER, ARGOSY COE

1. Park the vehicle, apply the parking brakes, and chock the tires.
2. Remove the four capscrews that hold the two grille brackets to the crossmember and remove the lower grille.
3. Remove the front bumper as described in Section 31.03, **Subject 120**.
4. Using a backup wrench to prevent the nuts on the back of the crossmember from turning, remove three of the four bolts that hold the left-hand side of the front crossmember to the frame. See **Fig. 4**.
5. Loosen, but do not remove, the remaining nut and bolt on the left-hand side.
6. Using a backup wrench on the right-hand side of the crossmember to prevent the nuts from turning, remove the four bolts and nuts that hold the front crossmember to the frame.
7. Remove the loosened nut and bolt from the left-hand side.
8. Slide the crossmember horizontally to the right so that the crossmember upper flange fits into the bend in the support bracket for the right-hand side headlight panel.
9. Lower the left-hand side of the crossmember and remove the crossmember from the vehicle.



1. Overslung Crossmember
2. Bolts (5/8–11)
3. Frame Rail Bracket
4. Frame Rail

Fig. 3, Overslung Crossmember Mounting, Argosy

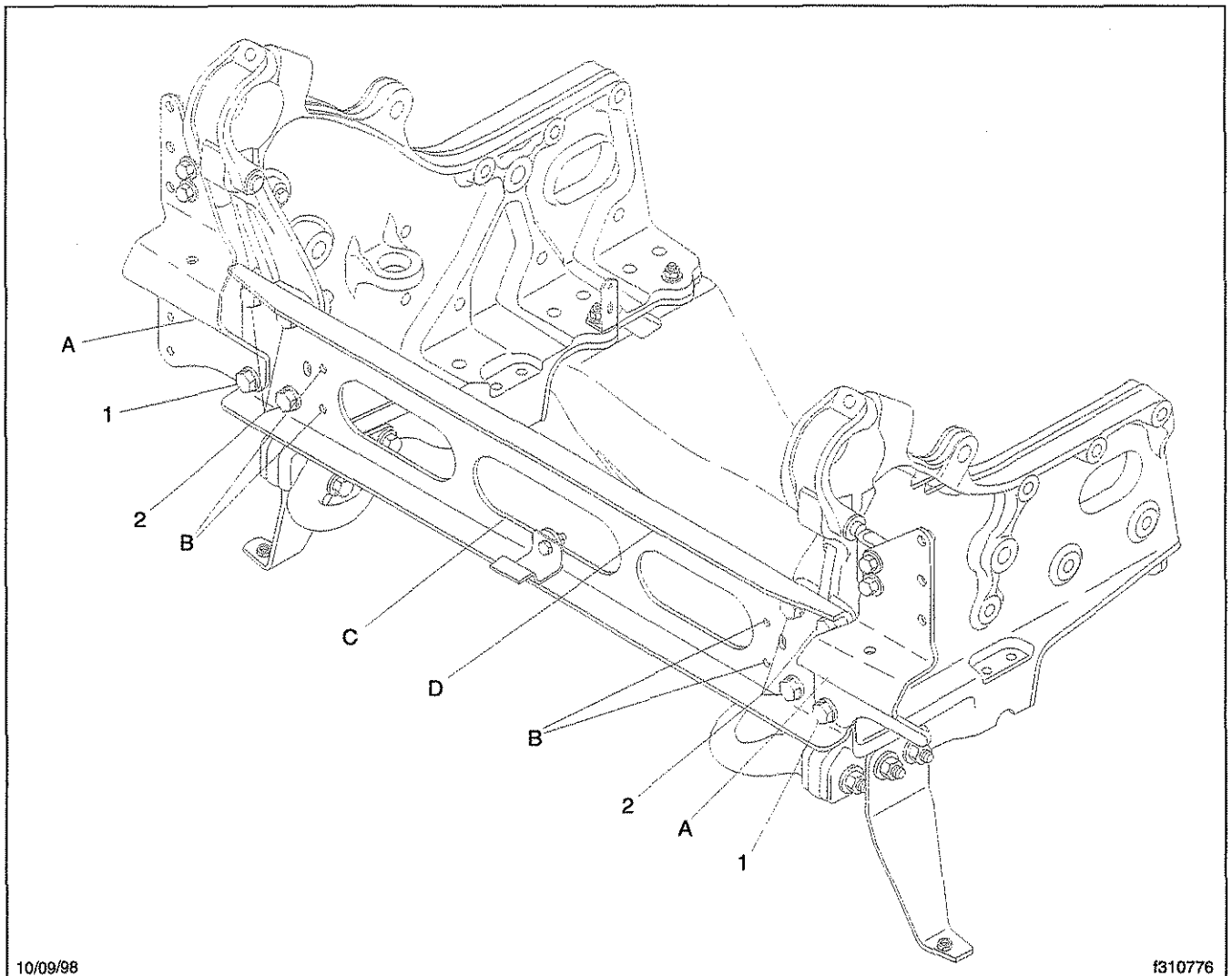
Frame Crossmember Removal and Installation

Installation

ALLIGATOR CROSSMEMBER

NOTE: If more than one alligator crossmember is being installed, begin with the one that belongs farthest toward the front of the vehicle.

1. Slide the crossmember into the opening at the rear of the frame rails, and work it over or under the weld studs until it is approximately aligned with its mounting holes in the frame rails.
2. If equipped, position the correct thickness of frame spacer between each end of the crossmember and the frame rail. Install the fasteners, but do not tighten them at this time. Be sure to install each bolt in the same direction that was noted during removal.



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A. Bend in support brackets
B. Holes for mounting lower grille
C. Oval hole close to lower flange
D. Upper flange on crossmember
1. 2-1/2 inch (63 mm) Mounting Bolts (long)
2. 2-1/8 inch (54 mm) Mounting Bolts (short)

Fig. 4, Front Crossmember Mounting, Argosy COE

3. If more than one alligator crossmember is being installed, repeat steps above as required for the other crossmember(s).
4. Install any clamps that were removed from the weld studs in the frame rails.
5. Install the lower struts, attaching them to the frame rails, and to the crossmember(s). Do not tighten the fasteners at this time.
6. Using the instructions below, install the channel crossmember, gussets, and (if equipped) frame spacers, then install the rear-closing crossmember and angle brackets.
7. Check the frame rail alignment and align the frame rails if needed; refer to **Subject 140.**
8. If the rear cab-mount crossmember was installed, attach the fuel tank brackets to the frame rails, if not already done. Tighten the fasteners to the torque values in the general information section in the vehicle maintenance manual.

   Install the cab suspension bracket on the crossmember, lower the cab, remove the overhead hoist, then attach the cab suspension bracket to the cab.
9. If the midship crossmember was installed, attach the midship bearing bracket to the crossmember. Tighten the fasteners to the applicable torque values in the general information section in the vehicle maintenance manual.
10. If any air reservoirs were removed, install them, using the instructions in the brake section in this manual.

CHANNEL CROSSMEMBER

IMPORTANT: If an alligator crossmember is also being installed, install it first.

1. If equipped, position the correct thickness of frame spacer in each channel of the frame.

   If they were removed, install the upper and lower gussets in both sides of the frame, but do not tighten the fasteners at this time. Be sure to install each bolt in the same direction that was noted during removal.
2. Work the channel crossmember into the top or bottom of the frame, then work it into position in the gussets. Install the fasteners that attach the crossmember to the gussets, but do not tighten them at this time.
3. If it was removed from the channel crossmember, install the relay valve or quick-release valve on the crossmember. Securely tighten the fasteners.

   Install any clamps that attach air lines or wiring to the crossmember.
4. If so equipped, attach the suspension torque rod bracket(s) to the crossmember. Be sure the spacers are installed in the same location noted during removal. Tighten the bracket fasteners to the applicable torque value in the general information section in the vehicle maintenance manual.
5. If an alligator crossmember is also being installed, go to "Rear-Closing Crossmember," below.

   If an alligator crossmember is *not* being installed, install the fifth wheel if it was removed; refer to the fifth wheel section in this manual. Tighten the fasteners that attach the channel crossmember gussets to the frame rails, then tighten the fasteners that attach the crossmember to the gussets. Tighten the fasteners to the applicable torque values in the general information section in the vehicle maintenance manual.

REAR-CLOSING CROSSMEMBER

IMPORTANT: If an alligator crossmember(s) is also being installed, install it first.

1. If they were removed, install the forwardmost angle brackets, but do not tighten the fasteners at this time. If the rear spring brackets attach to the frame rails with the same fasteners that attach the angle brackets, install the rear spring brackets at this time. Then, remove the safety stands from under the frame rails. Be sure to install each bolt in the same direction that was noted during removal.
2. Slide the crossmember into the opening at the rear of the frame rails, then turn it upright, to position it against the angle brackets.
3. Attach the rearmost angle brackets to the frame rails, but do not tighten the fasteners at this time.
4. Install but do not tighten the fasteners that attach the crossmember to the angle brackets.
5. Install the rear mud flap brackets, and tighten the fasteners to the applicable torque value in

Frame Crossmember Removal and Installation

the general information section in the vehicle maintenance manual.

6. If it was removed from the rear-closing crossmember, install the relay valve or quick-release valve on the crossmember. Securely tighten the fasteners.
7. Install the taillights on the rear-closing crossmember. If so equipped, install the backup alarm.

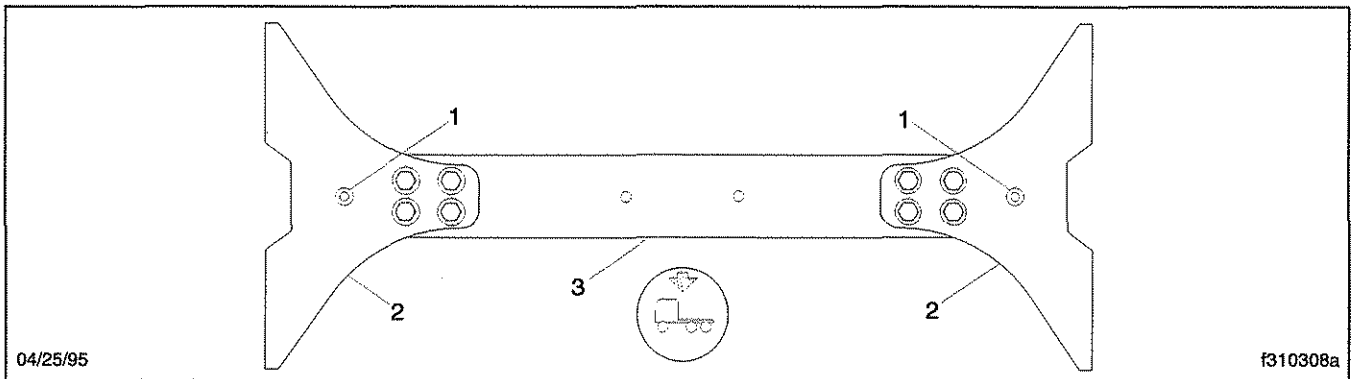
   Install any clamps that attach air lines or wiring to the crossmember.
8. If an alligator crossmember is also being installed, go to "Alligator Crossmember," above.

   If an alligator crossmember is *not* being installed, tighten the fasteners that attach the angle brackets to the frame rails, then tighten the fasteners that attach the crossmember to the angle brackets. Tighten the fasteners to the applicable torque values in the general information section in the vehicle maintenance manual.

FIVE-PIECE BOLTED CROSSMEMBER

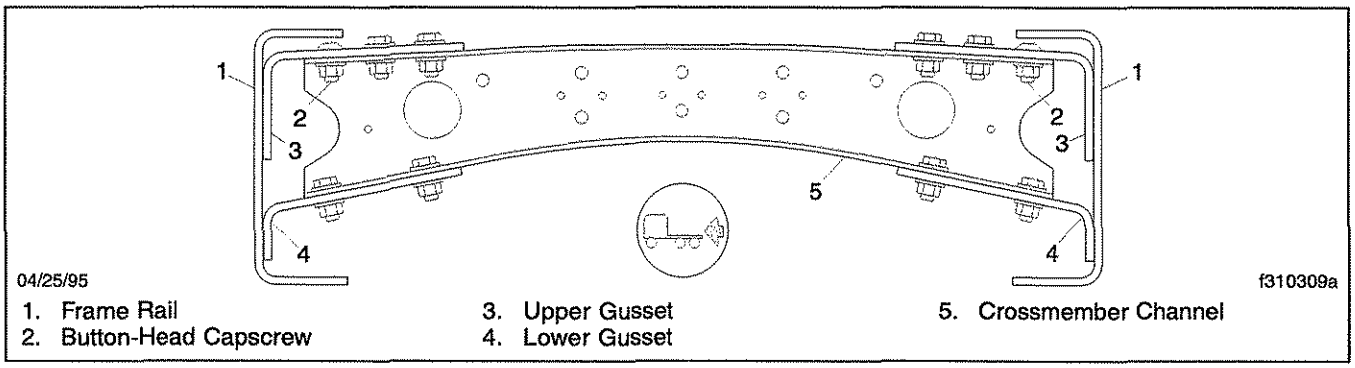
NOTE: Five-piece bolted crossmember assemblies (see **Fig. 5** and **Fig. 6**) are available as service parts to replace *some* five-piece *welded* crossmembers. Always follow Parts Department information when replacing a welded crossmember with a bolted crossmember.

1. Attach one new upper gusset to the crossmember channel. Tighten the fasteners snugly, but not to their final torque value.
2. Place the crossmember channel and gusset in the frame rails with the channel opening facing the same direction as the original crossmember. Position the crossmember so its channel is resting on the lower flanges of both frame rails.
3. Slide the other upper gusset into position and attach it to the crossmember channel. Tighten the fasteners snugly, but not to their final torque value.



1. Button-Head Capscrew
2. Upper Gusset
3. Crossmember Channel

Fig. 5, Five-Piece Bolted Crossmember, Top View



1. Frame Rail
2. Button-Head Capscrew
3. Upper Gusset
4. Lower Gusset
5. Crossmember Channel

Fig. 6, Five-Piece Bolted Crossmember, Rear View

4. With the crossmember channel still resting on the lower flanges of both frame rails, tighten the locknuts on the button-head capscrews at the outboard end of both upper gussets 68 lbf·ft (92 N·m). See **Fig. 5**.

NOTE: The locknuts must be tightened now since, when the crossmember is in place, the frame upper flange blocks access to the capscrews. See **Fig. 6**.

5. Using a deadblow hammer, tap the crossmember into place. Align the mounting holes of the upper gussets with the holes in the frame rails. Install the fasteners, but don't tighten them.
6. Place the lower gussets in position against the crossmember channel and insert the fasteners that secure the gussets to the channel. Do not tighten the fasteners.
7. Install the fasteners that attach the gussets to the frame rails. If the welded crossmember was secured by Huckbolts, refer to "Frame Fasteners" in this manual for installation information.
8. Tighten the fasteners that secure the gussets to the frame rails 136 lbf·ft (184 N·m). Then, tighten the fasteners that secure the gussets to the crossmember 68 lbf·ft (92 N·m).
9. If any air brake valve was removed from the old crossmember, install the valve(s) on the new crossmember and install any clamps attaching air lines or wiring to the crossmember.
10. Remove the chocks from the tires.

OVERSLUNG CROSSMEMBER, CENTURY CLASS CONVENTIONAL

1. Rotate the new crossmember into place from the right-hand side of the vehicle.
2. Align the holes in the crossmember with the holes in the mounting brackets. See **Fig. 1**.

IMPORTANT: To improve access, have an assistant hold the clutch pedal to the floor during the installation of the top crossmember fasteners on the left-hand side of the vehicle.

3. Install the 5/8–11 fasteners to hold the crossmember to its mounting brackets. Install the bolts so that the nuts can be tightened with a torque wrench and socket.
4. Tighten the crossmember nuts to 136 lbf·ft (184 N·m).
5. Remove the chocks from the tires.

OVERSLUNG CROSSMEMBER, ARGOSY COE

1. Move the crossmember into place between the battery box brackets and the mounting brackets on the frame rails. Install a 5/8–11 bolt with a washer into the bottom hole on each side of the crossmember. See **Fig. 3**. Install the washers and loosely thread the nuts on the bolts. Do not tighten any of the mounting fasteners until all the hardware is in position.
2. Install a washer on the other 5/8–11 bolt and insert them through the frame bracket, crossmember and the lower hole in each battery box bracket. Install the washers and nuts on the bolts, but do not tighten them at this time.
3. Remove the wooden blocks from under the battery box.
4. Install the 1/2–13 bolts with washers through the bottom holes in the cab stabilizer bar brackets, through the crossmember, and through the top holes of each battery box front bracket. See **Fig. 2**. Install the washers and nuts, but do not tighten them at this time.
5. Install the 1/2–13 bolts through the air line bracket on each side of the crossmember, the top hole in the cab stabilizer bar brackets and the crossmember. Install the washers and nuts, but do not tighten at this time.
6. Starting at the bottom bolt on each of the crossmember mounting brackets, tighten the 5/8–11 nuts 136 lbf·ft (184 N·m). Then, tighten the two 5/8–11 nuts that are directly above the bottom nuts to the same torque value.
7. Tighten the two 1/2–13 nuts on each cab stabilizer bar bracket 68 lbf·ft (92 N·m).
8. Install the air cleaner assembly and the center air line bracket and fasteners on the crossmember. Tighten the nuts to the standard torque values.
9. Lower the cab as described in Section 60.15, **Subject 060** in this manual. Remove the chocks from the tires.

Frame Crossmember Removal and Installation

FRONT CROSSMEMBER, ARGOSY COE

1. Make sure that the crossmember is in the proper orientation for installation so that the large oval holes are near the bottom of the crossmember. See **Fig. 4**.
2. Raise the right-hand side of the crossmember so that its upper flange fits into the bend in the right-hand headlight support bracket. Slide the crossmember into the gap between the right-hand support bracket and the frame.
3. Raise the left-hand side of the crossmember and slide it into the gap between the left-hand support bracket and the frame.
4. Separate the two 2-1/2 inch (63 mm) long bolts from the remaining six 2-1/8 inch (54 mm) mounting bolts.
5. Align the mounting holes in the crossmember with the holes in the frame. Slide washers onto the two longer mounting bolts and install the bolts through the lower hole in each of the support brackets for the headlight panels. See **Fig. 4**.
6. Install the remaining bolts, washers and nuts in the same manner. After all eight bolt assemblies are in position, use a wrench to hold the nuts and tighten each bolt to 136 lbf·ft (184 N·m).
7. Install the front bumper as described in Section 31.03, **Subject 120**.
8. Put the lower grille in position above the front bumper. Align the holes in the two grille brackets with the holes in the crossmember and install the four capscrews and washers through the crossmember holes into the grille brackets. Tighten the capscrews to 26 lbf·ft (35 N·m).
9. Remove the chocks from the tires.

Frame Rail Alignment

Frame rail alignment is checked by measuring the distances from two sets of points on the upper flanges of the frame rails. **See Fig. 1.** The rear set of points must be as far back as possible from the forward set of points. There must be no interference, along or between the frame rails, that would prevent measuring from any one of the four points to the other three points; the fifth wheel and deck plate (as equipped) must be removed.

There are no marks or bolt holes in the top flanges of the frame rails. Therefore, the points must be projected from the frame station marks and from the bolt holes on the frame rail webs.

IMPORTANT: Use a pencil or soapstone to make all lines, points, or other marks. Do not use any marker or tool that will scratch the surface of the frame rail. Use a machinist's square to project all points from the webs to the upper flanges, and to measure inboard from the outside face of the frame rails.

1. For each frame rail, project the exact vertical centerline of the frame station 1150 mark, from the frame web to the top flange, and mark it with a line across the top flange.

   If, because of interference, frame station 1150 cannot be used, choose and mark another matched set of points, as follows:

   1.1 Determine how far forward the upper flanges of both frame rails are clear.

   1.2 Find a matched set of bolt holes on the frame rail webs, that are aligned with, or just rearward of, the front of the clear area on the flanges. The bolt holes must be in exactly the same location in each frame rail.

   1.3 Project the exact vertical centerline of each bolt hole, and mark a line across the top flange of its respective frame rail.

2. Find the exact center of the width of each upper flange, and mark the point on each projected line. This will be the forward set of points. The forward points must be in identical locations on both frame rails.

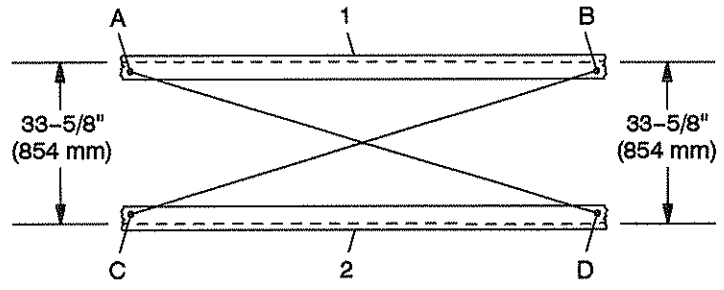
3. As equipped, remove the fifth wheel and deck plate from the frame. Refer to the fifth wheel section in this manual for instructions.

4. Measure back along each frame rail, to find a set of bolt holes *at least* 72 inches (183 cm) rearward from the forward set of points. The bolt holes must be in exactly the same location in each frame rail.

IMPORTANT: If, because of interference, the distance must be less than 72 inches (183 cm), the distance must be the maximum that is possible.

5. Project the exact vertical centerline of each bolt hole, and mark a line across the top flange of its respective frame rail.

6. Along each line, measure and mark a point 2 inches (5 cm) inboard from the outside face of



A. Right Forward Point or Bolt Hole
B. Right Rear Point or Hole
C. Left Forward Point or Bolt Hole
D. Left Rear Point or Bolt Hole

1. Right Frame Rail
2. Left Frame Rail

Fig. 1, Frame Rail Squaring

Frame Rail Alignment

its respective frame rail. The rear points must be in identical locations on both frame rails.

7. At the forward set of points, and again at the rear set of points, measure the distance across the frame, from the outside face of each frame rail. At both locations, this distance must be 33.50 inches (851 mm). **See Fig. 1.**

   If the distance at either location is incorrect, check the Freightliner *Parts Book* pages to determine which thickness of frame spacers, if any, belong between the crossmembers and the frame rails. Check for the correct spacers, and add or remove spacers as needed, using the procedures **In Subject 130.**

8. Measure the distance from the forward point on one frame rail to the rear point on the opposite frame rail. **See Fig. 1.** Then measure the distance from the other forward point to the rear point on its opposite frame rail. Compare the two measurements.

   If the values differ by more than 1/8 inch (3mm), proceed to the next step.

   If the measurements are within 1/8 inch (3 mm) of each other, the frame rails do not need to be aligned. If any frame fasteners are loose, tighten as described below. If no fasteners are loose, install the fifth wheel and proceed as described below.

9. Loosen all of the frame fasteners just enough to allow movement of the parts when force is applied.

IMPORTANT: To align the frame rails, the frame assembly must be assembled with all of the crossmembers in place, but the attachment fasteners not tightened.

10. Using a large hammer and a large wooden block, place the block against the rear end of the frame rail that had its rear point the greater distance from its opposite rail's front point. Tap the block until the measurements are within 1/8 inch (3 mm) of each other.

11. Tighten the fasteners for the front-and rear-closing crossmembers to their applicable torque values; refer to the general information section in the vehicle maintenance manual. Again, check the frame rail alignment (described above).

12. When the measurements are within specifications, install the fifth wheel and deck plate (as equipped); refer to the fifth wheel section in this manual for instructions.

13. Tighten all of the frame fasteners, starting at the middle of the frame and working alternately toward both ends. First, tighten the fasteners that attach crossmembers to the frame. Then, tighten the fasteners that attach the upper and lower struts or gussets to the frame. Finally, tighten the fasteners that attach the lower struts or gussets to the crossmembers. Tighten all fasteners to their applicable torque values, as specified in the general information section in the vehicle maintenance manual.

14. If the frame rails needed aligning, check the axle alignment; refer to the rear axle section in this manual for instructions.

Frame Shaping

IMPORTANT: Obtain approval from your regional service representative before doing any cutting or frame shaping.

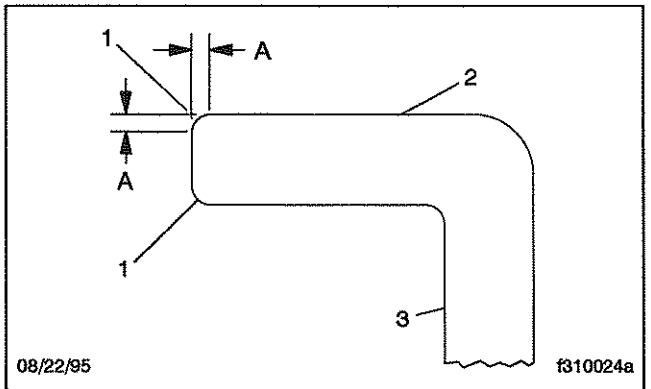
If the flange of a frame rail is cut (for relief cuts or notches), shape the edges of the flange to form a smooth ground radius of 0.06 to 0.12 inch (1.5 to 3.0 mm) over the entire length of the cut. **Figure 1** shows this dimension of the edge radius of the frame rail flanges.

NOTE: For information on relief cuts or notches, refer elsewhere in this group.

WARNING: Wear protective eye and facial gear when grinding. Failure to wear this gear can result in personal injury due to flying metal debris from the grinding process.

Using a clean, sharp, rotary drum grinder or flapper wheel grinder, apply light pressure and grind the cut edges in the direction of the length of the frame rail, to form the radius. Do not grind across the edges. **See Fig. 2.**

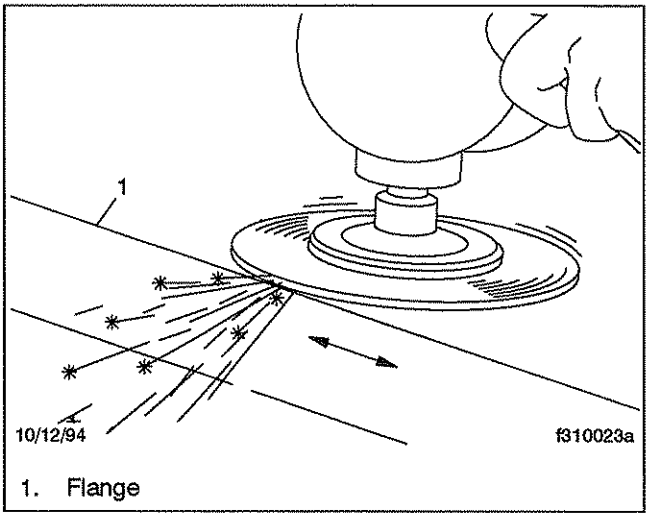
CAUTION: Apply light pressure only. Heavy pressure can result in harmful overheating and a loss of surface temper. Grind only in the direction of the cut. **See Fig. 2.** Grinding across the direction of the cut can reduce the structural strength of the frame rail.



A. 0.06" to 0.12" (1.5 to 3 mm)

1. Radius
2. Flange
3. Web

Fig. 1, Radius Dimensions



1. Flange

Fig. 2, Direction of Grind

Specifications

WIRE DIAMETER	CURRENT (amperes)		WIRE EXTENSION	
			OPTIMUM	MAXIMUM
inches (mm)	Minimum	Maximum	inches (mm)	inches (mm)
0.045 (1.14)	160	320	1/2 (13)	3/4 (19)
1/16 (1.6)	300	600	3/4 (19)	1-1/8 (29)
5/64 (2.0)	480	960	1 (25)	1-1/2 (38)

Table 1, Machine Settings for Gas-Metal Arc Welding

Weld Position	Amperes	Volts
Downhand	130/140	21/23
Overhead	130/140	21/23
Vertical Up	110/120	22/24

Table 2, Amperage and Voltage Settings for Coated-Electrode Arc Welding

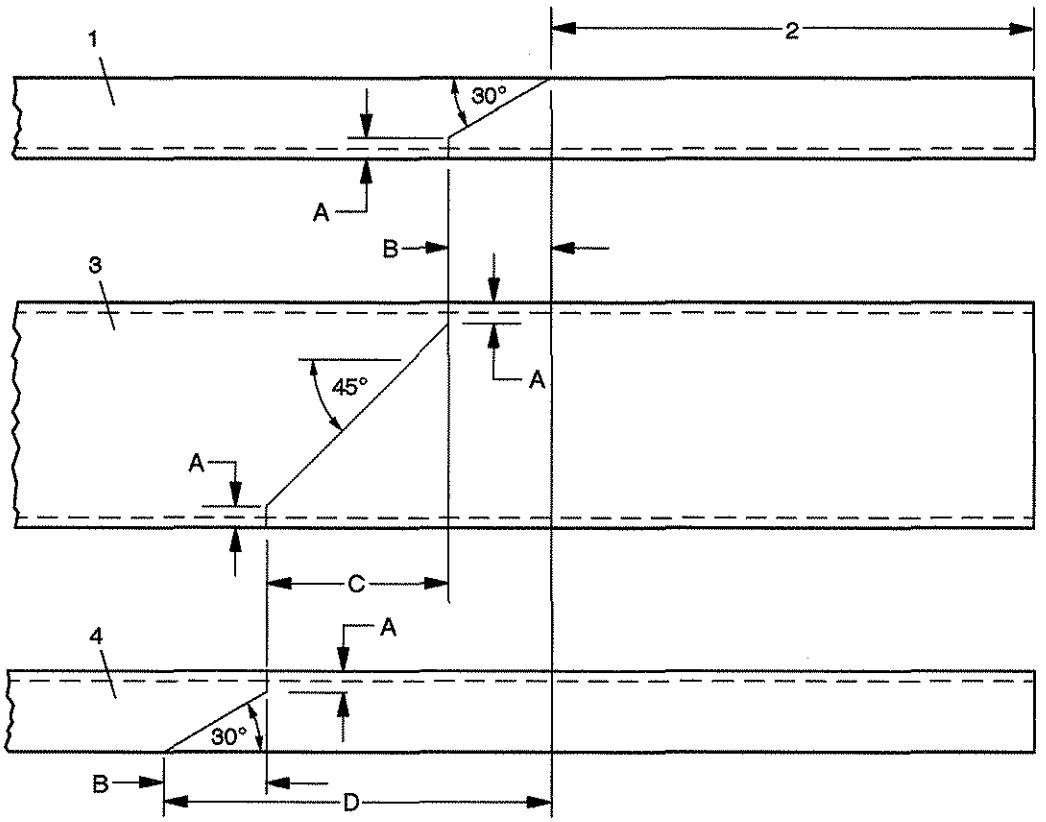
Size	Torque * lbf·ft (N·m)
1/2–13	68 (92)
9/16–12	98 (133)
5/8–11	136 (184)
3/4–10	241 (327)
3/4–16	269 (365)
7/8–9	388 (526
7/8–14	427 (579)

* Lubricated or plated threads.

Table 3, Torque Values for Frame Fasteners

Refer to the figures in this subject as follows: **Fig. 1, Frame Rail and Extension Cutting Dimensions for Truck Vehicles**; and **Fig. 2, Frame Rail and Extension Cutting Dimensions for Tractor Vehicles.**

Specifications



NOTE: Left rail shown; right rail will be opposite dimensions.

FRAME RAIL SIZE Inches	DIMENSION			
	A Inches (mm)	B Inches (mm)	C Inches (mm)	D Inches (mm)
10.06	0.69 (17.5)	5.00 (127.0)	8.75 (222.2)	18.75 (476.2)
10.12	0.69 (17.5)	5.00 (127.0)	8.75 (222.2)	18.75 (476.2)

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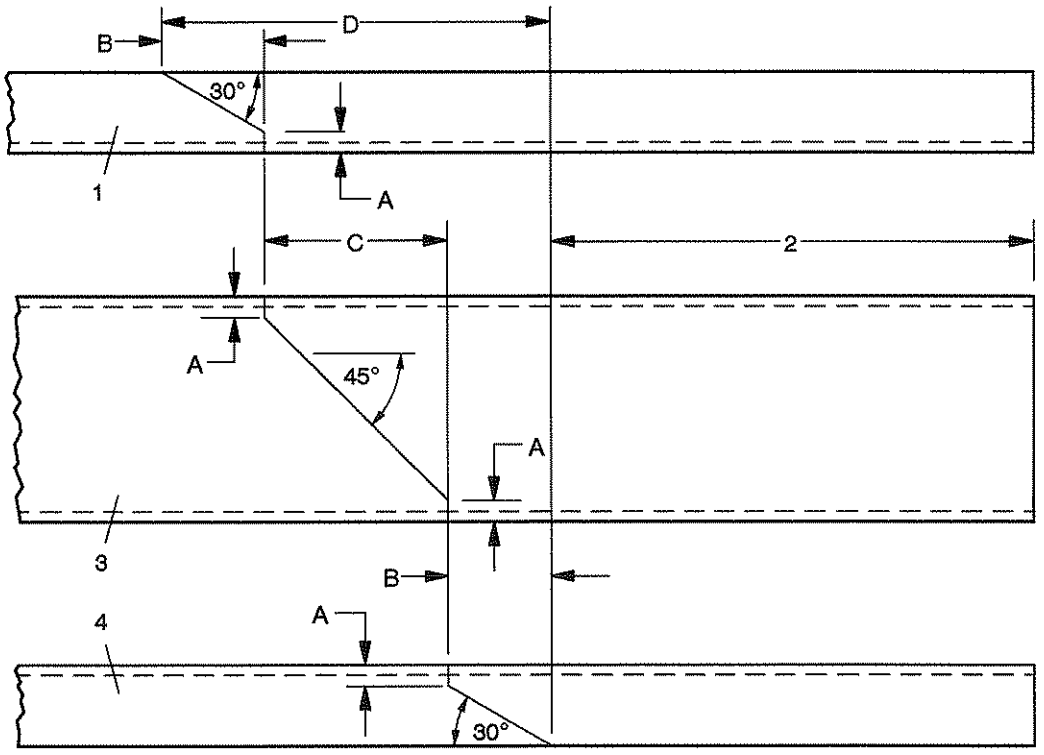
1. Upper Flange
2. Extension Length
3. Web
4. Lower Flange

Fig. 1, Frame Rail and Extension Cutting Dimensions for Truck Vehicles



NOTE: Left rail shown; right rail will be opposite dimensions.

FRAME RAIL SIZE inches	DIMENSION			
	A inches (mm)	B inches (mm)	C inches (mm)	D inches (mm)
10.06	0.69 (17.5)	5.00 (127.0)	8.75 (222.2)	18.75 (476.2)
10.12	0.69 (17.5)	5.00 (127.0)	8.75 (222.2)	18.75 (476.2)

11/22/95 f310508

1. Upper Flange
2. Extension Length
3. Web
4. Lower Flange

Fig. 2, Frame Rail and Extension Cutting Dimensions for Tractor Vehicles

Contents

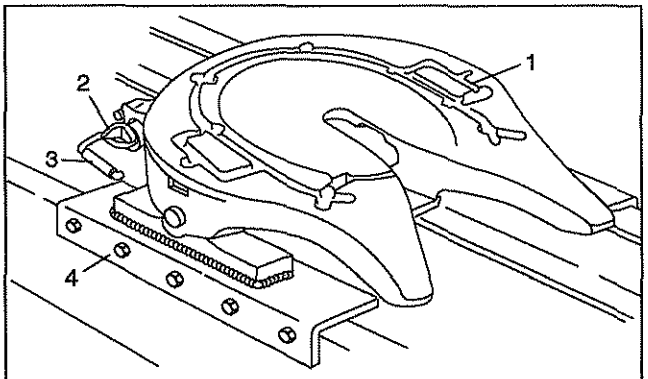
Subject	Subject Number
General Information and Principles of Operation	050
Service Operations	
Disassembly and Assembly	100
Troubleshooting	300

General Information

The ASF Castloc II™ and Simplex series fifth wheels are used for pulling trailers having the standard 2-inch diameter kingpin. When installed as a stationary fifth wheel (**Fig. 1**), they are bracket-mounted to the tractor frame in a position that best distributes the trailer load over the tractor axles. When used as a sliding fifth wheel (**Fig. 2**), they are mounted on the Taperloc® sliding mount (air-operated or manual release).

The fifth wheel lock mechanism for the trailer kingpin consists of a rotating jaw that grips the trailer kingpin, and a spring-actuated lock. The jaw rotates on a jaw pin during coupling and uncoupling operations. Kingpin release is accomplished by activating a manual lock control handle located on either the right side (curb-side) or left side (roadside) of the fifth wheel. Kingpin lockup occurs when the kingpin is forced into the jaw and the operating rod handle moves to the locked position.

On air-operated sliding mounts, release or lockup of the slider saddle plate occurs when the air cylinder is activated by a two-position air-control valve in the tractor cab (**Fig. 3**). The manually-operated slider saddle plate has an operating rod that moves the operating lever to lock or unlock both sides of the saddle plate at the same time.



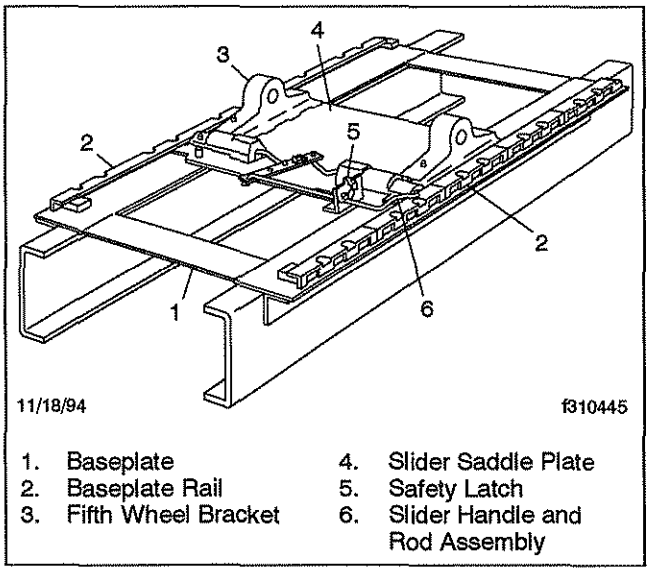
1. Lubricant Grooves
2. Safety Latch
3. Lock Control Handle
4. Mount

Fig. 1, Simplex II Stationary Fifth Wheel

Principles of Operation

When the tractor is moved out from under the trailer after unlocking the fifth wheel, the kingpin rotates the jaw until the jaw is in a position that allows the kingpin to disconnect. During coupling, the motion of the kingpin entering the jaw rotates the jaw into the locked position, locking the jaw around the kingpin. **See Fig. 4.**

Refer to the vehicle driver's manual for complete operating instructions.



1. Baseplate
2. Baseplate Rail
3. Fifth Wheel Bracket
4. Slider Saddle Plate
5. Safety Latch
6. Slider Handle and Rod Assembly

Fig. 2, Taperloc Slider, Manually-Operated Release

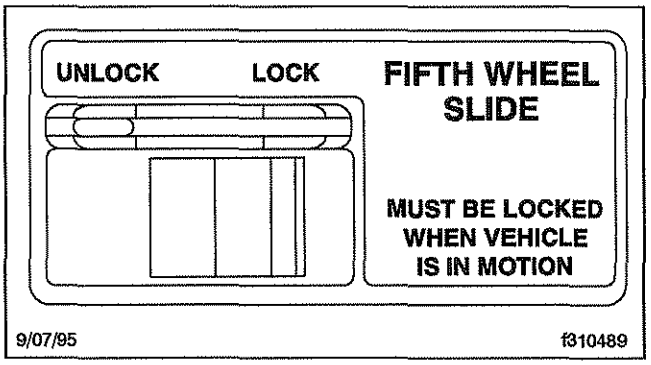
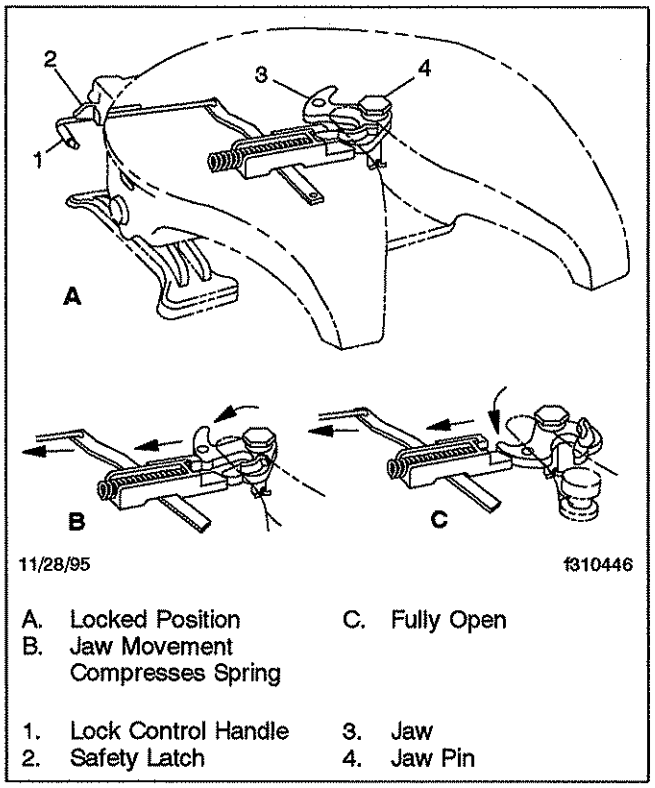


Fig. 3, Air Control Valve

General Information and Principles of Operation



A. Locked Position
B. Jaw Movement Compresses Spring
C. Fully Open

1. Lock Control Handle
2. Safety Latch
3. Jaw
4. Jaw Pin

Fig. 4, ASF Castloc II and Simplex Series Kingpin Locking Mechanism Operation

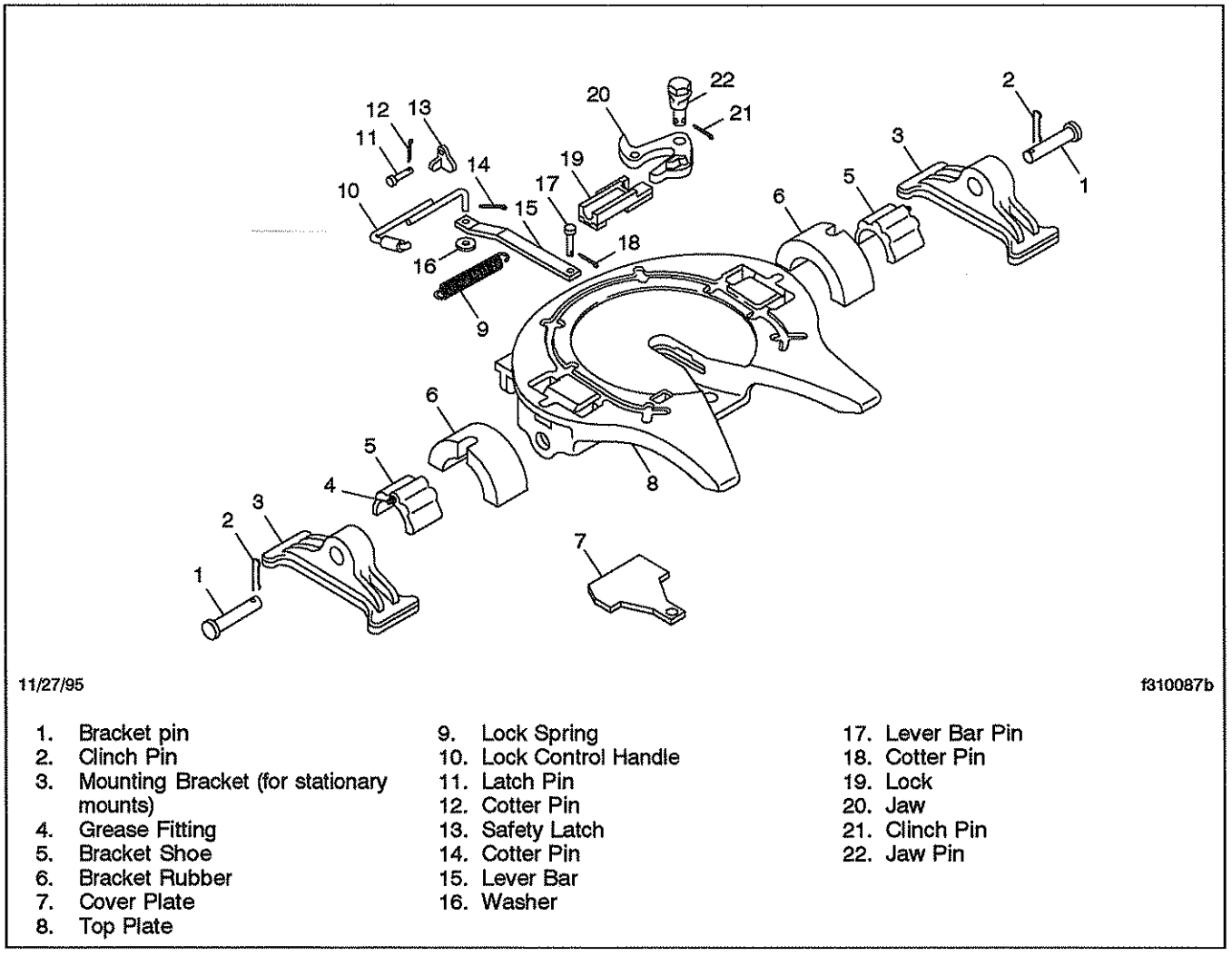
Disassembly (See Fig. 1)

WARNING: Fifth wheel maintenance, adjustment, and rebuilding procedures must be done only by a qualified mechanic. Incorrect or incomplete procedures could cause the trailer to disconnect from the tractor, which could result in an accident causing death or serious injury, and property damage.

Wear safety goggles during disassembly and assembly. Parts are under spring compression, and failure to wear goggles can result in personal injury, due to parts ejecting with force.

NOTE: Although some of the parts are shaped differently, disassembly and assembly procedures are the same for ASF Castloc II and Simplex series fifth wheels.

1. Lock the fifth wheel, using a bar.
2. Steam clean the top plate. Remove it from the sliding or stationary mount by removing the clinch pins and the bracket pins. If cotter pins are present instead of clinch pins, discard them. Clinch pins may be reused. If needed, use a clamp, and compress the top plate and brackets to relieve the pressure on the bracket pins.



1. Bracket pin
2. Clinch Pin
3. Mounting Bracket (for stationary mounts)
4. Grease Fitting
5. Bracket Shoe
6. Bracket Rubber
7. Cover Plate
8. Top Plate
9. Lock Spring
10. Lock Control Handle
11. Latch Pin
12. Cotter Pin
13. Safety Latch
14. Cotter Pin
15. Lever Bar
16. Washer
17. Lever Bar Pin
18. Cotter Pin
19. Lock
20. Jaw
21. Clinch Pin
22. Jaw Pin

Fig. 1, Fifth Wheel Assembly, Simplex II Shown

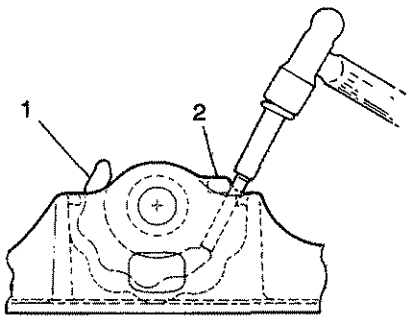
Fifth Wheel Disassembly and Assembly

3. Using an overhead hoist, lift the fifth wheel off the mount and tractor frame.
4. Turn the fifth wheel upside down.

NOTE: While disassembling the fifth wheel, check it for cracks and for missing or damaged parts.

WARNING: Do not attempt to repair or rebuild the top plate if it is cracked or if parts are damaged. The top plate or parts could malfunction. This could cause the trailer to disconnect from the tractor, which could result in an accident causing death or serious injury, and property damage.

5. Slide the jaw away from the lock, then remove the jaw from the top plate.
6. Remove the cotter pin and the lever bar pin. Discard the cotter pin. Remove the cover plate, lever bar, lock, and lock spring.
7. Remove the cotter pin holding the lock control rod to the lever bar; then remove the lock control rod and the washer. Discard the cotter pin.
8. Check the bracket shoes and bracket rubbers for wear. For instructions, refer to the vehicle maintenance manual. If needed, remove the bracket rubbers and bracket shoes as follows:
   - 8.1 Remove the grease fitting and drive out the bracket shoe. **See Fig. 2.**
   - 8.2 Remove the bracket rubbers.



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1. Bracket Shoe
2. Stop

Fig. 2, Bracket Shoe Removal

9. With the fifth wheel in the locked position, remove the clinch pin and the jaw pin.

Assembly

(See Fig. 1)

WARNING: Fifth wheel maintenance, adjustment, and rebuilding procedures must be done only by a qualified mechanic. Incorrect or incomplete procedures could cause the trailer to disconnect from the tractor, which could result in an accident causing death or serious injury, and property damage.

Wear safety goggles during disassembly and assembly. Parts are under spring compression, and failure to wear goggles can result in personal injury, due to parts ejecting with force.

IMPORTANT: Replace any parts that show signs of wear, damage, or deterioration. Brackets, bracket shoes, bracket rubbers, and bracket pins should be replaced in pairs.

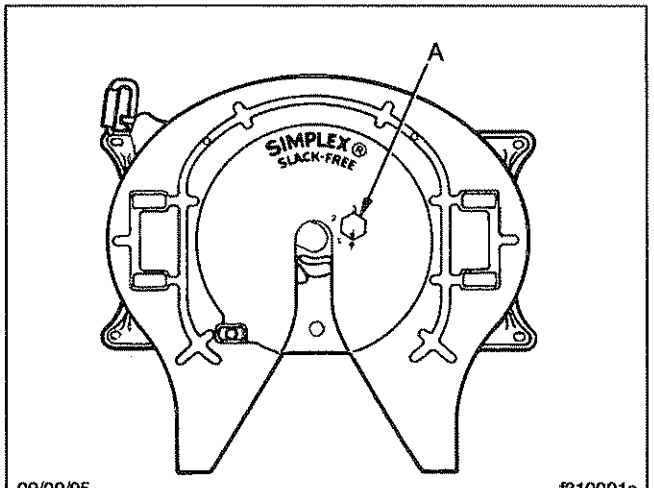
WARNING: When cleaning parts with no. 2 diesel fuel, do not smoke or use an open flame near the area. To do so could result in a possible fire.

1. Clean all moving parts with no. 2 diesel fuel before assembly.
2. Apply liquid soap to the bracket rubbers, then install them, making sure the cutout on them is facing outboard.
3. Grease the bracket shoe surfaces that contact the mounting brackets. Drive the bracket shoes in place against the stop and replace the bracket shoe grease fittings.

IMPORTANT: Do not grease the bracket rubbers or pockets.

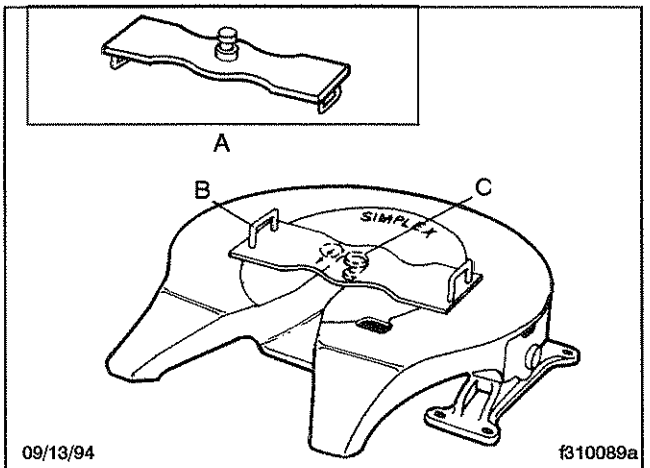
4. Apply a thin film of a multipurpose chassis grease to the cover plate, lever bar pin, lever bar, jaw, jaw pin, the lock, and the casting lock area. The casting lock area is underneath the top plate, where the lock sets.
5. Install the lock spring into the lock; then install them as a unit.
6. Install the lever bar, then the lever bar pin.
7. Install the cover plate; then install a new cotter pin in the lever bar pin.

8. Install the lock control handle onto the lever bar, using a new cotter pin and the existing washer.
9. Slide the jaw into the lock and install the jaw pin. Make sure the arrow on the jaw pin lines up with the arrow on the top plate. **See Fig. 3**. Install the clinch pin.
10. Using an overhead hoist, position the fifth wheel on the sliding or stationary mount brackets. Clamp the fifth wheel in place to compress the bracket rubbers. Insert the bracket pins and clinch pins.
11. Check for clearance between the jaw and kingpin as follows:
    - 11.1 With the jaw open, insert an ASF gauge part number 40-2-00171 (**Fig. 4**) or a new kingpin into the fifth wheel. Make sure the safety latch swings freely over the lock control handle (**Fig. 5**). This will place the fifth wheel in the coupled and locked position.
    - 11.2 Measure the distance between the kingpin (or gauge) and the front edge of the top plate slot. If using the gauge, make sure it is flat on the fifth wheel, and pulled as far to the rear as possible.
    - 11.3 Remove the gauge or kingpin.
    - 11.4 If the measurement was 1/8 inch (3.2 mm) or less, skip the next two steps and continue this procedure. If the measurement was more than 1/8 inch (3.2 mm), go to the next step.
12. Adjust the clearance between the jaw and kingpin as follows:
    - 12.1 Using a bar, move the jaw to the locked position. This will relieve the pressure on the jaw pin.



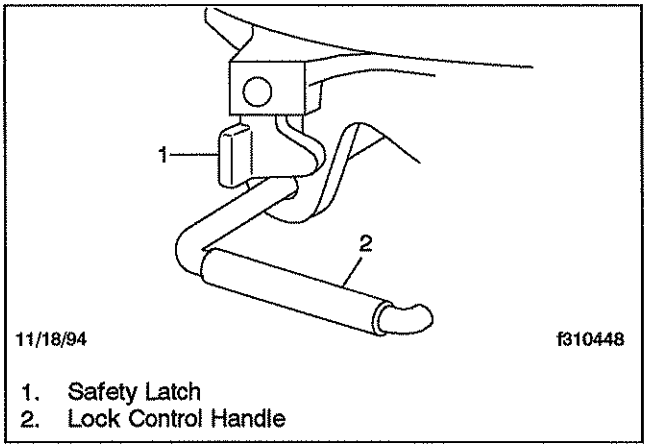
A. Jaw pin positioned arrow-to-arrow.

Fig. 3, Jaw Pin Location



A. Bottom View of Gauge 40-2-00171
B. Gauge Installed
C. Feeler Shim Opening

Fig. 4, Jaw Gauge



1. Safety Latch
2. Lock Control Handle

Fig. 5, Left-Side View

Fifth Wheel Disassembly and Assembly

12.2 Remove the clinch pin from the jaw pin. Lift the jaw pin just enough to clear the indexing head. Turn the jaw pin to the next higher numbered position.

NOTE: Starting from the original position, with the arrow pointing to the rear, each turn of the jaw pin (**Fig. 6**) to one of the three positions (position numbers are indented on the casting) reduces the distance between the kingpin and jaw. **See Table 1.**

12.3 Repeat the first two substeps in the last step above.

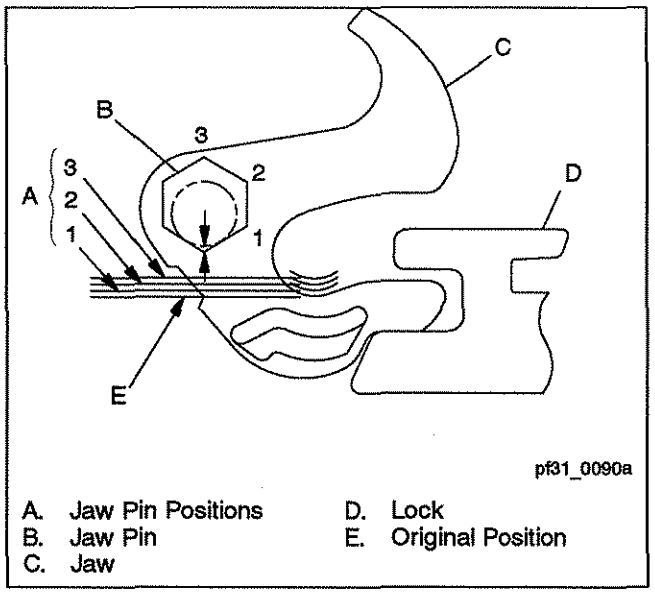
12.4 If the distance is 1/8 inch (3.2 mm) or less, the clearance between the jaw and kingpin is correct. Go to the next step.

12.5 If the distance is still more than 1/8 inch (3.2 mm), remove the gauge or kingpin.

12.6 Repeat the substeps above.

IMPORTANT: Don't turn the jaw past position 3. If more than 1/8 inch (3.2 mm) clearance remains at position 3, replace the jaw, jaw pin, and lock.

13. After the final adjustment, install the clinch pin in the jaw pin.



A. Jaw Pin Positions
B. Jaw Pin
C. Jaw
D. Lock
E. Original Position

Fig. 6, Jaw Pin Positions

Position	Distance	
	Each Turn	Total
1	1/16" (1.6 mm)	1/16" (1.6 mm)
2	3/32" (2.4 mm)	5/32" (4.0 mm)
3	1/16" (1.6 mm)	7/32" (5.6 mm)

Table 1

14. Using a multipurpose chassis grease, grease the top plate and the grease fittings.

IMPORTANT: The fifth wheel must be well lubricated to operate correctly. Refer to the fifth wheel section in the vehicle maintenance manual, for complete maintenance and lubrication instructions of the fifth wheel assembly.

15. Check the fifth wheel operation. For instructions, refer to the vehicle driver's manual.

WARNING: Don't use the fifth wheel if it doesn't work correctly. The fifth wheel could malfunction, causing the trailer to disconnect from the tractor. This could result in an accident causing death or serious injury, and property damage.

Troubleshooting

Problem—The Fifth Wheel Is Hard to Hook Up to the Trailer

Problem—The Fifth Wheel Is Hard to Hook Up to the Trailer	
Possible Cause	**Remedy**
The trailer may be too high; the kingpin is not entering the jaws correctly	Lower the trailer landing gear until the trailer plate contacts the fifth wheel.
Bent kingpin or damaged trailer plate is interfering with the jaw movement.	Check the kingpin and trailer plate. Replace parts as needed.
The jaw pin has not been adjusted correctly.	Check the clearance between the jaw and kingpin. Adjust as needed.
The lever bar is bent.	Check the lever bar. Replace it if needed.
The lock control handle is bent.	Check the lock control handle. Replace it if needed.
The safety latch is jammed.	Check the lock control handle. Replace it if it is bent.
The cover plate is bent	Check the cover plate. Replace it if needed.
Dirt has accumulated on the moving parts.	Clean all the parts and lubricate them lightly.

Problem—Too Much Slack at the Kingpin

Problem—Too Much Slack at the Kingpin	
Possible Cause	**Remedy**
The jaw pin has not been adjusted correctly.	Check the clearance between the jaw and kingpin. Adjust as needed.
The kingpin is worn.	Check the kingpin diameter; it should not be worn more than 1/8 inch (3.2 mm). Replace if needed.

Problem—The Fifth Wheel Is Hard to Unhook from the Trailer

Problem—The Fifth Wheel Is Hard to Unhook from the Trailer	
Possible Cause	**Remedy**
The operating rod is hard to pull out.	Back the tractor a little to relieve any kingpin load against the fifth wheel jaw.
There is pressure on the jaw from the kingpin.	Back the tractor into the trailer to reduce the pressure.
The jaw is adjusted too tightly.	Back the tractor inot the trailer to relieve the pressure on the jaw. Unlock the fifth wheel. Adjust the jaw as needed.
The lever bar or the lock control handle is bent.	Check both parts. Replace if needed.
The cover plate is bent.	Check the cover plate. Replace it if it is bent.

Contents

Subject	Subject Number
General Information	050
Service Operations	
Bumper and Air Dam Removal and Installation, Century Class Conventional	100
Air Dam Removal and Installation, Century Class Conventional	110
Bumper Removal and Installation, Argosy COE	120

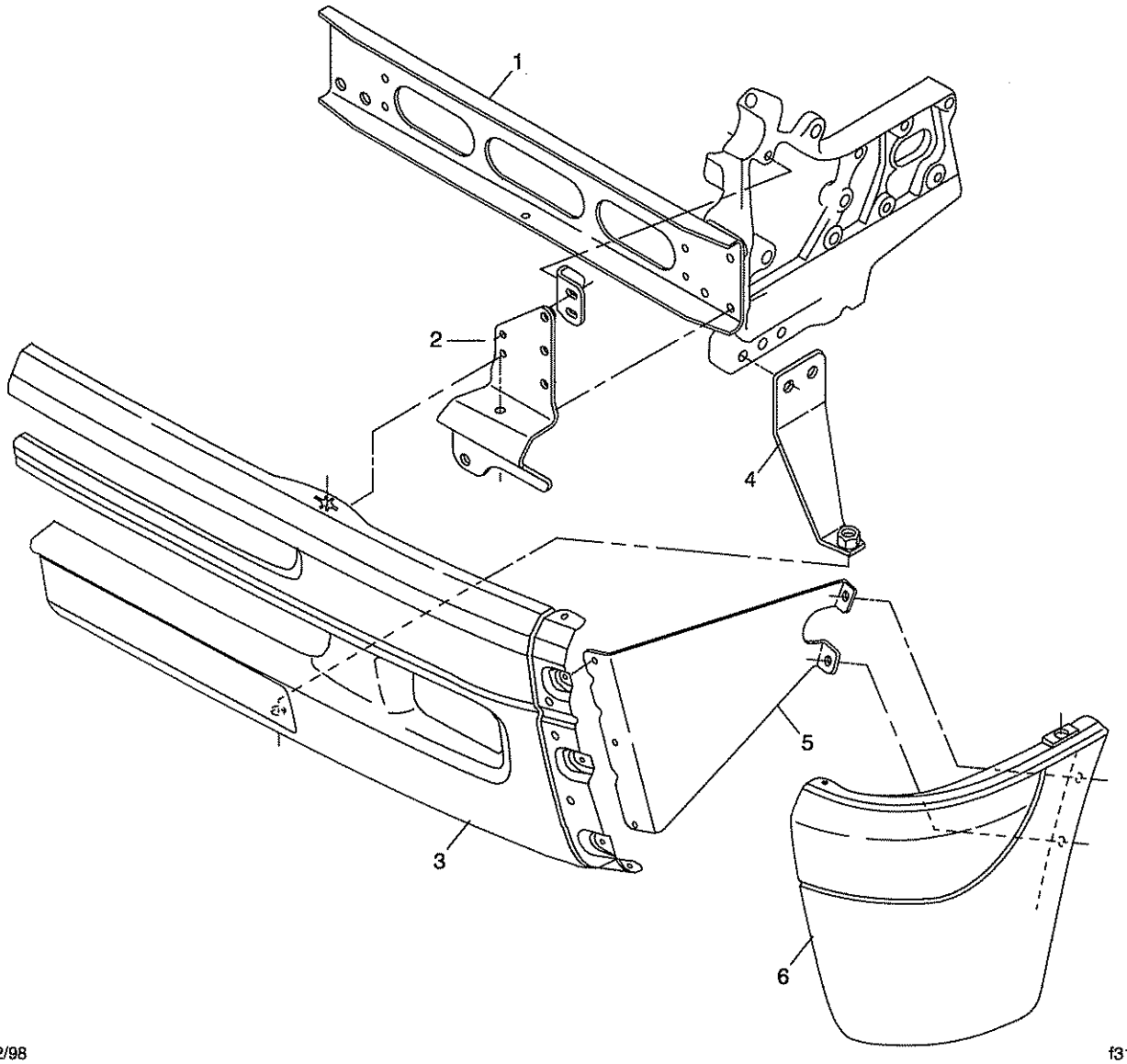
General Information

The Century Class Conventional aerodynamic bumper consists of a bumper beam, made of a vinyl ester plastic with 50% glass added, and a three-piece air dam, made of a thermo-plastic material.

The bumper beam is bolted to the rear surface of the air dam, and the entire assembly is bolted to the front of the frame rail. The air dam is painted to match the cab color. The bumper and air dam are not repairable. Replace them if they are damaged.

The Argosy COE bumper is steel with plastic end caps. See **Fig. 1**.

General Information



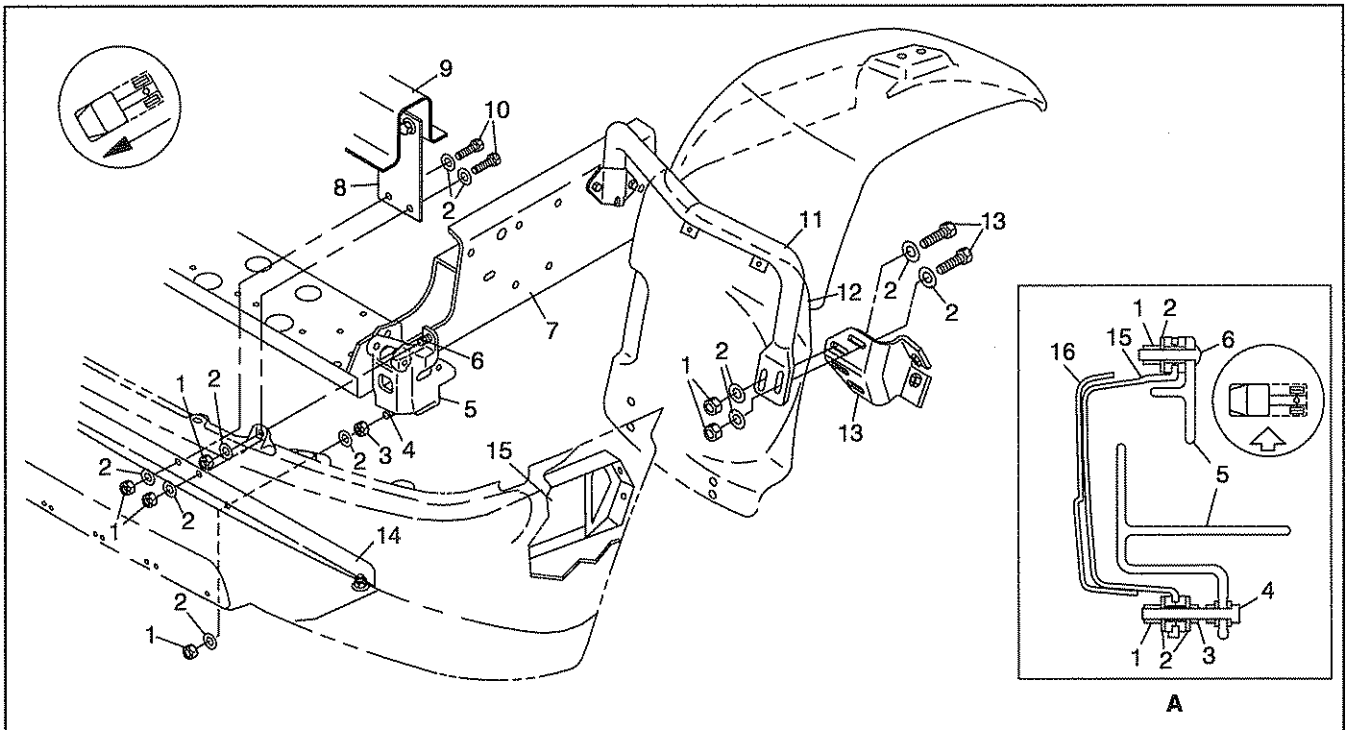
1. Front Closing Crossmember
2. Headlight Bracket
3. Bumper
4. Bumper Bracket
5. End Cap Brace
6. Bumper End Cap

Fig. 1, Argosy COE Bumper Components

Bumper and Air Dam Removal and Installation, Century Class Conventional

Removal

1. Park the vehicle, apply the parking brakes, then chock the tires.
2. Open the hood.
3. Remove the road lights from the bumper.
4. Remove the bumper step and the air temperature sensor, if equipped.
5. From underneath the vehicle, remove the two hexbolts, washers and nuts that attach the rubber support strap to the angle bracket at the lower rear edge of the air dam. See **Fig. 1**.
6. Remove the two hexbolts, washers, and nuts attaching the bumper support strut to the Z-bracket on the end of the bumper beam.
7. Repeat the previous step on the other side of the vehicle
8. Close the hood.
9. At the front of the vehicle, remove the four nuts (the two lower then the two upper) holding the bumper and air dam assembly to the frame rail brackets. See **Fig. 1**.
10. Pull the ends of the air dam away from the splash shields.



A. Side Cross-Sectional View

1. Hexnut
2. Flatwasher
3. Jam Nut
4. Lower Mounting Stud
5. Bumper/Hood Support Bracket
6. Upper Mounting Stud
7. Frame Rail
8. Support Strap
9. Crossmember
10. Hexbolt
11. Bumper Support Strut
12. Lower Splash Shield
13. Z-Bracket
14. Support Angle Bracket
15. Bumper Beam
16. Air Dam

Fig. 1, Bumper and Air Dam Installation, Left Side

Bumper and Air Dam Removal and Installation, Century Class Conventional

11. Using two people, remove the bumper and air dam from the vehicle.
12. Remove the Z-brackets from the ends of the bumper beam.
13. If you are replacing the air dam, remove it from the bumper beam. See **Subject 110** for instructions.

Installation

1. If not already done, attach the air dam to the bumper beam. See **Subject 110** for instructions.
2. Confirm that the bumper sections are aligned properly by measuring the bumper assembly as shown in **Fig. 2**. Adjust the bumper sections as necessary to achieve proper alignment.
3. Install the Z-brackets to the ends of the bumper beam.
4. Put the bumper in place onto the upper and lower mounting studs. See **Fig. 1**.
5. Install the hexnuts onto the upper mounting studs. Tighten them 68 lbf·ft (92 N·m).
6. Align the top edge of the bumper air dam with the bottom edge of the hood.
   - 6.1 On one side of the vehicle, back off the jam nut on the lower mounting stud.
   - 6.2 Install the hexnut and flatwasher onto the lower mounting stud, and tighten it until the top edge of the bumper air dam is parallel with the bottom edge of the hood.
   - 6.3 Tighten the jam nut up against the rear edge of the bumper beam.
   - 6.4 Repeat the procedure for the other side of the vehicle.
7. Install the support strap to the angle bracket at the center lower rear edge of the air dam. Tighten the fasteners firmly.
8. Attach the Z-brackets to the bumper support struts. Tighten the fasteners firmly.
9. Install the bumper step and the air temperature sensor, if equipped.
10. Install the road lights in the bumper.
11. Remove the chocks from the tires.

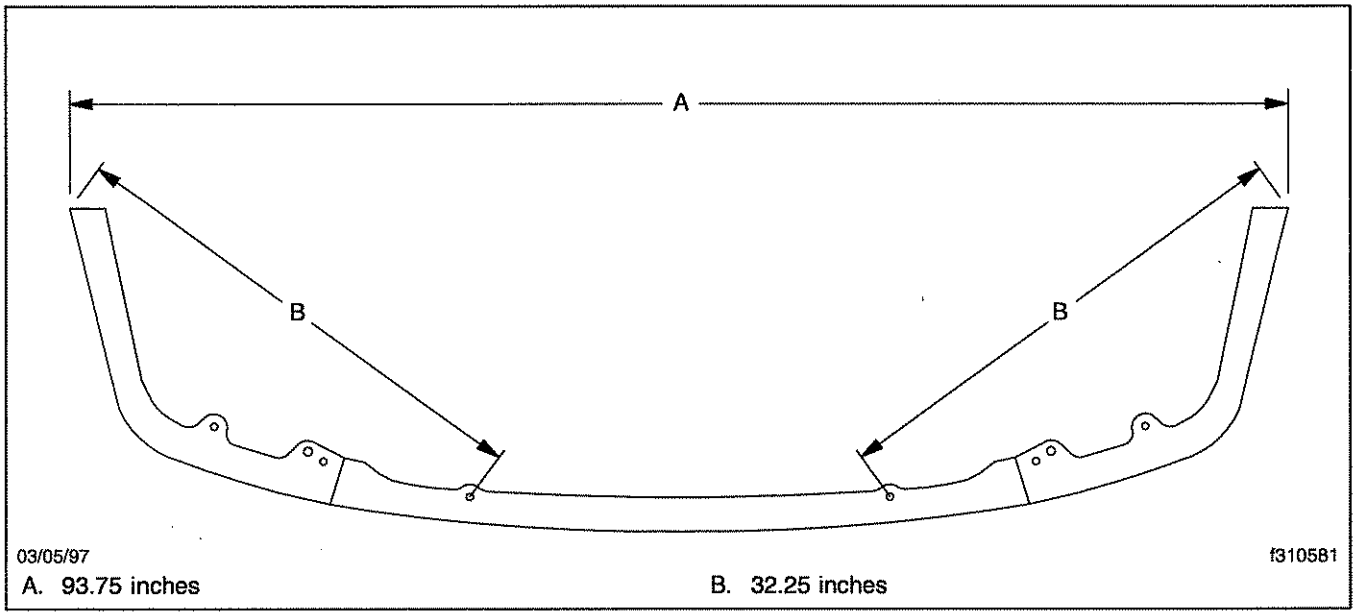


Fig. 2, Bumper Sections Alignment

Air Dam Removal and Installation, Century Class Conventional

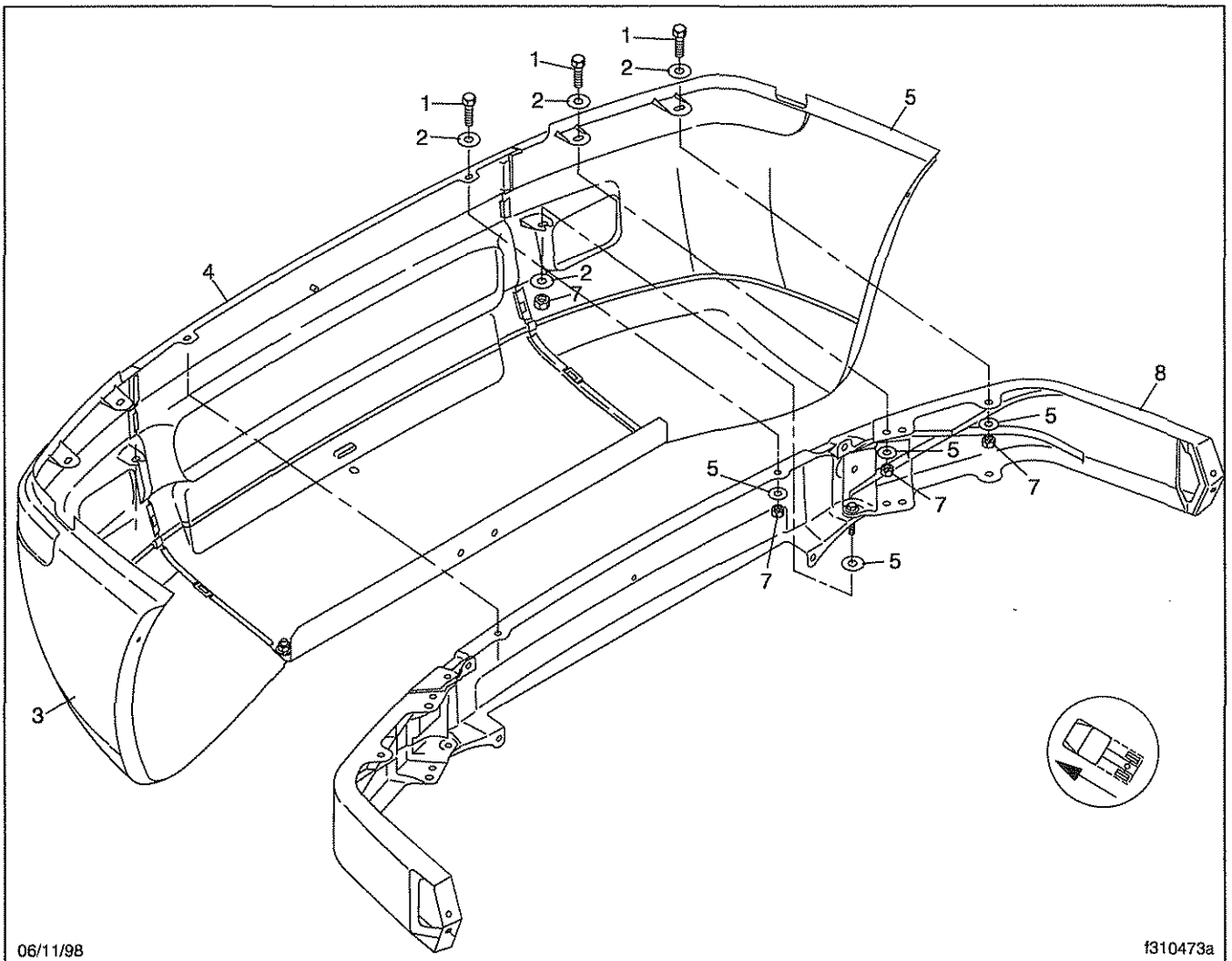
Removal

NOTE: The air dam can be removed as a unit, or in sections. This procedure covers removal of the air dam as a unit. To remove it in sections, remove only those fasteners holding the applicable section in place, then unhook it from the adjoining air dam section.

1. Remove the bumper and air dam assembly from the vehicle. See **Subject 100** for instructions.
2. Remove the hexbolts, hexnuts, and flatwashers holding the air dam to the bumper beam. See **Fig. 1**.
3. Remove the air dam from the bumper beam.

Installation

1. Put the bumper beam inside the air dam, making sure all the holes line up.



1. Hexbolt
2. Flatwasher
3. Air Dam Left Section
4. Air Dam Center Section
5. Air Dam Right Section
6. Hexnut
7. Bumper Beam

Fig. 1, Air Dam Installation

Air Dam Removal and Installation, Century Class Conventional

2. Install the fasteners. Tighten them firmly. See **Fig. 1**.
3. Install the bumper and air dam assembly on the vehicle. See **Subject 100** for instructions.

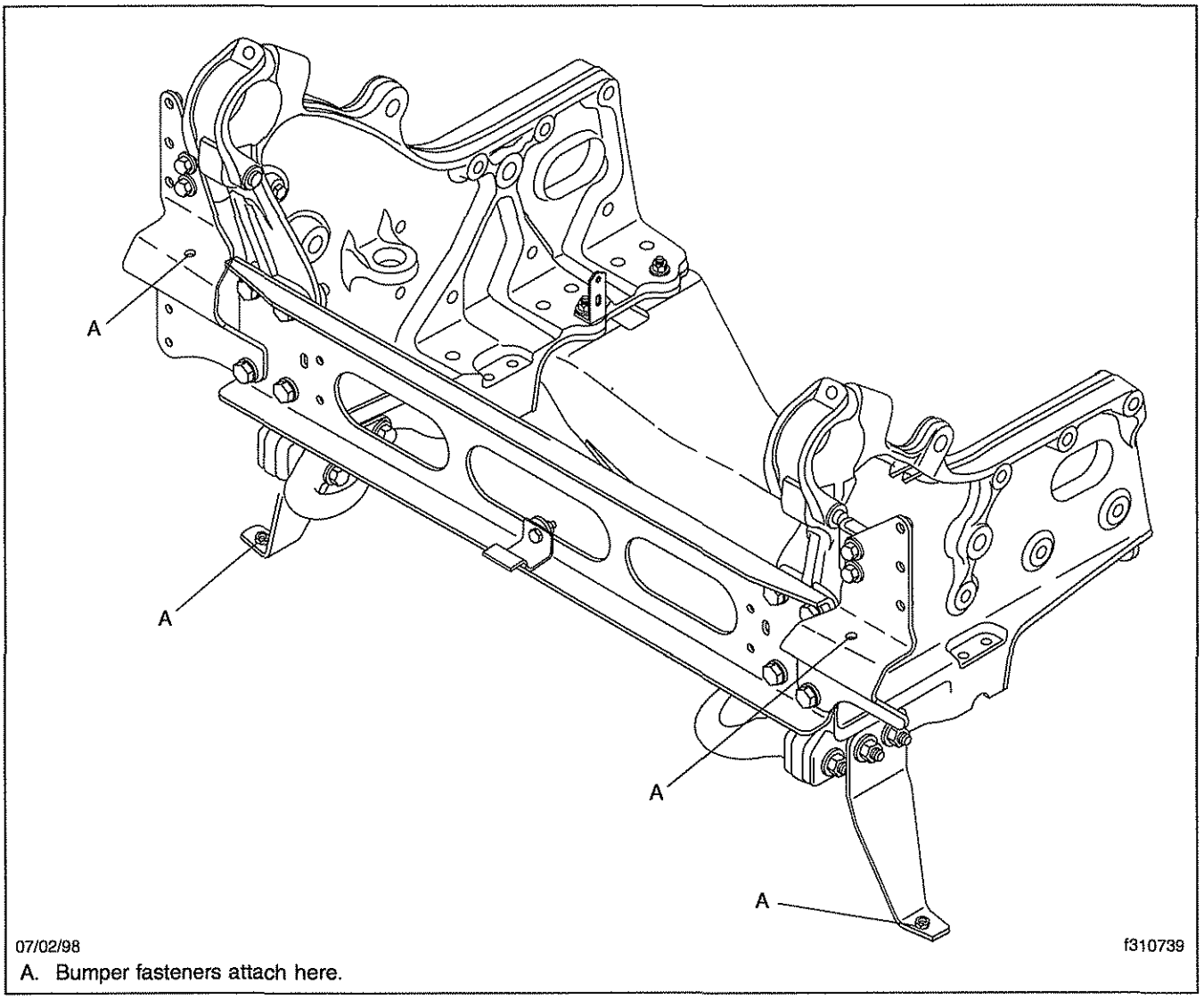
Bumper Removal and Installation, Argosy COE

Removal

1. Park the vehicle, apply the parking brakes, then chock the tires.
2. Remove the lower grille. For instructions, see **Section 60.16** in this manual.
3. Remove the fasteners that hold the bumper. See **Fig. 1**.
   - 3.1 Remove the clips that hold the bumper ends to the headlight panel.
   - 3.2 Remove the bolts that attach the bottom edge of the bumper to each bumper bracket. See **Fig. 2**.
   - 3.3 Remove the screws that hold the upper edge of the bumper. See **Fig. 3** and **Fig. 4**.
4. Lift the bumper off the front of the vehicle.

Installation

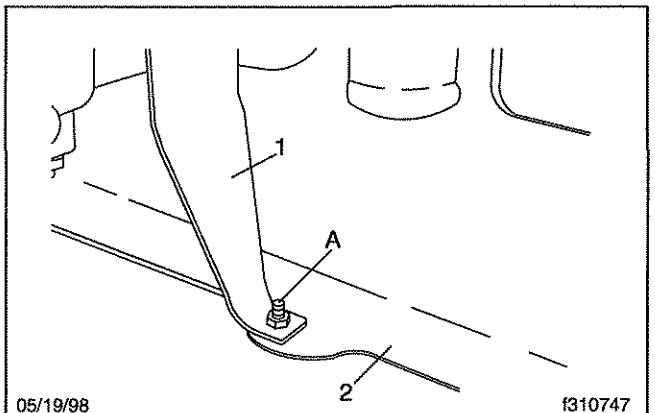
1. Position the bumper on the front of the vehicle.



A. Bumper fasteners attach here.

Fig. 1, Argosy Bumper Fastener Locations

Bumper Removal and Installation, Argosy COE



A. Remove or install this bolt.
1. Bumper Bracket
2. Bumper Lower Edge

Fig. 2, Bumper Bracket Connection

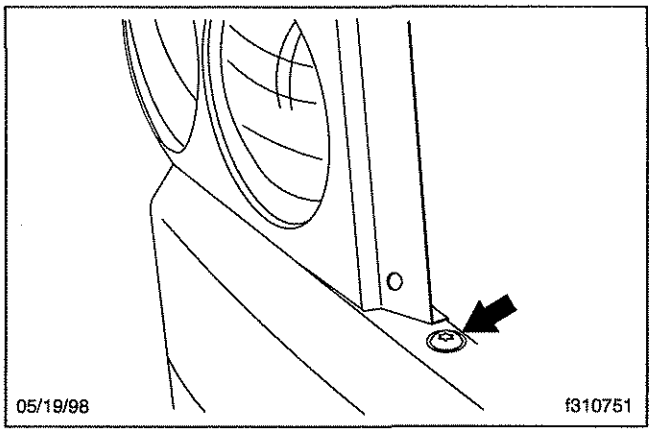


Fig. 3, Left Side Screw

2. Install the fasteners that hold the bumper.
   - 2.1 Install the screws that hold the upper edge of the bumper. See **Fig. 3** and **Fig. 4**. Tighten the screws firmly.
   - 2.2 Install the bolts that attach the bottom edge of the bumper to each bumper bracket. See **Fig. 2**.
3. Install the clips that hold the bumper ends to the headlight panel.
4. Install the lower grille. For instructions, see **Section 60.16** in this manual.

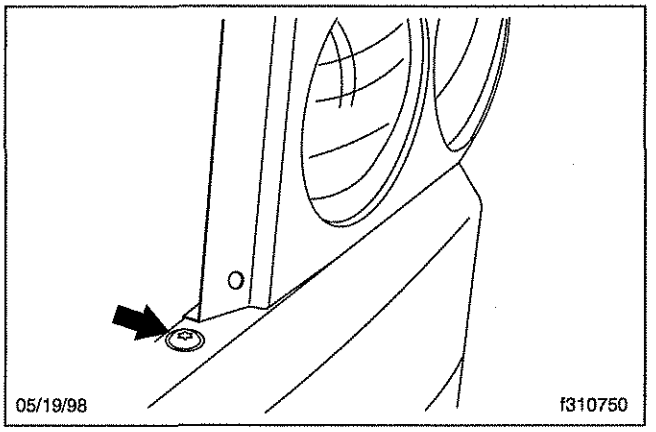


Fig. 4, Right Side Screw

5. Remove the chocks from the tires.

Chassis Side Fairing 31.04

Contents

Subject	Subject Number
General Information	050
Service Operations	
Panel Removal and Installation	100
Support Rail Removal and Installation, Century Class Conventional	110

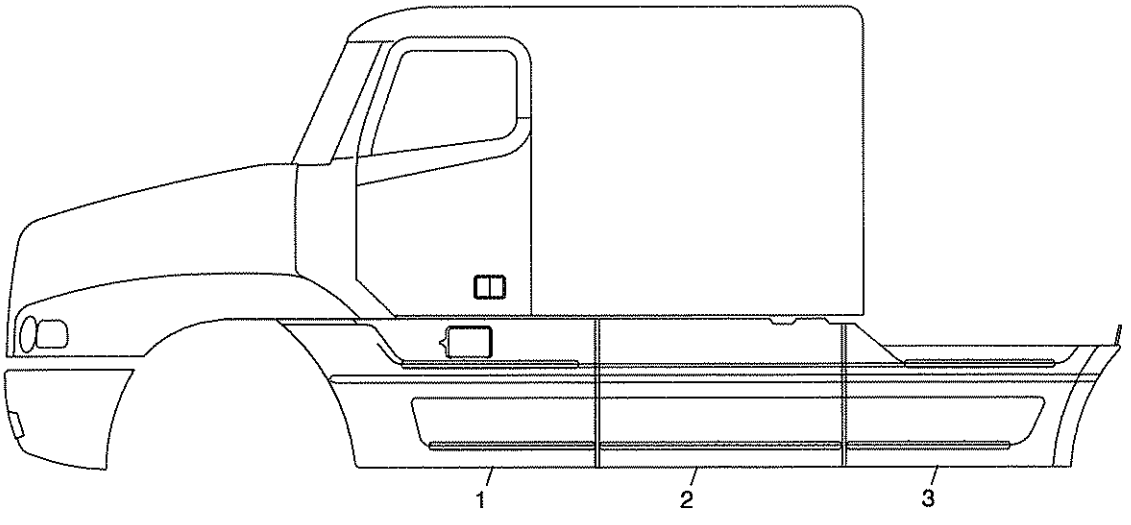
General Information

Chassis side fairing assemblies are sized to the cab or wheelbase, and ease air turbulence around the fuel tanks. They also provide access to the sleeper and back of the cab. For an example of Century Class Conventional side fairings, see **Fig. 1**.

For examples of Argosy COE side fairings, see **Fig. 2** and **Fig. 3**.

The side-fairing panels are made of plastic and are mounted on support rails. See **Fig. 4**. The support rails run parallel to the frame rails, and are mounted on brackets attached to the fuel tank mounting straps and the frame rail itself. On each side of the vehicle there may be one, two or three side fairing panels. The fairing panels are painted to match the color of the cab, and have perforated metal plates on each step surface to prevent slipping. Machine screws inserted through these step plates hold the fairings to the support rails underneath.

On Century Class Conventionals equipped with three fairing panels, the left aft fairing panel is latched, and swings out to allow access to the frame rail and battery box.



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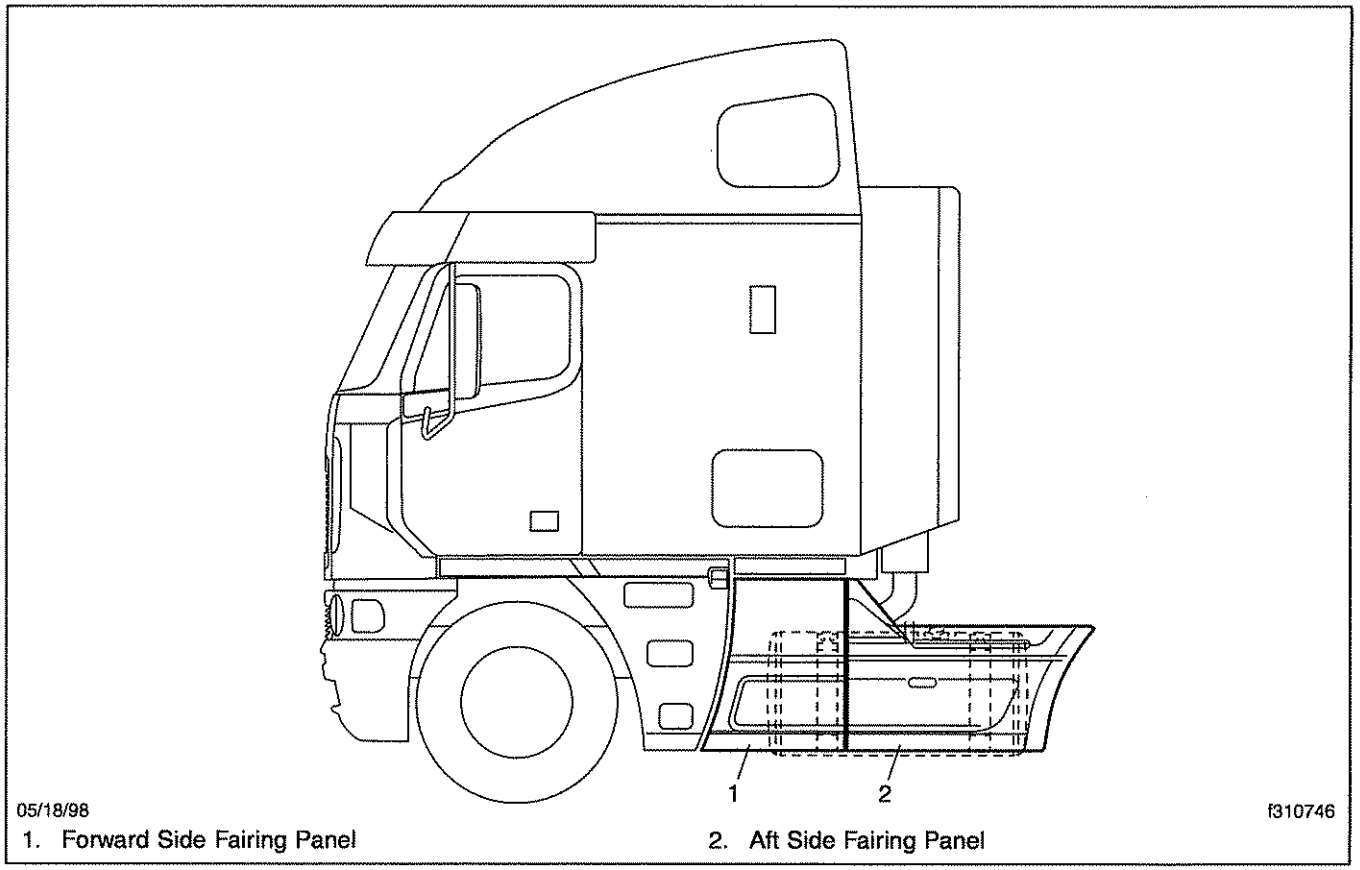
1. Forward Panel
2. Intermediate Panel
3. Aft Panel

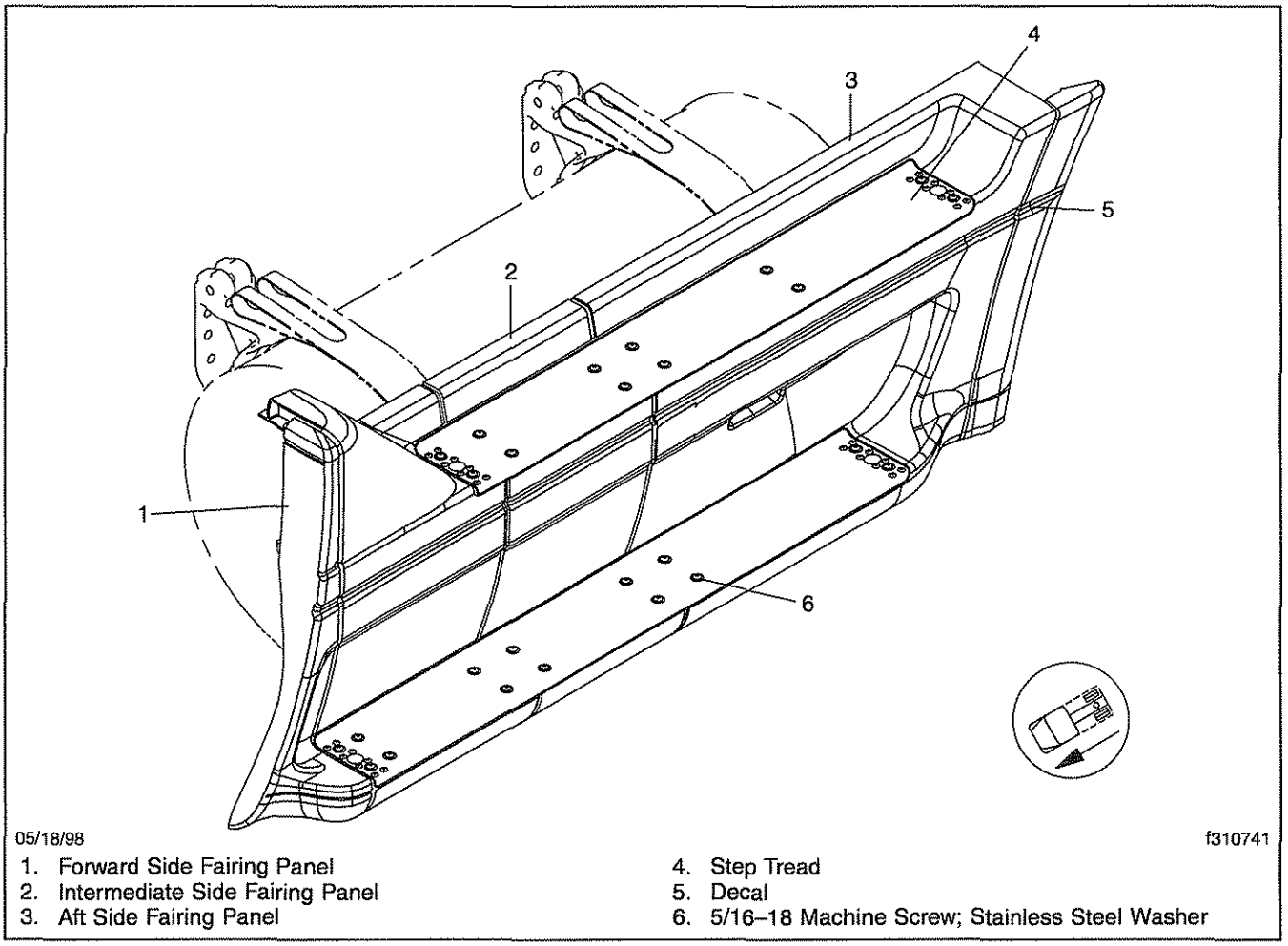
Fig. 1, Side-Fairing Panels, 48-Inch Century Class SleeperCab Shown

General Information



1. Forward Side Fairing Panel
2. Aft Side Fairing Panel

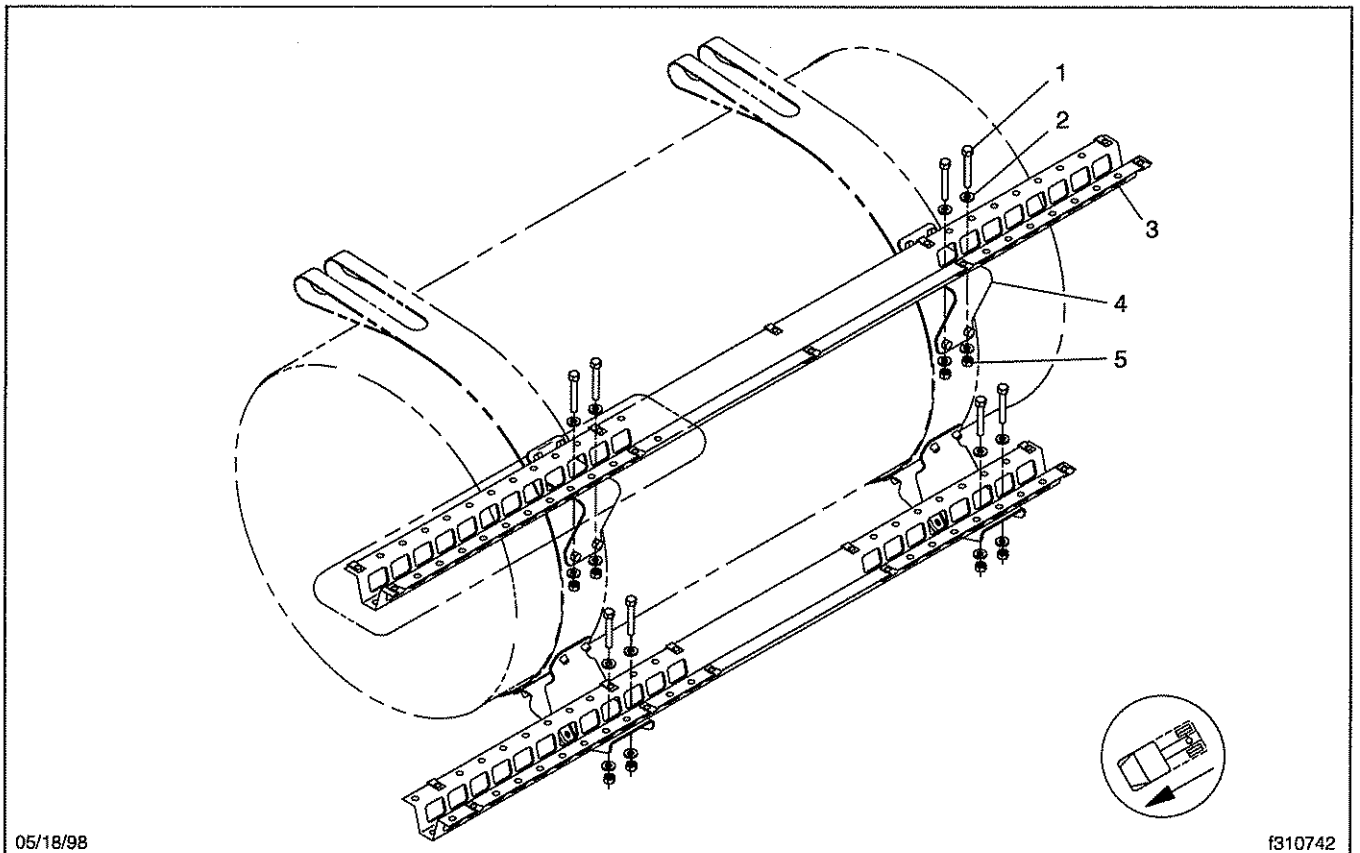
Fig. 2, Argosy COE Side Fairings, 110" BBC Shown



1. Forward Side Fairing Panel
2. Intermediate Side Fairing Panel
3. Aft Side Fairing Panel
4. Step Tread
5. Decal
6. 5/16–18 Machine Screw; Stainless Steel Washer

Fig. 3, Argosy COE Side Fairing Components, 90-Inch BBC Shown

General Information



1. Capscrew, 3/8–16, Grade 8
2. Washer
3. Chassis Side Fairing Support Rail
4. Fairing Bracket (attached to fuel tank band)
5. Locknut, 3/8–16

Fig. 4, Argosy COE Side Fairing Supports

Panel Removal and Installation

This subject covers both the Century Class Conventional and the Argosy COE. Refer to the procedure that applies to your vehicle.

Century Class Conventional

REMOVAL

NOTE: The following procedure covers the removal and installation of the forward, intermediate, and aft fairing panels. Not all vehicles are equipped with three fairing panels. Follow the applicable steps for the vehicle on which you are working.

When removing the side-fairing panels, it is easiest to remove the aft panel first, then the intermediate, and finally the forward panel.

1. Park the vehicle on a level surface. Apply the parking brakes; then chock the tires.
2. Remove the aft panel.
   - 2.1 Remove the Torx®-head screws and washers holding the upper and lower tread plates and the panel to the support rails. See **Fig. 1**.
   - 2.2 Remove the upper and lower tread plates from the panel.
   - 2.3 Remove the tread spacers from the upper and lower support rails.

⚠ CAUTION

Lift the panel only by the edges. Do not lift it by the oval holes that run the length of it. To do so could cause the plastic structure to break.

   - 2.4 Holding the panel by its edges, remove it from the upper and lower support rails.
3. Remove the intermediate panel using the same procedure above, except that it is necessary to lift the panel up and tilt the upper edge inward before removing it.

INSTALLATION

When installing the side fairing panels, install first the forward panel, then the intermediate panel, and finally the aft panel. This will allow you to fit them together correctly.

⚠ CAUTION

Lift the panels only by the edges. Do not lift them by the oval holes that run the length of them. To do so could cause the plastic structure to break.

1. Install the forward panel
   - 1.1 Put the forward panel in place on the upper and lower support rails.
   - 1.2 Install the tread spacers.

   IMPORTANT: Belleville washers are flat on the bottom, and convex (curved) on the top. Make sure they are installed correctly.

   - 1.3 Install the upper and lower tread plates, using the Torx-head screws and Belleville washers.
   - 1.4 Tighten the screws, but keep them loose enough to move the panel slightly.
2. Check the gap between of the upper edge of the forward panel and the lower edge of the hood. It should be 1-3/16 inches (30 mm). The edges of the panel and hood should also be parallel. See **Fig. 2**. If necessary, adjust the position of the forward panel by loosening the brackets holding the forward ends of the upper and lower support rails to the fuel tank brackets. Move the forward ends of the support rails up or down as needed.
3. Using the same procedure, install the intermediate panel.

   Make sure the plastic clips on the forward edge of the panel are underneath the rear edge of the forward panel, and that the plastic tabs on the back surface of panel hook onto the edges of the upper support rail.
4. Install the aft panel.
5. Check the vertical gaps between the panels. They should be 1/2-inch (13 mm) wide. See **Fig. 2**. Move the panels forward or backward as needed.
6. Tighten the Torx-head screws firmly.
7. Remove the chocks from the tires.

Panel Removal and Installation

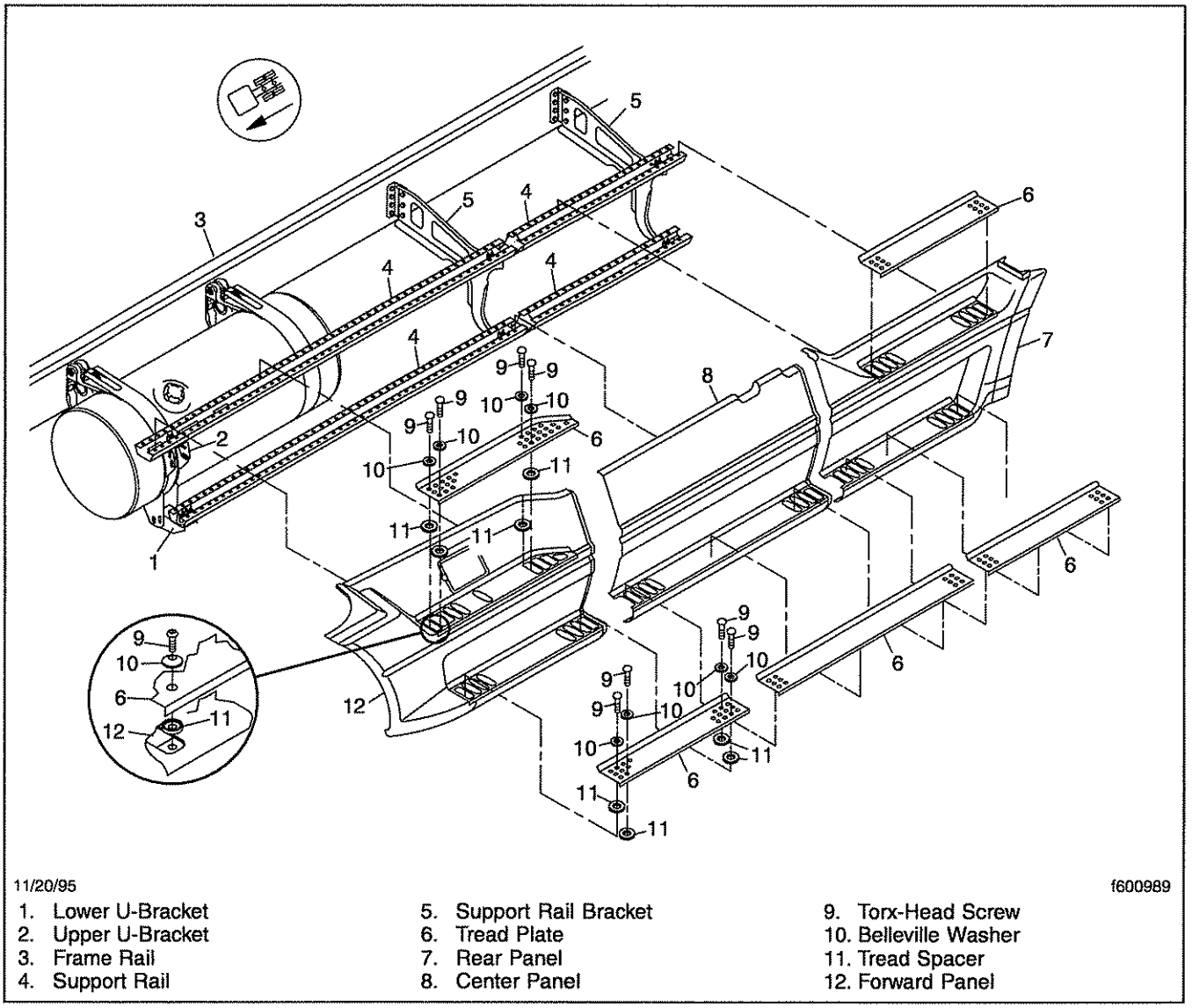


Fig. 1, Side Fairing Installation, Century Class Conventional (left side shown)

Argosy COE

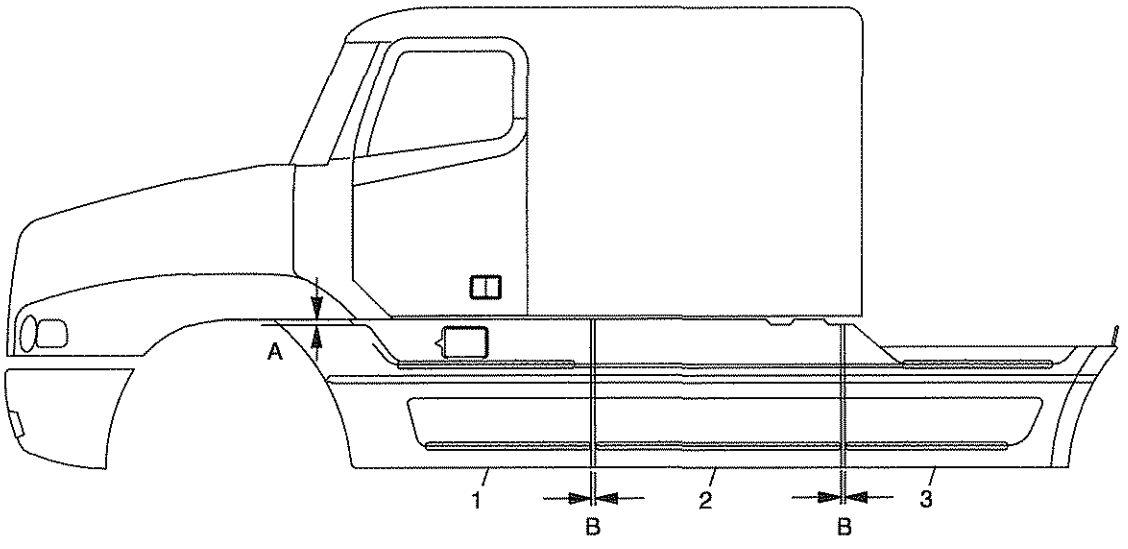
REMOVAL

1. Park the vehicle on a level surface. Apply the parking brakes; then chock the tires.
2. Remove the tread plate from each step.

⚠ CAUTION

Lift the panels only by the edges. Do not lift them by the oval holes that run the length of them. To do so could cause the plastic structure to break.

3. Remove the aft side fairing panel.
4. Remove the intermediate fairing panel.
5. Remove the forward fairing panel.



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A. These edges are to be parallel and 1-3/16 " (30 mm) apart.
B. 1/2-inch (12 mm)

1. Forward Panel
2. Center Panel
3. Rear Panel

Fig. 2, Panel Alignment

5.1 Remove the four bolts inside the fairing that hold it to the rail.

5.2 Remove the panel.

6. If needed, remove the support rails by removing the bolts that attach each to the brackets.

INSTALLATION

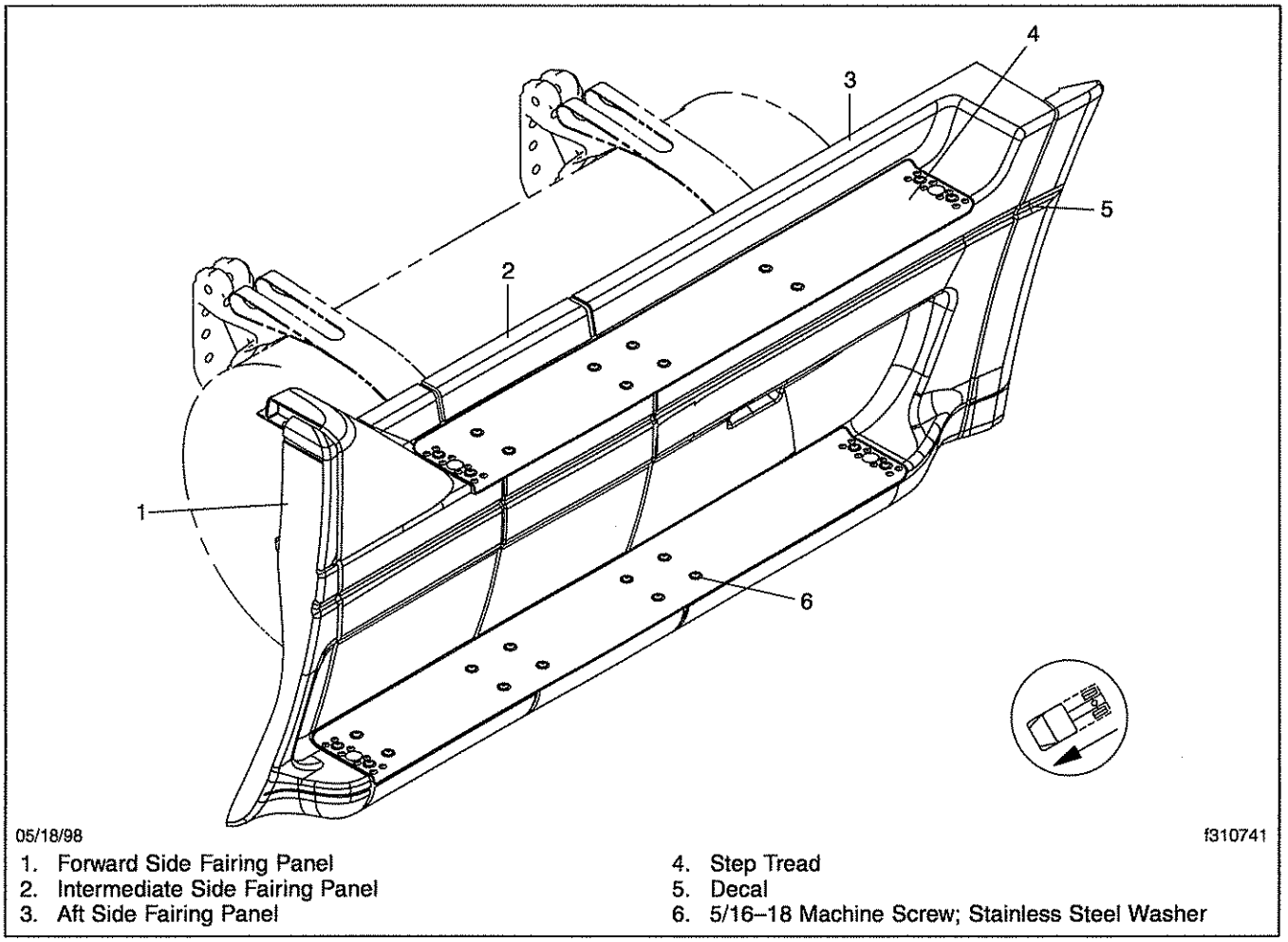
1. If needed, install the support rails by positioning them on the brackets and installing the fasteners. Tighten the nuts 28 lbf·ft (38 N·m). See **Fig. 3**.

⚠ CAUTION

Lift the panels only by the edges. Do not lift them by the oval holes that run the length of them. To do so could cause the plastic structure to break.

2. Position the forward side fairing panel, and install the four bolts inside. Tighten them 16 lbf·ft (22 N·m).
3. Position the intermediate and aft fairing panels.
4. Install the tread plates using the machine screws, and tighten the screws 16 lbf·ft (22 N·m). See **Fig. 4**.
5. Remove the chocks from the tires.

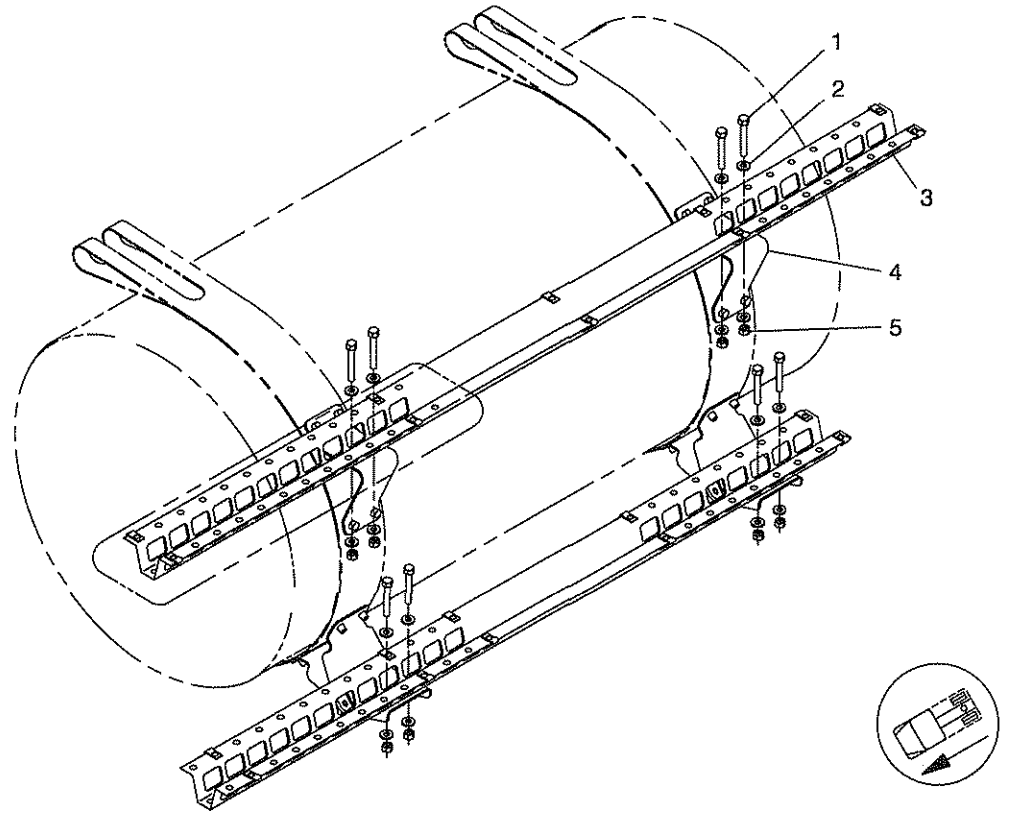
Panel Removal and Installation



1. Forward Side Fairing Panel
2. Intermediate Side Fairing Panel
3. Aft Side Fairing Panel
4. Step Tread
5. Decal
6. 5/16–18 Machine Screw; Stainless Steel Washer

Fig. 3, Argosy COE Side Fairing Components, 90-Inch BBC Shown

Panel Removal and Installation



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1. Capscrew, 3/8–16, Grade 8
2. Washer
3. Chassis Side Fairing Support Rail
4. Fairing Bracket (attached to fuel tank band)
5. Locknut, 3/8–16

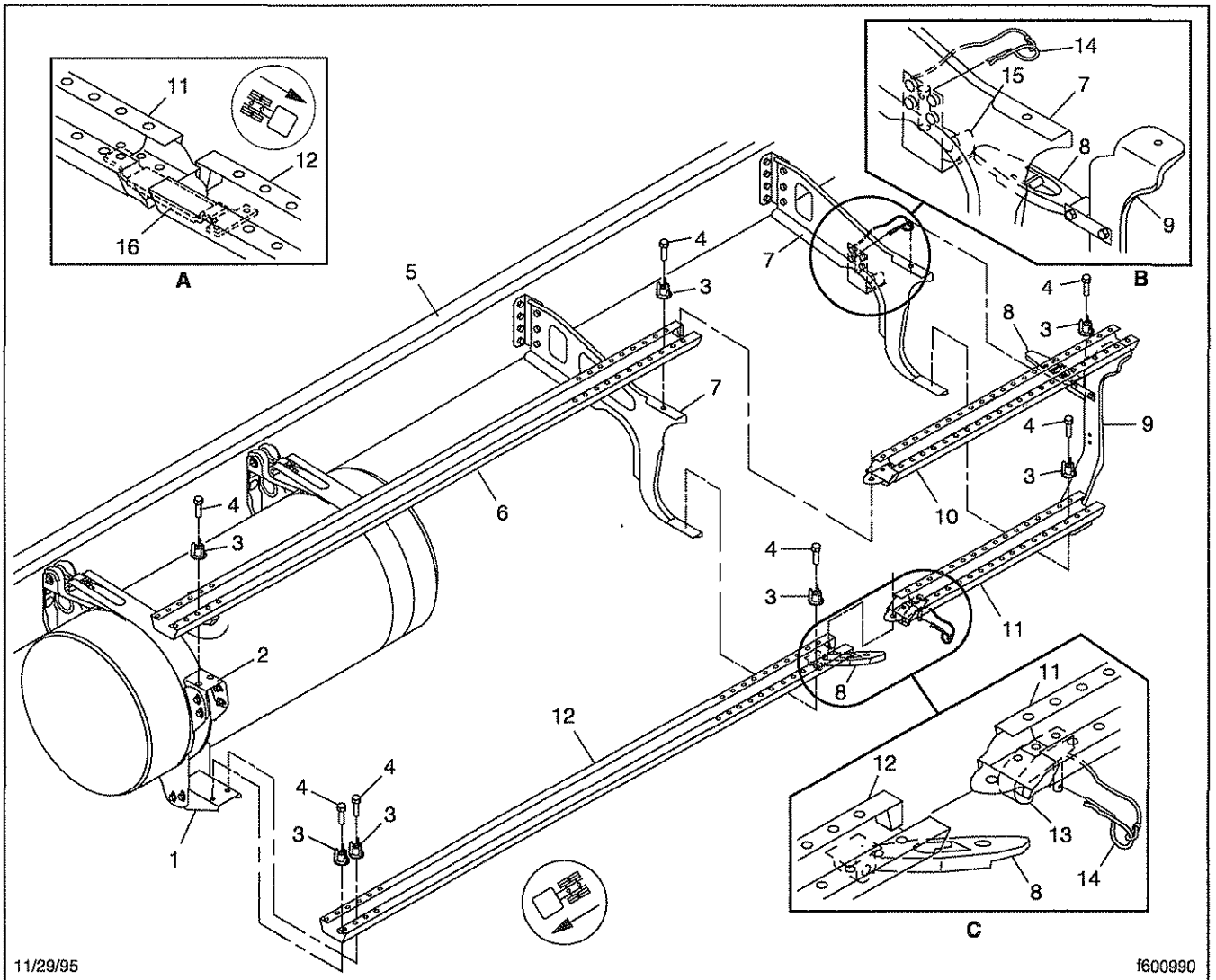
Fig. 4, Argosy COE Side Fairing Supports

Support Rail Removal and Installation, Century Class Conventionals

NOTE: This procedure applies only to Century Class Conventional vehicles. See **Fig. 1**. The removal and installation of support rails for Argosy COE vehicles is much simpler (**Fig. 2**). See **Subject 100** for COE side fairing service procedures.

Removal

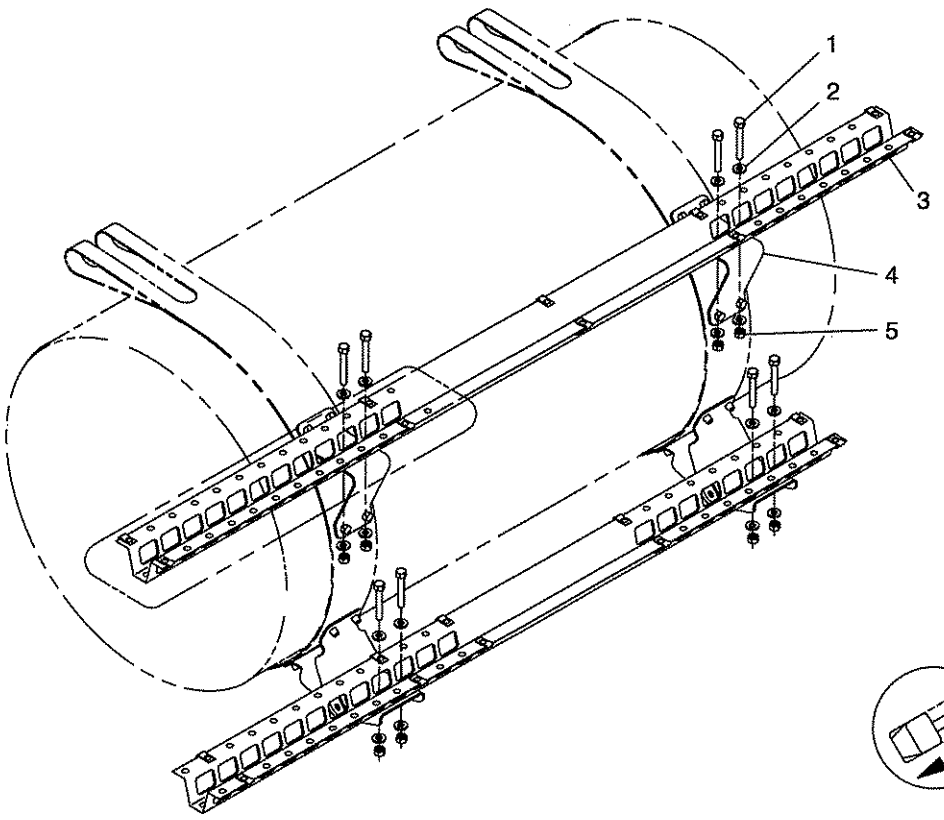
NOTE: This procedure covers removal of forward and rear support rails. Not all vehicles are so equipped. Follow the applicable steps for the vehicle on which you are working. On vehicles equipped with rear side fairings, the left rear upper and lower support



1. Lower U-Bracket
2. Upper U-Bracket
3. Aluminum Spacer
4. 3/8–16 Hexbolt
5. Frame Rail
6. Forward Upper Support Rail
7. Support Rail Mounting Bracket
8. Latch
9. Latch Bracket Assembly
10. Rear Upper Support Rail
11. Rear Lower Support Rail
12. Forward Lower Support Rail
13. Lower Latch Hook
14. Clinch Pin
15. Upper Latch Hook
16. Flexible Bracket

Fig. 1, Support Rail Installation, Century Class Conventionals

Support Rail Removal and Installation, Century Class Conventionals



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1. Capscrew, 3/8–16, Grade 8
2. Washer
3. Chassis Side Fairing Support Rail
4. Fairing Bracket (attached to fuel tank band)
5. Locknut, 3/8–16

Fig. 2, Support Rail Installation, Argosy COE Vehicles

rails are latched to the forward support rails for easy removal. They can be removed from the vehicle without removing the fairing panels from them.

1. On the left side, remove the rear upper and lower support rails and panel as a unit.

   1.1 Unlatch and remove the deck plate between the frame rail and upper edge of the rear fairing panel.

   1.2 Remove the clinch pins from the two latches, then unhook the upper and lower latches. See **Fig. 1**.

   1.3 Swing the rear end of the panel and support rails outboard, then remove them.

2. If not already done, remove the remaining side-fairing panels from the vehicle. See **Subject 100** for instructions. Remove the left rear fairing panel from the support rails, using the same procedure.

3. Remove the remaining support rails from the left side of the vehicle. See **Fig. 1**.

   3.1 Remove the 3/8–16 hexbolts and aluminum spacers that hold the forward upper rail to its mounting brackets; then remove the support rail.

   3.2 Using the same procedure, remove the forward lower support rail from its mounting bracket.

4. Remove the support rails from the right side of the vehicle.

Support Rail Removal and Installation, Century Class Conventionals

4.1 Remove the fasteners from one end of the flexible bracket holding the forward and rear lower support rails together. See **Fig. 1**.

4.2 Remove the 3/8–16 hexbolts and aluminum spacers that hold the forward upper rail to its mounting brackets; then remove the support rail.

4.3 Using the same procedure, remove the forward lower support rail from its mounting bracket; then remove the rear upper and lower support rails

Installation

1. On the right side of the vehicle, install the forward upper support rail. See **Fig. 1**.

   1.1 Put the rail in place on the mounting brackets.

   1.2 Install the aluminum spacers, then the 3/8–16 hexbolts. Tighten the hexbolts finger-tight.

   1.3 Make sure the support rail is level and parallel with the frame rail. Clamp the fairing panel in place, then check it's alignment with the hood and the bottom edge of the cab. If necessary, loosen the fasteners on the upper U-bracket (see **Fig. 1**); then move the front end of the support rail (along with the fairing panel) up or down as needed. Tighten the U-bracket fasteners firmly. Tighten the 3/8–16 hexbolts 28 lbf·ft (38 N·m).

   1.4 Put the rear upper support rail in place; then slide the tongue on the forward end of it into the groove in the rear end of the forward support rail.

   1.5 Install the aluminum spacer, then the 3/8–16 hexbolt. Tighten the hexbolt 28 lbf·ft (38 N·m).

2. Using the same procedure, install the forward and rear lower support rails.

3. Install the flexible bracket between the forward and rear lower support rails. Tighten the fasteners firmly.

4. Using the same procedure, install and level the forward upper support rail on the left side of the vehicle. Then install and level the forward lower support rail

5. Install the upper and lower rear support rails.

   5.1 If it was removed, install the latch bracket assembly (see **Fig. 1**) between the rear upper and lower support rails.

   5.2 Install the latches if they removed.

   5.3 Latch the support rails in place, then install the clinch pins.

6. Install the remaining side-fairing panels. See **Subject 100** for instructions.

Contents

Subject	Subject Number
General Information	050
Service Operations	
Model XA–3501 Top Plate Removal and Disassembly	100
Model XA–3501 Top Plate Assembly and Installation	110
Model XA–351 Top Plate Removal and Disassembly	120
Model XA–351 Top Plate Assembly and Installation	130
Troubleshooting	300

General Information

NOTE: The Holland 3500 series XA–3501 model fifth wheel top plate has been replaced by the XA–351 model. All 3500 series fifth wheel top plates which are marked with a manufactured date after June 1, 1996 are XA–351 models.

NOTE: Service operations for the Holland 3500 series slide mounts (FW2535/FW35) are covered in **Section 31.06** in this group.

MODEL XA–3501 TOP PLATE

NOTE: The part number prefix for the stationary fifth wheel is FW3500 and the part number prefix for the sliding fifth wheel is FW2535.

Holland 3500 series XA–3501 fifth wheels are used for pulling trailers having the standard SAE kingpin. When installed as stationary fifth wheels, they are bracket-mounted to the trailer frame in a position that best distributes the trailer load over the tractor axles. When installed as sliding fifth wheels, they are mounted on the Holland 3500 series sliding mount. These fifth wheels have a capacity of 150,000 lbf (667 000 N) maximum drawbar pull and 40,000 to 50,000 lbf (178 000 to 222 000 N) maximum vertical load. The fifth wheel (**Fig. 1**) has a cast steel top plate, and is equipped with a split type "B" mechanical spring lock. This steel kingpin lock system requires a 300 lbf (1330 N) push (force) to couple, and also includes a slack adjustment and the Holland lockguard (which prevents high kingpin coupling).

The two spring-loaded lock halves separate as the kingpin enters the lock mechanism. See **Fig. 2**. The final forward motion of the kingpin forces the lock to close in a 360 degree grip around the shoulder and neck of the kingpin, and moves the yoke between the lock halves and the tapered rib members of the fifth wheel understructure. The kingpin can be released only by manually operating the kingpin lock control handle. See **Fig. 1**. An adjustment nut compensates for wear on the lock or kingpin, if necessary.

See **Chapter 10** in the vehicle driver's manual for complete operating instructions.

MODEL XA–351 TOP PLATE

NOTE: The part number prefix for the stationary fifth wheel and the sliding fifth wheel is FW35.

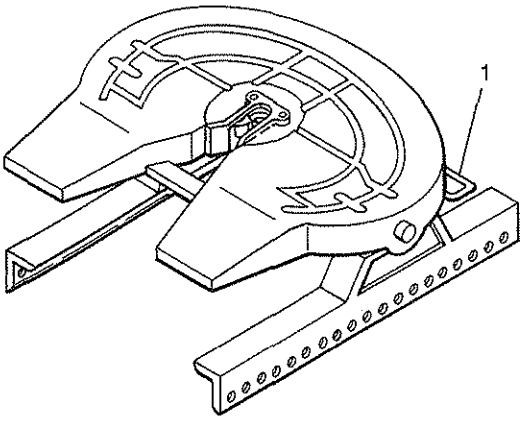
The Holland 3500 series XA–351 fifth wheels are applicable for general over-the-road use. They are designed to pull trailers having a 2 inch (5 cm) SAE J700b kingpin. They have a capacity of 150,000 lbf (667 000 N) maximum drawbar pull and 55,000 lbf (244 652 N) maximum vertical load. These fifth wheels are available in three different mounting assemblies: the Kompensator®; the slide mount; and the stationary mount.

The stationary mount fifth wheels are available with four different mounting bracket styles, which include:

- a bracket with a mounting base for over-the-frame mounting;
- a bracket with a mounting angle for over-the-frame mounting;
- a bracket for angle mounting (designed to be welded to the angle) for over-the-frame mounting;
- and, a bracket for outboard angle mounting.

The mounting brackets use nylon-lined "up-shock" bushings. These fifth wheels come in a variety of heights to accommodate many applications.

The sliding fifth wheels are available with either an over-the-frame mounting bracket or an outboard angle mounting bracket. These mounting brackets are either equipped with a manual slide release or an air slide release mechanism. These sliding mounts have a position adjustment that gives the fifth wheel top plate



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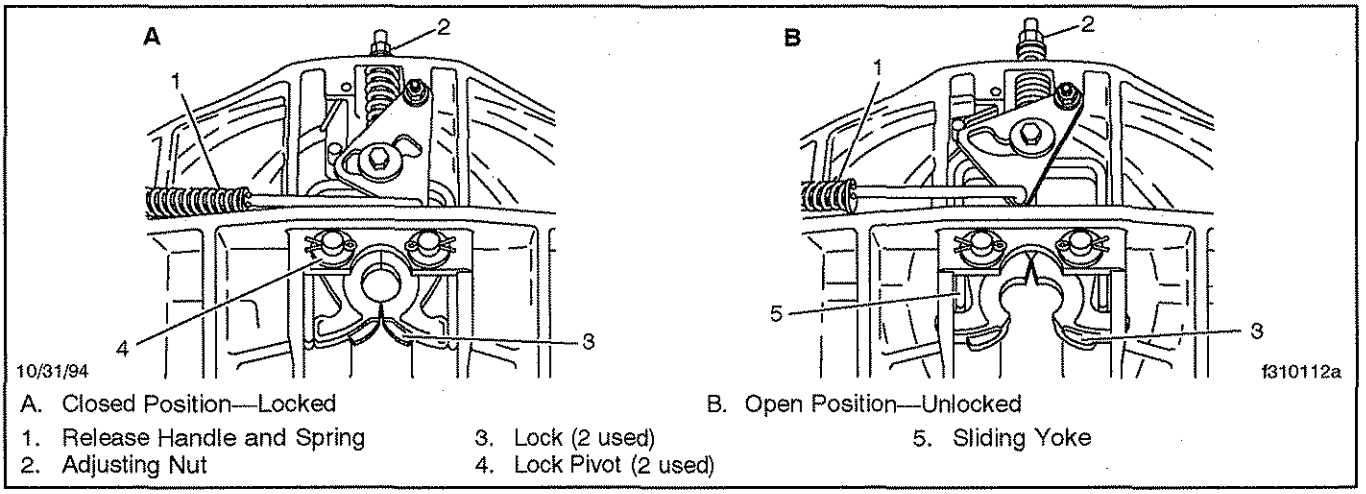
1. Kingpin Lock Control Handle

Fig. 1, XA-3501 Fifth Wheel

General Information



A. Closed Position—Locked
B. Open Position—Unlocked
1. Release Handle and Spring
2. Adjusting Nut
3. Lock (2 used)
4. Lock Pivot (2 used)
5. Sliding Yoke

Fig. 2, Type B Kingpin Lock Mechanism (bottom view)

the ability to be released, incrementally moved (by 1.5 inch [3.8 cm] displacements) and locked in alternate positions. The position adjustment feature allows the fifth wheel position to vary combination length and tractor axle load distribution for maximum equipment utilization. The mounting brackets use nylon-lined "up-shock" bushings. The sliding fifth wheels are available in a variety of heights and slide travel lengths.

The Kompensator® fifth wheel is equipped with either a stationary or sliding mounting bracket. This fifth wheel is designed for rigid trailers that don't flex during torsional loading. It provides torsional stress relief and promotes vehicle stability with trailers that have an unusually high center of gravity (where the center of gravity is up to 44 inches [111 cm] above the top plate surface). This fifth wheels unique cradle design provides side-to-side movement to help relieve the torque and twist of the trailer. Spring cushions act as a restoring force to provide stability after absorbing the strain and pressure of the load. Additionally, it keeps the center of compensation above the fifth wheel bearing surface and centered between the frame rails. All models are available with an optional "lock-out" feature to restrict compensation for applications that do not require compensation. See **Fig. 3**.

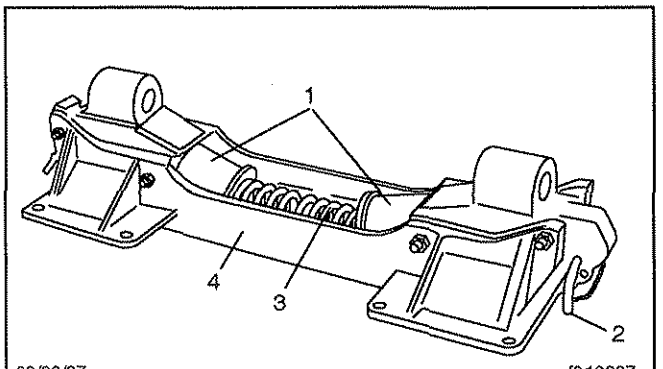
The 3500 series top plate consists of:

- the cast steel top plate;
- the bracket pin mount;
- the release handle;
- the infinite lock adjustment nut;
- and the kingpin lock mechanism.

See **Fig. 4**.

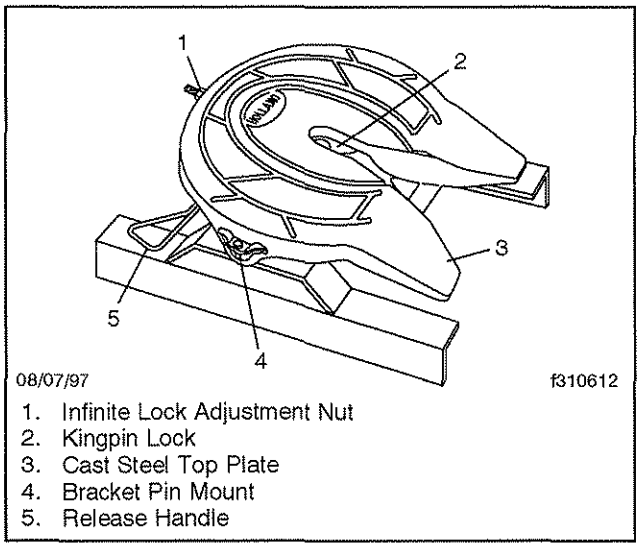
The kingpin lock mechanism consists of:

- the infinite lock adjustment nut;
- the secondary lock;
- the release handle;
- the type "B" forged steel split lock;



1. Urethane Cushions
2. Optional Lockout
3. Compression Springs
4. Kompensator® Cradle Design Mounting Bracket

Fig. 3, The Kompensator®Cradle



1. Infinite Lock Adjustment Nut
2. Kingpin Lock
3. Cast Steel Top Plate
4. Bracket Pin Mount
5. Release Handle

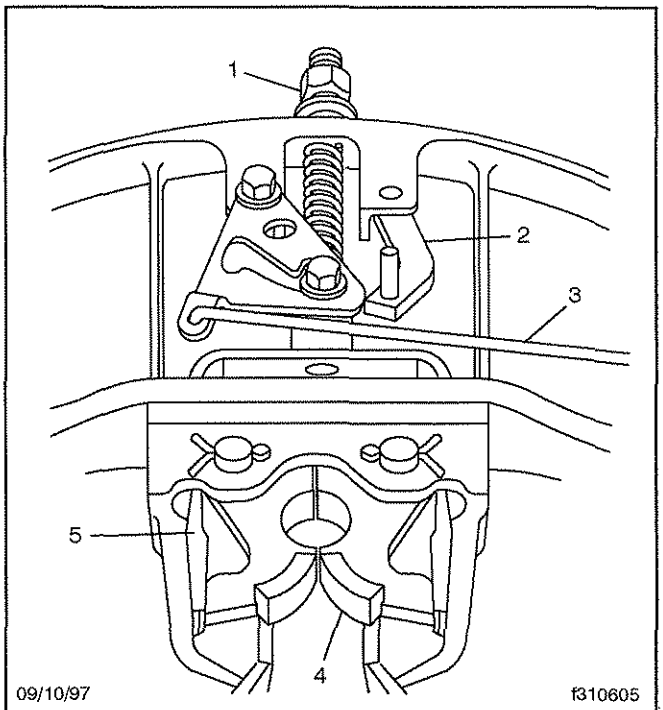
Fig. 4, XA-351 Fifth Wheel

- and, the yoke.

See **Fig. 5**.

When the yoke is retracted, the two spring-loaded lock halves separate as the kingpin enters the lock mechanism. When the yoke engages, the final forward motion of the kingpin forces the lock to close in a 360 degree grip around the shoulder and neck of the kingpin. After the yoke is engaged (positioned between the lock halves and the tapered rib members of the top plate casting), the secondary lock moves behind the yoke. For fifth wheels with an automatic secondary lock, the kingpin is released by manually operating the release handle. For fifth wheels with a manual secondary lock, the fifth wheel is released by pulling the secondary release handle, then hooking the secondary release handle to the top plate casting, and finally manually operating the primary release handle. For high coupling protection, a one step rear lock is incorporated into the split lock. For increased durability of the kingpin lock mechanism, the infinite lock adjustment positions are available to compensate for wear in both the kingpin and the lock jaws.

See **Chapter 10** in the vehicle driver's manual for complete operating instructions.



1. Infinite Lock Adjustment Nut
2. Secondary Lock (Automatic Shown)
3. Release Handle
4. Kingpin Guide
5. Yoke

Fig. 5, Kingpin Lock Mechanism (bottom view)

Model XA–3501 Top Plate Removal and Disassembly

Removal and Disassembly (See Fig. 1)

⚠ WARNING

All fifth wheel maintenance, adjustment, and rebuilding must be done only by a qualified mechanic. Improper or incomplete procedures could result in loss of trailer connection during vehicle travel, possibly causing bodily injury and property damage.

A fifth wheel rebuild kit is available for servicing the 3500 series XA–3501 fifth wheel (part number RK–63501 [left release] and RK–63500 [right release]). The kit contains all replacement parts for the fifth wheel, except the fifth wheel plate, slide mount assembly, rubber bushings, bushing pins, and roll pins.

Review the troubleshooting section before rebuilding the fifth wheel. Rebuilding may be unnecessary.

1. Steam clean the top plate. Remove it from the slide mounts (**Fig. 1**) by removing the roll pins from the bushing pins; then, remove the bushing pins from the slide mounts. Use an overhead hoist to lift the fifth wheel from the slide mount assembly and tractor frame.
2. Turn the fifth wheel upside down with the locks open.
3. While disassembling the fifth wheel, check it for cracks and for missing or damaged parts, as follows:

   3.1 Remove the lockguard, the lockguard torsion spring, the lockguard pin, and the lockguard cotter pins.

   3.2 On fifth wheels with a right-hand release, remove the secondary lock roll pin from hole F. Then, remove the right-hand secondary lock from under hole F.

   On fifth wheels with a left-hand release, remove the secondary lock roll pin from hole G. Then, remove the left-hand secondary lock with the secondary lock spring from under hole G.

   3.3 Remove the attaching release arm capscrew, capscrew washer, and roller from hole A of the release arm and yoke subassembly.

   3.4 Remove the release arm capscrew, release arm capscrew washer, and release arm roller from hole G for models with right-hand release or from hole F for models with left-hand release.

   3.5 Remove the release handle from the fifth wheel top plate. Remove the washer, release handle spring, and release handle washer from the release handle.

   3.6 Remove the yoke shaft locknut, yoke shaft washer, and rubber block from the yoke shank. Then, remove the yoke shank and the yoke shank spring from the yoke subassembly.

   3.7 Remove the yoke from the fifth wheel top plate.

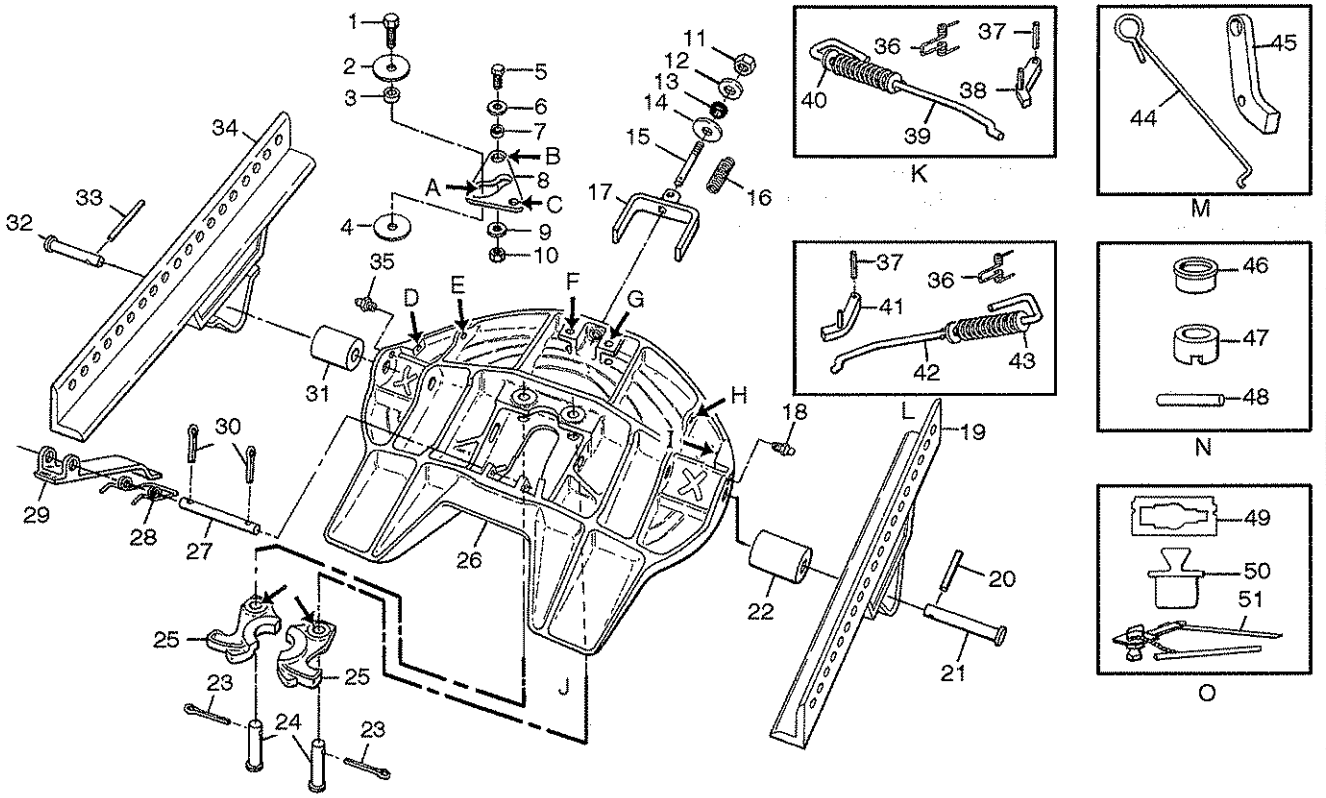
   3.8 Remove the lock cotter pins, lockpins, and the lock jaws from the fifth wheel top plate.

   3.9 If the top plate is cracked, discard it. If the lockpin hole is worn, the top plate can be returned for a factory rebuild.

⚠ WARNING

Do not attempt to repair or rebuild the top plate if it is cracked or if the lockpin does not fit tightly. The top plate could fail or the locks could malfunction. This could result in loss of trailer connection during vehicle travel, possibly causing bodily injury and property damage.

Model XA–3501 Top Plate Removal and Disassembly



A. Release Arm Cam Profile
B. Release Arm Pivot Hole
C. Hole for Attachment of Release Handle
D. Guide Hole for Right-Hand Release
E. Hole for Left-Hand Manual Secondary Lock Handle
F. Right-Hand Secondary Lock Anchor Hole
G. Left-Hand Secondary Lock Anchor Hole
H. Hole for Right-Hand Manual Secondary Lock Handle
I. Guide Hole for Left-Hand Release
J. Lockpin Holes
K. For Right-Hand Release
L. For Left-Hand Release
M. For Models With Secondary Lock
N. For Models With Lockpin Bushings
O. Accessories

1. Capscrew, 5/8–18 x 1-3/4
2. Flatwasher, 5/8" i.d.
3. Roller
4. Washer, 5/8" i.d.
5. Capscrew, 1/2–20
6. Washer, 1-3/4" o.d. x 9/16" i.d.
7. Roller
8. Release Arm (Cam Plate)
9. Washer, 1-3/4" o.d. x 13/16" i.d.
10. Locknut, 1/2–20
11. Locknut, 3/4–16
12. Washer, 1-1/2" o.d. x 13/16" i.d.
13. Rubber Block
14. Lock Adjustment Tag
15. Yoke Shank
16. Yoke Shank Spring
17. Yoke Subassembly
18. Grease Fitting
19. Mounting Bracket
20. Roll Pin
21. Bracket Pin
22. Rubber Bushing
23. Cotter Pins, 1/4" x 2"
24. Lockpins
25. Lock Jaws
26. Fifth Wheel Top Plate
27. Lockguard Pin
28. Lockguard Torsion Spring
29. Lockguard
30. Cotter Pins, 1/8" x 1"
31. Rubber Bushing
32. Bracket Pin
33. Roll Pin
34. Mounting Bracket
35. Grease Fitting
36. Secondary Lock Torsion Spring
37. Roll Pin
38. Right-Hand Secondary Lock
39. Right-Hand Release Handle
40. Washer, 1-3/4" o.d. x 9/16" i.d.
41. Left-Hand Secondary Lock
42. Left-Hand Release Handle
43. Washer, 1-3/4" o.d. x 9/16" i.d.
44. Manual Secondary Lock Handle
45. Manual Secondary Lock
46. Lockpin Bushings, 2
47. Lockpin Bushing, 2
48. Roll Pin, 2
49. Kingpin Gauge
50. Plug, 2"
51. Kingpin Lock Tester

Fig. 1, Holland 3500 Series XA-3501 Fifth Wheel and Accessories (bottom view)

Model XA–3501 Top Plate Assembly and Installation

Assembly and Installation

⚠ WARNING

All fifth wheel maintenance, adjustment, and rebuilding must be done only by a qualified mechanic. Improper or incomplete procedures could result in loss of trailer connection during vehicle travel, possibly causing bodily injury and property damage.

A fifth wheel rebuild kit is available for servicing the 3500 series XA–3501 fifth wheel (part numbers RK–63501 [left release] and RK–63500 [right release]). The kit contains all replacement parts for the fifth wheel, except the fifth wheel plate, slide mount assembly, rubber bushings, bushing pins, and roll pins.

Review the troubleshooting section before rebuilding the fifth wheel. Rebuilding may be unnecessary.

IMPORTANT: Use only Holland rebuilding kits. Replace all roll pins, cotter pins, springs, capscrews, nuts, and washers.

1. Clean all moving parts with no. 2 diesel fuel before assembly.
2. Before installing the lock jaws (**Fig. 1**), lubricate the lockpin holes (Ref. J) with Never-Seez®.

⚠ CAUTION

Use only Never-Seez®. Other lubricants can damage the lockpin holes.

3. Place the lock jaws in the top plate with the 2-7/8 inch bore toward the face of the top plate. See **Fig. 2**.
4. Drive the lockpins (**Fig. 1**) through the top plate and lockpin holes (Ref. J) in the lock jaws until the head of the pins are flush with the top plate.
5. If the top plate is equipped with lockpin bushings, use roll pins instead of cotter pins. See **Fig. 3**.
6. Check that the lock jaws move freely.

⚠ WARNING

Use only Holland part number TF–0237 or a precision plug machined to 2.000 ± 0.005 inch (5.08 ± 0.0127 cm) to adjust the locking mechanism. Failure to do so may cause locking mechanism malfunction. This could result in loss of trailer connection during vehicle travel, possibly causing bodily injury and property damage.

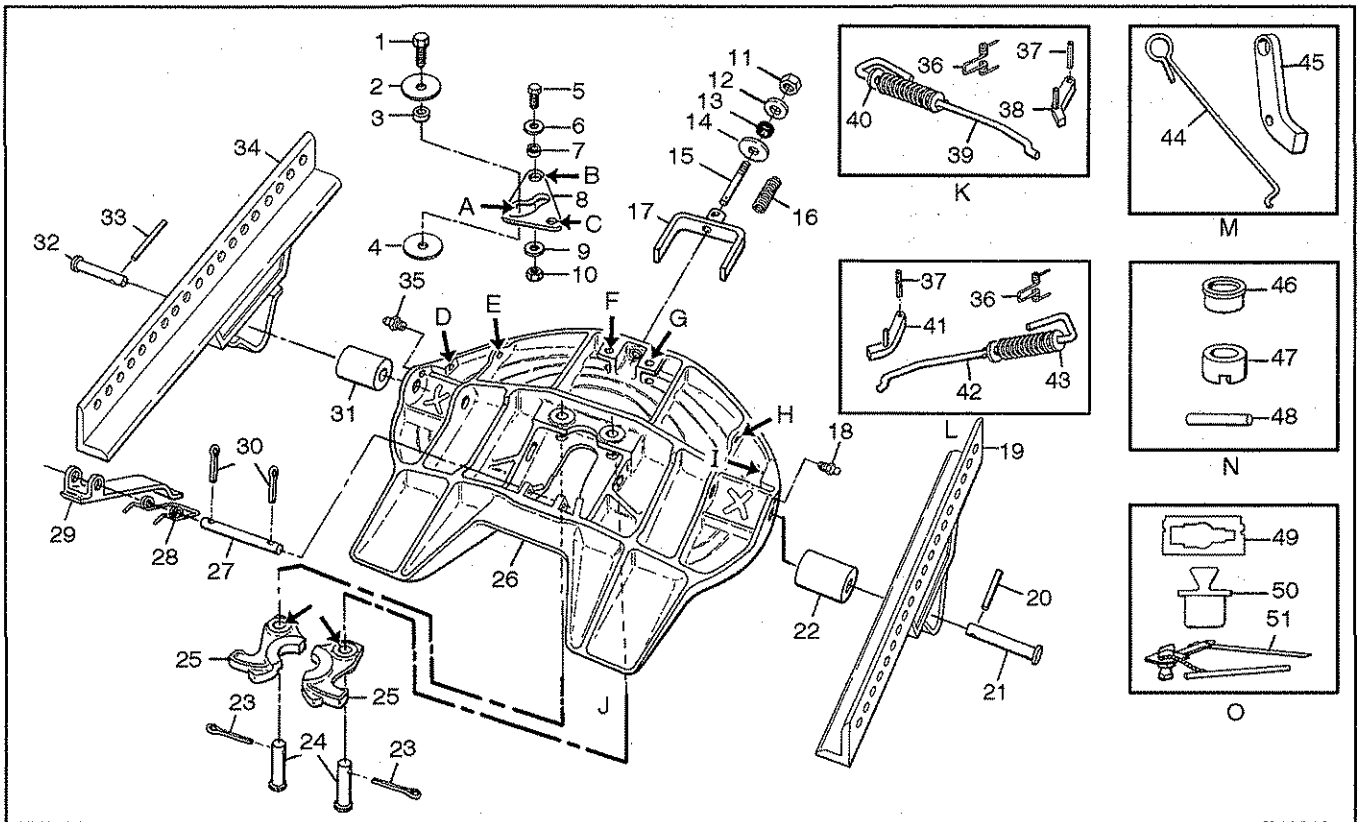
7. Install a 2-inch (5.08 cm) diameter plug (Holland part number TF–0237) in the lock jaws. See **Fig. 4**.
8. Strike the yoke with a mallet to bend the yoke tips outward slightly. See **Fig. 5**.
9. Slide the yoke into the top plate with the threaded hole facing up, and tap the yoke into position.

⚠ WARNING

Never grind on the inside of the yoke or on the locks. This can weaken the yoke structure, possibly causing the kingpin to fit loosely. This could result in loss of trailer connection during vehicle travel, possibly causing bodily injury and property damage.

10. Inspect the yoke tips. The tips must be flush with the ends of the locks, or extend no more than 1/32 inch (0.8 mm) beyond. See **Fig. 6**.
    - 10.1 If the yoke tips fall short (**Fig. 7**), use a belt sander or disk grinder to grind the outside surfaces of the yoke until it fits precisely into place. See **Fig. 8**.
    - 10.2 If the yoke tips extend beyond the ends of the locks, build up the outer surfaces of the yoke using a low hydrogen E70XX welding rod. See **Fig. 9**. After welding, grind the beads smooth.
11. The outside of each yoke tip has two contact areas. Check that all four surfaces have full area contact with the top plate ribs (**Fig. 10**) after welding and grinding.
12. Continue welding, grinding, and fitting until the yoke has full contact and the yoke tips are flush with the ends of the locks.
13. Apply a coat of light grease to both the inside and outside friction surfaces of the yoke, then slide the yoke into the top plate with the threaded hole facing up.
14. Install the spring (**Fig. 1**) between the yoke and the top plate. Insert the yoke shank through the

Model XA–3501 Top Plate Assembly and Installation



A. Release Arm Cam Profile
B. Release Arm Pivot Hole
C. Hole for Attachment of Release Handle
D. Guide Hole for Right-Hand Release
E. Hole for Left-Hand Manual Secondary Lock Handle
F. Right-Hand Secondary Lock Anchor Hole
G. Left-Hand Secondary Lock Anchor Hole
H. Hole for Right-Hand Manual Secondary Lock Handle
I. Guide Hole for Left-Hand Release
J. Lockpin Holes
K. For Right-Hand Release
L. For Left-Hand Release
M. For Models With Secondary Lock
N. For Models With Lockpin Bushings
O. Accessories

1. Capscrew, 5/8–18 x 1-3/4
2. Flatwasher, 5/8" i.d.
3. Roller
4. Washer, 5/8" i.d.
5. Capscrew, 1/2–20
6. Washer, 1-3/4" o.d. x 9/16" i.d.
7. Roller
8. Release Arm (Cam Plate)
9. Washer, 1-3/4" o.d. x 13/16" i.d.
10. Locknut, 1/2–20
11. Locknut, 3/4–16
12. Washer, 1-1/2" o.d. x 13/16" i.d.
13. Rubber Block
14. Lock Adjustment Tag
15. Yoke Shank
16. Yoke Shank Spring
17. Yoke Subassembly
18. Grease Fitting
19. Mounting Bracket
20. Roll Pin
21. Bracket Pin
22. Rubber Bushing
23. Cotter Pins, 1/4" x 2"
24. Lockpins
25. Lock Jaws
26. Fifth Wheel Top Plate
27. Lockguard Pin
28. Lockguard Torsion Spring
29. Lockguard
30. Cotter Pins, 1/8" x 1"
31. Rubber Bushing
32. Bracket Pin
33. Roll Pin
34. Mounting Bracket
35. Grease Fitting
36. Secondary Lock Torsion Spring
37. Roll Pin
38. Right-Hand Secondary Lock
39. Right-Hand Release Handle
40. Washer, 1-3/4" o.d. x 9/16" i.d.
41. Left-Hand Secondary Lock
42. Left-Hand Release Handle
43. Washer, 1-3/4" o.d. x 9/16" i.d.
44. Manual Secondary Lock Handle
45. Manual Secondary Lock
46. Lockpin Bushings, 2
47. Lockpin Bushing, 2
48. Roll Pin, 2
49. Kingpin Gauge
50. Plug, 2"
51. Kingpin Lock Tester

Fig. 1, Holland 3500 Series XA-3501 Fifth Wheel and Accessories (bottom view)

Model XA–3501 Top Plate Assembly and Installation

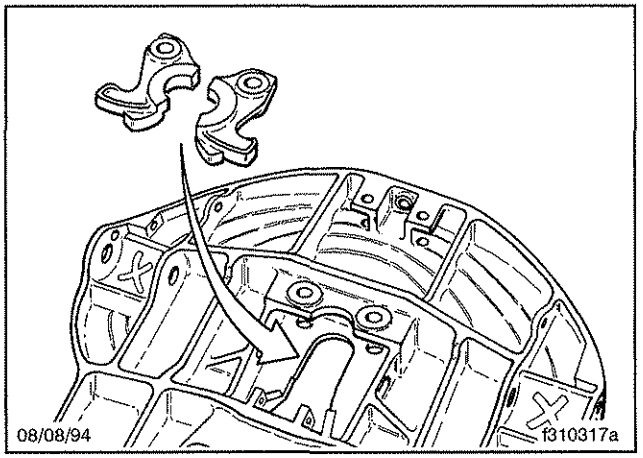


Fig. 2, Place the Lock Jaws

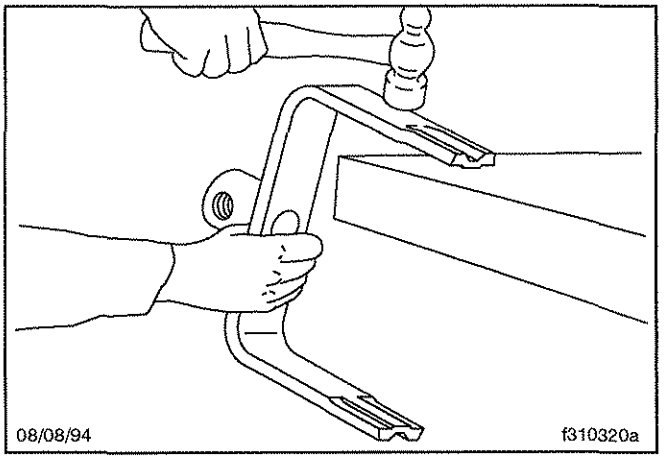


Fig. 5, Strike the Yoke

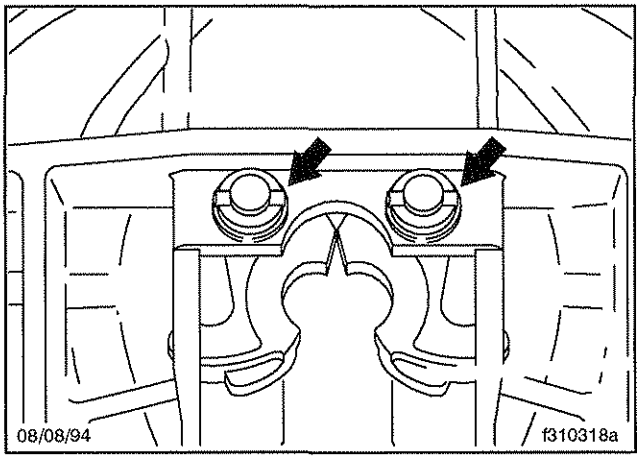


Fig. 3, Roll Pins Used

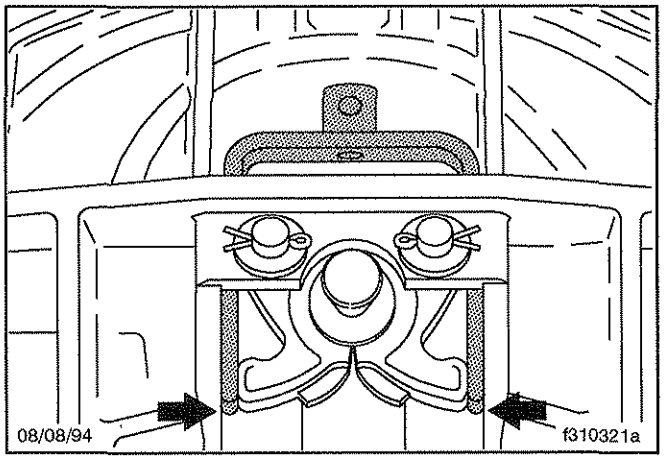


Fig. 6, Inspect the Tips

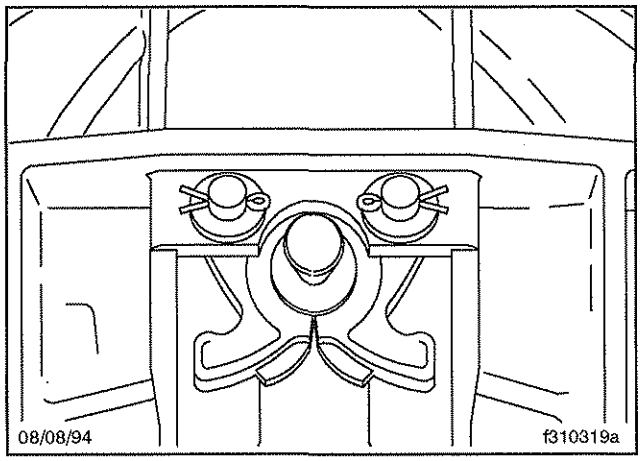


Fig. 4, Plug in the Lock Jaws

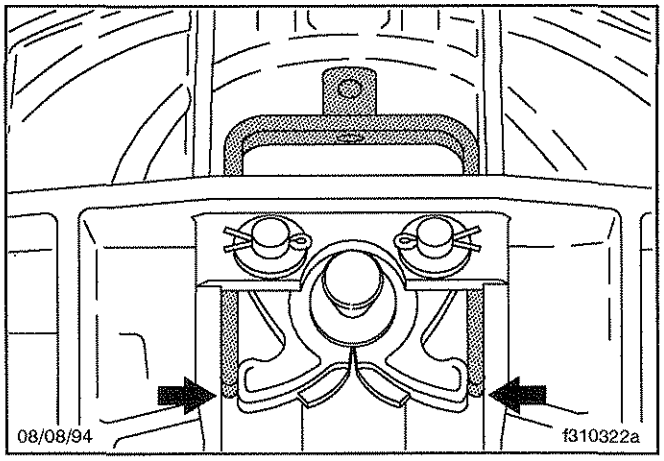
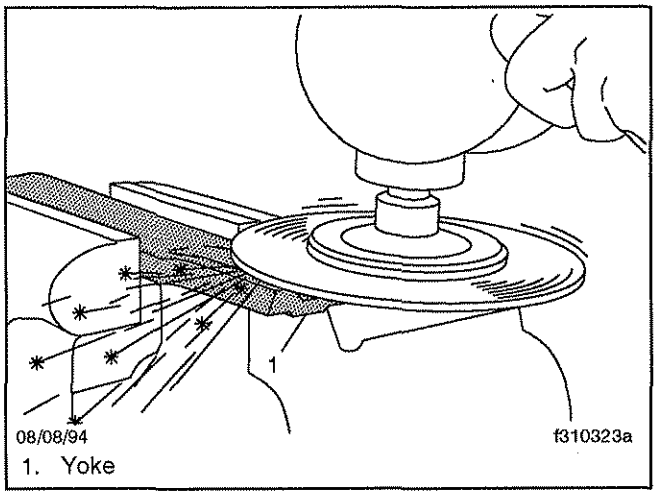


Fig. 7, Yoke Tips Fall Short

Model XA–3501 Top Plate Assembly and Installation



1. Yoke

Fig. 8, Grind the Yoke

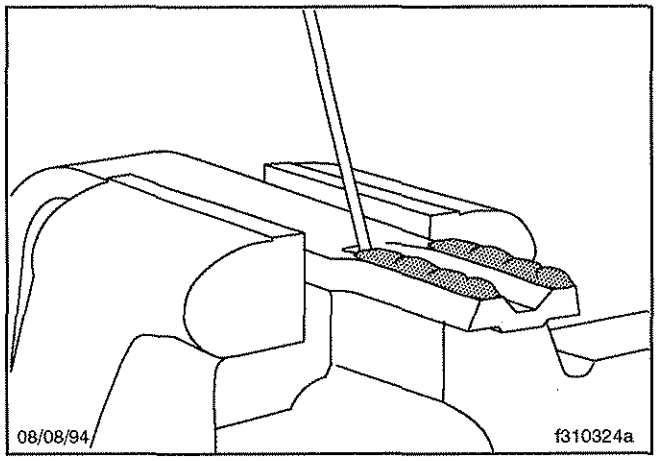


Fig. 9, Build Up the Yoke

top plate and spring, then into the yoke. Make sure that the predrilled recess in the yoke shank aligns with the threaded hole in the yoke.

15. Install the lock adjustment tag, the rubber block, a 13/16-inch i.d. steel washer, and the 3/4-inch locknut in the order stated.
16. Install the 9/16-inch i.d. washer on the release handle as shown in **Fig. 1**.
17. Pass the open end of the release handle through the guide hole (Ref. D for models with right-hand release, Ref. I for models with left-hand release) toward the outside of the top plate.

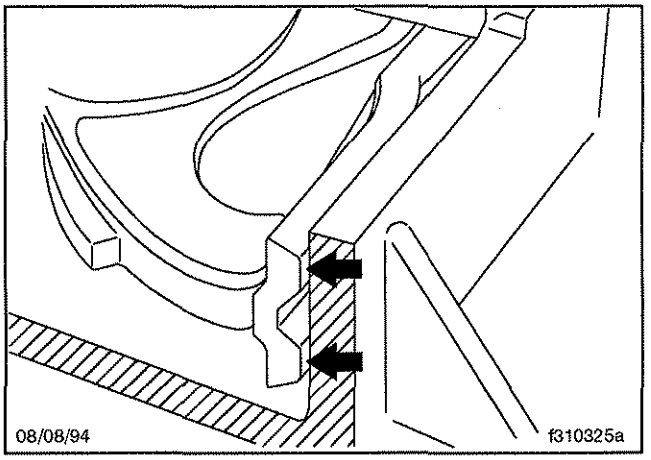


Fig. 10, Contact with Top Plate

18. Inspect the release arm (cam plate) for burrs or rough edges in the cam profile (Ref. A). Remove any burrs or rough edges.
19. Apply a light coat of grease to the cam profile and pivot holes.
20. Insert the "S" end of the release handle through the small hole in the release arm (cam plate).
21. Place the release arm (cam plate) on the top plate so that the cam profile (**Fig. 11**, Ref. A) is over the hole in the yoke and the large hole (Ref. B) is over the lug in the top plate opposite the release handle.
22. Slide a 9/16-inch i.d. flatwasher between the plate lug and the release arm with the rounded edge towards the cam. See **Fig. 12**.

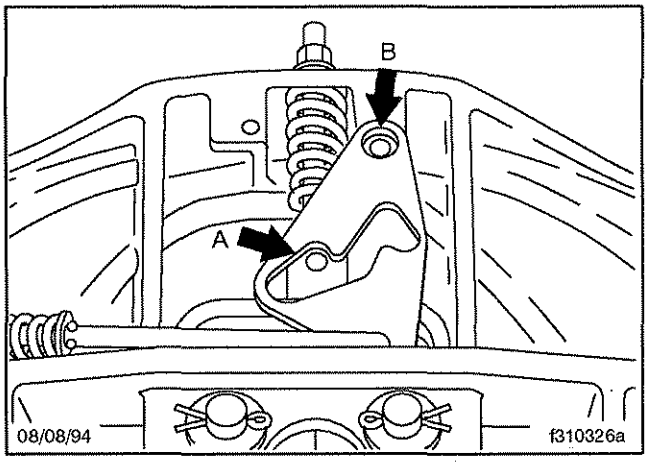


Fig. 11, Place the Release Arm

Model XA–3501 Top Plate Assembly and Installation

23. Install the 1/2-inch i.d. roller (**Fig. 1**) in the large hole of the release arm.
24. Place a second 9/16-inch i.d. flatwasher over the release arm. Make sure the rounded edge of the washer faces the cam.
25. Install the 1/2-inch diameter capscrew through the washers, roller, and hole in the top plate lug (Ref. G for right-hand release models, Ref. F for left-hand release models).
26. Secure the capscrew with a 1/2-inch locknut. Tighten the locknut; then, check that the release arm moves freely.
27. Place a 5/8-inch i.d. washer between the yoke and the release arm. Make sure that the rounded edge of the washer faces the release arm.
28. Insert the 5/8-inch i.d. roller in the release arm opening.
29. Install the second 5/8-inch i.d. washer on top of the release arm.
30. Pass the 5/8-inch diameter capscrew through the assembly. Be certain that the bolt passes through the yoke and into the recess in the yoke shank.
31. Tighten the capscrew securely, but make sure the top washer turns freely.
32. Turn the nut on the yoke shank clockwise until the yoke just begins to move.
33. Check the plug (Holland part number TF–0237). It should fit snugly in the locks, but you should be able to turn it with some force.
34. On models with an automatic secondary lock assembly, proceed as follows:
    - 34.1 Start the roll pin into the hole in the top plate lug opposite the release arm anchor capscrew.
    - 34.2 Install the torsion spring on the secondary lock, and position them on the lug. Be sure the open end of the spring faces toward the rib of the lug. See **Fig. 13**.
    - 34.3 While holding the parts in place, drive the roll pin until it is flush with the lug.
    - 34.4 Check the spring tension on the secondary lock. Check that the lock moves freely.
35. On models with a manual secondary lock assembly, proceed as follows:
    - 35.1 Pass the end of the manual secondary lock handle (**Fig. 1**) through the hole (Ref. E for right-hand release, Ref. H for left-hand release).
    - 35.2 Attach the handle to the secondary lock.
    - 35.3 Start the roll pin into the hole in the top plate lug opposite the release arm anchor capscrew.
    - 35.4 Install the torsion spring on the secondary lock, and place them in position on the lug. Be sure the open end of the spring faces toward the rib of the lug. See **Fig. 13**.
    - 35.5 While holding the parts in place, drive the roll pin until it is flush with the lug.
    - 35.6 Check the spring tension on the secondary lock. Check that the lock moves freely.
36. Pull the release handle, remove the plug, and pry open the lock jaws.

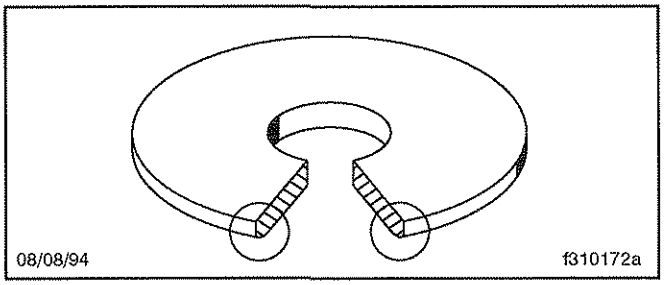


Fig. 12, Rounded Edge

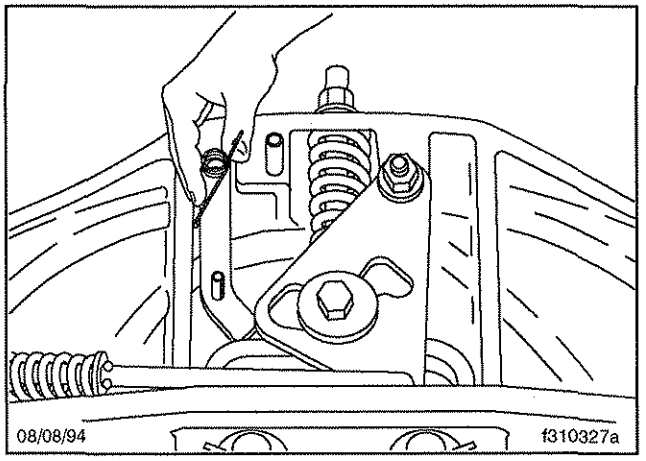


Fig. 13, Torsion Spring Installation

Model XA–3501 Top Plate Assembly and Installation

37. Assemble the lockguard and the torsion spring.
38. Mount the lockguard using the lockguard pin and cotter pins. See **Fig. 14**.
39. Check the spring tension on the lockguard. Check that the lockguard moves freely.
40. Check the adjustment. The tip of the guard should be even with the edge of the 2-inch bore in the lock jaw. See **Fig. 15**.
41. Adjust the lockguard position by supporting the end of the guard with a short piece of steel placed between the locks and the lock-guard. Tap the center of the guard to adjust it. See **Fig. 16**.

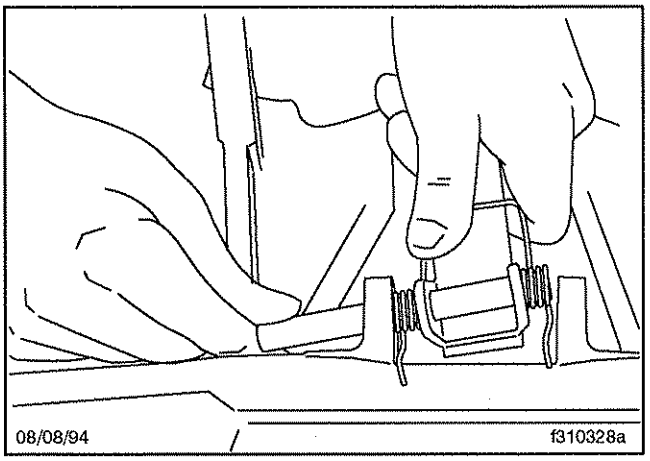


Fig. 14, Mount the Lockguard

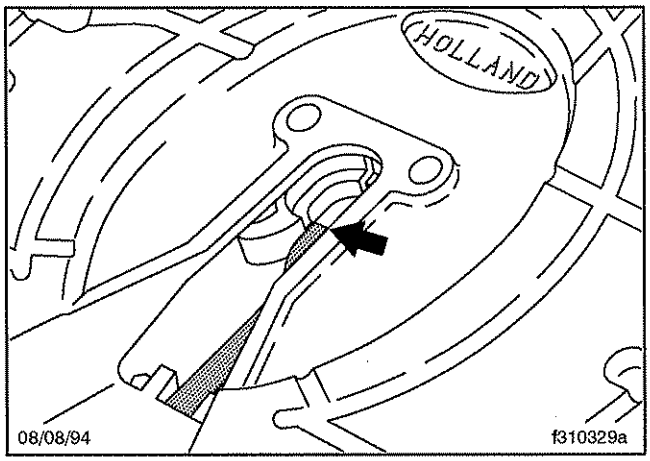


Fig. 15, Check the Guard

42. Using a Holland Lock Tester, close the locks. For instructions, refer to Holland Publication FW 130. Make sure that the locking mechanism functions properly. See **Fig. 17**. If the fifth wheel does not operate properly, repeat the above procedures or contact your local Holland representative for assistance.

IMPORTANT: The fifth wheel must be well lubricated to operate correctly. See **Group 31** in the vehicle maintenance manual, for complete maintenance and lubrication instructions of the fifth wheel assembly.

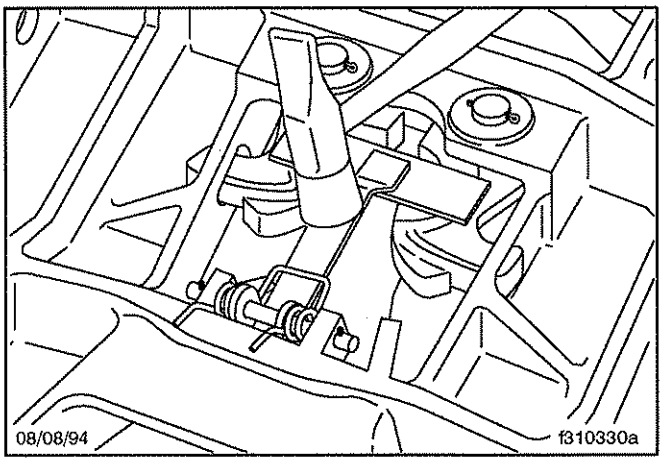


Fig. 16, Adjust the Guard

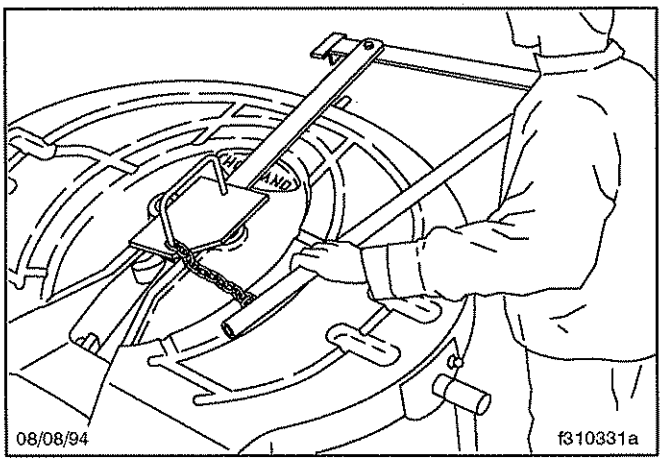


Fig. 17, Using the Lock Tester

Model XA–3501 Top Plate Assembly and Installation

⚠ WARNING

If the fifth wheel does not operate properly, do not use it. The fifth wheel could malfunction, resulting in bodily injury or property damage due to possible separation of the trailer from the tractor.

43. Using an overhead hoist, position the fifth wheel on the sliding mount assembly. Insert the bushing pins. Then install the roll pins.

Model XA–351 Top Plate Removal and Disassembly

⚠ WARNING

All fifth wheel maintenance, adjustment, and rebuilding must be done only by a qualified mechanic. Improper or incomplete procedures could result in loss of trailer connection during vehicle travel, possibly causing bodily injury and property damage.

Fifth wheel rebuild kits are available for servicing the 3500 series XA–351 fifth wheels. For the rebuild kits, the part numbers include:

- RK–351AL (left release with automatic secondary lock);
- RK–351A02L (left release with manual secondary lock);
- RK–351A (right release with automatic secondary lock);
- RK–351A02 (right release with manual secondary lock).

These fifth wheel rebuild kits contain all the replacement parts, except: the fifth wheel top plate; the bracket assembly rubber bushings; the bracket assembly bushing pins; and the bracket assembly bushing pin capscrews and locknuts.

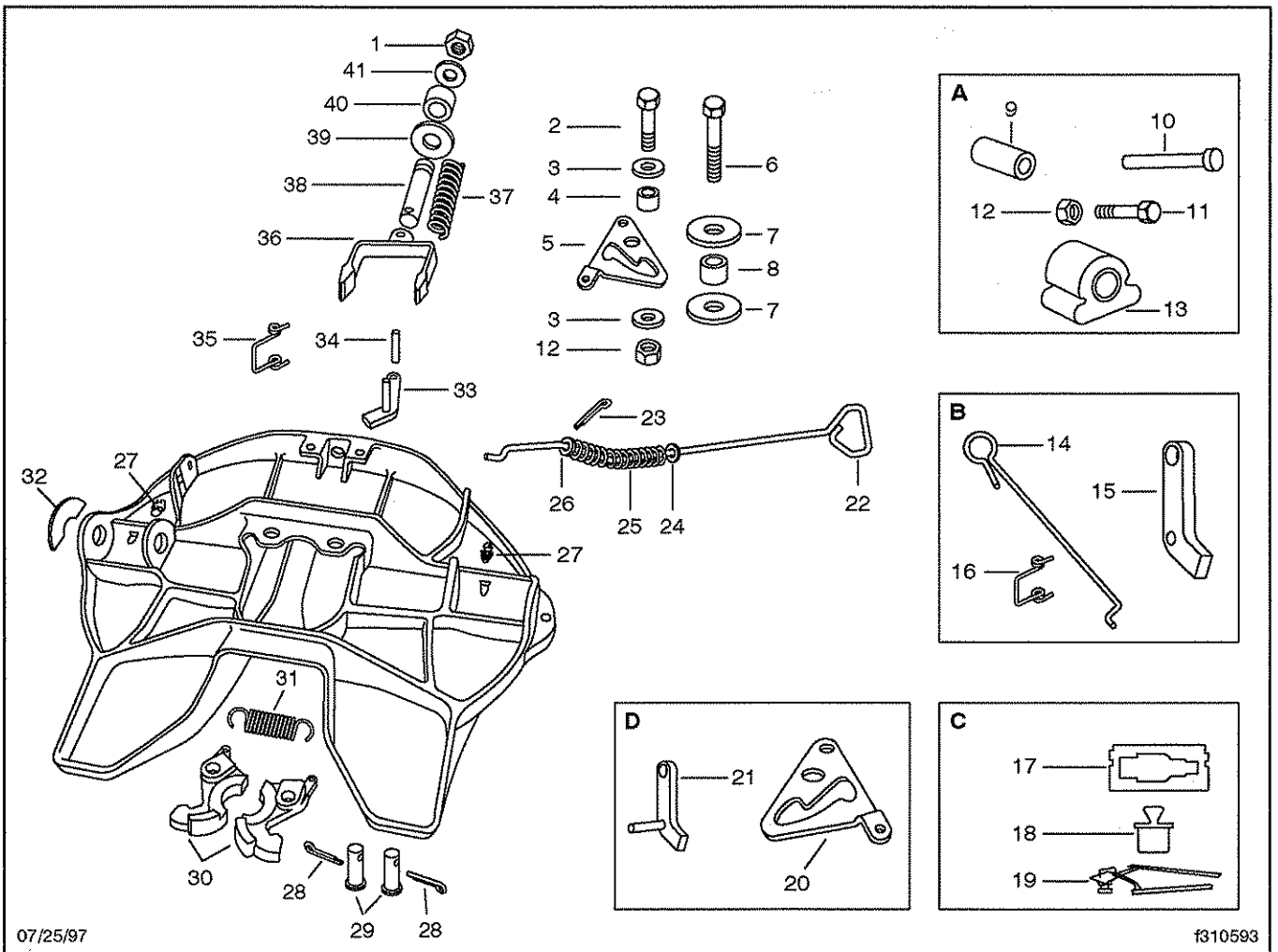
Rebuilding the fifth wheel may be unnecessary. Review the troubleshooting section before rebuilding the fifth wheel. If the troubleshooting section does not correct the problem, then the fifth wheel may need rebuilding.

While disassembling the fifth wheel, Check it for cracks and for missing or damaged parts. Discard all used components.

Removal and Disassembly (See Fig. 1)

1. Steam clean the top plate.
2. Remove the top plate from the bracket assembly.
   - 2.1 Loosen and remove the 1/2–20 bushing pin capscrews and locknuts from the top plate.
   - 2.2 Remove the bushing pins from the bracket assembly. See **Fig. 2**.
   - 2.3 Using an overhead hoist, lift the fifth wheel from the bracket assembly and tractor frame.
3. Disassemble the secondary lock.
   - 3.1 Turn the fifth wheel upside down with the locks open.
   - 3.2 Using a suitable driver and hammer, drive the 1/2-inch by 2-3/4 inch roll pin from the top plate and the secondary lock. See **Fig. 3**.
   - 3.3 If the fifth wheel has an automatic secondary lock, proceed to the next substep, otherwise, remove the manual secondary release handle by passing the "S" bend of the release handle through the large hole in the secondary lock and then through the guide hole. See **Fig. 4**.
   - 3.4 Remove the secondary lock.
4. Disassemble the cam plate.
   - 4.1 Loosen and remove the 5/8-inch capscrew from the threaded hole in the yoke. Remove the washers, and the roller from the cam plate. See **Fig. 5**.
   - 4.2 Loosen and remove the 1/2-inch capscrew and nut from the top plate lug. Remove the washers, and the roller from the cam plate. See **Fig. 6**.
   - 4.3 Remove the release handle by passing the "S" bend of the release handle through the large hole in the raised tab of the cam plate and through the top plate casting hole. See **Fig. 6**.
5. Disassemble the yoke.
   - 5.1 Slide the yoke shaft assembly away from the yoke, through the compression spring, and out of the top plate casting. See **Fig. 7**.
   - 5.2 Remove the compression spring and remove the yoke.
6. Disassemble the lock.
   - 6.1 Remove the cotter pins from the lockpins.
   - 6.2 Using a suitable driver and hammer, drive the lockpins out of the casting. See **Fig. 8**.

Model XA–351 Top Plate Removal and Disassembly

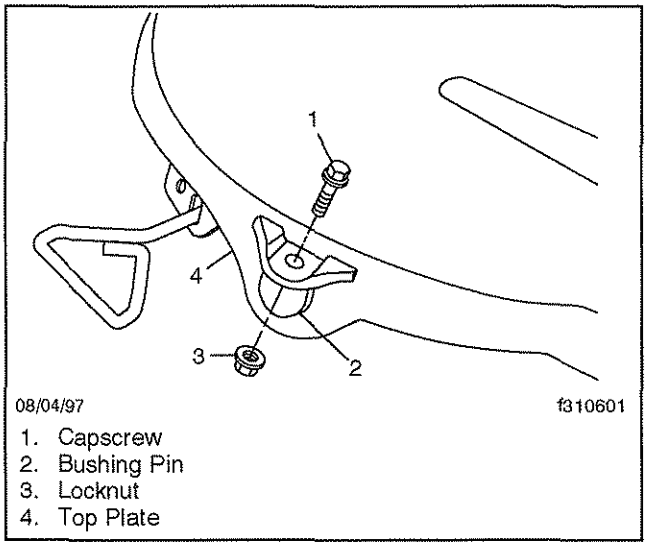


A. Bushing Pin Assembly
B. Manual Secondary Lock Assembly
C. Fifth Wheel Accessories
D. Right Hand Secondary Lock Assembly

1. Locknut, 3/4–16
2. Capscrew, 1/2–20 x 1–3/4)
3. Washer, 1–3/4" o.d. x 9/16" i.d.
4. Roller, 1/2" i.d.
5. Cam Plate (left-hand)
6. Capscrew, 5/8–18 x 3/4
7. Washer, 2–5/8 x 21/32
8. Roller, 5/8" i.d.
9. Rubber Bushing (brackets manufactured prior to 5/82)
10. Bracket Bushing Pin
11. Capscrew, 1/2–20 x 1–1/4
12. Locknut, 1/2–20
13. Rubber Bushing (brackets manufactured after 5/82)
14. Manual Secondary Lock Release Handle
15. Manual Secondary Lock
16. Torsion Spring
17. Kingpin Gauge
18. 2" Lock Gauge (Plug)
19. Kingpin Lock Tester
20. Cam Plate (right-hand)
21. Secondary Lock (right-hand)
22. Release Handle
23. Cotter Pin, 1/8 x 1–1/4
24. Washer, 1–3/8" o.d. x 9/16" i.d.
25. Compression Spring
26. Washer, 1–1/16" o.d. x 5/8" i.d.
27. Grease Zerk
28. Cotter Pin, 1/4 x 2
29. Lockpin
30. Lock Jaw Set
31. Extension Spring
32. Operation Tag
33. Secondary Lock (left-hand)
34. Roll Pin, 1/2 x 2–3/4
35. Torsion Spring
36. Yoke
37. Compression Spring
38. Yoke Shaft
39. Lock Adjustment Tag
40. Rubber Washer
41. Washer 1–1/2" o.d. x 13/16" i.d.

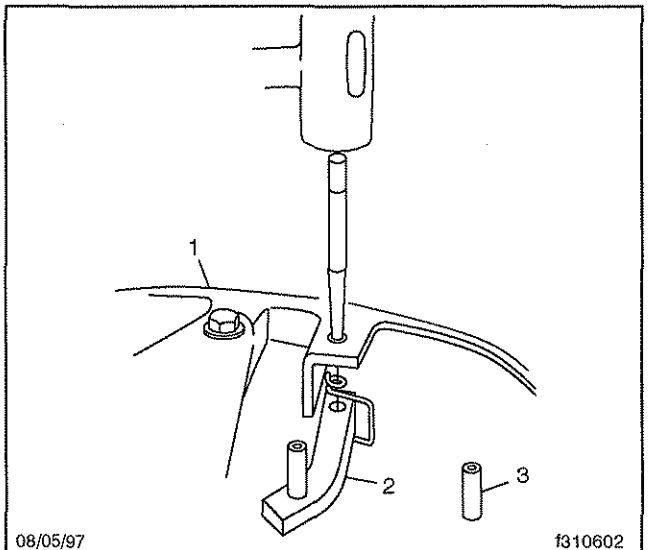
Fig. 1, Holland 3500 Series XA-351 Fifth Wheel and Accessories (bottom view)

Model XA–351 Top Plate Removal and Disassembly



1. Capscrew
2. Bushing Pin
3. Locknut
4. Top Plate

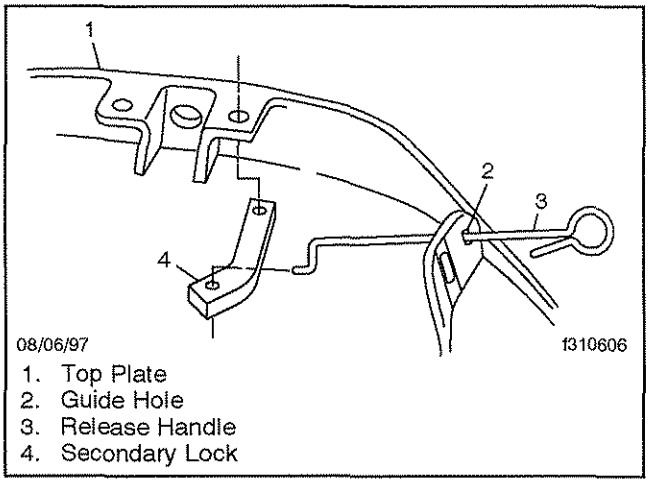
Fig. 2, Remove the Bushing Pin



1. Top Plate
2. Secondary Lock
3. Roll Pin

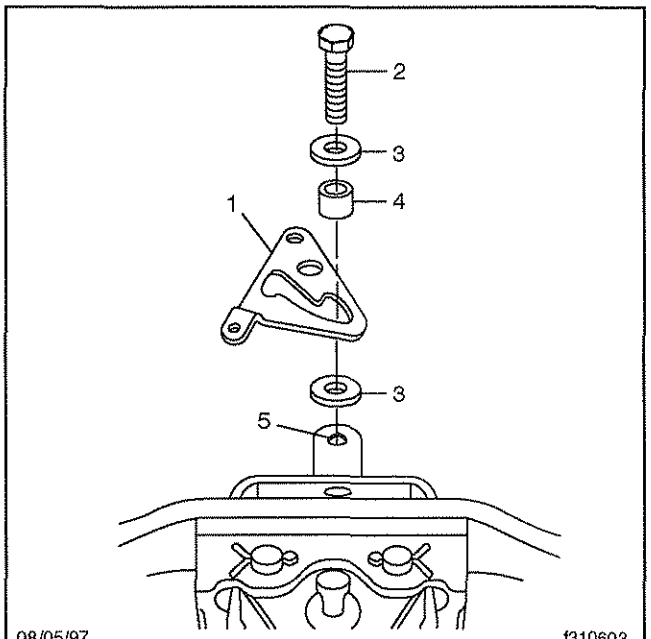
Fig. 3, Disassemble the Secondary Lock

This will free the lock jaws assembly. Remove the lock jaws and lock spring.



1. Top Plate
2. Guide Hole
3. Release Handle
4. Secondary Lock

Fig. 4, Remove the Release Handle



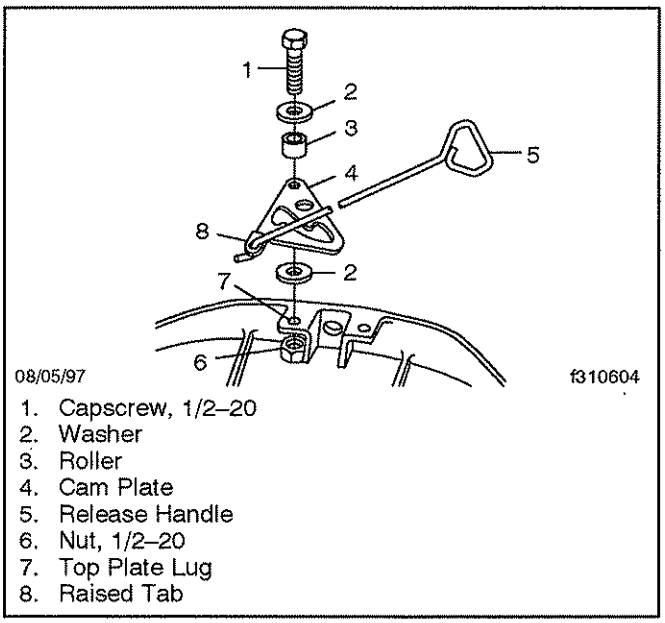
1. Cam Plate
2. Capscrew, 5/8–20
3. Washer
4. Roller
5. Threaded Hole In Yoke

Fig. 5, Remove the Capscrew From the Yoke

⚠ WARNING

Do not attempt to repair or rebuild the top plate if it is cracked or if the lockpin does not fit

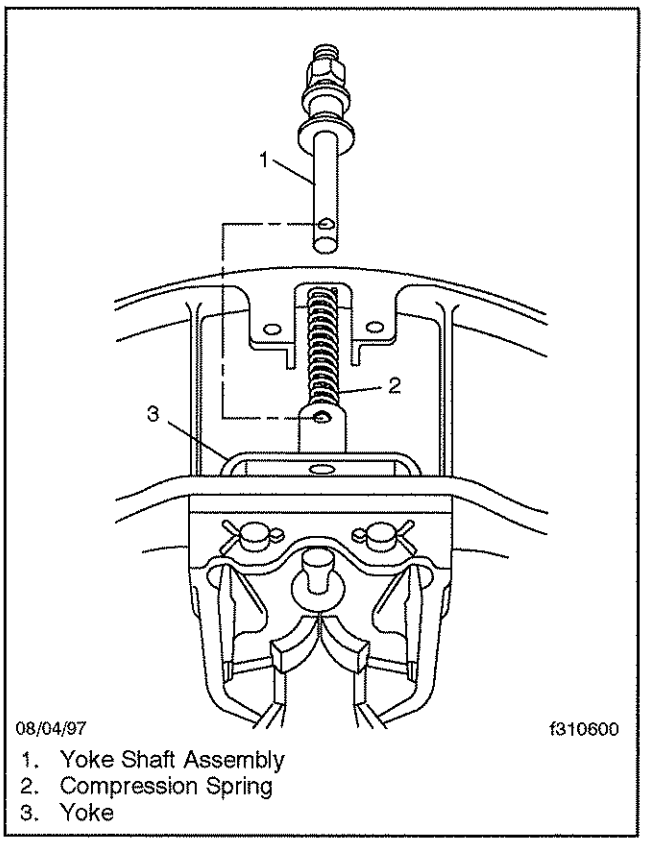
Model XA–351 Top Plate Removal and Disassembly



1. Capscrew, 1/2–20
2. Washer
3. Roller
4. Cam Plate
5. Release Handle
6. Nut, 1/2–20
7. Top Plate Lug
8. Raised Tab

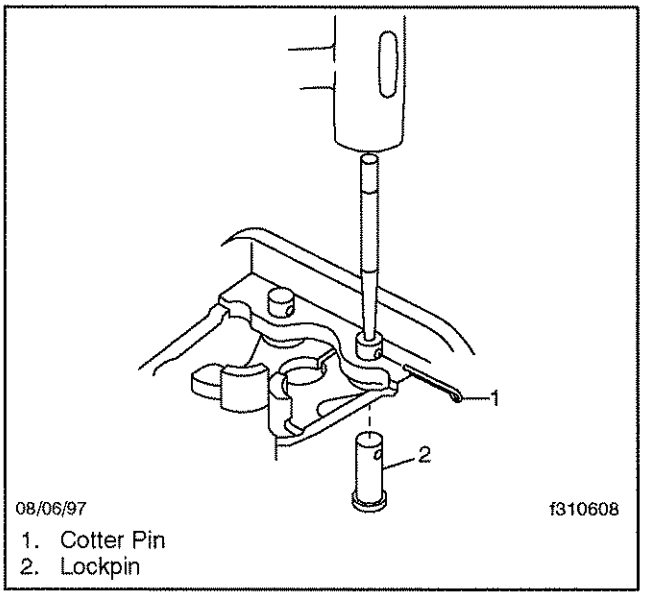
Fig. 6, Disassemble the Cam Plate

tightly. The top plate could fail or the locks could malfunction. This could result in loss of trailer connection during vehicle travel, possibly causing bodily injury and property damage.



1. Yoke Shaft Assembly
2. Compression Spring
3. Yoke

Fig. 7, Remove the Yoke Shaft Assembly



1. Cotter Pin
2. Lockpin

Fig. 8, Remove the Lockpins

Model XA–351 Top Plate Assembly and Installation

⚠ WARNING

All fifth wheel maintenance, adjustment, and rebuilding must be done only by a qualified mechanic. Improper or incomplete procedures could result in loss of trailer connection during vehicle travel, possibly causing bodily injury and property damage.

Fifth wheel rebuild kits are available for servicing the 3500 series XA–351 fifth wheels. For the rebuild kits, the part numbers include:

- RK–351AL (left release with automatic secondary lock);
- RK–351A (right release with automatic secondary lock);
- RK–351A02L (left release with manual secondary lock);
- RK–351A02 (right release with manual secondary lock).

These fifth wheel rebuild kits contain all the replacement parts, except: the fifth wheel top plate; the bracket assembly rubber bushings; the bracket assembly bushing pins; and the bracket assembly bushing pin capscrews and locknuts.

Review the troubleshooting section before rebuilding the fifth wheel. Rebuilding may be unnecessary.

IMPORTANT: Use only Holland rebuilding kits. Replace all roll pins, springs, capscrews, nuts, and washers that are included in the kit. Do not reuse all parts.

⚠ WARNING

Use only genuine Holland parts and do not modify, change or add to the product. Any alterations to the fifth wheel assembly could compromise its performance. This could result in the loss of the trailer connection during vehicle travel, possibly causing bodily injury and property damage.

Assembly and Installation (See Fig. 1)

⚠ WARNING

Do not attempt to repair or rebuild the top plate if it is cracked or distorted or if the lockpin does not fit tightly. The top plate could fail or the locks could malfunction. This could result in loss of trailer connection during vehicle travel, possibly causing bodily injury and property damage.

1. Inspect the top plate.
   - 1.1 If necessary, turn the fifth wheel upside down.
   - 1.2 Inspect the front lock surface for burrs or cracks. See **Fig. 2**. The front lock surface must be free of any burrs or cracks.
2. Install the lock.
   - 2.1 Lubricate the lockpin holes of the lock jaws with Never-Seez (provided in the kit). See **Fig. 3**.

⚠ CAUTION

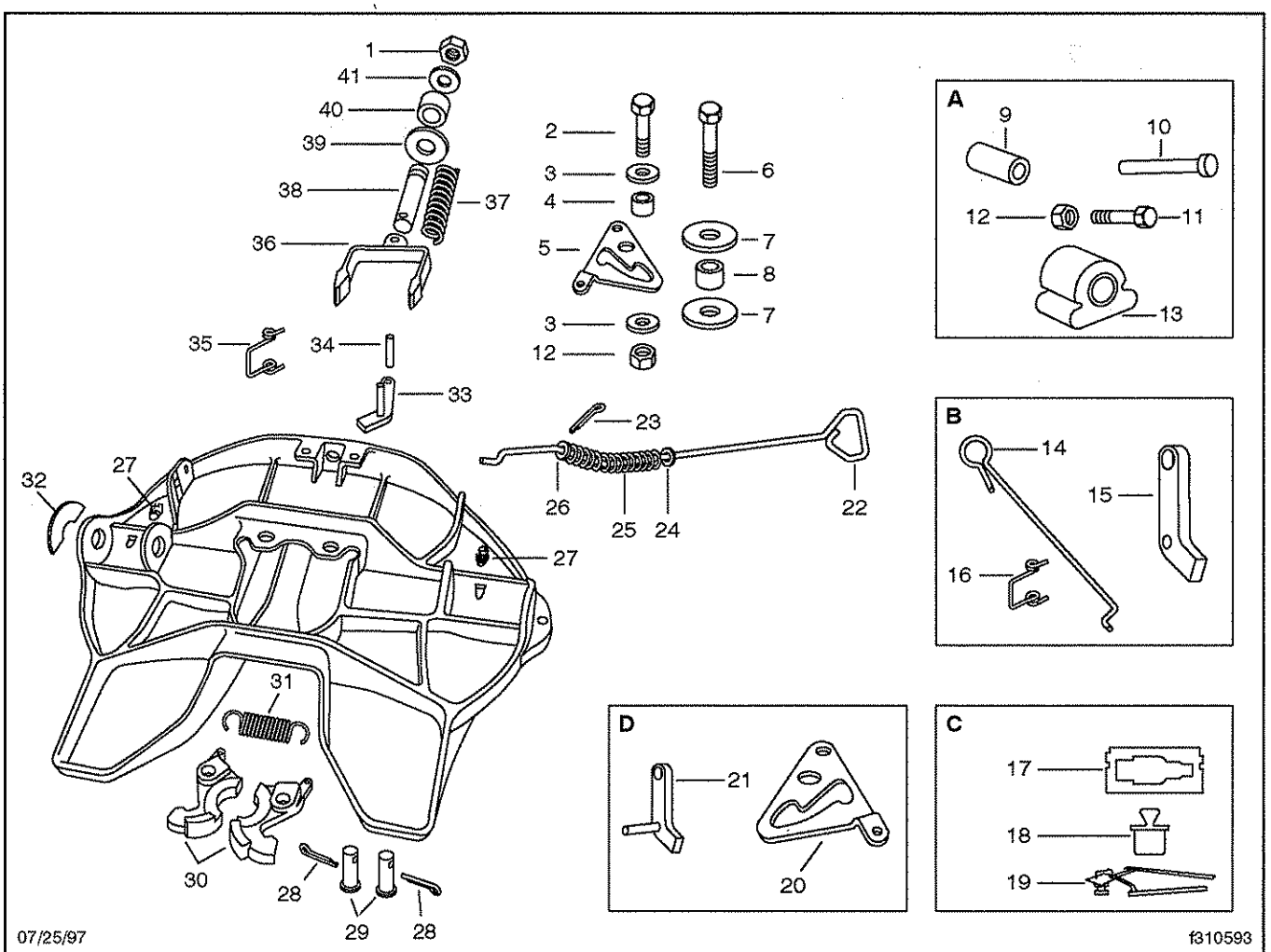
Use only Never-Seez. Other lubricants can damage the lockpin holes.

   - 2.2 Align the lock jaws in the casting and position the lock jaws so that the raised edge of the kingpin guides are facing up. See **Fig. 4**.
   - 2.3 Align the holes in the lockpins so that the cotter pins can be inserted. Insert the lockpins into the casting and through the lock jaws. Using a suitable hammer, drive the lockpins into the casting until the heads are flush with the casting. See **Fig. 5**.
   - 2.4 Insert the cotter pins and spread.
   - 2.5 Check that the lock jaws move freely.

⚠ WARNING

You must use a Holland lock gauge (TF–0237) or a precision plug that is 2.000 ± 0.005 inch (5.08 ± 0.0127 cm) for proper installation of the locking

Model XA–351 Top Plate Assembly and Installation



A. Bushing Pin Assembly
B. Manual Secondary Lock Assembly
C. Fifth Wheel Accessories
D. Right Hand Secondary Lock Assembly

1. Locknut, 3/4–16
2. Capscrew, 1/2–20 x 1–3/4
3. Washer, 1–3/4" o.d. x 9/16" i.d.
4. Roller, 1/2" i.d.
5. Cam Plate (left-hand)
6. Capscrew, 5/8–18 x 3/4
7. Washer, 2–5/8 x 21/32
8. Roller, 5/8" i.d.
9. Rubber Bushing (brackets manufactured prior to 5/82)
10. Bracket Bushing Pin
11. Capscrew, 1/2–20 x 1–1/4
12. Locknut, 1/2–20
13. Rubber Bushing (brackets manufactured after 5/82)
14. Manual Secondary Lock Release Handle
15. Manual Secondary Lock
16. Torsion Spring
17. Kingpin Gauge
18. 2" Lock Gauge (Plug)
19. Kingpin Lock Tester
20. Cam Plate (right-hand)
21. Secondary Lock (right-hand)
22. Release Handle
23. Cotter Pin, 1/8 x 1–1/4
24. Washer, 1–3/8" o.d. x 9/16" i.d.
25. Compression Spring
26. Washer, 1–1/16" o.d. x 5/8" i.d.
27. Grease Zerk
28. Cotter Pin, 1/4 x 2
29. Lockpin
30. Lock Jaw Set
31. Extension Spring
32. Operation Tag
33. Secondary Lock (left-hand)
34. Roll Pin, 1/2 x 2–3/4
35. Torsion Spring
36. Yoke
37. Compression Spring
38. Yoke Shaft
39. Lock Adjustment Tag
40. Rubber Washer
41. Washer, 1–1/2" o.d. x 13/16" i.d.

Fig. 1, Holland 3500 Series XA-351 Fifth Wheel and Accessories (bottom view)

Model XA–351 Top Plate Assembly and Installation

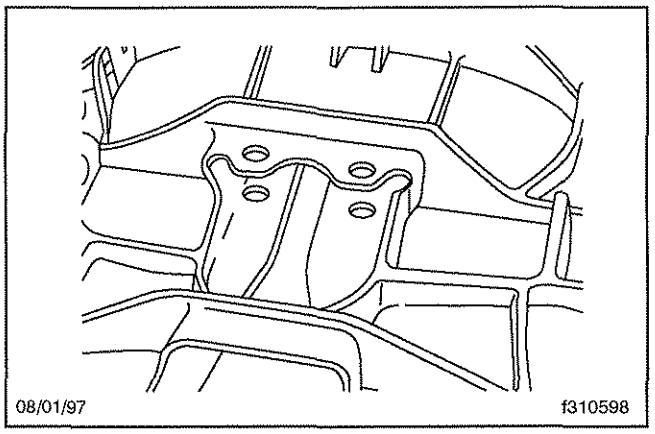


Fig. 2, Front Lock Surface Inspection

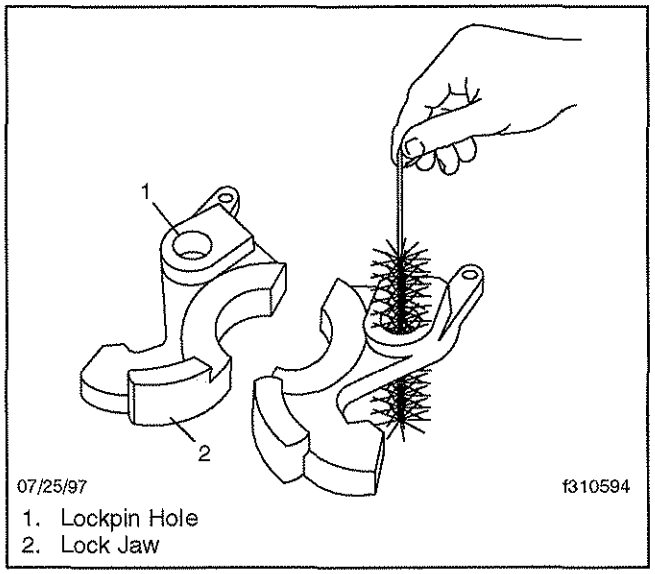


Fig. 3, Lubricate the Lockpin Holes

mechanism. If the proper plug is not used, the lock could malfunction or fail. This could result in the loss of the trailer connection during vehicle travel, possibly causing personal injury and property damage.

2.6 Position a 2-inch (5.08 cm) diameter "plug" into the lock jaws. See **Fig. 6**. A lock gauge, Holland part number TF–0237 is available at a Holland distributor.

3. Install the yoke.

3.1 Lubricate the surface area of the yoke tips with light grease. With the threaded hole facing up, slide the yoke into the casting and seat it around the locks. See **Fig. 7**.

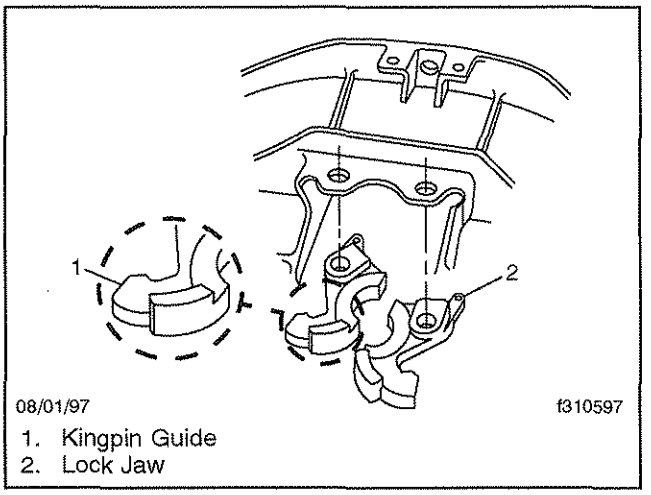


Fig. 4, Align the Lock Jaws

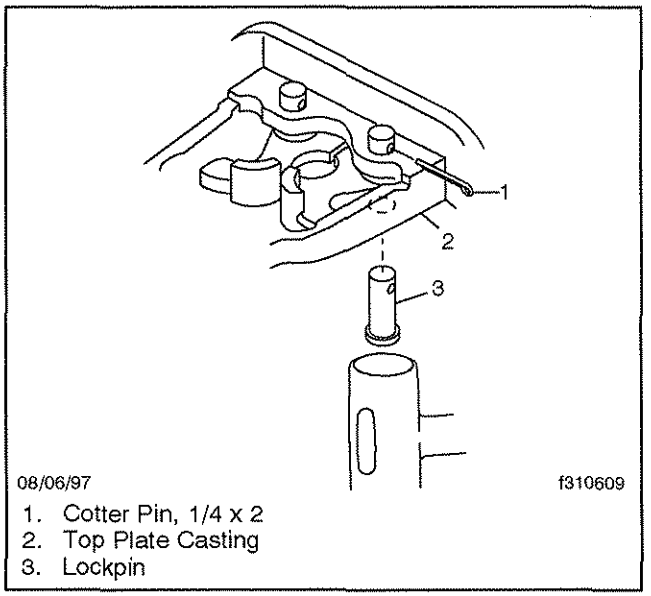
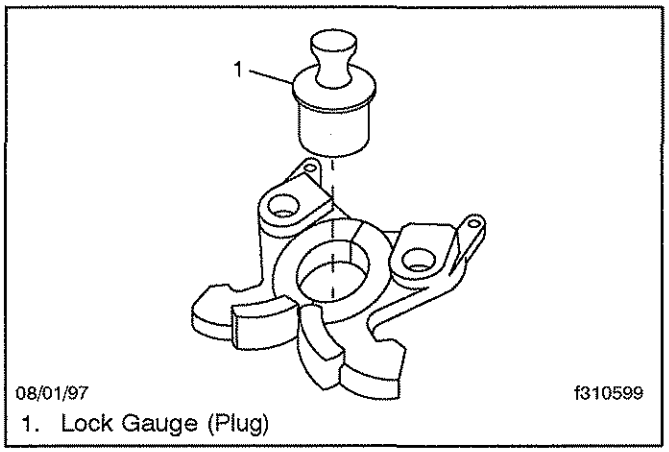


Fig. 5, Install the Lockpins

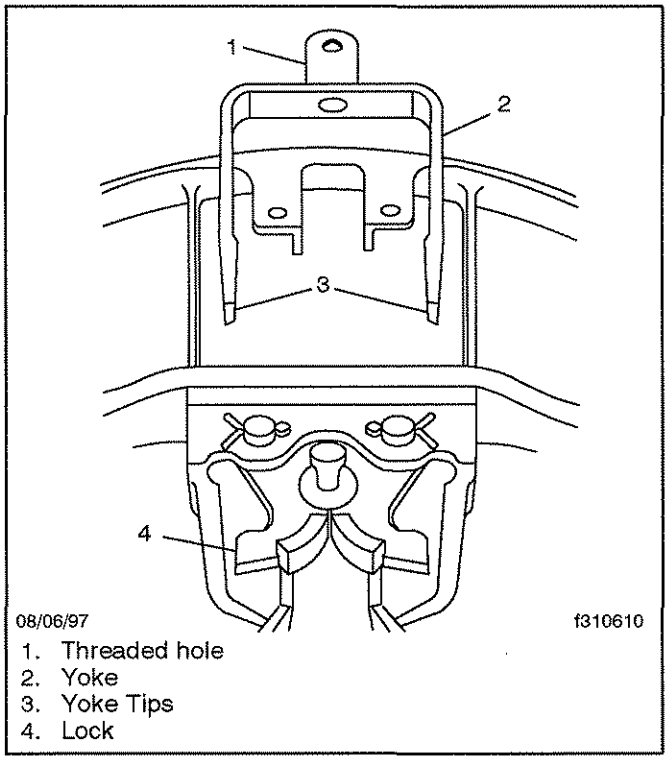
3.2 Inspect the amount of yoke tip engagement. Yoke tips must extend flush with the end of the locks and no more then 1/2 inch (12.7 mm) past the locks. See **Fig. 8**. If the new yoke extends more than 1/2 inch (12.7 mm) past the locks, *do not use it.* Discard it and order

Model XA–351 Top Plate Assembly and Installation



1. Lock Gauge (Plug)

Fig. 6, Install the Lock Gauge



1. Threaded hole
2. Yoke
3. Yoke Tips
4. Lock

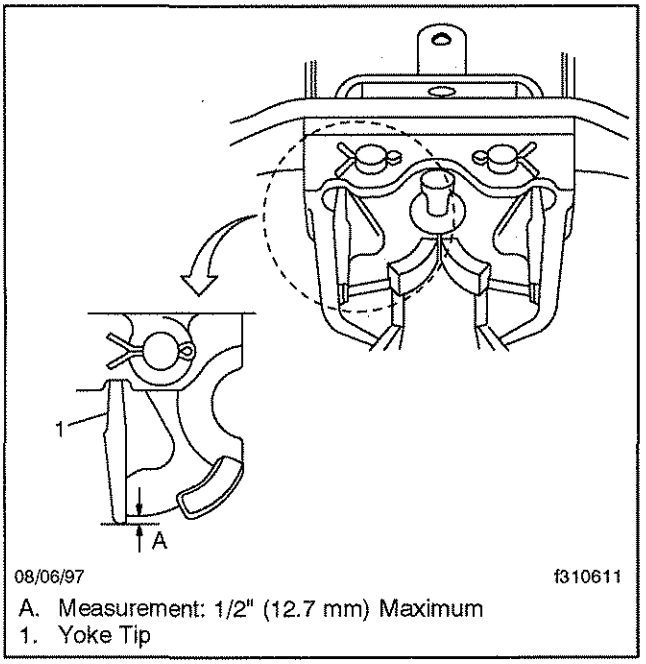
Fig. 7, Install the Yoke

part number XA–07295–THK from your nearest Holland distributor.

3.3 Install the lock spring. See **Fig. 9**.

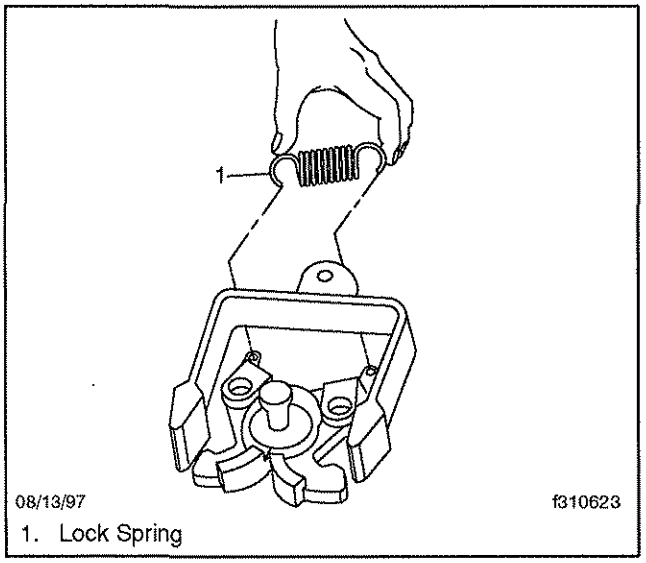
3.4 Install the yoke spring. Slide the yoke shaft into the casting, through the yoke spring and into the yoke. Align the recessed hole in the yoke shaft with the threaded hole in the yoke. See **Fig. 10**.

3.5 In this order, slide the lock adjustment tag, rubber washer, and 1-1/2 inch washer onto



A. Measurement: 1/2" (12.7 mm) Maximum
1. Yoke Tip

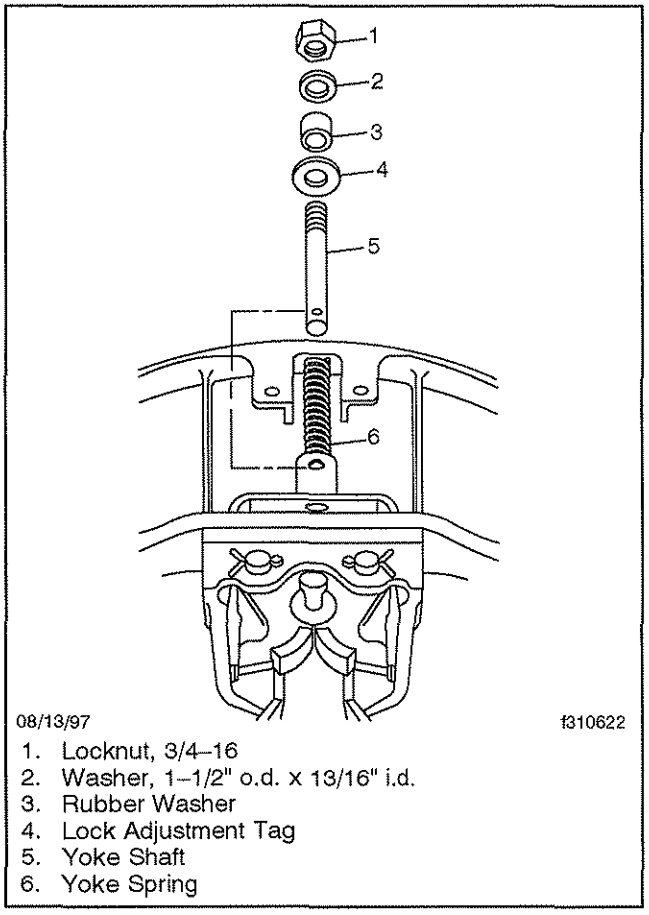
Fig. 8, Measure the Yoke Tip Engagement



1. Lock Spring

Fig. 9, Install the Lock Spring

Model XA–351 Top Plate Assembly and Installation



1. Locknut, 3/4–16
2. Washer, 1–1/2" o.d. x 13/16" i.d.
3. Rubber Washer
4. Lock Adjustment Tag
5. Yoke Shaft
6. Yoke Spring

Fig. 10, Install and Assemble the Yoke Shaft

the yoke shaft. Then, start the locknut and turn it finger tight. See **Fig. 10**

4. Install the release handle.

   4.1 Slide the release handle through the hole in the casting (on the left side for left release or on the right side for right release). See **Fig. 11.**

   4.2 In this order, slide the 1-3/4 inch washer, compression spring, and 1-1/16 inch washer over the "S" bend of the release handle.

   4.3 Compress the spring using the 1-1/16 inch washer until the cotter pin hole is exposed.

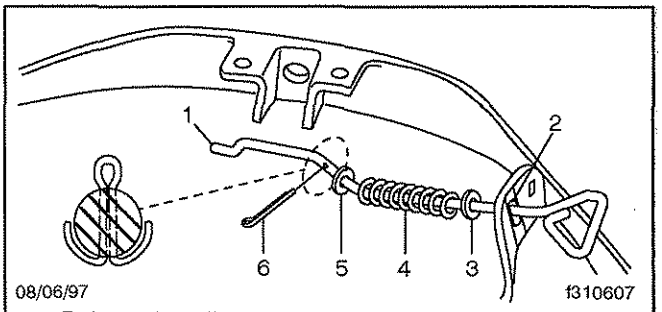
   4.4 Insert the cotter pin; spread it and wrap it completely around the release handle. See **Fig. 11.**

5. Install the cam plate.

   5.1 Inspect the cam plate for burrs and remove as required.

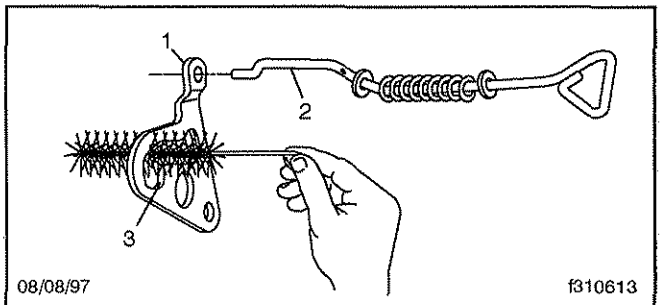
   5.2 Lubricate the cam plate track and pivot hole with light grease. Then connect the raised tab in the cam plate to the "S" bend in the release handle. See **Fig. 12.**

   5.3 Position the cam plate attachment hole over the proper casting lug hole. Then, slide the 1-3/4 inch washer between the cam plate and casting lug hole with the rounded side of the washer facing the cam plate. Then install the 1/2-inch roller into the cam plate and place the second 1-3/4 inch washer on top of the roller with the



1. Release Handle
2. Casting Hole
3. Washer, 1–3/8" o.d. x 9/16" i.d.
4. Compression Spring
5. Washer, 1–1/16" o.d. x 5/8" i.d.
6. Cotter Pin, 1/8 x 1–1/4

Fig. 11, Install the Release Handle



1. Cam Plate Raised Tab
2. Release Handle
3. Cam Plate Track

Fig. 12, Lubricate the Cam Plate

Model XA–351 Top Plate Assembly and Installation

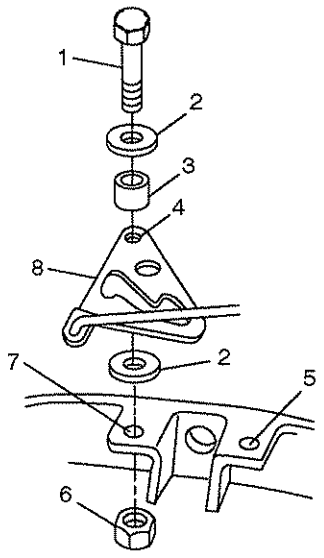
rounded side facing the cam plate. See **Fig. 13**.

5.4 Install the 1/2-inch capscrew through the washers, roller, and top plate lug. Then, secure the capscrew with the 1/2-inch locknut and tighten securely. See **Fig. 13**.

5.5 Check for free movement of the cam plate.

NOTE: When installing the washers, the rounded edge of the washers *must* always face the cam plate.

5.6 Align the cam plate track over the threaded hole in the yoke. Then slide a 2-5/8 inch o.d. washer between the yoke and the cam plate with the rounded side of the washer facing the cam plate. Then place the 5/8-inch roller into the cam plate track and place the second 2-5/8 inch o.d. washer over the roller with the rounded side of the washer facing the cam plate. See **Fig. 14**.



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1. Capscrew, 1/2–20 x 1–3/4
2. Washer, 1–3/4" o.d. x 9/16" i.d.
3. Roller, 1/2" i.d.
4. Cam Plate Attachment Pivot Hole
5. Hole for Right Release
6. Locknut, 1/2–20
7. Hole for Left Release
8. Cam Plate

Fig. 13, Install the Cam Plate

5.7 Check the alignment of the recessed hole in the yoke shaft. Then, install the 5/8-inch capscrew through the washers, roller, and cam plate and into the threaded hole in the yoke. Make sure the capscrew enters the recessed hole in the yoke shaft. Then, tighten the capscrew securely. See **Fig. 14**.

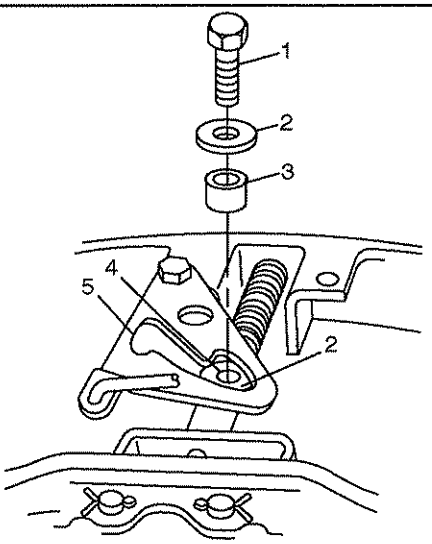
5.8 Check for free movement of the cam plate.

6. Install the secondary lock.

6.1 If equipped with the automatic version, start the roll pin into the hole in the top plate opposite the cam attachment capscrew. Then, assemble and install the secondary lock and torsion spring. Make sure the flats of the torsion spring are resting against the casting. See **Fig. 15**.

With a suitable hammer, drive the roll pin through the torsion spring and secondary lock until the roll pin is flush with the casting. See **Fig. 15**.

Check the lock spring for tension and lock for free movement.



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1. Capscrew (5/8–18 x 1–3/4")
2. Washer (2-5/8 x 21/32")
3. Roller (5/8" i.d.)
4. Threaded Hole in Yoke
5. Cam Plate Track

Fig. 14, Install the Capscrew Into the Yoke

Model XA–351 Top Plate Assembly and Installation

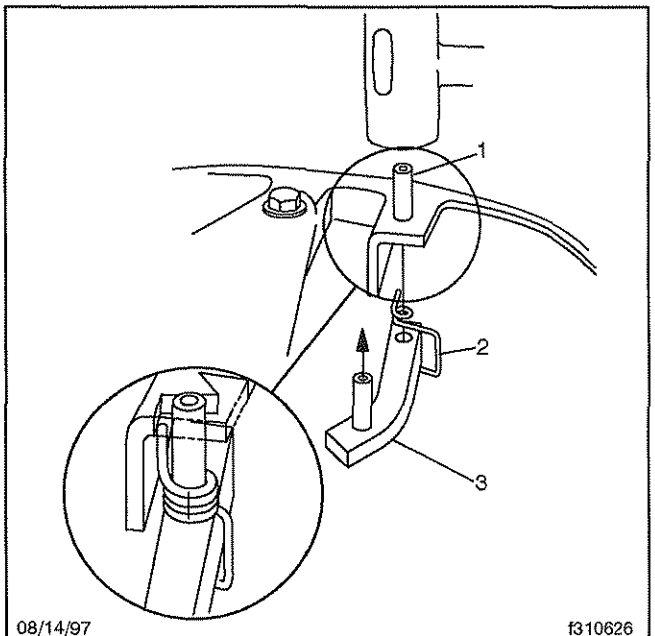
6.2 Pass the "S" bend of the manual secondary release handle through the casting guide hole (If equipped with the manual version). Then, pass the "S" bend of the release handle through the large hole in the secondary lock. See **Fig. 16**.

6.3 Start the roll pin into the hole in the top plate opposite the cam attachment capscrew (If equipped with the manual version). Then, assemble and install the secondary lock and torsion spring. Make sure the flats of the torsion spring are resting against the casting. See **Fig. 16**.

6.4 With a suitable hammer, drive the roll pin through the torsion spring and secondary lock until the roll pin is flush with the casting (If equipped with the manual version). See **Fig. 16**.

6.5 Check the lock spring for tension and lock for free movement.

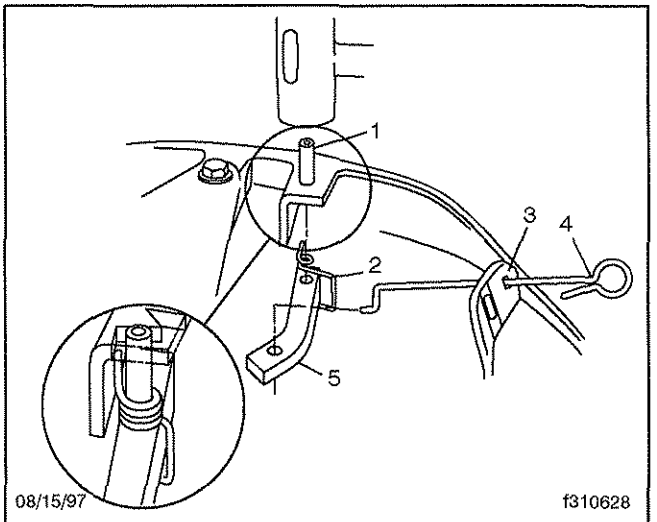
7. Adjust the lock. See **Fig. 17**.



1. Roll Pin, 1/2 x 2-3/4
2. Torsion Spring
3. Secondary Lock

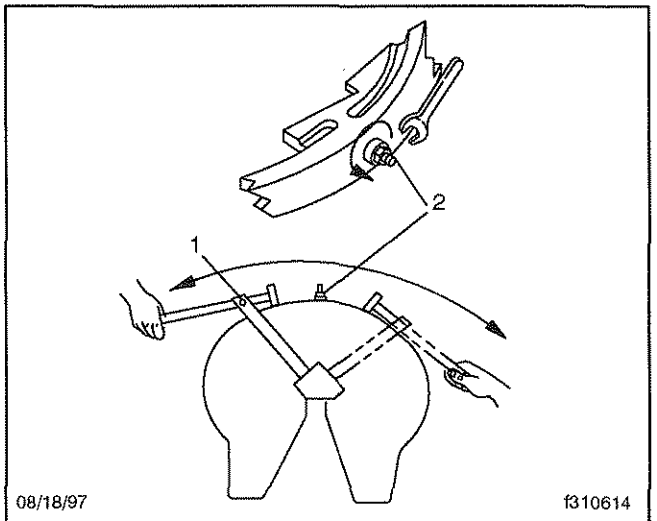
Fig. 15, Install the Secondary Lock

7.1 If equipped, pull the secondary release handle and hook it on the casting. Next, pull the primary release handle to open the locks. Now, remove the 2-inch plug.



1. Roll Pin, 1/2 x 2-3/4
2. Torsion Spring
3. Guide Hole
4. Secondary Lock Release Handle
5. Secondary Lock

Fig. 16, Install the Secondary Lock



1. Lock Tester
2. Adjustment Nut

Fig. 17, Adjusting the Lock

Model XA–351 Top Plate Assembly and Installation

7.2 Turn the fifth wheel right side up and close the locks using a Holland Lock tester (see Holland publication FW130 for operating instructions for the lock tester).

7.3 Verify that the locks are completely closed around the kingpin. The lock halves should be seated against each other.

7.4 Alternate tightening the adjustment nut and attempting to turn the lock tester back and forth. Continue tightening the adjustment nut until there is some resistance felt in the lock tester (as it is turned back and forth).

The fifth wheel is properly adjusted when there is resistance between locks and the lock tester, but the lock tester can still be turned by hand.

7.5 Pull the release handle and remove the lock tester.

8. Check the fifth wheel for proper operation.

8.1 Using the Holland lock tester, open and close the fifth wheel at least three times.

Each time you close the locks, verify that the locks have closed completely around the kingpin and that the adjustment nut and rubber bushing are seated snug against the casting.

8.2 Check for resistance between the locks and the lock tester one final time, and adjust as needed.

⚠ WARNING

If the fifth wheel does not operate properly, do not use it. Either disassemble it and repeat the rebuilding procedure or contact your nearest Holland representative for assistance. Never use a fifth wheel that does not operate properly. The fifth wheel could malfunction, resulting in bodily injury or property damage due to a possible separation of the trailer from the tractor.

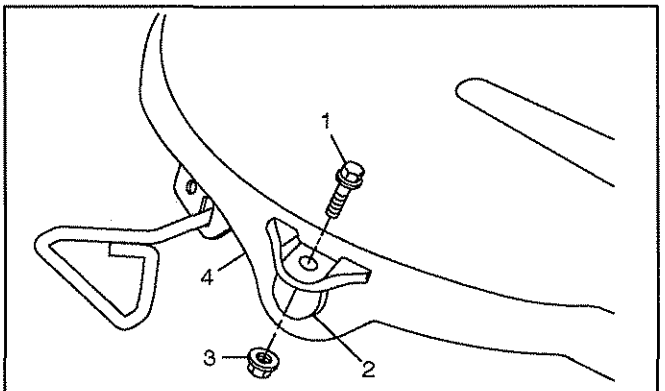
8.3 The fifth wheel is now ready for operation.

9. Install the top plate.

9.1 Using an overhead hoist, lift and position the fifth wheel over the bracket assembly.

9.2 Install the bushing pins through the fifth wheel and into the bracket assembly. Then, install and tighten securely the 1/2–20 bushing pin capscrews and locknuts. See **Fig. 18**. Remove the overhead hoist.

9.3 Lubricate the fifth wheel. For instructions, see **Group 31** in the vehicle maintenance manual.



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1. Capscrew
2. Bushing Pin
3. Locknut
4. Top Plate

Fig. 18, Install the Bushing Pin

Troubleshooting Chart

Problem—The Fifth Wheel Is Hard to Hook Up to the Trailer

Problem—The Fifth Wheel Is Hard to Hook Up to the Trailer	
Possible Cause	**Remedy**
The trailer may be too high; the kingpin is not entering the locks properly.	Lower the trailer landing gear until the bolster plate contacts the fifth wheel
The locks are closed.	Pull the release handle and pry open the locks.
Rust or grime is interfering with the lock operation.	Spray a light lubricant or diesel fuel on all moving parts including the release handle. Operate the release mechanism several times.
The fifth wheel locks are too tight.	Check the lock adjustment. Correct as needed.
A bent release handle, bent kingpin, or damaged bolster plate is interfering with the lock movement.	Check the release handle, kingpin, and bolster plate. Replace parts as required.
The locks are damaged.	Inspect the locks and replace parts as required.
The fifth wheel needs rebuilding.	Rebuild the fifth wheel, using the parts in the appropriate rebuilding kit.

Problem—The Fifth Wheel Is Hard to Unhook from the Trailer

Problem—The Fifth Wheel Is Hard to Unhook from the Trailer	
Possible Cause	**Remedy**
The secondary lock is not released.	If equipped with a manual secondary lock, pull the release handle and lock it open by resting it against the top plate. If equipped with an automatic secondary lock, inspect the lock for missing or broken parts, and repair or replace as required.
The tractor is putting pressure against the locks.	Set trailer brakes. Back the tractor into the trailer to relieve pressure and lock the tractor brakes before pulling the release handle.
There is rust or grime on the locking mechanism.	Spray a light lubricant or diesel fuel on all moving parts including the release handle. Operate the release mechanism several times.
The kingpin is bent or the bolster plate is damaged.	Check the kingpin, using a Holland TF–0110 Kingpin Gauge. Check the bolster plate, using a 48-inch (122 cm) straight edge. Repair or replace parts as required.
The fifth wheel locks are too tight.	Check the lock adjustment. Correct as needed.
The release handle will not stay out or must be held out when unlocking.	Replace the cam or release arm and the release handle spring.

Contents

Subject	Subject Number
General Information	050
Service Operations	
Sliding Mount Disassembly and Assembly	100
Sliding Mount Assembly Plunger Adjustment	110

General Information

NOTE: For Holland 3500 series fifth wheel service operations, see **Section 31.05** in this group.

NOTE: Prior to June 1, 1996, the Holland sliding fifth wheel mount carried a part number prefix FW2535. Since June 1,1996, the Holland sliding fifth wheel mount part number prefix has been replaced by FW35.

The Holland sliding fifth wheel mount is designed to provide maximum tractor use for different lengths and types of trailers. The FW2535/FW35 sliding fifth wheel mount is used with the Holland 3500 series fifth wheel, and is equipped with either a manually operated or an air-operated release slider.

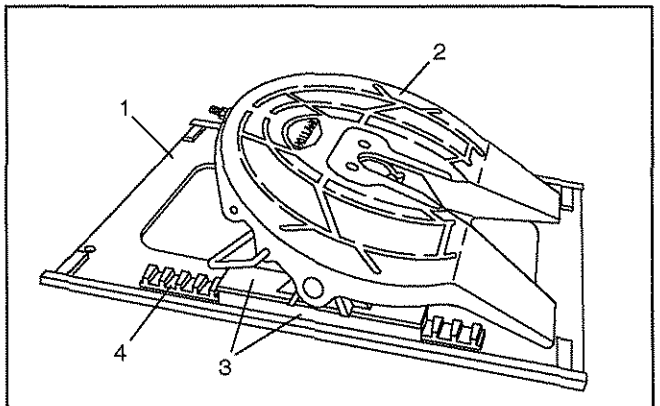
Sliding fifth wheel assemblies are mounted on a baseplate with notched rails. See **Fig. 1**. Plungers are meshed into teeth on the baseplate to lock the fifth wheel. This assembly allows forward or rearward movement of the fifth wheel along the notched rails for optimum weight distribution over the tractor axles. The mounting baseplate is bolted to the tractor frame.

When the fifth wheel is in the desired position, it is locked in place by wedge-shaped plungers that engage in the notched rails under the sliding mount. To release the fifth wheel, the plungers are withdrawn.

The manually operated release slider contains a release lever (**Fig. 2**), which when manually pulled or released, unlocks or locks both sides of the sliding mount at the same time.

The air-operated release slider contains a double-ended air cylinder (**Fig. 3**), which locks and unlocks both sides of the sliding mount at the same time. The air cylinder is activated by a two-position air-control valve in the tractor cab. See **Fig. 4**.

See **Chapter 10** in the vehicle driver's manual for complete operating instructions.



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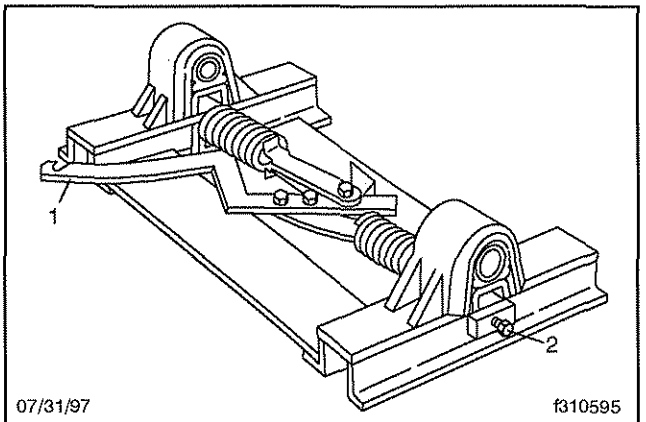
1. Baseplate
2. Fifth Wheel Top Plate (XA–3500)
3. Slide Mount
4. Baseplate Rail

Fig. 1, XA-3500 Sliding Fifth Wheel



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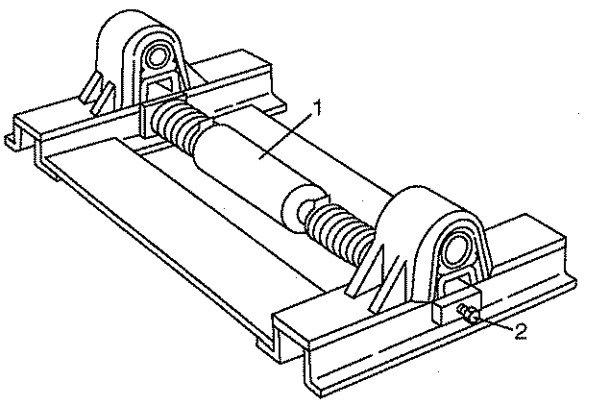
NOTE: Baseplate rails not shown.

1. Release Lever
2. Slider Plunger Release

Fig. 2, Manual Release Slider Assembly

General Information



NOTE: Baseplate rails not shown.

1. Double-Ended Air Cylinder
2. Slider Plunger Release

Fig. 3, Air Valve Release Slider Assembly

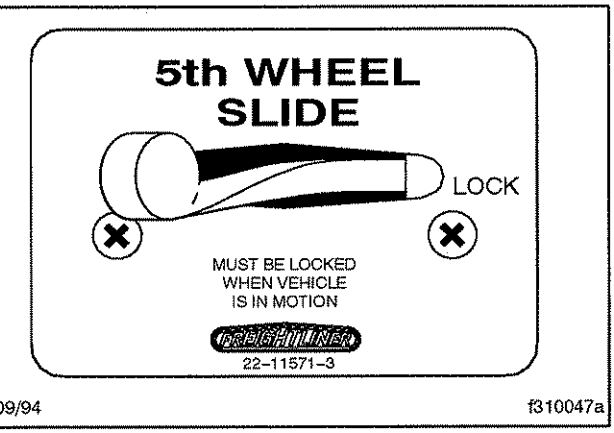


Fig. 4, Control Valve

Sliding Mount Disassembly and Assembly

Disassembly

⚠ WARNING

Fifth wheel maintenance, adjustment, and rebuilding must be done only by a qualified mechanic. Incorrect or incomplete procedures could result in loss of trailer connection during vehicle travel, possibly causing bodily injury and property damage.

1. Remove the top plate.

   1.1 If equipped with model XA–3501 top plate, remove the roll pins (**Fig. 1**) from both the right and left side of the top plate. Then, remove the bushing pins.

   Using an overhead hoist, lift the fifth wheel off the slide mount assembly.

   1.2 If equipped with model XA–351 top plate, loosen and remove the 1/2–20 bushing pin capscrews and locknuts from both the left and right sides of the top plate. Then, remove the bushing pins (**Fig. 1**) from the bracket assembly.

   Using an overhead hoist, lift the fifth wheel off the slide mount assembly.

⚠ WARNING

When draining the air reservoir, do not look into the air jets, or direct them toward anyone. Dirt or sludge particles may be in the airstream, and could cause injury if ejected.

2. If the fifth wheel has a manual release sliding mount, then go to the next step. Otherwise, drain the air reservoir; then disconnect and plug the air line from the air cylinder.

⚠ WARNING

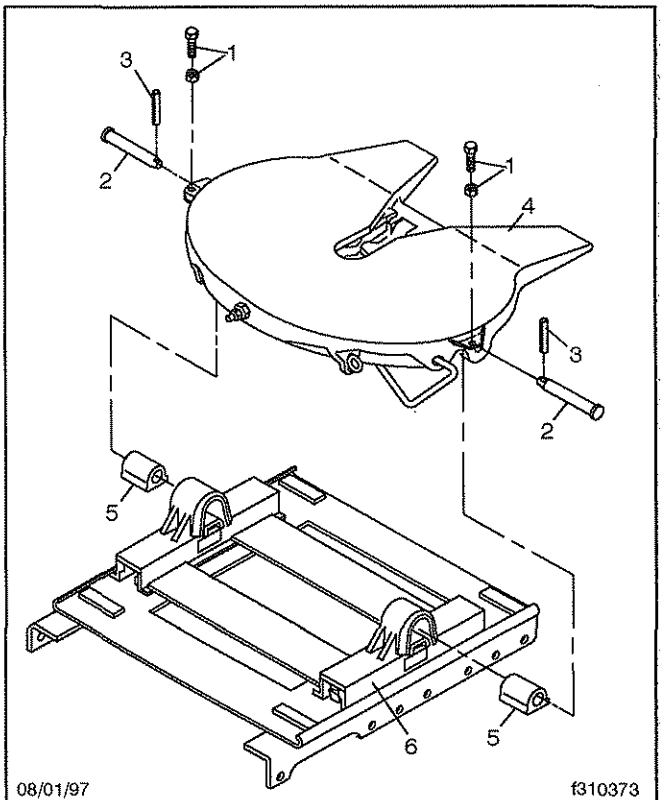
Parts are under spring compression. Wear safety goggles during disassembly and assembly, and keep fingers away from possible pinch points at the ends of springs. Failure to do so can result in bodily injury, due to parts ejecting with force.

3. Using a Holland TF–TN 2500 spring compressor (**Fig. 2**), compress one of the plunger return springs (**Fig. 3**).

4. Remove the plunger retaining pin (**Fig. 3**) from the plunger end, and either the air-release cylinder or manual release lever clevis. Then remove the plunger.

   If equipped with a fifth wheel height of 6.62 or 8.12 inches (16.8 or 20.6 cm), remove the plunger retaining pin from the release lever, then remove the plunger.

5. Carefully remove the spring compressor; then remove the plunger return spring, the spring compression stop, and the spring retainer (**Fig. 3**).



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1. Capscrew and Locknut (XA–351 only)
2. Bushing Pin
3. Roll Pin (XA–3501 only)
4. Fifth Wheel Top Plate
5. Rubber Bushing
6. Slide Mount Assembly

Fig. 1, Sliding Mount Components

Sliding Mount Disassembly and Assembly

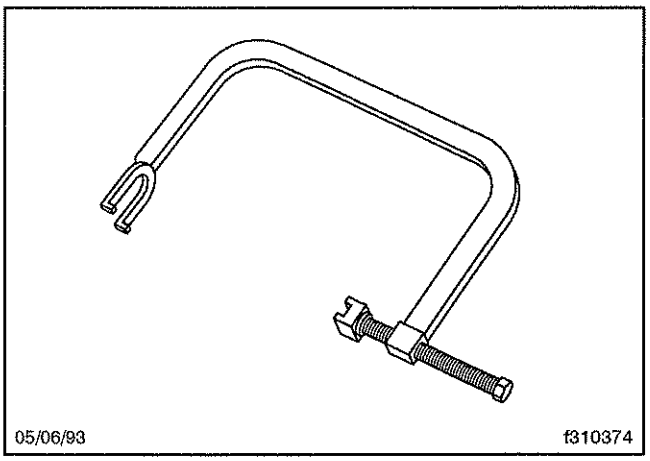


Fig. 2, Spring Compressor

Repeat the procedure for the other plunger.

6. Remove the air-release cylinder or the manual release lever.

   If equipped with a fifth wheel height of 6.62 or 8.12 inches (16.8 or 20.6 cm), remove the air-release cylinder or the manual release lever along with the right and left release levers (**Fig. 3**). Disconnect the release levers from the air-release cylinder or manual release lever.

⚠ WARNING

Wear protective eye and facial gear when grinding to remove the rear stops. Failure to do so could result in personal injury due to flying metal debris from the grinding.

7. If the slide mount assembly (**Fig. 3**) is damaged, dismantle it from the baseplate (Ref. 9).

   7.1 Grind down the welded area to remove the rear stops.

   7.2 Remove the slide mount assembly from the baseplate by sliding it off the rear of the tracks.

8. Remove all dirt and grease from the parts. Replace any parts that show signs of wear or damage.

NOTE: If the rubber bushings (**Fig. 1**) are damaged, or if they allow movement of more than 1/8 inch (3 mm), replace them.

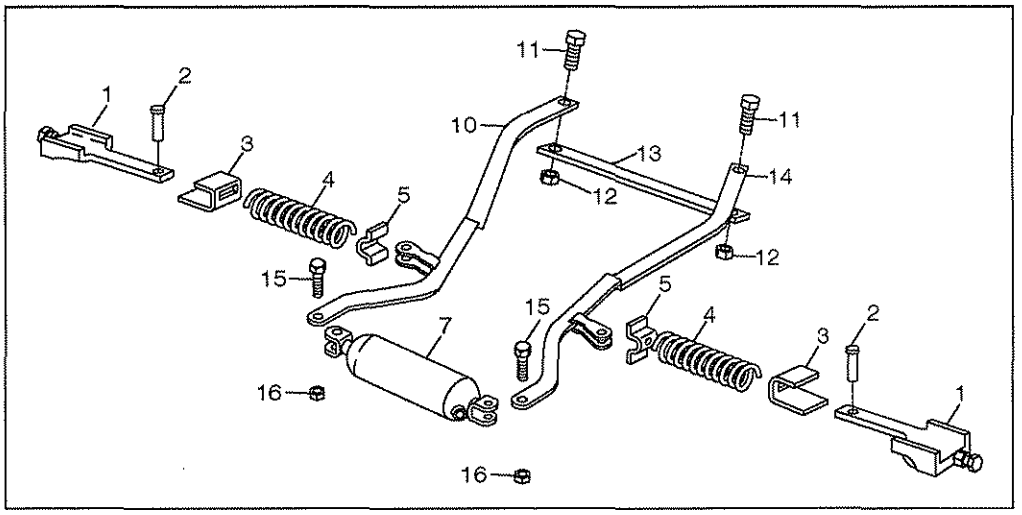
Assembly

⚠ WARNING

Fifth wheel maintenance, adjustment, and rebuilding must be done only by a qualified mechanic. Incorrect or incomplete procedures could result in loss of trailer connection during vehicle travel, possibly causing bodily injury and property damage.

1. Using a rubber lubricant or a waterless hand cleaner, lubricate the outer surfaces of the new rubber bushings.
2. Install the rubber bushings (**Fig. 1**) into the slide mount assembly until they are flush with the outboard ends of the assembly.
3. Using a multipurpose chassis grease, lubricate the flanges on the slide mount assembly. Then slide the assembly onto the tracks of the baseplate.
4. Move the slide mount assembly to the rearmost position. Install the plungers into the outboard ends of the slide mount. Engage the plungers in the rail teeth.
5. Install the rear stops under the curled edge of the baseplate. Allow a clearance of about 1/8 inch (3 mm) from the rear stops to the slide mount (when it's in the full rear position. The stops should be about 1/4 to 1/2 inch (6 to 13 mm) from the rear edge of the baseplate). See **Fig. 4**.
6. Clamp the rear stops in place, then move the slide mount assembly forward and out of the way.
7. Weld the stops in place. The welds should be 1/4-inch (6 mm) fillet. On the forward edge, weld only the center area; not the area where the slide mount assembly contacts the stop. See **Fig. 4**.
8. Move the slide mount assembly to the rearmost position and check for clearance. Make sure the plungers seat into the rail with all teeth engaged.
9. If equipped with a fifth wheel height of 6.62 or 8.12 inches (16.8 or 20.6 cm), and if new release levers are being installed, attach the right and left release levers to the tie bar (**Fig. 3**). Install 3/8–16 capscrews and locknuts and tighten them firmly, but make sure the parts are not binding.

Sliding Mount Disassembly and Assembly



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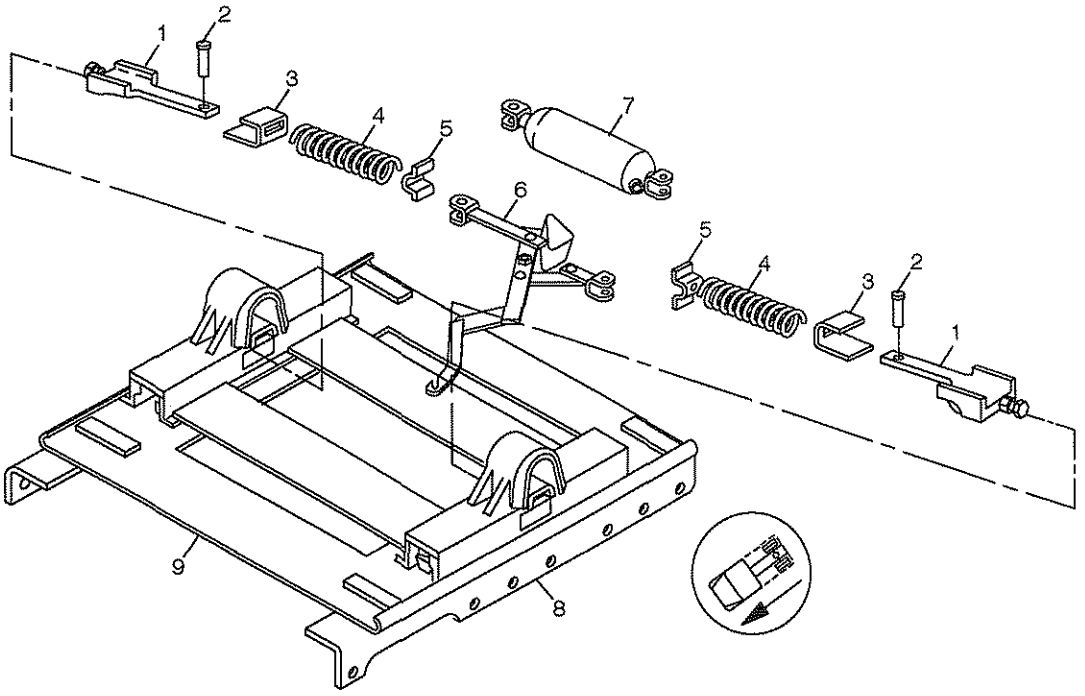

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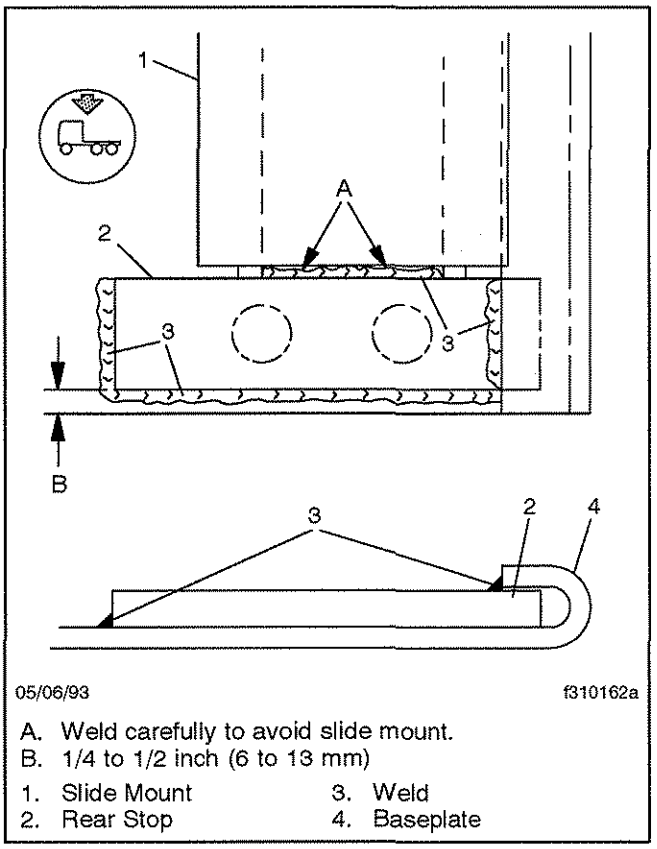
A. Spring assembly for 6.62 and 8.12 inch (16.8 and 20.6 cm) fifth wheel heights

1. Plunger
2. Retaining Pin
3. Spring Compression Stop
4. Plunger Return Spring
5. Spring Retainer
6. Manual Release Lever
7. Air-Release Cylinder
8. Slide Mount Assembly
9. Baseplate
10. Right Release Lever
11. Capscrew, 3/8–16
12. Locknut, 3/8–16
13. Tie Bar
14. Left Release Lever
15. Capscrew, 1/2–20
16. Locknut, 1/2–20

Fig. 3, Spring Assemblies

Sliding Mount Disassembly and Assembly



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A. Weld carefully to avoid slide mount.
B. 1/4 to 1/2 inch (6 to 13 mm)

1. Slide Mount
2. Rear Stop
3. Weld
4. Baseplate

Fig. 4, Slide Stop Installation

Using the 1/2–20 capscrews and locknuts, attach the air-release cylinder or the manual release lever to the ends of the release levers, tighten the nuts firmly, but make sure the parts are not binding.

10. Install the spring compression stops and the plunger return springs on the inboard ends of the plungers. Then install the spring retainers.

⚠ WARNING

Parts are under spring compression. Wear safety goggles during disassembly and assembly, and keep fingers away from possible pinch points at the ends of springs. Failure to do so can result in bodily injury, due to parts ejecting with force.

11. Using a Holland TF–TN 2500 spring compressor, compress one of the plunger return springs and its spring retainer enough to access the hole through the end of the plunger shaft.

12. If equipped with a standard fifth wheel, position the air-release cylinder or the manual release lever so that the holes in its clevis line up with the hole through the end of the plunger shaft. Install the retaining pin.

    If equipped with a fifth wheel height of 6.62 or 8.12 inches (16.8 or 20.6 cm), line up the holes in the clevis of one of the release levers (**Fig. 3**) with the hole in the end of the plunger shaft. Install the retaining pin.

13. Carefully remove the spring compressor.

14. Repeat the procedure on the other side of the vehicle.

15. If the fifth wheel has a manual release sliding mount, then go to the next step, otherwise connect the air lines.

    15.1 Remove the plugs from the air line.

    15.2 Connect the air line to the inlet on the air-release cylinder.

    15.3 Start the engine to build air pressure, then check the operation of the slide mechanism.

16. Adjust the plungers, following the procedure in **Subject 110**.

17. Install the top plate.

    17.1 If equipped with model XA–3501 top plate, using an overhead hoist, lift the fifth wheel onto the slide mount assembly.

    From both the right and left side of the top plate, install the bushing pins and the roll pins (**Fig. 1**).

    17.2 If equipped with model XA–351 top plate, using an overhead hoist, lift the fifth wheel onto the slide mount assembly.

    From both the right and left side of the top plate, Install the bushing pins. Then, install and tighten snugly the 1/2–20 bushing pin capscrews and locknuts (**Fig. 1**).

Sliding Mount Assembly Plunger Adjustment

Adjustment

⚠ WARNING

All fifth wheel maintenance, adjustment, and rebuilding must be done only by a qualified mechanic. Incorrect or incomplete procedures could result in loss of trailer connection during vehicle travel, possibly causing bodily injury and property damage.

NOTE: The locking plungers are adjusted at installation and again after one month of operation. Make additional adjustments as needed.

1. The plungers should seat in the pocket with a small amount of play when locked (engaged). See **Fig. 1**. If they wedge or bind, turn the adjusting bolt clockwise or counterclockwise as needed.

   Turning the adjusting bolt clockwise moves the plunger out of the pocket; turning it counterclockwise moves the plunger further into the pocket.

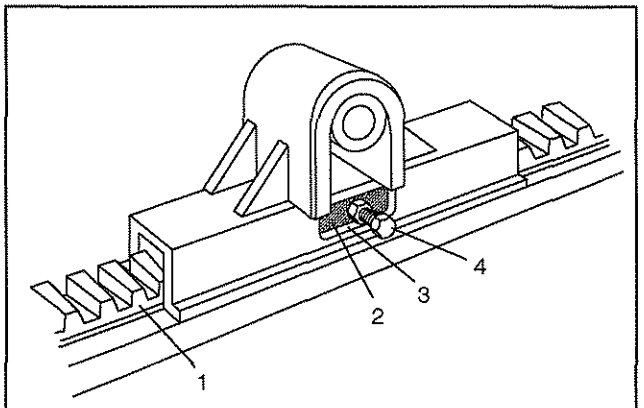
2. If the plungers don't unlock (release), check the air-release cylinder or the manual release lever for correct operation. Replace it if needed. See **Subject 100** for removal and installation instructions.

3. If the adjusted plunger binds on the bottom of the pocket, remove it; then grind the plunger top edges 1/16 inch (2 mm). See **Fig. 2**. Install the plunger. See **Subject 100** for plunger removal and installation instructions.

   Adjust the plunger, following the instructions above.

4. If the plungers are too loose, check the tension of the plunger return springs. If the springs are damaged or worn, replace them, following the instructions in **Subject 100**.

   If the plungers are still too loose, replace the plungers, following the instructions in **Subject 100**.



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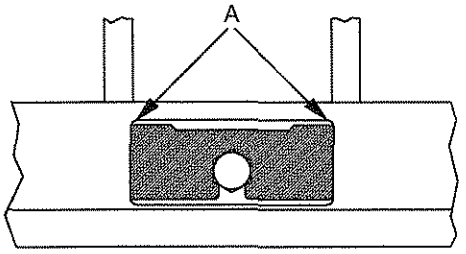
1. Plunger Adjusting Bolt
2. Pocket
3. Plunger
4. Rack

Fig. 1, Plunger Position



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A. Check for interference here.

Fig. 2, Plunger Checking

Contents

Subject	Subject Number
General Information	050
Service Operations	
Fifth Wheel Removal and Disassembly	100
Fifth Wheel Assembly and Installation	110
Troubleshooting	300

General Information

Fontaine H5092 series fifth wheels couple to trailers having a standard 2-inch kingpin. When installed as a stationary mount, the fifth wheel is bracket-mounted to the tractor frame in a position that best distributes the trailer load over the tractor axles. Sliding fifth wheels (**Fig. 1**), are mounted on the Fontaine HAWB or HMWS (previously called 5AWB and 5MWS) model slide mounts.

The Fontaine fifth wheel lock mechanism for the trailer kingpin consists of a spring-loaded jaw and sliding wedge. Kingpin release is accomplished by pulling a manual lock control handle located on either the right side (curbside) or left side (roadside) of the fifth wheel. Kingpin coupling occurs when the kingpin enters the throat of the fifth wheel, triggers the jaw and wedge to slide into place behind the kingpin, and moves the lock control handle into the locked position.

As the kingpin enters the lock mechanism, the jaw is moved first with the spring-loaded wedge sliding in place against the jaw. The jaw will move behind the kingpin, followed by the wedge. The wedge reinforces the jaw and automatically adjusts for slack around the kingpin. See **Fig. 2** for an illustration of the jaw and wedge in the locked position.

Placing the lock control handle in the unlocked position moves the wedge and jaw out from behind the kingpin and unlocks the fifth wheel. See **Fig. 3** for an illustration of the jaw and wedge in the unlocked postition.

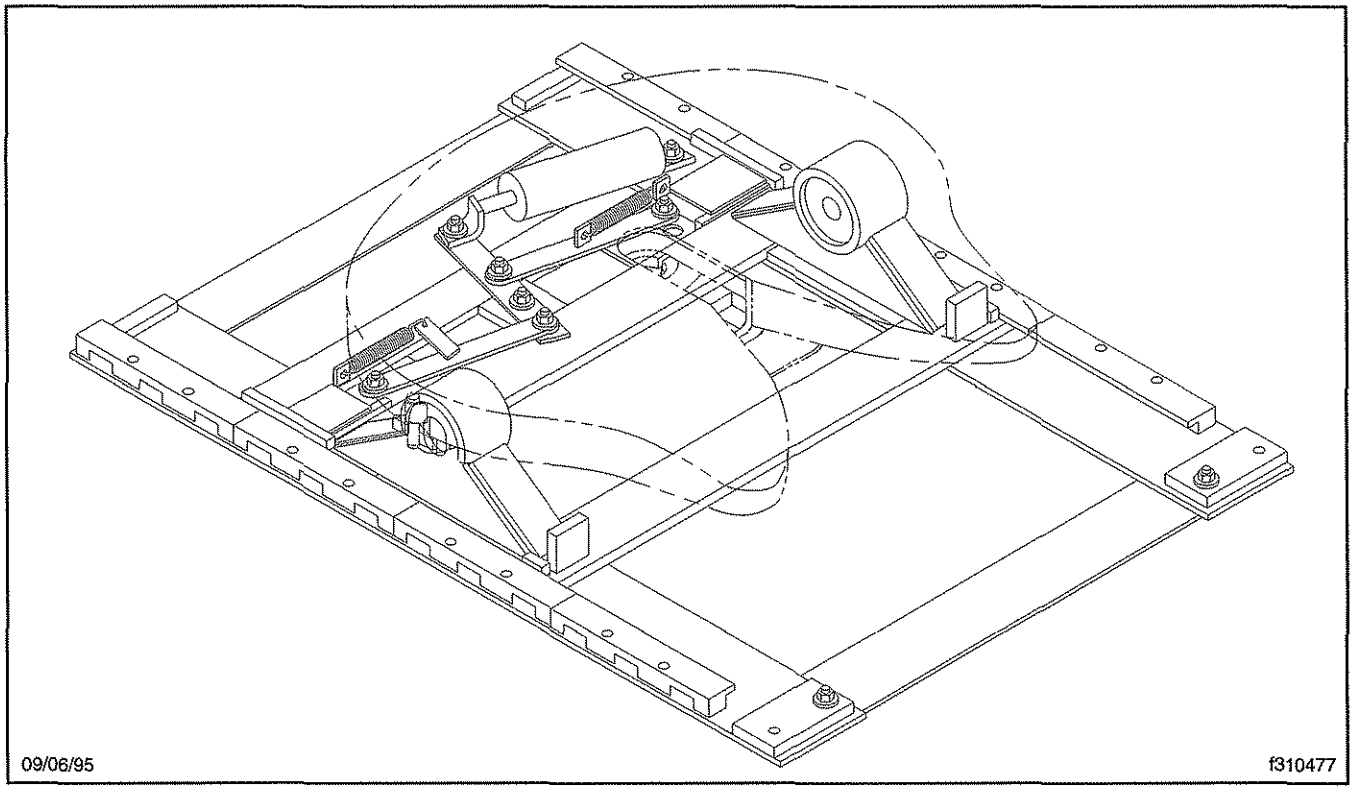


Fig. 1, Fontaine H5092 Series Air Slide Fifth Wheel

General Information

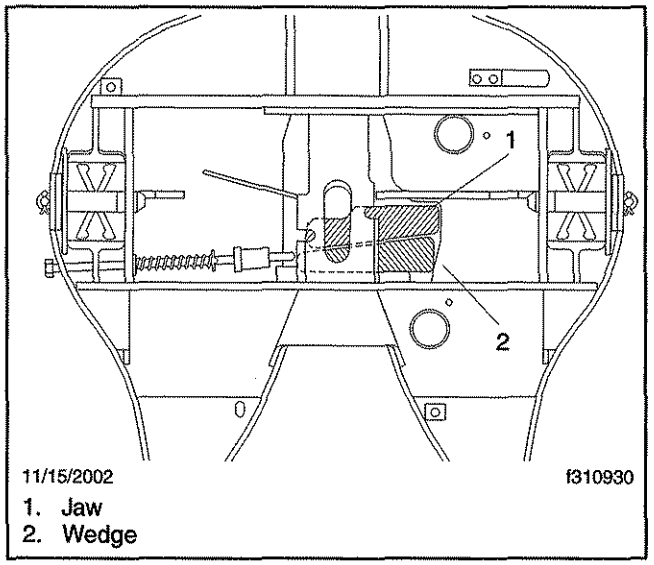


Fig. 2, Locked Position

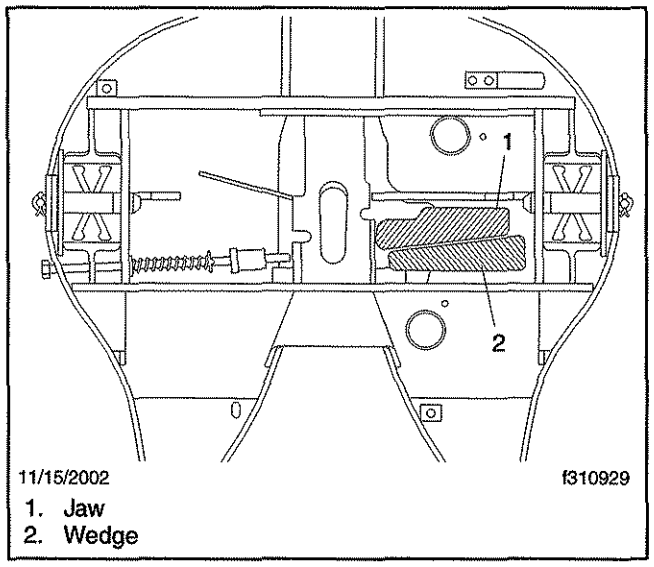


Fig. 3, Unlocked Position

Fifth Wheel Removal and Disassembly

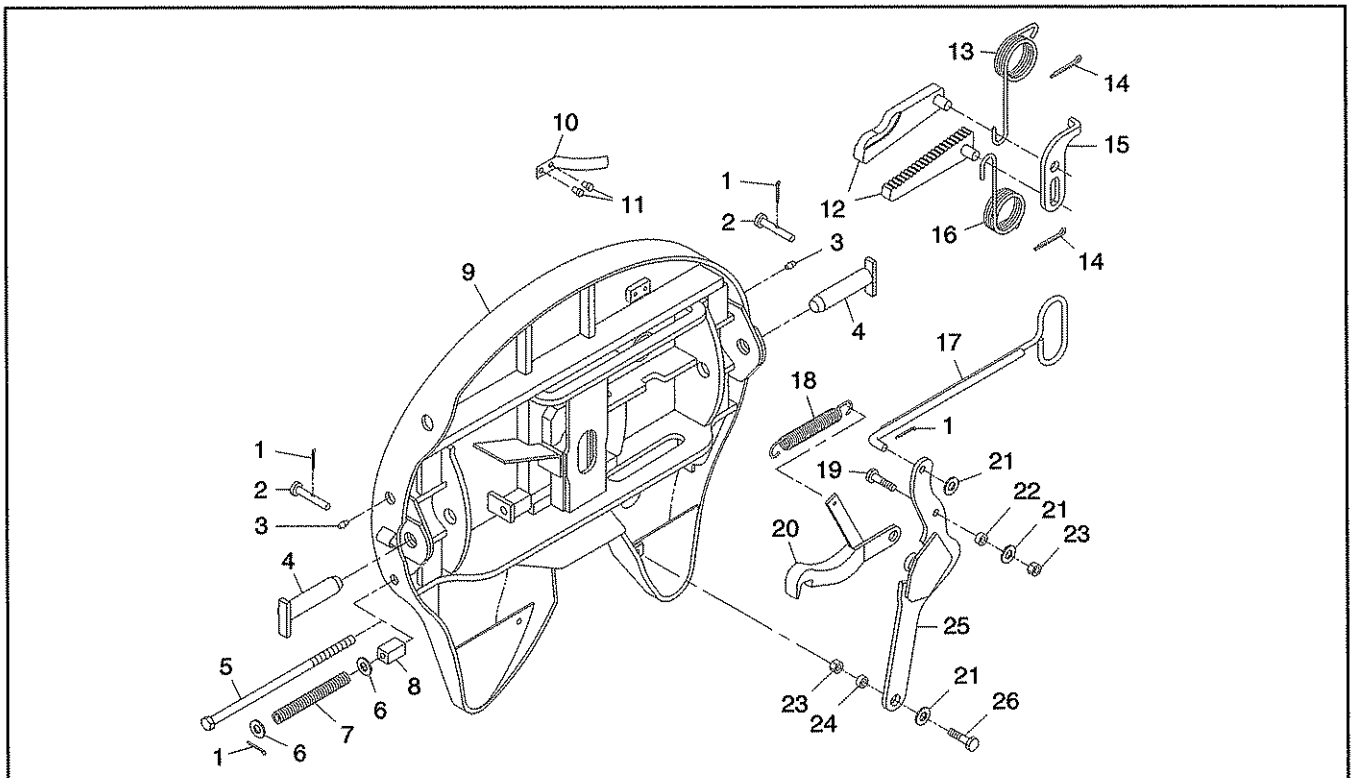
See **Fig. 1** for an exploded view of the Fontaine® H5092 fifth wheel.

⚠ WARNING

All fifth wheel maintenance, adjustment, and rebuilding must be done only by a qualified mechanic. Improper or incomplete procedures could result in disengagement of the trailer from the tractor, leading to personal injury or property damage.

Parts are under spring compression. Wear safety goggles during disassembly and assembly. Failure to do so can result in personal injury, due to parts ejecting with force.

1. Steam clean the top plate. Remove it from the sliding mount by removing the cotter pins from the retaining pins. Remove the retaining pins and bushing pins from both sides of the top plate.



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1. Cotter Pin, 3/16" x 1"
2. Lower Bracket Retainer Pin
3. Grease Fitting
4. Lower Bracket Pin
5. Wedge Stop Rod
6. Flatwasher
7. Wedge Stop Rod Spring
8. Nut, Wedge Stop Rod
9. Upper Assembly, Side Release
10. Leaf Spring
11. Thread-Cutting Screw, 1/4–20 x 3/8"
12. Step Jaw and Wedge
13. Jaw Spring
14. Cotter Pin, 1/4" x 3"
15. Timer
16. Wedge Spring
17. Pull Handle
18. Bumper Handle Spring
19. Hex-Head Bolt, 1/2–13 x 2", Bumper Pivot
20. Bumper
21. Flatwasher
22. Bushing, 5/16", Bumper Pivot
23. Hex Locknut, 1/2–13
24. Bushing, 7/16", Handle Pivot
25. Operating Handle, Side Release Only
26. Hex-Head Bolt, 1/2–13 x 2", Handle Pivot

Fig. 1, Fontaine H5092 Series Fifth Wheel (left-side release shown)

Removal and Disassembly

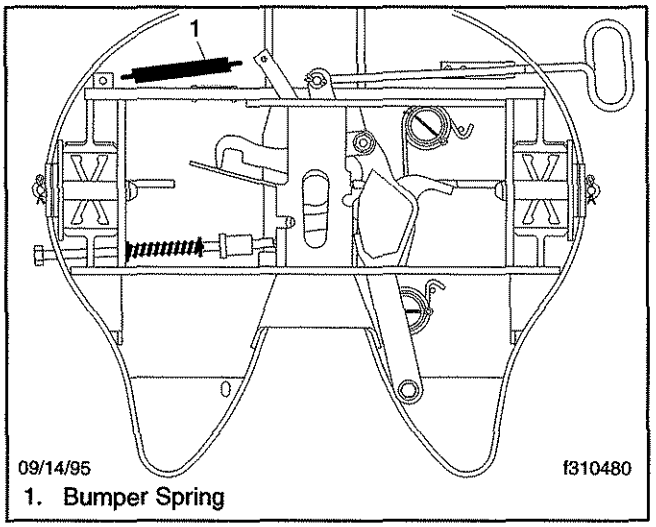
2. Using an overhead hoist, lift the fifth wheel off the sliding mount and tractor frame.
3. Turn the fifth wheel upside down.

NOTE: While disassembling the fifth wheel, check it for cracks and for missing or damaged parts.

⚠ WARNING

Do not attempt to repair or rebuild the top plate if it is cracked or if parts are damaged. The top plate or parts could malfunction. This could result in disengagement of the trailer during vehicle travel, possibly causing personal injury and property damage.

4. Set the fifth wheel in a locked position, then unhook the bumper spring from the bumper tang and the tab on the side of the fifth wheel substructure. See **Fig. 2**. Remove the bumper spring.
5. Remove the two bolts on the operating handle. **Fig. 3.** Each bolt has a nut, washer, and bushing. Discard the bushings.
6. Remove the cotter pin and washer that holds the pull handle to the operating handle. Slide the pull handle out through the side of the fifth wheel. See **Fig. 4**.
7. Slide the operating handle over to the side of the fifth wheel. Slide the bottom part first. This will allow the handle to clear the jaw and wedge studs on the underside and clear the timer. See **Fig. 5**.
8. Remove the timer by lifting upward. See **Fig. 6**.
9. Slide the operating handle out through the slot in the rear crossmember of the fifthwheel. See **Fig. 7**.
10. Slide the bumper toward the operating handle slot and to the rear of the fifth wheel until the bumper tang clears the operating handle slot. Lift upward and remove. See **Fig. 8**.



1. Bumper Spring

Fig. 2, Bumper Spring Removal

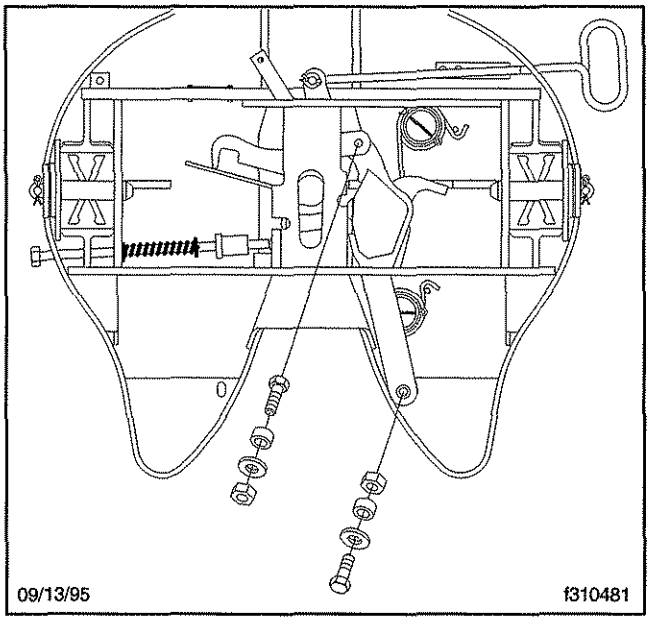


Fig. 3, Bolt Removal

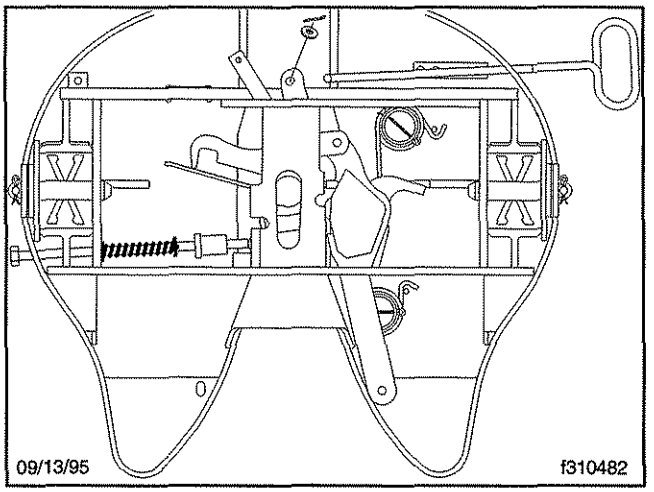


Fig. 4, Pull Handle Removal

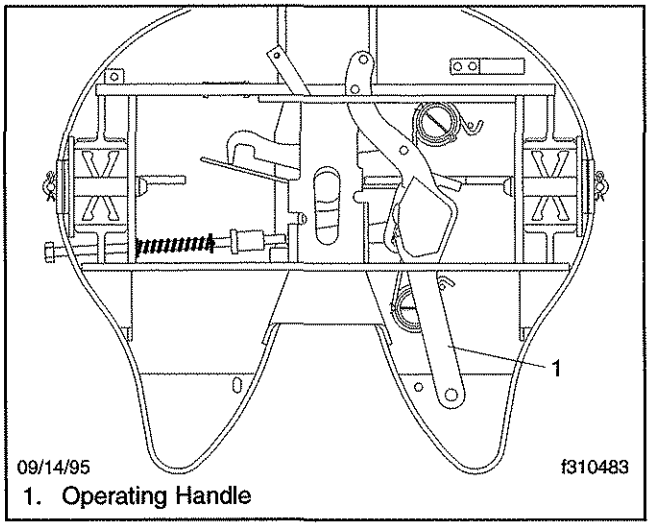


Fig. 5, Operating Handle Positioning

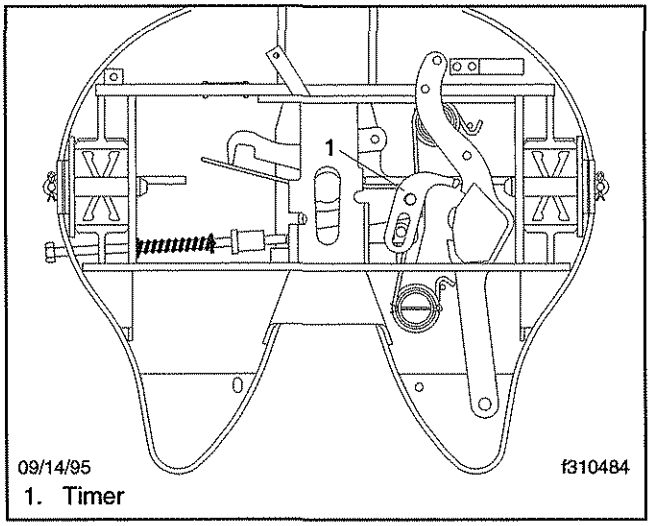


Fig. 6, Timer Removal

⚠ WARNING

The wedge spring is under extreme tension. Always wear safety glasses. Do not stand directly over the springs. A flying spring could cause personal injury.

11. Remove the cotter pins from the jaw and wedge springs. Discard the cotter pins, and pry the small hooked tail of the jaw and wedge spring up over the jaw and wedge studs. Remove and discard both springs. See **Fig. 9**.

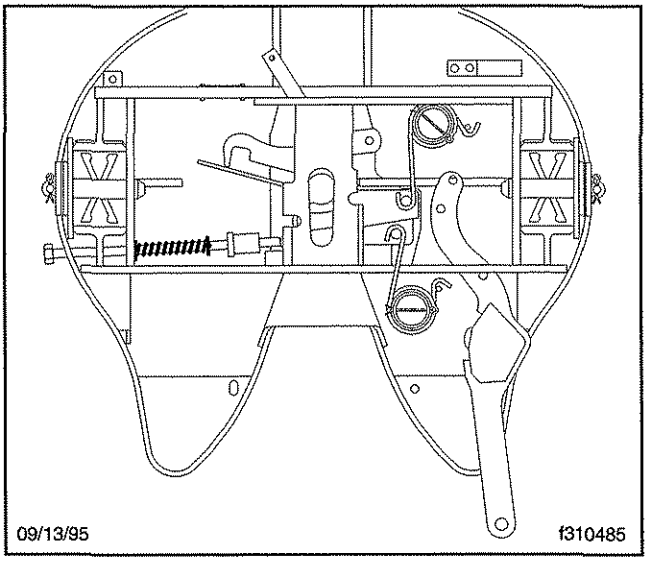


Fig. 7, Operating Handle Removal

12. Remove the wedge first, and then the jaw. Discard the jaw and wedge. See **Fig. 10**.

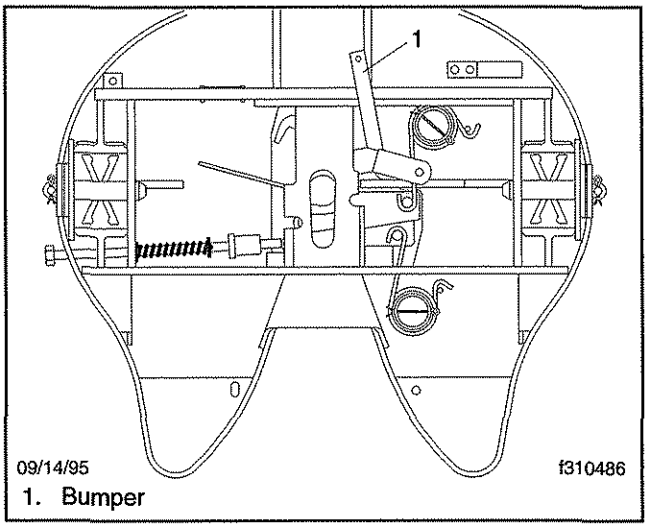


Fig. 8, Bumper Removal

Removal and Disassembly

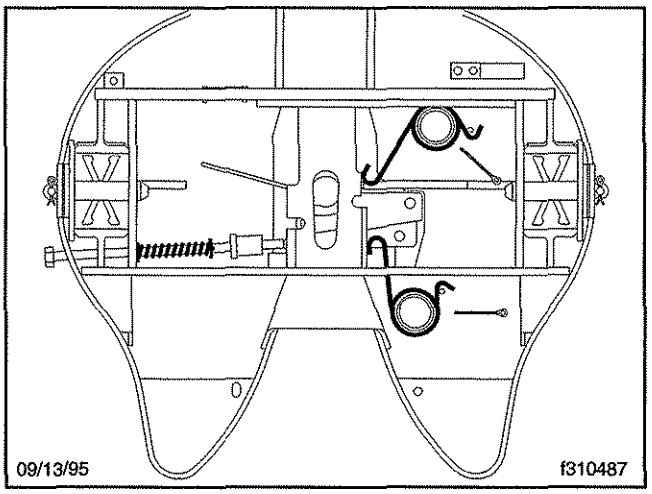


Fig. 9, Spring Removal

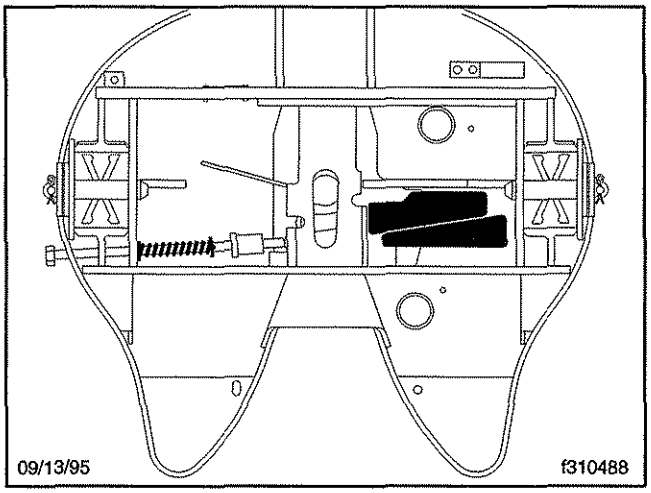


Fig. 10, Jaw and Wedge Removal

Fifth Wheel Assembly and Installation

Assembly and Installation

See **Fig. 1** for an exploded view of a Fontaine® H5092 fifth wheel.

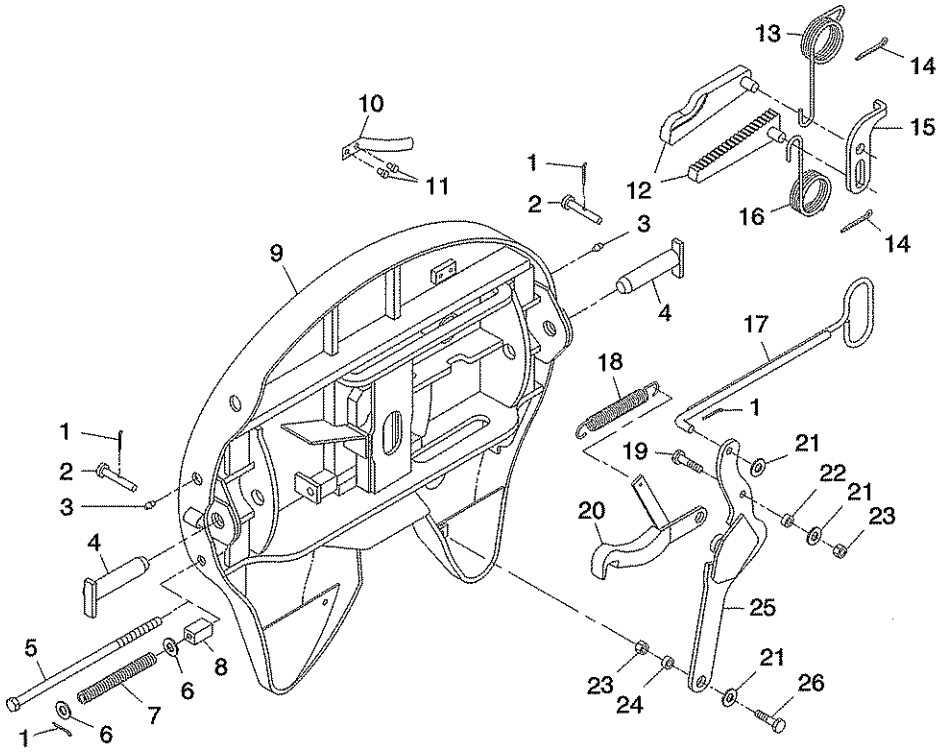
⚠ WARNING

All fifth wheel maintenance, adjustment, and rebuilding must be done only by a qualified mechanic. Improper or incomplete procedures could result in possible disengagement of the trailer from the tractor, leading to personal injury and property damage.

Parts are under spring compression. Wear safety goggles during disassembly and assembly. Failure to do so can result in personal injury, due to parts ejecting with force.

IMPORTANT: Replace any parts that show signs of wear, damage, or deterioration.

1. Clean all moving parts with no. 2 diesel fuel before assembly.



09/18/95 f310476

1. Cotter Pin, 3/16" x 1"
2. Lower Bracket Retainer Pin
3. Grease Fitting
4. Lower Bracket Pin
5. Wedge Stop Rod
6. Flatwasher
7. Wedge Stop Rod Spring
8. Nut, Wedge Stop Rod
9. Upper Assembly, Side Release
10. Leaf Spring
11. Thread-Cutting Screw, 1/4–20 x 3/8"
12. Step Jaw and Wedge
13. Jaw Spring
14. Cotter Pin, 1/4" x 3"
15. Timer
16. Wedge Spring
17. Pull Handle
18. Bumper Handle Spring
19. Hex-Head Bolt, 1/2–13 x 2", Bumper Pivot
20. Bumper
21. Flatwasher
22. Bushing, 5/16", Bumper Pivot
23. Hex Locknut, 1/2–13
24. Bushing, 7/16", Handle Pivot
25. Operating Handle, Side Release Only
26. Hex-Head Bolt, 1/2–13 x 2", Handle Pivot

Fig. 1, Fontaine H5092 Series Fifth Wheel (left-side release shown)

Fifth Wheel Assembly and Installation

2. Always assemble the parts around a 2-inch kingpin or a shaft with a 2-inch diameter. Insert the jaw first and then the new wedge below it. Apply a moderate amount of grease having EP (extra pressure) additives to the sides and serrated edges of the jaw and wedge. Also apply grease to the stationary jaw in the throat of the fifth wheel. See **Fig. 2**.
3. Insert the new wedge spring through the slot in the rear crossmember and lay the coil over the spring boss. Using a spring tool, engage the small hooked tail of the wedge spring and wind it around until it is directly over the small stud at the back of the bracket. Using a hammer, nudge the spring downward allowing it to catch on the stud. Insert a new cotter pin. See **Fig. 3**.

   Repeat these steps to replace the jaw spring.

NOTE: The jaw spring has minimal tension and can be replaced by hand.

4. Place the bumper back in position, sliding the bumper tang through the operating handle guide slot and toward the tab on the side of the fifth wheel substructure. See **Fig. 4**.
5. Apply a liberal amount of grease to the grooved middle section of the operating handle, then insert the operating handle and move it over to the side of the wheel. See **Fig. 5**.
6. Insert the timer over the jaw and wedge studs. the small hole on the timer fits over the jaw stud and the slotted hole fits over the wedge stud. Be certain the small bent arm of the timer is facing downward. See **Fig. 6**.
7. Slide the operating handle toward the center of the wheel to engage the handle with the studs on the jaw and wedge. Slide the top part first. This will ensure that the grooves on the operating handle are aligned with the studs. A correctly aligned operating handle should be in a vertical position once it goes over the studs. See **Fig. 7**.
8. Slide the pull handle in through the safety lock and using the cotter pin and washer, fasten it in the top hole of the operating handle. See **Fig. 8**.

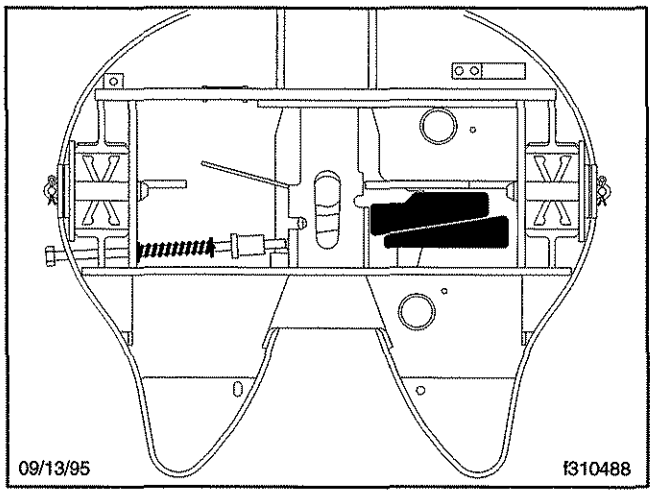


Fig. 2, Wedge and Jaw Installation

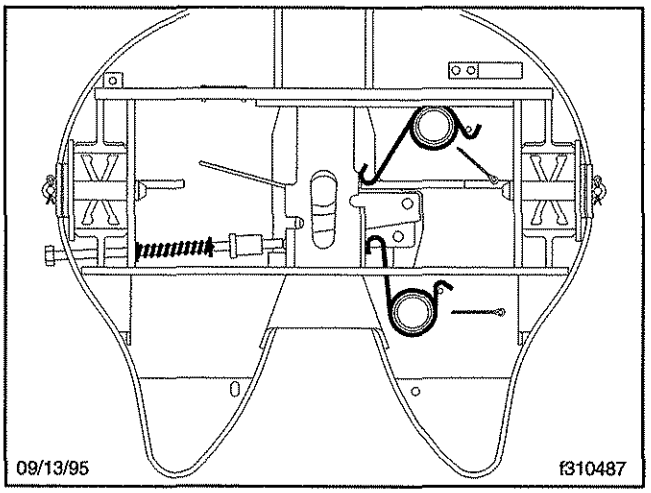


Fig. 3, Spring Installation

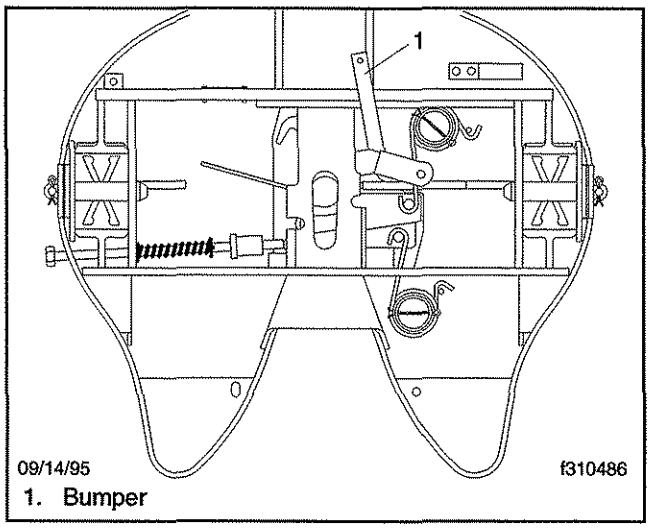


Fig. 4, Bumper Installation

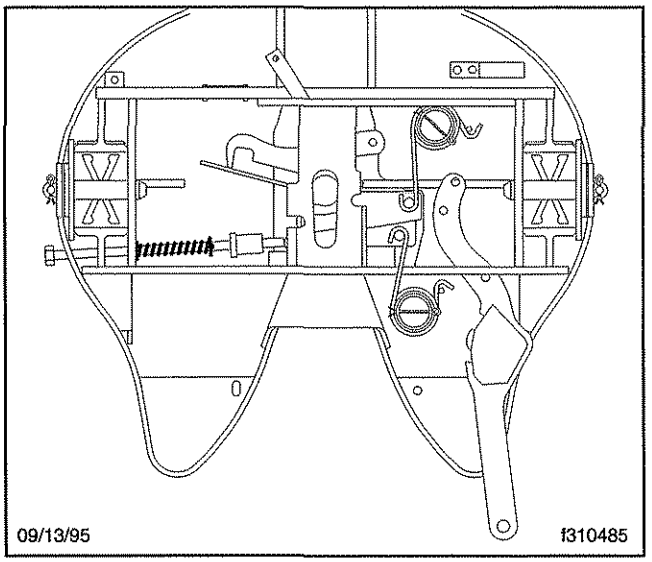


Fig. 5, Operating Handle Installation

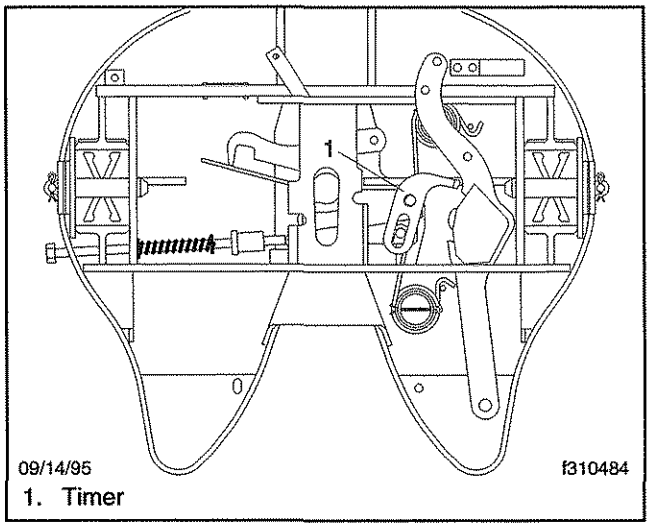


Fig. 6, Timer Installation

9. Align the bumper hole with the hole in the operating handle. Replace the bolts on the operating handle. The bolt which fastens the operating handle to the bumper must be inserted with the threads facing toward you to prevent interference with the jaw springs. The other bolt should be positioned with the threads facing downward. Each bolt has a nut, washer, and new bushings. Apply grease to the bolt parts and where there is metal to metal contact with the operating handle. See **Fig. 9**. Do not overtighten the bolts. Lubricate all pivot points.

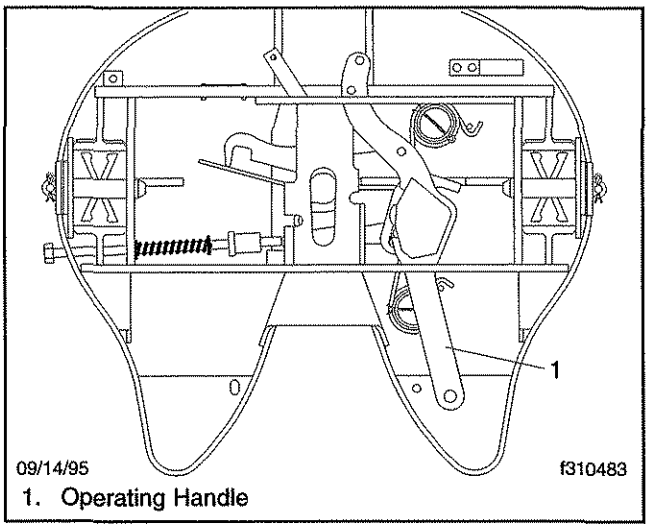


Fig. 7, Operating Handle Positioning

IMPORTANT: The fifth wheel must be well lubricated to operate correctly. Refer to **Group 31** of the *Century Class Maintenance Manual* for complete maintenance and lubrication instructions for the fifth wheel assembly.

10. Connect the bumper spring to its clasp. Apply grease to the bracket pockets and to the grease fittings on the side of the fifth wheel until grease flows into the upper brackets. Also apply a liberal amount of grease to the top plate. See **Fig. 10**.

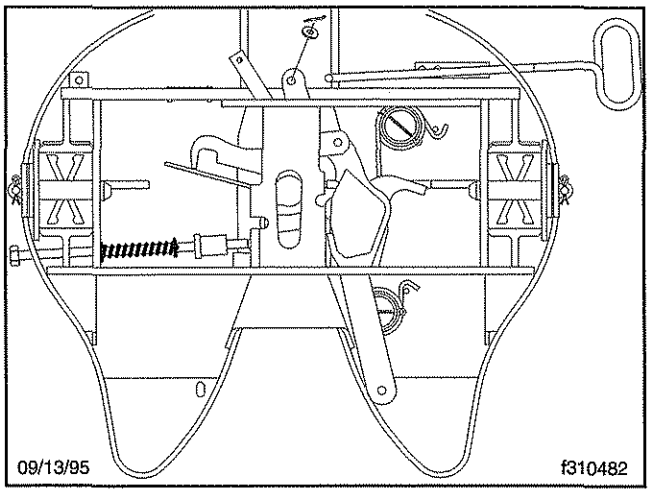


Fig. 8, Pull Handle Installation

Fifth Wheel Assembly and Installation

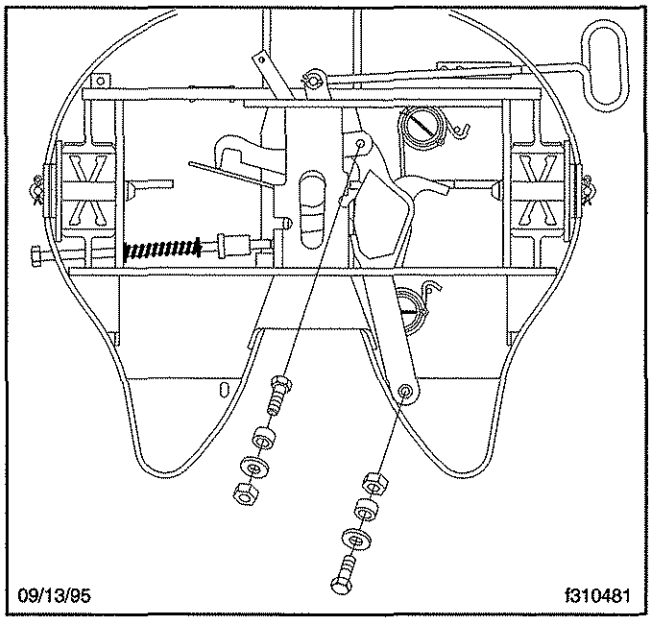
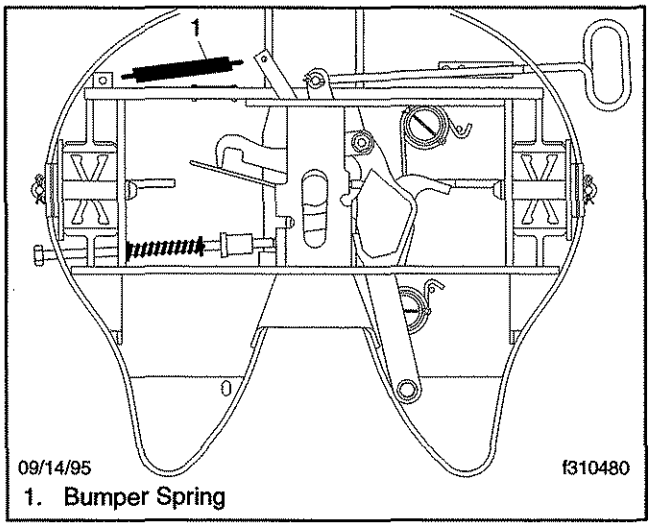


Fig. 9, Bolt Installation

⚠ WARNING

If the fifth wheel does not operate properly, do not use it. The fifth wheel could malfunction, resulting in personal injury or property damage due to possible disengagement of the trailer from the tractor.



1. Bumper Spring

Fig. 10, Spring Installation

11. Using an overhead hoist, position the fifth wheel on the sliding mount assembly. Insert the bushing pins. Install the retaining pins and the 1-inch long cotter pins.

Troubleshooting Tables

Problem—Difficulty Coupling

Possible Cause	Remedy
The kingpin is too high to trip the latch	Lower the landing gear.
The trailer plate or kingpin is damaged	Check the trailer plate for flatness. Check the kingpin for squareness with the trailer plate.

Problem—Excessive Wear on the Fifth Wheel Top Plate

Possible Cause	Remedy
Damaged trailer plate	If the trailer plate is not flat, replace it.

Problem—Difficulty Uncoupling

Possible Cause	Remedy
Pressure on the locking mechanism caused by truck drifting apart from the trailer putting excess pressure on the lock	Back up the trailer and set the brakes. Strike the wedge stop rod which protrudes through the side of the fifth wheel. This spring-loaded rod will release the pressure on the locking mechanism.
Oval-shaped kingpin	Lower the landing gear.
Debris build-up in the grease	

Problem—Slack

Possible Cause	Remedy
Undersized kingpin	Replace the kingpin if worn greater than 1/8 inch (3 mm) at the 2-inch (5 cm) diameter.
Worn jaw and wedge	Jaw and wedge could have excessive wear. Replace them.

Contents

Subject	Subject Number
General Information	050
Service Operations	
Sliding Mount Disassembly and Assembly	100

General Information

The Fontaine sliding fifth-wheel mount is designed to provide optimum axle loading for maximum tractor use with different lengths and types of trailers. The sliding fifth-wheel mount is used with the Fontaine 5092 series fifth wheel and is equipped with either an air-operated release slide (5AWB model), or a manual release slide (5MWS model).

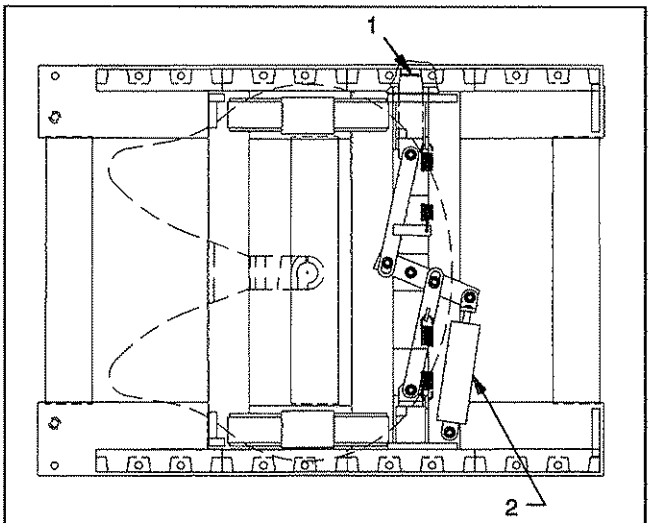
Sliding fifth wheel assemblies are mounted on slide rails that are attached to the vehicle frame. Slots are evenly spaced along the slide rails, and retractable tapered wedges are positioned through the slots to hold the fifth wheel in the desired position. This assembly allows forward or rearward movement of the fifth wheel along the slide rails for optimum weight distribution over the tractor axles. The slide rails are bolted to the tractor frame.

When the fifth wheel is in the desired position, it is locked in place by tapered wedges that engage in the slots under the sliding mount. To release the fifth wheel, the wedges are withdrawn (manually or air-operated).

The air-operated release slide contains an air cylinder (**Fig. 1**) which locks and unlocks both sides of the sliding mount at the same time. The air cylinder is activated by a two-position air-control valve in the tractor cab.

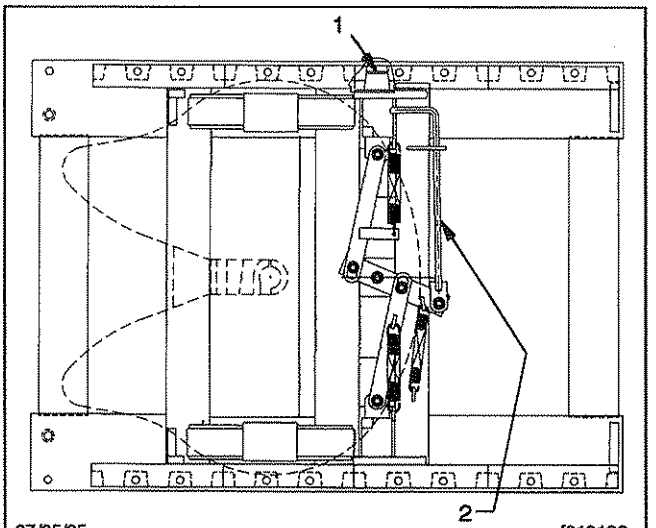
The manual release slide assembly (**Fig. 2**) contains a slide locking control handle, located on the left side (roadside) of the fifth wheel, which locks or unlocks both sides of the sliding mount.

Refer to the vehicle driver's manual for complete operating instructions.



1. Locking Wedge
2. Air Cylinder

Fig. 1, Air-Operated Sliding Fifth Wheel Mount, 5AWB Model



1. Locking Wedge
2. Slide Release Pull Handle

Fig. 2, Manual Release Sliding Fifth Wheel Mount, 5MWS Model

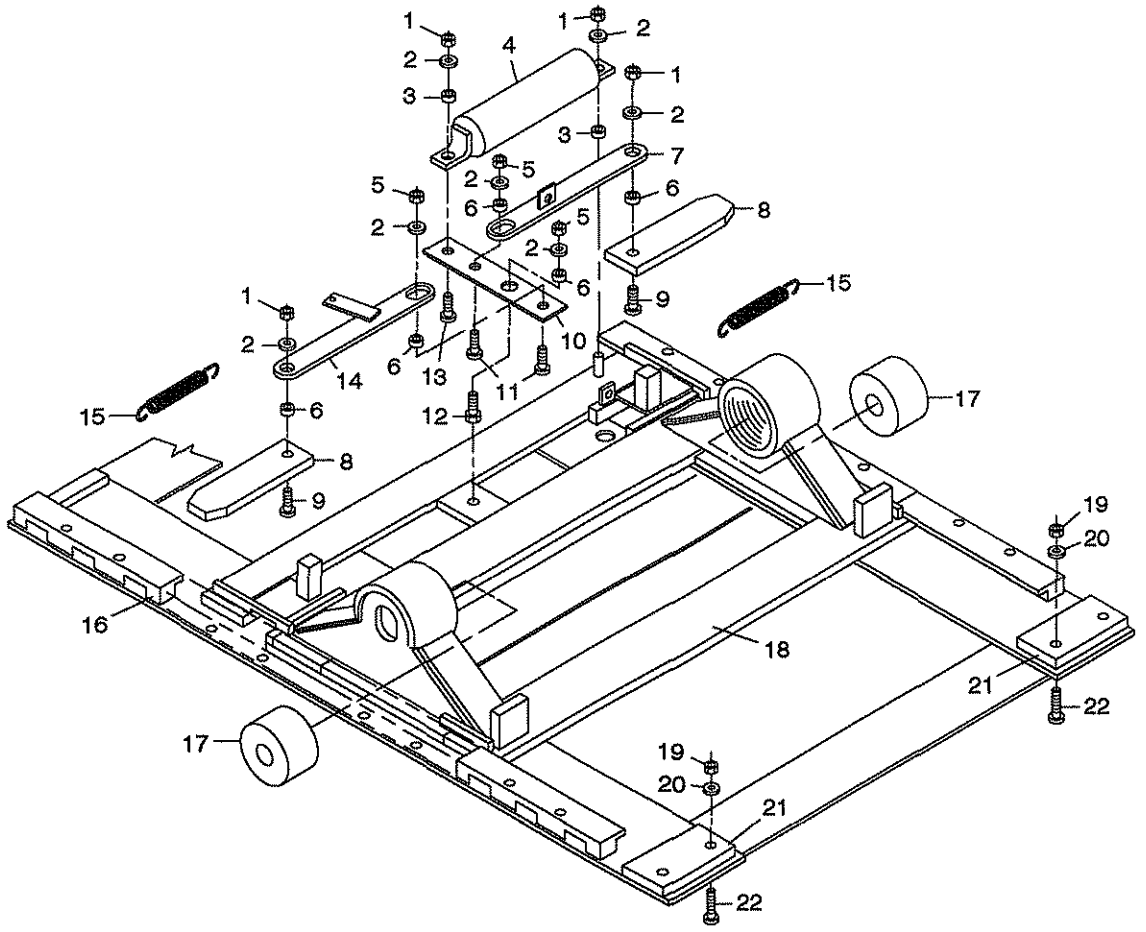
Sliding Mount Disassembly and Assembly

Disassembly (See Fig. 1 or Fig. 2)

WARNING: All fifth wheel maintenance, adjustment, and rebuilding must be done only by a qualified mechanic. Improper or incomplete procedures could result in possible disengagement of the trailer from the tractor, leading to personal injury and property damage.

WARNING: The lifting device used to remove the top plate must be able to lift 500 lbs (227 kg). The top plate weighs 254 lbs (115 kg) and if dropped could cause personal injury or property damage.

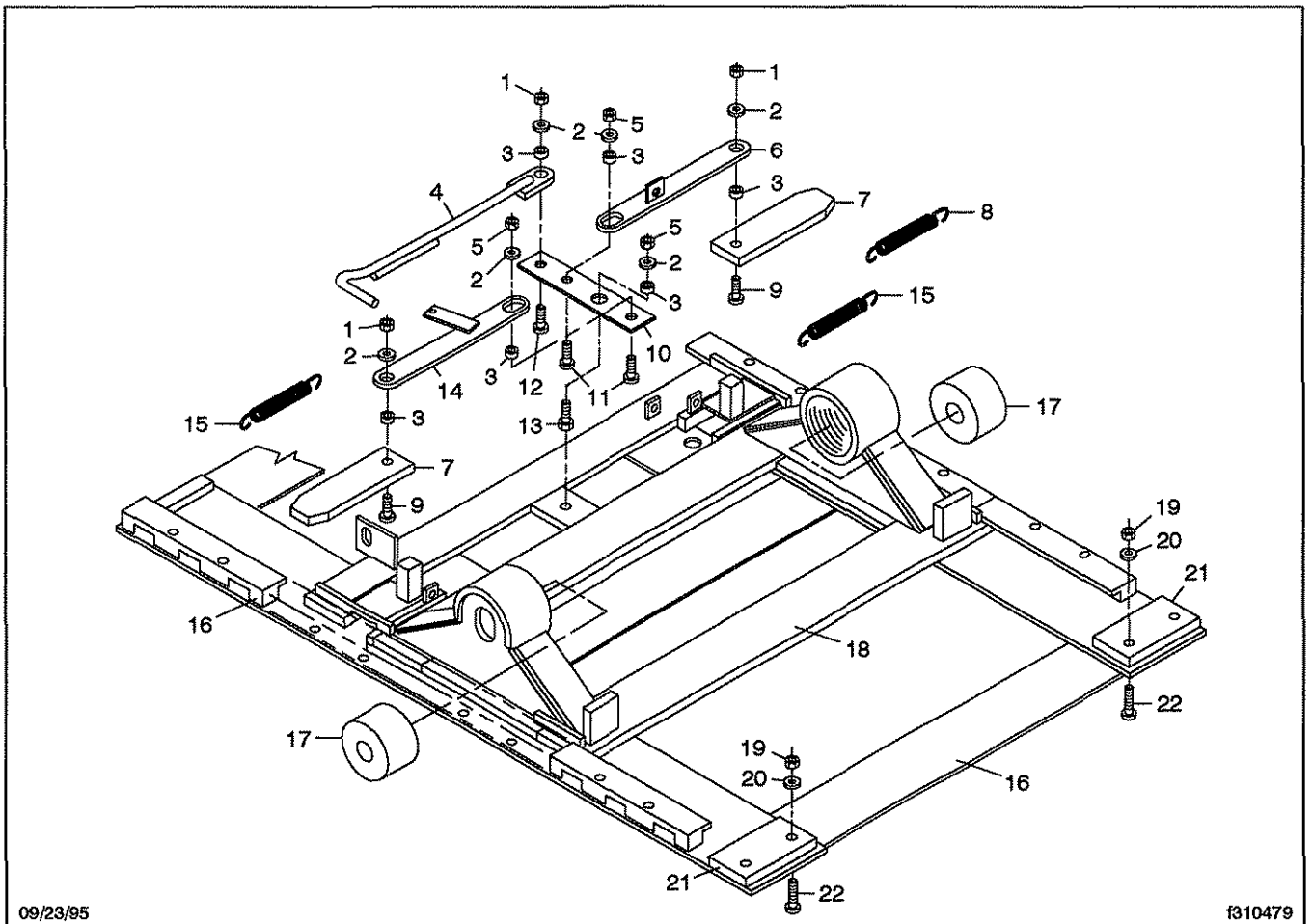
1. Remove the top plate. **See Fig. 3.**



1. Hex Locknut, 1/2–13, Grade B
2. Flatwasher
3. Bushing Spacer, 7/16"
4. Air Cylinder
5. Hex Jam Nut, 1/2–13
6. Bushing Spacer, 5/16"
7. Locking Wedge Release Bar (Right Side)
8. Locking Wedge
9. Capscrew, 1/2–13 x 2"
10. Latching Lever
11. Capscrews, 1/2–13 x 1"
12. Capscrew, 1/2–13 x 1"
13. Capscrew, 1/2–13 x 1–1/2"
14. Locking Wedge Release Bar (left side)
15. Locking Member Spring
16. Slide Rail
17. Bracket Bushing
18. Slide Bracket
19. Locknut, 5/8" Grade C
20. Flatwasher
21. Rear Slide Stop
22. Capscrew, 5/8–11 x 1–3/4"

Fig. 1, Fontaine Sliding Fifth Wheel Mount, Model 5AWB (Air-Operated)

Sliding Mount Disassembly and Assembly



1. Hex Locknut, 1/2–13, Grade B
2. Flatwasher
3. Spacer Bushing, 5/16"
4. Pull Handle
5. Hex Jam Nut, 1/2–13
6. Locking Wedge Release Bar (Right Side)
7. Locking Wedges
8. Latching Lever Spring
9. Capscrew, 1/2–13 x 2"
10. Latching Lever
11. Capscrews, 1/2–13 x 1"
12. Capscrew, 1/2–13 x 1–1/2"
13. Capscrew, 1/2–13 x 1"
14. Locking Wedge Release Bar (left side)
15. Locking Member Spring
16. Slide Rail
17. Bracket Bushing
18. Slide Bracket
19. Locknut, 5/8–11, Grade C
20. Flatwasher
21. Rear Slide Stop
22. Capscrew, 5/8–11 x 1–3/4"

Fig. 2, Fontaine Sliding Fifth Wheel Mount, Model 5MWS (Manual Release)

1.1 Using a lifting device to support the top plate, remove the two cotter pins.

1.2 Remove the two lower bracket retainer pins, and discard them.

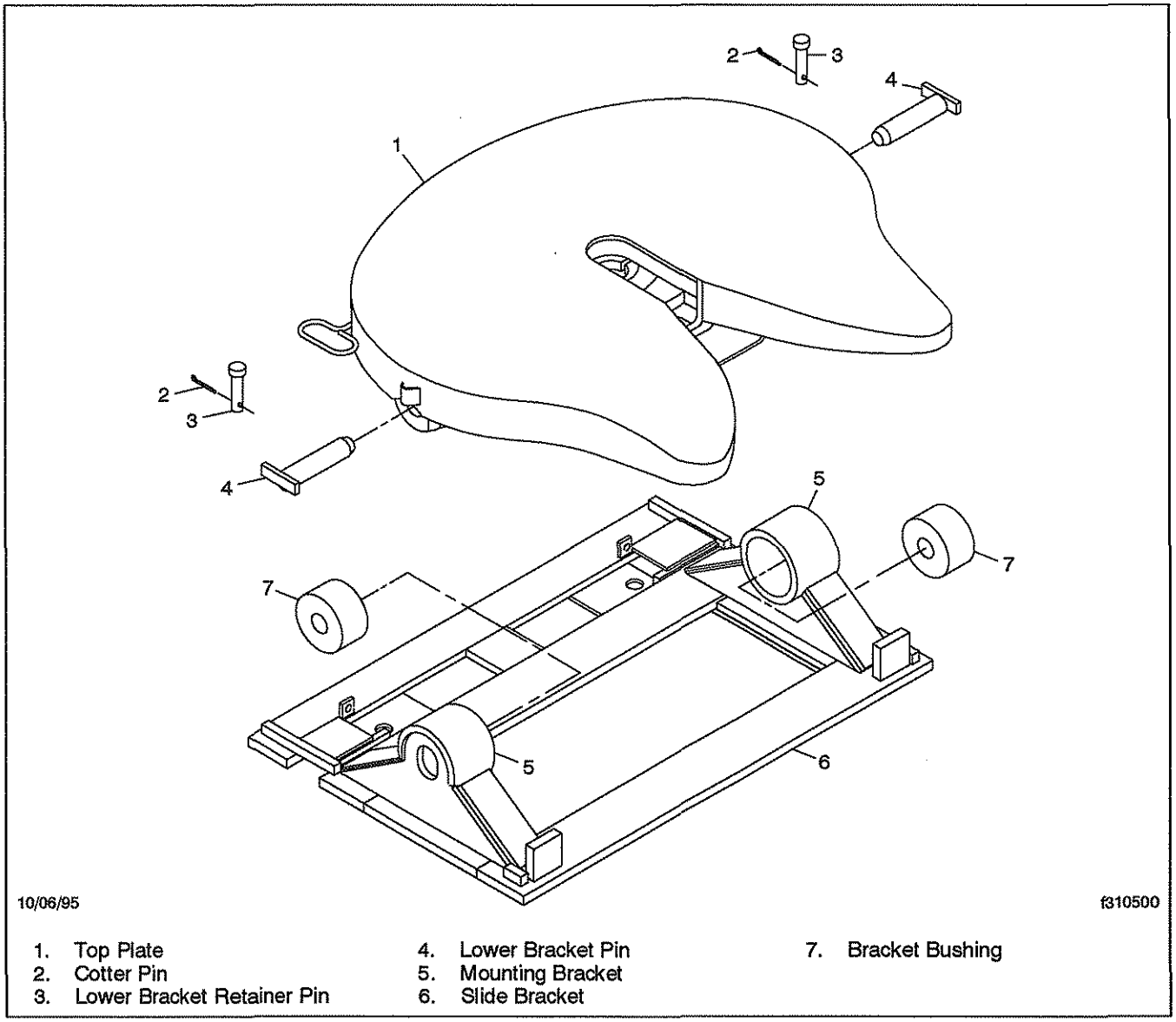
1.3 Remove the lower bracket pins, and lift the top plate from the slide bracket.

1.4 Remove and discard the bracket bushings.

1.5 Clean and inspect all the parts. Replace parts as needed.

2. If the fifth wheel mount is equipped with a manual release (**Fig. 2**), go to the next step for disassembly instructions.

Sliding Mount Disassembly and Assembly



1. Top Plate
2. Cotter Pin
3. Lower Bracket Retainer Pin
4. Lower Bracket Pin
5. Mounting Bracket
6. Slide Bracket
7. Bracket Bushing

Fig. 3, Top Plate Removal

If the fifth wheel mount is equipped with an air release cylinder (**Fig. 1**), disassemble it as follows:

2.1 Drain the air from the air cylinder, and disconnect the air line from the cylinder. Install plugs in the air line and the cylinder to prevent dirt or other matter from entering them.

2.2 Remove the locking wedge springs (**Fig. 1**, Ref. 15), the capscrews (Ref. 9), the spacers, the washers, and the locknuts. Discard the locknuts and spacers.

2.3 Remove the locking wedge release bars.

2.4 Remove the capscrew (Ref. 12), the spacer, the washer, and the locknut. Discard the locknut.

Sliding Mount Disassembly and Assembly

Remove the capscrew (Ref. 11), the spacers, the washers, and the locknuts. Discard the locknuts and the spacers.

2.5 Remove the locking wedges.

2.6 Remove the capscrew (Ref. 13), the spacer, the washer, and the locknut. Discard the locknut and the spacer.

2.7 Remove the air cylinder.

3. If the fifth wheel mount is equipped with a manual release (**Fig. 2**) disassemble it as follows:

3.1 Remove the three springs from the sliding mount assembly.

3.2 Remove the locknuts (**Fig. 2**, Ref. 1), the washers, the spacer bushings, and the capscrews from the tapered wedges.

3.3 Remove the locking wedges.

3.4 Remove the locknuts from the pull handle, and the locking wedge release bars.

Remove the spacer bushings, washers, and capscrews.

Remove the locking wedge release bars and the pull handle from the latching lever.

3.5 Remove the locknut, washer, spacer bushing, and capscrew from the latching lever.

Remove the latching lever.

4. If the sliding mount assembly is damaged, remove it as follows:

4.1 Remove the nuts, washers, and capscrews that secure the rear slide stops to the rear of the slide rail.

4.2 Grind down the welded area to remove the rear stops.

4.3 Remove the sliding mount assembly from the baseplate by sliding it off the rear of the tracks.

5. Remove all dirt and grease from the parts. Replace any parts that show signs of wear, damage, or deterioration.

Assembly (See Fig. 1 or Fig. 2)

WARNING: All fifth wheel maintenance, adjustment, and rebuilding must be done only by a qualified mechanic. Improper or incomplete procedures could result in possible disengagement of the trailer from the tractor, leading to personal injury or property damage.

1. Using a multipurpose chassis lube, grease the flanges on the sliding mount. Then, slide the assembly onto the tracks of the baseplate.

2. Slide the mounting assembly to the rearmost position. Position the wedges in the rail.

Install the capscrews, washers, and nuts that secure the rear stops to the baseplate.

3. Slide the mounting assembly out of the way, then weld the stops in place. The welds should be 1/4-inch (6 mm) fillet.

4. Slide the mounting assembly to the rearmost position and check for clearance. Make sure that the wedges seat in the rail.

5. If the fifth wheel mount is equipped with a manual release (**Fig. 2**), go to the next step for assembly instructions.

If the fifth wheel mount is equipped with an air release cylinder (**Fig. 1**), assemble it as follows:

NOTE: To avoid damaging the spacers, tighten the locknuts only one turn beyond finger tight.

5.1 Install the capscrews (**Fig. 1**, Ref. 9) and spacers in the locking wedges.

5.2 Using capscrews, spacers, washers, and new locknuts, fasten the latching lever to the locking wedge release bars.

5.3 Slide the locking wedges into the slide assembly guide, and place the locking wedge bars and latching lever on the assembly. Bolt down the locking wedge release bars with new washers and locknuts.

5.4 Apply grease to the locking member and the assembly.

5.5 Install the air cylinder using new spacers and locknuts. Install the locking member spring.

6. If the fifth wheel mount is equipped with a manual release (**Fig. 2**) assemble it as follows:

   NOTE: To avoid damaging the spacers, tighten the locknuts only one turn beyond finger tight.

   6.1 Using a capscrew, spacer bushing, washer, and locknut, install the latching lever.

   6.2 Using capscrews, spacer bushings, washers, and locknuts, attach the locking wedge release bars and pull handle to the latching lever.

   6.3 Using capscrews, spacer bushings, washers, and locknuts, attach the locking wedges to the locking wedge release bars.

   6.4 Install the three springs on the bracket assembly.

WARNING: The lifting device used to remove the top late must be able to lift 500 lbs (227 kg). The top plate weighs 254 lbs (115 kg) and if dropped could cause personal injury or property damage.

7. Install the top plate on the fifth wheel mount. **See Fig. 3.**

   7.1 Install new bracket bushings in the slide bracket.

   7.2 Lubricate the brackets and the bearing pockets in the top plate with bearing grease.

   7.3 Set the top plate on the mounting brackets, and align the bracket pin holes in the top plate with the mounting bracket holes.

   7.4 Insert new lower bracket pins.

   7.5 Insert new lower bracket retainer pins. Insert new cotter pins in the lower bracket retainer pins.

Contents

Subject	Subject Number
General Information	050
Service Operations	
Pintle Hook Inspection	100
Trailer Coupling Disassembly and Assembly	110

General Information

The Premier models 260 and 460 trailer couplings (**Fig. 1**) are air adjusted. When they are in use, an air chamber and push rod at the rear of the coupling (**see Fig. 2**) reduce any slack between the coupling and the drawbar eye of the trailer. This provides smoother towing and reduces wear on the parts.

The design and load capacity of the 260 and 460 models are the same; the only difference between the two models is the bolt-hole pattern for mounting.

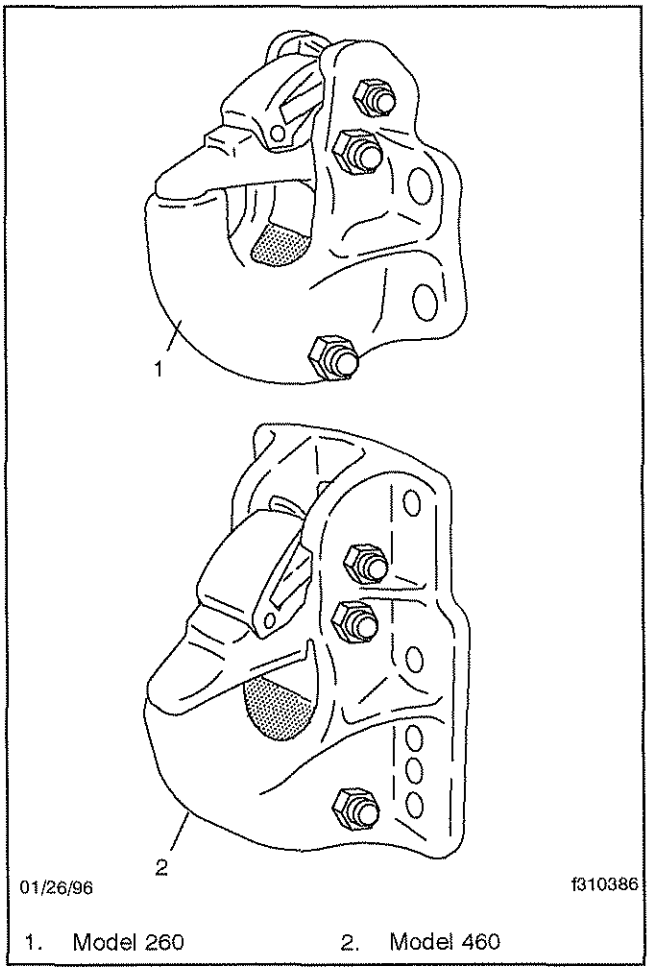


Fig. 1, Premier Trailer Couplings

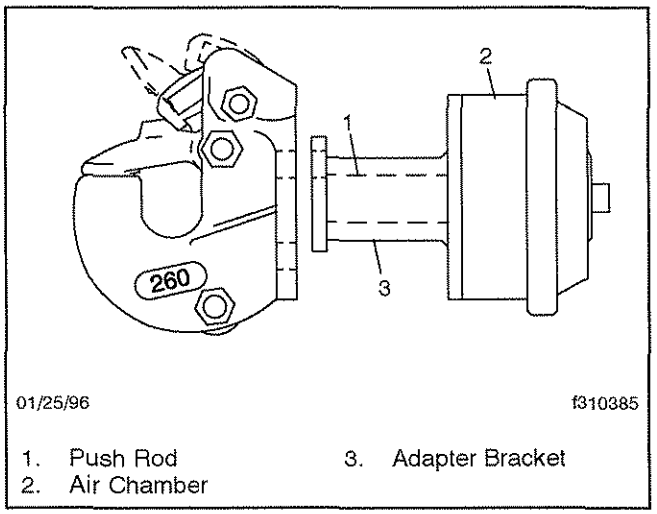


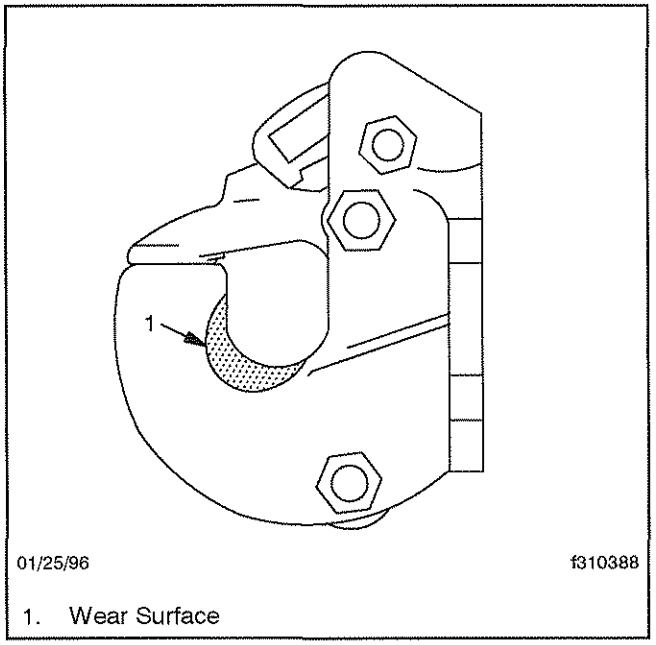
Fig. 2, Air Chamber and Push Rod

Pintle Hook Inspection

Check the pintle hook for damage or stress cracks, then check it for wear on its lower inside surface. **See Fig. 1.** Use Premier wear gauge 14014 (**see Fig. 2**) to check the percentage of wear on the pintle hook.

WARNING: If the pintle hook is damaged, has stress cracks, or if it's worn beyond 20% of its original diameter, replace the entire coupling; don't repair it. Using a worn or damaged trailer coupling could cause the trailer to disconnect from the vehicle, which could result in an accident causing serious personal injury and property damage.

If the pintle hook is damaged, or if it's worn beyond 20% of its original diameter, replace the entire coupling; it is not repairable.



1. Wear Surface

Fig. 1, Wear Checking

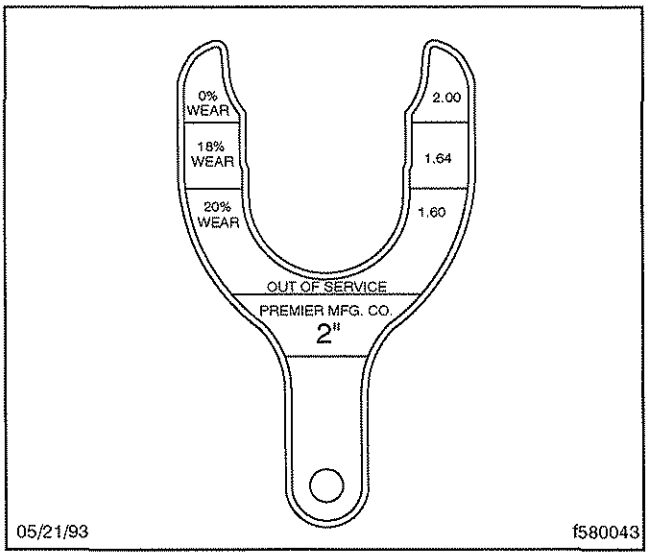


Fig. 2, Typical Wear Gauge

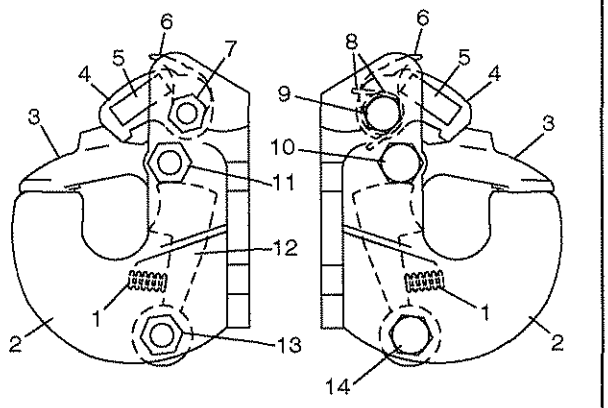
Check the pintle hook for wear on its lower inside surface. See **Subject 100** for wear checking instructions.

Disassembly

CAUTION: If the pintle hook is damaged, has stress cracks, or if it's worn beyond 20% of its original diameter, replace the entire coupling; don't repair it.

WARNING: When disassembling the trailer coupling, wear safety glasses. Some of the parts are under tension (such as springs), and could fly out, possibly causing eye injury.

1. Remove the coupling from the vehicle; then put it on its side, with the pawl-, latch-, and shoe-bolt nuts facing up.
2. Remove the pawl-bolt nut and pawl bolt (**see Fig. 1** and **Fig. 2**); then remove the pawl assembly from the coupling body.
3. Disassemble the pawl. **See Fig. 3.**
   - 3.1 Remove the pawl lock and spring.
   - 3.2 Remove the two nylon bushings, then the pawl wedges and compression spring.
4. Remove the latch nut and bolt (**see Fig. 1**); then remove the latch.
5. Remove the shoe nut and bolt.
6. From the bottom of the coupling body, compress the shoe spring, then remove the shoe from the coupling body.



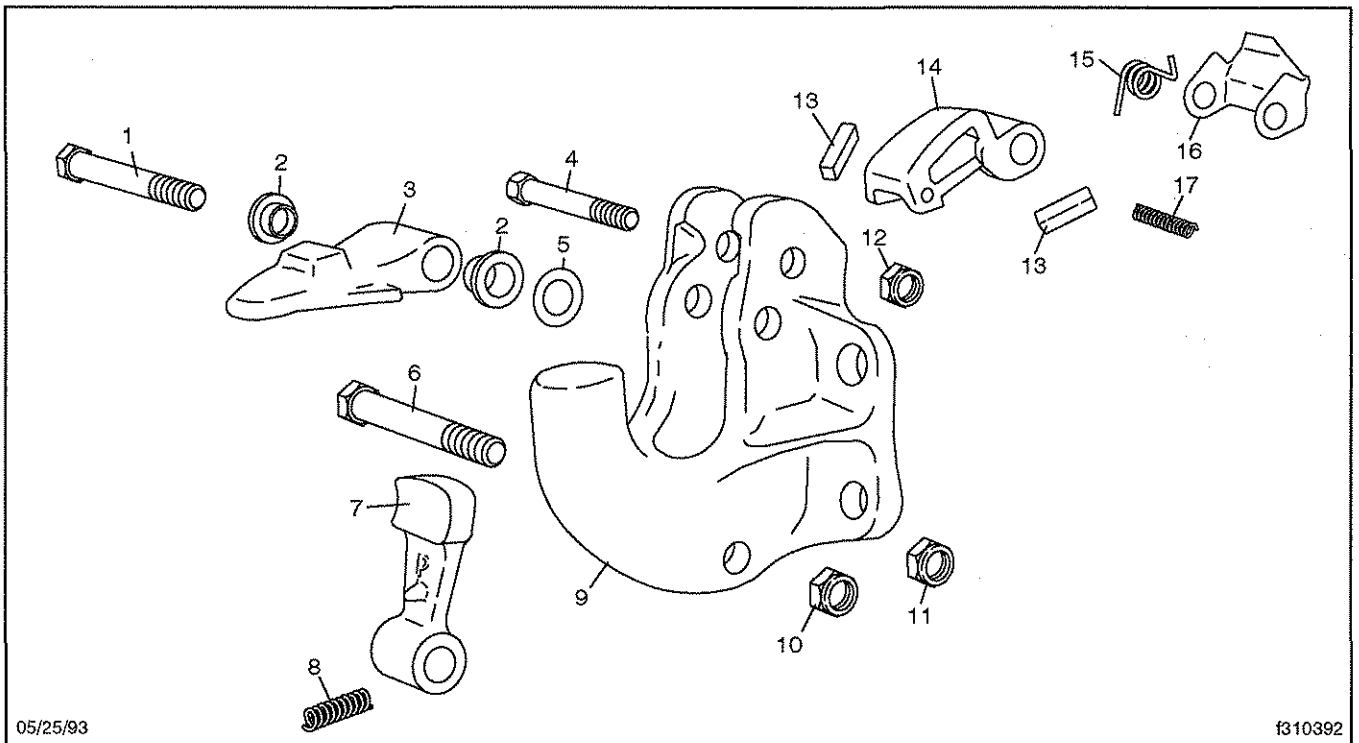
1. Shoe Spring
2. Pintle Hook/Coupling Body
3. Latch
4. Pawl
5. Pawl Wedge
6. Pawl Lock
7. Pawl-Bolt Nut
8. Pawl Spring
9. Pawl Bolt
10. Latch Bolt
11. Latch-Bolt Nut
12. Shoe
13. Shoe Nut
14. Shoe Bolt

Fig. 1, Model 260 Shown

Assembly

1. Check for wear on all the parts that aren't included in the new parts kit. Replace them if needed.
2. Put the coupling body on the workbench with the mounting surface down, and the bottom of the body facing you.
3. Install the shoe, then the shoe bolt and nut (**see Fig. 1**) in the bottom of the coupling body.
4. Install the shoe spring in the recess inside the coupling body.
5. Install the pawl bolt part way into the left side of the coupling body; then put the pawl spring over the end of the bolt. Make sure the tang on the spring is pointing inboard.
6. Install the pawl lock (**see Fig. 2**) in the body so the spring tang hooks onto the lip of the pawl lock. **See Fig. 3.**
7. Install new nylon bushings in the pawl, then install the compression spring and wedges in the pawl.
8. While compressing the pawl wedges, install the pawl assembly in the pawl lock and the coupling body, aligning the holes of the pawl and pawl lock with the pawl bolt.
9. Push the pawl bolt through the holes of the pawl lock and the pawl just far enough to hold them in place, then install the spacer (**see Fig. 2**) onto the end of the pawl bolt.
10. Push the pawl bolt all the way through the right side of the coupling body.
11. Raise the pawl assembly (push it away from you), then slide the latch (**see Fig. 1**) into the body, below the pawl assembly.

Trailer Coupling Disassembly and Assembly



1. Latch Bolt
2. Nylon Bushing
3. Latch
4. Pawl Bolt
5. Spacer
6. Shoe Bolt
7. Shoe
8. Shoe Spring
9. Pintle Hook/Coupling Body
10. Shoe-Bolt Nut
11. Latch-Bolt Nut
12. Pawl-Bolt Nut
13. Pawl Wedge
14. Pawl
15. Pawl Spring
16. Pawl Lock
17. Compression Spring

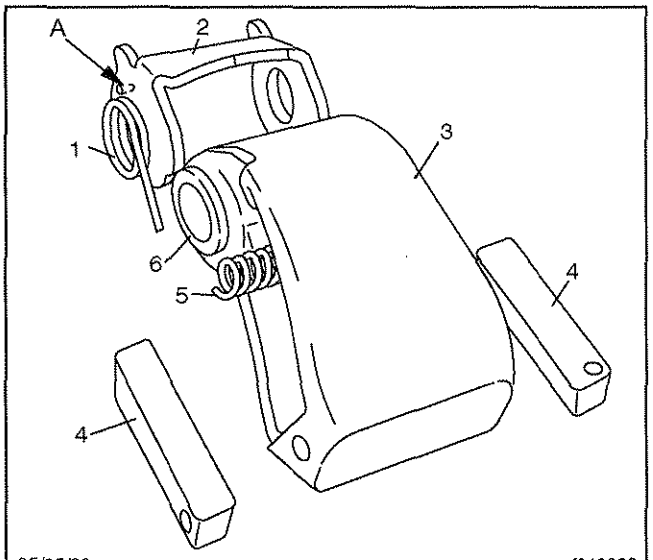
Fig. 2, Trailer Coupling Parts

Install the latch bolt.

CAUTION: Don't overtighten the pawl-, latch-, and shoe-bolt nuts. To do so may cause the parts to bind, which could result in unnecessary wear on the latch assembly.

12. Install the nuts on the pawl bolt, latch bolt, and shoe bolt. Tighten them snugly.

13. Lubricate all the moving parts—but not the pintle hook—with a light penetrating oil. Open and close the latch several times to distribute the oil.



A. Spring tang hooks here.

1.	Pawl Spring	4.	Pawl Wedge
2.	Pawl Lock	5.	Compression Spring
3.	Pawl	6.	Nylon Bushing

Fig. 3, Pawl Assembly

14. Install the coupling on the vehicle. Tighten the fasteners 320 lbf·ft (434 N·m).

Contents

Subject	Subject Number
General Information	050
Service Operations	
Pintle Hook Inspection	100
Trailer Coupling Disassembly and Assembly	110

General Information

The Premier model 690 trailer coupling (**see Fig. 1**) is a non-air-adjusted, heavy-duty coupling. It is used for load capacities up to 90,000 lbs, and is available with either right- or left-hand operation.

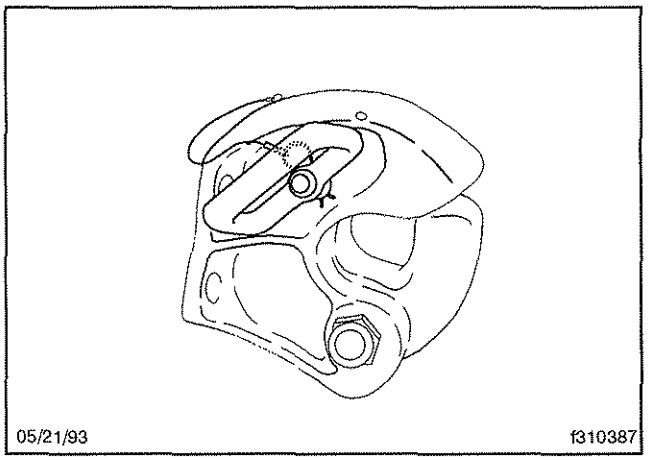


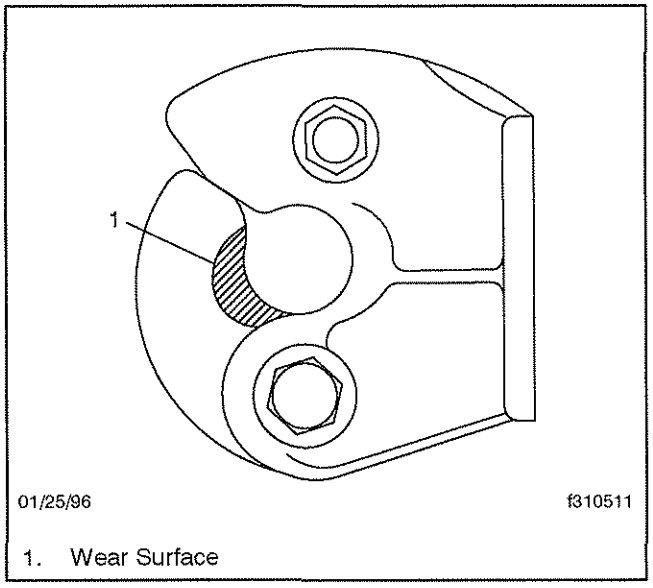
Fig. 1, Premier 690 Trailer Coupling

Pintle Hook Inspection

Check the pintle hook for damage or stress cracks, then check it for wear on its lower inside surface. **See Fig. 1.** Use Premier wear gauge 14014 (**see Fig. 2**) to check the percentage of wear on the pintle hook.

WARNING: If the pintle hook is damaged, has stress cracks, or if it's worn beyond 20% of its original diameter, replace the entire coupling; don't repair it. Using a worn or damaged trailer coulpling could cause the trailer to disconnect from the vehicle, which could result in an accident causing serious personal injury and property damage.

If the pintle hook is damaged, or if it's worn beyond 20% of its original diameter, replace the entire coupling; it is not repairable.



1. Wear Surface

Fig. 1, Wear Checking

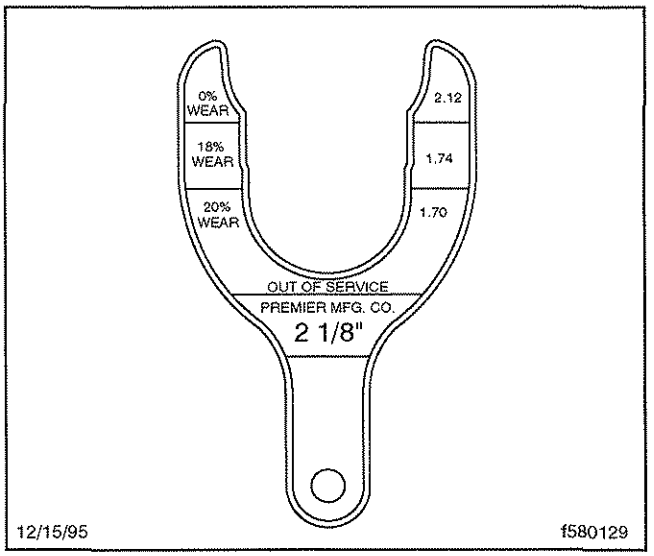


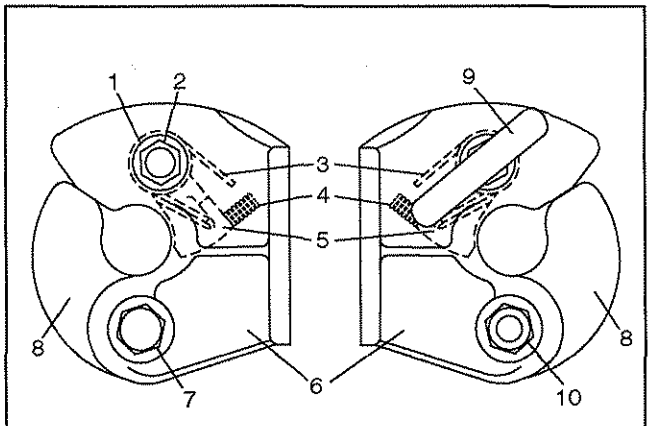
Fig. 2, Wear Gauge

Disassembly (See Fig. 1)

1. Remove the coupling from the vehicle.
2. Remove the pintle-hook nut and bolt, then remove the pintle hook from the coupling body.
3. With the handle pushed in, remove the nut from the end of the handle.
4. Remove the bushing, then the handle from the body.
5. From the bottom of the coupling body, remove the small pawl spring, then the pawl and the large pawl spring. Discard the two springs.
6. Remove and discard the locking pin assembly (**see Fig. 2**) from the coupling body.

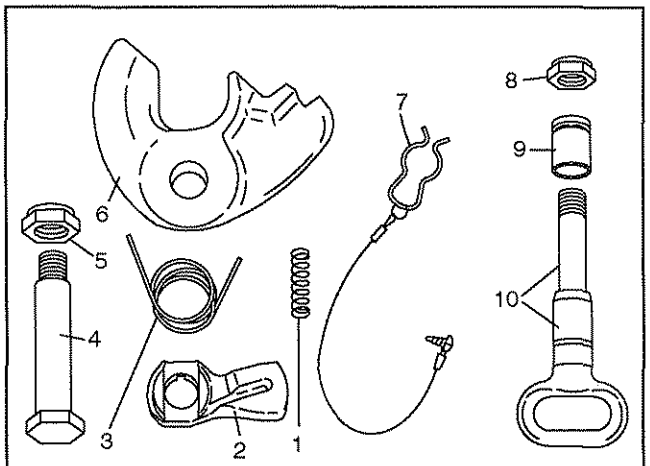
Assembly (See Fig. 2)

1. Check for wear on any parts that aren't included in the new parts kit. Replace them if needed.
2. Put the coupling body on its face, with the mounting surface up and the bottom of the coupling body toward you. **See Fig. 3**
3. Place a new large spring on the pawl, so that one leg of the spring fits into the groove in the pawl. **See Fig. 4**
4. Install the pawl and spring in the bottom of the coupling body, with the spring to your left. **See Fig. 5**. Make sure the other leg of the spring sits in the slot inside the body.
5. Install the handle (**see Fig. 2**) into the coupling body and the pawl. Make sure the taper of the handle matches the taper of the hole in the pawl, and that the handle locks into place.
6. Install the bushing over the threaded end of the handle, then install the nut.
7. Turn the handle toward yourself, then—from the bottom of the coupling body—install the small pawl spring (**see Fig. 2**) in the depression on the pawl. **See Fig. 5**. Make sure the other end of the spring fits into the depression inside the coupling body.



1. Bushing
2. Nut
3. Large Pawl Spring
4. Small Pawl Spring
5. Pawl
6. Coupling Body
7. Pintle-Hook Bolt
8. Pintle Hook
9. Handle
10. Pintle-Hook Nut

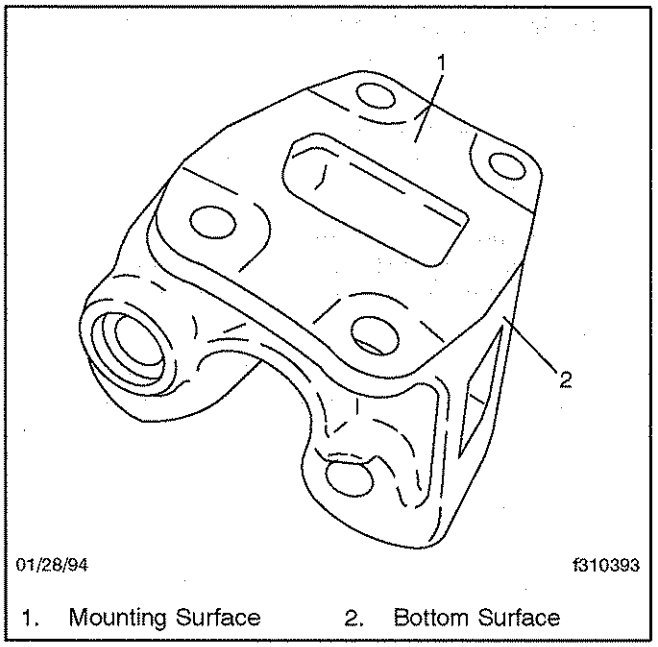
Fig. 1, Trailer Coupling Parts



1. Pintle Hook
2. Locking Pin Assembly
3. Nut
4. Bushing
5. Handle
6. Small Pawl Spring
7. Pawl
8. Large Pawl Spring
9. Pintle-Hook Bolt
10. Pintle-Hook Nut

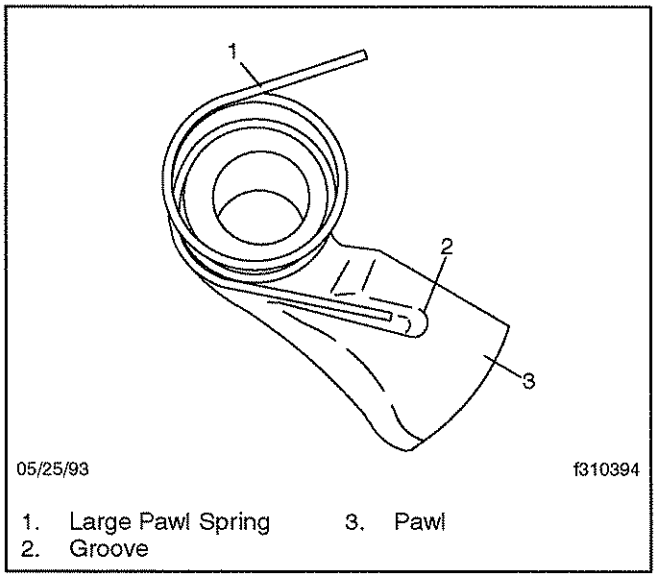
Fig. 2, Parts Disassembled

Disassembly and Assembly



1. Mounting Surface 2. Bottom Surface

Fig. 3, View of the Mounting Surface

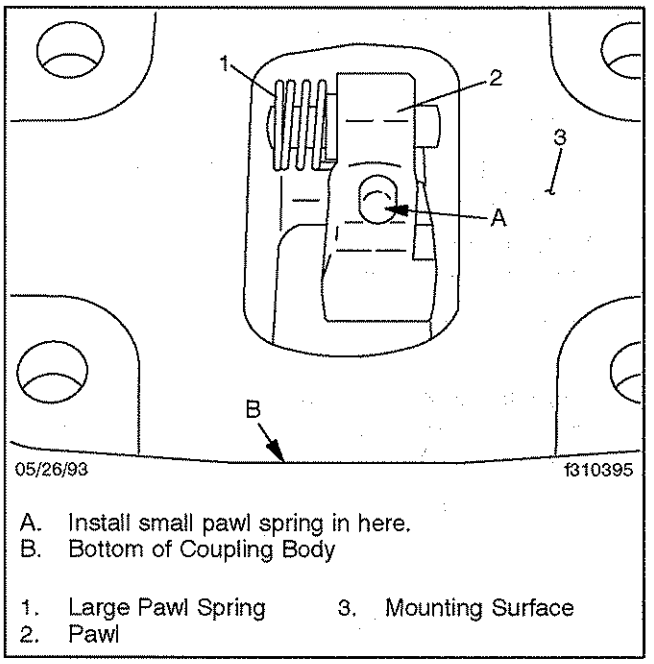


1. Large Pawl Spring 3. Pawl
2. Groove

Fig. 4, Pawl and Pawl Spring

8. Rotate the pawl up and lock it into position by turning the handle away from you, then pushing it in.

CAUTION: Don't overtighten the nuts for the pintle hook and the handle. To do so may cause the parts to bind, which could result in unnecessary wear on the coupling.



A. Install small pawl spring in here.
B. Bottom of Coupling Body

1. Large Pawl Spring 3. Mounting Surface
2. Pawl

Fig. 5, Pawl Spring Installation

9. Set the coupling body on its mounting surface, then install the new pintle hook, bolt, and nut. Tighten the nuts on the pintle hook bolt and the handle snugly.

10. Install the new locking pin assembly (**see Fig. 2**) on the top of the coupling body.

11. Lubricate all the moving parts with light penetrating oil. Don't lubricate the wear surface of the pintle hook. Open and close the pintle hook several times to distribute the oil.

12. Install the coupling on the vehicle. Tighten the mounting bolts 320 lbf·ft (434 N·m).

Trailer Coupling, Holland PH–T–60–AL 31.11

Contents

Subject	Subject Number
General Information	050
Service Operations	
Pintle Hook Inspection	100
Trailer Coupling Disassembly and Assembly	110

General information

The Holland model PH–60–AL–60 trailer coupling (**see Fig. 1**) has a rigid-type pintle hook. It is designed for trailers with a maximum gross weight of 10,000 lbs. It is mounted to the vehicle by 1/2–13 fasteners.

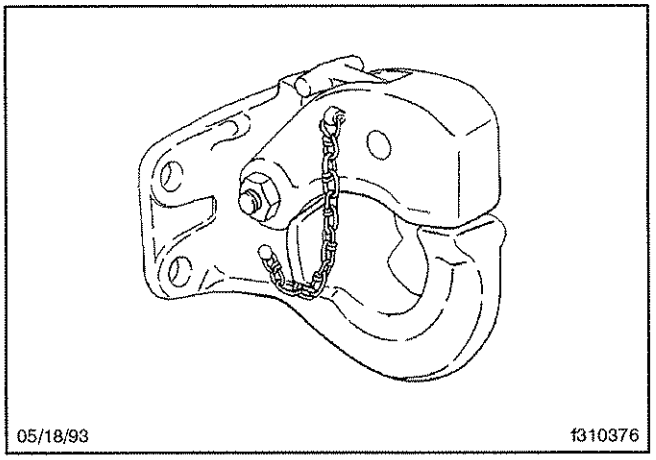


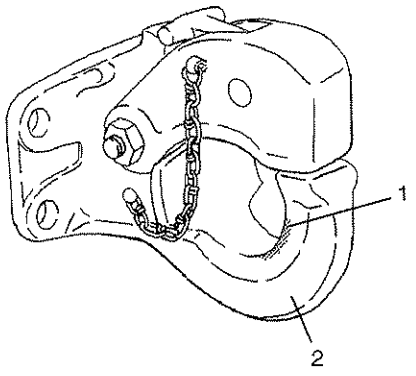
Fig. 1, Trailer Coupling

Pintle Hook Inspection

WARNING: If the pintle hook is damaged, has stress cracks, or if it's worn beyond 1/8 inch of its original diameter, replace the entire coupling; don't repair it. Using a worn or damaged trailer coupling could cause the trailer to disconnect from the vehicle, which could result in an accident causing serious personal injury and property damage.

Check the pintle hook for damage or stress cracks, then check it for wear on its lower inside surface. **See Fig. 1**.

If the pintle hook is damaged, or if the wear surface is worn deeper than 1/8 inch (3 mm), replace the entire coupling; it is not repairable.



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1. Wear Surface 2. Pintle Hook

Fig. 1, Checking for Wear

Disassembly

WARNING: If the pintle hook is damaged, has stress cracks, or if it's worn beyond 1/8 inch of its original diameter, replace the entire coupling; don't repair it. Using a worn or damaged trailer coupling could cause the trailer to disconnect from the vehicle, which could result in an accident causing serious personal injury and property damage. See Subject 100 for wear checking information.

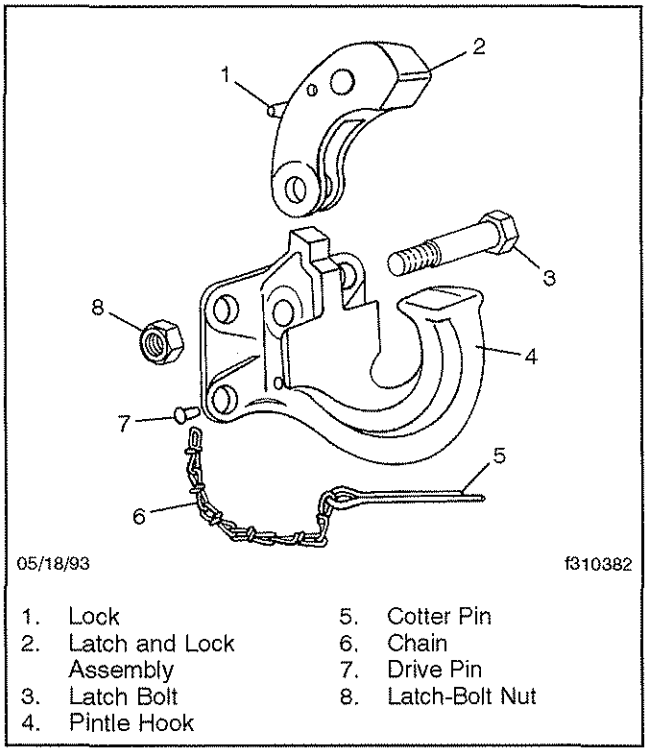
1. Remove the coupling from the vehicle.
2. Remove the latch-bolt nut and the latch bolt (**see Fig. 1**).
3. Remove the latch and lock assembly.
4. If the cotter pin and chain need replacing, remove the drive pin attaching them to the coupling.

Assembly

1. Install a new latch and lock assembly, aligning its holes with the holes in the coupling body. **See Fig. 1**.

CAUTION: Don't overtighten the latch-bolt nut. To do so may cause the parts to bind, which result in unnecessary wear on the coupling.

2. Install the latch bolt, then the latch bolt nut. Tighten the nut snugly.
3. If replacing the cotter pin and chain, install them using a new drive pin.
4. Lubricate all the moving parts—but not the pintle hook—with a light penetrating oil. Open and close the latch several times to distribute the oil.
5. Install the coupling on the vehicle. Tighten the fasteners 68 lbf·ft (92 N·m).



1. Lock
2. Latch and Lock Assembly
3. Latch Bolt
4. Pintle Hook
5. Cotter Pin
6. Chain
7. Drive Pin
8. Latch-Bolt Nut

Fig. 1, Trailer Coupling Parts

Contents

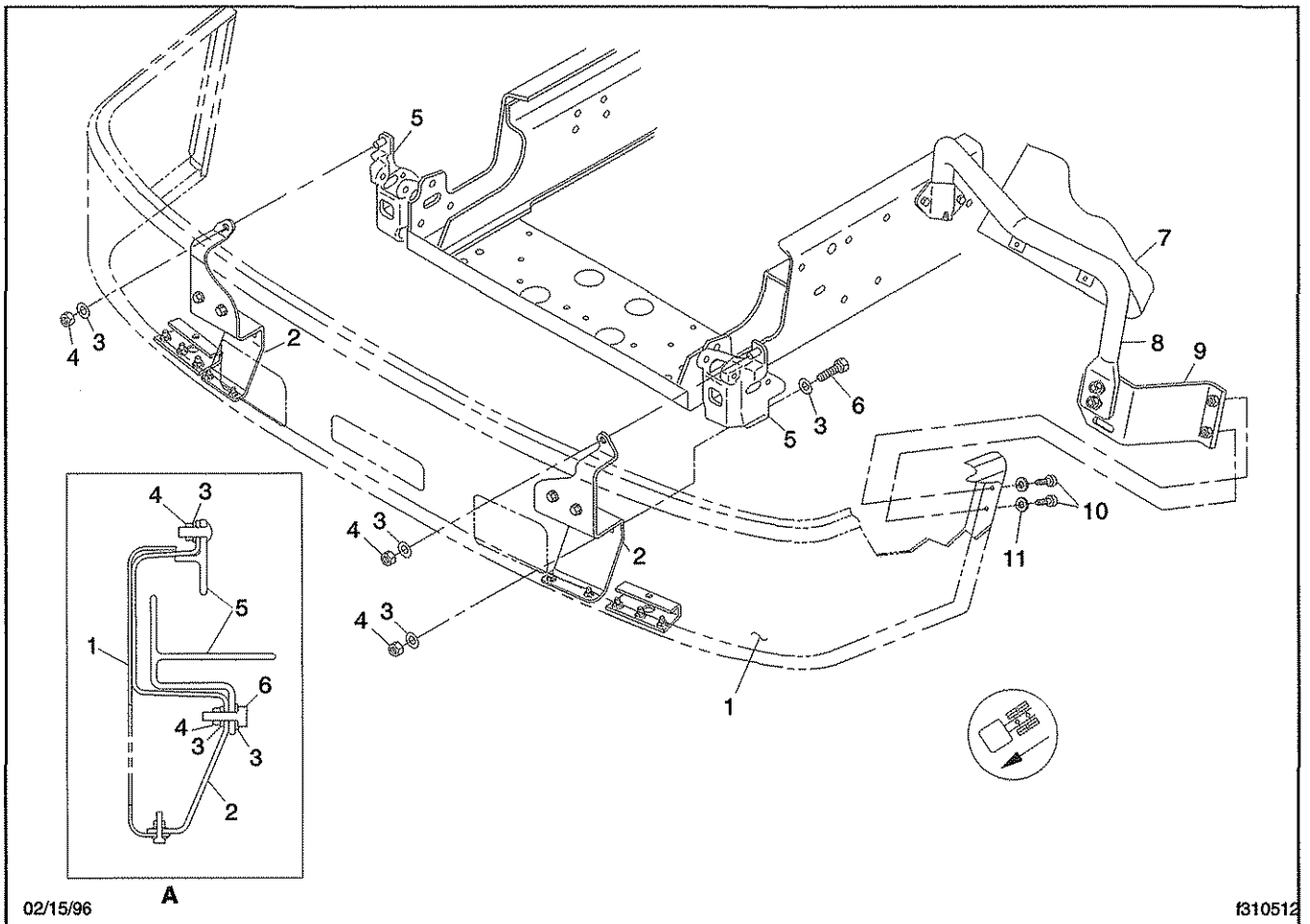
Subject	Subject Number
Service Operations	
Non-Aerodynamic Bumper Removal and Installation, Century Class S/T	100
Non-Aerodynamic Bumper Removal and Installation, Coronado	110

Non-Aerodynamic Bumper Removal and Installation, Century Class S/T

Old-Style Bumper

Removal

1. Park the vehicle, apply the parking brakes, and chock the front tires.
2. If equipped with road lights, disconnect the wiring harness from each road light.
3. Support the bumper; then remove the upper mounting hexnut and washer, and lower capscrew and washer from each side of the bumper front. See **Fig. 1**.
4. At one end of the bumper, remove the hexnuts and washers that attach the Z-bracket to the end of the tubular support. See **Fig. 1**. Repeat the procedure on the other end of the bumper.



NOTE: Not all fasteners are shown.

A. Cross-Section View

1. Bumper
2. Bumper Mounting Bracket
3. Washer, 1/2-inch
4. Mounting Hexnut, 1/2–13
5. Hood and Bumper Support Bracket
6. Capscrew, 1/2–13
7. Splash Shield
8. Tubular Support Strut
9. Z-Bracket
10. Torx®-Head Screws
11. Washer

Fig. 1, Non-Aerodynamic Bumper, Century Class S/T (old style)

Non-Aerodynamic Bumper Removal and Installation, Century Class S/T

5. Remove the bumper and the Z-brackets from the vehicle.
6. If you are replacing the bumper, remove the Z-brackets from the bumper ends. Also remove the road lights, if so equipped.

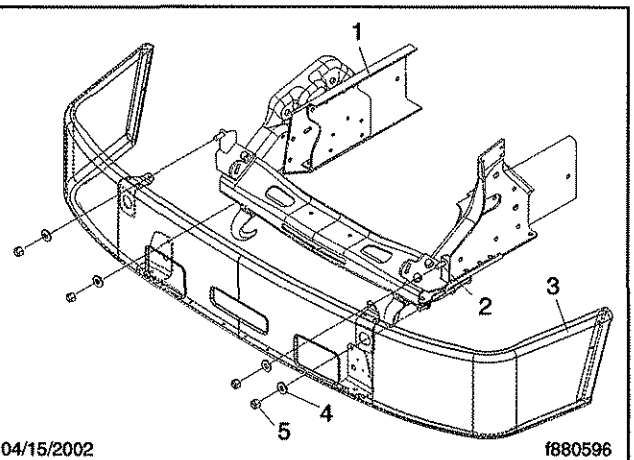
Installation

1. If they were removed, attach the Z-brackets to the ends of the bumper, using Torx-head screws and washers. Tighten the screws firmly.
2. Put the bumper in position, aligning the upper holes in the bumper mounting brackets with the threaded studs on the hood and bumper support brackets. Align the holes in the lower part of the mounting brackets with those in the lower part of the hood and bumper support brackets. See **Fig. 1**.
3. Adjust the bumper-to-hood gap.
   - 3.1 On one side of the vehicle, install the washer and the 1/2–13 capscrew into the slotted hole on the lower part of the hood and bumper support bracket. Then install the capscrew into the lower hole on the bumper mounting bracket. See **Fig. 1**.
   - 3.2 Install the 1/2–13 hexnut and washer onto the capscrew, and tighten it finger-tight.
   - 3.3 Move the bumper up or down as needed until the upper edge of the bumper is parallel to the lower edge of the hood.
   - 3.4 Tighten the hexnut 50 lbf·ft (68 N·m).
   - 3.5 Repeat the procedure for the other side of the vehicle.
4. Install the upper mounting hexnuts and washers. Tighten them 50 lbf·ft (68 N·m).
5. On one side of the vehicle, connect the Z-bracket to the tubular support strut, using the fasteners previously removed. Tighten the fasteners 15 lbf·ft (20 N·m). Repeat the procedure on the other side of the vehicle.
6. If removed, attach the road lights to the bumper. Connect the wiring harness to each road light.
7. Remove the chocks from the front tires.

New-Style Bumper, Three-Point Hood Mounting

Removal

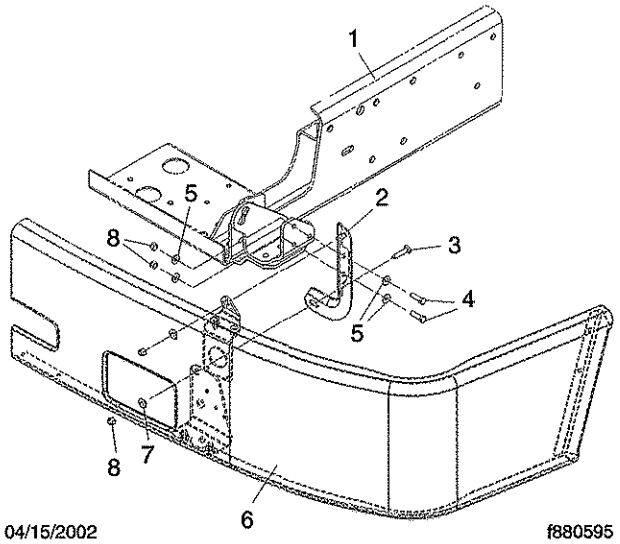
1. Park the vehicle, apply the parking brakes, and chock the front tires.
2. If equipped with road lights, disconnect the wiring harness from each road light.
3. Support the bumper; then remove the upper and lower mounting hexnut and washer from each side of the bumper front. See **Fig. 2** for vehicles with 1350 sq. in. radiators and **Fig. 3** for vehicles with 1200 sq. in. radiators.
4. Remove each end of the bumper from the tubular support and the splash shield. See **Fig. 4**.
   - 4.1 At one end of the bumper, remove the 1/2–13 mounting bolt and washer attaching the support arm to the outboard bumper support bracket.
   - 4.2 Remove the 5/16–18 mounting bolt, locknut, and washers attaching the splash shield to the outboard bumper support bracket.



1. Frame Rail
2. Mounting Stud
3. Bumper
4. Stainless Steel Washer, 1-1/16
5. Mounting Locknut

Fig. 2, Non-Aerodynamic Bumper, Century Class S/T (new style, 1350-sq. in. radiator)

Non-Aerodynamic Bumper Removal and Installation, Century Class S/T



NOTE: The left-hand side is shown; the right-hand side is similar.

1. Frame Rail
2. J-Bracket
3. J-Bracket Mounting Bolt, 3/8–16
4. Bumper Mounting Bolt, 1/2–13
5. Washer, 0.053"
6. Bumper
7. Stainless Steel Washer, 1-1/16"
8. Mounting Locknut

Fig. 3, Non-Aerodynamic Bumper, Century Class S/T (new style, 1200-sq. in. radiator)

4.3 Repeat this procedure at the other end of the bumper.

5. Remove the bumper from the vehicle with the outboard bumper support bracket attached.

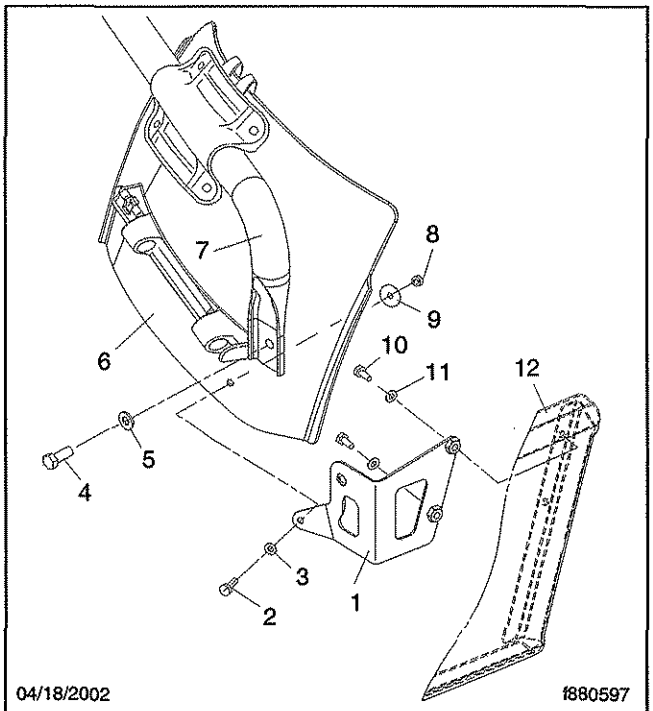
6. If you are replacing the bumper, remove the outboard bumper support brackets from each end of the bumper.

7. If you are replacing the bumper, remove the road lights, if so equipped.

Installation

1. If removed, attach an outboard bumper support bracket to each end of the bumper, using 5/16–18 Torx-head screws and load-bearing washers. Tighten the screws firmly.

2. Put the bumper in position. See **Fig. 2.**



NOTE: Left-hand is shown; right-hand is similar.

1. Outboard Bumper Support Bracket
2. Splash Shield Mounting Bolt, 5/16–18
3. Hardened Flatwasher, 0.34"
4. Support Arm Mounting Bolt, 1/2–13
5. Hardened Flatwasher, 0.53"
6. Splash Shield
7. Support Arm
8. Splash Shield Mounting Locknut, 5/16–18
9. Steel-Plated Washer, 5/16
10. Torx®-Head Machine Screw, 5/16–18
11. Load-Bearing Washer
12. End of Bumper

Fig. 4, Bumper Support (new style)

2.1 On vehicles with 1350 sq. in radiators, align the upper and lower holes in the bumper with the threaded studs on the frame.

2.2 On vehicles with 1200 sq. in radiators, align the upper and lower holes in the bumper with the bumper mounting bolts installed on the J-brackets.

3. Fasten the bumper to the center mounts.

3.1 On one side of the vehicle, install the upper 1/2–13 locknut and washer.

3.2 Install the lower 1/2–13 locknut and washer.

Non-Aerodynamic Bumper Removal and Installation, Century Class S/T

3.3 Tighten the locknuts 64 lbf·ft (87 N·m).

3.4 Repeat this procedure on the other side of the vehicle.

4. Attach each end of the bumper to the tubular support and splash shield. See **Fig. 4**.

4.1 Attach the outboard bumper support bracket to the support arm, using the 1/2–13 support arm mounting bolt and washer. Tighten the mounting bolt 64 lbf·ft (87 N·m).

4.2 Attach the outboard bumper support bracket to the splash shield, using the 5/16–18 splash shield mounting bolt, locknut and two washers. Tighten the locknut 15 lbf·ft (20 N·m).

4.3 Repeat the procedure on the other side of the vehicle.

5. If removed, attach the road lights to the bumper. Connect the wiring harness to each road light.

6. Remove the chocks from the front tires.

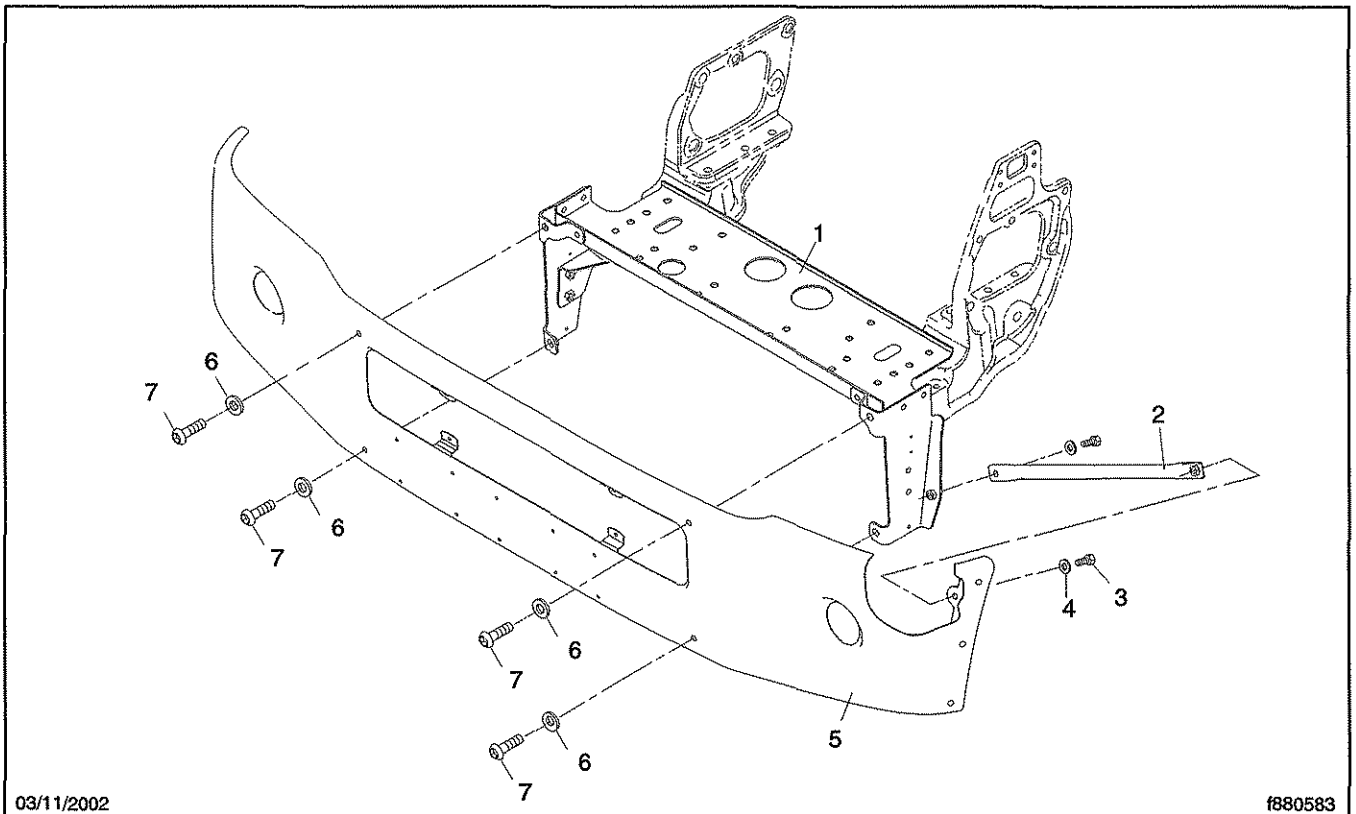
Non-Aerodynamic Bumper Removal and Installation, Coronado

Removal

1. Park the vehicle, apply the parking brakes, and chock the front tires.
2. If equipped with road lights, disconnect the wiring harness from each road light.
3. On both sides of the vehicle, remove the fasteners (strut mounting bolt and flatwasher) that attach the strut to the bumper end cap. See **Fig. 1**.
4. Remove the four Torx®-head mounting screws attaching the bumper to the frame extension.

NOTE: It is not necessary to remove the strut from the frame extension.

5. Remove the bumper and the end cap from the vehicle.
6. If you are replacing the bumper, remove the road lights from the bumper cut-outs, if so equipped. See **Fig. 2**.
   - 6.1 Remove the machine screws attaching each retainer bracket to the road light housing.
   - 6.2 Push the road light housing out through the front of the cut-out in the bumper.
   - 6.3 Attach the retainer bracket to the road light housing for ease of installation.
7. If you are replacing the bumper, remove the grille insert from the bumper. See **Fig. 3**.
   - 7.1 Turn the four quarter-turn fasteners attaching the grille insert to the bumper counterclockwise until they release.



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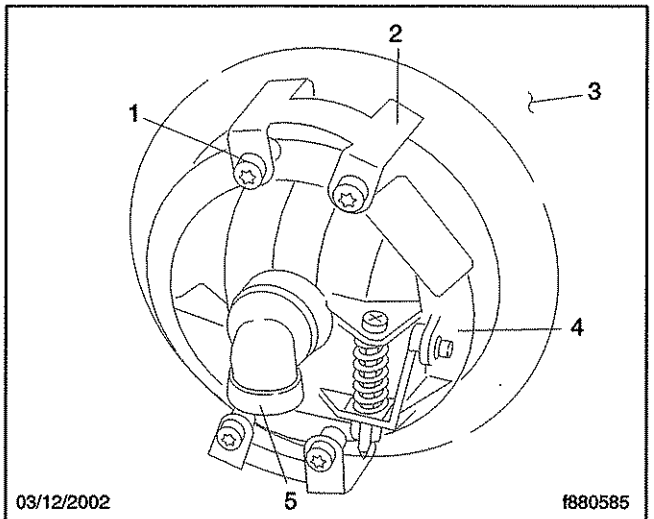
1. Frame Extension
2. Strut
3. Strut Mounting Bolt, 1/2–13 (grade 8)
4. Flatwasher
5. Bumper
6. Washer, Stainless Steel
7. Mounting Screw, Torx-Head

Fig. 1, Non-Aerodynamic Bumper, Coronado

Non-Aerodynamic Bumper Removal and Installation, Coronado



1. Machine Screw (4 qty.)
2. Retainer Bracket (2 qty.)
3. Bumper
4. Road Light Housing
5. Electrical Connector

Fig. 2, Road Light (optional)

7.2 Remove the grille insert from the bumper.

Installation

1. Install the grille insert, If removed. Turn the quarter-turn fasteners clockwise until they lock.
2. Install the road lights, if removed.

NOTE: This procedure requires two persons, one on each end of the bumper.

3. With one person holding each end of the bumper, put the bumper in position on the struts. Install the fasteners (strut mounting bolts and flatwashers) and tighten them enough to bring the center holes into alignment.
4. Install the four Torx-head mounting screws that attach the bumper to the frame extension.
5. Tighten the 1/2–13 grade 8 strut mounting bolts 91 lbf·ft (123 N·m).
6. Tighten the Torx-head mounting screws to take up any slack caused by the tightening of the strut mounting bolts.
7. Connect the wiring harness to each road light, as removed.
8. Remove the chocks from the front tires.

Non-Aerodynamic Bumper Removal and Installation, Coronado

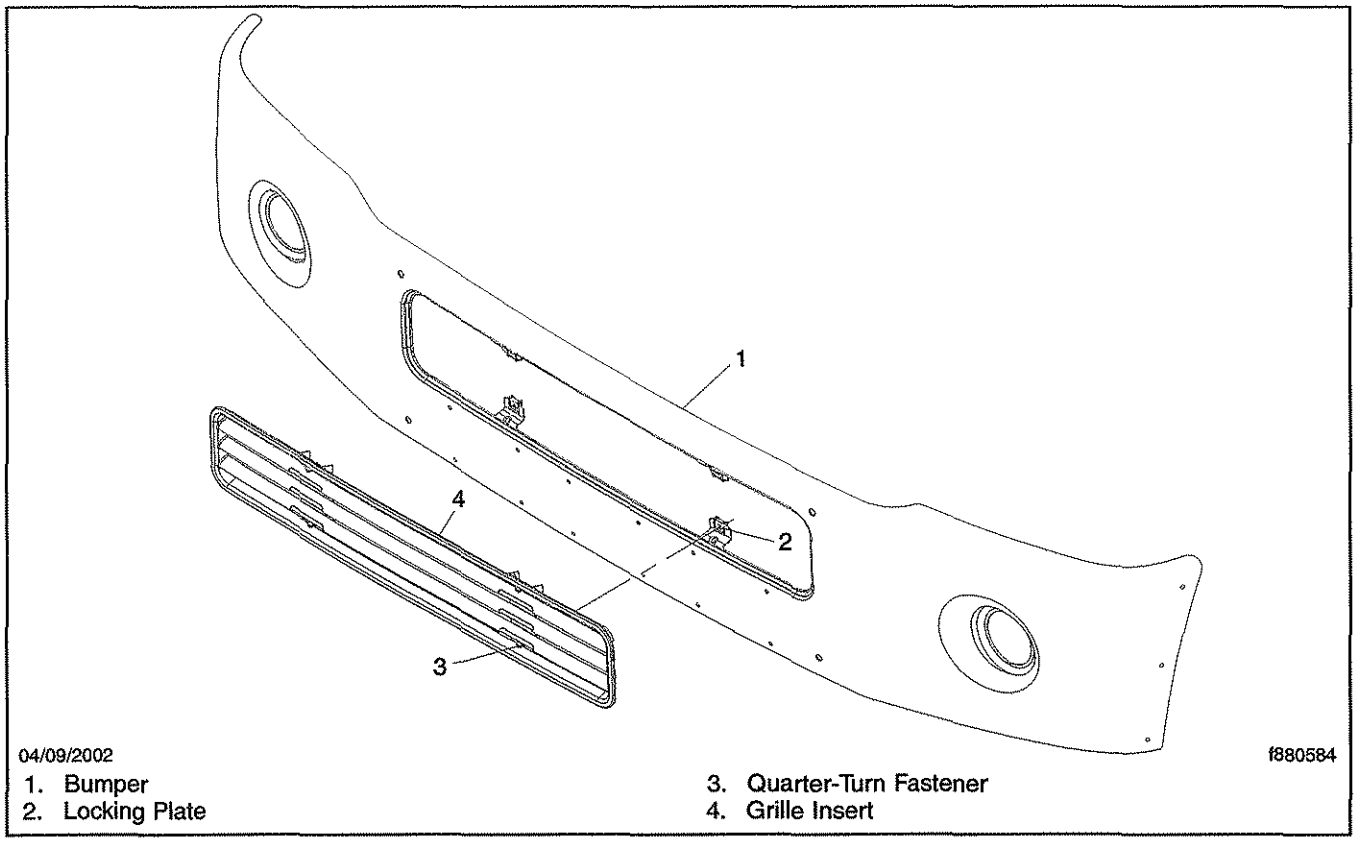


Fig. 3, Grille Insert in Bumper

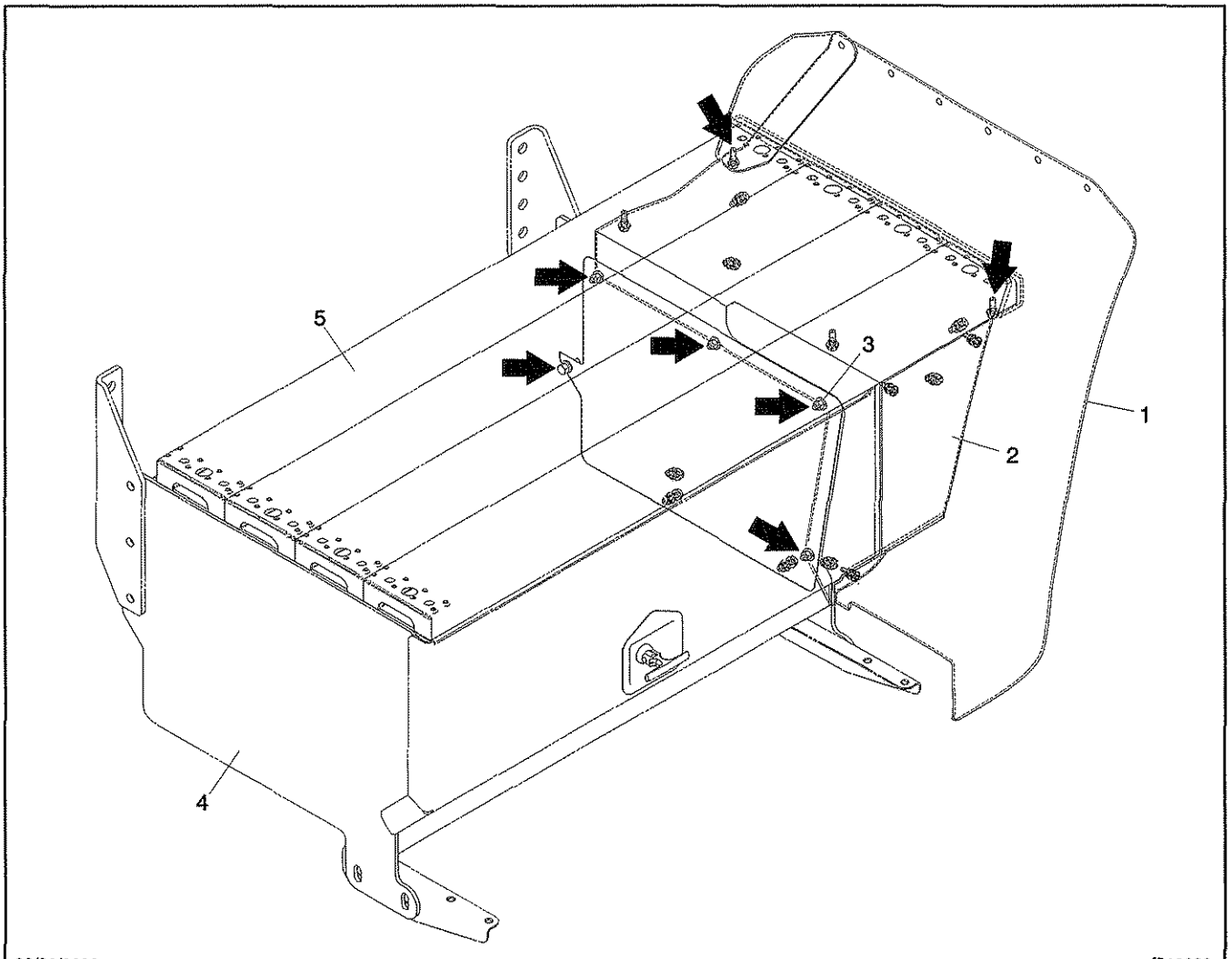
Contents

Subject	Subject Number
Service Operations	
Rear Quarter-Fender Removal and Installation, Coronado	100

Rear Quarter-Fender Removal and Installation, Coronado

Removal

1. Park the vehicle, apply the parking brakes, and chock the front tires.
2. Open the rear tool-box door and leave it up.
3. Remove the four mounting bolts attaching the rear quarter-fender to the tool box. See **Fig. 1**. Close the tool-box door.
4. Remove the bolt outside the tool box attaching the rear quarter-fender to the tool-box hanger bracket.
5. Remove the two bolts underneath the fender attaching the rear quarter-fender to the top chassis-access step.
6. Remove the rear quarter-fender, backing plate, and mudflap from the vehicle.



Remove each of the fasteners indicated by arrows.

1. Mudflap
2. Rear Quarter-Fender
3. Mounting Bolt, 1/2–13
4. Rear Tool Box
5. Top Chassis-Access Step

Fig. 1, Rear Quarter-Fender and Tool Box

Rear Quarter-Fender Removal and Installation, Coronado

Installation

1. Install the two bolts that attach the rear quarter-fender to the top chassis-access step, as removed. Make the bolts finger-tight only.
2. Attach the rear quarter-fender to the tool box, as removed.
   - 2.1 Open the tool-box door and leave it up.
   - 2.2 Position the backing plate on the rear surface of the tool box and align it over the holes for the mounting screws.
   - 2.3 Install the four bolts that attach the rear quarter-fender to the tool box, as removed. Make the bolts finger-tight only.
   - 2.4 Close the tool-box door.
3. Install the bolt that attaches the rear quarter-fender to the tool-box hanger bracket, as removed.
4. Tighten all the fasteners 50 lbf·ft (68 N·m).
5. Remove the chocks from the front tires.

Contents

Subject	Subject Number
General Information	050
Service Operations	
Tool Box Removal and Installation, Coronado	100

General Information

Frame-mounted tool/storage boxes are available on Coronado models only. Tool boxes are mounted on each side of the vehicle, front and rear, for a maximum of four tool boxes. A full-length running board extends from the front fender to the rear quarter-fender.

The upper mountings of the tool boxes are attached to the frame by means of steel hanger brackets. The lower mountings of the tool boxes are attached to the step brackets.

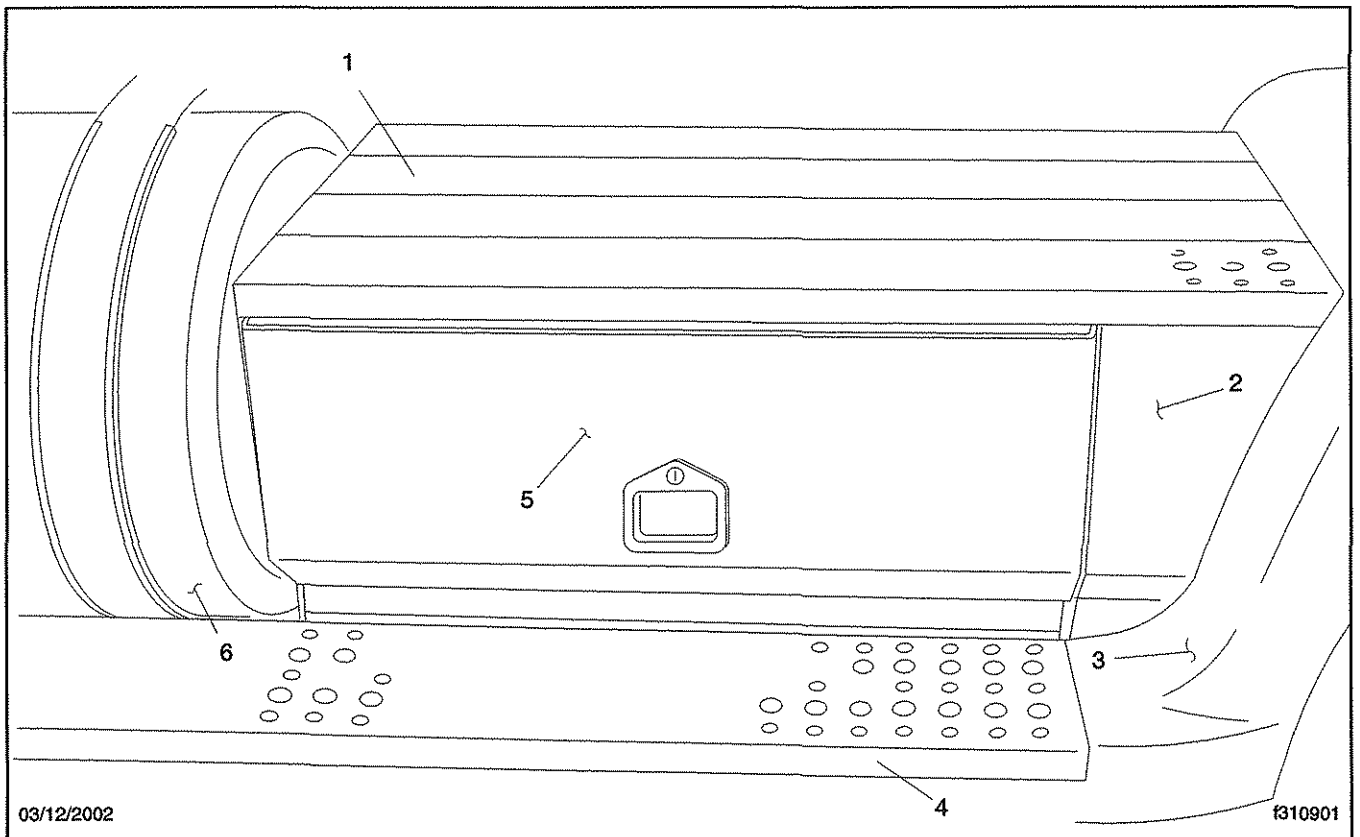
Tool boxes come in the following lengths:

- 23.6 inches (600 mm)
- 27.6 inches (700 mm)
- 31.5 inches (800 mm)
- 35.4 inches (900 mm)

Tool boxes come with removable covers, or with sealed doors. Each sealed-door box has a door lock and an actuator to allow the door to remain in the open position. Removable covers are standard on the front tool box, and locking doors are standard on the rear tool box.

The front tool box is normally mounted underneath the cab between the front fender and the fuel tank. See **Fig. 1**. In some installations, it can be mounted aft of the fuel tank. The front tool box requires a battery box mounted between the frame rails. If a side-mounted battery box is specified, it replaces one of the front tool boxes.

The rear tool box is mounted underneath the cab between the fuel tank and the rear quarter-fender. See



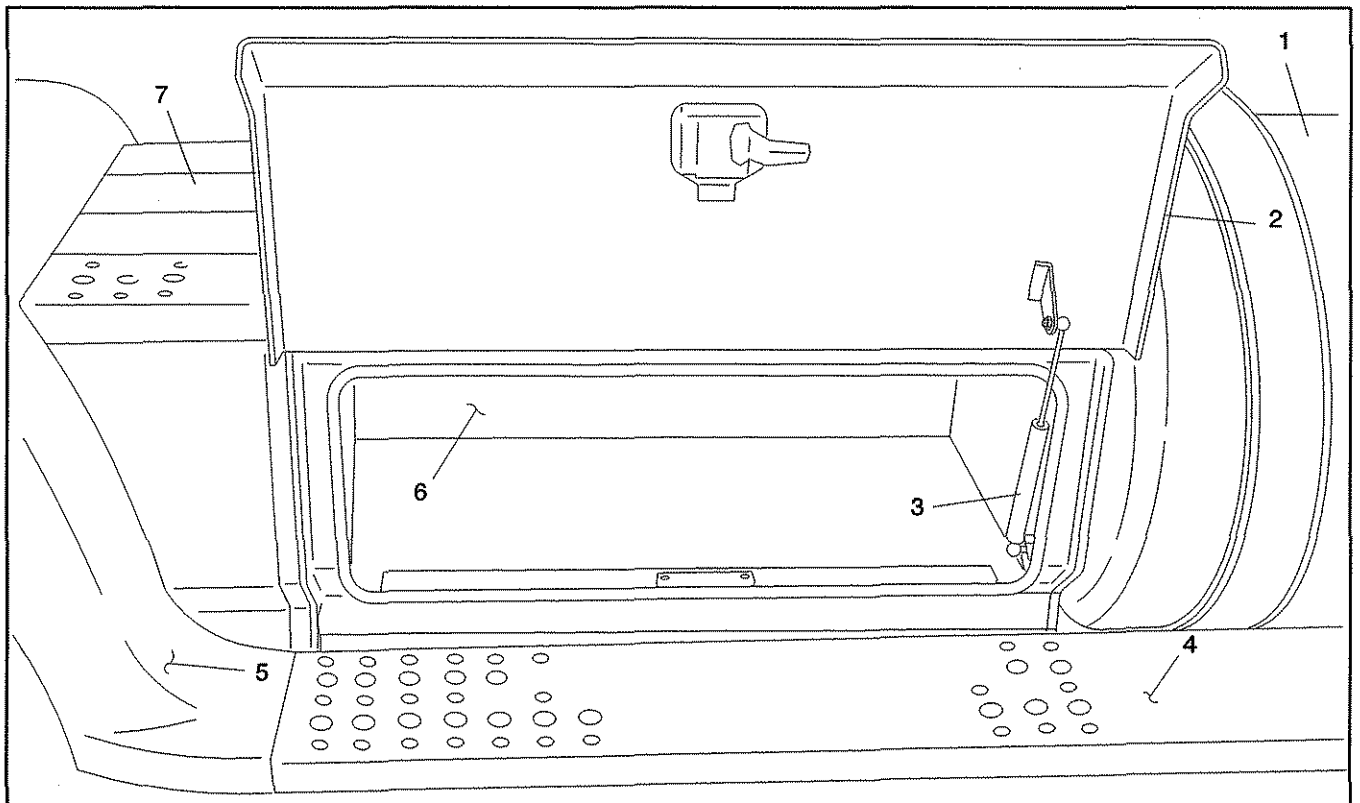
NOTE: This tool box is shown installed on the right-hand side of the vehicle.

1. Top Cab-Access Step
2. Front Tool Box
3. Front Fender
4. Running Board
5. Tool-Box Door (optional)
6. Fuel Tank

Fig. 1, Front Tool Box (closed)

General Information

Fig. 2. On some vehicles, the rear quarter-fender is bolted to the aft end of the tool box.



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NOTE: This tool box is shown installed on the right-hand side of the vehicle.

1. Fuel Tank
2. Tool Box Door (open)
3. Door Actuator
4. Running Board
5. Rear Quarter-Fender
6. Tool Box (interior)
7. Top Chassis-Access Step

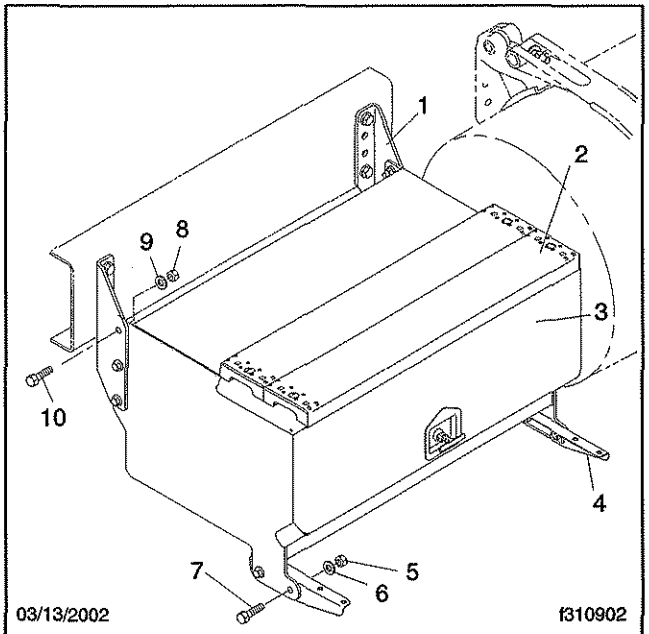
Fig. 2, Rear Tool Box (open)

Tool Box Removal and Installation, Coronado

Front Tool Box

Removal

1. Park the vehicle and apply the parking brakes. Chock all the tires.
2. Place a floor jack underneath the tool box and raise it until it exerts light pressure on the base of the tool box.
3. Remove the lower mounting bolts, two on each side, that attach the tool box to the step brackets. See **Fig. 1**.
4. Remove the upper mounting bolts, three on each side, that attach the tool box to the tool-box hanger brackets. Allow the jack to carry the weight of the tool box.
5. Remove the front portion of the running board. See **Section 60.21** for procedures.
6. Use the floor jack to slide the tool box out of the space between the front fender and the fuel tank.



NOTE: This tool box is shown installed on the left-hand side of the vehicle.

1. Tool Box Hanger Bracket
2. Top Cab-Access Step
3. Tool Box
4. Step Bracket
5. Locknut, 5/8–11
6. Hardened Flatwasher, 0.069
7. Lower Mounting Bolt, 5/8–11 x 2
8. Locknut, 1/2–13
9. Hardened Flatwasher, 0.053
10. Upper Mounting Bolt, 1/2–13 x 1.75

Fig. 1, Front Tool Box

Installation

1. Using a floor jack, slide the tool box in between the hanger brackets. The upper mountings of the tool box insert inside the hanger brackets, fore and aft.

NOTE: If necessary, use a prybar and/or rubber mallet to pound the upper mountings into place.

2. Attach the 1/2–13 x 1.75 upper mounting bolts, three to each hanger bracket, as removed. If necessary, re-position the jack until the bolt holes in each tool-box mounting line up with the holes in each hanger bracket. Tighten the locknuts 68 lbf·ft (92 N·m).
3. Install the front portion of the running board, as removed. See **Section 60.21** for procedures.
4. Attach the 5/8–11 x 2 lower mounting bolts, two to each step bracket, as removed. Tighten the bolts 136 lbf·ft (184 N·m).
5. Lower the floor jack and roll it out of the way.
6. Remove the chocks from the tires.

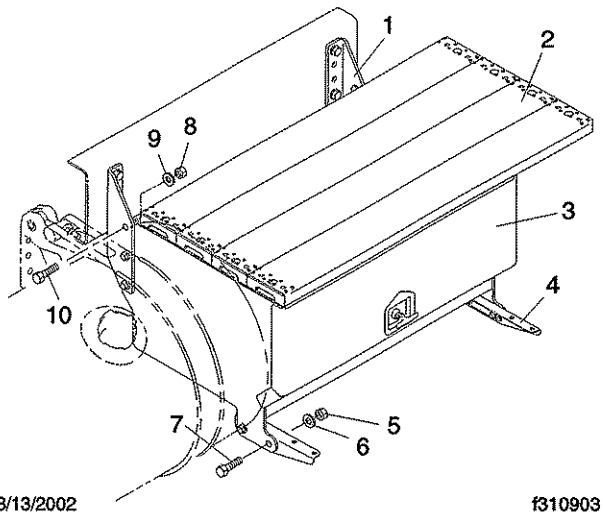
Rear Tool Box

Removal

1. Park the vehicle, apply the parking brakes, then chock all the tires.
2. Remove the running board. See **Section 60.21** for procedures.
3. Remove the rear quarter-fender. See **Section 31.13**, Subject 100, for procedures.
4. Remove the upper mounting bolts, three on each side, that attach the tool box to the tool-box hanger brackets. See **Fig. 2**.

NOTE: Two persons are recommended for this step.

Tool Box Removal and Installation, Coronado



NOTE: This tool box is shown installed on the left-hand side of the vehicle.

1. Tool Box Hanger Bracket
2. Top Chassis-Access Step
3. Tool Box
4. Step Bracket
5. Locknut, 5/8–11
6. Hardened Flatwasher, 0.069
7. Lower Mounting Bolt, 5/8–11 x 2
8. Locknut, 1/2–13
9. Hardened Flatwasher, 0.053
10. Upper Mounting Bolt, 1/2–13 x 1.75

Fig. 2, Rear Tool Box

5. Remove the tool box from the vehicle, with the step brackets attached.
6. If you are replacing the tool box, remove the step brackets and the top chassis-access step (if installed).

Installation

1. If removed, attach the 5/8–11 x 2 lower mounting bolts, two to each step bracket, as removed. Tighten the bolts 136 lbf·ft (184 N·m).
2. If removed, install the top chassis-access step on the tool box. Tighten the screws firmly.

NOTE: Two persons are required for this step.

3. While one person holds the tool box in position, the other person attaches enough upper mounting fasteners to hold the tool box in place (two on one side, one on the other).
4. Install the remaining mounting fasteners and tighten the locknuts 68 lbf·ft (92 N·m).
5. Install the rear quarter-fender. See **Section 31.13**, Subject 100, for procedures.
6. Install the running board. See **Section 60.21** for procedures.
7. Remove the chocks from the tires.

Contents

Subject	Subject Number
General Information	050
Service Operations	
Fifth Wheel Removal and Disassembly	100
Fifth Wheel Assembly and Installation	110
Troubleshooting	300

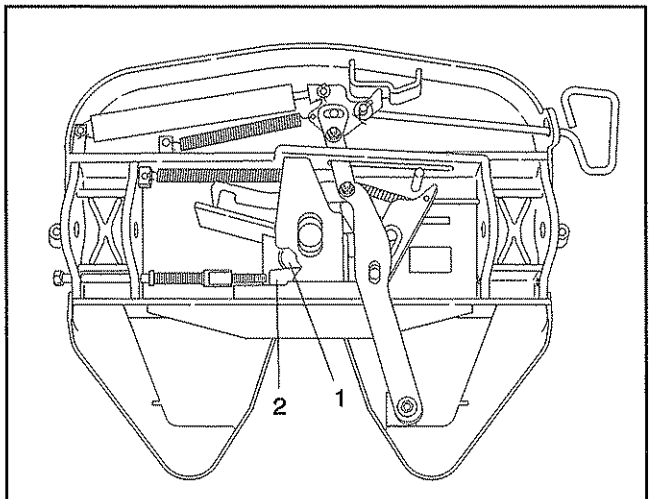
General Information

Fontaine 6000 and 7000 series fifth wheels couple to trailers having a standard 2-inch kingpin. When installed as a stationary mount, the fifth wheel is bracket-mounted to the tractor frame in a position that best distributes the trailer load over the tractor axles. Sliding fifth wheels are mounted on the Fontaine AWB or MWS model slide mounts.

The Fontaine fifth wheel lock mechanism for the trailer kingpin consists of a spring-loaded jaw and sliding wedge. Kingpin release is accomplished by pulling a manual lock control handle located on either the right side (curbside) or left side (roadside) of the fifth wheel. Kingpin coupling occurs when the kingpin enters the throat of the fifth wheel, triggers the jaw and wedge to slide into place behind the kingpin, and moves the lock control handle into the locked position.

As the kingpin enters the lock mechanism, the jaw is moved first with the spring-loaded wedge sliding in place against the jaw. The jaw will move behind the kingpin, followed by the wedge. The wedge reinforces the jaw and automatically adjusts for slack around the kingpin. See **Fig. 1** for an illustration of the jaw and wedge in the locked position.

Placing the lock control handle in the unlocked position moves the wedge and jaw out from behind the kingpin and unlocks the fifth wheel. See **Fig. 2** for an illustration of the jaw and wedge in the unlocked postition.



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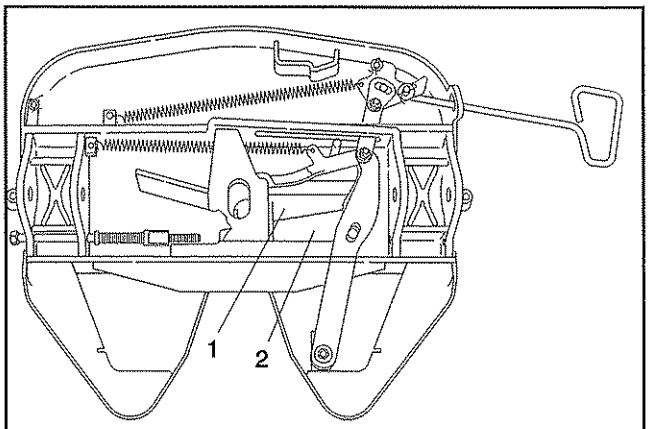
1. Jaw
2. Wedge

Fig. 1, Locked Position



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1. Jaw
2. Wedge

Fig. 2, Unlocked Position

Fifth Wheel Removal and Disassembly

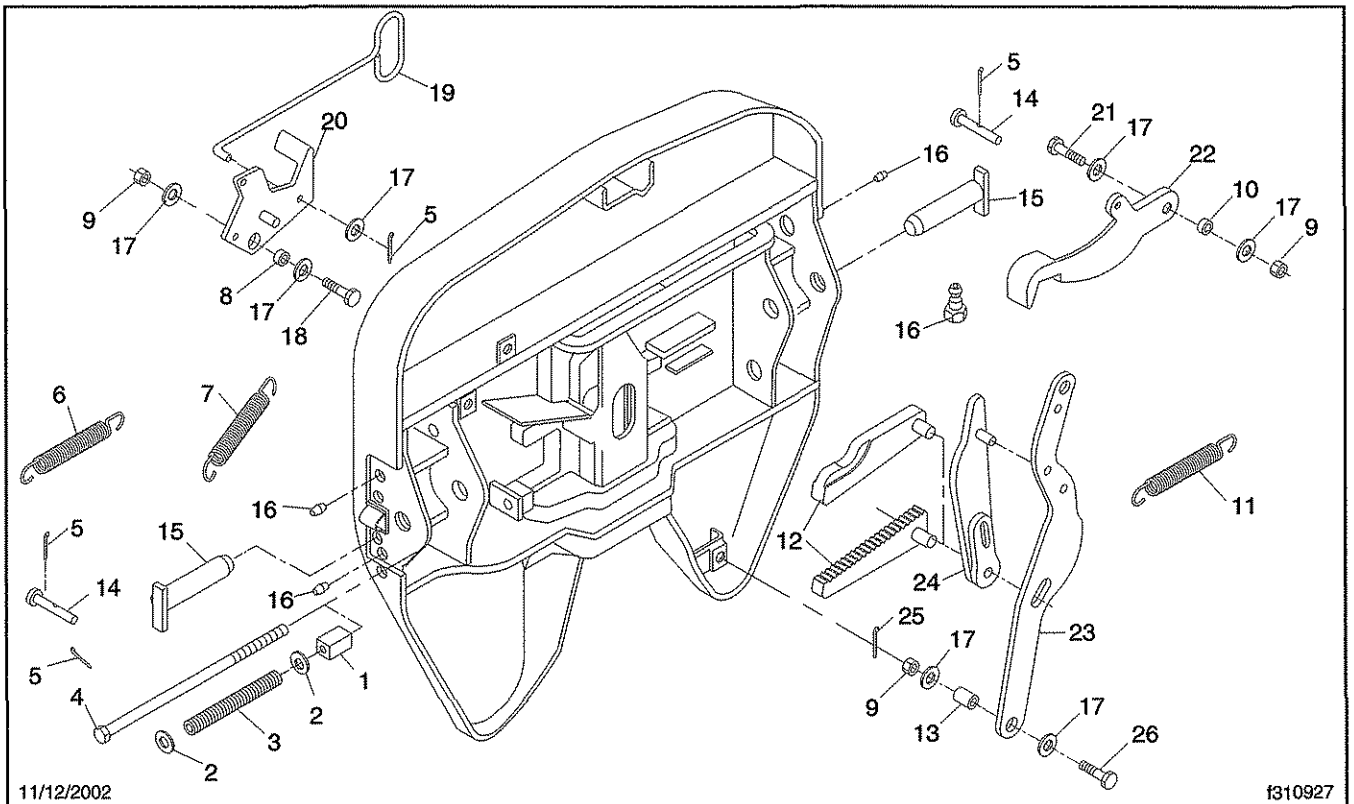
See **Fig. 1** for an exploded view of a Fontaine® 6000 or 7000 No-Slack II series fifth wheel.

⚠ WARNING

All fifth wheel maintenance, adjustment, and rebuilding must be done only by a qualified mechanic. Improper or incomplete procedures could result in disengagement of the trailer from the tractor, leading to personal injury or property damage.

Parts are under spring compression. Wear safety goggles during disassembly and assembly. Failure to do so can result in personal injury, due to parts ejecting with force.

1. Steam clean the top plate. Remove it from the sliding mount by removing the cotter pins from the retaining pins. Remove the retaining pins and bushing pins from both sides of the top plate.



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1. Wedge Stop Rod Nut
2. Flatwasher, 5/8", Plain
3. Wedge Stop Rod Spring
4. Wedge Stop Rod
5. Cotter Pin, 3/16 x 1"
6. Bumper Spring
7. Handle Spring
8. Bushing, 7/16"
9. Hex Locknut, 1/2–13
10. Bushing, 5/16"
11. Timer Spring
12. Step Jaw and Wedge Set
13. Bushing
14. Bracket Retainer Pin
15. Bracket Pin
16. Grease Fitting
17. Flatwasher, 1/2" I.D. x 1-3/4" O.D., Plain
18. Hexhead Bolt, 1/2–13 x 1-1/2", Grade 5
19. Pull Handle
20. Secondary Lock
21. Hexhead Bolt, 1/2–13 x 1-3/4", Grade 5
22. Bumper
23. Operating Handle
24. Timer
25. Hairpin Cotter Pin
26. Hexhead Bolt, 1/2–13 x 2-3/4", Grade 5

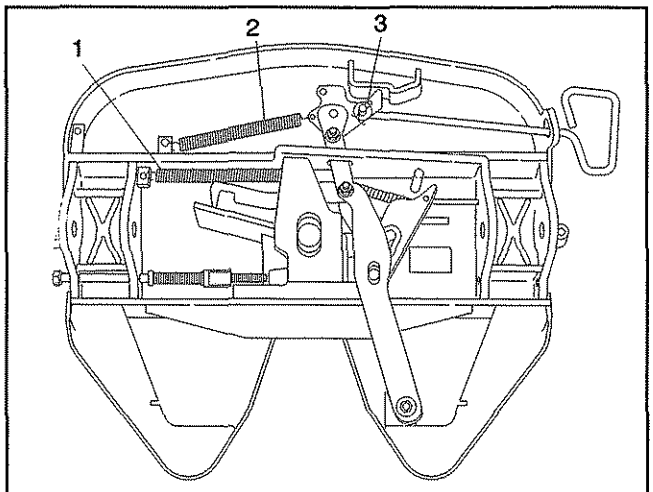
Fig. 1, Fontaine 6000 and 7000 No-slack II Series Fifth Wheel (left side release shown)

Removal and Disassembly

2. Using an overhead hoist, lift the fifth wheel off the sliding mount and tractor frame.
3. Turn the fifth wheel upside down.

NOTE: While disassembling the fifth wheel, check it for cracks and for missing or damaged parts.

4. Remove the secondary lock spring and bumper spring. See **Fig. 2**. Remove the pull handle cotter pin and washer, then slide out the pull handle.
5. Unbolt and remove the secondary lock from the operating handle. Discard the locknut and bushing. See **Fig. 3**.
6. Unbolt and remove the bumper from the operating handle. Discard the locknut and bushing. See **Fig. 4**.
7. Unbolt the operating handle from the pivot mount and remove. Discard the locknut. See **Fig. 5**.
8. Remove the timer spring and timer. See **Fig. 6**.
9. Remove the jaw and wedge. See **Fig. 7**.



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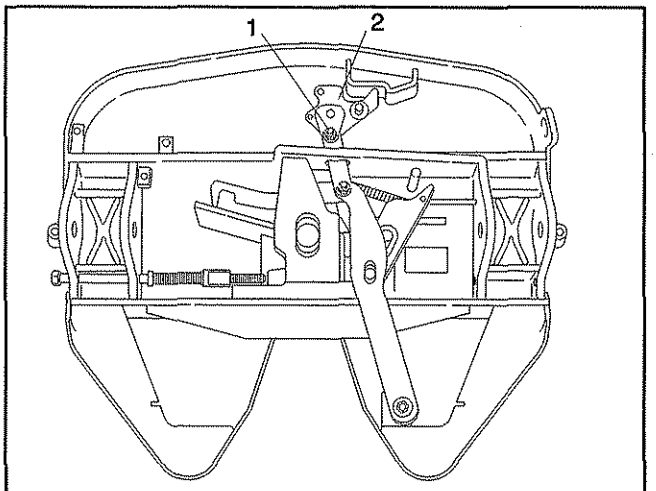
1. Bumper Spring
2. Secondary Lock Spring
3. Pull Handle Cotter Pin

Fig. 2, Pull Handle



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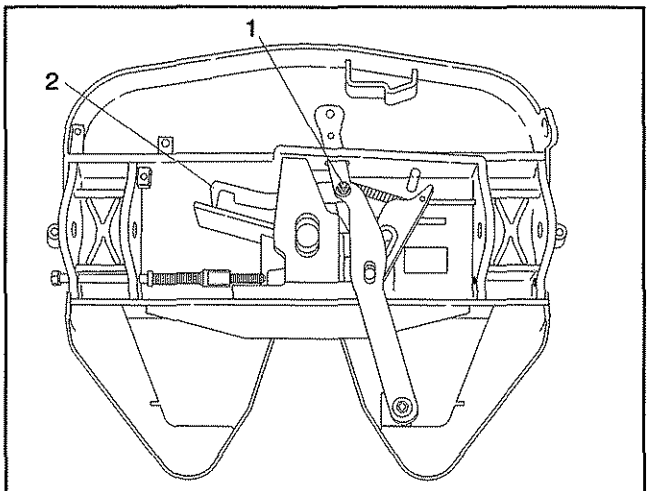
1. Bolt
2. Secondary Lock

Fig. 3, Secondary Lock



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1. Bolt
2. Bumper

Fig. 4, Bumper

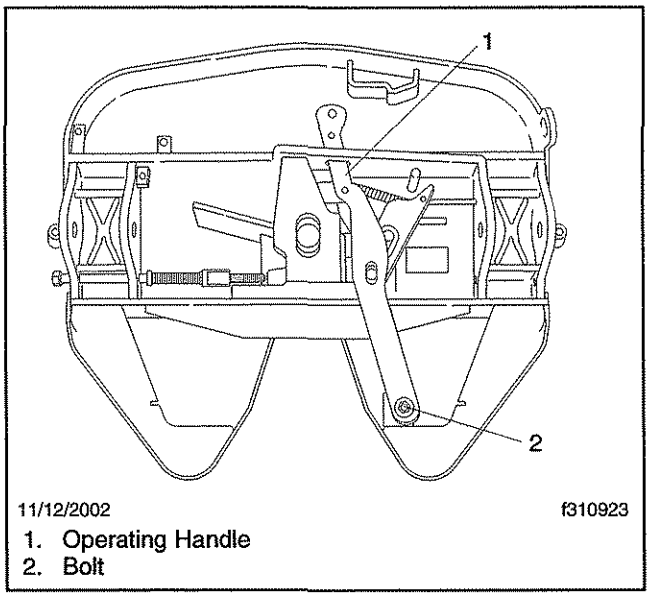


Fig. 5, Operating Handle

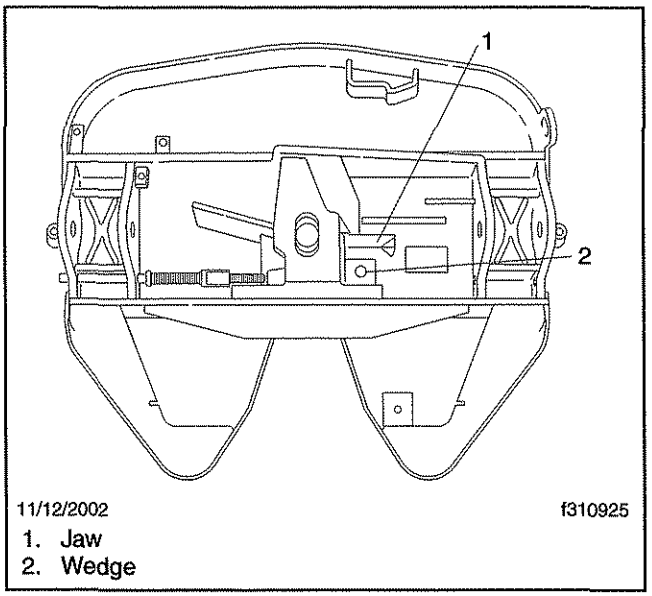


Fig. 7, Jaw and Wedge

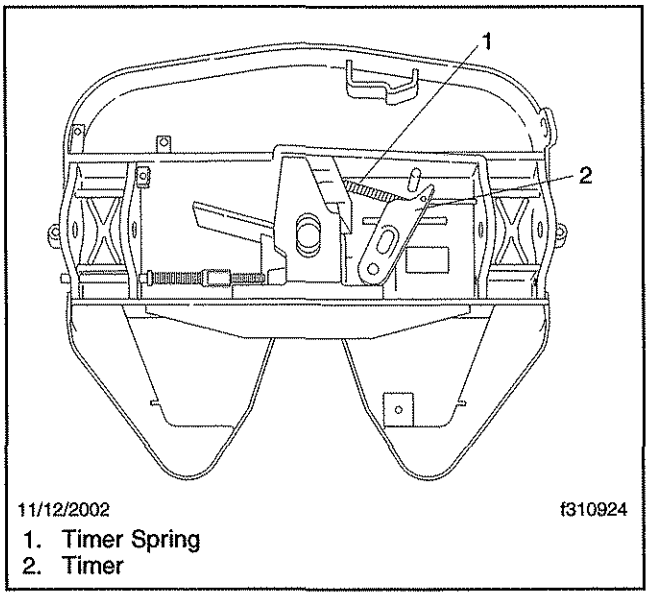


Fig. 6, Timer Spring and Timer

Assembly and Installation

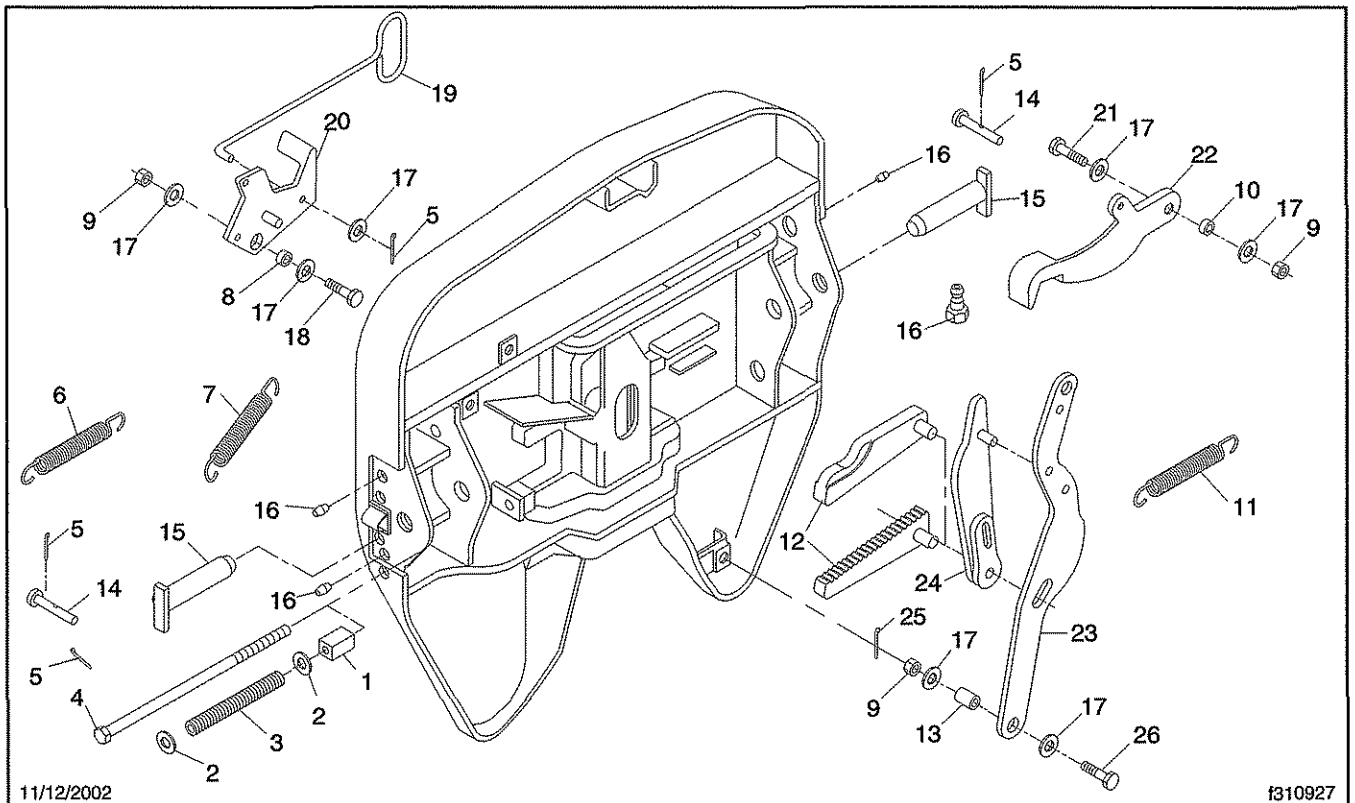
⚠ WARNING

Before rebuilding the assembly, check to make sure that there are no cracks in the crossmembers or other components. Also check the bracket pin holes to ensure they are not worn oversize (pins should fit snugly). Under no circumstances should a fifth wheel be repaired or used if any component (crossmember, saddle bearing, etc.) is cracked. Operating a fifth wheel with damaged components could result in disengagement of the trailer from the tractor, leading to personal injury or property damage.

Use a Moly-based lubricant such as Mobil grease Moly 50 or equivalent when applying lubricant to the locking jaw and wedge. Lightly oil other moving parts in the fifth wheel.

See **Fig. 1** for an exploded view of a Fontaine® 6000 or 7000 No-Slack II series fifth wheel.

1. Always assemble parts around a 2-inch kingpin or a 2-inch diameter shaft. Insert the jaw first, then



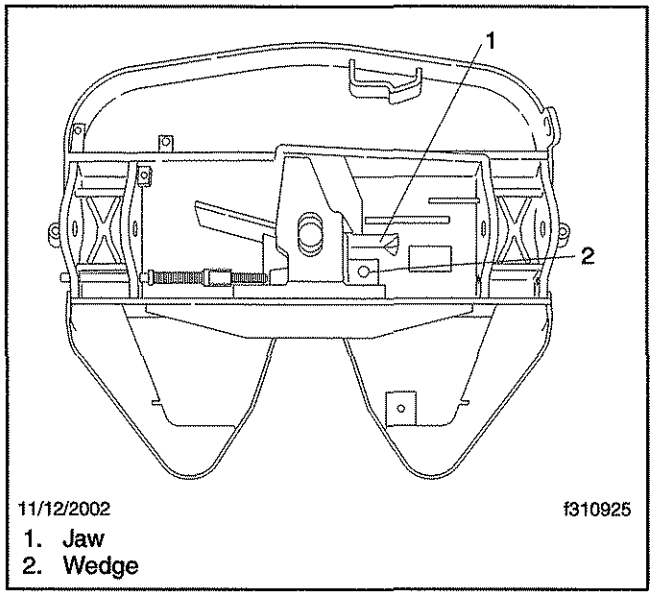
1. Wedge Stop Rod Nut
2. Flatwasher, 5/8", Plain
3. Wedge Stop Rod Spring
4. Wedge Stop Rod
5. Cotter Pin, 3/16 x 1"
6. Bumper Spring
7. Handle Spring
8. Bushing, 7/16"
9. Hex Locknut, 1/2–13
10. Bushing, 5/16"
11. Timer Spring
12. Step Jaw and Wedge Set
13. Bushing
14. Bracket Retainer Pin
15. Bracket Pin
16. Grease Fitting
17. Flatwasher, 1/2" I.D. x 1-3/4" O.D., Plain
18. Hexhead Bolt, 1/2–13 x 1-1/2", Grade 5
19. Pull Handle
20. Secondary Lock
21. Hexhead Bolt, 1/2–13 x 1-3/4", Grade 5
22. Bumper
23. Operating Handle
24. Timer
25. Hairpin Cotter Pin
26. Hexhead Bolt, 1/2–13 x 2-3/4", Grade 5

Fig. 1, Fontaine 6000 and 7000 No-slack II Series (left-side release shown)

Assembly and Installation

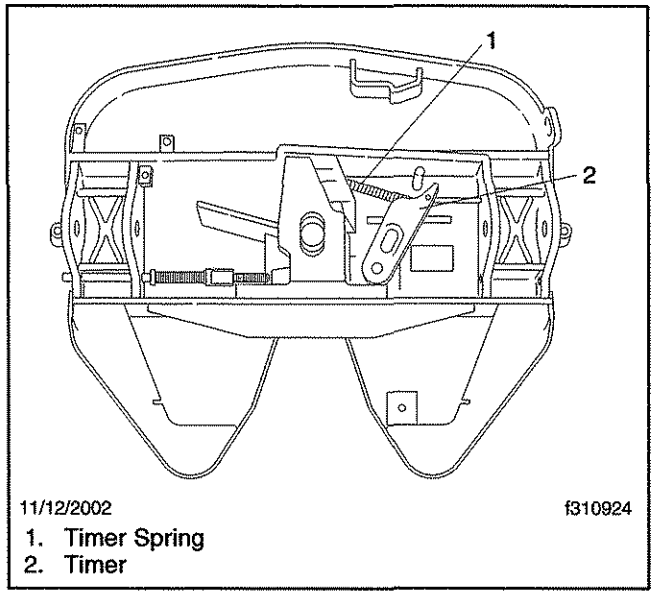
the wedge below it. See **Fig. 2**. Grease the jaw and wedge on the top and bottom.

2. Install the timer and the timer spring. See **Fig. 3**.
3. Install the operating handle and bolt to the pivot mount. See **Fig. 4**. Use the existing bolt, washer, hairpin cotter pin and bushing. Inspect the bushing for wear before using it and replace it if necessary.



1. Jaw
2. Wedge

Fig. 2, Jaw and Wedge



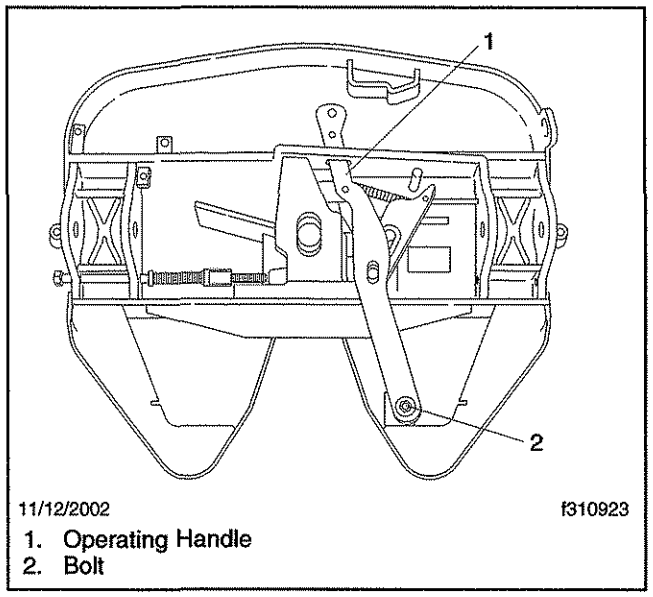
1. Timer Spring
2. Timer

Fig. 3, Timer Spring and Timer

Use the new locknut that is supplied in the repair kit. Note the orientation of the bolt (**Fig. 1**).

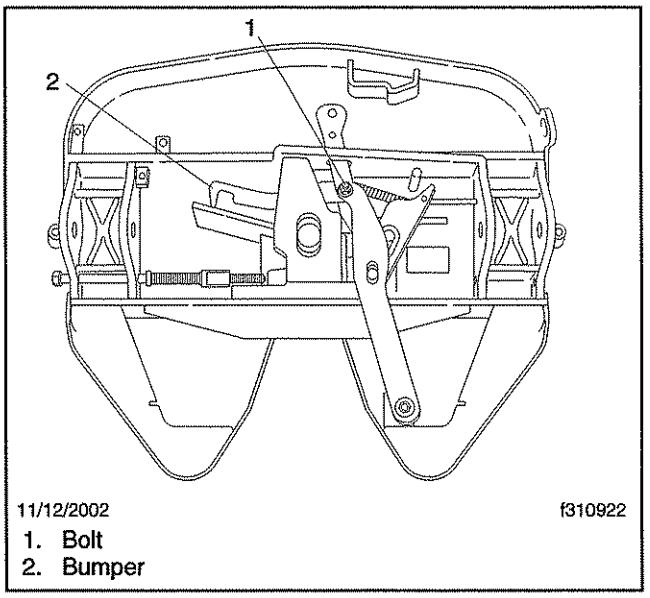
4. Install the bumper and bolt it to the operating handle. See **Fig. 5**. Use the existing bolt and washers (inspect for wear before using and replace if necessary). Use the new locknut and bushing that is supplied in the repair kit. Note the orientation of the bolt (**Fig. 1**). After installing the bumper, check to make sure that it can pivot freely.
5. Insert the secondary lock and bolt it to the operating handle. See **Fig. 6**. Use the existing bolt and washers (inspect for wear before using and replace if necessary). Use the new locknut and bushing that is supplied in the repair kit. Note the orientation of the bolt (**Fig. 1**).
6. Install the pull handle. See **Fig. 7**. Use the existing washer and cotter pin (inspect for wear before using and replace if necessary). Attach the new secondary lock/bumper spring that is supplied in the repair kit. Open and close the fifth wheel to ensure that it works properly. The fifth wheel must be properly lubricated before opening and closing the wheel.

Use a Moly-based lubricant such as Mobil grease Moly 50 or equivalent when applying lubricant to the locking jaw and wedge. Lightly oil other moving parts in the fifth wheel.



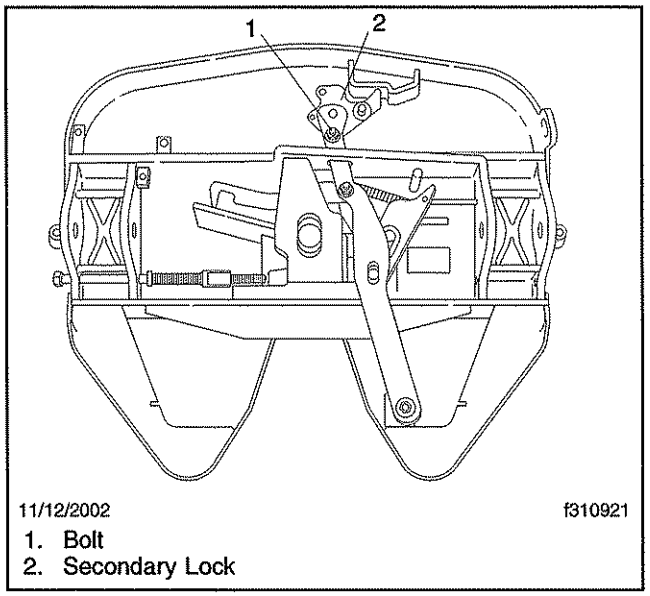
1. Operating Handle
2. Bolt

Fig. 4, Operating Handle



1. Bolt
2. Bumper

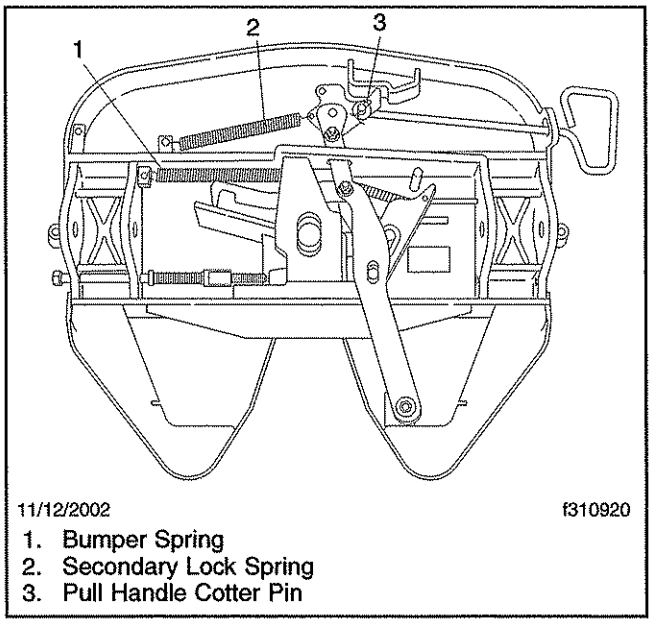
Fig. 5, Bumper



1. Bolt
2. Secondary Lock

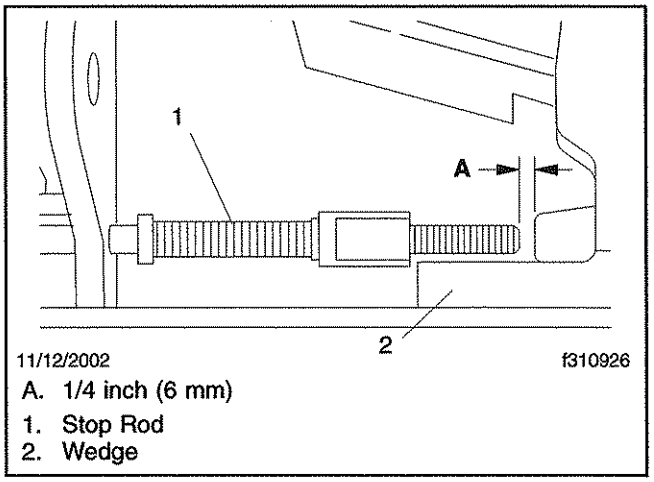
Fig. 6, Secondary Lock

7. Close the fifth wheel several times with a standard 2-inch kingpin tool. With the lock closed, adjust the wedge stop rod so that the end is 1/4 inch (6 mm) from the wedge. See **Fig. 8**.
8. Using an overhead hoist, position the fifth wheel on the sliding mount assembly. Insert the bushing pins. Install the retaining pins and the 1-inch-long cotter pins.



1. Bumper Spring
2. Secondary Lock Spring
3. Pull Handle Cotter Pin

Fig. 7, Pull Handle



A. 1/4 inch (6 mm)
1. Stop Rod
2. Wedge

Fig. 8, Wedge Stop Rod Adjustment

Troubleshooting Tables

Problem—Difficulty Coupling

Possible Cause	Remedy
The kingpin is too high to trip the latch	Lower the landing gear.
The trailer plate or kingpin is damaged	Check the trailer plate for flatness. Check the kingpin for squareness with the trailer plate.

Problem—Excessive Wear on the Fifth Wheel Top Plate

Possible Cause	Remedy
Damaged trailer plate	If the trailer plate is not flat, replace it.

Problem—Difficulty Uncoupling

Possible Cause	Remedy
Pressure on the locking mechanism caused by truck drifting apart from the trailer putting excess pressure on the lock	Back up the trailer and set the brakes. Strike the wedge stop rod which protrudes through the side of the fifth wheel. This spring-loaded rod will release the pressure on the locking mechanism.
Oval-shaped kingpin	Lower the landing gear.
Debris build-up in the grease	

Problem—Slack

Possible Cause	Remedy
Undersized kingpin	Replace the kingpin if worn greater than 1/8 inch (3 mm) at the 2-inch (5-cm) diameter.
Worn jaw and wedge	Jaw and wedge could have excessive wear. Replace them.

Group Index, Alphabetical

Section	Section Number
Freightliner AirLiner Suspension	32.04
Freightliner TufTrac™ Suspension	32.13
Front Suspension	32.00
Rear Spring Suspension, Single Axle	32.02
Rear Spring Suspension, Tandem Axle	32.03
Rear Suspension, Chalmers 800 Series	32.11
Rear Suspension, Freightliner AirLiner Plus™	32.09
Rear Suspension, Hendrickson HAS	32.08
Rear Suspension, Hendrickson RS	32.07
Rear Suspension, Hendrickson RT2 and RTE2	32.06
Rear Suspension, Neway® Air Ride, Models AD-123 and AD-246	32.10
Rear Suspension, Reyco®	32.05
Rough Ride Diagnosis	32.01

Contents

Subject	Subject Number
General Information	050
Service Operations	
Leaf Spring and Components Removal, Inspection and Cleaning, and Installation	100
Bushing Replacement	110
Shock Absorber Removal and Installation	120
Troubleshooting	300
Specifications	400

General Information

Standard Freightliner front suspensions use tapered leaf spring assemblies, with shock absorbers as standard equipment. **See Fig. 1.**

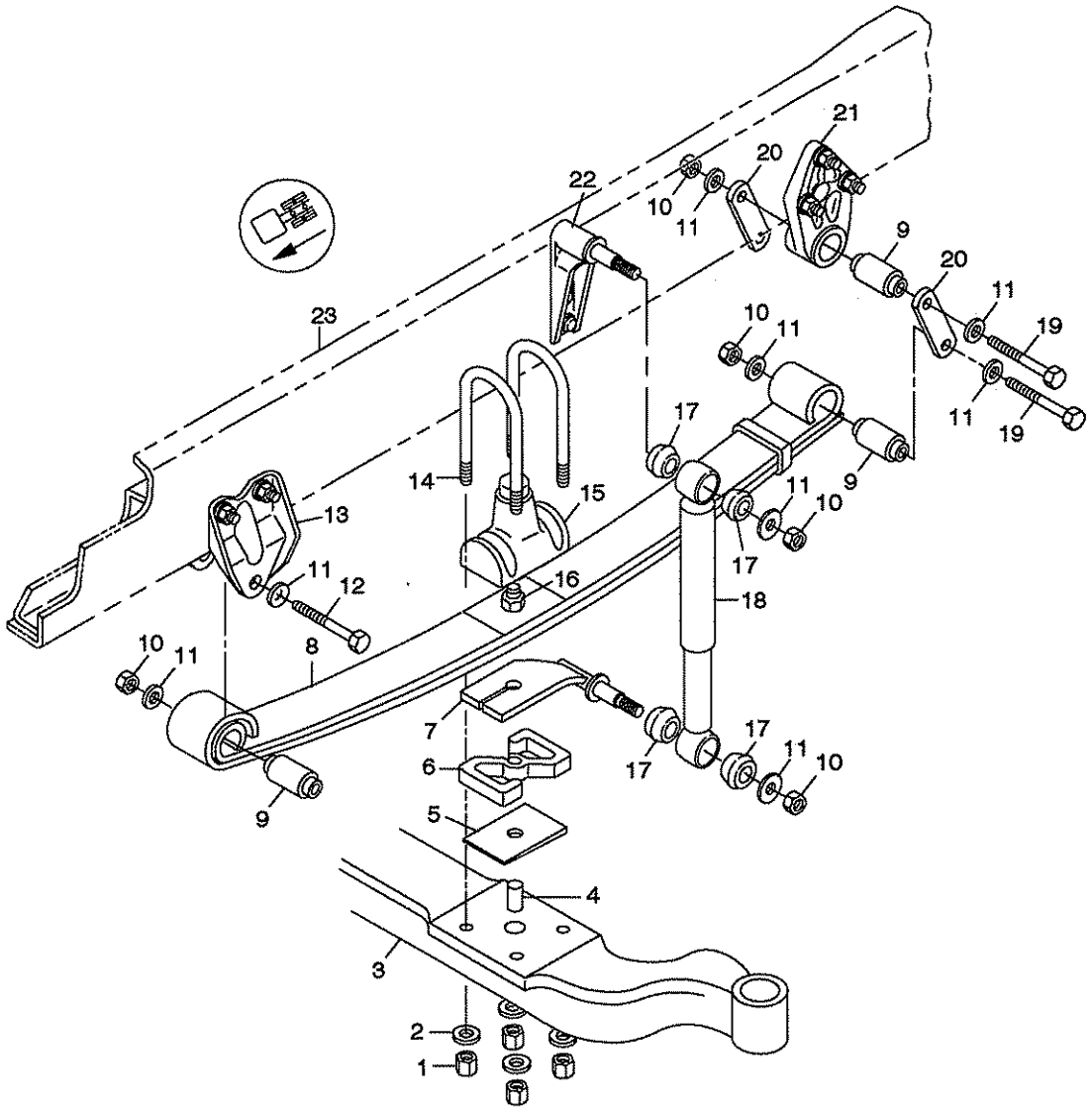
The spring assemblies are attached to the axle with U-bolts, hardened washers, and high nuts. The forward end of each spring contains a rubber bushing and a through-bolt that mounts to a stationary front suspension bracket. The rear of each spring mounts to a pair of spring shackles that are suspended from a frame-mounted bracket. The rear spring eye and shackle bracket each contain a rubber bushing and a through-bolt to allow the spring shackles to pivot. The spring shackles allow for variations in spring length during spring flexing.

The leaf spring assembly absorbs and stores energy, then releases it. The individual leaves are held together by a center bolt, with the center bolt nut used as a locating dowel for the axle stop and shock-absorber lower bracket installation on the vehicle.

Steel spring pins with bronze bushings are available as an option. **See Fig. 2.** These pins have a longitudinal lubrication groove in them. Bronze bushings are used with 12,000-pound or 14,000-pound leaf springs, and are graphite impregnated with a grease seal at each end.

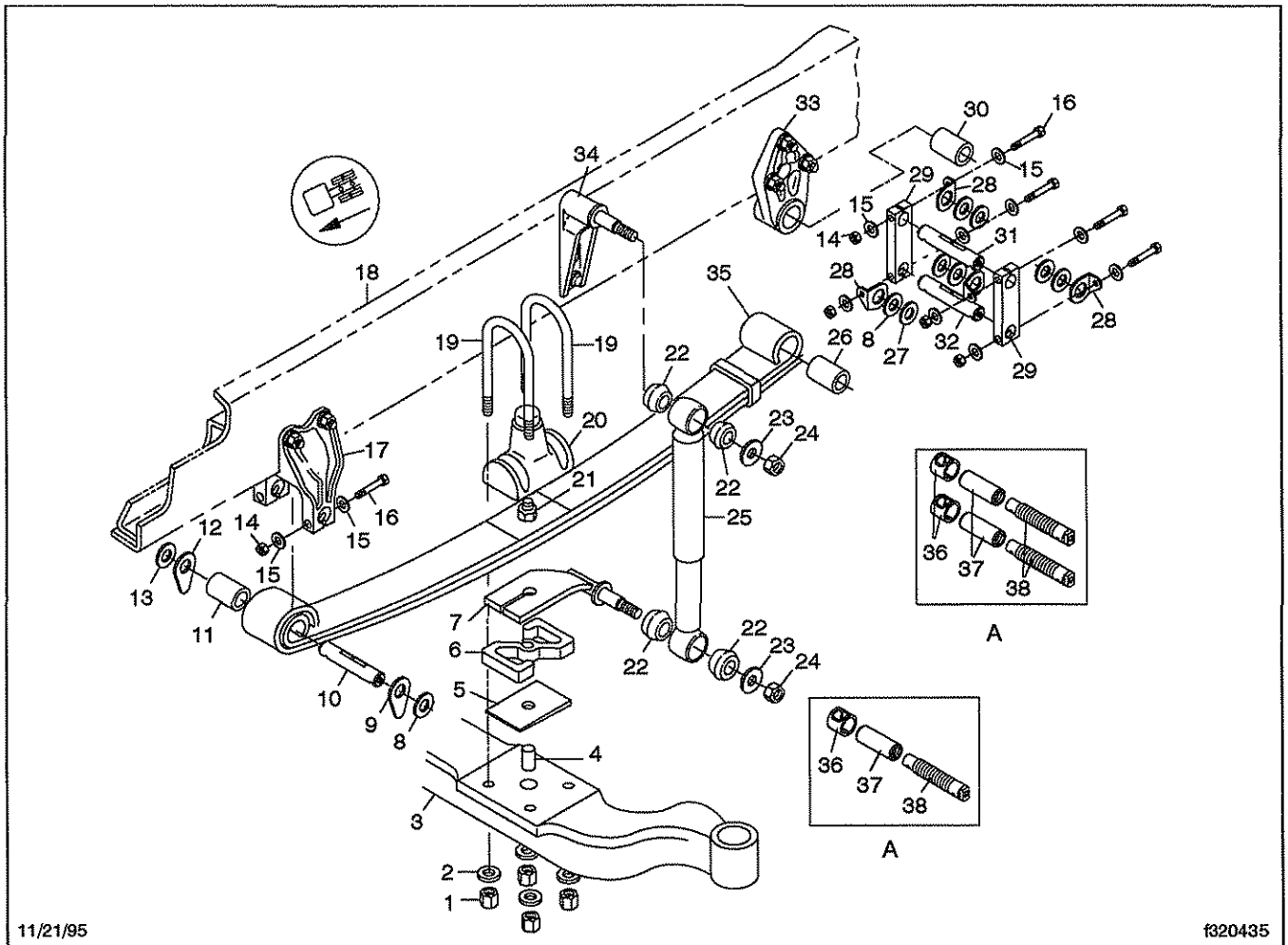
Threaded spring pins with threaded steel bushings are also available with 12,000-pound or 14,000-pound front leaf suspensions.

General Information



1. U-Bolt High Nut
2. Bearing Washer
3. Axle
4. Dowel
5. Caster Adjustment Shim
6. Spacer
7. Shock Absorber Lower Mounting Bracket
8. Spring Assembly
9. Spring Pin and Rubber Bushing Assembly
10. Self-Locking Nut, 1/2–13
11. Hardened Washer
12. Spring-Eye Bolt
13. Forward Spring Bracket
14. U-Bolt
15. Axle Pad
16. Spring Center-Bolt and Nut
17. Shock Absorber Bushing
18. Shock Absorber
19. Shackle Bolt
20. Spring Shackle
21. Shackle Bracket
22. Shock Absorber Upper Bracket
23. Frame Rail

Fig. 1, Front Suspension with Rubber Bushings



A. Equipped with Threaded Spring Pins

1. U-Bolt High Nut
2. Bearing Washer
3. Axle
4. Dowel
5. Caster Adjustment Shim
6. Spacer
7. Shock Absorber Lower Mounting Bracket
8. Outboard Spacing Washer(s)
9. Outboard Spring Spacer
10. Spring Pin, Forward Spring Eye
11. Spring Bushing, Forward Spring Eye
12. Inboard Spring Spacer
13. Inboard Spacing Washers
14. Self-Locking Nut, 1/2–13
15. Hardened Washer
16. Pinch Bolt, 1/2–13 x 4"
17. Front Suspension Bracket
18. Frame Rail
19. U-Bolt
20. Axle Stop
21. Spring Center-Bolt and Center-Bolt Nut
22. Shock Absorber Bushing
23. Hardened Washer
24. Self-Locking Nut, 1/2–13
25. Shock Absorber
26. Spring Bushing, Rear Spring Eye
27. Hardened Washer, 2-1/4" o.d.
28. Wear Plate
29. Shackle
30. Shackle Bracket Bushing
31. Spring Pin, Shackle Bracket
32. Spring Pin, Rear Spring Eye
33. Shackle Bracket
34. Shock Absorber Upper Bracket
35. Leaf Spring
36. Split Ring
37. Threaded Bushing
38. Threaded Spring Pin

Fig. 2, Front Suspension with Bronze Bushings or Threaded Spring Pins

Leaf Spring and Components Removal, Cleaning and Inspection, and Installation

Removal (See Fig. 1, Fig. 2, or Fig. 3)

1. Apply the parking brakes and chock the rear tires. Raise the vehicle until both wheels are off the ground and the frame is supported with safety stands. The axle and leaf springs can then be manipulated with the floor jack.

IMPORTANT: Make sure the frame rails are level and an equal distance off the ground.

2. On vehicles with tapered leaf spring assemblies, unplug the road-light wires behind the front bumper. Remove the bumper mounting bolts; reference the location of the mounting bolt spacers for later assembly. Remove the bumper from the vehicle.

   On vehicles with flat leaf spring assemblies, remove the wheel and tire. For instructions, refer to the wheels and tires section in this manual.

3. Remove the U-bolts, stop assembly, and spring liner (if equipped) from the spring.

4. On vehicles equipped with shock absorbers, swing the lower shock absorber bracket assembly away from under the axle and compress the shock absorber fully. This prevents the shock absorber and its lower bracket from interfering with further work.

NOTE: if necessary, remove the mud guards to access the shackles.

5. Starting at the aft end of the spring, remove the flanged pinch bolts and flanged nuts securing the shackle spring pin.

6. If the spring pin is threaded, unscrew it from the bushing.

   If the spring pin is nonthreaded, drive it outboard with a suitable drift and remove it.

   Remove the spacing washers (used only with nonthreaded pins) and keep them with the pin. Make note of their correct location for later installation.

7. Remove the flanged pinch bolts and flanged nuts from the forward frame bracket.

8. If the spring pin is threaded, unscrew it from the bushing.

   If the spring pin is nonthreaded, drive it inboard with a suitable drift to remove it.

   Remove the spacing washers (used only with nonthreaded pins) and keep them with the pin. Make note of their correct location for later installation.

9. Remove the spring assembly by lifting it up off the axle and out the front of the truck. Note the taper direction of the caster shim so that it will not be reversed during installation

10. If the shackle pin or shackle bracket bushings are to be inspected or replaced, remove the pin.

    10.1 Remove the flanged pinch bolts and flanged nuts.

    10.2 Remove the spacing washers (used only with nonthreaded pins) and keep them with the pin. Make note of their correct location for later installation.

    10.3 If the shackle pin is threaded, unscrew it from the shackle pin bushing.

    10.4 If the shackle pin is nonthreaded, drive the pin outboard using a suitable drift to remove it.

11. Remove the shackle bracket for inspection; replace its bushing if necessary. See the applicable steps under "Cleaning and Inspection" in this subject.

Cleaning and Inspection

1. Using a wire brush and solvent or steam cleaning equipment, wash all parts to remove dirt, grease, and scale.

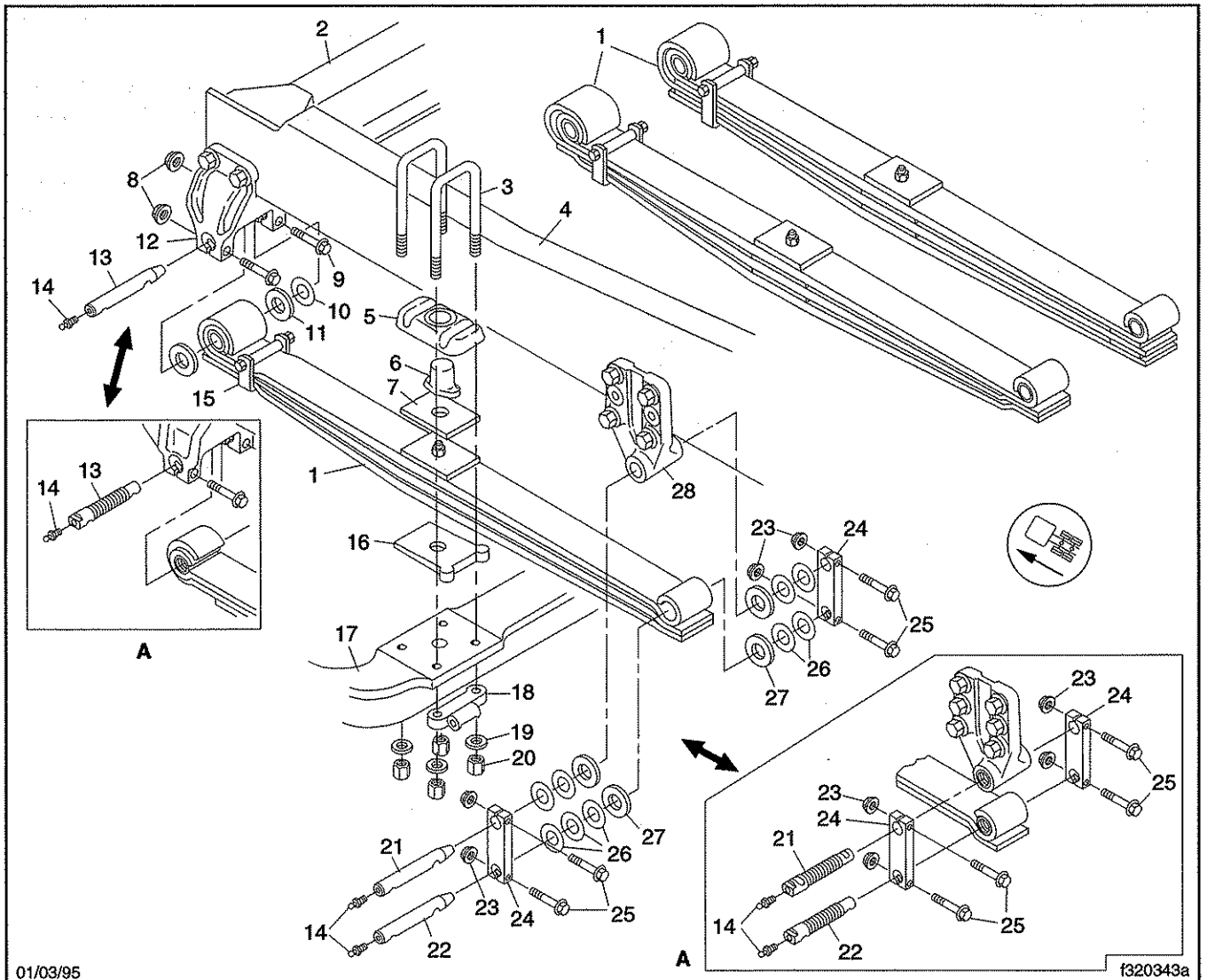
⚠ WARNING

Commercial cleaning solvents are toxic, can cause severe skin irritation, and may be fire hazards. When using solvents, follow the safety precautions recommended by the solvent manufacturer.

2. Inspect the shackle bracket and the spring shackles for cracks, wear, or other damage. Replace damaged parts.

3. Inspect the spring for cracks and corrosion. If any leaves are cracked or broken, replace the entire spring assembly.

Leaf Spring and Components Removal, Cleaning and Inspection, and Installation

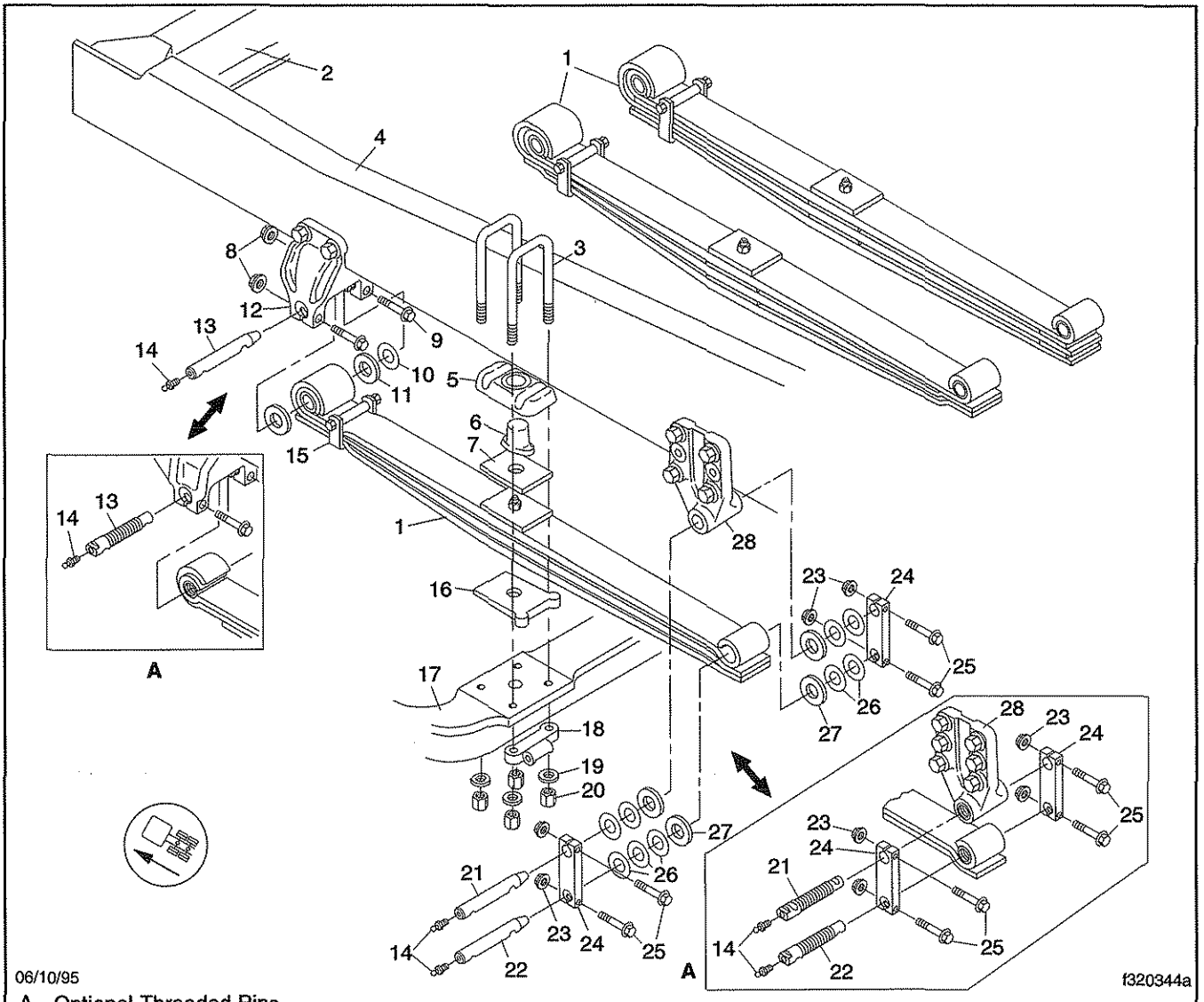


A Optional Threaded Pins

1 Spring Assembly
2 Front Closing Crossmember
3 U-Bolt
4 Frame Rail
5 U-Bolt Pad
6 Bumper
7 Spring Liner
8 Flanged Locknut
9 Flanged Bolt
10 Washer
11 Hardened Washer
12 Forward Spring Bracket
13 Spring Pin
14 Lube Fitting
15 Spring Clip
16 Caster Shim
17 Front Axle
18 Shock Absorber Mounting Bracket
19 Washer
20 High Nut
21 Shackle Pin
22 Spring Pin
23 Flanged Locknut
24 Shackle
25 Flanged Bolt
26 Washers
27 Hardened Washer
28 Rear Spring Bracket (Shackle Bracket)

Fig. 1, Tapered Leaf Spring Assembly, Set-Forward Axle

Leaf Spring and Components Removal, Cleaning and Inspection, and Installation

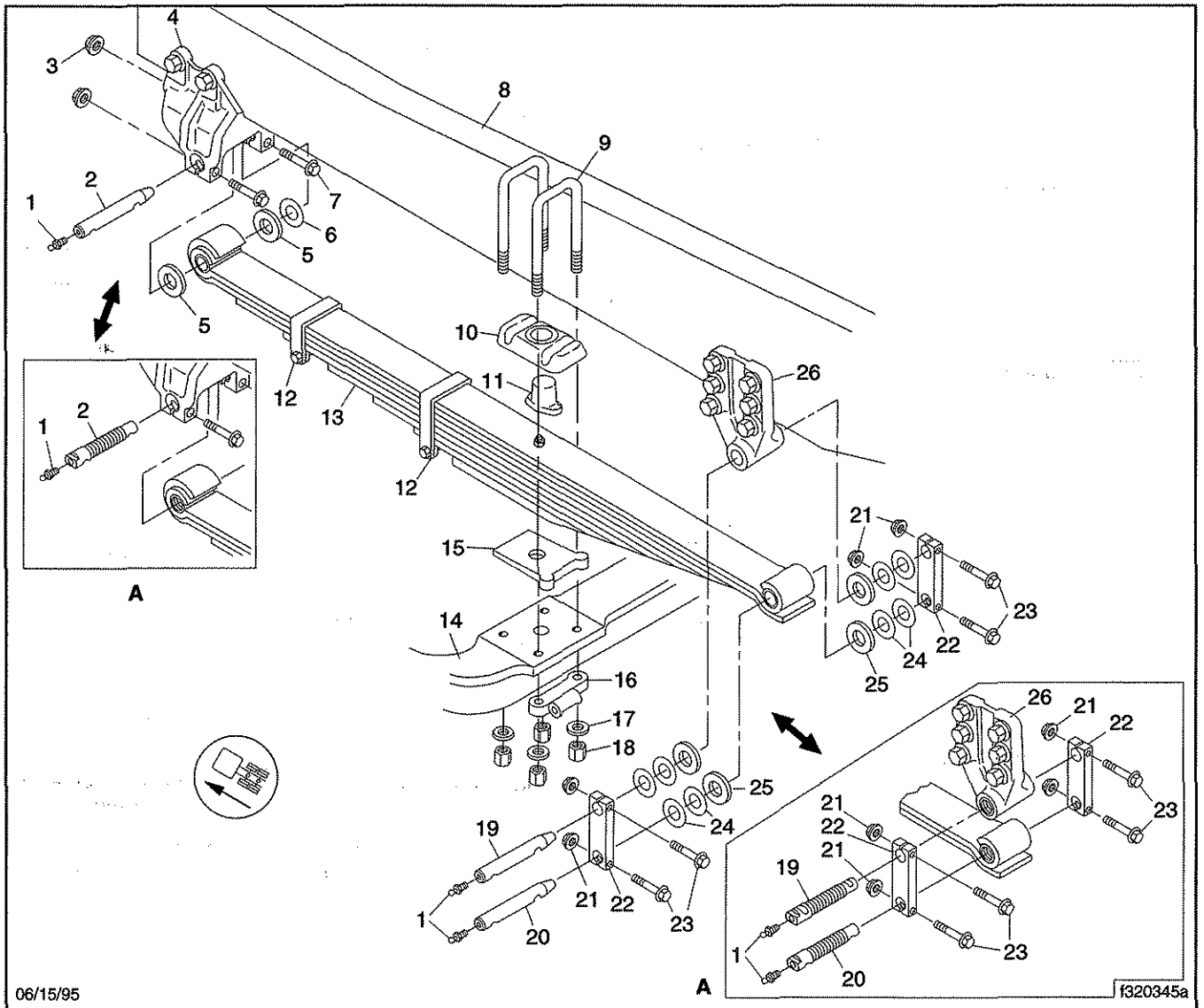


A. Optional Threaded Pins

1. Spring Assembly
2. Front Closing Crossmember
3. U-Bolt
4. Frame Rail
5. U-Bolt Pad
6. Bumper
7. Spring Liner
8. Flanged Locknut
9. Flanged Bolt
10. Washer
11. Hardened Washer
12. Forward Spring Bracket
13. Spring Pin
14. Lube Fitting
15. Spring Clip
16. Caster Shim
17. Front Axle
18. Shock Absorber Mounting Bracket
19. Washer
20. High Nut
21. Shackle Pin
22. Spring Pin
23. Flanged Locknut
24. Shackle
25. Flanged Bolt
26. Washers
27. Hardened Washer
28. Rear Spring Bracket (Shackle Bracket)

Fig. 2, Tapered Leaf Spring Assembly, Setback Axle

Leaf Spring and Components Removal, Cleaning and Inspection, and Installation



A. Optional Threaded Pins

1. Lube Fitting
2. Spring Pin
3. Flanged Locknut
4. Forward Spring Bracket
5. Hardened Washer
6. Washer
7. Flanged Bolt
8. Frame Rail
9. U-Bolt
10. U-Bolt Pad
11. Bumper
12. Spring Clip
13. Spring Assembly
14. Front Axle
15. Caster Shim
16. Shock Absorber Mounting Bracket
17. Washer
18. High Nut
19. Shackle Pin
20. Spring Pin
21. Flanged Locknut
22. Shackle
23. Flanged Bolt
24. Washers
25. Hardened Washer
26. Rear Spring Bracket (Shackle Bracket)

Fig. 3, Flat Leaf Spring Assembly (set-forward axle shown)

Leaf Spring and Components Removal, Cleaning and Inspection, and Installation

⚠ WARNING

Do not replace individual leaves of a damaged leaf spring assembly; replace the complete spring assembly. Visible damage (cracks or breaks) to one leaf causes hidden damage to other leaves. Replacement of only the visibly damaged part(s) is no assurance that the spring is safe. On front spring assemblies, if cracks or breaks exist in the two top leaves, a loss of vehicle control could occur. Failure to replace a damaged spring assembly could cause an accident resulting in serious personal injury or property damage.

4. If the protective coating is gone from some areas of the spring, paint the cleaned areas with a rust-inhibiting paint. If rusting or corrosion is severe, replace the spring.
5. Using a micrometer, check nonthreaded spring pins and shackle pin for wear.

   On tapered leaf spring assemblies, replace a pin if the diameter at any point on the pin is less than 1.245 inches (31.62 mm).

   On flat leaf spring assemblies, replace a pin if the diameter at any point on the pin is less than 1.122 inches (28.50 mm).
6. Inspect threaded spring and shackle pins for cracked or broken threads. Replace any pin that has damaged threads.
7. Inspect the spring and bracket bushings. Replace the bushings if gouged, cracked, pitted, or otherwise damaged. For instructions, see **Subject 110** .
8. If nonthreaded bushings are not damaged, inspect them for wear. Using a micrometer, check the inside diameter of each bushing. The inside diameter of any bushing should not exceed the diameter of its pin by more than 0.010 inch (0.25 mm). Replace any bushing that exceeds this limit.

Installation (See Fig. 1, Fig. 2, or Fig. 3)

⚠ WARNING

Failure to install identical spring assemblies could affect the balance of the front suspension and cause difficult handling of the vehicle, resulting in injury or property damage.

1. Install the shackle bracket if previously removed. Tighten the mounting fastener locknuts 190 lbf·ft (260 N·m).

NOTE: All suspension bracket (frame) fasteners require periodic retorquing. Refer to the suspension section in the vehicle maintenance manual for instructions.

2. Using multipurpose chassis grease, lubricate both spring pins, the shackle pin, and the inside surfaces of the bushings.
3. If the shackle was disconnected from the shackle bracket, attach it to the bracket.

   3.1 Apply Alumilastic® or similar compound to all areas of the shackle that contact metal. This includes all capscrews, washers, and locknuts that contact the aluminum shackle. Do not apply the compound to the inner (bearing) surface of the bushing or on fastener threads.

⚠ CAUTION

Failure to apply Alumilastic or similar compound will result in electrolytic corrosion of dissimilar metal components, and will damage the suspension system.

   3.2 Install the shackles.

   NOTE: When nonthreaded shackle pins are used, make sure the correct spacing washers are inserted between bracket ends and shackles. Be sure the hardened wear washers are in direct contact with the spring eye.

   3.3 Insert the nonthreaded pin or screw in the threaded pin with its grease fitting end toward the outboard side. Install the split ring on the inboard end of the threaded pin. Align the grooves of the pin with the flanged pinch-bolt bores.

   3.4 Install the flanged pinch bolts and flanged nuts to hold the shackle pin and spacing washers in place. Torque the nuts 95 lbf·ft (130 N·m).

Leaf Spring and Components Removal, Cleaning and Inspection, and Installation

⚠ CAUTION

Do not overtighten the shackle pinch-bolt nuts. Overtightening these nuts could distort and weaken the aluminum shackles.

4. Place the caster shim on the front axle in the position referenced earlier.
5. Install the spring assembly on the caster shim; make sure the spring bolt head fits into the bore in the axle.
6. Place the axle stop assembly and spring liner (if equipped) on top of the spring assembly. Make sure the high leg is aft.
7. Place the U-bolts over the axle stop and spring assembly and through the holes in the axle. It may be necessary to slightly compress the sides of the U-bolts in order to get the U-bolt ends to align with the axle holes. A C-clamp attached above the U-bolt threads can be used for this purpose.
8. Attach the hardened washers and the high nuts finger-tight.
9. Attach the spring assembly to the frame bracket.
   - 9.1 With nonthreaded spring pins, hold the correct number of spacing washers, as referenced during removal, between the outboard end of the bracket and the spring; insert the grease fitting end of the pin far enough into the bushing to hold the spacers in place. Hold the remaining spacers in place and push the spring pin in until its grooves align with the frame bracket's flanged pinch-bolt bores.

     With threaded pins, screw the pin all the way into the bushing with the grease fitting end toward the outboard side until the spring pin grooves align with the frame bracket's flanged pinch-bolt bores. Install the split ring on the inboard end of the pin.
   - 9.2 With nonthreaded spring pins, check for play between the spring and the bracket ends. If needed, install additional 1/32-inch spacing washers (1-1/8 inch i.d., 1-7/8 inch o.d.) so that there is less than one washer thickness of end play. It is preferable to have an equal number of washers on each side of the spring. However, if the amount of play requires an uneven number of washers, the difference between the two sides should be no more than one spacing washer.
   - 9.3 Install the flanged pinch bolts and flanged nuts. Tighten the nuts 95 lbf·ft (130 N·m).
10. Attach the spring assembly to the shackle bracket.
    - 10.1 With nonthreaded spring pins, hold the correct number of spacing washers, as referenced during removal, between the outboard shackle and the spring. With the grease fitting pointed to the outboard side, insert the spring pin far enough into the bushing to hold the spacers in place. Hold the remaining spacers in place and push the pin until its grooves align with the shackle pinch-bolt bores.

      With threaded spring pins, screw the pin all the way into the bushing with the grease fitting end toward the outboard side until the spring pin grooves align with the shackle pinchbolt bores. Install the split ring on the inboard end of the pin.
    - 10.2 With nonthreaded spring pins, check for play between the spring and the shackle ends. If needed, install additional 1/32-inch spacing washers (1-1/8 inch i.d., 1-7/8 inch o.d.) so that there is less than one washer thickness of end play. It is preferable to have an equal number of washers on each side of the spring. However, if the amount of play requires an uneven number of washers, the difference between the two sides should be no more than one spacing washer.
    - 10.3 With both threaded and nonthreaded spring pins, install the flanged pinch bolts and flanged nuts. Tighten the nuts 95 lbf·ft (130 N·m).

⚠ CAUTION

Do not overtighten the shackle pinch-bolt nuts. Overtightening these nuts could distort and weaken the shackles.

11. On vehicles equipped with shock absorbers, remove the applicable pair of high nuts and hard-

ened washers and align the lower shock absorber bracket assembly so that the U-bolt ends pass through the holes in the plate.

12. Attach the hardened washers and high nuts to the U-bolts. For U-bolt tightening instructions and torque values, see the applicable table in **Specifications, 400.**

⚠ CAUTION

Failure to retorque the fasteners as instructed could result in spring breakage and abnormal tire wear.

13. Wipe all dirt from the grease fittings on the spring pins and the shackle pin. Apply multipurpose chassis grease with a pressure gun until grease appears at the opposite end of the pin.
14. On vehicles with flat leaf spring assemblies, install the tire and wheel. For instructions, refer to the wheels and tires section in this manual.
15. Remove the jack stands from the chassis, and lower the truck.
16. On vehicles with tapered leaf spring assemblies, install the bumper and attach the road-light wires. Make sure the spacers are in the locations referenced earlier.

Shackle Bracket Bushing Replacement

1. With the shackle bracket removed from the vehicle, press out the worn or damaged bushing.
2. With an inside micrometer or bore gauge, check the bracket bore for damage or wear. Replace the bracket if the bushing bore is damaged or worn.
3. *If installing rubber bushings,* check the shackle bracket bolt for ease of fit in the bushing. It should have an easy slip fit without wobble between it and the bushing.

CAUTION: Do not press in rubber bushings by the center sleeve. To do so could damage the bushings.

4. Press the new bushing into the bracket until the bushing is centered in the bracket.
5. Check the shackle bracket bolt again for ease of fit in the bushing. It should still have an easy slip fit without wobble between it and the bushing. If binding occurs, the bushing may have been distorted during installation. Replace the bushing and check again for correct fit.
6. *If installing bronze bushings,* check the shackle pin for ease of fit in the bushing. It should have an easy slip fit without wobble between it and the bushing.
7. Press the new bushing into the bracket until the bushing is centered in the bracket. The bushing ends must be flush or inside the vertical edges of the bracket bore, and the split in the bushing must be within 1/4 inch (6 mm) of the bottom of the bracket bore.

   Check the shackle pin again for ease of fit in the bushing. It should still have an easy slip fit without wobble between it and the bushing. If binding occurs, the bushing may have been distorted during installation. Replace the bushing and check again for correct fit.
8. *If installing threaded shackle pins,* check the fit of the threaded pin in the bushing. It should screw in easily by hand without binding. Press the new bushing into the bracket until the bushing is centered in the bracket. Check the threaded pin again for ease of fit in the bushing. It should still screw in easily by hand without binding. If binding occurs, the bushing may have been distorted during installation. Replace the bushing and check again for correct fit.

Spring Bushing Replacement

1. Remove the leaf spring. See **Subject 100** for instructions
2. Press out the worn or damaged bushing.

CAUTION: Do not press in the bushing by the center sleeve. To do so could damage the bushing.

3. *If installing rubber bushings,* apply a coating of Perma-Bond® HM–160 or Loctite® RC–609 adhesive to the inside of the spring eye, and to the outside of the bushing. Press the new bushing into the spring eye until the bushing is flush with the edges of the spring eye.

   If installing bronze bushings, press the new bushing into the spring eye until the bushing and the spring edges are flush. The split in the bushing must be within 3/16 inch (5 mm) of the top of the spring eye.

   If installing bushings for threaded spring pins, press the new bushing into the spring eye until the bushing is flush with the edges of the spring eye.
4. Install the leaf spring. See **Subject 100** for instructions.

Shock Absorber Removal and Installation

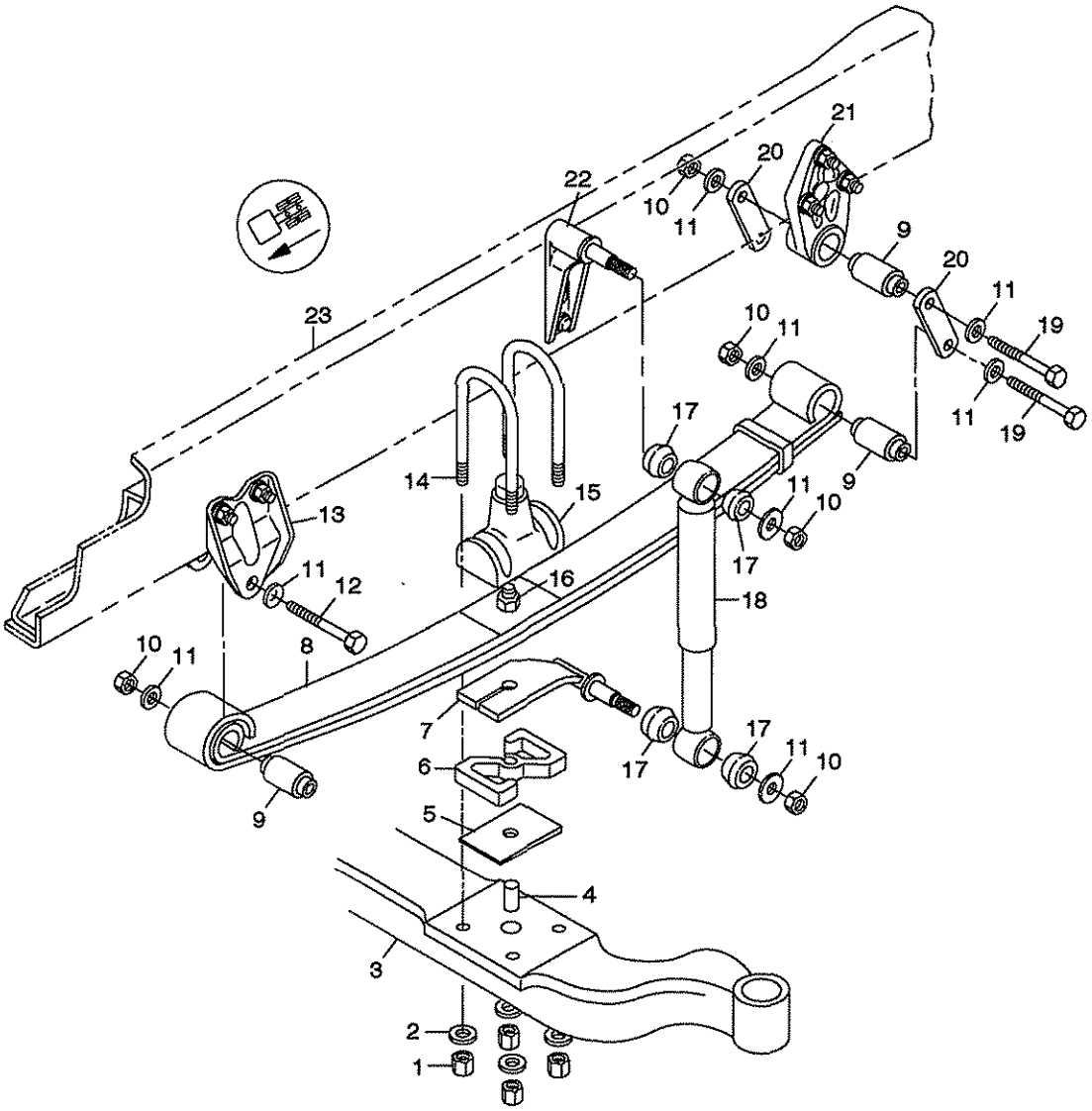
Removal (See Fig. 1)

Remove the locknuts and hardened washers from the shock absorber upper and lower bracket studs. Pull straight out on the shock absorber to remove it.

Installation (See Fig. 1)

1. Check the shock absorber bushings (two bushings in each eye) for wear or damage, and replace them if needed.
2. Make sure the 2-inch o.d. by 1-inch i.d. washer is installed on the stud of the shock absorber upper bracket.
3. Install the eyes of the shock absorber on the upper and lower bracket studs.
4. Install the washer and a new self-locking nut on each of the bracket studs. Tighten the locknuts 150 lbf·ft (203 N·m).

Shock Absorber Removal and Installation



1. U-Bolt High Nut
2. Bearing Washer
3. Axle
4. Dowel
5. Caster Adjustment Shim
6. Spacer
7. Shock Absorber Lower Mounting Bracket
8. Spring Assembly
9. Spring Pin and Rubber Bushing Assembly
10. Self-Locking Nut, 1/2–13
11. Hardened Washer
12. Spring-Eye Bolt
13. Forward Spring Bracket
14. U-Bolt
15. Axle Pad
16. Spring Center-Bolt and Nut
17. Shock Absorber Bushing
18. Shock Absorber
19. Shackle Bolt
20. Spring Shackle
21. Shackle Bracket
22. Shock Absorber Upper Bracket
23. Frame Rail

Fig. 1, Front Suspension with Rubber Bushings

Troubleshooting Chart

Problem—Vehicle Leans to One Side

Problem—Vehicle Leans to One Side	
Possible Cause	**Remedy**
One or more spring leaves are broken.	Replace the spring assembly.
The spring assembly is weak or fatigued.	Replace the spring assembly.
Unmatched spring-design/load-capacity spring assemblies are installed.	Install the correct spring assemblies as originally specified for the vehicle.
A frame rail is bent or twisted.	Check the frame rails for bends and twists. Correct as needed.

Problem—Vehicle Wanders

Problem—Vehicle Wanders	
Possible Cause	**Remedy**
One or more spring leaves are broken.	Replace the spring assembly.
The wheels are out of alignment.	Adjust the wheel alignment using the instructions in the front axle section in this manual.
Caster is incorrect.	Install correct caster shims. Refer to the front axle section in this manual for specifications.
Steering gear is not centered.	Adjust steering using the instructions in the steering section in this manual.
Drive axles are out of alignment.	Align the drive axles using the instructions in the rear axle section in this manual.

Problem—Vehicle Bottoms Out

Problem—Vehicle Bottoms Out	
Possible Cause	**Remedy**
Excessive weight on the vehicle is causing an overload.	Reduce the loaded vehicle weight to the maximum spring capacities.
One or more spring leaves are broken.	Replace the spring assembly.
The spring assembly is weak or fatigued.	Replace the spring assembly.

Problem—Frequent Spring Breakage

Problem—Frequent Spring Breakage	
Possible Cause	**Remedy**
The vehicle is overloaded or operated under severe conditions.	Reduce the loaded vehicle weight to the maximum spring capacities. Caution the driver on improper vehicle handling.
There is insufficient torque on the U-bolt high nuts.	Torque the U-bolt high nuts to the value listed in **Table 1 under Specifications, 400.**

Troubleshooting

Problem—Frequent Spring Breakage	
Possible Cause	**Remedy**
A loose center bolt is allowing the spring leaves to slip.	Check the spring leaves for damage. If damaged, replace the spring assembly. If not, tighten the center-bolt nut to the value listed in torque table in **Specifications, 400.**
Worn or damaged spring pin bushings are allowing spring end-play.	Replace the spring pin and bushing.

Problem—Noisy Spring

Problem—Noisy Spring	
Possible Cause	**Remedy**
A loose U-bolt nut or center bolt is allowing spring leaf slippage.	Inspect the components for damage. Replace damaged components as necessary. Torque the fasteners to the values listed in the torque table in **Specifications, 400.**
A loose, bent, or broken spring shackle or front suspension bracket is impairing the spring flex.	Inspect the shackles and brackets for damage. Replace damaged components as necessary. Torque the fasteners to the values listed in the torque table under **Specifications, 400.**
Worn or damaged spring pins are allowing spring end-play.	Replace any worn or damaged spring pins.

Problem—Rough Ride

Problem—Rough Ride	
Possible Cause	**Remedy**
Refer to the suspension section in this manual.	

Specifications

Front Suspension Fastener Torque Values		
Description	**Size**	**Torque: lbf·ft (N·m)**
Shackle Bracket-to-Frame Locknut	1/2–13	80 (108)
	5/8–11	160 (217)
Spring Shackle Pinch-Bolt Locknut	1/2–13	45 (61)
Front Suspension Bracket Pinch-Bolt Locknut	1/2–13	80 (108)
Forward Spring-Eye Bolt	3/4–10	240 (325)
Upper and Lower Shackle Bolt	3/4–10	240 (325)
Axle U-bolt High Nuts (Tighten in a diagonal pattern as shown in **Fig.** .)	7/8–14	Stage 1: Hand tighten Stage 2: 60 (81) Stage 3: 200 (271) Stage 4: 420–500 (571–680)
	1–14	Stage 1: Hand tighten Stage 2: 60 (81) Stage 3: 200 (271) Stage 4: 520–600 (707–816)
Spring Assembly Center-Bolt Nut	1/2–20	65 (88)
Shock Absorber Upper and Lower Mounting Locknut	3/4–16	150 (203)

Table 1, Front Suspension Fastener Torque Values

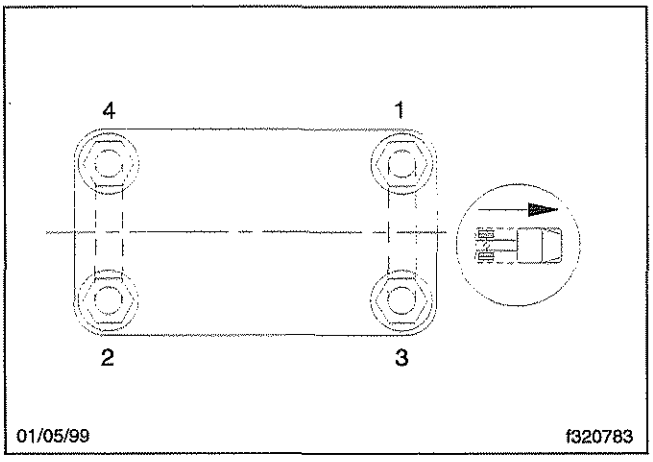


Fig. 1, Tightening Pattern for U-bolt High Nuts

Specifications

Torque Values			
Description	**Size**	**IFI Grade**	**Torque lbf·ft (N·m)**
Forward Spring Bracket-to-Frame Rail Locknut*	3/4–10	C	240 (325)
Axle U-bolt High Nuts	7/8–14	C	Stage 1: Hand tighten Stage 2: 60 (81)† Stage 3: 200 (271)† Stage 4: 420 to 500 (571 to 680)†
	1–14	C	Stage 1: Hand tighten Stage 2: 60 (81)† Stage 3: 200 (271)† Stage 4: 520 to 600 (707 to 816)†
Rear Spring Bracket-to-Frame Rail Locknut*	5/8–11	C	135 (184)
Radius Rod Locknut*	5/8–18	C	135 (184)

* Cadmium-plated, wax-coated nuts, and grade 8 hexbolts with phosphate- and oil-coated threads; both used with hardened washers.
† Tighten in a diagonal pattern as shown in **Fig. 1**.

Table 1, Torque Values

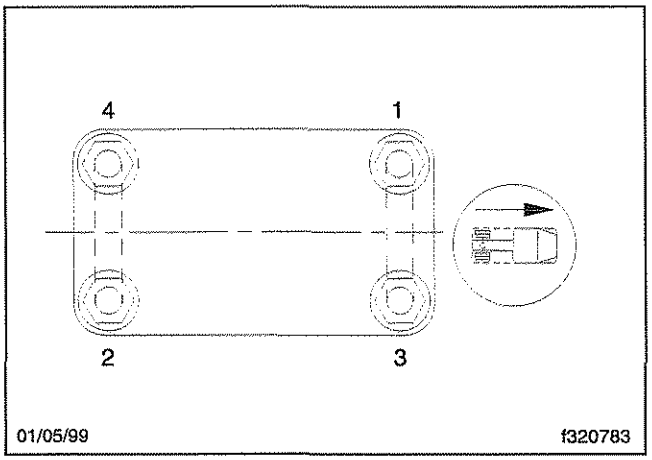


Fig. 1, Tightening Pattern for U-bolt High Nuts

Contents

Subject	Subject Number
General Description	050
Service Operations	
Harmonic and Harsh Ride Checks	100
Troubleshooting	300

General Description

There are two terms used to describe rough ride conditions: harmonic and harsh. Harmonic ride problems are those in which the once-per-revolution energy input from such things as bent or imbalanced wheels match the natural frequency of the frame flexing. This produces a fore-and-aft motion in the cab, which continues as long as the critical road speed is maintained. Harmonic ride problems can occur on smooth roads.

Harsh ride problems are those in which the suspension transfers, rather than absorbs, the momentary energy inputs produced when the tires hit bumps or holes in the road. Wavy asphalt, or a series of bumps, may cause repetition of the harsh, jarring motion in the cab, but the motion stops after the tires pass over the bumps. Harsh ride problems occur on rough roads.

This section is designed for use as an aid in locating and correcting rough ride problems. It is not intended for use as a replacement for the detailed service information located in the applicable subjects in this manual, or in the component manufacturer's service manuals.

Harmonic Ride Checks

1. Visually check the vehicle for signs of damaged or missing suspension components. Repair or replace the components using the instructions in the applicable sections in this manual.
2. Test drive the vehicle.

NOTE: When test driving the vehicle, duplicate as closely as possible the conditions under which the problem occurs. Note the area of the vehicle where the problem seems to be coming from. Pay special attention to this area during the service operations.

WARNING: Use safety stands to securely support all of the wheel and frame weight during suspension repairs. Unsecured components may drop when the fasteners are loosened or removed, causing serious personal injury and component damage.

3. Raise the vehicle until the tires are off the ground, and all of the weight is removed from the leaf springs. Block the axle and frame with safety stands. Perform the corrections under "Harmonic Ride, Tires Off the Ground" in **Troubleshooting, 300**.
4. Remove the safety stands from under the frame and axle, then lower the vehicle. Perform the corrections under "Harmonic Ride, Tires On the Ground" in **Troubleshooting, 300**.

Harsh Ride Checks

1. Visually check the vehicle for signs of damaged or missing suspension components. Repair or replace the components using the instructions in the applicable sections in this manual.
2. Test drive the vehicle.

NOTE: When test driving the vehicle, duplicate as closely as possible the conditions under which the problem occurs. Note the area of the vehicle where the problem seems to be coming from. Pay special attention to this area during the service operations.

WARNING: Use safety stands to securely support all of the wheel and frame weight during suspension repairs. Unsecured components may drop when the fasteners are loosened or removed, causing serious personal injury and component damage.

3. Raise the vehicle until the tires are off the ground, and all of the weight is removed from the leaf springs. Block the axle and frame with safety stands. Perform the corrections under "Harsh Ride, Tires Off the Ground" in **Troubleshooting, 300**.
4. Remove the safety stands from under the frame and axle, then lower the vehicle. Perform the corrections under "Harsh Ride, Tires On the Ground" in **Troubleshooting, 300**.
5. If the problem persists, perform the harmonic ride checks in this subject. Occasionally, ride problems associated with rough roads are harmonic ride problems masked by the road conditions.

Problem—Harmonic Ride, Tires Off the Ground

Possible Cause	Remedy
Bent, distorted, or out-of-round wheels or rims are causing a rough ride.	Inspect and repair the assemblies using the instructions in the wheels and tires section in this manual.
Bent, distorted, or out-of-round brake drums or hubs are causing a rough ride.	Replace damaged components using the instructions in the front or rear axle section in this manual.
An improperly seated tire-to-rim bead is causing an out-of-round assembly.	Inspect the tires and rims for proper bead seating. Correct the problem using the instructions in the wheels and tires section in this manual.
A tire and rim assembly on spoke wheels is improperly installed, causing an out-of-round assembly.	Remove and install the tire and rim assembly using the instructions in the wheels and tires section in this manual.
Worn or distorted rim spacers are causing an out-of-round assembly.	Replace damaged spacers using the instructions in the wheels and tires section in this manual.
The wheels, brake drums, or hub assemblies are out of balance.	Inspect the components for missing balance weights. Balance, as necessary.
Radial force variations in the tires are causing a rough ride.	Exchange the tires and wheels with a set that is known to cause no ride problems. If this corrects the problem, discard the old tires. For instructions, refer to the wheels and tires section in this manual.

Problem—Harmonic Ride, Tires On the Ground

Possible Cause	Remedy
Worn or loose cab mounts allow the cab to bounce.	With a long bar, lever the cab legs up and down. If there is looseness, replace or tighten the mounts, as necessary.
Forces from the trailer suspension are pushing on the tractor fifth wheel.	Review the ride problems that apply to the trailer suspension. Refer to the trailer manufacturer for instructions. Perform the corrections, as necessary.

Problem—Harsh Ride, Tires Off the Ground

Possible Cause	Remedy
Seized front spring shackle pins are not allowing the springs to flex.	Replace seized shackle pins. For instructions, refer to the suspension section in this manual.

Problem—Harsh Ride, Tires On the Ground

Possible Cause	Remedy
The tires are improperly inflated.	Adjust the tire pressure using the instructions in the wheels and tires section in the vehicle maintenance manual.
The frame is bottoming out against the suspension.	Check the suspension for weak or damaged springs or components. Inspect the springs for "gull-winging" when the vehicle is loaded. Replace the spring assembly, as necessary, using the instructions in the suspension section in this manual.
	Reduce the overall loaded weight on each axle to conform with the maximum spring load capacities on the vehicle specification sheet. Do not exceed the maximum spring load capacities.
	Adjust the air spring height using the instructions in the suspension section in this manual.

Troubleshooting

Possible Cause	Remedy
The vehicle normal loaded weight is markedly below the spring load capacity.	Contact the Freightliner Service Operations Regional Office for the correct application of a lower rated spring. Replace the spring assembly using the instructions in the suspension section in this manual.
When the vehicle is loaded, the front axle spring shackle angle is not within the rearward 3- to 18-degree angle.	Contact the Freightliner Service Operations Regional Office for shackle angle corrective measures. Refer to the suspension section in this manual for service instructions.
The weight on the tractor fifth wheel is causing overloading on the front axle springs.	If possible, move the fifth wheel toward the rear of the vehicle; otherwise, change the loading pattern on the trailer.
There is a loaded weight differential between the rear axles greater than 800 pounds (363 kg).	Contact the Freightliner Service Operations Regional Office for corrective measures.
Forces from the trailer suspension are pushing on the tractor fifth wheel causing a rough ride condition.	Review the ride problems that apply to the trailer suspension. Refer to the trailer manufacturer for instructions. Perform the corrections, as necessary.

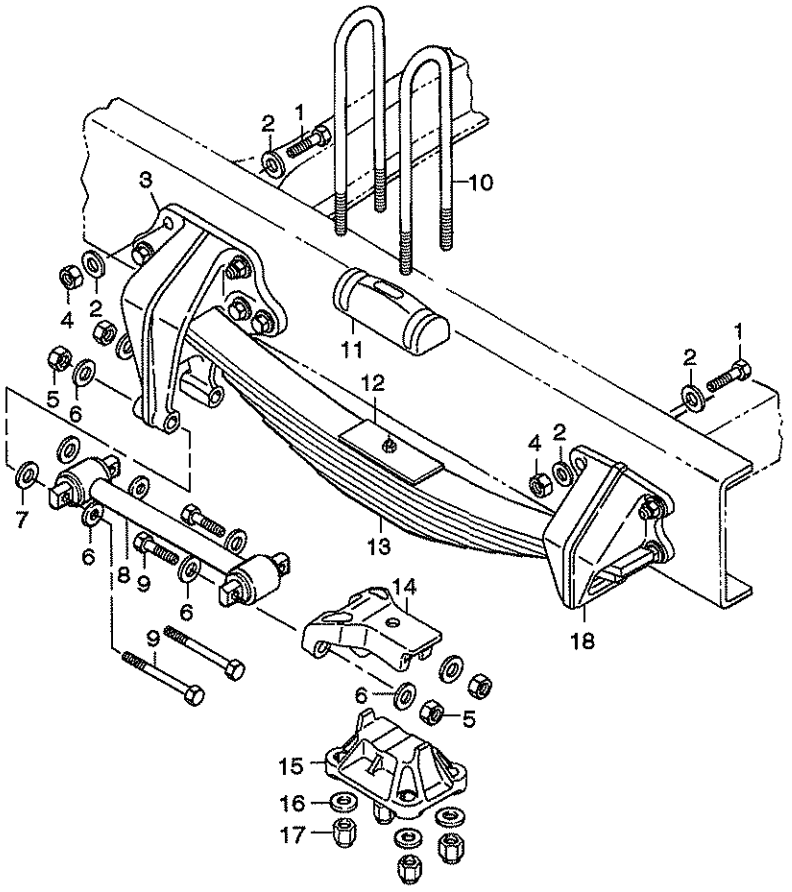
Rear Spring Suspension, Single Axle 32.02

Contents

Subject	Subject Number
General Description	050
Service Operations	
Radius Rod Removal and Installation	100
Spring Assembly Replacement	110
Spring Bracket Replacement	120
Rear Axle Alignment Adjustment	130
Specifications	400

General Description

The single-axle rear spring suspension (**Fig. 1**) uses a full-floating spring design. Semi-elliptical spring assemblies are attached to the axles with U-bolt assemblies. The spring ends ride in aluminum brackets that are mounted on the frame rails. Steel wear shoes are cast into each bracket. Radius rods attached to the axle seats and the forward spring brackets hold the axle in alignment.



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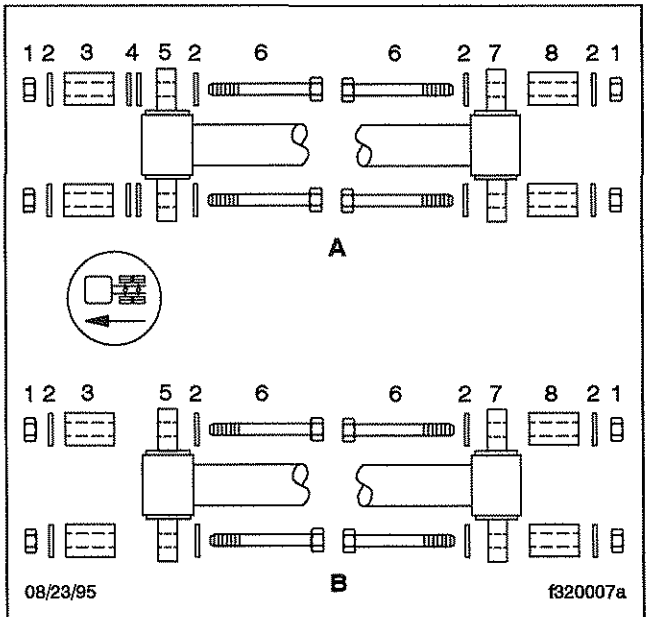
1. Suspension Bracket Hexhead Bolt
2. Hardened Washer
3. Forward Spring Bracket
4. Suspension Bracket Hex Locknut
5. Radius Rod Hexhead Bolt
6. Hardened Washer
7. Axle Alignment Washer
8. Radius Rod
9. Radius Rod Hexhead Bolt
10. U-Bolt
11. U-Bolt Pad
12. Spring Liner
13. Leaf Spring Assembly
14. Spring Seat
15. U-Bolt Retainer
16. Hardened Washer
17. U-Bolt High Nut
18. Rear Spring Bracket

Fig. 1, Single-Axle Spring Suspension

Radius Rod Removal and Installation

Removal (See Fig. 1)

1. Apply the parking brakes, and chock the tires.
2. Note the number of axle alignment washers (Ref. 4) at the forward end of the radius rod that is being removed.
3. Remove the fasteners that attach the radius rod to the forward spring bracket and to the axle seat.
4. Remove the radius rod and any axle alignment washers.



A. Right-Side Radius Rod
B. Left-Side Radius Rod

1. Hex Locknut
2. Hardened Washer
3. Forward Spring Bracket
4. Alignment Washers (install only on one side; right-side installation shown.)
5. Radius Rod Front Pin
6. Hexbolt
7. Radius Rod Rear Pin
8. Axle Seat

Fig. 1, Radius Rod Attachment (top view)

Installation (See Fig. 1)

IMPORTANT: At all points where steel parts contact the aluminum forward spring bracket, apply Alumilastic® compound, or an equivalent, on the mating surfaces.

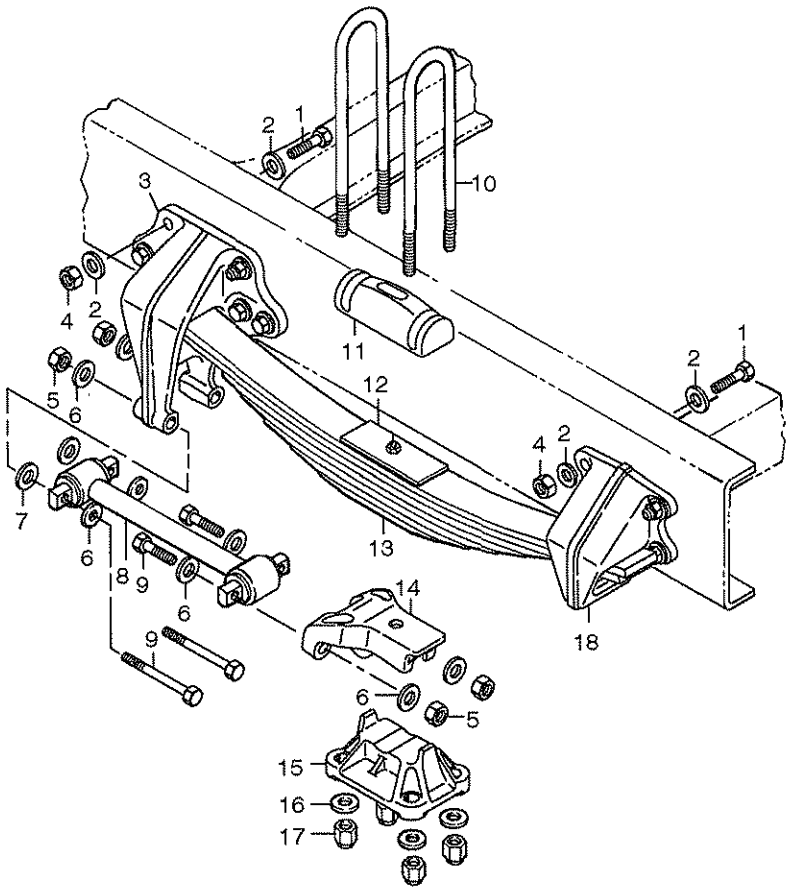
CAUTION: Failure to apply Alumilastic compound, or an equivalent, to areas where aluminum and steel parts contact each other, could lead to corrosion of the metals, resulting in damage to the suspension.

1. Place the radius rod pins between the rear side of the forward spring bracket, and the front side of the axle seat.
2. Install the hexhead bolts, hardened washers, and locknuts in the axle seat and the radius rod rear pin.
3. Install any previously removed axle alignment washers between the radius rod front pin and the forward spring bracket. Install the hexhead bolts, hardened washers, and locknuts in the radius rod front pin and the forward spring bracket.
4. Tighten the radius rod locknuts to the torque value in **Specifications, 400.**
5. Check the axle alignment. For instructions, refer to the rear axle section in this manual. If necessary, adjust the rear axle alignment, using the instructions in **Subject 130.**

Replacement (See Fig. 1)

WARNING: Do not replace individual leaves of a damaged leaf spring assembly; replace the complete spring assembly. Visible damage (cracks or breaks) to one leaf causes hidden damage to other leaves. Replacement of only the visibly damaged part(s) is no assurance that the spring is safe. Failure to replace a damaged spring assembly could cause an accident resulting in serious personal injury or property damage.

1. Chock the front tires.
2. Raise the frame so that all weight is removed from the leaf springs, then block the frame with safety stands. Raise the rear axle until the spring no longer contacts the spring bracket wear shoes, then block the axle. Make sure the stands will securely support the weight of the axles and frame. To gain easy access to the suspension



1. Suspension Bracket Hexhead Bolt
2. Hardened Washer
3. Forward Spring Bracket
4. Suspension Bracket Hex Locknut
5. Radius Rod Hexhead Bolt
6. Hardened Washer
7. Axle Alignment Washer
8. Radius Rod
9. Radius Rod Hexhead Bolt
10. U-Bolt
11. U-Bolt Pad
12. Spring Liner
13. Leaf Spring Assembly
14. Spring Seat
15. U-Bolt Retainer
16. Hardened Washer
17. U-Bolt High Nut
18. Rear Spring Bracket

Fig. 1, Single-Axle Spring Suspension

Spring Assembly Replacement

system, remove the wheel assembly; refer to the wheels and tires section in this manual for instructions.

3. Remove the U-bolt high nuts, hardened washers, U-bolt retainer, U-bolts, and upper U-bolt pad.
4. Lift the spring assembly off the axle seat, then move it to the rear, out of the forward spring bracket. Lift the front of the spring, then move it forward, out of the rear spring bracket.
5. Using chassis grease, lubricate the ends of the new spring where they contact the stationary wear shoes in the spring brackets.
6. Work the new spring assembly into the spring brackets, and place it on the axle seat. Make sure the spring center-bolt head seats in the axle seat hole.
7. Place the upper U-bolt pad on the spring assembly. Place the U-bolts over the upper U-bolt pad and the spring assembly.
8. Install the U-bolt retainer, hardened washers, and U-bolt high nuts. Tighten the high nuts until snug.
9. In a diagonal pattern, hand tighten the axle U-bolt high nuts. In the same pattern, tighten them 100 lbf·ft (136 N·m); then, 200 lbf·ft (270 N·m); then, 300 lbf·ft (407 N·m); then, torque to the final value of 420 lbf·ft (569 N·m).

CAUTION: Failure to periodically torque the suspension fasteners can result in abnormal tire wear, and damage to the springs, spring brackets, and frame rail.

IMPORTANT: All suspension fasteners require periodic torquing. For suspension component inspecting and fastener torque checking intervals and instructions, see **Group 32** in the vehicle maintenance manual.

10. Install the wheel assembly, using the instructions in **Group 40**. Remove the safety stands from under the frame and axle, and lower the vehicle.
11. Check the axle alignment. For instructions, see **Group 35**. If necessary, adjust the rear axle alignment, using the instructions in **Subject 130**.

Replacement

WARNING: Replace worn, cracked, or damaged spring brackets. Failure to do so could result in bracket breakage, possibly leading to loss of vehicle control and resulting in personal injury or property damage.

IMPORTANT: At all points where steel parts (including bolts, washers, and nuts) contact the aluminum spring brackets, apply Alumilastic® compound, or an equivalent, on the mating surfaces.

CAUTION: Failure to apply Alumilastic compound, or an equivalent, to areas where aluminum and steel parts contact each other, could lead to corrosion of the metals, resulting in damage to the suspension.

1. Chock the front tires.
2. Raise the rear of the vehicle, and block the rear axle with safety stands. Raise the vehicle frame so that all weight is removed from the leaf springs, then block the frame with safety stands. Make sure the stands will securely support the weight of the axle and frame.
3. If removing the forward spring bracket, note the number of axle alignment washers, if any, between the bracket and the radius rod front pin. Remove the fasteners that attach the radius rod to the bracket, and remove any axle alignment washers.
4. Remove the fasteners that attach the spring bracket to the frame rail, and remove the spring bracket.
5. Place the new spring bracket on the frame rail. Align the mounting holes, and install the spring bracket bolts, hardened washers, and locknuts.

NOTE: If installing the forward spring bracket, install the nuts for the top two bolts on the outboard side of the frame rail, and install the nuts for the bottom four bolts on the inboard side of the frame rail. **See Fig. 1.**

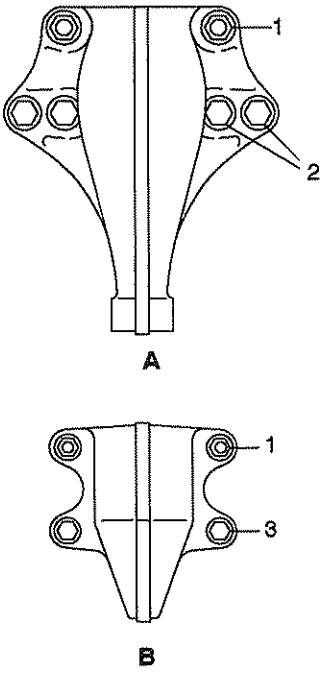
If installing the rear spring bracket, install the nuts for the top two bolts on the outboard side of the frame rail, and install the nuts for the bottom two bolts on the inboard side of the frame rail. **See Fig. 1.**

6. Tighten the locknuts to the applicable torque value in **Specifications, 400.**

CAUTION: Failure to periodically torque the suspension fasteners can result in abnormal tire wear, and damage to the springs, spring brackets, and frame rail.

IMPORTANT: All suspension fasteners require periodic torquing. For suspension component inspecting and fastener torque checking intervals and instructions, refer to the suspension section in the vehicle maintenance manual.

7. If replacing the forward spring bracket, position any previously removed axle alignment washers between the bracket and the radius rod front pin. Install the bolts, hardened washers, and locknuts in the radius rod front pin and the forward spring bracket. Tighten the locknuts to the torque value in **Specifications, 400.**
8. Remove the safety stands from under the frame and axle, and lower the vehicle.



A. Forward Spring Bracket
B. Rear Spring Bracket

1. Nut (outboard)
2. Bolt Heads (outboard)
3. Bolt Head (outboard)

Fig. 1, Frame Brackets

Spring Bracket Replacement

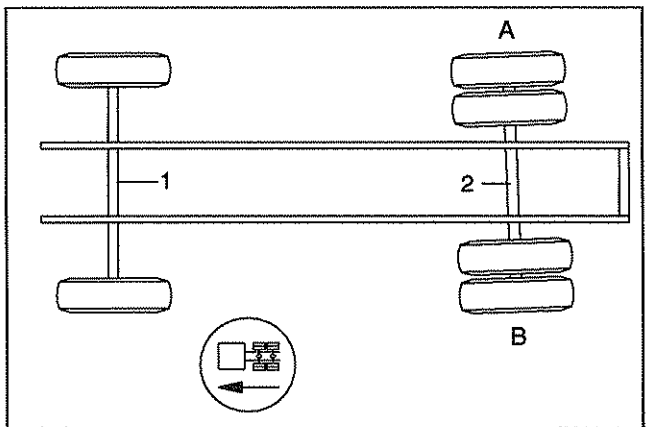
9. Check the axle alignment. For instructions, refer to the rear axle section in this manual. If necessary, adjust the rear axle alignment, using the instructions in **Subject 130**.

Adjustment

1. Using a straightedge and a tape measure, determine the amount of adjustment needed to align the axle at a right angle to the frame. For instructions, refer to the rear axle section in this manual. The difference in measurements between the sides of the vehicle is the approximate amount that the trailing end of the axle will have to be brought forward, or the leading end will have to be moved back to align it at a right angle to the frame. **See Fig. 1.**

NOTE: To adjust the axle alignment, add washers between the radius rod front pin and the forward spring bracket on the leading end, to adjust the leading end backward. Or, remove washers from the trailing end, to bring the trailing end forward. When possible, alignment washers should be removed instead of added.

2. On both sides of the axle, loosen the axle U-bolts enough to allow the springs to shift on the axle seats.
3. On the side of the vehicle that is to be adjusted, remove the fasteners that attach the radius rod to the forward spring bracket. Remove any axle alignment washers.



A. Leading End
B. Trailing End

1. Front Axle
2. Rear Axle

Fig. 1, Single Axle, Shown Out of Alignment

4. Raise the frame just enough to relieve the weight from the springs. Place safety stands under the frame. Make sure the stands will support the weight of the frame.
5. Move the loosened end of the axle forward or backward as needed, by rolling the wheels.
6. Insert the correct thickness of axle alignment washers between the radius rod front pin and the forward spring bracket.
7. Install the hexhead bolt, hardened washers, and locknut in the radius rod pin and forward spring bracket. Place an equal thickness of washers on the other end of the radius rod pin, and install the fasteners.
8. Tighten the locknuts to the applicable torque value in **Specifications, 400.**
9. Remove the safety stands, and lower the vehicle. Remove the chocks from the front tires.
10. Check the axle alignment with the straightedge and the tape measure. If alignment is within specifications, center the spring in the forward spring bracket, if needed, then tighten the axle U-bolt nuts to the torque value in **Specifications, 400.**

    If not in alignment, repeat the procedure above.

CAUTION: Failure to periodically torque the suspension fasteners can result in abnormal tire wear, and damage to the springs, spring brackets, and frame rail.

IMPORTANT: All suspension fasteners require periodic torquing. For suspension component inspecting and fastener torque checking intervals and instructions, refer to the suspension section in the vehicle maintenance manual.

Specifications

Description	Size	IFI Grade	Torque lbf·ft (N·m)
Forward Spring Bracket-to-Frame Rail Locknut*	3/4–10	C	240 (325)
Rear Spring Bracket-to-Frame Rail Locknut*	5/8–11	C	135 (184)
Axle U-Bolt High Nuts	7/8–14	C	Stage 1: Hand tighten Stage 2: 100 (136)† Stage 3: 200 (270)† Stage 4: 300 (407)† Stage 5: 420 (569)†
Radius Rod Locknut*	5/8–18	C	135 (184)

* Cadmium-plated, wax-coated nuts, and grade 8 hexbolts with phosphate- and oil-coated threads; both used with hardened washers.
† Tighten in a diagonal pattern.

Table 1, Torque Values

Contents

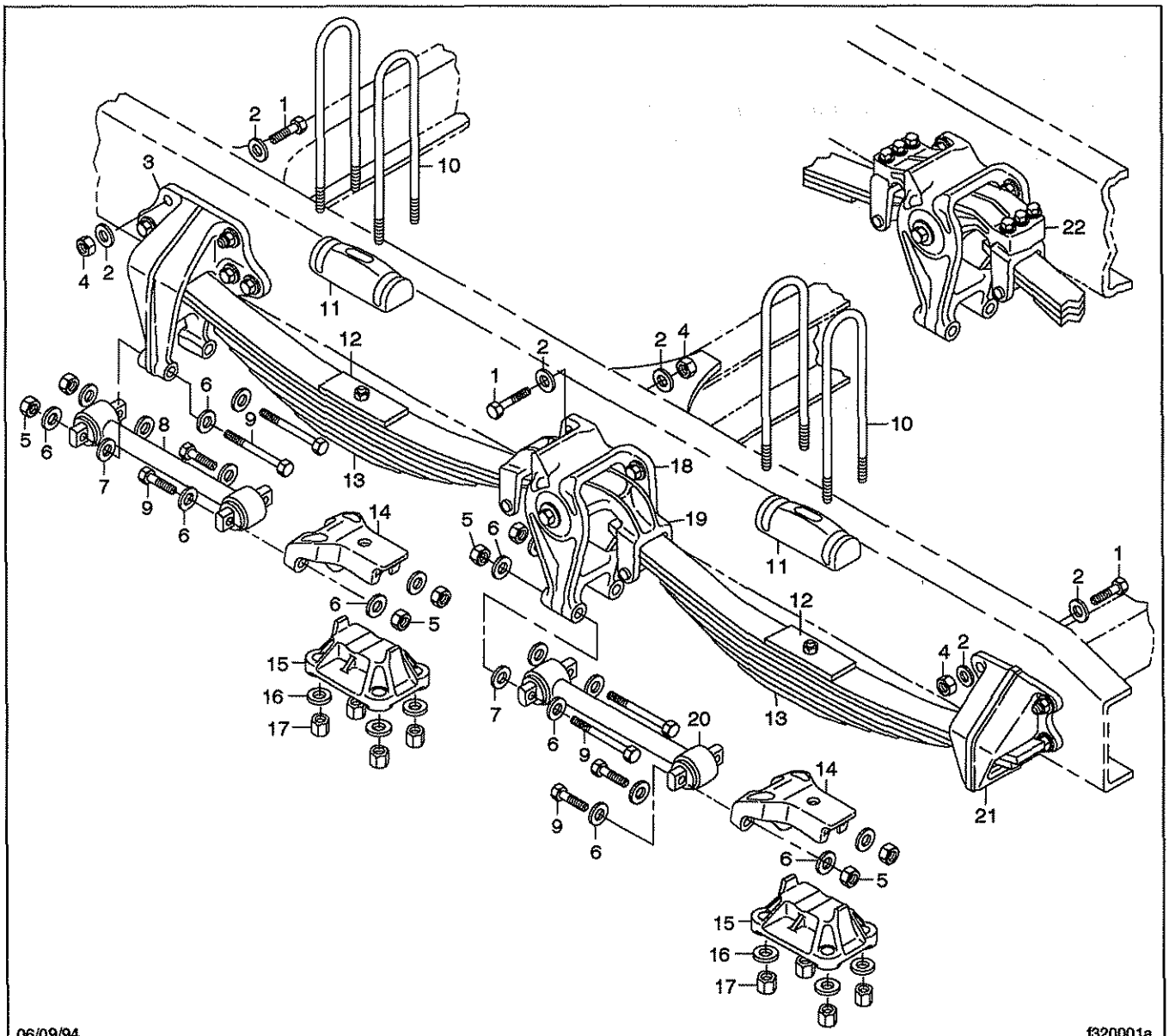
Subject	Subject Number
General Description	050
Service Operations	
Radius Rod Removal and Installation	100
Equalizer Removal, Inspection, and Installation	110
Spring Assembly Replacement	120
Spring Bracket and Equalizer Bracket Replacement	130
Rear Axle Alignment Adjustment	140
Specifications	400

General Description

The tandem-axle rear spring suspension (**See Fig. 1**) uses a six-point equalizing leaf spring design, which compensates for axle articulation, from side to side, and front to rear. Four semi-elliptical spring assemblies are attached to the axles with U-bolts. On both sides of the vehicle, the forward end of the forward spring and the rear end of the rear spring ride in aluminum brackets that are mounted on the frame rails. Steel wear shoes are cast into each bracket.

At the center, between the forward and rear springs, the springs ride on an equalizer, which pivots on a sleeve in the equalizer bracket. Equalizer travel is stopped when the top of the equalizer and equalizer bracket make contact. Each axle is held in alignment by a pair of radius rods that extend forward from the axle seats to the forward spring brackets for the forward-rear axle, and to the equalizer brackets for the rearmost axle.

General Description



1. Suspension Bracket Hexbolt
2. Hardened Washer
3. Forward Spring Bracket
4. Suspension Bracket Hex Locknut
5. Radius Rod Hex Locknut
6. Hardened Washer
7. Axle Alignment Washer
8. Forward Radius Rod
9. Radius Rod Hexbolt
10. U-Bolt
11. U-Bolt Pad
12. Spring Liner
13. Leaf Spring Assembly
14. Spring Seat
15. U-Bolt Retainer
16. Hardened Washer
17. U-Bolt High Nut
18. Equalizer Bracket
19. Equalizer, One-Piece (tandem drive axles)
20. Rear Radius Rod
21. Rear spring Bracket
22. Equalizer, Three-Piece (tag or pusher axle)

Fig. 1, Tandem-Axle Spring Suspension

Radius Rod Removal and Installation

Removal (See Fig. 1)

1. Apply the parking brakes, and chock the tires.
2. Note the number of axle alignment washers (Ref. 4) at the forward end of each radius rod that is being removed.
3. Remove the fasteners that attach the radius rod to the forward spring bracket or equalizer bracket, and to the axle seat.
4. Remove the radius rod and any axle alignment washers.

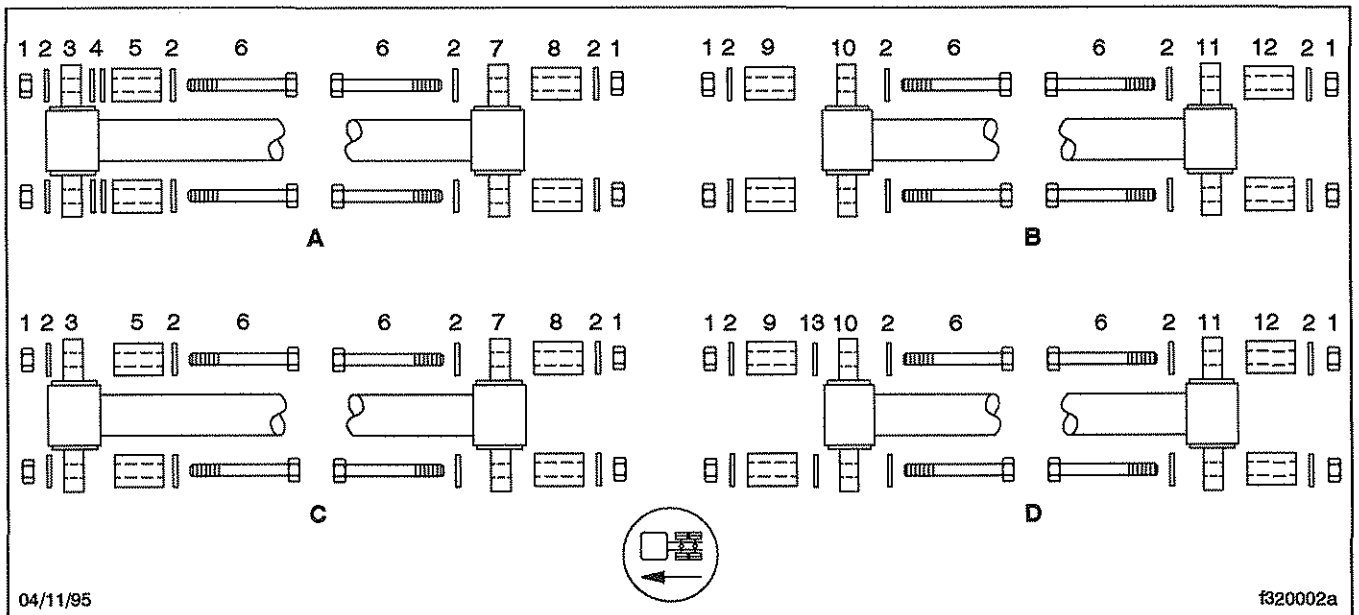
Installation (See Fig. 1)

IMPORTANT: At all points where steel parts (including bolts, washers, and nuts) contact aluminum brackets, apply Alumilastic compound, or an equivalent, on the mating surfaces.

CAUTION: Failure to apply Alumilastic compound, or an equivalent, to areas where aluminum and steel parts contact each other, could lead to corrosion of the metals, resulting in damage to the suspension.

If installing forward and rear radius rods, install the forward radius rod before installing the rear radius rod.

1. If installing a forward radius rod, place the radius rod front pin on the front side of the forward spring bracket, and place the radius rod rear pin in front of the axle seat.



A. Forward Right-Side Radius Rod
B. Rear Right-Side Radius Rod
C. Forward Left-Side Radius Rod
D. Rear Left-Side Radius Rod

1. Hex Locknut
2. Hardened Washer
3. Forward Radius-Rod Front Pin
4. Alignment Washers (Install only on one side of front axle; right-side installation shown.)
5. Forward Spring Bracket
6. Hexbolt
7. Forward Radius Rod Rear Pin
8. Forward Axle Seat
9. Equalizer Bracket
10. Rear Radius-Rod Front Pin
11. Rear Radius-Rod Rear Pin
12. Rear Axle Seat
13. Alignment Washers (Install only on one side of rear axle; left-side installation shown.)

Fig. 1, Radius Rod Attachment (top view)

Radius Rod Removal and Installation

If installing a rear radius rod, place the radius rod pins between the rear side of the equalizer bracket and the front side of the axle seat.

2. Install a hexhead bolt with a hardened washer through each end of the radius rod rear pin and the axle seat ears. Install the hardened washers and locknuts.

3. If installing a forward radius rod, install any previously removed axle alignment washers between the radius rod front pin and the forward spring bracket. Install the hexhead bolts, hardened washers, and locknuts.

   If installing a rear radius rod, install any previously removed axle alignment washers between the radius rod front pin and the equalizer bracket. Install the hexhead bolts, hardened washers, and locknuts.

4. Tighten the radius rod locknuts to the torque value in **Specifications, 400**.

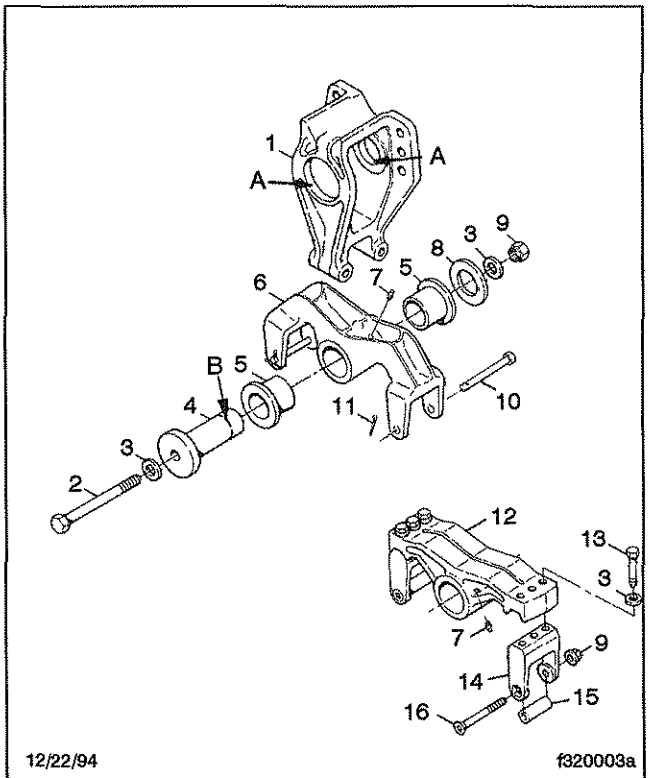
5. After all of the radius rods are installed, check the rear axle alignment. For instructions, refer to the rear axle section in this manual. If necessary, adjust the axle alignment, using the instructions in **Subject 140**.

Equalizer Removal, Inspection, and Installation

Removal (See Fig. 1)

1. Chock the front tires.
2. Raise the rear of the vehicle, and block the axles with safety stands. Raise the vehicle frame so that all weight is removed from the leaf springs, then block the frame with safety stands. Make sure the stands will securely support the weight of the axles and frame. To allow access to the equalizer, remove the wheel assemblies on that side, using the instructions in the wheels and tires section in this manual.
3. If removing an equalizer from a vehicle with two drive axles, remove the cotter pin from the outboard end of each spring retainer pin, then remove the retainer pins.

   If removing an equalizer from a vehicle with a pusher or tag axle, remove the nuts from the flathead bolts in the wear-shoe side-restraints, on each end of the equalizer. Remove the flathead bolts and side-restraint sleeves. Remove the six capscrews and washers, and remove both wear-shoe side-restraints from the equalizer.
4. Remove the cap and tube assembly locknut, inboard bearing washer, bolt, and outboard bearing washer.
5. Insert a bar between the bottom of the equalizer and the equalizer bracket. Gently lever the weight of the equalizer off the cap and tube assembly. Insert a piece of barstock through the inboard cap and tube assembly bolt hole, and lightly tap the cap and tube assembly out of the equalizer.
6. Remove the equalizer from the equalizer bracket. Remove the wear washer(s) and equalizer bushings from the equalizer.



A. Apply Loctite here.
B. No grease.

1. Equalizer Bracket
2. Hexhead Bolt
3. Bearing Washer
4. Cap and Tube Assembly
5. Equalizer Assembly Bushing
6. Equalizer (used on vehicles with two drive axles)
7. Grease Fitting
8. Wear Washer(s)
9. Locknut
10. Spring Retainer Pin
11. Cotter Pin
12. Equalizer (used on vehicles with a tag or pusher axle)
13. Capscrew
14. Wear-Shoe Side-Restraint
15. Side-Restraint Sleeve
16. Flathead Bolt

Fig. 1, Equalizer Assembly

Inspection

1. Thoroughly clean the equalizer with steam or a hot soap solution. Inspect it for wear, cracks,or other damage. Replace the equalizer if any of these conditions are present.

CAUTION: Failure to replace the equalizer if it is cracked or otherwise damaged could result in progressive damage to, and eventual breakage of the equalizer. Breakage of the equalizer could cause a loss of vehicle control, resulting in personal injury or property damage.

2. Inspect the equalizer bushings, cap and tube assembly, and the equalizer bracket for wear, cracks, or other damage. If any of these conditions are present, replace the bushings or the cap and tube assembly.

Equalizer Removal, Inspection, and Installation

Installation (See Fig. 1)

1. Apply a thin film of multipurpose chassis grease to the outside of the equalizer bushings, then install the bushings in the equalizer.
2. Install the equalizer in the equalizer bracket.

NOTE: The next four steps must be completed before the Loctite begins to cure (approximately 5 to 10 minutes).

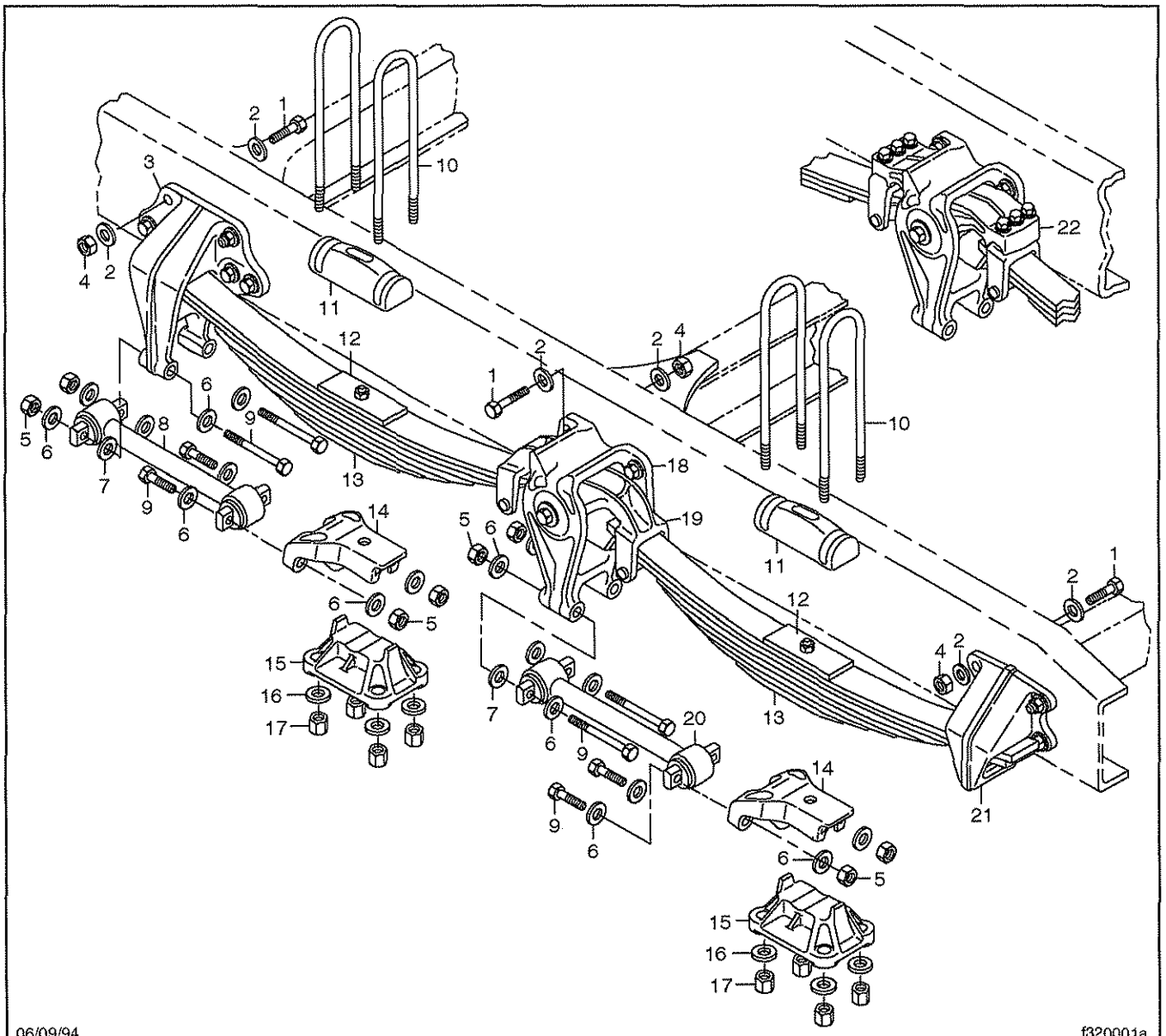
3. Apply Loctite 680 to both interior surfaces of the equalizer bracket, where the cap and tube assembly is inserted. Apply multipurpose chassis grease to the cap and tube assembly, except the last inch which connects to the equalizer bracket. Start the cap and tube assembly into the equalizer, through the equalizer bracket.
4. Push the cap and tube assembly part way through the equalizer, then place the wear washer(s) between the inboard equalizer bushing and the equalizer bracket. Push the cap and tube assembly the rest of the way into the equalizer bracket.
5. Place the outboard bearing washer on the equalizer cap and tube assembly bolt, and install the bolt in the cap and tube assembly.
6. Install the inboard bearing washer and locknut on the cap and tube assembly bolt. Tighten the locknut to the torque value in **Specifications, 400**.
7. Lubricate the equalizer assembly by applying multipurpose chassis grease at the grease fitting. Lubricate with a hand gun or pressure gun until grease is forced past the bushing seals, or if equipped with a pressure-relief grease fitting, until grease is forced out from the base of the pressure relief fitting.
8. If installing an equalizer on a vehicle with two drive axles, apply Alumilastic compound, or an equivalent, to the spring retainer pins, then install them from the inboard side. Be sure the hooked ends of the spring leaves are above the retainer pins. Install a cotter pin in the outboard end of each retainer pin, and lock it in place.

   If installing an equalizer on a vehicle with a pusher or tag axle, apply Alumilastic compound, or an equivalent, to the surfaces where the wear-shoe side-restraints contact the equalizer. Attach the side-restraints to the equalizer, offsetting them toward the inboard side of the equalizer. Tighten the equalizer wear-shoe capscrews to the torque value in **Specifications, 400**. Install the side-restraint sleeves and flathead bolts in the wear-shoe side-restraints. Be sure the hooked ends of the spring leaves are above the side-restraint sleeves. Install the nuts, and tighten them to the applicable torque value in **Specifications, 400**.

CAUTION: Failure to apply Alumilastic compound, or an equivalent, to areas where aluminum and steel contact each other, could lead to corrosion of the metals, resulting in suspension damage.

9. Install the wheel assemblies, using the instructions in the wheels and tires section in this manual. Remove the safety stands from under the frame and axle, and lower the vehicle.
10. If the radius rods have been loosened, or the equalizer bracket has been removed, check the rear axle alignment. For instructions, refer to the rear axle section in this manual. If necessary, adjust the axle alignment using the instructions in **Subject 140**.

Replacement (See Fig. 1)



1. Suspension Bracket Hexbolt
2. Hardened Washer
3. Forward Spring Bracket
4. Suspension Bracket Hex Locknut
5. Radius Rod Hex Locknut
6. Hardened Washer
7. Axle Alignment Washer
8. Forward Radius Rod
9. Radius Rod Hexbolt
10. U-Bolt
11. U-Bolt Pad
12. Spring Liner
13. Leaf Spring Assembly
14. Spring Seat
15. U-Bolt Retainer
16. Hardened Washer
17. U-Bolt High Nut
18. Equalizer Bracket
19. Equalizer, One-Piece (tandem drive axles)
20. Rear Radius Rod
21. Rear spring Bracket
22. Equalizer, Three-Piece (tag or pusher axle)

Fig. 1, Tandem-Axle Spring Suspension

Spring Assembly Replacement

WARNING: Do not replace individual leaves of a damaged leaf spring assembly; replace the complete spring assembly. Visible damage (cracks or breaks) to one leaf causes hidden damage to other leaves. Replacement of only the visibly damaged part(s) is no assurance that the spring is safe. Failure to replace a damaged spring assembly could cause an accident resulting in serious personal injury or property damage.

1. Chock the front tires.
2. Raise the frame so that all weight is removed from the leaf springs; then block the frame with safety stands. Raise the rear axle until the spring no longer contacts the spring bracket wear shoes and the spring retainer pin (or side-restraint sleeve); then block the axle. Make sure the stands will securely support the weight of the axles and frame. To access the spring assembly, remove the wheel assembly. See **Group 40** for instructions.
3. If equipped with two drive axles, remove the cotter pin from the spring retainer pin on the end of the equalizer where the spring is being replaced. Drive the spring retainer pin out of the equalizer.

   If equipped with a pusher or tag axle, remove the nut from the flathead bolt on the end of the equalizer where the spring is being replaced. Remove the bolt and the side-restraint sleeve from the wear-shoe side-restraint.
4. Remove the U-bolt high nuts, hardened washers, U-bolt retainer, U-bolts, and upper U-bolt pad.
5. Remove the spring assembly by lifting it off the axle seat, then moving it toward the equalizer, out of the forward or rear spring bracket.
6. Using chassis grease, lubricate the new spring assembly where the ends will contact the stationary wear shoes in the spring bracket and equalizer.
7. Place the new spring assembly in the spring bracket and on the axle seat. Make sure the spring center-bolt head seats in the axle seat hole.
8. If the upper U-bolt pad is aluminum, apply Alumilastic compound, or an equivalent, to those areas of the pad that will come in contact with the U-bolts and with the upper spring leaf.

CAUTION: Failure to apply Alumilastic® compound, or an equivalent, to areas where aluminum and steel contact each other, could lead to corrosion of the metals, resulting in suspension damage.

9. Place the upper U-bolt pad on the spring assembly. Place the U-bolts over the upper U-bolt pad and the spring assembly.
10. Install the U-bolt retainer, hardened washers, and U-bolt high nuts. Tighten the high nuts until snug.
11. If installing a spring assembly on a vehicle with two drive axles, apply Alumilastic compound, or an equivalent, to the spring retainer pins, then install them from the inboard side. Be sure the hooked ends of the spring leaves are above the retainer pins. Install a cotter pin in the outboard end of each retainer pin, and lock it in place.

    If installing a spring assembly on a vehicle with a pusher or tag axle, install the side-restraint sleeves and flathead bolts in the wear-shoe side-restraints. Be sure the hooked ends of the spring leaves are above the side-restraint sleeves. Install the nuts, and tighten them to the applicable torque value in **Specifications, 400**.
12. In a diagonal pattern, hand tighten the axle U-bolt high nuts. In the same pattern, tighten them 100 lbf·ft (136 N·m); then, 200 lbf·ft (270 N·m); then, 300 lbf·ft (407 N·m); then, torque to the final value of 420 lbf·ft (569 N·m).

CAUTION: Failure to periodically torque the suspension fasteners can result in abnormal tire wear, and damage to the springs, spring brackets, and frame rail.

IMPORTANT: All suspension fasteners require periodic torquing. For suspension component inspecting and fastener torque checking intervals and instructions, see **Group 32** in the vehicle maintenance manual.

13. Install the wheel assembly, using the instructions in **Group 40**. Remove the safety stands from under the frame and axle, and lower the vehicle.
14. Check the rear axle alignment. For instructions, see **Group 35.** If necessary, adjust the axle alignment, using the instructions in **Subject 140**.

Spring Bracket and Equalizer Bracket Replacement

Replacement (See Fig. 1)

WARNING: Replace worn, cracked, or damaged spring brackets or equalizer brackets. Failure to do so could result in breakage of the bracket, possibly leading to loss of vehicle control and resulting in personal injury or property damage.

IMPORTANT: At all points where steel parts contact the aluminum spring brackets, apply Alumilastic compound, or an equivalent, on the mating surfaces.

CAUTION: Failure to apply Alumilastic compound, or an equivalent, to areas where aluminum and steel parts contact each other, could lead to corrosion of the metals, resulting in damage to the suspension.

1. Chock the front tires.
2. Raise the rear of the vehicle, and block the axles with safety stands. Raise the vehicle frame so that all weight is removed from the leaf springs, then block the frame with safety stands. Make sure the stands will securely support the weight of the axles and frame.
3. If removing the forward spring bracket or the equalizer bracket, note the number of any axle alignment washers, then remove the fasteners that attach the radius rod to the forward spring bracket or equalizer bracket. Remove any axle alignment washers.
4. If removing an equalizer bracket, remove the equalizer. For instructions, refer to **Subject 110.**
5. Remove the fasteners that attach the forward or rear spring bracket, or equalizer bracket, to the frame rail. Remove the bracket.
6. Place the new spring bracket or equalizer bracket on the frame rail. Align the mounting holes, and install the bracket bolts, hardened washers, and locknuts.

NOTE: If installing the forward spring bracket, install the nuts for the top two bolts on the outboard side of the frame rail, and install the nuts for the bottom four bolts on the inboard side of the frame rail. **See Fig. 2.**

If installing the equalizer bracket, for clearance, install all of the nuts on the inboard side of the frame rail. **See Fig. 2.**

If installing the rear spring bracket, install the nuts for the top two bolts on the outboard side of the frame rail, and install the nuts for the bottom two bolts on the inboard side of the frame rail. **See Fig. 2.**

7. Tighten the bracket mounting locknuts to the applicable torque value in **Specifications, 400.**

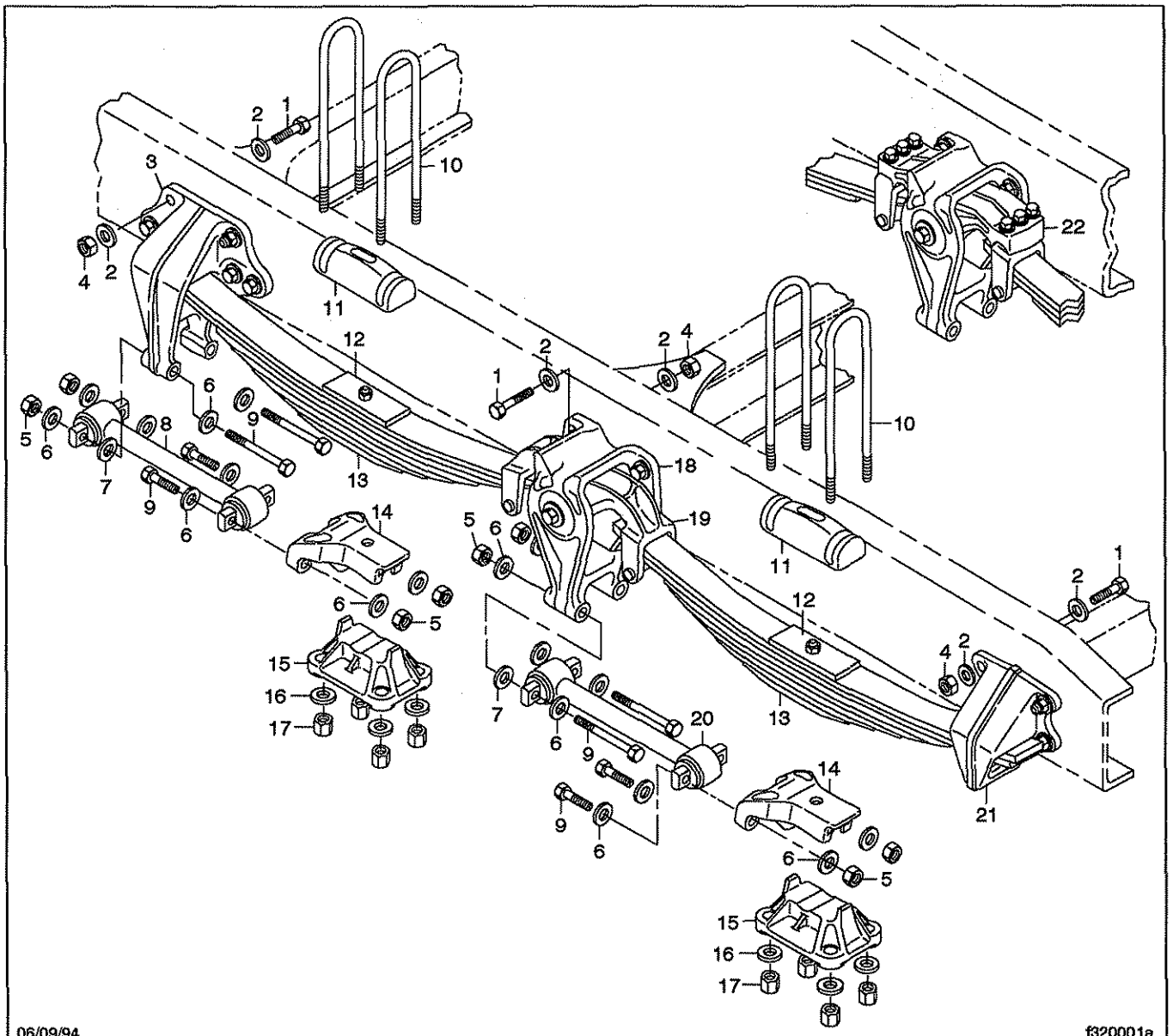
CAUTION: Failure to periodically torque the suspension fasteners can result in abnormal tire wear, and damage to the springs, spring brackets, and frame rail.

IMPORTANT: All suspension fasteners require periodic torquing. For suspension component inspecting and fastener torque checking intervals and instructions, refer to the suspension section in the vehicle maintenance manual.

8. When replacing the forward spring bracket or equalizer bracket, install any previously removed axle alignment washers between the forward radius rod front pin and the forward spring bracket, or between the rear radius rod front pin and the equalizer bracket, as applicable. **See Fig. 3.**

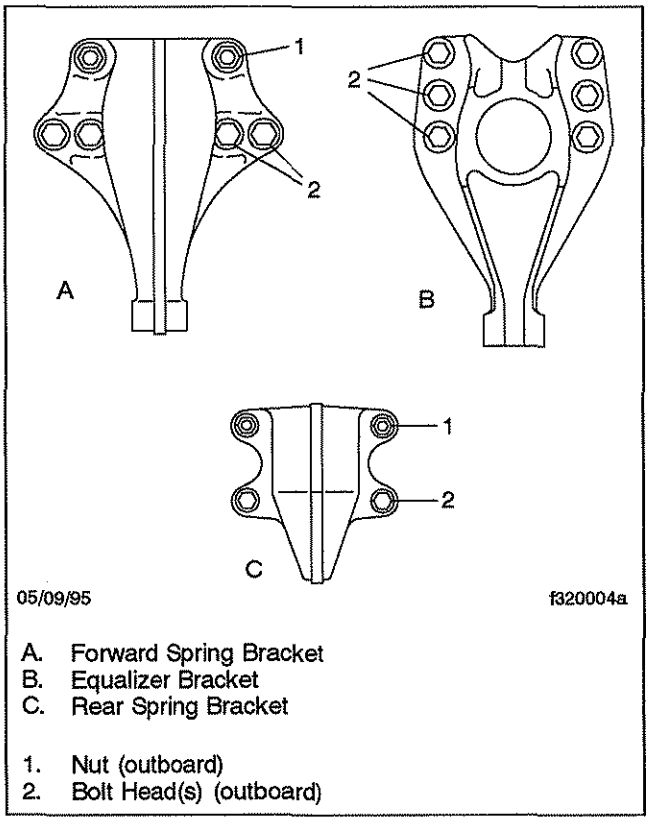
   Install bolts with hardened washers in the radius rod front pin, and the forward spring bracket or equalizer bracket. Install the hardened washers and locknuts, and tighten the locknuts to the torque value in **Specifications, 400.**
9. If replacing an equalizer bracket, install the equalizer. For instructions, refer to **Subject 110.**
10. Remove the safety stands from under the frame and axle, and lower the vehicle.
11. Check the rear axle alignment. For instructions, refer to the rear axle section in this manual. If necessary,adjust the axle alignment, using the instructions in **Subject 140.**

Spring Bracket and Equalizer Bracket Replacement



1. Suspension Bracket Hexbolt
2. Hardened Washer
3. Forward Spring Bracket
4. Suspension Bracket Hex Locknut
5. Radius Rod Hex Locknut
6. Hardened Washer
7. Axle Alignment Washer
8. Forward Radius Rod
9. Radius Rod Hexbolt
10. U-Bolt
11. U-Bolt Pad
12. Spring Liner
13. Leaf Spring Assembly
14. Spring Seat
15. U-Bolt Retainer
16. Hardened Washer
17. U-Bolt High Nut
18. Equalizer Bracket
19. Equalizer, One-Piece (tandem drive axles)
20. Rear Radius Rod
21. Rear spring Bracket
22. Equalizer, Three-Piece (tag or pusher axle)

Fig. 1, Tandem-Axle Spring Suspension

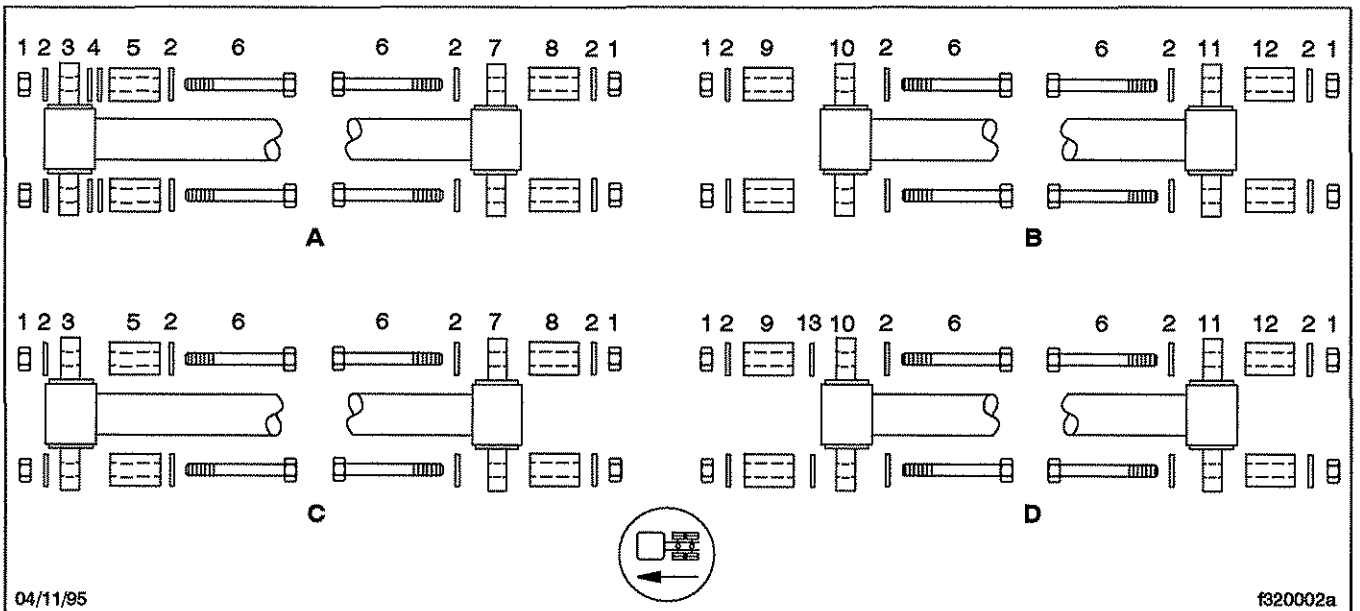


A. Forward Spring Bracket
B. Equalizer Bracket
C. Rear Spring Bracket

1. Nut (outboard)
2. Bolt Head(s) (outboard)

Fig. 2, Frame Brackets

Spring Bracket and Equalizer Bracket Replacement



A. Forward Right-Side Radius Rod
B. Rear Right-Side Radius Rod
C. Forward Left-Side Radius Rod
D. Rear Left-Side Radius Rod

1. Hex Locknut
2. Hardened Washer
3. Forward Radius-Rod Front Pin
4. Alignment Washers (Install only on one side of front axle; right-side installation shown.)
5. Forward Spring Bracket
6. Hexbolt
7. Forward Radius Rod Rear Pin
8. Forward Axle Seat
9. Equalizer Bracket
10. Rear Radius-Rod Front Pin
11. Rear Radius-Rod Rear Pin
12. Rear Axle Seat
13. Alignment Washers (Install only on one side of rear axle; left-side installation shown.)

Fig. 3, Radius Rod Attachment (top view)

Adjustment

1. Using a straightedge and a tape measure, determine the amount of adjustment needed to align the forward-rear axle at a right angle to the frame. For instructions, refer to the rear axle section in this manual. The difference in measurements between the sides of the vehicle is the approximate amount that the trailing end of the forward-rear axle will have to be brought forward, or the leading end will have to be moved back to align it at a right angle to the frame. **See Fig. 1.**

   If the forward-rear axle alignment is within specifications, go to the step that begins "Using a center-point bar, determine...".

2. Chock the front tires. On both sides of the forward-rear axle, loosen the axle U-bolts enough to allow the springs to shift on the axle seats.

3. On the side of the vehicle that is to be adjusted, remove the fasteners that attach the forward radius rod to the forward spring bracket. Remove any axle alignment washers.

NOTE: To adjust the forward-rear axle alignment, add alignment washers between the radius rod and the forward spring bracket on the leading end, to adjust the leading end backward. Or, remove alignment washers from the trailing end, to bring the trailing end forward. When possible, alignment washers should be removed instead of added.

4. Raise the frame just enough to relieve the weight from the springs. Place safety stands under the frame. Make sure the stands will securely support the weight of the frame.

5. Move the loosened end of the axle forward or backward as needed, by rolling the wheels.

6. Between one end of the radius rod front pin and the forward spring bracket, insert the correct thickness of axle alignment washers needed to bring the forward-rear axle into alignment. Install the hexhead bolt, hardened washers, and locknut in the radius rod pin and forward spring bracket.

7. Place an equal thickness of washers on the other end of the radius rod pin, and install the fasteners.

8. Tighten the radius rod locknuts to the torque value in **Specifications, 400.**

9. Remove the safety stands, and lower the vehicle.

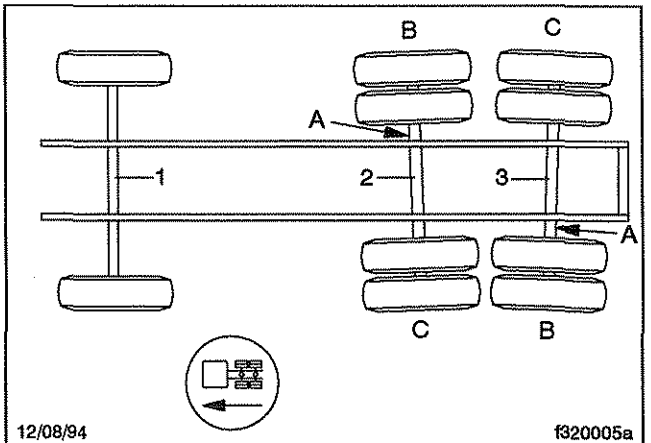
10. Check the forward-rear axle alignment with the straightedge and the tape measure. If alignment is within specifications, center the spring in the forward spring bracket, if needed, then tighten the axle U-bolt nuts to the torque value in **Specifications, 400.**

    If not in alignment, repeat all of the steps above.

CAUTION: Failure to periodically torque the suspension fasteners can result in abnormal tire wear, and damage to the springs, spring brackets, and frame rail.

IMPORTANT: All suspension fasteners require periodic torquing. For suspension component inspecting and fastener torque checking intervals and instructions, refer to the suspension section in the vehicle maintenance manual.

11. Using a center-point bar, determine the difference between the forward-rear and the rearmost axles' center-to-center measurements on each side of the vehicle. For instructions, refer to the rear axle section in this manual. This difference is the approximate distance that the leading end of the rearmost axle will have to be adjusted rearward,



A. Adjust here.
B. Leading End
C. Trailing End

1. Front Axle
2. Forward Rear Axle
3. Rearmost Axle

Fig. 1, Tandem Axle, Shown Out of Alignment

Rear Axle Alignment Adjustment

or that the trailing end will have to be adjusted forward, to align it at a right angle to the frame, and to align it parallel to the forward-rear axle. **See Fig. 1.**

12. On both sides of the rearmost axle, loosen the axle U-bolts enough to allow the springs to shift on the axle seats.
13. On the side of the vehicle that is to be adjusted, remove the fasteners that attach the rear radius rod to the equalizer bracket. Remove any axle alignment washers.
14. Raise the frame just enough to relieve the weight from the springs. Place safety stands under the frame. Make sure the stands will securely support the weight of the frame.
15. Move the loosened end of the axle forward or backward, by rolling the wheels. Move the axle just enough to provide space to allow installation of alignment washers between the equalizer bracket and the radius rod pin.
16. Between one end of the radius rod pin and the equalizer bracket, insert the additional thickness of alignment washers needed to make up for the difference in center-point bar measurements.

    For example, if one end of the axle was equipped with a 3/16-inch (4.5-mm) thickness of washers, and the difference in the center-point bar measurements is 1/4 inch (6 mm) less on that side, add an additional 1/4 inch (6 mm) of washers (for a total of 7/16 inch [10.5 mm]) to correct the alignment.

    Or, if one end of the axle was equipped with a 1/4-inch thickness of washers, and the difference in center-point bar measurements is 3/16 inch (4.5 mm) more on that side, install a 1/16-inch (1.6-mm) thickness of washers in place of the 1/4-inch (6-mm) thickness.
17. Install the bolt, hardened washers, and locknut in the equalizer bracket and the radius rod pin. Place an equal thickness of alignment washers on the other end of the radius rod pin, and install the fasteners at that end.
18. Tighten the radius rod locknuts to the torque value in **Specifications, 400.**
19. Remove the safety stands, and lower the vehicle. Remove the chocks from the front tires.
20. Using the center-point bar, check the rearmost axle alignment. If alignment is within specifications, center the spring in the rear spring bracket, if needed, then tighten the axle U-bolt nuts to the applicable torque value in **Specifications, 400.**

    If not in alignment, repeat the applicable steps above.

CAUTION: Failure to periodically torque the suspension fasteners can result in abnormal tire wear, and damage to the springs, spring brackets, and frame rail.

IMPORTANT: All suspension fasteners require periodic torquing. For suspension component inspecting and fastener torque checking intervals and instructions, refer to the suspension section in the vehicle maintenance manual.

Specifications

Torque Values			
Description	**Size**	**IFI Grade**	**Torque lbf·ft (N·m)**
Equalizer Bracket-to-Frame Rail Locknut*	3/4–10	C	240 (325)
Forward Spring Bracket-to-Frame Rail Locknut*	3/4–10	C	240 (325)
Rear Spring Bracket-to-Frame Rail Locknut*	5/8–11	C	135 (184)
Axle U-bolt High Nuts	7/8–14	C	Stage 1: Hand tighten Stage 2: 60 (81)† Stage 3: 200 (271)† Stage 4: 420 to 500 (571 to 680)†
	1–14	C	Stage 1: Hand tighten Stage 2: 60 (81)† Stage 3: 200 (271)† Stage 4: 520 to 600 (707 to 816)†
Radius Rod Locknut*	5/8–18	C	135 (184)
Equalizer Cap and Tube Assembly Locknut*	3/4–16	C	270 (365)
Equalizer Wear Shoe Capscrew	5/8–11	8	135 (184)
Side-Restraint Sleeve Locknut	1/2–13	C	68 (93)

* Cadmium-plated, wax-coated nuts, and grade 8 hexbolts with phosphate- and oil-coated threads; both used with hardened washers.
† Tighten in a diagonal pattern as shown in **Fig. 1**.

Table 1, Torque Values

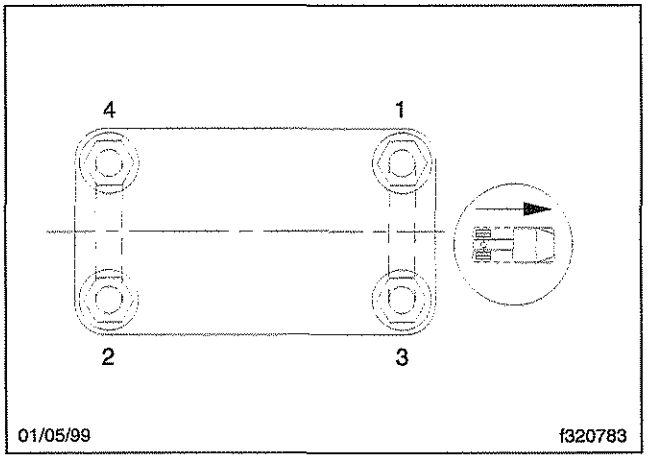


Fig. 1, Tightening Pattern for U-bolt High Nuts

Contents

Subject	Subject Number
General Information	050
Service Operations	
General Guidelines	100
Height Control Valve Adjustment	110
Height Control Valve Checking	120
Height Control Valve Replacement	130
Shock Absorber Replacement	140
Air Spring Replacement	150
Air Spring Bag Replacement	155
Leaf Spring Replacement	160
Rear Axle Alignment	170
Control Rod Replacement	180
Specifications	400

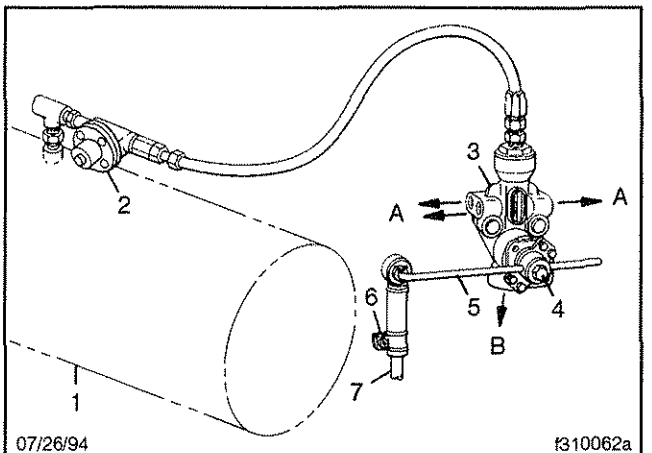
General Information

The Freightliner AirLiner Suspension is a single axle or tandem axle suspension that uses a combination of air and leaf springs. The suspension is manufactured at numerous weight ratings up to 46,000 pounds (20 865 kg). The top of the air spring is bolted to a bracket on the frame rail or through the bottom flange of the frame rail; the bottom is bolted to the rear end of the tapered leaf spring assembly or, for the 23,000-pound (10 433 kg) and 46,000-pound suspensions, to a cross bar. The axle housing is fastened to the leaf spring assembly by U-bolts. A control rod, mounted between the axle housing and the frame rail, can be used to help locate the assembly laterally.

The air springs compensate for changes in road conditions and vehicle load, maintaining vehicle height. The air springs also absorb road shock.

A height control valve regulates the air flow into or out of all the air springs. See **Fig. 1**. As the air spring compresses or expands, changes in the clearance between the vehicle frame and the differential housing activate the height control valve.

The pressure holding valve (**Fig. 1**, Ref. 2), located in the air line to the height control valve, is preset to maintain a minimum pressure of 65 psi (448 kPa) in the vehicle secondary air system if a leak should occur in the air suspension system.



A. To Air Springs
B. To Atmosphere
1. Secondary Air Reservoir
2. Pressure Holding Valve
3. Height Control Valve
4. Adjusting Locknut
5. Overtravel Lever
6. Linkage Adjustment Clamp
7. Height Control Valve Linkage

Fig. 1, Height Control Valve Assembly

General Guidelines

To keep the air suspension system operating reliably, the air system must be kept free of any oil, moisture, or foreign material. Inspect and maintain the air system components regularly. Refer to the vehicle maintenance manual for maintenance operations.

CAUTION: Failure to take precautions against the entry of moisture, oil, or other foreign material into the air suspension system could eventually lead to sludge forming in the air system. Sludge could adversely affect the operation of the air suspension system and other air system components.

Use only SAE grade 8 hexbolts and grade G prevailing torque locknuts to attach spring hangers and brackets to the frame.

For suspension component inspecting, lubricating, and fastener torque checking intervals and instructions, refer to the maintenance schedule and the suspension section in the vehicle maintenance manual.

Height Control Valve Adjustment

General Information

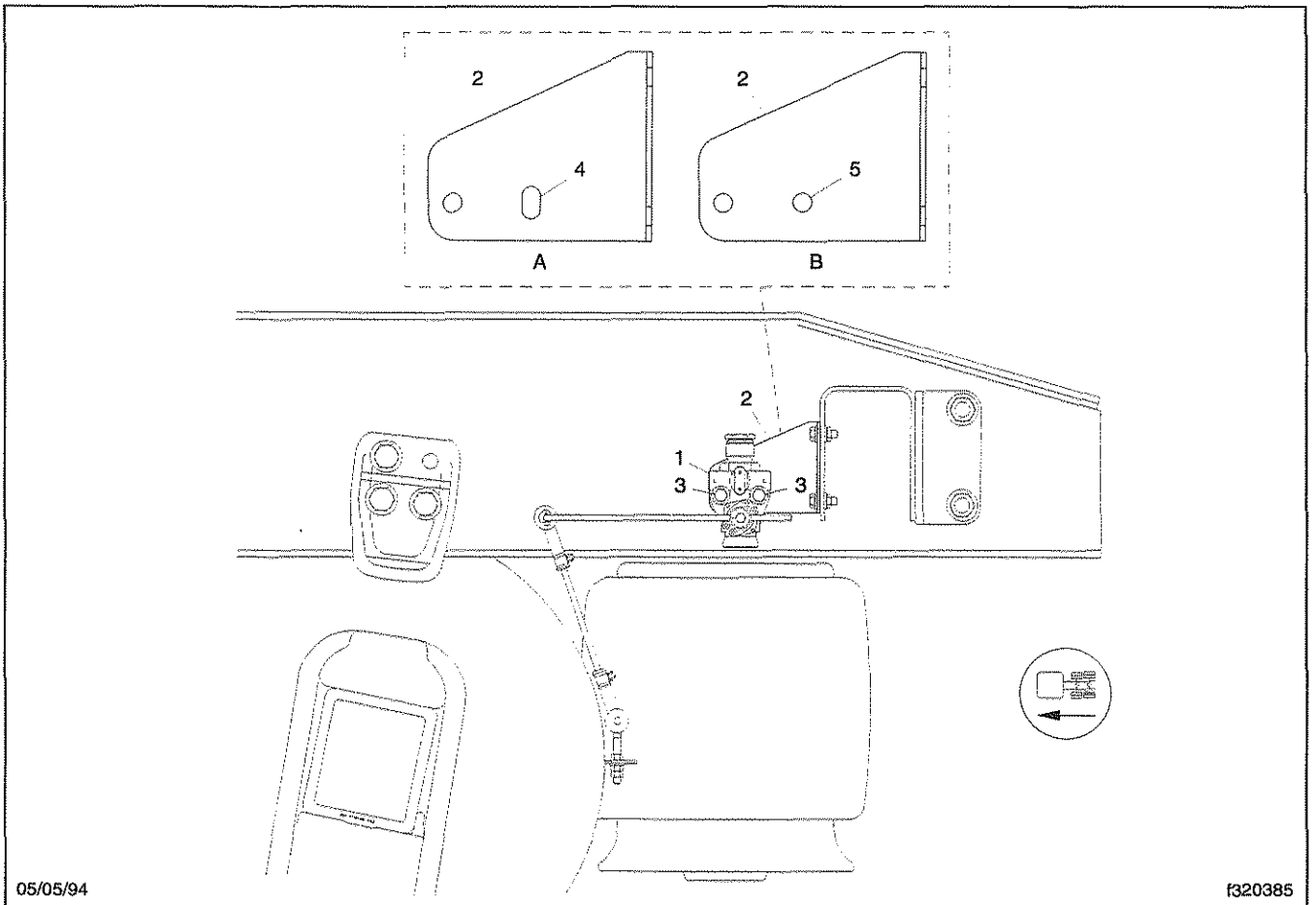
Adjust the height control valve with the vehicle on a level surface.

NOTE: A new type of height control valve (manufactured by Barksdale Inc.) replaced the Meritor WABCO valve. On vehicles with tandem-axle AirLiner rear suspensions, the Barksdale valve linkage rod is attached to the forward drive axle instead of the rearmost drive axle, and the valve is mounted on the frame rail. The Barksdale valves are installed on Century Class vehicles built after July 25, 1997.

⚠ CAUTION

Failure to adjust the height control valve could adversely affect driveline angles. Also, if the air springs are set too high, the driver may have difficulty (or be prevented from) backing the vehicle under a trailer. If the air springs are set too low, rapid wear of suspension parts will result.

There are two types of height control valve installations: adjustable and fixed. See **Fig. 1**.



A. Adjustable Installation
B. Fixed Installation
1. Height Control Valve
2. Mounting Bracket
3. Height Control Valve Mounting Fasteners
4. Slotted Hole
5. Round Hole

Fig. 1, Meritor WABCO Height Control Valve Installation

Height Control Valve Adjustment

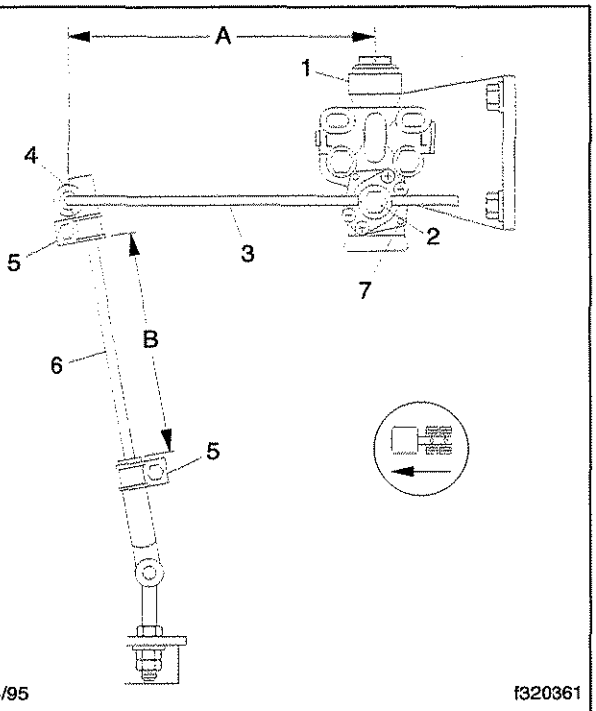
On adjustable installations, the suspension height is changed by tilting the height control valve up or down. On fixed installations, the height is changed by adjusting the length of the vertical linkage. Use the applicable procedure below to adjust the suspension height.

Height Control Valve Adjustment, Vehicles Equipped with Meritor WABCO Adjustable Valves

IMPORTANT: Before checking the AirLiner suspension height, make sure there is no load on the chassis. For tractors, unhitch the trailer. Trucks are to be empty.

1. Park the vehicle on a level surface, using a light application of the brakes. Do not apply the parking brakes. Put the transmission in neutral. Build the secondary air pressure to at least 100 psi (690 kPa). Shut down the engine.
2. Mark the location of the front and rear tires on the floor; then chock the tires on one axle only.
3. Check the length of the overtravel lever between its pivot points. See **Fig. 2**, Ref. A. The length should be 8 inches (203 mm). If needed, adjust the length of the overtravel lever.
   - 3.1 Loosen the adjustment locknut (Ref. 2) on the control shaft.
   - 3.2 Move the overtravel lever fore or aft until the length between the pivot points is 8 inches (203 mm).
   - 3.3 Tighten the adjustment locknut 62 lbf·in (700 N·cm).
4. Measure the distance from the bottom of the left forwardmost axle stop to the top of the axle U-bolt pad. See **Fig. 3**, Ref. A.

   The correct distances are listed in **Table 1**.



A. Measure the length of the overtravel lever between these two points.
B. Measure the length of the linkage rod between these two points.

1. Height Control Valve
2. Adjustment Locknut
3. Overtravel Lever
4. Cotter Pin
5. Adjustment Clamp
6. Linkage Rod
7. Valve Centering Hole

Fig. 2, Meritor WABCO Height Control Valve Overtravel Lever and Linkage Rod Measurement

Suspension Height Adjustment Distances			
Suspension Type	Distance in Inches (mm)		
	Minimum	Target	Maximum
20/40K AirLiner	2-3/8 (60)	2-5/8 (67)	2-7/8 (73)
23/46K AirLiner	2-3/4 (70)	3 (76)	3-1/4 (83)
Low/Mid-Ride Height AirLiner	2-1/4 (57)	2-1/2 (64)	2-3/4 (70)

Table 1, Suspension Height Adjustment Distances

Height Control Valve Adjustment

On adjustable installations, the suspension height is changed by tilting the height control valve up or down. On fixed installations, the height is changed by adjusting the length of the vertical linkage. Use the applicable procedure below to adjust the suspension height.

Height Control Valve Adjustment, Vehicles Equipped with Meritor WABCO Adjustable Valves

IMPORTANT: Before checking the AirLiner suspension height, make sure there is no load on the chassis. For tractors, unhitch the trailer. Trucks are to be empty.

1. Park the vehicle on a level surface, using a light application of the brakes. Do not apply the parking brakes. Put the transmission in neutral. Build the secondary air pressure to at least 100 psi (690 kPa). Shut down the engine.
2. Mark the location of the front and rear tires on the floor; then chock the tires on one axle only.

   Check the length of the overtravel lever between its pivot points. See **Fig. 2**, Ref. A. The length should be 8 inches (203 mm). If needed, adjust the length of the overtravel lever.

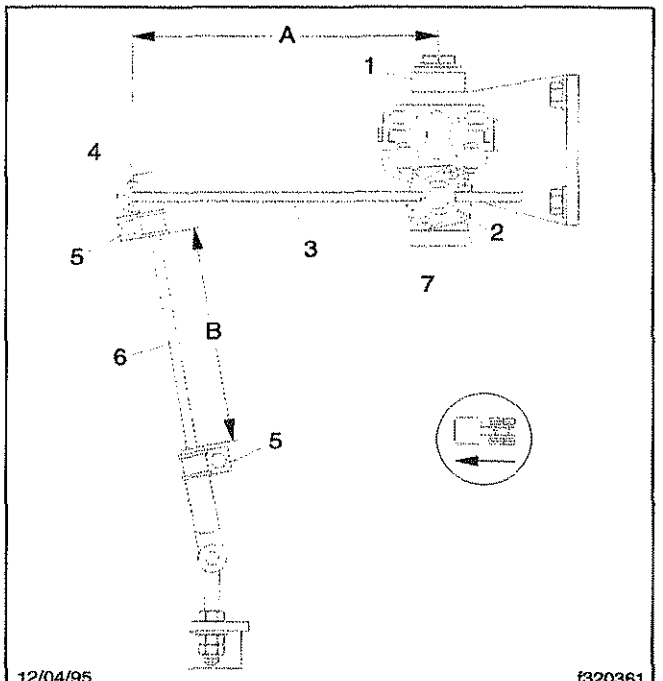
   3.1 Loosen the adjustment locknut (Ref. 2) on the control shaft.

   3.2 Move the overtravel lever fore or aft until the length between the pivot points is 8 inches (203 mm).

   3.3 Tighten the adjustment locknut 62 lbf·in (700 N·cm).

4. Measure the distance from the bottom of the left forwardmost axle stop to the top of the axle U-bolt pad. See **Fig. 3**, Ref. A.

   The correct distances are listed in **Table 1**.



A. Measure the length of the overtravel lever between these two points.
B. Measure the length of the linkage rod between these two points.

1. Height Control Valve
2. Adjustment Locknut
3. Overtravel Lever
4. Cotter Pin
5. Adjustment Clamp
6. Linkage Rod
7. Valve Centering Hole

Fig. 2, Meritor WABCO Height Control Valve Overtravel Lever and Linkage Rod Measurement

Suspension Height Adjustment Distances			
Suspension Type	Distance in Inches (mm)		
	Minimum	Target	Maximum
20/40K AirLiner	2-3/8 (60)	2-5/8 (67)	2-7/8 (73)
23/46K AirLiner	2-3/4 (70)	3 (76)	3-1/4 (83)
Low/Mid-Ride Height AirLiner	2-1/4 (57)	2-1/2 (64)	2-3/4 (70)

Table 1, Suspension Height Adjustment Distances

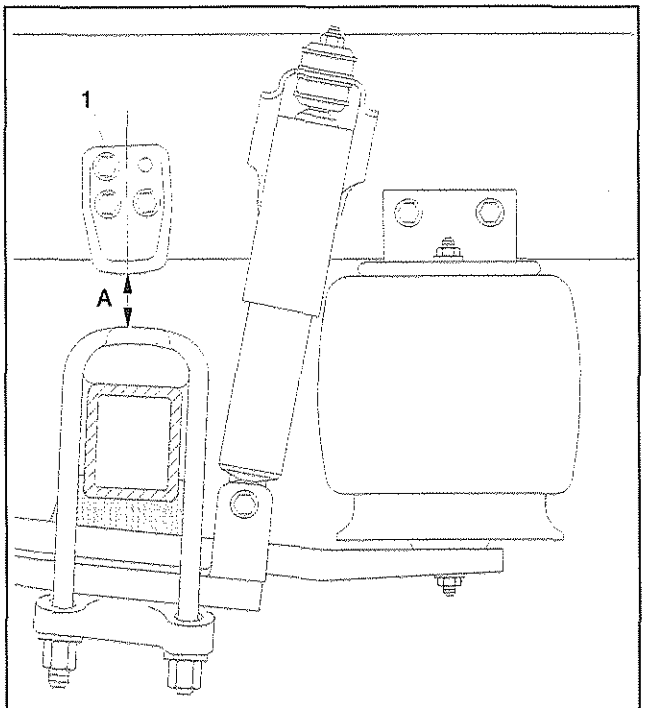
NOTE: AirLiner suspensions feature three types of axle seats:

- a one-piece, cast axle seat, which is not welded to the axle housing;
- a one-piece, cast axle seat, which is welded to the axle housing;
- a two-piece, fabricated axle seat, which is welded to the axle housing.

Refer to **Fig. 4** to determine axle seat type.

5. If the distance is correct, nothing more needs to be done. Apply the parking brakes; then remove the chocks from the tires.

   If the distance isn't correct, go to the next step.



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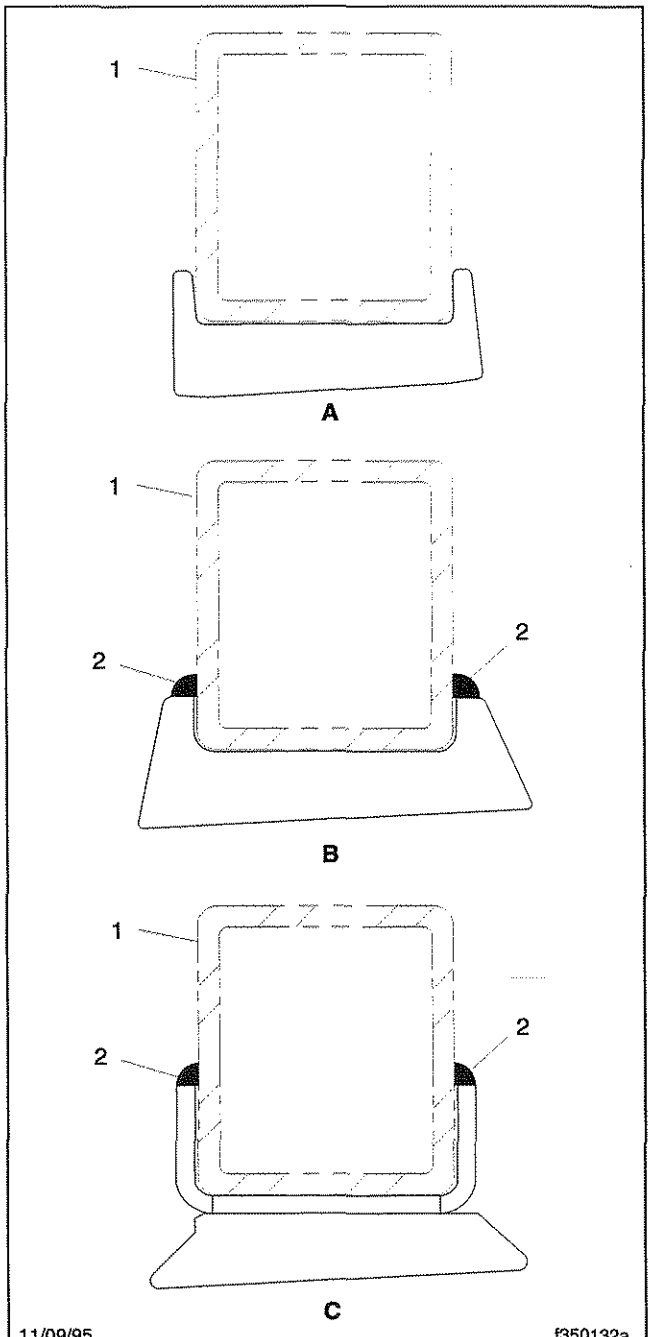
A. Measure height here.
1. Left Forwardmost Axle Stop

Fig. 3, Axle Stop Measurement



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A. One-Piece Cast Axle Seat
B. One-Piece Cast Axle Seat
C. Two-Piece Fabricated Axle Seat
1. Axle Housing 2. Welds

Fig. 4, Axle Seats

Height Control Valve Adjustment

NOTE: If height adjustment is needed, use the target value for standard vehicles with one-piece axle seats, and subtract 1/4-inch (6 mm) from the target value for other vehicles.

6. Loosen the two fasteners attaching the height control valve to the mounting bracket.
7. Rotate the height control valve clockwise (as you are facing it from the driver's side of the vehicle). Let the air exhaust from the valve until the distance from the bottom of the left forwardmost axle stop to the top of the axle U-bolt pad is 2 inches (51 mm) or less.
8. Rotate the height control valve counterclockwise, and raise the suspension height to the target value. Stop the air flow to the air bag by rotating the height control valve clockwise.
9. Center the height control valve.
   - 9.1 Rotate the valve very slightly clockwise and counterclockwise until you can insert a 4-mm pin into the valve centering hole. Don't rotate the valve too much, or you will change the suspension height.
   - 9.2 Tighten the height control valve mounting fasteners firmly.
10. Drive the vehicle unloaded for about 1/4 mile (1/2 km); then stop the vehicle in the exact location (as previously marked) of the original measurement.

    Park the vehicle using a light brake application. Chock the tires on one axle only, and put the transmission in neutral. Do not apply the parking brakes.
11. Check the adjusted distance between the bottom of the left forwardmost axle stop and the top of the axle U-bolt pad. See **Fig. 3**, Ref. A.
12. If the distance isn't right, repeat the adjustment procedure.
13. Apply the parking brakes; then remove the chocks from the tires.

Height Control Adjustment, Vehicles Equipped with Barksdale Valve

1. Park the vehicle on a level surface, using a light application of the brakes. Do not apply the parking brakes. Put the transmission in neutral. Build the secondary air pressure to at least 100 psi (690 kPa). Shut down the engine.
2. Mark the location of the front and rear tires on the floor; then chock the tires on one axle only.

NOTE: The stud bolt fastening the lever arm to the linkage rod is installed correctly on AirLiner suspensions with Eaton 404 or Meritor RT40–145 axles when the threaded end of the stud bolt points toward the front of the vehicle. On AirLiner suspensions with Eaton 461 or Meritor RT46–160 axles, the threaded end of the stud bolt points to the rear of the vehicle. See **Fig. 5**.

3. Measure the distance between the top of the U-bolt and the bottom of the axle stop. See **Fig. 6**, **Fig. 7** and **Fig. 8**.

   If the measurement is acceptable, no more work is necessary.

   If the measurement is not acceptable, go to the next step.

IMPORTANT: Before checking the suspension height, make sure there is no load on the chassis. For tractors, unhitch the trailer. Trucks must be empty.

4. Adjust the suspension height. See **Table 1** for the correct distances.
   - 4.1 Loosen the two fasteners attaching the valve to the valve mounting bracket.
   - 4.2 Adjust the position of the valve body until the distance from the bottom of the left forwardmost axle stop to the top of the axle U-bolt pad is correct.
   - 4.3 Center the lever arm on the valve by inserting a 0.171-inch (4.4-mm) pin into the hole in the lever arm and aligning the hole with the valve body.
   - 4.4 Tighten the two fasteners attaching the valve to the mounting bracket.
   - 4.5 Remove the pin from the hole in the lever arm.

Height Control Valve Adjustment

NOTE: If height adjustment is needed, use the target value for standard vehicles with one-piece axle seats, and subtract 1/4-inch (6 mm) from the target value for other vehicles.

6. Loosen the two fasteners attaching the height control valve to the mounting bracket.
7. Rotate the height control valve clockwise (as you are facing it from the driver's side of the vehicle). Let the air exhaust from the valve until the distance from the bottom of the left forwardmost axle stop to the top of the axle U-bolt pad is 2 inches (51 mm) or less.
8. Rotate the height control valve counterclockwise, and raise the suspension height to the target value. Stop the air flow to the air bag by rotating the height control valve clockwise.
9. Center the height control valve.
   - 9.1 Rotate the valve very slightly clockwise and counterclockwise until you can insert a 4-mm pin into the valve centering hole. Don't rotate the valve too much, or you will change the suspension height.
   - 9.2 Tighten the height control valve mounting fasteners firmly.
10. Drive the vehicle unloaded for about 1/4 mile (1/2 km); then stop the vehicle in the exact location (as previously marked) of the original measurement.

    Park the vehicle using a light brake application. Chock the tires on one axle only, and put the transmission in neutral. Do not apply the parking brakes.
11. Check the adjusted distance between the bottom of the left forwardmost axle stop and the top of the axle U-bolt pad. See **Fig. 3**, Ref. A.
12. If the distance isn't right, repeat the adjustment procedure.
13. Apply the parking brakes; then remove the chocks from the tires.

Height Control Adjustment, Vehicles Equipped with Barksdale Valve

1. Park the vehicle on a level surface, using a light application of the brakes. Do not apply the parking brakes. Put the transmission in neutral. Build the secondary air pressure to at least 100 psi (690 kPa). Shut down the engine.
2. Mark the location of the front and rear tires on the floor; then chock the tires on one axle only.

NOTE: The stud bolt fastening the lever arm to the linkage rod is installed correctly on AirLiner suspensions with Eaton 404 or Meritor RT40–145 axles when the threaded end of the stud bolt points toward the front of the vehicle. On AirLiner suspensions with Eaton 461 or Meritor RT46–160 axles, the threaded end of the stud bolt points to the rear of the vehicle. See **Fig. 5**.

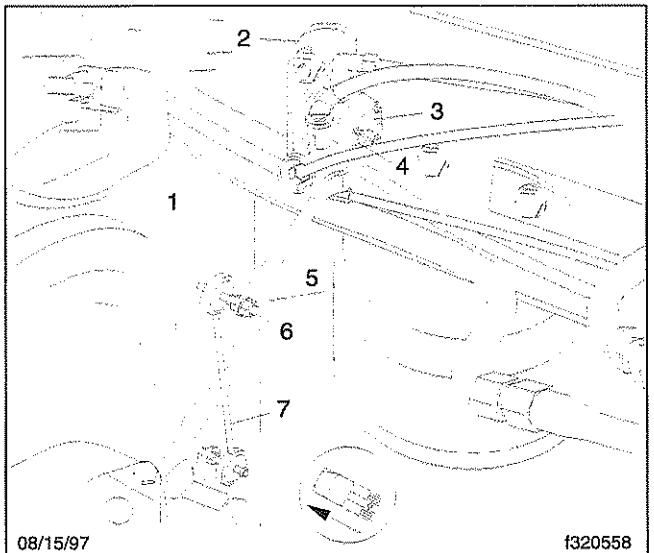
3. Measure the distance between the top of the U-bolt and the bottom of the axle stop. See **Fig. 6**, **Fig. 7** and **Fig. 8**.

   If the measurement is acceptable, no more work is necessary.

   If the measurement is not acceptable, go to the next step.

IMPORTANT: Before checking the suspension height, make sure there is no load on the chassis. For tractors, unhitch the trailer. Trucks must be empty.

4. Adjust the suspension height. See **Table 1** for the correct distances.
   - 4.1 Loosen the two fasteners attaching the valve to the valve mounting bracket.
   - 4.2 Adjust the position of the valve body until the distance from the bottom of the left forwardmost axle stop to the top of the axle U-bolt pad is correct.
   - 4.3 Center the lever arm on the valve by inserting a 0.171-inch (4.4-mm) pin into the hole in the lever arm and aligning the hole with the valve body.
   - 4.4 Tighten the two fasteners attaching the valve to the mounting bracket.
   - 4.5 Remove the pin from the hole in the lever arm.



1. Forward Drive Axle
2. Valve Mounting Bracket
3. Height Control Valve
4. Pilot Hole
5. Lever Rod
6. Stud Bolt
7. Linkage Rod

Fig. 5, Barksdale Height Control Valve Installation (Eaton 461/Meritor RT46-160 axle shown)

5. Drive the vehicle unloaded for about 1/4 mile (1/2 km); then, stop the vehicle in the exact location (as previously marked) of the original measurement.

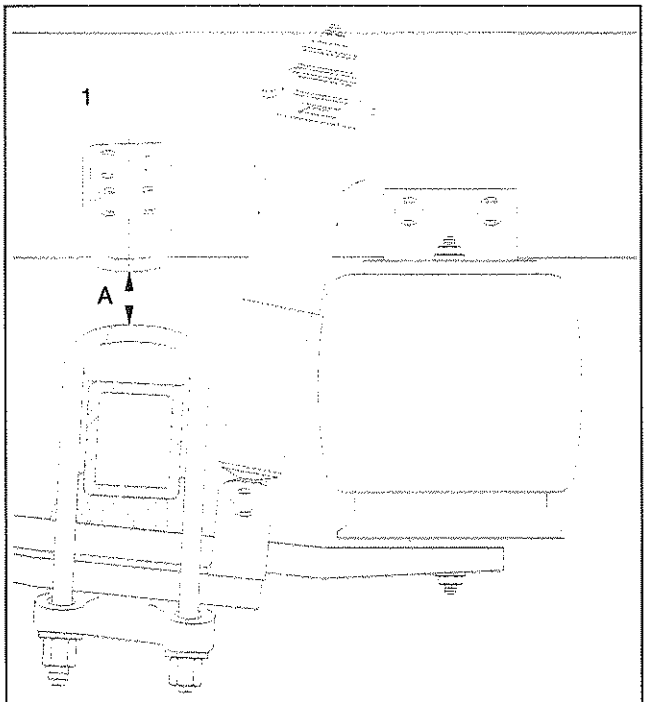
   Park the vehicle using a light brake application. Chock the tires on one axle only, and put the transmission in neutral. Do not apply the parking brakes.

6. Check the distance between the bottom of the left forwardmost axle stop and the top of the U-bolt.

7. If the distance is not correct, repeat the adjustment procedure.

Height Control Valve Adjustment, Vehicles Equipped with Meritor WABCO Fixed Valves

the AirLiner suspension height, make sure there is no load on the chassis. For tractors, unhitch the trailer. Trucks are to be empty. In order to adjust the suspension height, you must change the length of the linkage rod using the following procedure. The



A. Measure here.
1. Left Forwardmost Axle Stop

Fig. 6, Barksdale Height Control Valve Adjustment Measurement (20k/Dual-leaf 40k AirLiner and 23/46k shown)

previous method of centering the control valve and then adjusting the linkage no longer applies.

1. Park the vehicle on a level surface, using a light application of the brakes. Do not apply the parking brakes. Put the transmission in neutral. Build the secondary air pressure to at least 100 psi (690 kPa). Shut down the engine.

2. Mark the location of the front and rear tires on the floor; then chock the tires on one axle only.

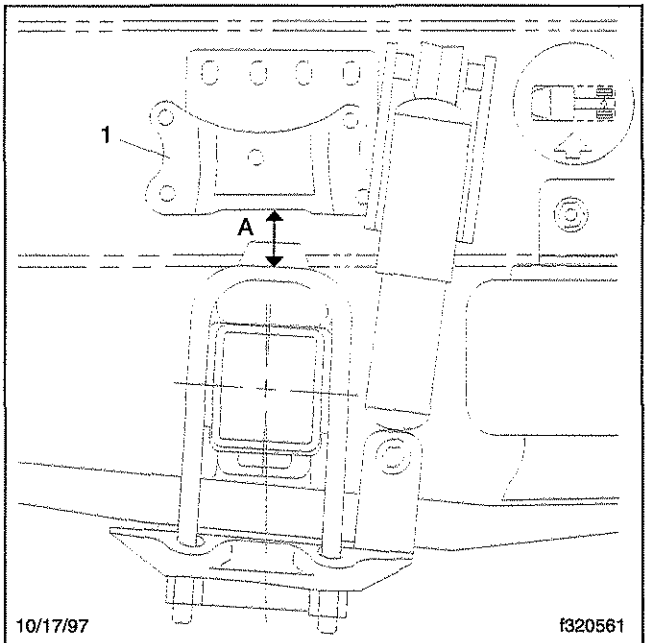
3. Check the length of the suspension overtravel lever (see **Fig. 2**, Ref. A) to be consistant with adjusting the adjustable height control valve between its pivot points.

   If the length is acceptable, go to the step for measuring the suspension height.

   If the length is not acceptable, go to the next step.

4. Adjust the length of the overtravel lever.

Height Control Valve Adjustment



A. Measure here.
1. Left Forwardmost Axle Stop

Fig. 7, Barksdale Height Control Valve Adjustment Measurement (Low/Mid-Ride Height AirLiner shown)

4.1 Loosen the adjustment locknut (Ref. 2) on the control shaft.

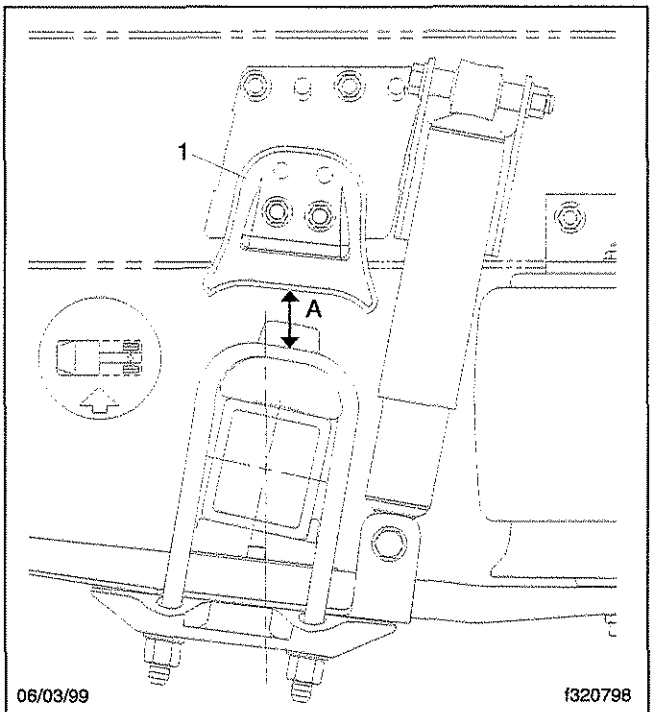
4.2 Move the overtravel lever fore or aft until it is the correct length. See **Table 2** for the correct length.

4.3 Tighten the adjustment locknut 62 lbf·in (700 N·cm).

5. Measure the distance from the bottom of the left forwardmost axle stop to the top of the axle U-bolt pad. See **Fig. 3**, Ref. A. The correct distance is listed in **Table 1**.

   If the distance is correct, nothing more needs to be done. Apply the parking brakes, then remove the chocks from the tires.

   If the distance isn't correct, go to the next step.



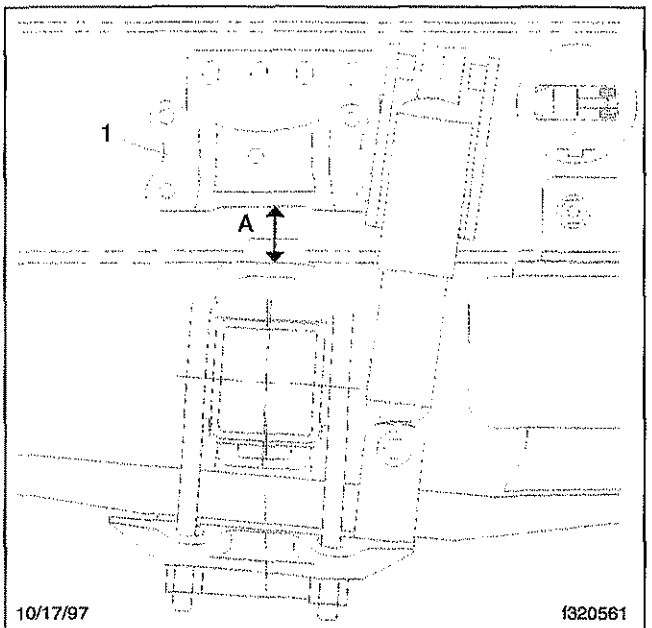
A. Measure here.
1. Left Forwardmost Axle Stop

Fig. 8, Barksdale Height Control Valve Adjustment Measurement (40k Single-leaf AirLiner)

Overtravel Lever Lengths	
Axle Designation	**Overtravel Lever Length In Inches (mm)**
Meritor RS23–161	8 (203)
Meritor 23–180	7-3/8 (187)
Eaton 23105 SC	7-1/4 (184)
Meritor SQ100	9-1/4 (235)
Meritor SSHD	9 (229)
Meritor RT40–145	9-3/4 (248)
Meritor RT44–145	9-3/4 (248)
Meritor RT46–160	8-1/8 (206)
Eaton 402	8-3/8 (213)
Eaton 404	8-3/8 (213)
Eaton 461	8-3/8 (213)

Table 2, Overtravel Lever Lengths

Height Control Valve Adjustment



A. Measure here.
1. Left Forwardmost Axle Stop

Fig. 7, Barksdale Height Control Valve Adjustment Measurement (Low/Mid-Ride Height AirLiner shown)

4.1 Loosen the adjustment locknut (Ref. 2) on the control shaft.

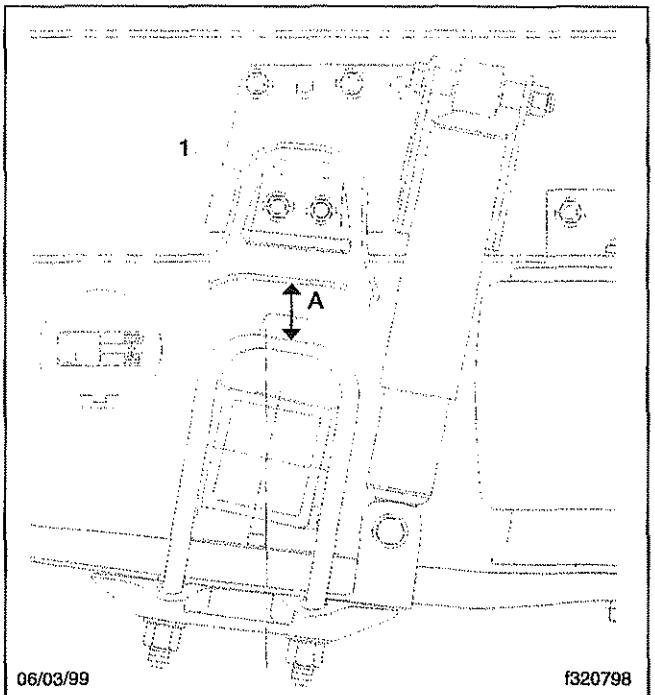
4.2 Move the overtravel lever fore or aft until it is the correct length. See **Table 2** for the correct length.

4.3 Tighten the adjustment locknut 62 lbf·in (700 N·cm).

5. Measure the distance from the bottom of the left forwardmost axle stop to the top of the axle U-bolt pad. See **Fig. 3**, Ref. A. The correct distance is listed in **Table 1**.

   If the distance is correct, nothing more needs to be done. Apply the parking brakes, then remove the chocks from the tires.

   If the distance isn't correct, go to the next step.



A. Measure here.
1. Left Forwardmost Axle Stop

Fig. 8, Barksdale Height Control Valve Adjustment Measurement (40k Single-leaf AirLiner)

Overtravel Lever Lengths	
Axle Designation	**Overtravel Lever Length In Inches (mm)**
Meritor RS23–161	8 (203)
Meritor 23–180	7-3/8 (187)
Eaton 23105 SC	7-1/4 (184)
Meritor SQ100	9-1/4 (235)
Meritor SSHD	9 (229)
Meritor RT40–145	9-3/4 (248)
Meritor RT44–145	9-3/4 (248)
Meritor RT46–160	8-1/8 (206)
Eaton 402	8-3/8 (213)
Eaton 404	8-3/8 (213)
Eaton 461	8-3/8 (213)

Table 2, Overtravel Lever Lengths

NOTE: If height adjustment is needed, use the target value for standard vehicles with one-piece axle seats and subtract 1/4-inch (6 mm) from the target value for all other vehicles.

6. Determine how much the suspension height needs to be adjusted so the distance is correct. Then, using **Table 3**, find the amount the length of the linkage rod (see **Fig. 2**, Ref. 6) needs to be changed.

Vertical Linkage Lengths	
Suspension Height Change In Inches (mm)	**Vertical Linkage Length Change In Inches (mm)**
1/16 (2)	1/16 (2)
1/8 (3)	3/16 (5)
3/16 (5)	1/4 (6)
1/4 (6)	5/16 (8)
5/16 (8)	3/8 (10)
3/8 (10)	1/2 (13)
7/16 (11)	9/16 (14)
1/2 (13)	5/8 (16)
9/16 (14)	3/4 (19)
5/8 (16)	13/16 (21)
11/16 (17)	7/8 (22)
3/4 (19)	1 (25)
13/16 (21)	1-1/16 (27)
7/8 (22)	1-3/16 (30)
15/16 (24)	1-1/4 (32)
1 (25)	1-5/16 (33)

Table 3, Vertical Linkage Lengths

7. Adjust the length of the linkage rod as needed, adding or subtracting the amount shown in **Table 3**.

   NOTE: If the linkage rod is too short, replace it with a new rod, part number 16–13485–000. The linkage rod should be long enough so that at least 1/2 inch (13 mm) of it fits into both flexible end-sections of the linkage.

   7.1 Mark the existing length of the linkage rod between the upper and lower flexible end-sections of the linkage (see **Fig. 2**, Ref. B).

   7.2 Loosen both linkage adjustment clamps (Ref. 5).

   7.3 Slide the flexible end-sections of the linkage over the linkage rod until the rod is the correct length.

   To increase the suspension height, lengthen the linkage rod; to decrease the suspension height, shorten the rod.

   7.4 Tighten the adjustment clamps.

8. Drive the vehicle unloaded for about 1/4 mile (1/2 km); then stop the vehicle in the exact location (as previously marked) of the original measurement.

   Park the vehicle using a light brake application. Chock the tires on one axle only, and put the transmission in neutral. Don't apply the parking brakes.

9. Again, check the distance between the bottom of the left forwardmost axle stop and the top of the axle U-bolt pad.

10. If the distance isn't right, repeat the adjustment procedure.

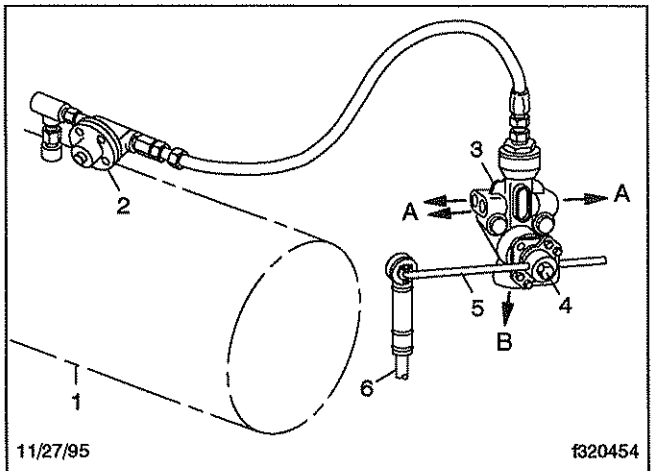
11. Apply the parking brakes; then remove the chocks from the tires.

Height Control Valve Checking

The height control valve responds to changes in height, and is the control center of any air suspension system. When correctly adjusted, it maintains the correct suspension ride height.

Carefully check the valve before replacing it. Do the following steps to see if a valve is working correctly.

1. Disconnect the height control valve linkage from the overtravel lever. **See Fig. 1.**
2. Pull the overtravel lever up about 45 degrees. **See Fig. 2**, Ref. A. If air passes through the valve, that section of the valve is working.
3. Return the valve to the neutral position. **See Fig. 2**, Ref. B. Air should stop flowing. If so, that section of the valve is working.
4. Push the overtravel lever down about 45 degrees. **See Fig. 2**, Ref. C. If air exhausts from the valve, that section of the valve is working.



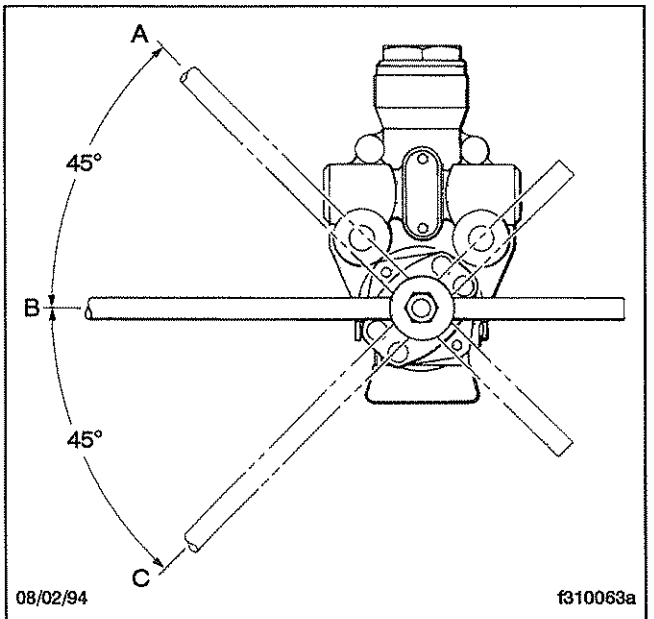
A. to air springs
B. to atmosphere
C. Disconnect the linkage here.

1. Secondary Air Reservoir
2. Pressure Protection Valve
3. Height Control Valve
4. Adjusting Locknut
5. Overtravel Lever
6. Height Control Valve Linkage

Fig. 1, Height Control Valve

5. Return the valve to the neutral position. If the air stops again in the neutral position, the valve is working correctly.
6. If the valve works as stated in all of the above steps, then no further checking is necessary. Connect the height control valve linkage to the overtravel lever. Secure the linkage with a cotter pin.

   If the valve needs adjusting, refer to **Subject 110.** If the valve needs replacing, refer to **Subject 130.**



A. Up Position
B. Neutral Position
C. Down Position

Fig. 2, Overtravel Lever Positions

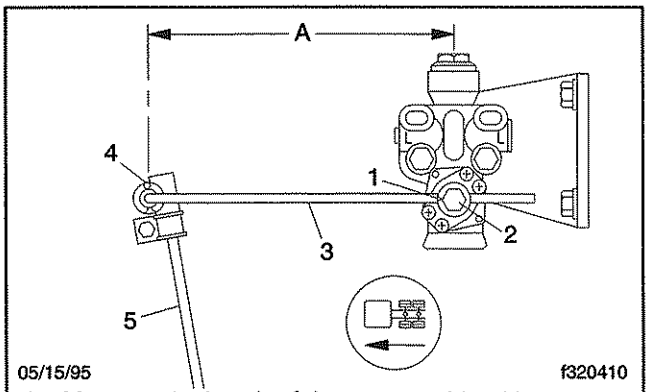
Height Control Valve Replacement

Replacement

NOTE: A new type of height control valve (manufactured by Barksdale Inc.) replaced the Meritor WABCO valve. On vehicles with tandem-axle AirLiner rear suspensions, the Barksdale valve linkage rod is attached to the forward drive axle instead of the rearmost drive axle, and the valve is mounted on the frame rail. The Barksdale valves are installed on Century Class vehicles built after July 25, 1997.

Meritor WABCO

1. Park the vehicle on a level surface. Shut down the engine and apply the parking brake. Chock the front tires.
2. Drain the air reservoirs.
3. Disconnect the linkage from the overtravel lever. See **Fig. 1**. Exhaust all air from the air springs by moving the overtravel lever down.
4. Disconnect the air lines at the height control valve, and mark the lines for later reference. Using tape, cover the open ends of the air lines and fittings to prevent dirt or foreign material from entering.
5. Remove the height control valve mounting bolts and nuts, and remove the height control valve from the bracket.



A. Measure the length of the overtravel level between these two points.
1. V-Shaped Mark
2. Adjustment Locknut
3. Overtravel Lever
4. Cotter Pin
5. Linkage Rod

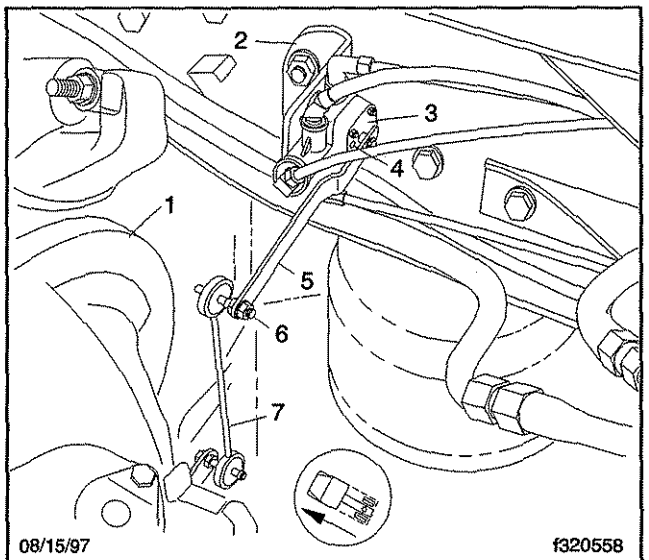
Fig. 1, Meritor Height Control Valve Linkage Measurement

6. Remove the overtravel lever from the height control valve.
7. Attach the new height control valve to the bracket. Tighten the valve mounting bolt nuts 14 lbf·ft (19 N·m).
8. Remove the tape from the air lines and fittings, and connect the air lines to the height control valve as marked earlier. Tighten nylon tube air fittings until only two threads show on the fitting. On wire-braid hose fittings, tighten the nut with a wrench until there is firm resistance, then tighten one-sixth turn more.
9. Connect the height control valve linkage to the overtravel lever. Secure the linkage with a cotter pin.
10. Connect the overtravel lever to the height control valve. Insert the overtravel lever into the valve at the hole with the V-shaped mark. See **Fig. 1**. Be sure the length between pivot points is 8 inches (20.3 cm). See **Fig. 1**, Ref. A.
11. Close the drain cocks on all reservoirs.
12. Build up normal operating pressure in the air system. Check all air lines and connections for leaks. Eliminate all leaks.
13. Remove the chocks from the tires.
14. Adjust the height control valve. For instructions, see **Subject 110**.

Barksdale Inc.

1. Park the vehicle on a level surface. Shut down the engine and apply the parking brake. Chock the front tires.
2. Drain the air reservoirs.
3. Disconnect the linkage from the overtravel lever. See **Fig. 2**. Exhaust all air from the air springs by moving the overtravel lever down.
4. Disconnect the air lines at the height control valve, and mark the lines for later reference. Using tape, cover the open ends of the air lines and fittings to prevent dirt or foreign material from entering.
5. Remove the height control valve mounting bolts and nuts, and remove the height control valve from the bracket.

Height Control Valve Replacement



1. Forward Drive Axle
2. Valve Mounting Bracket
3. Height Control Valve
4. Pilot Hole
5. Overtravel Lever
6. Stud Bolt
7. Linkage Rod

Fig. 2, Barksdale Height Control Valve Installation

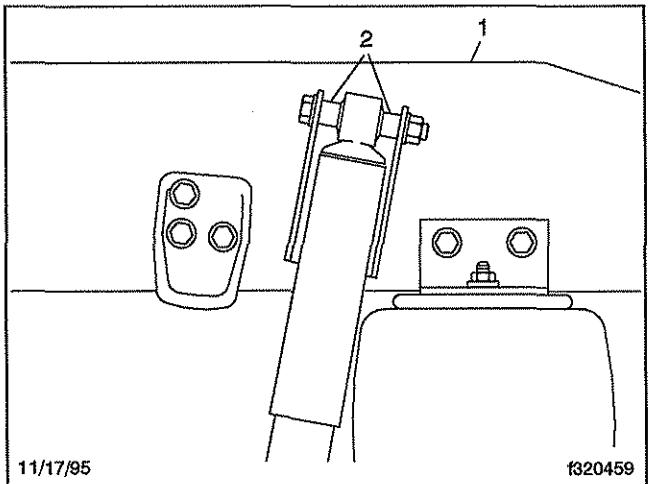
6. Attach the new height control valve to the bracket. Tighten the valve mounting bolt nuts 14 lbf·ft (19 N·m).
7. Remove the tape from the air lines and fittings, and connect the air lines to the height control valve as marked earlier. Tighten nylon tube air fittings until only two threads show on the fitting. On wire-braid hose fittings, tighten the nut with a wrench until there is firm resistance, then tighten one-sixth turn more.
8. Connect the height control valve linkage to the overtravel lever.
9. Close the drain cocks on all reservoirs.
10. Build up normal operating pressure in the air system. Check all air lines and connections for leaks. Eliminate all leaks.
11. Remove the chocks from the tires.
12. Adjust the height control valve. For instructions, see **Subject 110.**

Shock Absorber Replacement

1. Chock the tires.
2. Remove the locknut, bolt, and spacer from the shock absorber lower mounting bracket. **See Fig. 1.**
3. Remove the nut, upper retainer, and upper bushing from the top of the shock absorber.
4. Pull the shock absorber out of the upper mounting bracket, and remove the retainer and bushing.
5. Install the replacement shock absorber, making sure the new bushings and retainers are correctly positioned. **See Fig. 1.**

WARNING: Use only the retainers included with the replacement shock absorber. Do not use washers. They can be extruded over the nut and be ejected violently, possibly causing personal injury and property damage.

6. Tighten the shock absorber lower mounting locknut 170 lbf·ft (230 N·m).
7. Tighten the shock absorber upper mounting nut to compress the bushings to the dimension **as shown in Fig. 1.**



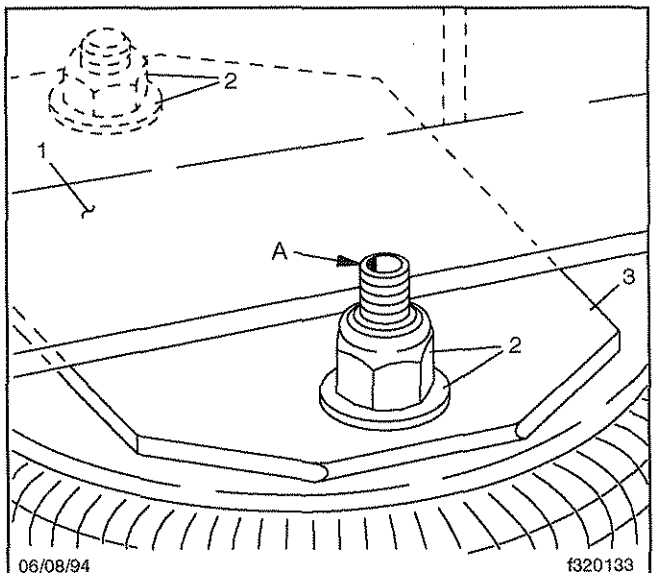
1. Frame Rail
2. Bushings

Fig. 1, Shock Absorber Installation

Air Spring Replacement

1. Chock the front tires. Raise the vehicle frame and support it with safety stands to remove all weight from the air springs. The leveling valve automatically releases air from the air springs when all weight is removed from the suspension.
2. Disconnect the air supply line,including the brass tee, from the air spring. Using tape, cover the ends of the air supply line and the fitting to prevent dirt or foreign material from entering.
3. Remove the locknuts and washers that connect the air spring to the upper mounting bracket, or to the frame rail flange. See **Fig. 1** and **Fig. 2.**
4. Remove the capscrews and lockwashers that connect the air spring to the rear of the leaf spring. Remove the air spring. **See Fig. 3.**

NOTE: Suspensions manufactured to a 46,000-pound (20 865 kg) or 23,000-pound (10 433 kg) weight rating have a different leaf spring, and an additional cross bar attached between the air spring and rear of the leaf spring. **See Fig. 4.**



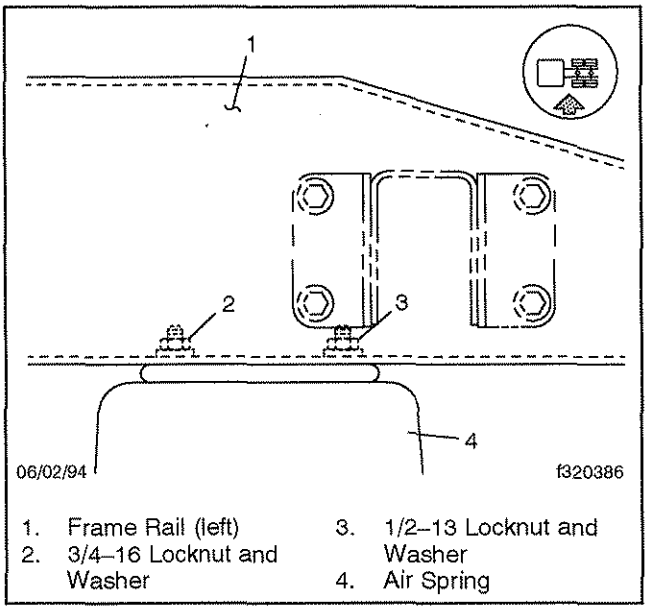
A. Air line connects here.

1. Right Frame Rail Flange
2. Locknut and Washer
3. Upper Mounting Bracket

Fig. 1, Bracket-Mounted Air Spring

5. Place the new air spring on the rear of the leaf spring (or the cross bar on the 23,000- and 46,000-pound suspensions), and install the washer and locknut that hold the air spring (and cross bar) in place. **See Fig. 3.** Tighten the locknut 55 lbf·ft (75 N·m).
6. *For bracket-mounted air springs:* Attach the air spring to the upper mounting bracket, using the 1/2–13 locknut on the outside of the frame rail and the 3/4–16 locknut on the inside. **See Fig. 1.** Tighten the 3/4–16 locknut 45 lbf·ft (61 N·m); tighten the 1/2–13 locknut 23 lbf·ft (31 N·m).

   For flange-mounted air springs: Attach the air spring to the frame rail flange, using the 3/4–16 locknut on the forward stud of the air spring, and the 1/2–13 locknut on the rear stud. **See Fig. 2.** Tighten the 3/4–16 locknut 45 lbf·ft (61 N·m); tighten the 1/2–13 locknut 23 lbf·ft (31 N·m).
7. Remove the tape from the ends of the air supply line, the fitting, and the brass tee. Connect the air supply line to the air spring. Tighten nylon tube air fittings until only two threads show on the fitting. On wire-braid hose fittings, tighten the nut with a wrench until there is firm resistance, then tighten one-sixth turn more.
8. Remove the safety stands, and lower the vehicle. Remove the chocks from the tires.



1. Frame Rail (left)
2. 3/4–16 Locknut and Washer
3. 1/2–13 Locknut and Washer
4. Air Spring

Fig. 2, Flange-Mounted Air Spring

Air Spring Replacement

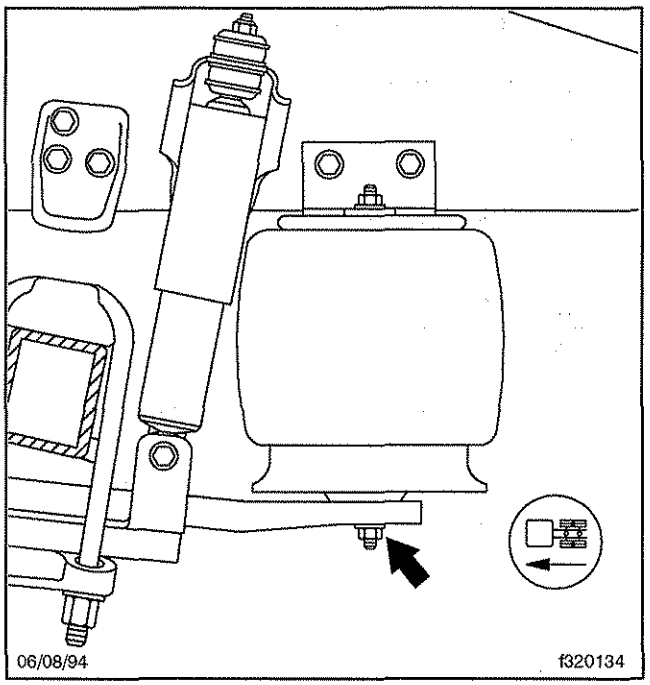
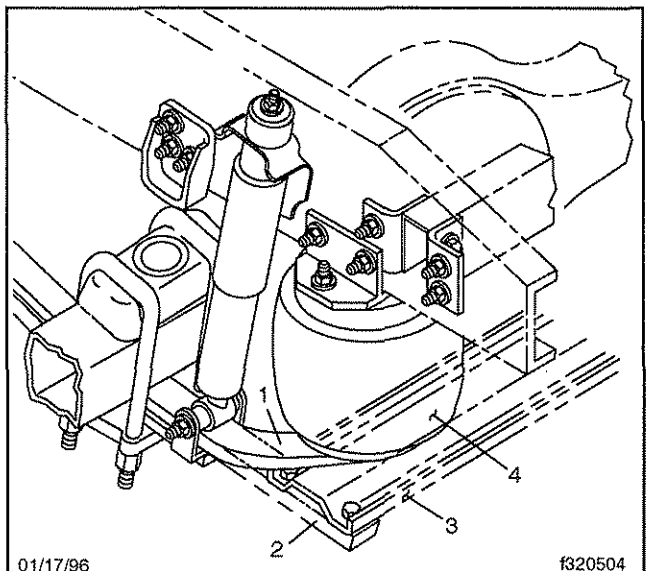


Fig. 3, Capscrew Connecting Leaf Spring and Air Spring



1. Leaf Spring
2. Leaf Spring
3. Cross Bar
4. Air Spring

Fig. 4, Leaf Spring and Air Spring Assembly (23,000- and 46,000-pound suspensions)

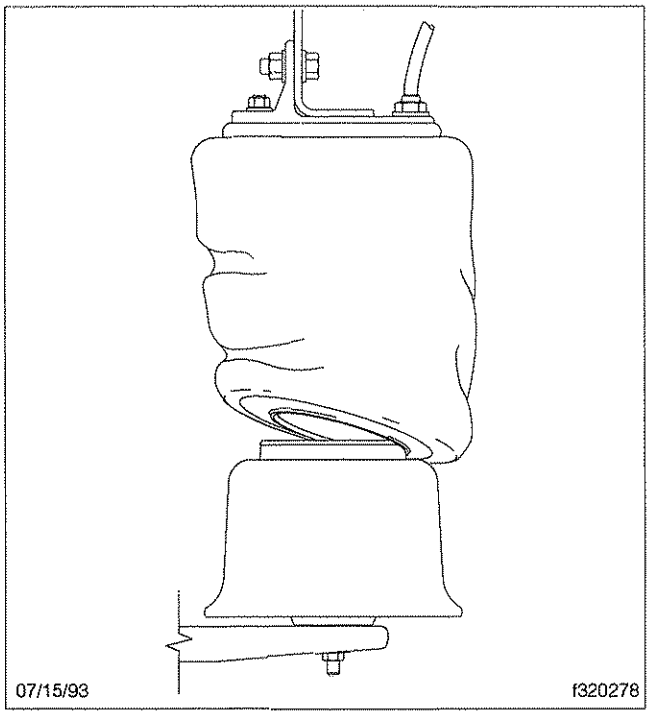


Fig. 3, Air Spring Bag Aligned with Piston

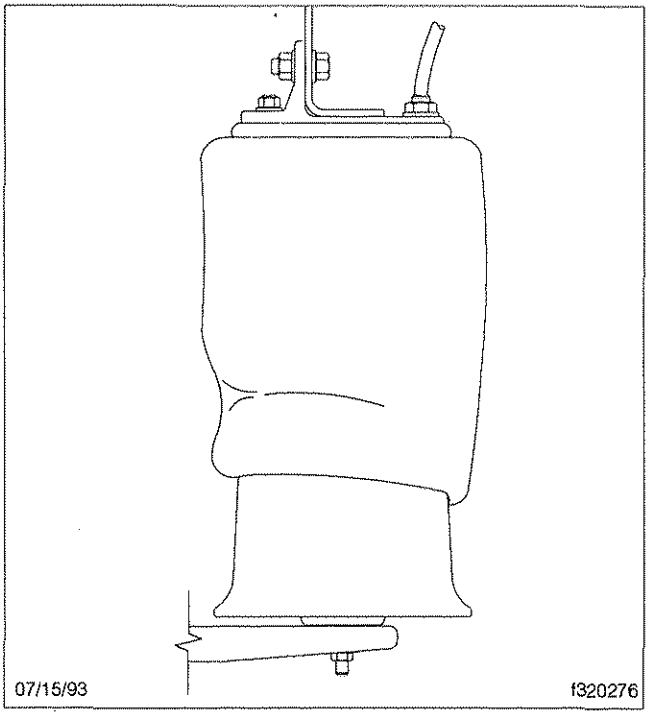


Fig. 4, Air Spring Bag Rolling Onto Piston

Air Spring Bag Replacement

Replacement

1. Park the vehicle on a level surface. Shut down the engine. Set the parking brake and chock the front tires. Raise the vehicle frame and support it with safety stands to remove all weight from the air springs.

IMPORTANT: Do not disconnect the shock absorbers while the vehicle frame is raised. They limit downward suspensiontravel,. preventing the piston from being pulled out of the air bag.

2. Exhaust all air from the air springs by disconnecting the height control valve linkage and holding the overtravel lever down.
3. Using a dull instrument, pry the air spring bead off the piston lip. Be careful not to damage the piston.
4. Disconnect the air supply line and, if so equipped, the brass tee from the air spring. Using tape, cover the ends of the air supply line and the fitting to prevent dirt or foreign material from entering.
5. Remove the locknuts and washers that connect the air spring bag to the upper mounting bracket.
6. Remove the air spring bag.
7. Check the piston for residue and remove any if found.

NOTE: When space is limited (such as at the forward axle of tandem axles), it may be easier to remove the piston from the leaf spring and assemble the bag and piston on a workbench. Secure the air spring mounting bracket, which is attached to the bag, in a vise. Fully extend the air bag and plug the air supply port. Apply a soap-and-water solution to the piston lip and air bag bead, and, using a twisting motion, push the piston onto the air bag until the piston is fully seated. Inspect the circumference of the bag-to-piston connection to make sure there is less than 1/8 inch (3.2 mm) of clearance between the air bag and the piston shoulder. The gap should be uniform around the assembly. After inspecting, remove the plug in the air supply port and push the piston into the air bag so that it rolls over the piston. Then, install on the vehicle.

⚠ WARNING

Do not add air pressure to the air spring assembly when it is not mounted on a vehicle. Doing so could cause components to eject from the assembly, which could cause serious personal injury or property damage.

8. Attach the new air spring bag to the upper mounting bracket, using the 1/2–13 locknut on the outside of the frame rail, and the 3/4–16 locknut on the inside. Tighten 3/4–16 locknuts 45 lbf·ft (61 N·m); tighten 1/2–13 locknuts 23 lbf·ft (31 N·m).
9. Remove the tape from the ends of the air supply line, the fitting, and the brass tee. Connect the air supply line to the air spring. Tighten nylon tube air fittings until only two threads show on the fitting. On wire-braid hose fittings, tighten the nut with a wrench until there is firm resistance, then tighten one-sixth turn more.
10. Make sure the air spring bag is fully extended alongside the piston so there are no folds in the bag near the bead. See **Fig. 1.**
11. Fold the air spring bag so the bead is fully parallel with the piston lip. See **Fig.2.**
12. Apply a soap-and-water solution to the bead and piston lip.
13. Pull the rear of the air spring bag over the piston lip making sure the bead is the lowest part of the bag—none of the bag should droop over the piston. Then, work the front of the bag over the piston lip like a button in a buttonhole. See **Fig. 3.**
14. Feeling the bead through the folds of the air spring bag, partially inflate the bag. This will cause snapping of the bead over the piston lip so it seats fully. A snapping sound confirms correct seating of the bead.

NOTE: The air bag should seat from 10 to 40 psi (69 to 276 kPa). Do not overinflate it to try to force it to seat. If there is no snapping sound before reaching 50 psi (345 kPa), release the air pressure and realign the air bag bead and piston. Then, try again to seat the bag using air pressure.

15. Inspect the circumference of the bag-to-piston connection to make sure there is less than 1/8 inch (3.2 mm) of clearance between the air bag and the piston shoulder. The gap should be uniform around the assembly.
16. Connect the height control valve and inflate the air spring bag. As it's inflating, the bag should roll into position over the piston. See **Fig. 4.**

Air Spring Bag Replacement

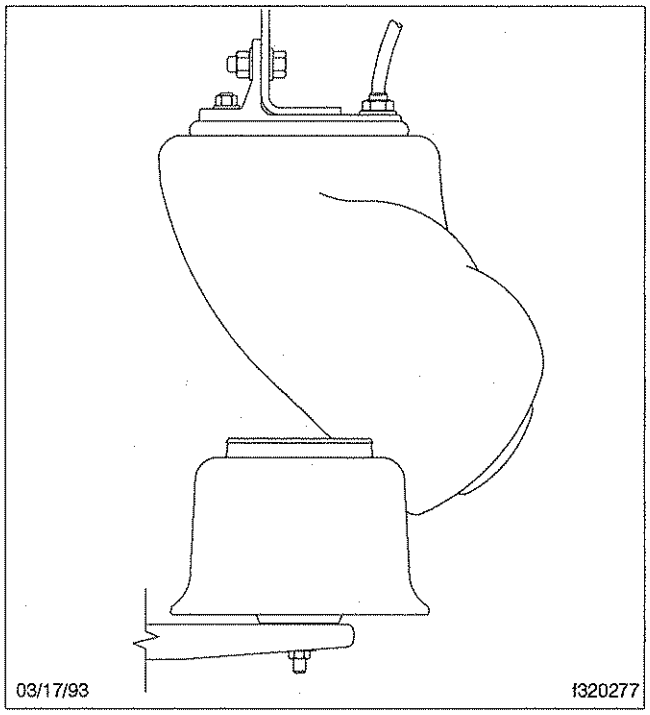


Fig. 1, Air Spring Bag Extended

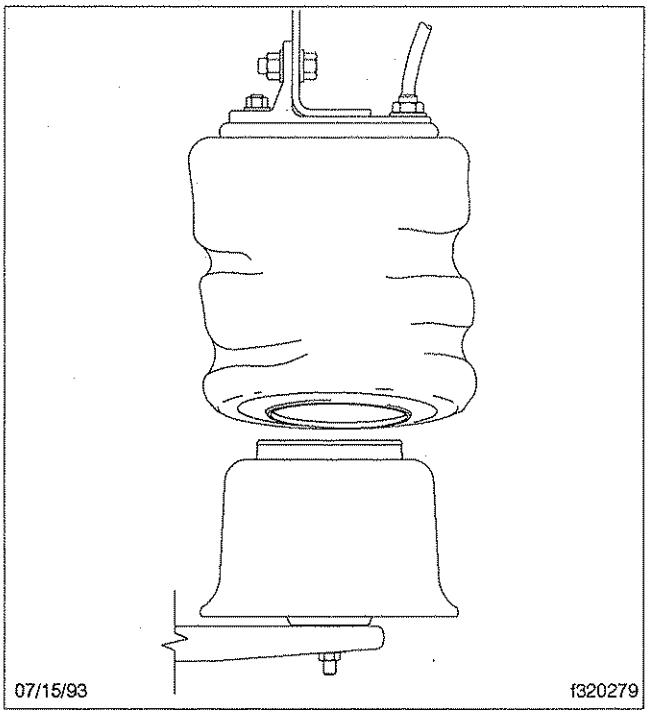
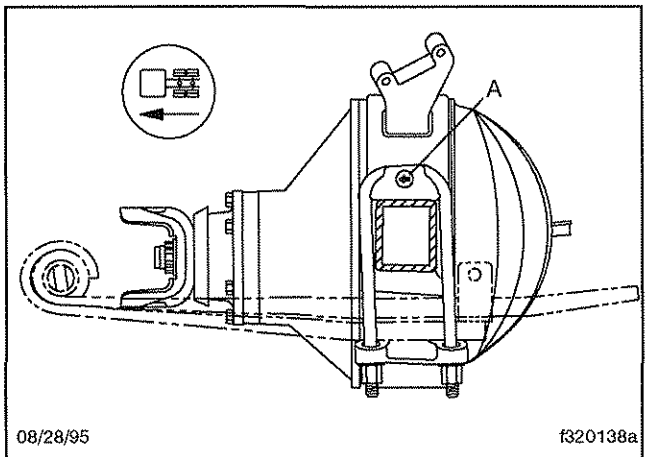


Fig. 2, Air Spring Bag Folded

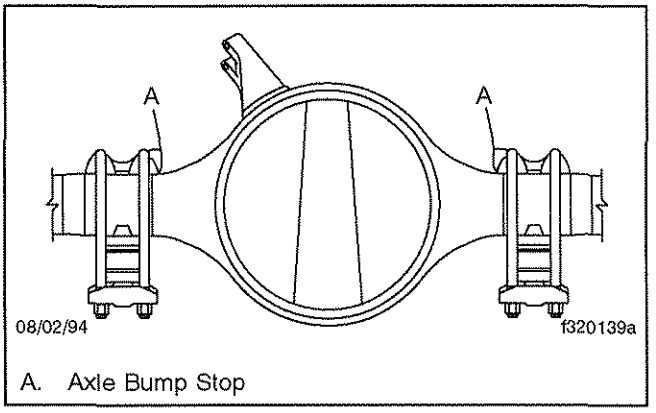
17. Check the suspension ride height. See **Subject 110** for instructions.
18. Remove the safety stands, and lower the vehicle. Remove the chocks from the tires.

15. Install the wheel and tire assembly. For instructions, refer to**Group 40**. Remove the safety stands, and lower the vehicle.
16. Check the rear axle alignment. For instructions, refer to the rear axle section in this manual. If necessary, adjust the rear axle alignment using the instructions in **Subject 170**.



A. Arrow on U-Bolt Pad

Fig. 3, U-bolt Pad Arrow Positioning



A. Axle Bump Stop

Fig. 4, Axle Bump Stop Positioning

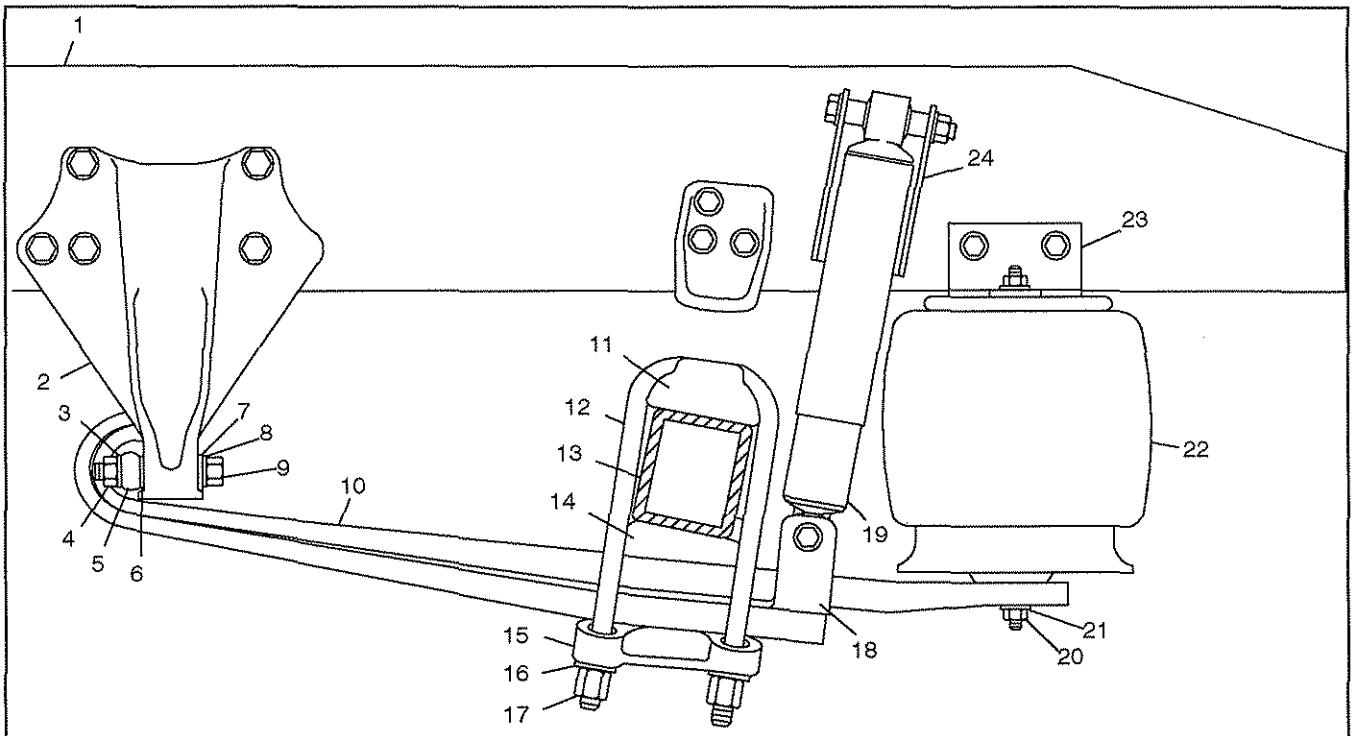
Axle Designation		U-Bolt Pad Orientation
Rockwell SQ 100, SSHD	Forward Rear Axle	No arrow; axle bump stop toward vehicle centerline.
	Rearmost Axle	No arrow; axle bump stop toward vehicle centerline.
Rockwell RT40-145, RT44-145, RT46-160	Forward Rear Axle	No arrow; axle bump stop toward vehicle centerline.
	Rearmost Axle	Arrow toward front of vehicle.
Eaton 402, 461	Forward Rear Axle	No arrow; axle bump stop toward vehicle centerline.
	Rearmost Axle	No arrow; axle bump stop toward vehicle centerline.

Table 1, U-Bolt Pad Orientation for Axles

Leaf Spring Replacement (See Fig. 1)

WARNING: Do not replace individual leaves of a damaged leaf spring assembly; replace the complete spring assembly. Visible damage (cracks or breaks) to one leaf causes hidden damage to other leaves. Replacement of only the visibly damaged part(s) is no assurance that the spring is safe. Failure to replace a damaged spring assembly could cause an accident resulting in serious personal injury or property damage.

1. Chock the front tires.
2. Raise the rear of the vehicle, and support the rear axle(s) with safety stands. Raise the vehicle so that all weight is removed from the leaf springs, then securely support the frame with safety stands. Remove the wheel and tire assembly to easily access the suspension. Refer to the wheels and tires section in this manual for instructions.
3. Remove the nut, bolt, and washers from the shock absorber lower mounting bracket. Remove the high nuts, flatwashers, and axle clamp from each U-bolt. Support the leaf spring assembly with a jack.



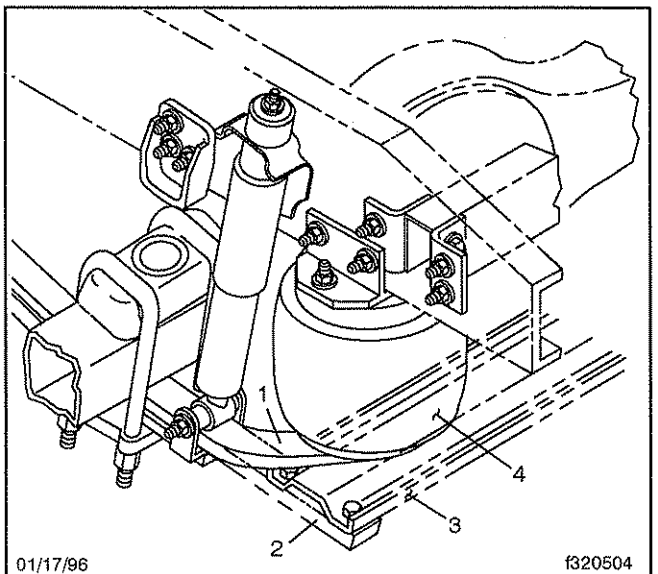
1. Frame Rail
2. Spring Hanger
3. Washer
4. Hexnut
5. Spring Mounting Eye Pin
6. Alignment Shim
7. Wear Shoe Clip
8. Washer
9. Spring Mounting Bolt
10. Leaf Spring Assembly
11. U-Bolt Pad
12. U-Bolt
13. Axle
14. Axle Seat
15. Axle Clamp
16. Flatwasher
17. High Nut
18. Shock Absorber Lower Mounting Bracket
19. Shock Absorber
20. Nylon Locknut
21. Washer
22. Air Spring
23. Air Spring Mounting Bracket
24. Shock Absorber Upper Mounting Bracket

Fig. 1, AirLiner Leaf Spring Assembly

Leaf Spring Replacement

4. If the air spring mounts to the leaf spring, disconnect the bottom of the air spring from the leaf spring.

   If the air spring mounts to a cross bar, disconnect the cross bar from the leaf spring by removing the capscrews, nuts, and washers. **See Fig. 2.**



1. Leaf Spring
2. Leaf Spring
3. Cross Bar
4. Air Spring

Fig. 2, Leaf Spring and Air Spring Assembly (23,000- and 46,000-pound suspensions)

5. Note the number and position of the alignment shims (**See Fig. 1**) on the spring mounting bolt.

6. Remove the hexnut, washers, alignment shim(s), spring mounting bolt, and wear shoe clip from the spring hanger. **See Fig. 1.**

WARNING: The leaf spring assembly is heavy. Use care when handling it to prevent injury.

7. Remove and discard the leaf spring assembly.

8. While supporting a new leaf spring assembly with a jack, position the assembly on the spring hanger. Install the bolts, wear shoe clips, washers, alignment shims, and hexnuts. Tighten the bolts just enough to hold the leaf spring assembly in place.

9. If the air spring mounts to the leaf spring, attach the air spring to the leaf spring assembly. Install the washer and locknut. Tighten the locknut 55 lbf·ft (75 N·m).

   If the air spring mounts to a cross bar, attach the cross bar to the leaf spring assembly. The longer capscrews attach in the forwardmost holes; the shorter capscrews attach in the aft holes.

10. Making sure that the U-bolt pads are in place on the top of the axle, fasten the leaf spring assembly to the axle using the U-bolts, axle clamp, washers, and high nuts making sure the U-bolt pads and axle clamps are positioned correctly.

NOTE: On single-drive axles angled 5 degrees, the arrow on the U-bolt pads must point to the front of the axle housing. **See Fig. 3**. On single-drive axles angled 3 degrees, there is no arrow. Make sure that the axle bump stop on the U-bolt pad is positioned toward the vehicle centerline. **See Fig. 4.**

With both 5- and 3-degree single-drive axle angles, the arrow on the bottom of the axle clamp (**See Fig. 1**) must point toward the rear of the vehicle.

On tandem axle suspensions, refer to **Table 1** for U-bolt pad orientation. The arrow on the bottom of the axle clamp must point toward the rear of the vehicle on the forward rear axle and toward the front of the vehicle on the rearmost axle.

11. Hand tighten the high nuts. In a diagonal pattern, tighten the axle U-bolt high nuts 60 lbf·ft (81 N·m). Then, in the same pattern, tighten them 200 lbf·ft (271 N·m); then, torque to the final value of 400 to 460 lbf·ft (542 to 624 N·m).

    For the 23,000-pound and 46,000-pound suspensions, tighten the high nuts in a diagonal pattern to a final torque value of 520 to 600 lbf·ft (705 to 813 N·m).

12. Install the bolt, washers, and hexnut to connect the shock absorber to its lower mounting bracket. Tighten the hexnut 170 lbf·ft (230 N·m).

13. Tighten the locknut on the bottom of the air spring 55 lbf·ft (75 N·m).

    On 23,000-pound and 46,000-pound suspensions, tighten the locknuts on the bottom of the cross bar 241 lbf·ft (327 N·m).

14. Tighten the hexnuts at the front of the leaf spring 170 lbf·ft (230 N·m).

Rear Axle Alignment Adjusting

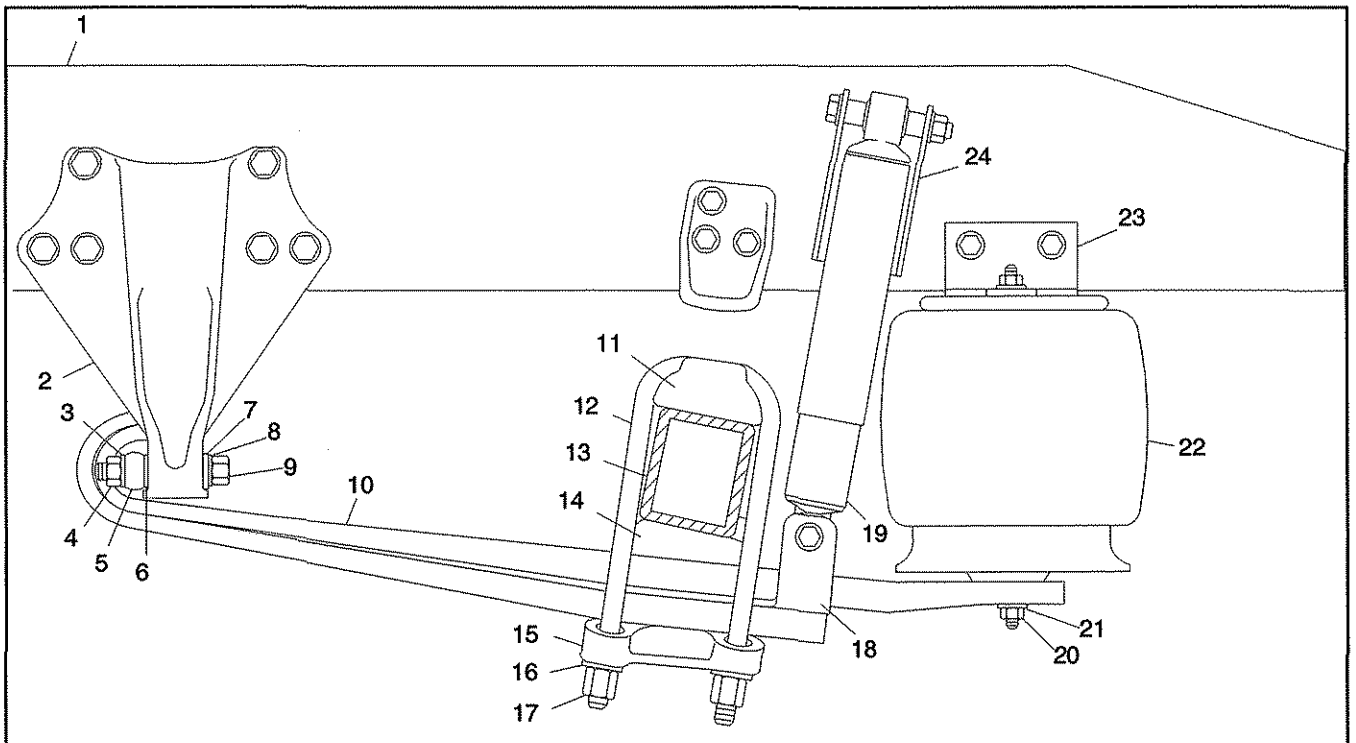
See **Fig. 1**.

Follow the instructions in the rear axle section of this manual to see if rear axle alignment adjustment is needed. If adjustment is needed, proceed as follows:

1. Loosen the spring pinch bolts so that the forward end of the leaf spring can slide fore and aft in the spring hanger.
2. Move the axle forward or backward until it is aligned within the tolerances in the rear axle alignment checking section of this manual.
3. When the axle is in alignment, install alignment shim(s) to take up the slack between the spring hanger and the spring pin.

IMPORTANT: Make sure the same number of shims is installed on both ends of the spring pin.

4. Tighten the spring pinch bolts 170 lbf·ft (230 N·m).
5. Check the axle alignment again. If necessary, repeat the above procedure until the alignment is within tolerances.



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1. Frame Rail
2. Spring Hanger
3. Washer
4. Hexnut
5. Spring Pin
6. Alignment Shim
7. Wear Shoe Clip
8. Washer
9. Spring Pinch Bolt
10. Leaf Spring Assembly
11. U-Bolt Pad
12. U-Bolt
13. Axle
14. Axle Seat
15. Axle Clamp
16. Flatwasher
17. High Nut
18. Shock Absorber Lower Mounting Bracket
19. Shock Absorber
20. Nylon Locknut
21. Washer
22. Air Spring
23. Air Spring Mounting Bracket
24. Shock Absorber Upper Mounting Bracket

Fig. 1, Rear Axle Suspension

Rear Axle Alignment

Rear Axle Tracking Adjustment

Single Axle

1. At the forward edge of the right rear tire, measure the distance from the inner side of the tire to the outer side of the right frame rail. See **Fig. 2.**
2. At the rear edge of the left rear tire, measure the distance from the inner side of the tire to the outer side of the left frame rail. See **Fig. 2.**

IMPORTANT: Measurement "A" should not vary by more than 1/4-inch (6 mm) from measurement "B."

3. If measurements "A" and "B" vary by more than 1/4-inch (6 mm), loosen the fasteners holding the lateral torque rod to the frame rail. Add or remove torque-rod shims as needed.
4. For bar-pin style torque rods, tighten the fasteners 136 lbf·ft (184 N·m).

   For taper-pin style torque rods, tighten the fasteners 165 lbf·ft (224 N·m). See **Fig. 3.**

Tandem Axles

1. Check the tracking of the forward-rear axle. For instructions, see "Single Axle" in this subject. Adjust the tracking if needed.
2. At the forward-rear drive axle, measure the distance from the inner side of the right rear tire to the outer side of the right frame rail. Measure at the forward edge of the tire. See **Fig. 4.**

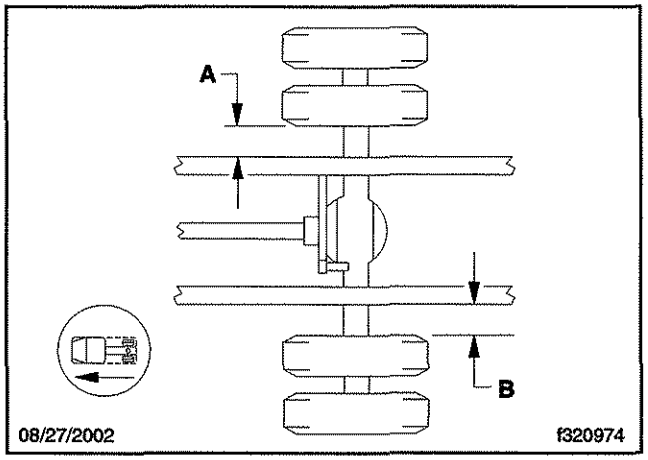


Fig. 2, Rear Axle Tracking Measurements (single axle)

3. At both sides of the rear-rear drive axle, measure the distance from the inner side of the rear tires to the outer side of each frame rail. Measure at the rear edge of each tire. See **Fig. 4.**

IMPORTANT: Measurements "B" and "C" should not vary by more than 1/4-inch (6 mm) from measurement "A."

4. If measurements "B" and "C" vary by more than 1/4-inch (6 mm) from measurement "A," loosen the fasteners holding the axle lateral torque rod at the rear-rear drive axle to the frame rail. Add or remove torque-rod shims as needed.
5. For bar-pin style torque rods, tighten the fasteners 136 lbf·ft (184 N·m). For taper-pin style torque

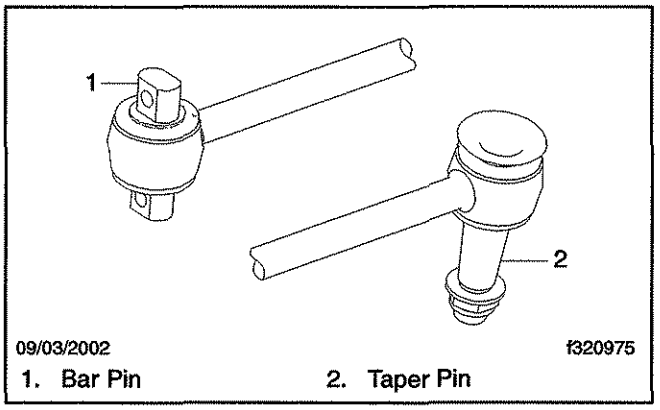


Fig. 3, Torque Rod Types

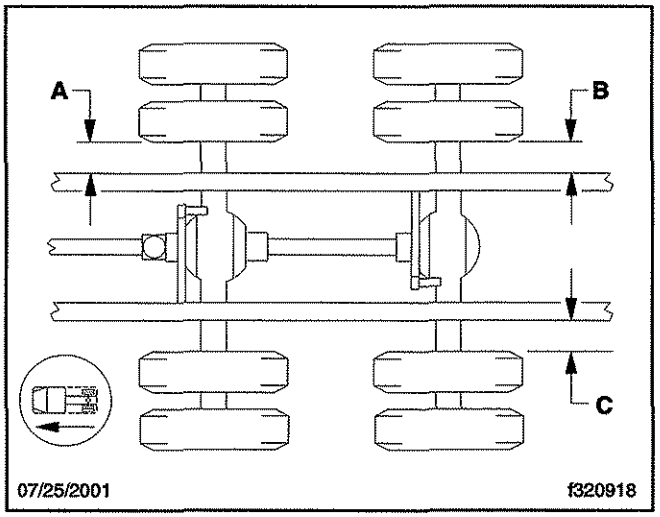
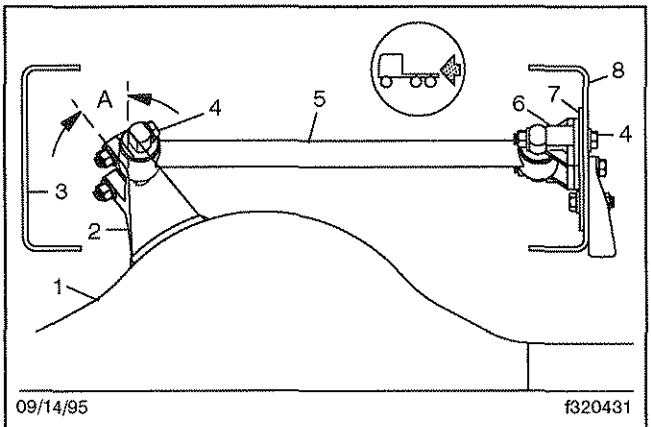


Fig. 4, Rear Axle Tracking Measurements (tandem axles)

rods, tighten the fasteners 165 lbf·ft (224 N·m).
See **Fig. 3.**

Replacement

1. Park the vehicle. Shut down the engine, and apply the brakes.
2. Chock the tires. Raise the vehicle. Support the frame rails with jack stands.
3. Remove the fasteners holding the control rod to the frame rail bracket. Remove the shims, and set the shims aside.
4. Remove the control rod.
5. Position the new control rod so that the end with the fasteners angled up at 35 degrees is installed in the axle housing bracket. **See Fig. 1.**
6. Install the fasteners with the bolt heads facing up. Tighten the fasteners enough to hold the control rod in place.
7. Install the shims that were previously removed.
8. Install the other end of the control rod in the frame rail bracket; then, install the fasteners. Tighten the fasteners enough to hold the control rod in place.
9. Tighten all the fasteners 136 lbf·ft (184 N·m).



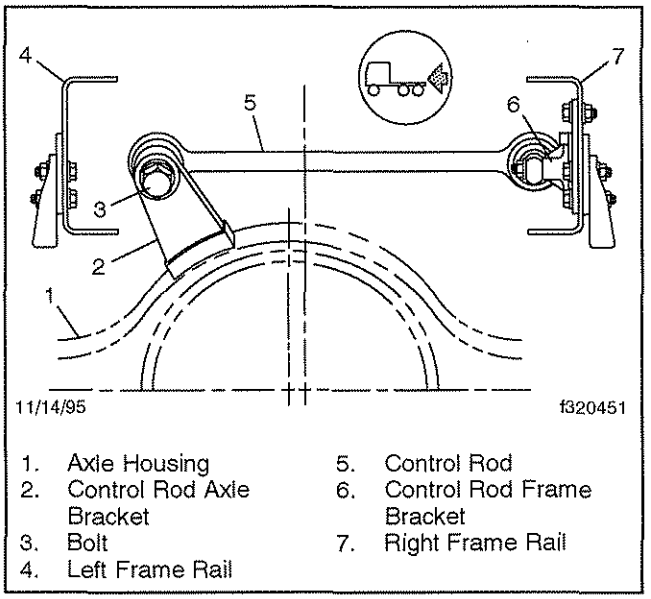
A. Angle: 35 degrees

1. Axle Housing
2. Control Rod Axle Bracket
3. Left Frame Rail
4. Bolt
5. Control Rod
6. Control Rod Frame Bracket
7. Shim
8. Right Frame Rail

Fig. 1, AirLiner Control Rod Installation

10. Remove the jack stands. Lower the vehicle. Remove chocks.

NOTE: Control rods on suspensions manufactured to a 23,000-pound (10 433 kg) or 46,000-pound (20 865 kg) weight rating are larger and are attached to the axle bracket with a single bolt. Tighten the fasteners attaching the control rod frame bracket to the frame rail 160 to 170 lbf·ft (217 to 230 N·m), and the bolt connecting the control rod to the axle housing 175 to 225 lbf·ft (237 to 305 N·m). **See Fig. 2.**



1. Axle Housing
2. Control Rod Axle Bracket
3. Bolt
4. Left Frame Rail
5. Control Rod
6. Control Rod Frame Bracket
7. Right Frame Rail

Fig. 2, Control Rod Installation on 23,000- and 46,000-pound AirLiner Suspensions

Spring Eye Bushing Replacement

Replacement

⚠ WARNING

Do not replace individual leaves of a damaged leaf spring assembly; replace the complete spring assembly. Visible damage (cracks or breaks) to one leaf causes hidden damage to other leaves. Replacement of only the visibly damaged part(s) is no assurance that the spring is safe. Failure to replace a damaged spring assembly could cause an accident resulting in serious personal injury or property damage.

1. Park the vehicle on a level surface. Shut down the engine. Set the parking brake and chock the front tires.
2. Raise the rear of the vehicle, and support the rear axle(s) with safety stands. Raise the vehicle so that all weight is removed from the leaf springs, then securely support the frame with safety stands.
3. Remove the wheel and tire assembly to easily access the suspension. For instructions, see the information in **Group 40**.
4. Remove the leaf spring assembly. See removal information in **Subject 160**.

⚠ WARNING

The leaf spring assembly is heavy. Use care when handling it to prevent injury.

5. Remove the bushing from the leaf spring eye.

⚠ WARNING

Do not use a cutting torch to remove the outer metal of the bushing from the spring eye. Welding, torching or cutting the leaf spring assembly can damage the leaf spring material, which may result in the failure of the components and cause serious personal injury, death, or property damage.

   5.1 Using a shop press with a capacity of at least 10 tons (9 072 kg), place the spring assembly in the shop press with the spring assembly squarely supported on the press bed for safety and to avoid bending the spring assembly.

   5.2 Center the bushing tool on the outer metal of the bushing and push the bushing from the spring eye.

   5.3 Remove any burrs or material left behind by the old bushing.

6. Install the new bushing in the leaf spring eye.

   6.1 Position the bushing on the shop press.

   6.2 Apply a bonding agent, either Perma-bond HM–160 or Loctite RC–609 or 680, liberally around the outside surface of the bushing.

   6.3 Press the bushing into place.

   6.4 Allow the bonding agent to cure for 24 hours.

   NOTE: After the curing time, the bushing must resist a minimum 7,700 lb (3 490 kg) pushout force.

7. Install the leaf spring assembly. See the information in **Subject 160**.
8. Install the wheel and tire assembly. For instructions, see **Group 40**. Remove the safety stands, and lower the vehicle.
9. Check the rear axle alignment. For instructions, refer to **Group 35** in this manual. If necessary, adjust the rear axle alignment using the instructions in **Group 35**.
10. Remove the chocks from the tires.

Torque Values for AirLiner Suspension			
Description	Size	Torque	
		lbf·ft (N·m)	lbf·in (N·cm)
Height Control Valve Adjustment Nut	1/4–20	—	62 (700)
Height Control Valve Mounting Bolt Nuts	5/16–18	14 (19)	—
Shock Absorber Mounting Locknuts	3/4–10	165 (220)	—
Air Spring Upper Mounting Locknuts	3/4–16	45 (61)	—
	1/2–13	23 (31)	—
Air Spring Lower Mounting Locknuts	1/2–13	55 (75)	—
Leaf Spring Mounting Eye Bolt Locknuts	3/4–10	241 (327)	—
Control Rod Mounting Bolt Locknuts	5/8–11	136 (184)	—
Axle U-Bolt High Nuts Tighten in a diagonal pattern as shown in **Fig. 1**.	3/4–16	Stage 1: Hand tighten Stage 2: 60 (81) Stage 3: 200 (271) Stage 4: 270 to 330 (367 to 449)	—
	7/8–14	Stage 1: Hand tighten Stage 2: 60 (81) Stage 3: 200 (271) Stage 4: 420 to 500 (571 to 680)	—
	1–14	Stage 1: Hand tighten Stage 2: 60 (81) Stage 3: 200 (271) Stage 4: 520 to 600 (707 to 816)	—
Air Spring Upper Mounting Bracket	5/8–11	136 (184)	—
Spring Hanger Mounting Locknuts	3/4–10	240 (325)	—

Table 1, Torque Values for AirLiner Suspension

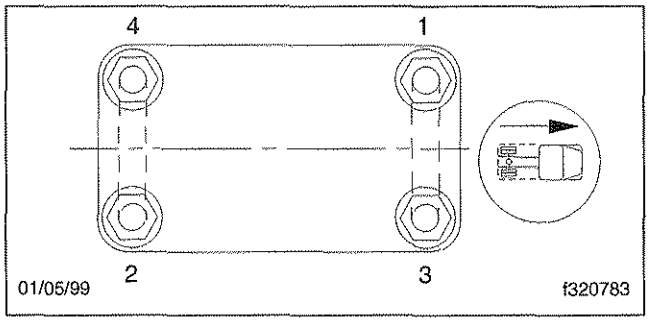


Fig. 1, Tightening Pattern for U-Bolt High Nuts

Specifications

Torque Values	
Description	**Torque, lbf·ft (N·m)**
Equalizer Pivot Shaft: 101A, 102	600 (814)
Equalizer Nut: 102W	975 (1330)
Equalizer Arm Rebound Bolt	45 (61)
Rebound Bolt	60–80 (80–110)
Spring Center Bolt Nut	75–80 (105–110)
Spring-Bracket-to-Frame Bolt	180 (244)
Radius Rod Clamp Nut: 101A, 5/8" bolt	125–150 (170–205)
Radius Rod Clamp Nut: 102, 5/8" bolt	125–150 (170–205)
Radius Rod Clamp Nut: 102W	175–200 (240–275)
Radius Rod Eye Bolt: 101A	160 (217)
Radius Rod Eye Bolt: 102	500–525 (670–704)
Radius Rod Eye Bolt: 102W	160–200 (220–271)
Radius Rod Bolt: 101A	250 (339)
Radius Rod Bolt: 102	200 (271)
Radius Rod Bolt: 102W	400–425 (550–580)
Axle U-Bolt High Nuts: 3/4–16	
First Stage	Hand tighten
Second Stage	60 (81)*
Third Stage	200 (271)*
Final Stage	270 to 330 (367 to 449)*
Axle U-Bolt High Nuts: 7/8–14	
First Stage	Hand tighten
Second Stage	60 (81)*
Third Stage	200 (271)*
Final Stage	420 to 500 (571 to 680)*

* Tighten in a diagonal pattern as shown in **Fig. 1**.

Table 1, Torque Values

Specifications

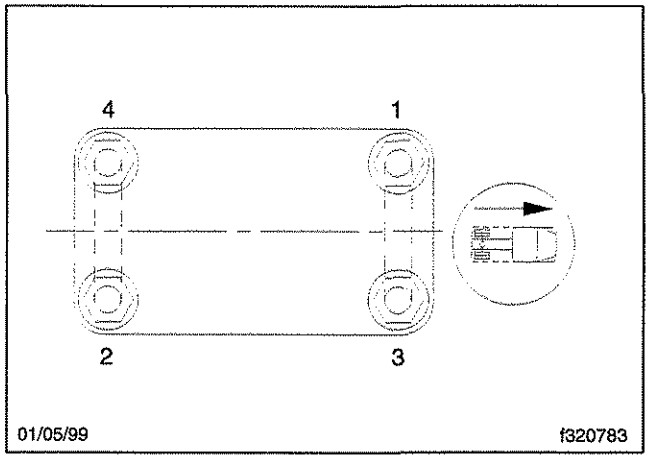


Fig. 1, Tightening Pattern for U-bolt High Nuts

Rear Suspension, Reyco®

32.05

Contents

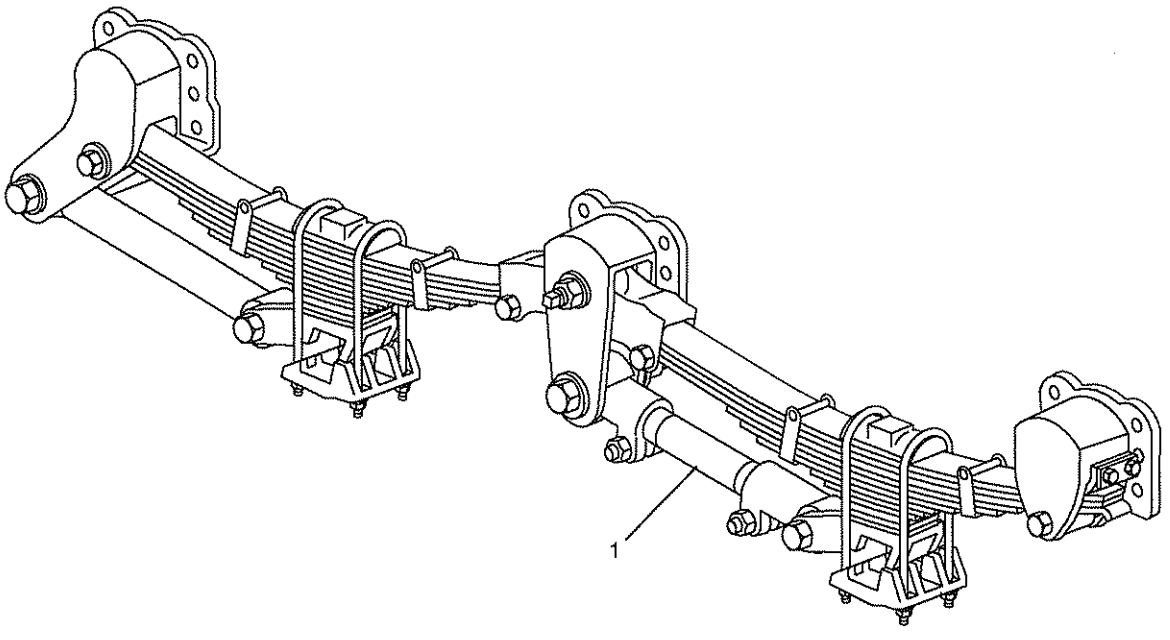
Subject	Subject Number
General Information	050
Service Operations	
Suspension Removal, Inspection, and Installation, Reyco	100
Spring Removal and Installation, Reyco	110
Spring Disassembly, Inspection, and Assembly, Reyco	115
Spring Bracket Removal and Installation, Reyco	117
Radius Rod and Radius Rod Bushing Replacement, Reyco	120
Equalizer Arm Bushing Replacement, Reyco	130
Axle Alignment Checking and Adjusting, Reyco	140
Troubleshooting	300
Specifications	400

General Information

The Reyco suspension has two springs at each side of the vehicle frame. See **Fig. 1.** These springs are supported and held in place by three frame-mounted brackets. The two forward brackets also serve as mounts for the axle radius rod eyes. The middle bracket is a two-piece assembly that supports one end of each tandem spring. The two pieces are fastened together in a pivoting manner, permitting movement of the individual leaf springs as they adjust to varying load and changing road contours. The distribution of the vehicle load is equalized between the axles by the leveling action of this pivoting assembly.

Driving and braking forces are transmitted to the vehicle frame through radius rods or torque leaves. Eccentric bushings at the forward end (or eye) of each radius rod permit alignment of each axle independently of the other. A total adjustment of 7/16 inch (11 mm) can be made on each side of the vehicle.

Road shock is cushioned by rubber bushings and cushions at most points of movement. Lubrication of suspension parts is not necessary. The rear end of each spring assembly is formed into a hook which catches on a spring roller and rebound bolt to prevent excessive forward movement of the axle if a radius rod were to break.



1. Adjustable Torque Tracking Rod

Fig. 1, Reyco Suspension

Suspension Removal, Inspection, and Installation, Reyco

Removal

If the suspension system is being overhauled, remove the suspension using the following procedure:

1. Chock the front tires. Drain the vehicle air system. Disconnect all air lines leading to the rear axles, marking the lines for later assembly reference. Plug all lines and fittings to prevent dirt or foreign material from entering the lines.
2. Disconnect the driveline rear universal joint from the forward-rear axle. For instructions refer to **Group 41** of this manual.
3. Manually cage the parking brake chambers. For instructions, refer to **Group 42** of this manual.
4. Using an overhead hoist, raise the rear of the vehicle enough to relieve the weight from the suspension. Support the frame and axle with safety stands.

WARNING: Securely support all axle and frame weight with safety stands during suspension repairs. Unsecured components may drop when fasteners are loosened or removed, causing serious personal injury and component damage.

NOTE: Do not raise the vehicle to the point where the suspension and axles hang from the vehicle.

5. On both sides of the vehicle, remove the forward rear spring bracket rebound bolt, spring roller, radius rod eye bolt, large flatwashers, and eccentric rubber bushings. **See Fig. 1.**

NOTE: The radius rod eye bushing is a two-piece unit. Insert a punch into the inside of the bushing and drive out one side of the bushing. Insert the punch from the opposite side to remove the remaining half of the bushing.

6. On both sides of the vehicle, remove the rebound bolts and the spring rollers from the equalizer arm.

NOTE: For clarity, only one of each of the rebound components is shown in **Fig. 1** even though two are used on the equalizer arm.

7. Secure all radius rods to the spring assemblies.
8. On both sides of the vehicle, remove the rear spring bracket rebound bolt, spring roller, and bushing.
9. Using the hoist, raise the frame high enough to remove the tandem assembly out from under the frame.

Inspection

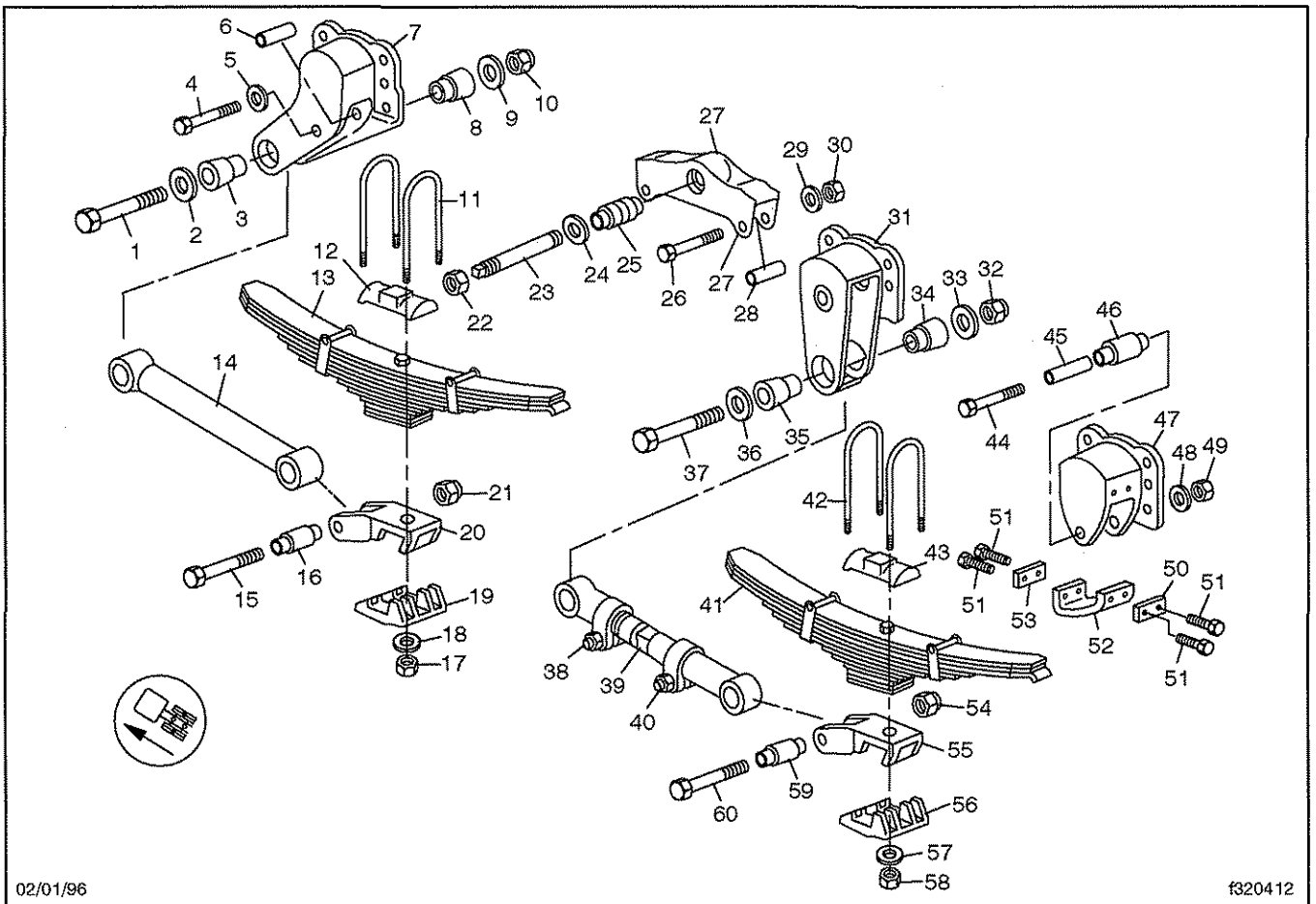
1. Clean the suspension parts and inspect all parts carefully for cracks, excessive wear, or damage.
2. Inspect the rubber bushings for damage or wear.
3. Replace components as required, following the instructions in this subject.

NOTE: When repairs are made on the removed tandem suspension that involve removal and installation of the spring U-bolts or radius rods, the mounting nuts should be tightened only partially before installation. When the tandem suspension is installed, do a preliminary alignment of the axles to the frame as described below. Then tighten the rear axle U-bolt nuts to the final torque. Tighten the radius rod bolts to the final torque only after the final alignment of the axles. Refer to **Specifications, 400** for the torque settings.

Installation

1. With the frame raised on a hoist and a hydraulic floor jack under the forward rear axle differential carrier, roll the axles and suspension assembly into position under the frame; then, lower the frame.
2. On both sides of the vehicle install the rear spring bracket bushing, spring roller, and rebound bolt, washer, and nut. Tighten the nut 75 lbf·ft (102 N·m).
3. On both sides of the vehicle install the spring rollers, rebound bolts, washers, and nuts in the center spring equalizer arm. Tighten the nuts 75 lbf·ft (102 N·m).
4. On both sides of the vehicle install the forward spring bracket rebound bolt, washer, and spring roller. There is no nut on the forward spring bracket rebound bolt. Tighten the bolt 75 lbf·ft (102 N·m).
5. Connect the driveline rear universal joint to the forward-rear axle. Refer to **Group 41** in this manual. Remove the hydraulic floor jack.

Suspension Removal, Inspection, and Installation, Reyco



1. Radius Rod Eye Bolt
2. Flatwasher
3. Rubber Bushing (half)
4. Rebound Bolt
5. Rebound Bolt Washer
6. Spring Roller
7. Forward Spring Bracket
8. Rubber Bushing (half)
9. Flatwasher
10. Radius Rod Eye Bolt Nut
11. U-Bolts
12. U-Bolt Pad
13. Forward Rear Spring Assembly
14. Radius Rod (rigid type)
15. Radius Rod Bolt
16. Bushing
17. U-Bolt Nut
18. U-Bolt Washer
19. U-Bolt Anchor Plate
20. Forward Rear Axle Seat
21. Locknut
22. Pivot Shaft Nut
23. Pivot Shaft
24. Lockwasher
25. Pivot Shaft Bushing
26. Rebound Bolt
27. Equalizer Arm
28. Spring Roller
29. Rebound Bolt Washer
30. Rebound Bolt Nut
31. Equalizer Bracket
32. Radius Rod Eye Bolt Nut
33. Flatwasher
34. Rubber Bushing (half)
35. Rubber Bushing (half)
36. Flatwasher
37. Radius Rod Eye Bolt
38. Capscrew, Washer, and Nut
39. Radius Rod (adjustable type)
40. Capscrew, Washer, and Nut
41. Rearmost Spring Assembly
42. U-Bolts
43. U-Bolt Pad
44. Rebound Bolt
45. Spring Roller
46. Bushing
47. Rear Spring Bracket
48. Rebound Washer
49. Rebound Bolt Nut
50. Clamp Plate
51. Capscrew
52. Plastic Pad
53. Clamp Plate
54. Lock Nut
55. Rearmost Axle Seat
56. U-Bolt Anchor Plate
57. U-Bolt Washer
58. U-Bolt Nut
59. Bushing
60. Radius Rod Bolt

Fig. 1, Reyco Suspension (exploded view)

6. Lower each radius rod and align the radius rod eye with the spring bracket. Install both halves of the rubber eccentric bushing into the spring bracket from the outside with the flat of the bushing insert in the down position, or with the arrow pointing up. Install the large flatwasher onto the bolt and insert the bolt into the bushing with the arrow on the bolt head also pointing up. Install the large flatwasher and nut on the bolt. Tighten the nut, but not to its final torque.

NOTE: With all four radius rod eccentric bushings and bolts installed with the arrows pointing up, the suspension is in its base alignment to the frame.

7. Tighten the rear axle U-bolt nuts to the final torque listed in **Specifications, 400** in the sequence shown in **Fig. 2.**

8. Taking care to prevent dirt and other foreign material from entering the lines or fittings, connect the air brake lines leading to the axles. Close the air system drain valve.

9. Check the axle pinion angle. For instructions, refer to **Group 41** of this manual. Adjust the angle if it is not according to specifications.

10. Check the axle alignment and adjust it if needed.

11. Make sure the radius rod eye bolt nuts are tightened to the applicable torque value in **Specifications, 400**.

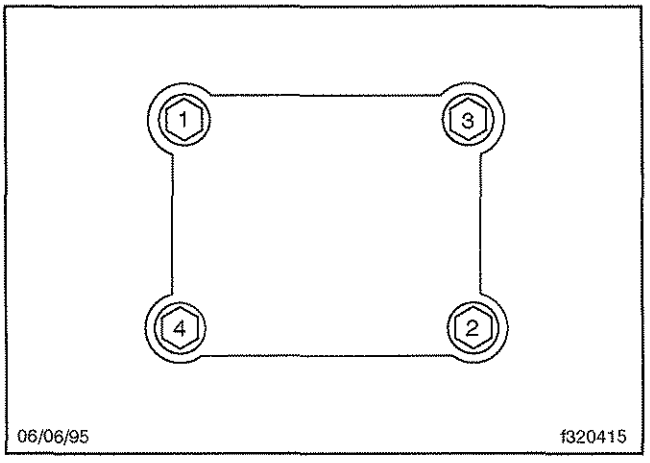


Fig. 2, U-Bolt Tightening Sequence

Spring Removal and Installation, Reyco

Forward Rear Spring Removal

1. Park the vehicle and chock the tires.
2. Raise the vehicle and block the axles with safety stands. Raise the vehicle frame so that all weight is removed from the leaf springs, then block the frame with safety stands. Make sure the stands will support the weight of the axles and frame securely. Remove the wheel assembly to gain easy access to the suspension system.
3. Remove the U-bolts and the U-bolt anchor plate. Remove the front rebound bolt, washer, and spring roller from the front spring bracket. **See Fig. 1.**
4. Remove the rebound bolt, nut, washer, and spring roller from the front of the equalizer arm in the equalizer bracket.

NOTE: Some references in **Fig. 1** are shown at the rear of the equalizer arm. For clarity, they have been omitted at the front of the equalizer arm.

5. Slide the spring forward until it clears the equalizer arm. Lift the spring assembly at the rear to clear the equalizer arm; then, slide the spring to the rear and remove it.

Forward Rear Spring Installation

1. Locate the spring in the front spring bracket and slide it forward until the rear of the spring is in position to clear the equalizer arm.
2. Slide the spring rearward into position in the equalizer arm.
3. Install the rebound bolts, washers, spring rollers, and nuts in the front spring bracket and in the equalizer arm. There is no nut on the rebound bolt in the front spring bracket. Tighten the fasteners 75 lbf·ft (102 N·m).
4. Place the spring assembly on the axle spring seat with the center bolt head in the locating hole of the lower spring seat.
5. Place the upper U-bolt spacer pad on top of the spring. Install the U-bolts and the U-bolt anchor plate. Install the U-bolt washers and nuts. Partially tighten the nuts until preliminary adjustment of the suspension has been made; then, tighten them in sequences shown in **Fig. 2.**
6. Install the wheels. Remove all safety stands. Remove the chocks from the tires.

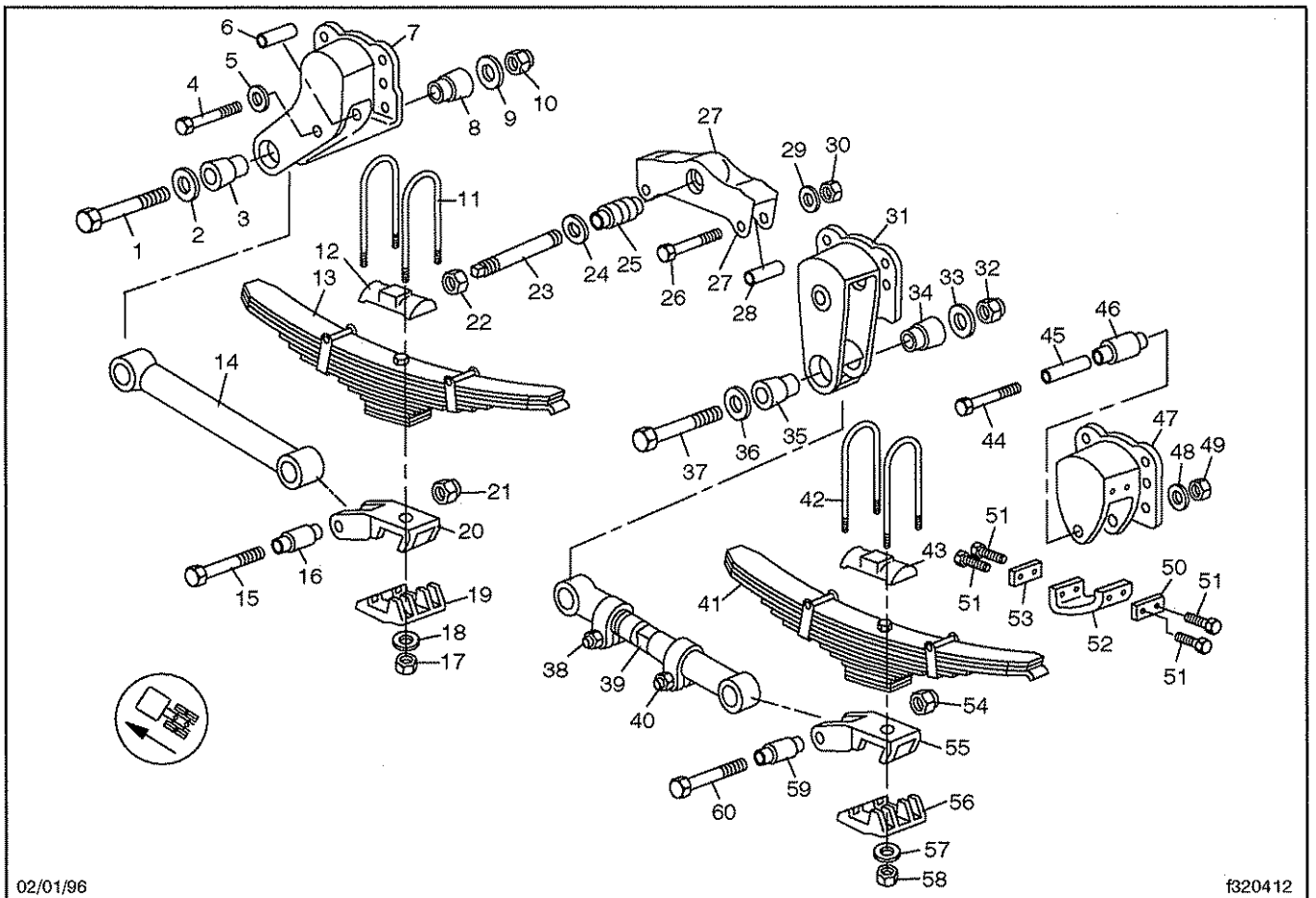
Rearmost Spring Removal

1. Park the vehicle and chock the tires.
2. Raise the vehicle and block the axles with safety stands. Raise the vehicle frame so that all weight is removed from the leaf springs, then block the frame with safety stands. Make sure the stands will support the weight of the axles and frame securely. Remove the wheel assembly to gain easy access to the suspension system.
3. Remove the U-bolt nuts and washers, the U-bolt anchor plate, the U-bolts, and the upper U-bolt spacer pad.
4. Remove the rear rebound bolt, nut, washer, spring roller, and bushing from the rear spring bracket.
5. Remove the rear rebound bolt, nut, washer, and spring roller from the equalizer arm in the equalizer bracket.
6. Slide the spring rearward until it clears the equalizer arm. Lift the spring assembly at the front to clear the equalizer arm and remove the spring.

Rearmost Spring Installation

1. Locate the spring in the front spring bracket and slide it to the rear until the front of the spring is in position to clear the equalizer arm.
2. Slide the spring forward into position in the equalizer arm.
3. Install the rebound bolts, washers, and spring rollers in the rear spring bracket and in the equalizer arm. Tighten the nuts 75 lbf·ft (102 N·m).
4. Place the spring assembly on the axle spring seat with the center bolt head in the locating hole of the lower spring seat.
5. Place the upper U-bolt spacer plate on top of the spring. Install the U-bolts and the U-bolt anchor

Spring Removal and Installation, Reyco



1. Radius Rod Eye Bolt
2. Flatwasher
3. Rubber Bushing (half)
4. Rebound Bolt
5. Rebound Bolt Washer
6. Spring Roller
7. Forward Spring Bracket
8. Rubber Bushing (half)
9. Flatwasher
10. Radius Rod Eye Bolt Nut
11. U-Bolts
12. U-Bolt Pad
13. Forward Rear Spring Assembly
14. Radius Rod (rigid type)
15. Radius Rod Bolt
16. Bushing
17. U-Bolt Nut
18. U-Bolt Washer
19. U-Bolt Anchor Plate
20. Forward Axle Seat
21. Locknut
22. Pivot Shaft Nut
23. Pivot Shaft
24. Lockwasher
25. Pivot Shaft Bushing
26. Rebound Bolt
27. Equalizer Arm
28. Spring Roller
29. Rebound Bolt Washer
30. Rebound Bolt Nut
31. Equalizer Bracket
32. Radius Rod Eye Bolt Nut
33. Flatwasher
34. Rubber Bushing (half)
35. Rubber Bushing (half)
36. Flatwasher
37. Radius Rod Eye Bolt
38. Capscrew, Washer, and Nut
39. Radius Rod (adjustable type)
40. Capscrew, Washer, and Nut
41. Rearmost Spring Assembly
42. U-Bolts
43. U-Bolt Pad
44. Rebound Bolt
45. Spring Roller
46. Bushing
47. Rear Spring Bracket
48. Rebound Washer
49. Rebound Bolt Nut
50. Clamp Plate
51. Capscrew
52. Plastic Pad
53. Clamp Plate
54. Lock Nut
55. Rearmost Axle Seat
56. U-Bolt Anchor Plate
57. U-Bolt Washer
58. U-Bolt Nut
59. Bushing
60. Radius Rod Bolt

Fig. 1, Reyco Suspension (exploded view)

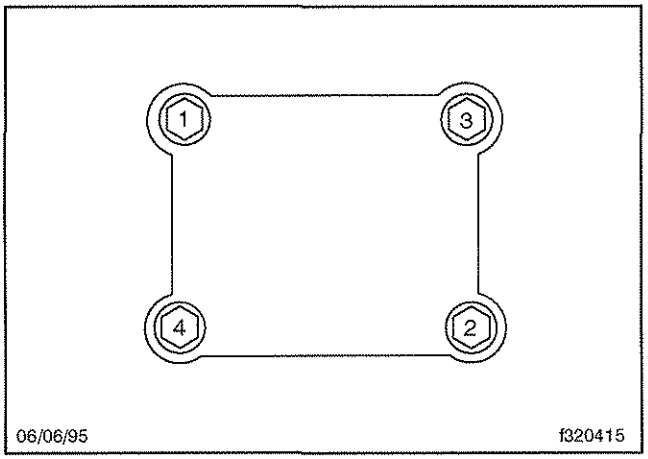


Fig. 2, U-Bolt Tightening Sequence

plate. Install the U-bolt washers and nuts. Partially tighten the nuts until preliminary adjustment of the suspension has been made; then, tighten them in the sequence as shown in **Fig. 2.**

6. Install the wheels. Remove all safety stands. Remove the chocks from the tires.

Spring Disassembly, Inspection, and Assembly, Reyco

Disassembly, Inspection, and Assembly

1. To disassemble, use chalk or a grease pencil to make a mark down the side of the spring pile so the spring leaves can be assembled in the same relative position.
2. Anchor the spring at a point near the center bolt in a vise or arbor press. Tighten the vise or arbor press firmly.
3. Remove the bolts, nuts, and sleeve from the spring clips. Observe the spring leaves. Pay special attention to the top three leaves, since the spring easily can be assembled incorrectly even though reference marks are used.
4. Prior to inspection, wash all parts in a suitable solvent. Remove any scale, rust, or deposits from the spring leaves.
5. Inspect all the leaves for breaks and small cracks. If any are found, replace the entire spring assembly.

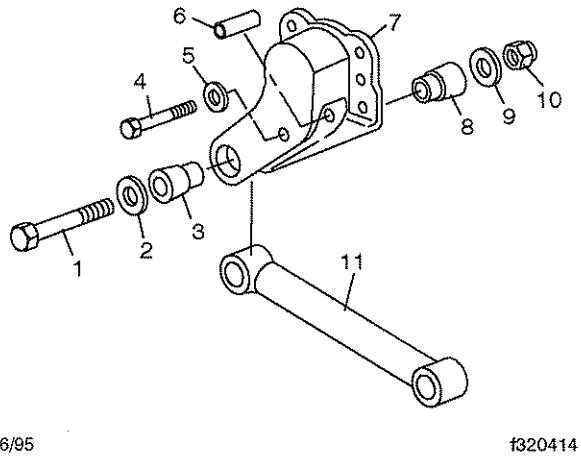
WARNING: Do not replace individual leaves of a damaged leaf spring assembly; replace the complete spring assembly. Visible damage (cracks or breaks) to one leaf causes hidden damage to other leaves. Replacement of only the visibly damaged part(s) is no assurance that the spring is safe. Failure to replace a damaged spring assembly could cause an accident resulting in serious personal injury or property damage.

6. Inspect the spring assembly for loose or broken rebound clips. Rebound clips should be tight enough to hold the spring leaves in alignment, but not tight enough to restrict the free movement of the leaves.
7. Inspect the center bolt for distortion and wear. Replace the bolt if it is not in good condition.
8. Inspect the U-bolts and spring spacer plates. Replace them if they are damaged or cracked.
9. Inspect the spring brackets at the reinforcing webs and in the corners. Do not weld or braze cracks. If the bracket is cracked, replace it.
10. For assembly, stack the spring leaves using care to position them in the proper sequence.
11. Using a long punch or other suitable tool, align the center bolt holes. Anchor the spring at a point near the center bolt hole in a vise or arbor press. Tighten the vise or arbor press firmly. Remove the alignment tool.
12. Install the center bolt and nut. Tighten the nut 70 lbf·ft (95 N·m) and peen the end of the bolt.
13. Install the bolts, nuts, and spacer sleeves to the spring clips. Tighten the nuts firmly. Peen the ends of the bolts.
14. Remove the assembly from the vise or arbor press.

Spring Bracket Removal and Installation, Reyco

Bracket Removal and Installation

1. To remove the forward spring bracket, raise the frame until all weight is off the spring, and safely block it in position.
2. Remove the rebound bolt, washer, and spring roller from the front spring bracket. **See Fig. 1.**
3. Remove the radius rod eye bolt nut and large flatwasher from the eye bolt.
4. Using a brass drift, drive the eye bolt with the remaining flatwasher from the spring bracket. Secure the radius rod to the spring.
5. Using a brass drift inside the rubber bushing, drive out one half of the bushing. Reverse the position of the drift and drive out the other half of the bushing from the opposite side of the bracket.
6. Remove all the bolts, nuts, and washers securing the spring bracket to the frame.
7. Remove the spring bracket and spacer plate, moving it away from the spring end and lifting it straight up from the frame.

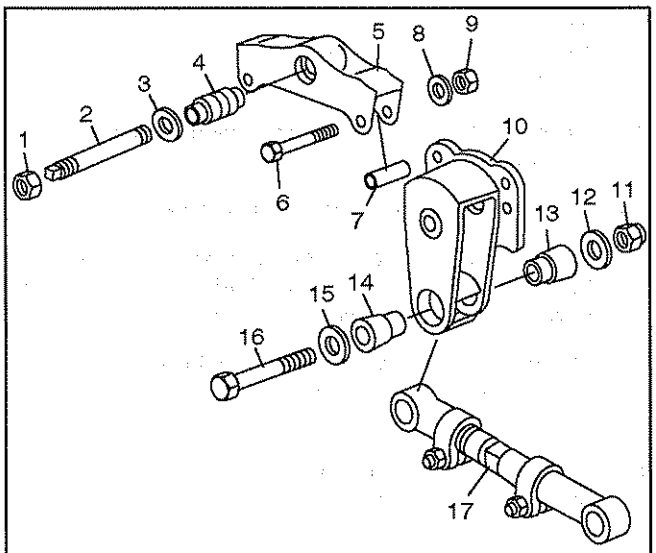


1. Radius Rod Eye Bolt
2. Flatwasher
3. Rubber Bushing (half)
4. Rebound Bolt
5. Rebound Bolt Washer
6. Spring Roller
7. Forward Spring Bracket
8. Rubber Bushing (half)
9. Flatwasher
10. Radius Rod Eye Bolt Nut
11. Radius Rod

Fig. 1, Forward Spring Bracket Assembly

8. To remove the rear spring bracket, raise the frame until all weight is off the spring, then safely block it in position.
9. Remove the bolts, nuts, and washers that secure the rear spring bracket to the frame.
10. Remove the spring bracket and spacer plate.
11. To remove the equalizer bracket (center spring bracket), raise the frame until all weight is off the spring, then safely block it in position.
12. Remove the rebound nuts, washers, bolts, and spring rollers from the ends of the equalizer arm. **See Fig. 2.**
13. Remove the radius rod eye bolt nut and large flatwasher from the eye bolt.
14. Using a brass drift, drive the eye bolt with the remaining flatwasher from the equalizer bracket.
15. Secure the radius rod to the spring.
16. Using a brass drift inside the rubber bushing, drive out one half of the bushing. Reverse the position of the drift and drive out the other half of the bushing from the opposite side of the bracket.
17. Remove the equalizer pivot nut, lockwasher, and shaft.
18. Slide the equalizer back and forth as necessary to gain access to the mounting bracket bolts.
19. Remove all the bolts, nuts, and washers that secure the equalizer bracket to the frame.
20. Remove the equalizer bracket and the spacer plate.
21. To install spring or equalizer brackets, reverse the removal procedure. Make sure the spacer plates are installed between the frame and bracket. Check the axle alignment and correct it if necessary, before tightening the radius rod eye bolt nuts to the final torque.

Spring Bracket Removal and Installation, Reyco



1. Pivot Shaft Nut
2. Pivot Shaft
3. Lockwasher
4. Pivot Shaft Bushing
5. Equalizer Arm
6. Rebound Bolt
7. Spring Roller
8. Rebound Bolt Washer
9. Rebound Bolt Nut
10. Equalizer Bracket
11. Radius Rod Eye Bolt Nut
12. Flatwasher
13. Rubber Bushing (half)
14. Rubber Bushing (half)
15. Flatwasher
16. Radius Rod Eye Bolt
17. Radius Rod

Fig. 2, Equalizer Arm and Bracket Assembly

Radius Rod and Radius Rod Bushing Replacement, Reyco

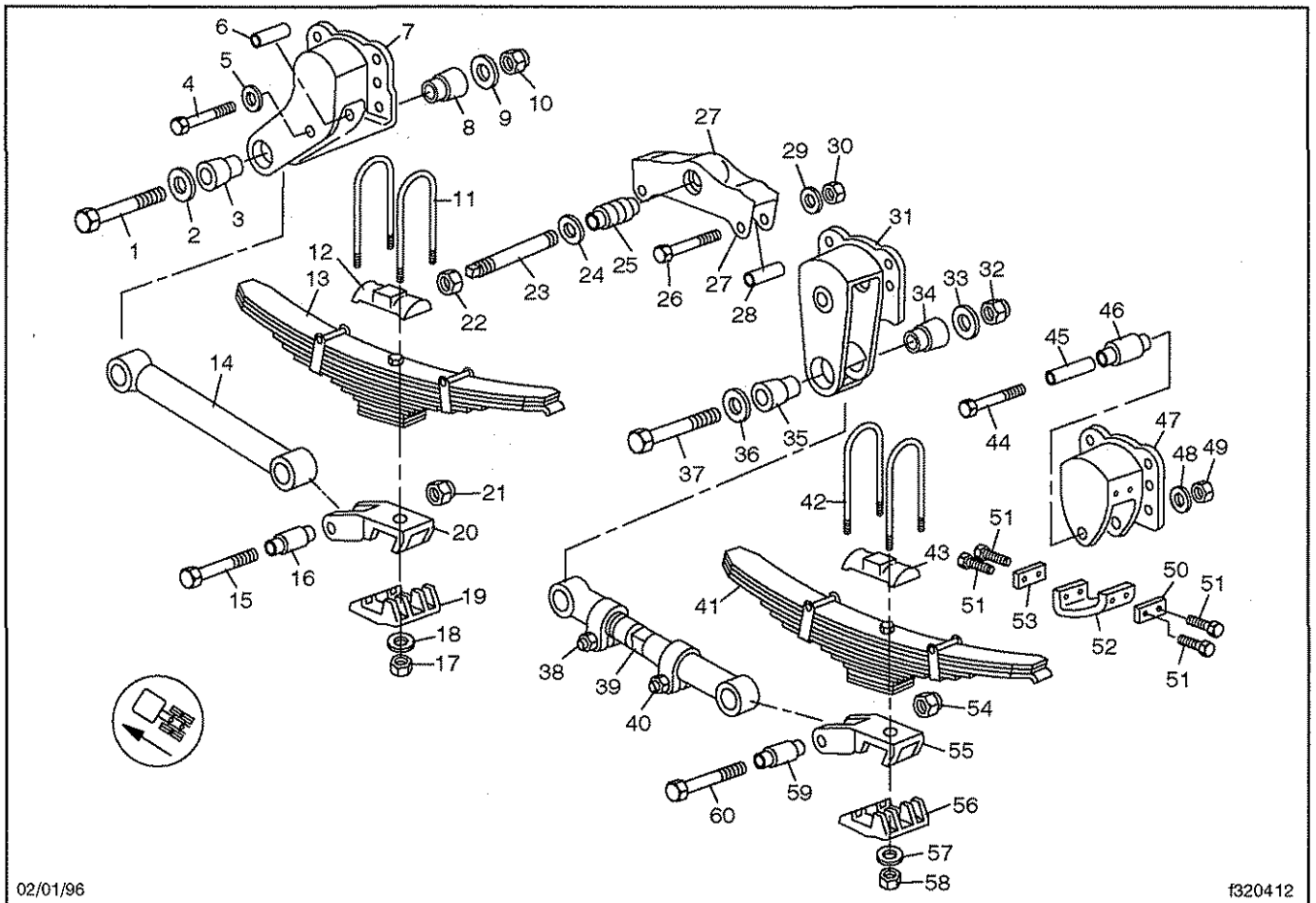
Radius Rod Replacement

1. Raise the frame until all weight is off the spring, then safely block the frame in position.
2. Remove the locknut, washer (if so equipped), and bolt from the radius rod at the axle seat. Lower the rod. **See Fig. 1.**
3. Remove the nut and large flatwasher from the radius rod eye bolt. Using a brass drift tool, drive the eye bolt with the remaining flatwasher from the forward spring bracket or equalizer bracket.
4. Using a brass drift inside the rubber bushing, drive out one half of the bushing. Reverse the position of the drift and drive out the other half of the bushing from the opposite side of the bracket.
5. Remove the radius rod.
6. Place the eye of the new radius rod into the front spring or equalizer bracket.
7. Install both halves of the rubber eccentric bushing into the bracket from the outside with the flat of the bushing insert pointing down or the arrow pointing up.
8. Install the large flatwasher onto the radius rod eye bolt and insert the bolt into the bushing with the arrow on the bolt head pointing up.
9. Install the large flatwasher and the nut on the radius rod eye bolt. Tighten the nut, but not to its final torque.
10. Check the axle alignment and adjust it if necessary.
11. After the adjustment has been made, lower the vehicle and tighten the radius rod eye bolt nut to the applicable torque value in **Specifications, 400.**

Radius Rod Bushing Replacement

1. Raise the frame until all weight is off the spring, then safely block the frame in position.
2. Remove the radius rod as follows:
   - 2.1 Remove the locknut, washer (if so equipped), and bolt from the radius rod at the axle seat. Lower the rod. **See Fig. 1.**
   - 2.2 Remove the nut and large flatwasher from the radius rod eye bolt. Using a brass drift tool, drive the eye bolt with the remaining flat washer from the front spring or equalizer bracket.
   - 2.3 Using a brass drift inside the rubber bushing, drive out one half of the bushing. Reverse the position of the drift and drive out the other half of the bushing from the opposite side of the bracket.
   - 2.4 Remove the radius rod.
3. Press the old bushing out of the radius rod.
4. Coat the new bushing with a rubber lubricant and press it in so that the bushing is equal on both sides of the rod.
5. Install the radius rod as follows:
   - 5.1 Place the eye of the radius rod into the front spring or equalizer bracket.
   - 5.2 Install both halves of the rubber eccentric bushing into the bracket from the outside with the flat of the bushing insert pointing down or the arrow pointing up.
   - 5.3 Install the large flatwasher onto the radius rod eye bolt and insert the bolt into the bushing with the arrow on the bolt head pointing up.
   - 5.4 Install the large flatwasher and the nut on the radius rod eye bolt. Tighten the nut, but not to its final torque.
6. Check the axle alignment and adjust it if necessary.
7. After the adjustment has been made, lower the vehicle and tighten the radius rod eye bolt nut to the applicable torque value in **Specifications, 400.**

Radius Rod and Radius Rod Bushing Replacement, Reyco



1. Radius Rod Eye Bolt
2. Flatwasher
3. Rubber Bushing (half)
4. Rebound Bolt
5. Rebound Bolt Washer
6. Spring Roller
7. Forward Spring Bracket
8. Rubber Bushing (half)
9. Flatwasher
10. Radius Rod Eye Bolt Nut
11. U-Bolts
12. U-Bolt Pad
13. Forward Rear Spring Assembly
14. Radius Rod (rigid type)
15. Radius Rod Bolt
16. Bushing
17. U-Bolt Nut
18. U-Bolt Washer
19. U-Bolt Anchor Plate
20. Forward Rear Axle Seat
21. Locknut
22. Pivot Shaft Nut
23. Pivot Shaft
24. Lockwasher
25. Pivot Shaft Bushing
26. Rebound Bolt
27. Equalizer Arm
28. Spring Roller
29. Rebound Bolt Washer
30. Rebound Bolt Nut
31. Equalizer Bracket
32. Radius Rod Eye Bolt Nut
33. Flatwasher
34. Rubber Bushing (half)
35. Rubber Bushing (half)
36. Flatwasher
37. Radius Rod Eye Bolt
38. Capscrew, Washer, and Nut
39. Radius Rod (adjustable type)
40. Capscrew, Washer, and Nut
41. Rearmost Spring Assembly
42. U-Bolts
43. U-Bolt Pad
44. Rebound Bolt
45. Spring Roller
46. Bushing
47. Rear Spring Bracket
48. Rebound Washer
49. Rebound Bolt Nut
50. Clamp Plate
51. Capscrew
52. Plastic Pad
53. Clamp Plate
54. Lock Nut
55. Rearmost Axle Seat
56. U-Bolt Anchor Plate
57. U-Bolt Washer
58. U-Bolt Nut
59. Bushing
60. Radius Rod Bolt

Fig. 1, Reyco Suspension (exploded view)

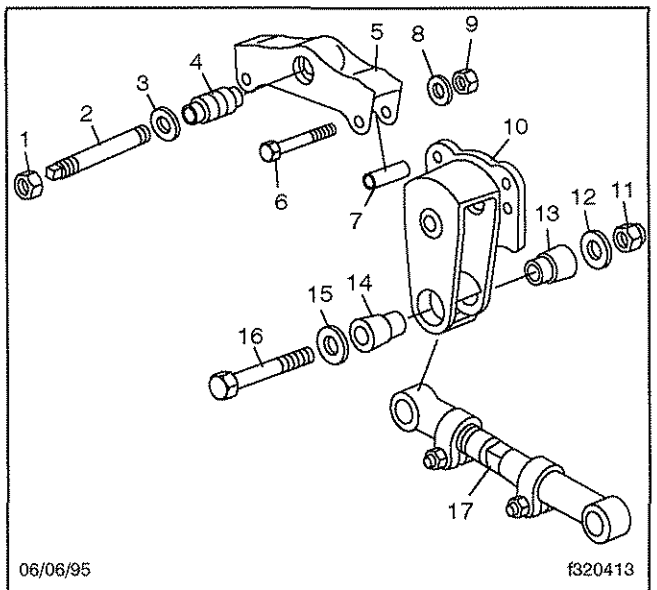
Equalizer Arm Bushing Replacement, Reyco

Replacement

1. Raise the frame until all the weight is off the springs, then safely block the frame into position.
2. Remove the rebound nuts, washers, bolts, and spring rollers from the ends of the equalizer arm. **See Fig. 1.**

NOTE: For clarity, only one of each of the rebound components is shown, even though two are used on the equalizer arm.

3. Remove the nut and large flatwasher from the radius rod eye bolt. Using a brass drift, drive the eye bolt with the remaining flatwasher from the equalizer bracket.
4. Secure the radius rod to the spring.
5. Remove the equalizer pivot nut, washer, and shaft.



1. Pivot Shaft Nut
2. Pivot Shaft
3. Lockwasher
4. Pivot Shaft Bushing
5. Equalizer Arm
6. Rebound Bolt
7. Spring Roller
8. Rebound Bolt Washer
9. Rebound Bolt Nut
10. Equalizer Bracket
11. Radius Rod Eye Bolt Nut
12. Flatwasher
13. Rubber Bushing (half)
14. Rubber Bushing (half)
15. Flatwasher
16. Radius Rod Eye Bolt
17. Radius Rod

Fig. 1, Equalizer Arm and Bracket Assembly

6. Move the equalizer arm forward over the forward rear spring. Raise the frame. Slide the equalizer arm rearward through the bracket, then up and out.
7. Using a suitable press, press out the equalizer bushing.
8. Coat the new bushing with a rubber lubricant.
9. Press the bushing into the equalizer arm.
10. With the frame raised and the equalizer arm properly positioned, slide the equalizer arm into the equalizer bracket and forward over the front spring assembly.
11. Lower the frame and slide the equalizer arm over the rear spring until the center hole aligns with the hole in the equalizer bracket.
12. Apply anti-seize compound to the pivot shaft threads; then, install the pivot shaft by hand in the bracket. With steel crossmembers, install the bolt with the nut inside the frame; with aluminum crossmembers, install it with the nut outside the frame. When the shaft reaches the frame rail, back it out one-half turn. Install the lockwasher and nut. Tighten the nut 975 lbf·ft (1330 N·m).
13. Install the radius rod as follows. (**See Fig. 1**):
    - 13.1 Place the radius rod eye into the equalizer bracket. Install both halves of the rubber eccentric bushing into the bracket from the outside, with the flat of the bushing insert pointing down or the arrow pointing up.
    - 13.2 Install the large flatwasher onto the radius rod eye bolt and insert the bolt into the bushing with the arrow on the bolt head pointing up.
    - 13.3 Install the large flatwasher and the nut on the bolt. Tighten the nut, but not to its final torque.
    - 13.4 Check the axle alignment and adjust it if necessary. After the adjustment has been made, lower the vehicle and tighten the radius rod eye bolt nut to the applicable torque value shown in **Specifications, 400**.
14. Install the spring rollers and rebound bolts in the equalizer arm and tighten the nuts 45 lbf·ft (61 N·m).

Axle Alignment Checking and Adjusting, Reyco

Axle Alignment Checking

Manufacturers of axle alignment equipment offer a variety of systems to precisely measure and correct rear axle alignment. If access to this type of equipment is not available, check the axle alignment using the following procedure:

1. Position the vehicle on a level surface. Using the engine, rock the vehicle back and forth several times with the brakes applied lightly. This will release any "set" of the suspension joint.
2. Obtain a piece of bar stock, angle iron, or other suitable material about 96 in (2.5 m) long. Inspect the material for straightness. The bar should be long enough to extend past the outside edge of one outside dual tire to a similar point on the opposite dual tire.
3. Measure from the center point of the equalizer bracket to any open part of the frame in front of the wheels where the bar stock can be placed across the frame. This point must be accessible for the use of C-clamps. A point in front of the forward rear axle is recommended; however, a point behind the rearmost axle will work if none is available in front of the axle.
4. Using a square, mark a chalk line across the top of the frame rail.
5. Repeat previous steps for the opposite side of the vehicle.
6. Position the bar stock across the frame rails so that it extends an equal distance beyond the frame rail on each side. Line up the bar stock with the chalk lines and secure it with C-clamps.
7. Measure the distance from the outside edge of the secured bar stock to the center of the rearmost axle shaft.
8. Repeat previous steps on the opposite side of the vehicle. Compare the measurements taken on both sides. If they are equal or vary no more than 1/8-in (3 mm), the axle alignment is correct. If the measurements differ by more than 1/8-in (3 mm), adjust the axle alignment.
9. If the rearmost axle alignment is correct, check the forward rear axle alignment as follows:
   - 9.1 Measure the distance from the rearmost axle shaft center to the center of the forward rear axle or the bar stock.
   - 9.2 Repeat the measurement for the opposite side and compare the measurements. If they are equal or vary no more than 1/8-in (3 mm), the axle alignment is correct. If the measurements differ by more than 1/8-in (3 mm), adjust the axle alignment as described above.

Axle Alignment Adjustment (Models 101 and 101A)

1. Loosen the nut on the radius rod eye bolt three full turns.
2. Using a soft brass or lead hammer to avoid damage to the eye bolt threads, tap the end of the eye bolt and the end of the rod between the front spring bracket casting. This should loosen the components so the adjustment can be made.

NOTE: The maximum adjustment on each side of the vehicle is 7/16 inch (11 mm). In most cases, the axle alignment can be corrected by adjusting one side only; however, additional adjustment can be made from the other side of the axle if necessary.

3. Jack up the frame on the side to be corrected to remove the weight from the springs.
4. To adjust the axle forward, rotate the radius rod eye bolt forward. To adjust the axle rearward, rotate the radius rod eye bolt to the rear.
5. Lower the vehicle and check the axle alignment as described above. Repeat the adjustment as needed.
6. After the final adjustment has been made, lower the vehicle and tighten the radius rod eye bolt nut to the applicable torque value in **Specifications, 400**.

Axle Alignment Adjustment (Models 102 and 102W)

1. Jack up the frame on the side to be corrected to remove the weight from the springs.

Axle Alignment Checking and Adjusting, Reyco

2. Loosen the clamp nuts on the radius rod being adjusted.
3. Using a wrench on the radius rod flats, turn the adjustable section to move the axle forward or rearward.
4. Lower the vehicle and check the axle alignment. Repeat the adjustment as needed.
5. After the adjustment has been made, lower the vehicle and tighten the radius rod clamp nuts 190 lbf·ft (258 N·m).
6. Tighten the radius rod eye bolt nuts to the applicable torque value in **Specifications, 400**.

Problem—Spring is Noisy

Possible Cause	Remedy
The U-bolts are loose.	Tighten the U-bolts to the recommended torque
The radius rod eye bushings are worn.	Replace the radius rod eye bushings.
The shock absorbers are worn or damaged.	Replace the shock absorbers.

Problem—Spring Sags or Bottoms Out

Possible Cause	Remedy
The shock absorbers are not working properly.	Replace the shock absorbers
A spring leaf is broken.	Replace the spring leaf assembly.
The vehicle is overloaded.	Check the load capacity rating and correct if needed.

Problem—Springs Break

Possible Cause	Remedy
The U-bolts are loose.	Tighten the U-bolts to the recommended torque.
The springs are experiencing normal fatigue.	Replace the springs.
The vehicle is overloaded.	Check the load capacity rating and correct if needed.

Description	Torque, lbf-ft (N.m)
Equalizer Pivot Shaft: 101A, 102	600 (814)
Equalizer Nut: 102W	975 (1330)
Equalizer Arm Rebound Bolt	45 (61)
Rebound Bolt	60-80 (80-110)
Spring Center Bolt Nut	75-80 (105-110)
Spring-Bracket-to-Frame Bolt	180 (244)
Radius Rod Clamp Nut: 101A, 5/8" bolt	125-150 (170-205)
Radius Rod Clamp Nut: 102, 5/8" bolt	125-150 (170-205)
Radius Rod Clamp Nut: 102W	175-200 (240-275)
Radius Rod Eye Bolt: 101A	160 (217)
Radius Rod Eye Bolt: 102	500-525 (670-704)
Radius Rod Eye Bolt: 102W	160-200 (220-271)
Radius Rod Bolt: 101A	250 (339)
Radius Rod Bolt: 102	200 (271)
Radius Rod Bolt: 102W	400-425 (550-580)
U-Bolt Nuts: First Stage, all models	100 (136)
U-Bolt Nuts: Second Stage, all models	200 (271)
U-Bolt Nuts: Final Stage, 101A & 102, 3/4" bolt	300-325 (407-440)
U-Bolt Nuts: Final Stage, 102W, 3/4" bolt	400 (550)

Table 1, Torque Settings

Rear Suspension, Hendrickson RT2 & RTE2 32.06

Contents

Subject	Subject Number
General Information	050
Service Operations	
Suspension Removal and Installation, RT2 & RTE2	100
Spring and Saddle Removal and Installation, RT2 & RTE2	110
Spring Leaf, Spring Pin, and Spring Eye Bushing Replacement, RT2 & RTE2	120
Equalizer Beam Removal and Installation, RT2 & RTE2	130
Equalizer Beam Rubber Center Bushing Removal and Installation, RT2 & RTE2	140
Equalizer Beam Bronze Center Bushing Removal and Installation, RT2 & RTE2	150
Torque Rod and Bushing Removal and Installation, RT2 & RTE2	160
Specifications	400

General Description

The Hendrickson RT2 series suspension (**see Fig. 1**) uses leaf springs to lessen road shocks. The forward and rear ends of the spring assembly ride in hangers. At the forward end, the springs are attached to the hanger with pins. At the rear end, the springs have no rigid attachment to the hangers, and are free to move forward and backward to compensate for spring deflection.

The RTE2 series suspension is basically the same as the RT2 suspension. However, the RTE2 series uses a different spring assembly and a third spring hanger. This design provides a two-stage spring rate, depending on vehicle load condition. When the vehicle is unloaded, a gap exists between the top spring leaf and the no. 2 spring hanger. The weight of the vehicle is then carried through the no. 3 spring hanger, and most of the spring deflection through the top extended leaves. When the vehicle is loaded, the top extended leaf contacts the no. 2 spring hanger and the spring weight is carried through the nos. 1 and 2 spring hangers.

The RTE2A series suspension is similar to the RTE2 suspension, but the RTEA series uses aluminum equalizer beams instead of steel.

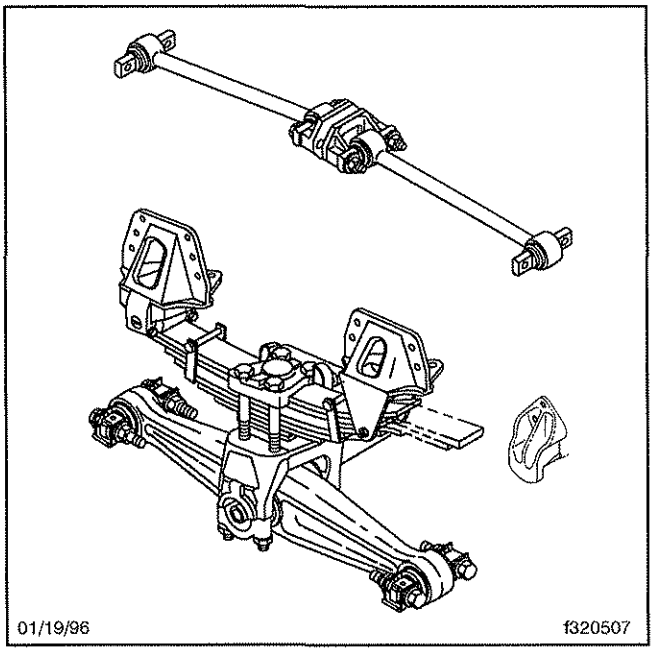


Fig. 1, RT2 and RTE2 Series Suspension

CAUTION: Failure to apply Alumilastic® compound, or an equivalent, to areas where aluminum and steel parts contact each other, could lead to corrosion of the metals, resulting in damage to the components or parts.

The axles are attached to beam hangers at the ends of the equalizer beams, allowing an articulating action between the axles to lessen road shock. Torque rods, mounted between the axles and frame rails, stabilize axle and vehicle movement caused by accelerating and braking.

All suspension fasteners require periodic tightening. For suspension inspecting, lubricating, and fastener torque checking instructions, refer to **Group 32** in the vehicle maintenance manual.

WARNING: Periodically, torque the suspension fasteners. Failure to do so could result in damage to the frame hangers or separation of components. This could cause a loss of vehicle control, resulting in injury or property damage.

Suspension Removal and Installation, RT2 & RTE2

Removal (See Fig. 1)

1. Chock the front tires.
2. Drain the vehicle air system.
3. Disconnect all air lines leading to the rear axles, marking the lines for later assembly.

   Plug or cap all lines and fittings to prevent dirt from entering the system.
4. Disconnect the driveline rear universal joint from the forward-rear axle. Then, remove the interaxle driveline. For instructions, see **Group 41**.
5. Manually release the spring brake chambers. For instructions, see **Group 42** .

⚠ WARNING

When the torque rods are disconnected from the axle brackets, the axles become free to pivot on the equalizer beam end bushings. Keep clear of the beam hangers and beam ends to avoid possible injury.

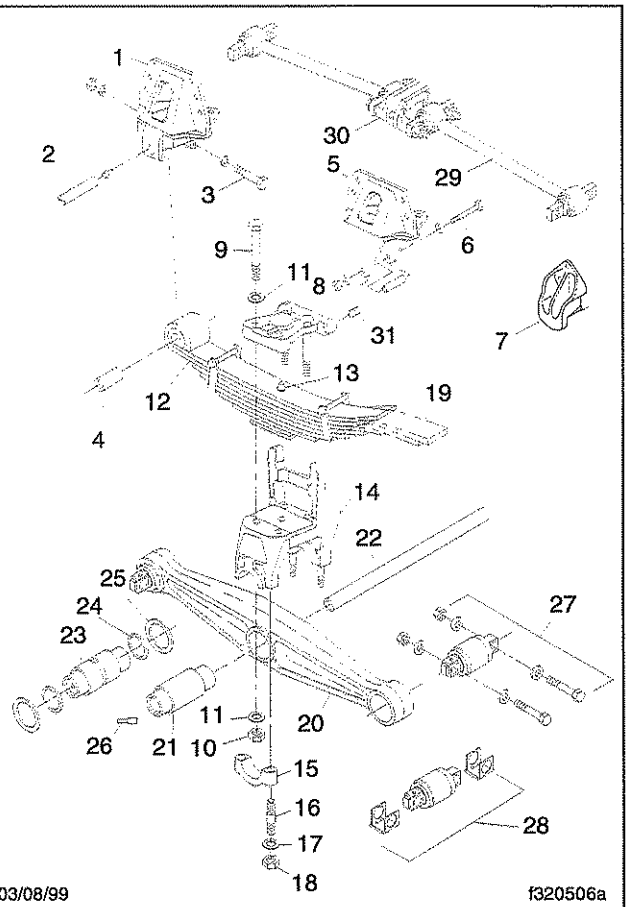
6. Remove the torque rods. For instructions, see **Subject 160**.
7. Raise the rear of the vehicle so that all weight is removed from the suspension. Then, block the axles and the frame with safety stands. Make sure the stands will securely support the weight of the axles and the frame.

NOTE: Do not raise the vehicle to the point where the weight of the suspension and axles hangs from the vehicle.

8. Remove the saddle cap nuts and washers from each side of the vehicle, and remove the saddle caps.

NOTE: If the saddle cap studs are damaged, replace them.

9. Raise the rear of the vehicle frame until there is enough clearance to roll the axles out from under the vehicle. Install safety stands under the frame, then roll the axles—with the equalizer beams attached—out from under the vehicle.



1. Forward Spring Hanger
2. Spring Pin
3. Lock Bolt
4. Spring Eye Bushing
5. Rear Spring Hanger
6. Set Screw
7. Spring Hanger (RTE2 suspension)
8. Top Pad
9. Top Pad Bolt
10. Nut
11. Washer
12. Spring Assembly
13. Spring Center Bolt and Nut
14. Saddle
15. Saddle Cap
16. Saddle Cap Stud
17. Washer
18. Locknut
19. Spring (RTE2 suspension)
20. Equalizer Beam
21. Rubber Center Bushing
22. Cross Tube
23. Bronze Center Bushing
24. Bushing Grease Seal
25. Thrustwasher
26. Grease Fitting
27. Bar Pin Bushing (non-shim type)
28. Bar Pin Bushing (shim type)
29. Torque Rod
30. Torque Rod Frame Bracket
31. Set Screw

Fig. 1, RT2 and RTE2 Series (exploded view)

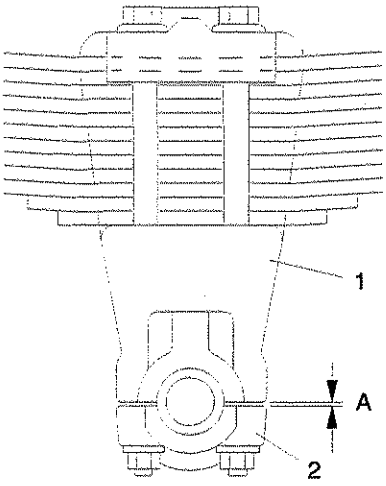
Suspension Removal and Installation, RT2 & RTE2

Installation

1. Roll the axles under the vehicle frame. Align the center bushing of each equalizer beam with the center of the saddle legs.
2. Raise the vehicle frame off the safety stands, then remove the safety stands.
3. Lower the frame, centering the saddles on the beam center bushings.
4. Lubricate the saddle cap studs with SAE 20 oil. Install the saddle caps, washers and new self-locking nuts. Do not tighten.
5. Install the torque rods. For instructions, see **Subject 160**.
6. Tighten the saddle cap locknuts 225 to 275 lbf·ft (305 to 373 N·m).

NOTE: Maintain an even gap between the saddle cap and the saddle when tightening the self-locking nuts (see **Fig. 2**).

7. Remove the safety stands from under the frame and axle, and lower the vehicle.
8. Manually reset the spring brake chambers. For instructions, see **Group 42**.
9. Connect the driveline rear universal joint to the forward-rear axle. Connect the interaxle driveline. For instructions, see **Group 41**.
10. Uncap all air lines and fittings, then connect the lines leading to the rear axles.
11. Check the axle pinion angle. For instructions, see **Group 41**.



A. Maintain an even gap
1. Saddle
2. Saddle Cap

Fig. 2, Tightening Self-Locking Nuts

Spring and Saddle Removal and Installation, RT2 & RTE2

Removal

1. Remove the suspension. For instructions, **refer to Subject 100**.
2. Support the spring and saddle assembly with a floor jack.
3. Remove the locknuts from the spring pin lockbolts; then remove the lockbolts and washers from the number one spring hanger.
4. Using a suitable drift, drive the spring pin through the no. 1 spring hanger and out the inboard side of the spring hanger (**see Fig. 1**).
5. Remove the locknut and lockwasher from the rebound spacer bolt in the no. 2 spring hanger. Remove the rebound spacer bolt and the spacer.

WARNING: The leaf spring assembly is heavy. Use care when handling it to prevent injury.

6. Lower the spring and saddle assembly from the spring hangers.
7. Loosen the spring alignment setscrews on the top pad. Remove the top pad nuts, washers, and bolts.
8. Remove the top pad from the spring assembly, then remove the spring from the saddle.

Installation

1. Seat the leaf spring assembly on the saddle.

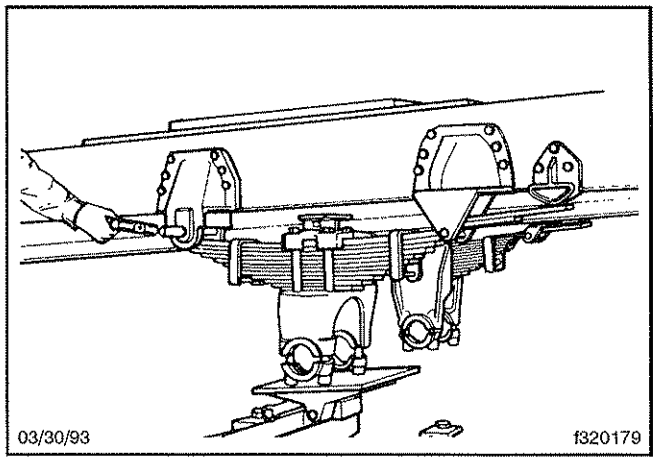


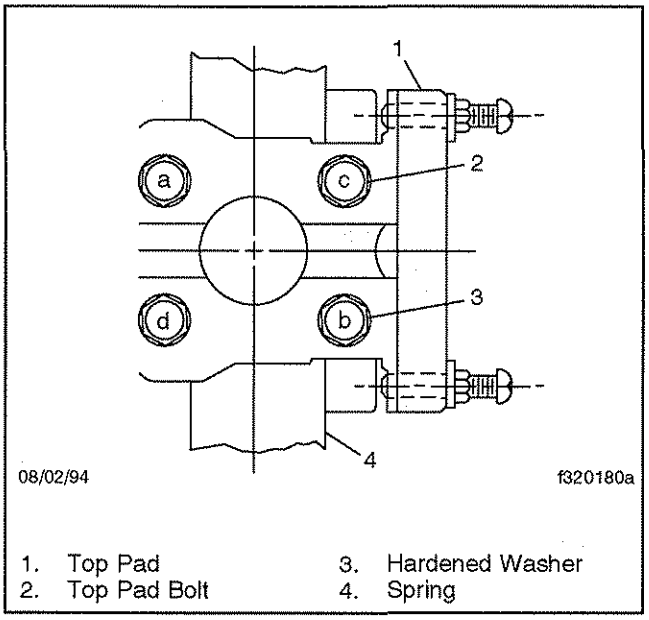
Fig. 1, Spring Hanger

2. Position the top pad on the spring assembly. Check that the top pad is properly seated.

NOTE: The main leaf has a cup that is forged upward at the center bolt. This cup serves as a pilot when installing the top pad, and ensures correct alignment of the spring assembly.

3. Lubricate the threads on the top pad bolts with SAE 20 oil, then install the washers and bolts through the top pad and saddle. Install new nuts and washers finger-tight. Do not tighten at this time.
4. Lubricate the threads on the spring setscrews with SAE 20 oil. Hand-tighten the spring setscrews against the leaf springs. Tighten the setscrews 100 to 150 lbf·ft (135 to 203 N·m), then tighten the setscrew locknuts until the lockwasher is locked.
5. Tighten the top pad nuts 275 to 400 lbf·ft (373 to 542 N·m). Use the tightening sequence **shown in Fig. 2**.
6. Position the spring and saddle assembly into the no. 1 and no. 2 spring hangers.
7. Coat the spring pin and the inside diameter of the spring eye bushing with multipurpose chassis grease.
8. Align the spring pin with the spring eye bushing in the forward spring hanger.
9. From the outboard side of the spring hanger, tap the spring pin into the bushing with a soft hammer. If necessary, adjust the spring to assist spring pin entry.
10. Place washers on the spring pin lockbolts, and insert the lockbolts through the spring hanger. If necessary, use a screwdriver to turn the spring pin until the lockbolts can slide past it.
11. Lubricate the lockbolt threads with SAE 20 oil. Install the lockwashers and locknuts. Tighten the locknuts 45 to 63 lbf·ft (61 to 85 N·m).
12. Position the rebound spacer in the no. 2 spring hanger leg, then install the rebound spacer bolt, lockwasher, and locknut. Tighten the locknut 38 to 45 lbf·ft (51 to 61 N·m).
13. Install the grease fittings in both spring eye pins. Apply multipurpose chassis grease to the grease

Spring and Saddle Removal and Installation, RT2 & RTE2



1. Top Pad
2. Top Pad Bolt
3. Hardened Washer
4. Spring

Fig. 2, Top Pad Bolt Tightening Sequence

fittings until grease appears on both sides of the spring eye bushings.

14. Install the suspension. **Refer to Subject 100** for instructions.

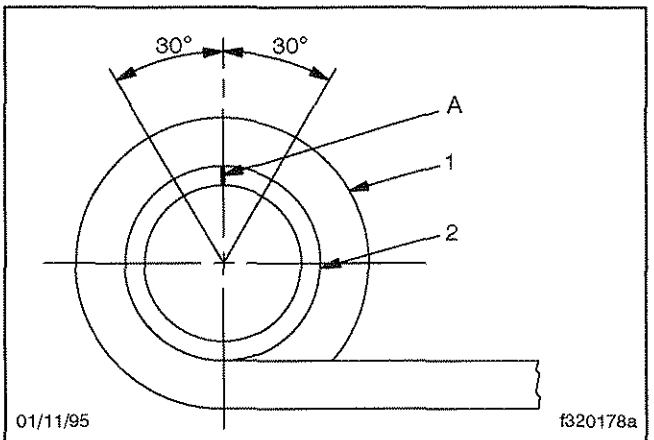
Spring Leaf, Spring Pin, and Spring Eye Bushing Replacement, RT2 & RTE2

Replacement

1. Remove the spring and saddle assembly. For instructions, **refer to Subject 110**.
2. Using a C-clamp to hold the spring leaves together, remove the center bolt and nut, and the spring alignment clips. Remove the C-clamp and separate the leaves.
3. Using a wire brush and solvent, clean all grease, dirt, and rust from the spring leaves. Inspect the spring leaves for cracks, gouges, wear, or abnormal bends. The no. 1 main and no. 2 wrapper spring leaves (the top two spring leaves) may each be replaced; if equipped with the RTE series suspension, the nos. 1, 2, and 3 spring leaves (the top three spring leaves) may each be replaced. If a spring leaf is damaged below these numbers in a pack, replace the spring assembly. Replace both spring assemblies to ensure even spring deflection.
4. Inspect the spring pin and spring eye bushing for wear or damage. If the pin diameter is less than 1.367 inch, replace it. If the inside diameter of the spring eye bushing is more than 1.395 inch, replace it.

NOTE: If necessary, press out the bushing with a hydraulic press. Install the new bushing with the split of the bushing positioned at the top (30 degrees) of the spring eye (**see Fig. 1**).

5. Position the spring leaves in order, then insert a drift through the center bolt hole to align the leaves.
6. Compress the leaves with a C-clamp, then install the spring alignment clips on the spring leaves. Install the spring alignment clip nuts and bolts. Tighten the nuts 15 lbf·ft (20 N·m).
7. Remove the drift punch. At the bottom of the spring, insert a new center bolt. Install a new center bolt nut and tighten to the value in the table under **Specifications, 400**.
8. Install the spring and saddle assembly. For instructions, refer to **Subject 110**.



A. Split

1. Main Spring Plate 2. Spring Eye Bushing

Fig. 1, Bushing Split Position

Equalizer Beam Removal and Installation, RT2 & RTE2

Removal

1. Chock the front tires.
2. Remove the saddle cap nuts and washers, then remove the saddle cap. Support the equalizer beam with safety stands.
3. Raise the rear of the vehicle until the saddle studs clear the equalizer beam. Block the axles and frame with safety stands.
4. Remove the wheels and tires. For instructions, refer to **Group 40**.
5. Remove the brake shoes, brake spider, and brake backing plate (dust shield). Refer to **Group 42** for instructions.
6. Apply a penetrating oil to all beam end connections.
7. Remove the bar pins.

NOTE: The bar pin-style beam end connection is a rubber bushing assembly consisting of a rubber insert, and outer metal tube and and inner casting. It is fastened to the axle by two 1-inch (25 mm) bolts and locknuts. The bolts are positioned parallel to the vehicle's longitudinal axis making removal and installation easy.

WARNING: Don't use a cutting torch to remove the equalizer beams from the beam hangers. The equalizer beams are heat-treated, and using a cutting torch could weaken them, causing them to break. This could result in a loss of vehicle control, possible personal injury and property damage.

8. Remove the ends of the equalizer beams from the axle beam hangers.
9. Lower the equalizer beams and the crosstube to the ground. Remove the thrustwashers and pull the beams from the crosstube.

Installation

1. Install the crosstube and thrustwashers in both equalizer beam center bushings.

   Install the bar pins, then install the crosstube and thrustwashers in both equalizer beam center bushings.

2. Position the equalizer beam assembly under the axles, then raise the assembly and place the forward ends of each beam in the forward-rear axle beam hangers. Align the beam end bushings with the beam hangers.
3. Place the rear ends of each beam in the rearmost axle beam hangers. Align the beam end bushings with the beam hangers.
4. Position the saddle caps on the saddle cap studs, then install the washers and new self-locking nuts. Tighten the nuts 225 to 275 lbf·ft (305 to 373 N·m).
5. Install the bar pin bolt locknuts, and tighten 450 to 600 lbf·ft (610 to 813 N·m).

WARNING: Tighten the bar pin locknuts to the specified torque values. Otherwise, component wear will occur. This could result in separation of suspension components, loss of vehicle control, and possible injury or property damage.

6. Install the brake backing plate (dust shield), brake spider, and brake shoes. Refer to **Group 42** for instructions.
7. Install the wheels and tires. For instructions, refer to **Group 40**.

Equalizer Beam Rubber Center Bushing Removal and Installation, RT2 & RTE2

Removal

NOTE: If using Owatonna tools, removal of the equalizer beam is not required for removal or installation of the rubber center bushing.

1. Chock the front tires.
2. Raise the rear of the vehicle so that all weight is removed from the suspension. Block the axles and the frame with safety stands. Make sure the stands will securely support the weight of the axles and the frame.

NOTE: Do not raise the vehicle to the point where the weight of the suspension and axles hangs from the vehicle.

3. Remove the saddle cap nuts and washers from each side of the vehicle, and remove the saddle caps.
4. Raise the rear of the truck frame until the saddle studs clear the equalizer beam. Install safety stands under the frame.
5. Using a 2-1/2 inch diameter hole saw (**see Fig. 1**), cut out the end plug from the center bushing on each side of the suspension, and remove the crosstube.
6. On the inboard side of the equalizer beam, inspect the exposed edge of the bushing's outer sleeve.
7. Chisel or grind off any portion of the outer sleeve that has flared over the surface of the equalizer beam.
8. If using Owatonna tools, remove the rubber center bushings as follows (**see Fig. 2**):
   - 8.1 Position the hydraulic ram and slide the pulling screw through the center bushing.
   - 8.2 Install the center bushing removing adapter on the inboard side of the beam eye.

   IMPORTANT: Align the receiving tube so that the bushing will clear the edges of the tube when force is exerted against the beam. Align the removing adapter so that force is exerted only on the bushing to ensure a clean pull through the beam.
   - 8.3 Install the hexnut on the pulling screw. Full thread engagement is needed.
   - 8.4 Install spacers between the ram cylinder and the speed nut. Tighten the speed nut and remove any slack in the assembly.
   - 8.5 Connect a hydraulic pumping unit to the ram and apply force until the ram cylinder reaches its stroke limit.
   - 8.6 Release the pressure, add spacers, and tighten the speed nut. About three adjustments are needed to completely remove the bushing.

   NOTE: If the pressure gauge on the hydraulic pumping unit reads 10,000 psi (68 950 kPa) and the bushing has not broken loose, stop and check the alignment of the receiving tool and removal adapter. If both tools are aligned correctly, attach a sledging adapter on the speed nut end of the pulling screw. Maintaining hydraulic pressure, strike the sledging adapter with a heavy hammer. A loud noise followed by a sudden drop of the pressure gauge reading indicate that the bushing has broken loose.
9. If using shop-made adapters, remove the equalizer beams. For instructions, refer to **Subject 130**.
   - 9.1 Position the equalizer beam on a 50-ton vertical hydraulic press.

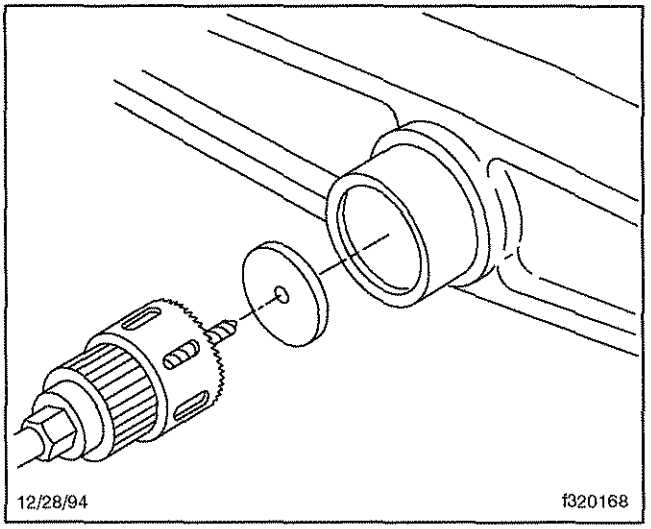
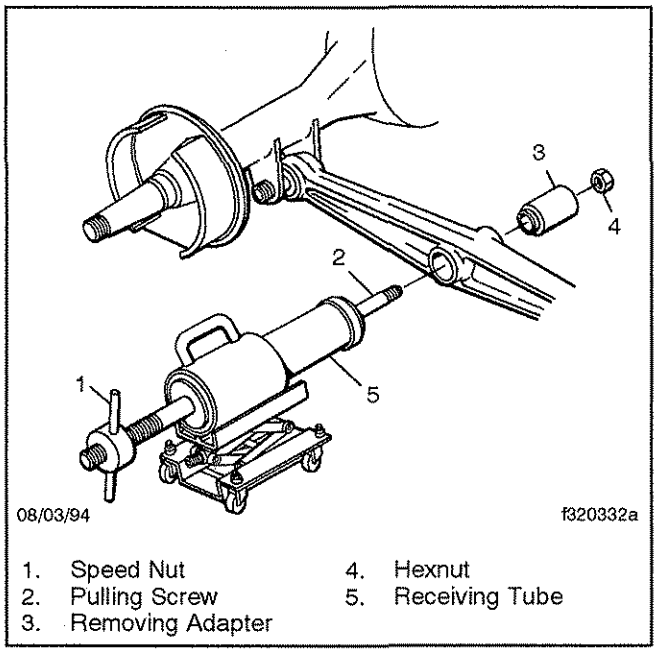


Fig. 1, Removing End Plug

Equalizer Beam Rubber Center Bushing Removal and Installation, RT2 & RTE2



1. Speed Nut
2. Pulling Screw
3. Removing Adapter
4. Hexnut
5. Receiving Tube

Fig. 2, Removal of Rubber Center Bushing

9.2 Center the shop-made adapter (refer to the table under **Specifications, 400**) on the trimmed end of the equalizer beam bushing. Press the center bushing from the beam eye.

Installation

1. Using emery cloth, remove all scale, rust, or corrosion from the beam eyes. Inspect the equalizer beam eyes for cracks, gouges, or damage. Replace the equalizer beam if any of these conditions exist.

2. Using emery cloth, clean the outer sleeves of the new equalizer beam center bushings. Apply a thin coating of Texaco Compound L, or an equivalent rust preventive lubricant, to the surface of the outer sleeves on the new bushing.

3. If using Owatonna tools, install the rubber center bushings as follows (**see Fig. 3**):

   3.1 Center the hydraulic ram and slide the pulling screw through the beam eye.

   3.2 Position the bushing on the inboard side of the beam eye.

   IMPORTANT: Center the new bushing to ensure a clean pull through the beam eye.

   3.3 Fit the installing adapter over the inner sleeve and against the outer sleeve of the bushing.

   3.4 Install the hexnut on the pulling screw. Full thread engagement is needed.

   3.5 Install spacers between the ram cylinder and the speed nut. Tighten the speed nut and remove any slack in the assembly.

   3.6 Connect a hydraulic pumping unit to the ram and apply force until the ram cylinder reaches its stroke limit.

   3.7 Release the pressure, add spacers, and tighten the speed nut. About three adjustments are needed to completely install the center bushing.

   NOTE: The pressure gauge on the pumping unit should read 4000 to 5500 psi (27 580 to 37 920 kPa) during installation. If the reading reaches the operating limit of 10,000 psi (68 950 kPa) and the bushing is not going into the beam, check the alignment of the bushing, tooling, and hydraulic equipment. Installation is complete when the installing adapter is flush against the beam.

   3.8 Position the crosstube in the center bushings.

   3.9 Arc weld new end plugs to the tire side of each center bushing inner sleeve.

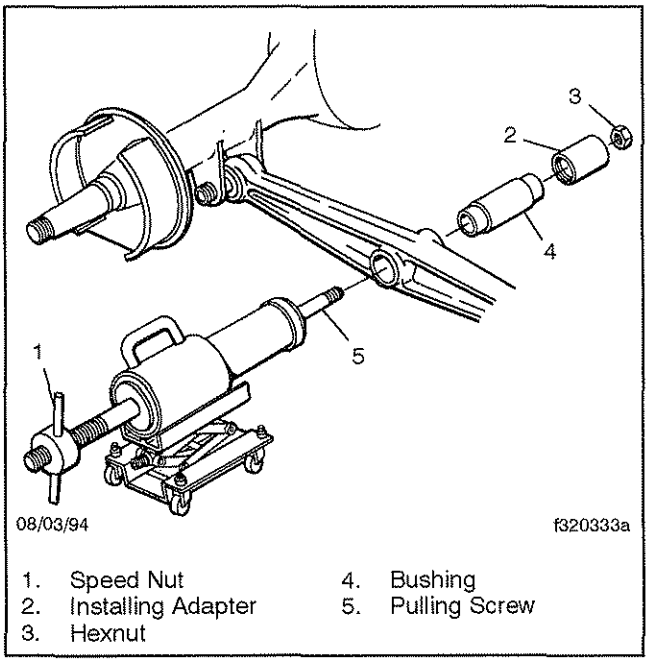
   NOTE: Heat from welding the end plugs will not affect the beam or the new rubber bushings because of their distance from the point of welding.

4. Position the saddle caps on the saddle cap studs, then install the washers and new self-locking nuts. Tighten the nuts 225 to 275 lbf·ft (305 to 373 N·m).

5. If using shop-made adapters, position the equalizer beam on a 50-ton hydraulic press.

   5.1 Using standard center bushings with the end plugs welded in place, position the shop-made adapter (refer to the table under **Specifications, 400**) over the inner sleeve of the bushing. Check that the adapter bottoms against the bushing outer

Equalizer Beam Rubber Center Bushing Removal and Installation, RT2 & RTE2



1. Speed Nut
2. Installing Adapter
3. Hexnut
4. Bushing
5. Pulling Screw

Fig. 3, Installing Rubber Center Bushing

sleeve, then press the new bushing into the beam eye.

5.2 Install the equalizer beams. For instructions, **refer to Subject 130.**

Equalizer Beam Bronze Center Bushing Removal and Installation, RT2 & RTE2

Removal

NOTE: If using Owatonna tools, you can remove or install the bronze center bushing without removing the equalizer beam.

1. Chock the front tires.
2. Raise the rear of the vehicle so that all weight is removed from the suspension. Block the axles and the frame with safety stands. Make sure the stands will securely support the weight of the axles and the frame.

NOTE: Do not raise the vehicle to the point where the weight of the suspension and axles hangs from the vehicle.

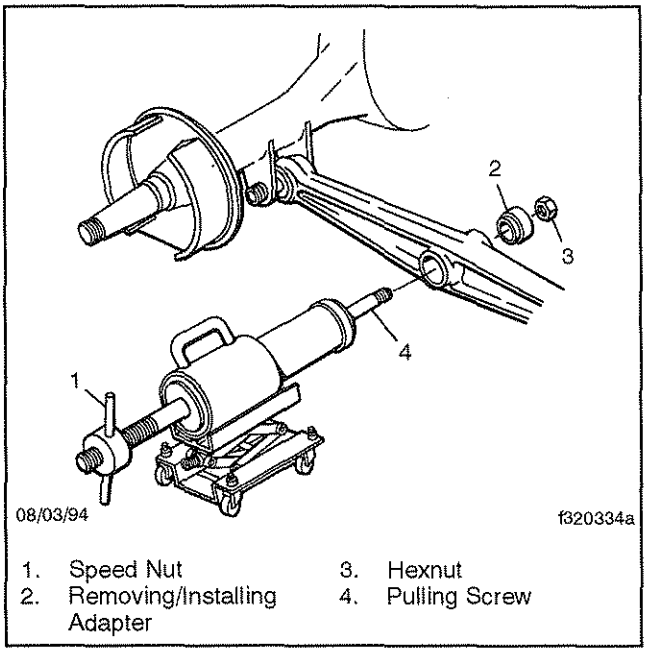
3. Remove the saddle cap nut and washers from each side of the suspension, and remove the saddle caps.
4. Raise the rear of the truck frame until the saddle studs clear the equalizer beam. Install safety stands under the frame.
5. Using a 2-1/2 inch diameter hole saw, cut out the retaining disk from the center bushing on each side of the suspension, and remove the crosstube.

CAUTION: Do not use a cutting torch to burn out the retaining disk. The equalizer beams are heat treated, and the use of a cutting torch could weaken the beam.

6. If using Owatonna tools, remove the bronze center bushing as follows (**see Fig. 1**):
   - 6.1 Position the hydraulic ram and slide the pulling screw through the center bushing.
   - 6.2 Install the center bushing removing adapter on the inboard side of the beam eye.

     IMPORTANT: Align the receiving tube so that the bushing will clear the edges of the tube when force is exerted against the beam. Align the removing adapter so that force is exerted only on the bushing to ensure a clean pull through the beam.
   - 6.3 Install the hexnut on the pulling screw. Full thread engagement is needed.
   - 6.4 Install spacers between the ram cylinder and the speed nut. Tighten the speed nut and remove any slack in the assembly.
   - 6.5 Connect a hydraulic pumping unit to the ram and apply force until the ram cylinder reaches its stroke limit.
   - 6.6 Release the pressure, add spacers, and tighten the speed nut. About three adjustments are needed to completely remove the center bushing.

     NOTE: If the pressure gauge on the hydraulic pumping unit reads 10,000 psi (68 950 kPa) and the bushing has not broken loose, stop and check the alignment of the receiving tool and removal adapter. If both tools are aligned correctly, attach a sledging adapter on the speed nut end of the pulling screw. Maintaining hydraulic pressure, strike the sledging adapter with a heavy hammer. A loud noise followed by a sudden drop of the pressure gauge reading indicate that the bushing has broken loose.
7. If using shop-made adapters, remove the equalizer beams. For instructions, refer to **Subject 130**.
   - 7.1 Position the equalizer beam on a 50-ton vertical hydraulic press.



1. Speed Nut
2. Removing/Installing Adapter
3. Hexnut
4. Pulling Screw

Fig. 1, Removal of Bronze Center Bushing

Equalizer Beam Bronze Center Bushing Removal and Installation, RT2 & RTE2

7.2 Center the shop-made adapter (refer to the table under **Specifications, 400**) on the center bushing. Press the bushing from the beam eye.

Installation

1. Using emery cloth, remove all scale, rust, or corrosion from the beam eyes. Inspect the equalizer beam eyes for cracks, gouges, or damage. Replace the equalizer beam if any of these conditions exist.
2. Using emery cloth, clean the outer sleeves of the new equalizer beam center bushings. Apply a thin coating of Texaco Compound L, or an equivalent rust preventive lubricant, to the surface of the outer sleeves on the new bushing, and to the inside surface of the beam eye.
3. Position the bushing on the equalizer beam eye.
4. If using Owatonna tools, install the bronze center bushings as follows (**see Fig. 2**):

   4.1 Center the hydraulic ram and slide the pulling screw through the beam eye.

   4.2 Position the bushing on the inboard side of the beam eye. Check that the grooves of the bushing are aligned with the vertical centerline of the equalizer beam (**see Fig. 3**).

   4.3 Fit the installing adapter and the removing/installing adapter against the outer sleeve of the bushing. Make sure the deep ridge on the installing adapter is positioned against the bronze bushing (**see Fig. 4**).

   4.4 Install the hexnut on the pulling screw. Full thread engagement is needed.

   4.5 Install spacers between the ram cylinder and the speed nut. Tighten the speed nut and remove any slack in the assembly.

   4.6 Connect a hydraulic pumping unit to the ram and apply force until the ram cylinder reaches its stroke limit.

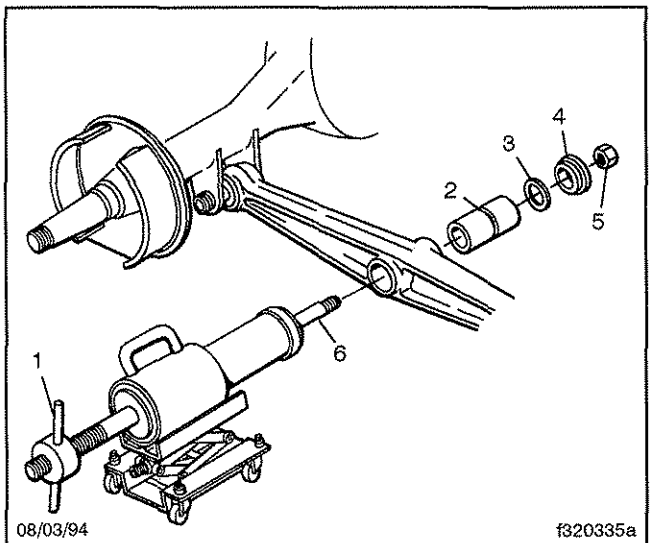
   4.7 Release the pressure, add spacers, and tighten the speed nut. About three adjustments are needed to completely install the center bushing.

   NOTE: The pressure gauge on the pumping unit should read 4000 to 5500 psi (27 580 to 37 920 kPa) during installation. If the reading reaches the operating limit of 10,000 psi (68 950 kPa) and the bushing is not going into the beam, check the alignment of the bushing, tooling, and hydraulic equipment. Installation is complete when the installing adapter is flush against the beam.

   4.8 On the inboard side of the beam, position a grease seal and installing adapter against the center bushing. Make sure the shallow end of the adapter is against the grease seal (**see Fig. 5**). Using a hammer, tap the installing adapter until it is flat against the beam. Using the same procedure, install a grease seal on the outboard side of the beam.

5. If using shop-made adapters, position the equalizer beam on a 50-ton hydraulic press.

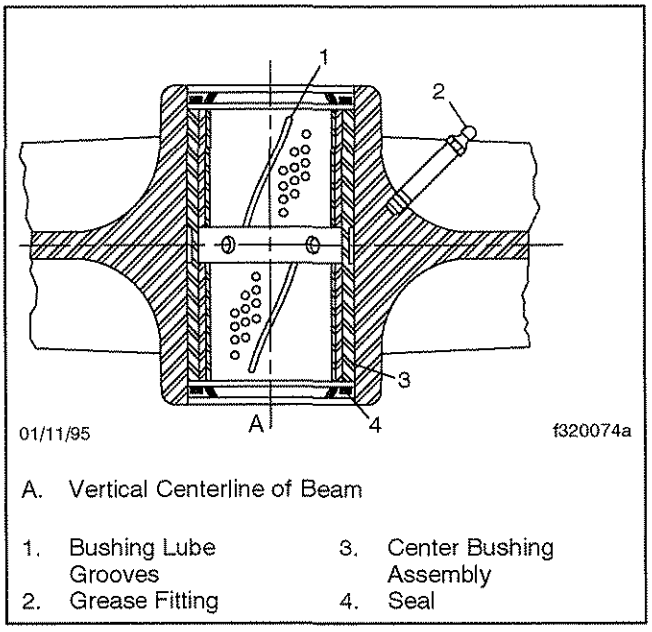
   5.1 Center the new bushing in the beam eye. Using a standard bushing driver, press the bushing in until there is equal spacing



1. Speed Nut
2. Bushing
3. Installing Adapter
4. Removing/Installing Adapter
5. Hexnut
6. Pulling Screw

Fig. 2, Installing the Bronze Center Bushing

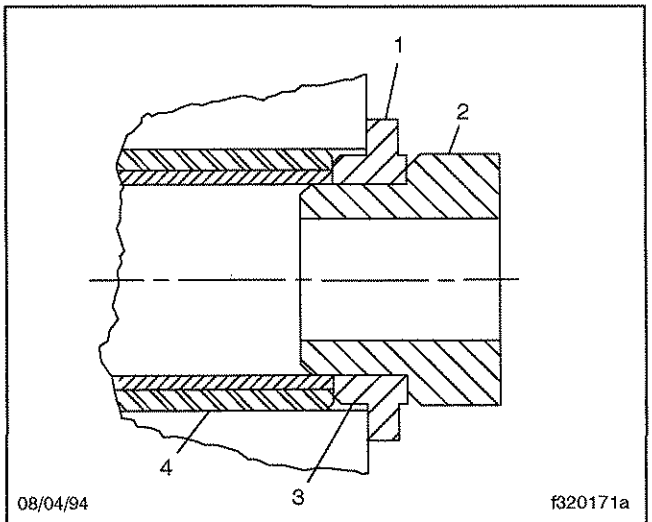
Equalizer Beam Bronze Center Bushing Removal and Installation, RT2 & RTE2



A. Vertical Centerline of Beam

1. Bushing Lube Grooves
2. Grease Fitting
3. Center Bushing Assembly
4. Seal

Fig. 3, Check Bushing Grooves



1. Installing Adapter
2. Removing/Installing Adapter
3. Deep Ridge
4. Bushing

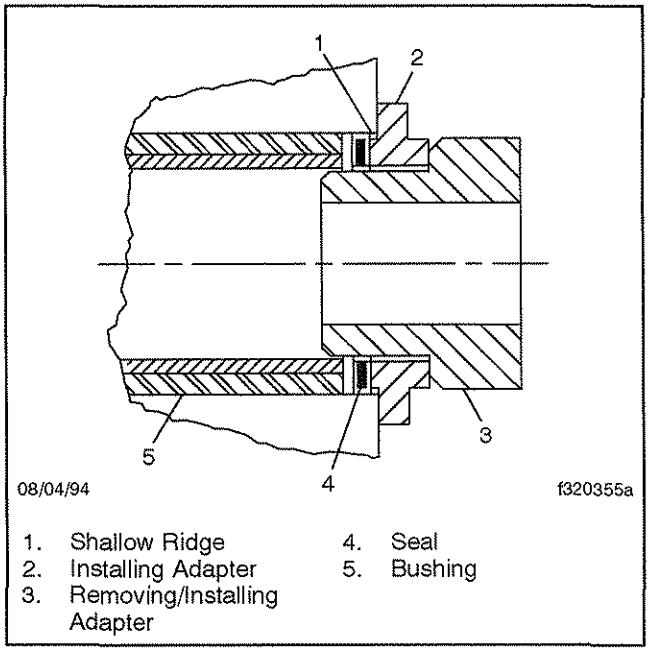
Fig. 4, Position of Adapter

between both bushing ends and the sides of the beam eye.

5.2 Install the new grease seals (with the seal lips facing out).

NOTE: Check that the new seals are 1/6 inch (4 mm) inside the beam hub surface to ensure clearance and protection of the seals when the saddle cap is installed.

6. Apply a thin coating of multipurpose chassis grease to the inside surface of the center bushing. Slide the bushing center sleeve into the bushing.
7. Install the grease fitting into the beam hub. Rotate the center sleeve and apply multipurpose chassis grease in the grease fitting. Lubricate until clean grease appears at both ends of the grease seals.
8. Install the crosstube.
9. Install the saddle caps or the equalizer beam (if removed) on the axle beam hangers. For instructions, **refer to Subject 130**.



1. Shallow Ridge
2. Installing Adapter
3. Removing/Installing Adapter
4. Seal
5. Bushing

Fig. 5, Seating Adapter and Seal

Torque Rod and Bushing Removal and Installation, RT2 & RTE2

Removal (see Fig. 1)

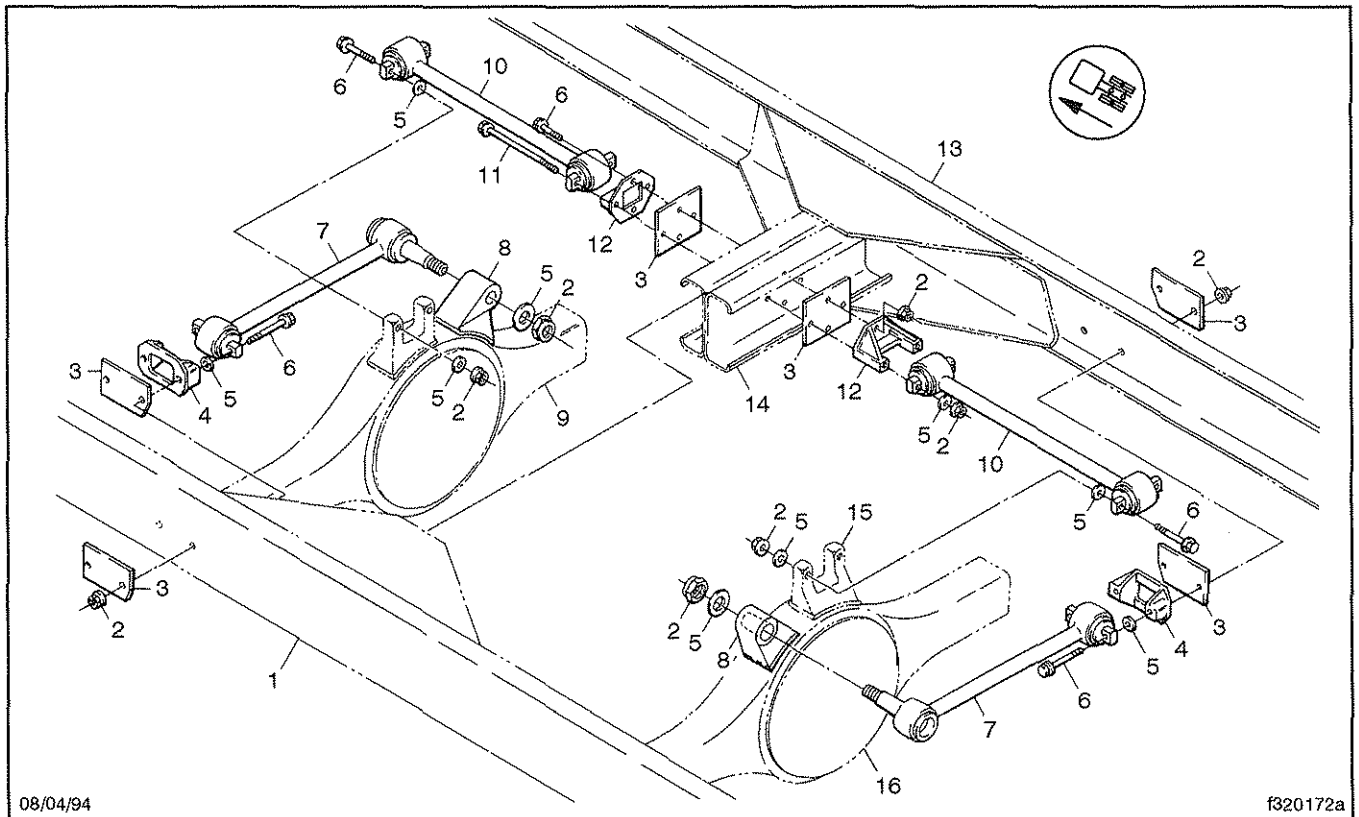
IMPORTANT: To ensure that the required tools are available, see the table under **Specifications, 400**, before beginning these procedures. Special tools are available from the Owatonna Tool Company, Owatonna, Minnesota, or an affiliated dealer.

WARNING: When the torque rods are disconnected from the axle brackets, the axles become free to pivot on the equalizer beam end bushings.

Keep clear of the beam hangers and beam ends to avoid possible injury.

1. On fore and aft torque rods, remove the flanged bolts and nuts from the torque rod axle brackets, and the crossmember mounting brackets (**see Fig. 1**). Remove the torque rods.

   On transverse torque rods, remove the nuts and washers from the axle brackets, and remove the flanged bolts and nuts from the frame rail mounting brackets (**see Fig. 1**). Remove the torque rods.



1. Left-Hand Frame Rail
2. Flanged Hexnut
3. Spacer
4. Transverse Torque Rod Mounting Bracket
5. Hardened Washer
6. Flanged Hexbolt
7. Transverse Torque Rod
8. Transverse Torque Rod Axle Mounting Bracket
9. Forward Rear-Axle
10. Fore and Aft Torque Rod
11. Capscrew
12. Fore and Aft Torque Rod Mounting Bracket
13. Right-Hand Frame Rail
14. Crossmember
15. Fore and Aft Torque Rod Axle Mounting Bracket
16. Rearmost Axle

Fig. 1, Torque Rod Mounting Assembly

Torque Rod and Bushing Removal and Installation, RT2 & RTE2

NOTE: If necessary, use an impact hammer and tap the top of the axle bracket to disengage the rod stud from the axle bracket.

2. Inspect the torque rods. If bent or cracked, replace. Check the torque rod bushings. If one of the bushings is loose or damaged, replace both of the bushings.

3. Position the press plate on the hydraulic press. Check that the small counterbore of the plate hole is facing up.

NOTE: Some tapered stud torque rod bushings have a large non-removable washer on the stud that will not fit though the press plate hole. Loosen the press plate capscrews and separate the halves (**see Fig. 2**) until the washer clears the counterbore, and the torque rod sets on the press plate. Tighten the capscrews until the press plate halves are closed.

4. Position the tapered stud removal tool (using the end with the larger inside diameter) on the torque rod stud. Apply lubricating oil (**see Fig. 3**), then press the stud out of the bushing.

5. Position the bushing remover/replacer tool (using the end with the larger outside diameter) on the bushing. Install the cap, then apply lubricating oil to the torque rod bushing.

6. Press the rubber bushing out of the torque rod eye.

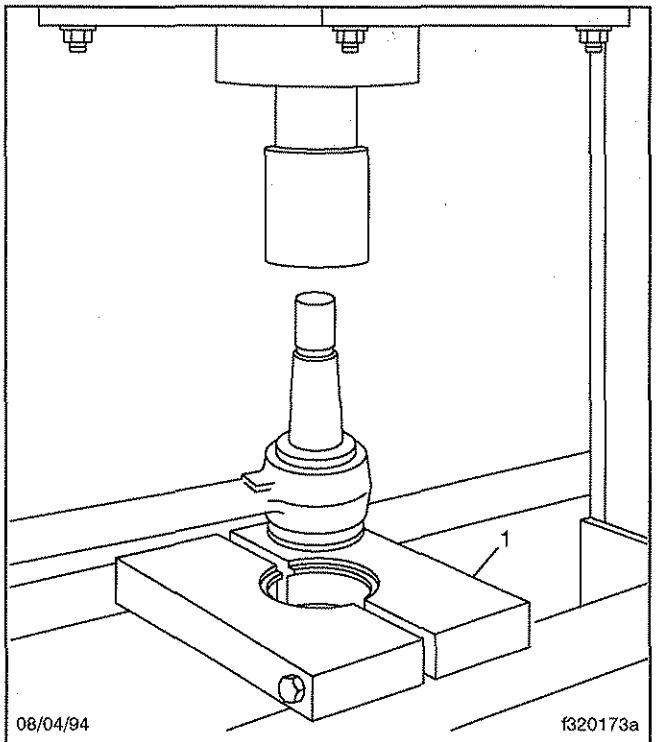
7. Position the straddle mount end of the torque rod into the hole of the press plate. Tighten the press plate capscrews.

8. Position the straddle mount pin remover on the straddle mount pin (**see Fig. 4**).

9. Apply lubricating oil to the straddle mount pin. Press the straddle mount pin out of the bushing.

10. Position the end of the rubber bushing remover/replacer tool (using the end that has the larger outside diameter) on the bushing. Install the cap, then apply lubricating oil to the torque rod bushing.

11. Press the rubber bushing out of the torque rod eye.



1. Clamping Tool

Fig. 2, Tool for Separating Halves

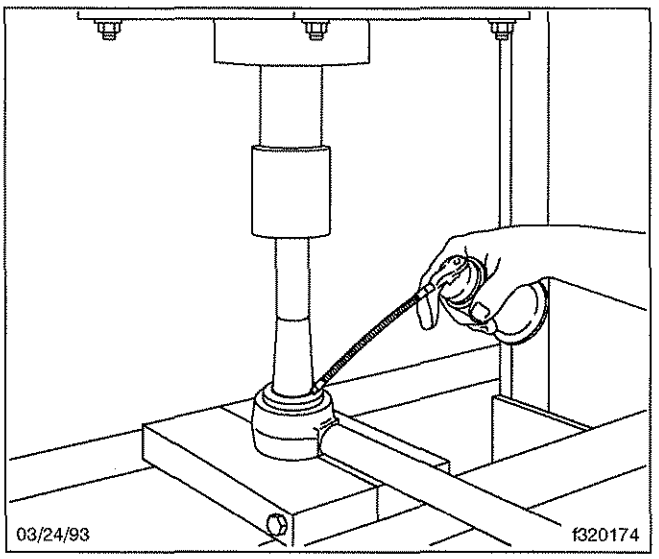


Fig. 3, Applying Lubrication Oil

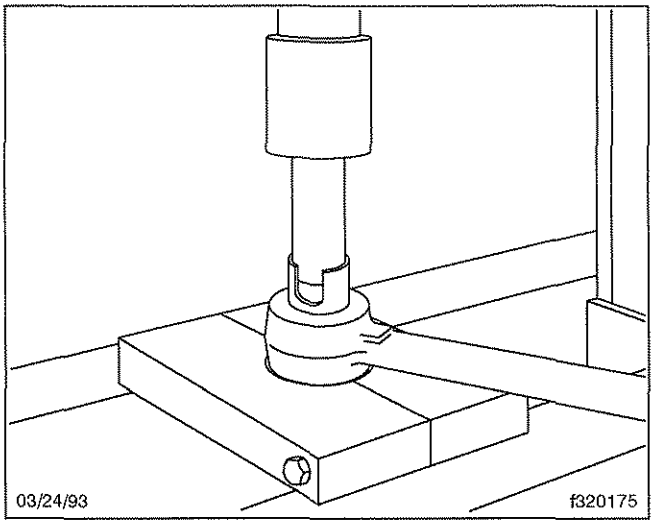


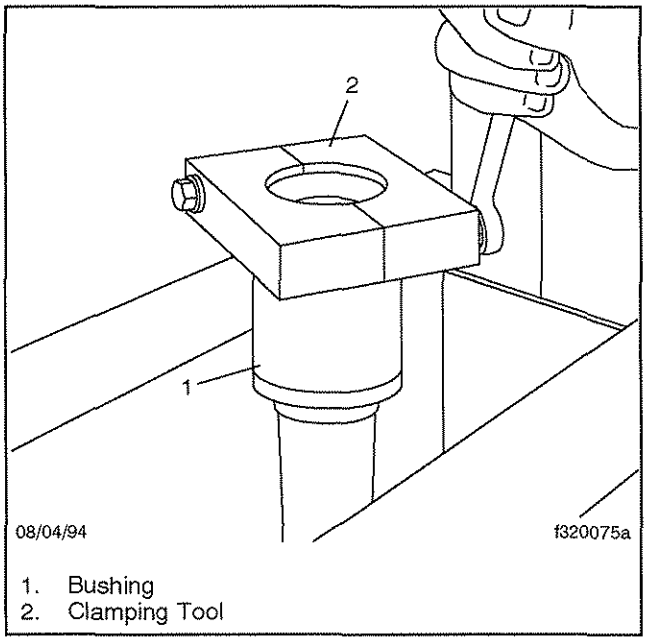
Fig. 4, Straddle Mount Pin Position

Installation

1. Remove all dirt and grease from the torque rod ends. Apply lubricant on the new bushings and in the torque rod eyes.
2. Position the press plate on the hydraulic press. Check that the small counterbore of the plate hole is facing up.
3. Position the new bushing on the tapered stud of transverse torque rods. Position the clamp and tighten it to compress the rubber (**see Fig. 5**).
4. Place the torque rod end, the bushing, and the clamp on the press plate.
5. Place the remover/replacer tool (**see Fig. 6**) and cap on top of the clamping tool and press the bushing in the torque rod end. Check that the bushing sleeve protrudes equally on each side of the torque rod end.
6. On straddle mount end assemblies, align the clamping tool on the bushing **as shown in Fig. 7**. Tighten the clamp to compress the rubber of the new straddle mount bushing.

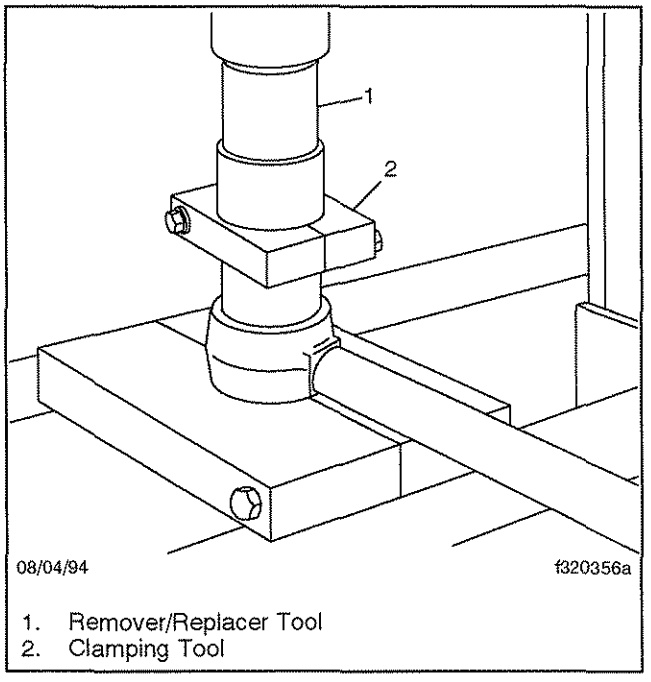
NOTE: When tightening the clamp, make sure that the position of the bushing pin is at a right angle to the center line of the torque rod shank (**see Fig. 8**).

7. Place the torque rod end, the bushing, and the clamp on the press plate.
8. Using the larger end of the remover/ replacer tool, position the tool and cap on top of the clamp assembly.



1. Bushing
2. Clamping Tool

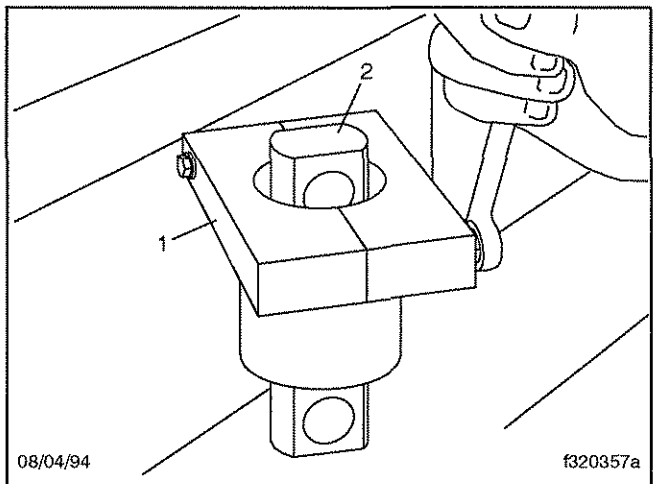
Fig. 5, Rubber Compression



1. Remover/Replacer Tool
2. Clamping Tool

Fig. 6, Pressing Bushing into Torque Rod End

Torque Rod and Bushing Removal and Installation, RT2 & RTE2



1. Clamping Tool
2. Pin

Fig. 7, Clamping Tool Alignment

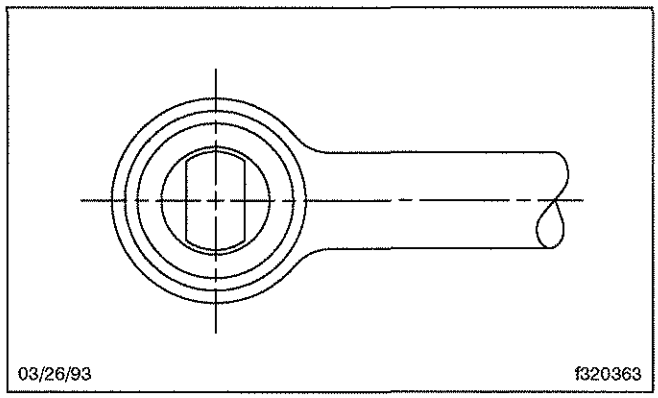


Fig. 8, Bushing Pin Positioning

9. Press the bushing in the torque rod end. Check that the bushing's outer sleeve protrudes equally on each side of the torque rod end.

10. Install the fore and aft torque rods as follows (**see Fig. 1**):

    10.1 Position a torque rod straddle mount pin in the forward-rear axle bracket. Install the flanged bolts through the axle bracket and the straddle mount pin. Install a spacer and nut on each bolt, and tighten 190 lbf·ft (260 N·m).

    10.2 Position a torque rod straddle mount pin in the rearmost axle bracket. Install the flanged bolts through the axle bracket and the straddle mount pin. Install a spacer and nut on each bolt, and tighten 190 lbf·ft (260 N·m).

    10.3 Position a torque rod spacer and straddle mount bracket on each side of the crossmember. Insert bolts through the upper and lower holes of the forward mounting bracket. Install nuts and tighten 95 lbf·ft (130 N·m).

    10.4 Position the straddle mount pin of the forward torque rod in the mounting bracket. Insert bolts through the forward pin, both bracket assemblies, and the straddle mount pin of the rear torque rod. Install the nuts and bearing washers. Tighten the nuts 190 lbf·ft (260 N·m).

11. Install the transverse torque rods as follows (**see Fig. 1**):

    11.1 Check that the tapered stud end and the tapered stud bracket hole are clean. Lubricate the tapered stud ends with SAE 20 oil.

    11.2 Install the tapered stud in the axle bracket. Install a washer and nut. Tighten the nut 175 to 225 lbf·ft (235 to 305 N·m).

    11.3 Align the straddle mount end, the mounting bracket, and the spacer against the inside frame rail.

    11.4 On the inboard side of the frame rail, install the bolts through the mounting assembly and the frame rail.

    11.5 On the outboard side of the frame rail, install a spacer over the mounting bolt studs. Install the nuts and tighten them 190 lbf·ft (260 N·m).

12. Check the axle pinion angle. For instructions, refer to **Group 41**.

Part Number	Tool	Usage
1761	Torque Rod Set	Torque Rod Bushing Removal and Installation
28536	Installing Adapter (5-3/4" o.d.)	Bronze Center Bushing and Seal Removal and Installation
44119	Receiving Tube	Center and End Bushing Removal and Installation
51678	80-Ton Hydraulic Ram	All Operations
51695	Jack	All Operations
302018	Spacer (3 qty.)	Center and End Bushing Removal and Installation
302023	Pulling Screw	All Operations
302024	Removing and Installing Adapter	Bronze Center Bushing Removal and Installation
302026	Installing Adapter	Rubber Center Bushing Removal and Installation
302027	Removing Adapter	Rubber Center Bushing Removal and Installation
302028	Hexnut	All Operations
302029	Speed Nut	All Operations

Table 1, Special Tools (Owatonna Tool Company)

Tool Number	Dimensions	Usage
3	4-5/8 inch o.d. by 7 inch	Beam Center Bushing Removal and Installation

Table 2, Shop-Made Adapters

Description	Size	Torque lbf·ft (N·m)
Top Pad to Spring Aligning Setscrew	—	100-150 (135-200)
Top Pad Nut	—	275-400 (375-542)
Spring Pin Locknut	1/2-13	45-63 (61-85)
Torque Rod Straddle Mount Nut	5/8-11	190 (260)
Torque Rod Stud Locknut	1-1/4-12	175-225 (235-305)
Saddle Cap Stud	7/8-14	55-65 (75-90)
Saddle Cap Locknut	7/8-14	225-275 (305-373)
Bar Pin Locknut	1-8	450-600 (610-813)
Spring Center Bolt	7/16-20	50-60 (70-80)
	1/2-20	65-75 (90-100)
Rebound Spacer Locknut	1/2-13	38-45 (51-61)
Spring Alignment Clip	—	15 (20)
Fore and Aft Torque Rod Mount Nut	—	95 (130)

Table 3, Torque Values

Contents

Subject	Subject Number
General Information	050
Service Operations	
Suspension Removal and Installation, RS	100
Saddle Removal and Installation, RS	110
Load Cushion and Vertical Drive Pin Bushing Replacement, RS	120
Equalizer Beam Removal and Installation, RS	130
Equalizer Beam Rubber Center Bushing Removal and Installation, RS	140
Equalizer Beam Bronze Center Bushing Removal and Installation, RS	150
Torque Rod Removal, Bushing Replacement, and Installation, RS	160
Specifications	400

General Information

The Hendrickson RS suspension **(see Fig. 1)** is a heavy-duty tandem drive that uses six rubber load cushions in place of leaf springs to lessen road shocks. Frame hangers above the four outside cushions have vertical drive pins and bushings **(see Fig. 2)** that extend down through the cushions. All driving, braking, and cornering forces are transmitted and controlled through these pins and bushings.

The axles are attached to beam hangers at the ends of the equalizer beams, allowing an articulating action between the axles to absorb road shock. Torque rods, mounted between the axles and frame rails, stabilize axle and vehicle movement caused by accelerating and braking.

All suspension fasteners require periodic tightening. For suspension inspecting, lubricating, and fastener torque checking instructions, **refer to Group 32** in the vehicle maintenance manual.

WARNING: Torque suspension fasteners on a periodic schedule as suggested in the vehicle maintenance manual. Failure to to do so could result in damage to the frame hangers or separation of components. This could cause a loss of vehicle control, resulting in personal injury or property damage.

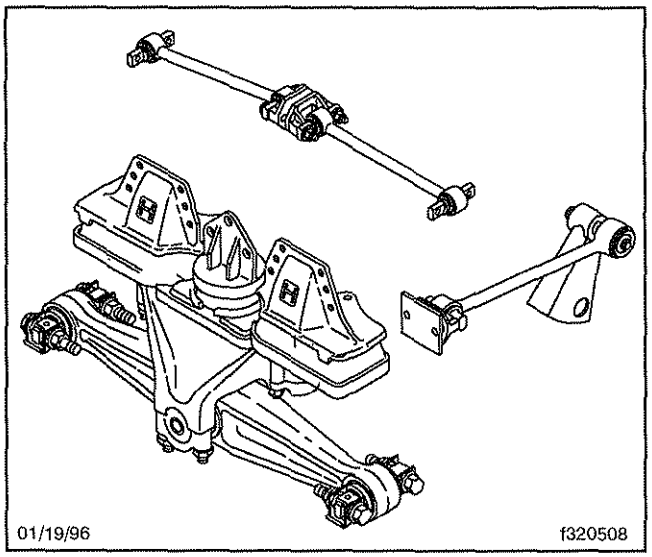
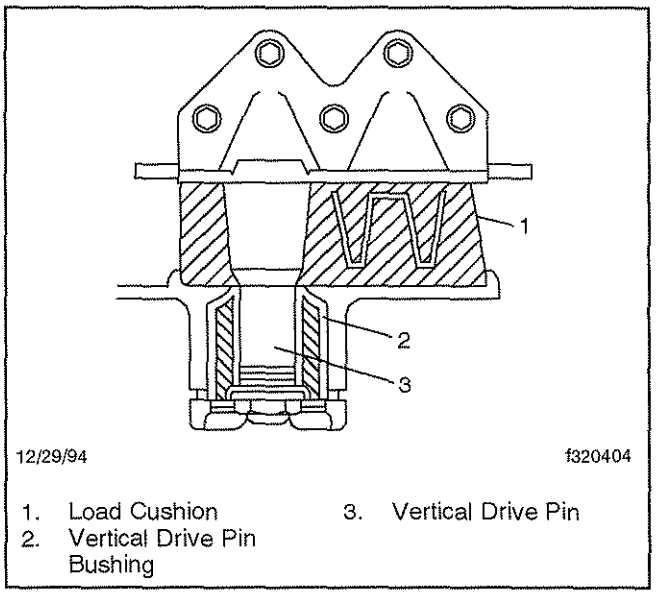


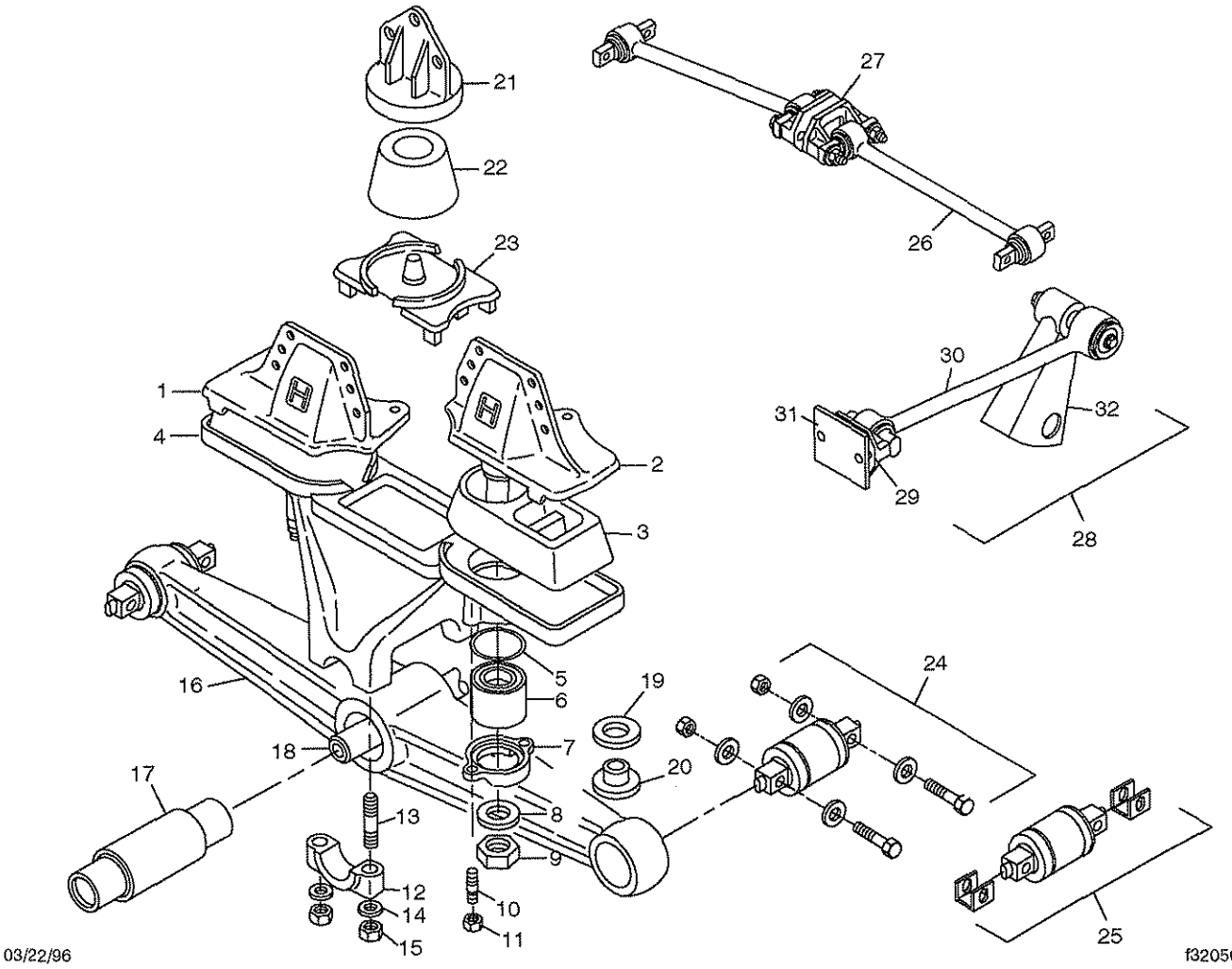
Fig. 1, Hendrickson RS Heavy-Duty Suspension



1. Load Cushion
2. Vertical Drive Pin Bushing
3. Vertical Drive Pin

Fig. 2, Load Cushion Assembly

Removal (See Fig. 1)



1. Frame Hanger
2. Frame Hanger and Vertical Drive Pin
3. Load Cushion
4. Saddle Assembly
5. Saddle Bearing Ring
6. Bushing
7. Cap
8. Washer
9. Nut
10. Stud
11. Nut
12. Saddle Cap
13. Stud
14. Washer
15. Saddle Cap Stud Nut
16. Equalizing Beam
17. Center Bushing
18. Cross Tube
19. Rebound Bumper
20. Stop Nut
21. Frame Hanger
22. Heavy-Duty Load Cushion
23. Saddle Plate
24. Bar Pin Bushing Kit (non-shim type)
25. Bar Pin Bushing Kit (shim type)
26. Torque Rod
27. Torque Rod Frame Bracket
28. Transverse Torque Rod Asssembly
29. Transverse Torque Rod Frame Bracket
30. Transverse Torque Rod
31. Backup Plate
32. Axle Bracket

Fig. 1, Hendrickson RS Heavy-Duty Suspension

Suspension Removal and Installation, RS

1. Chock the front tires.
2. Drain the vehicle air system.
3. Disconnect all air lines leading to the rear axles, marking the lines for later assembly reference. Plug or cap all lines and fittings to prevent dirt from entering the system.
4. Disconnect the driveline rear universal joint from the forward-rear axle. Then, remove the interaxle driveline. For instructions, **refer to Group 41.**
5. Manually release the spring brake chambers. For instructions, **refer to Group 42.**
6. Remove the torque rods. For instructions, **refer to Subject 160.**

WARNING: When the torque rods are disconnected from the axle brackets, the axles become free to pivot on the equalizer beam end bushings. Keep clear of the beam hangers and beam ends to avoid possible injury.

7. Raise the rear of the vehicle so that all weight is removed from the suspension. Then, block the axles and the frame with safety stands. Make sure the stands will securely support the weight of the axles and the frame.

NOTE: Do not raise the vehicle to the point where the weight of the suspension and axles hangs from the vehicle.

8. Remove the saddle cap nuts and washers from each side of the vehicle, and remove the saddle caps.
9. Raise the rear of the vehicle frame until there is enough clearance to roll the axles out from under the vehicle. Install safety stands under the frame, then roll the axles—with the equalizer beams attached—out from under the vehicle.

Installation (See Fig. 1)

1. Roll the axles under the vehicle frame. Align the center bushing of each equalizer beam with the center of the saddle legs.
2. Raise the vehicle frame off the safety stands, then remove the safety stands.
3. Lower the frame, centering the saddles on the beam center bushings.
4. Install the saddle caps, washers and new self-locking nuts. Do not tighten.
5. Install the torque rods. For instructions, **refer to Subject 160.**
6. Tighten the saddle cap locknuts 225 to 275 lbf·ft (300 to 375 N·m).

NOTE: Maintain an even gap between the saddle cap and the saddle when tightening the self-locking nuts.

7. Remove the safety stands from under the frame and axle, and lower the vehicle.
8. Manually reset the spring brake chambers. For instructions, **refer to Group 41.**
9. Connect the driveline rear universal joint to the forward-rear axle. Connect the interaxle driveline. For instructions, **refer to Group 41** in this manual.
10. Uncap all air lines and fittings, then connect the lines leading to the rear axles.
11. Check the axle pinion angle. For instructions, **refer to Group 41.**

Saddle Removal and Installation, RS

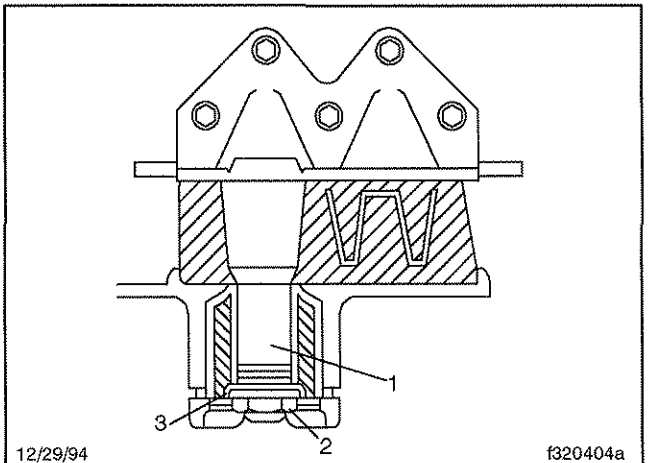
Removal

1. Remove the suspension. For instructions, **refer to Subject 100.**
2. Support the saddle assembly with a floor jack.
3. Remove the vertical drive pin locknuts and the concave washers **(see Fig. 1).**

   On rebound control kit installations, use a 3/4–inch drive socket to remove the stop nuts. Then remove the bumper and the concave washers. **See Fig. 2.**
4. Lower the saddle and load cushions from the frame hanger and the vertical drive pins.

Installation

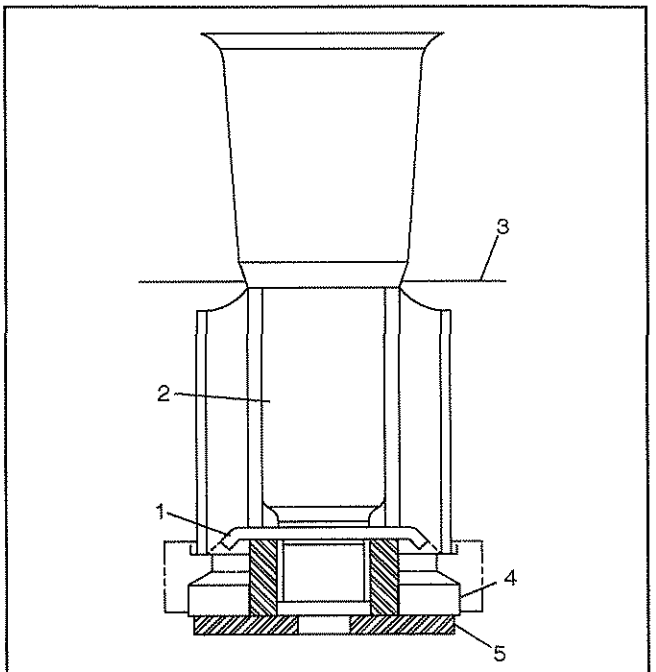
1. Apply Texaco Compound L, or an equivalent rust preventive lubricant, on the vertical drive pins and the vertical drive pin bushings.
2. Position the rubber load cushions on the saddle. Raise the saddle assembly, guiding the vertical drive pin bushings over the vertical drive pin.
3. Install the drive pin washers (with the concave end pointing down) over the threaded ends of the drive pins.



1. Vertical Drive Pin
2. Locknut
3. Concave Washer

Fig. 1, Vertical Drive Pin Assembly

4. Install the vertical drive pin locknuts and tighten 175 to 225 lbf·ft (235 to 300 N·m).
5. On rebound control kit installations, install the stop nuts, bumpers, and the concave washers. Tighten the stop nuts 175 to 225 lbf·ft (235 to 300 N·m).
6. Install the suspension. For instructions, **refer to Subject 100.**



1. Concave Washer
2. Vertical Drive Pin
3. Saddle
4. Bumper
5. Stop Nut

Fig. 2, Rebound Control Kit

Load Cushion and Vertical Drive Pin Bushing Replacement

1. Remove the saddle assembly. For instructions, **refer to Subject 110.**

NOTE: If replacing only the heavy-duty load cushions, removal of the saddle assembly is not needed. These cushions can be forced out after raising the frame to open the area between the saddle and the frame hanger brackets.

2. Inspect all of the rubber load cushions for cuts or other damage. Replace a load cushion if these conditions exist.
3. Measure each load cushion. If the height of a load cushion is less than 3-11/16 inches (94 mm), replace it.
4. Remove the retainer locknuts from the drive pin bushing retainer cap, and remove the retainer cap.
5. Using a hydraulic press, press the vertical drive pin bushings out of the saddle from the top.
6. If the outer sleeve of the bushing is frozen in the saddle bore, press out the inner sleeve and rubber insert, then work the outer sleeve out of the saddle bore.

WARNING: Do not use a cutting torch to remove the vertical drive pin bushings. Using high heat will weaken the saddle, which could cause the saddle to break. This could result in a loss of vehicle control, possible personal injury, and property damage.

7. Using emery cloth, remove small nicks or scratches from the vertical drive pin and the vertical drive pin bushing. Clean the saddle bores with a solvent.
8. Apply Texaco Compound L, or an equivalent rust preventive lubricant, on the drive pin bushings and the saddle bores.
9. Fit the bushings into the saddle bores. Position the drive pin bushing retainer cap and install the retainer cap locknuts. Tighten the locknuts 100 to 125 lbf·ft (135 to 170 N·m).
10. Install the rubber load cushions.
11. Install the saddle assembly. For instructions, **refer to Subject 110.**

Equalizer Beam Removal and Installation, RS

Removal

1. Chock the front tires.
2. Remove the saddle cap nuts and washers, then remove the saddle cap. Support the equalizer beam with safety stands.
3. Raise the rear of the vehicle until the saddle studs clear the equalizer beam. Block the axles and frame with safety stands.
4. Remove the wheels and tires. For instructions, **refer to Group 40.**
5. Apply a penetrating oil to all beam end connections.
6. Remove the bar pins.

NOTE: The bar pin-style beam end connection is a rubber bushing assembly consisting of a rubber insert and outer metal tube with inner casting. It is fastened to the axle by two 1-inch (25 mm) bolts and locknuts. The bolts are positioned parallel to the vehicle's longitudinal axis, making removal and installation easy.

WARNING: Don't use a cutting torch to remove the equalizer beams from the beam hangers. The equalizer beams are heat-treated, and using a cutting torch could weaken them, causing them to break. This could result in a loss of vehicle control, possible personal injury and property damage.

7. Remove the ends of the equalizer beams from the axle beam hangers.
8. Lower the equalizer beams and the crosstube to the ground. Remove the thrustwashers and pull the beams from the crosstube.

Installation

1. Install the crosstube and thrustwashers in both equalizer beam center bushings.
2. Install the bar pins, then install the crosstube and thrustwashers in both equalizer beam center bushings.

   Position the equalizer beam assembly under the axles, then raise the assembly and place the forward ends of each beam in the forward-rear axle beam hangers. Align the beam end bushings with the beam hangers.
3. Place the rear ends of each beam in the rearmost-axle beam hangers. Align the beam end bushings with the beam hangers.
4. Position the saddle caps on the saddle cap studs, then install the washers and new self-locking nuts. Tighten the nuts 225 to 275 lbf·ft (300 to 375 N·m).
5. Install the bar pin bolt locknuts, and tighten 450 to 600 lbf·ft (610 to 813 N·m).

WARNING: Tighten the bar pin locknuts to the specified torque values. Otherwise, excessive component wear could result. This could result in separation of suspension components, loss of vehicle control, and possible personal injury or property damage.

6. Install the wheels and tires. For instructions, **refer to Group 40.**

Equalizer Beam Rubber Center Bushing Removal and Installation, RS

Removal

NOTE: If using Owatonna tools, removal of the equalizer beam is not required for removal or installation of the rubber center bushing.

1. Chock the front tires.
2. Raise the rear of the vehicle so that all weight is removed from the suspension. Block the axles and the frame with safety stands. Make sure the stands will securely support the weight of the axles and the frame.

NOTE: Do not raise the vehicle to the point where the weight of the suspension and axles hangs from the vehicle.

3. Remove the saddle cap nuts and washers from each side of the vehicle, and remove the saddle caps.
4. Raise the rear of the truck frame until the saddle studs clear the equalizer beam. Install safety stands under the frame.
5. Using a 2-1/2-inch diameter hole saw (**see Fig. 1**), cut out the end plug from the center bushing on each side of the suspension, and remove the crosstube.

WARNING: Don't use a cutting torch to remove the beam end bushing. Equalizer beams are heat-treated by the manufacturer. Using a cutting torch could weaken the beams, which could cause the beams to break. This could cause a loss of vehicle control, resulting in injury or property damage.

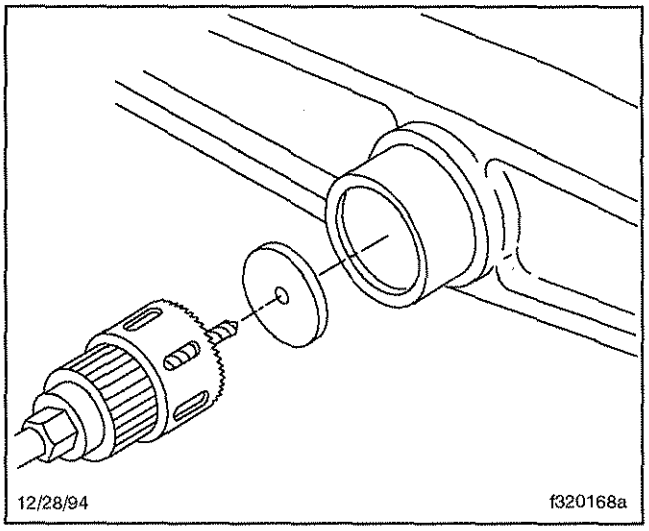


Fig. 1, End Plug Removal

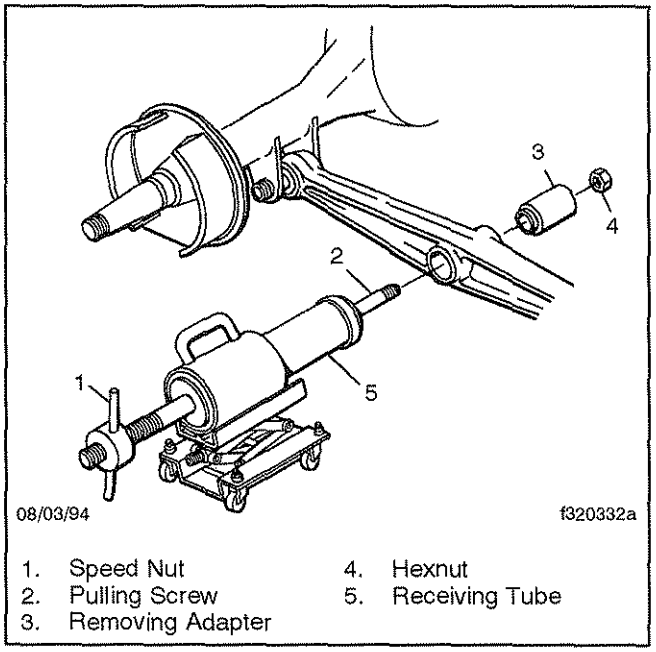
6. On the inboard side of the equalizer beam, inspect the exposed edge of the bushing's outer sleeve.
7. Chisel or grind off any portion of the outer sleeve that has flared over the surface of the equalizer beam.
8. If using Owatonna tools, remove the rubber center bushings as follows (**see Fig. 2**):

   8.1 Position the hydraulic ram and slide the pulling screw through the center bushing.

   8.2 Install the center bushing removing adapter on the inboard side of the beam eye.

   IMPORTANT: Align the receiving tube so that the bushing will clear the edges of the tube when force is exerted against the beam. Align the removing adapter so that force is exerted only on the bushing to ensure a clean pull through the beam.

   8.3 Install the hexnut on the pulling screw. Full thread engagement is needed.



1. Speed Nut
2. Pulling Screw
3. Removing Adapter
4. Hexnut
5. Receiving Tube

Fig. 2, Rubber Center Bushings Removal

Equalizer Beam Rubber Center Bushing Removal and Installation, RS

8.4 Install spacers between the ram cylinder and the speed nut. Tighten the speed nut and remove any slack in the assembly.

8.5 Connect a hydraulic pumping unit to the ram and apply force until the ram cylinder reaches its stroke limit.

8.6 Release the pressure, add spacers, and tighten the speed nut. About three adjustments are needed to completely remove the bushing.

NOTE: If the pressure gauge on the hydraulic pumping unit reads 10,000 psi (68 900 kPa) and the bushing has not broken loose, stop and check the alignment of the receiving tool and removal adapter. If both tools are aligned correctly, attach a sledging adapter on the speed nut end of the pulling screw. Maintaining hydraulic pressure, strike the sledging adapter with a heavy hammer. A loud noise followed by a sudden drop of the pressure gauge reading indicate that the bushing has broken loose.

9. If using shop-made adapters, remove the equalizer beams. For instructions, refer to **Subject 130**.

9.1 Position the equalizer beam on a 50-ton vertical hydraulic press.

9.2 Position the shop-made adapter (refer to **Specifications, 400**) on the outer metal edge of the equalizer beam bushing. Press the center bushing from the beam eye.

Installation

1. Using emery cloth, remove all scale, rust, or corrosion from the beam eyes. Inspect the equalizer beam eyes for cracks, gouges, or damage. Replace the equalizer beam if any of these conditions exist.

2. Using emery cloth, clean the outer sleeves of the new equalizer beam center bushings. Apply a thin coating of Texaco Compound L, or an equivalent rust preventive lubricant, to the surface of the outer sleeves on the new bushing.

3. If using Owatonna tools, install the rubber center bushings as follows (**see Fig. 3**):

3.1 Center the hydraulic ram and slide the pulling screw through the beam eye.

3.2 Position the bushing on the inboard side of the beam eye.

IMPORTANT: Center the new bushing to ensure a clean pull through the beam eye.

3.3 Fit the installing adapter over the inner sleeve and against the outer sleeve of the bushing.

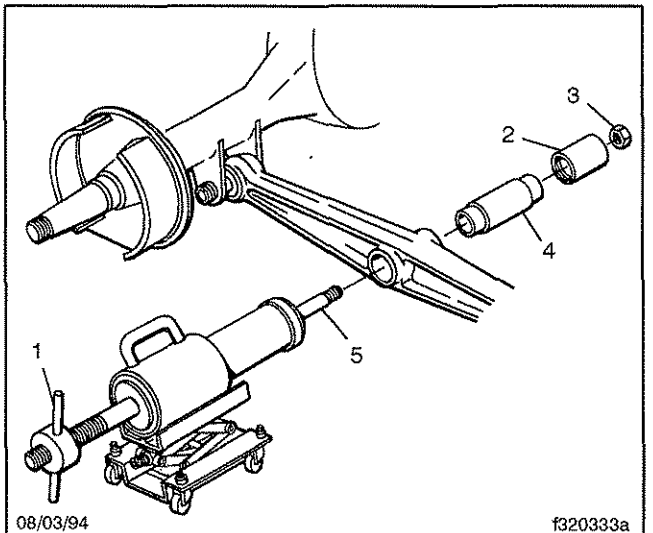
3.4 Install the hexnut on the pulling screw. Full thread engagement is needed.

3.5 Install spacers between the ram cylinder and the speed nut. Tighten the speed nut and remove any slack in the assembly.

3.6 Connect a hydraulic pumping unit to the ram and apply force until the ram cylinder reaches its stroke limit.

3.7 Release the pressure, add spacers, and tighten the speed nut. About three adjustments are needed to completely install the center bushing.

NOTE: The pressure gauge on the pumping unit should read 4000 to 5500 psi (27 560 to 37 895 kPa) during installation. If the reading reaches the operating limit of 10,000 psi (68 900 kPa) and the bushing is not going into



1. Speed Nut
2. Installing Adapter
3. Hexnut
4. Bushing
5. Pulling Screw

Fig. 3, Rubber Center Bushings Installation

the beam, check the alignment of the bushing, tooling, and hydraulic equipment. Installation is complete when the installing adapter is flush against the beam.

3.8 Position the crosstube in the center bushings.

3.9 Arc weld new end plugs to the tire side of each center bushing inner sleeve.

NOTE: Heat from welding the end plugs will not affect the beam or the new rubber bushings because of their distance from the point of welding.

4. Position the saddle caps on the saddle cap studs, then install the washers and new self-locking nuts. Tighten the nuts 225 to 275 lbf·ft (300 to 375 N·m).

5. If using shop-made adapters, position the equalizer beam on a 50-ton hydraulic press.

5.1 Using standard center bushings with the end plugs welded in place, position the shop-made adapter (refer to **Specifications, 400**) over the inner sleeve of the bushing. Check that the adapter bottoms against the bushing outer sleeve, then press the new bushing into the beam eye.

5.2 Install the equalizer beams. For instructions, refer to **Subject 130**.

Equalizer Beam Bronze Center Bushing Removal and Installation, RS

Removal

NOTE: If using Owatonna tools, you can remove or install the bronze center bushing without removing the equalizer beam.

1. Chock the front tires.
2. Raise the rear of the vehicle so that all weight is removed from the suspension. Block the axles and the frame with safety stands. Make sure the stands will securely support the weight of the axles and the frame.

NOTE: Do not raise the vehicle to the point where the weight of the suspension and axles hangs from the vehicle.

3. Remove the saddle cap nuts and washers from each side of the suspension, and remove the saddle caps.
4. Raise the rear of the truck frame until the saddle studs clear the equalizer beam. Install safety stands under the frame.
5. Using a 2-1/2-inch diameter hole saw, cut out the retaining disk from the center bushing on each side of the suspension, and remove the crosstube.

WARNING: Do not use a cutting torch to burn out the retaining disk. The equalizer beams are heat treated, and the use of a cutting torch could weaken the beam, causing it to break, which could result in loss of vehicle control, and possible personal injury or property damage.

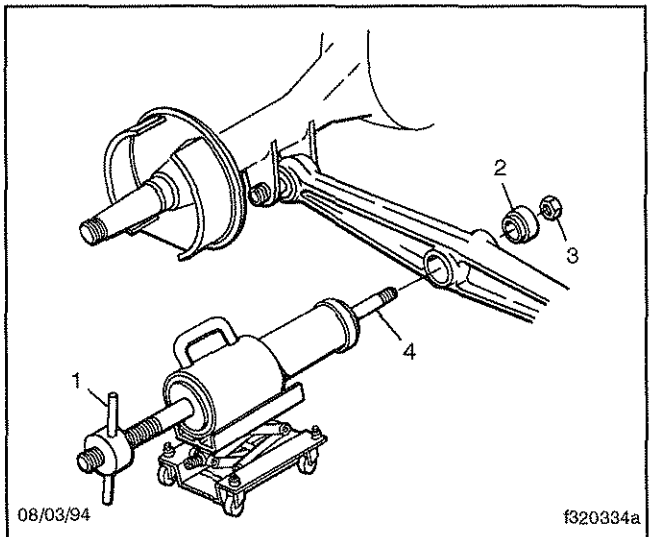
6. If using Owatonna tools, remove the bronze center bushing as follows (see **Fig. 1**):
   - 6.1 Position the hydraulic ram and slide the pulling screw through the center bushing.
   - 6.2 Install the center bushing removing adapter on the inboard side of the beam eye.

   IMPORTANT: Align the receiving tube so that the bushing will clear the edges of the tube when force is exerted against the beam. Align the removing adapter so that force is exerted only on the bushing to ensure a clean pull through the beam.

   - 6.3 Install the hexnut on the pulling screw. Full thread engagement is needed.
   - 6.4 Install spacers between the ram cylinder and the speed nut. Tighten the speed nut and remove any slack in the assembly.
   - 6.5 Connect a hydraulic pumping unit to the ram and apply force until the ram cylinder reaches its stroke limit.
   - 6.6 Release the pressure, add spacers, and tighten the speed nut. About three adjustments are needed to completely remove the center bushing.

NOTE: If the pressure gauge on the hydraulic pumping unit reads 10,000 psi (68 900 kPa) and the bushing has not broken loose, stop and check the alignment of the receiving tool and removal adapter. If both tools are aligned correctly, attach a sledging adapter on the speed nut end of the pulling screw. Maintaining hydraulic pressure, strike the sledging adapter with a heavy hammer. A loud noise followed by a sudden drop of the pressure gauge reading indicate that the bushing has broken loose.

7. If using shop-made adapters, remove the equalizer beams. For instructions, refer to **Subject 130**.
   - 7.1 Position the equalizer beam on a 50-ton vertical hydraulic press.



1. Speed Nut
2. Removing/Installing Adapter
3. Hexnut
4. Pulling Screw

Fig. 1, Bronze Center Bushings Removal

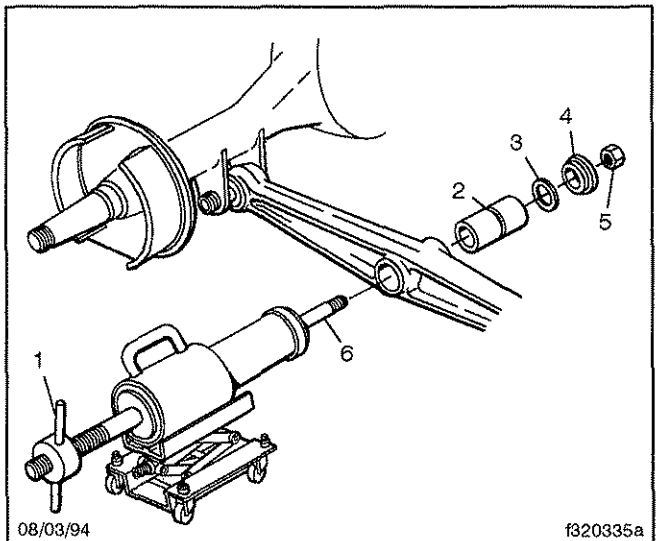
Equalizer Beam Bronze Center Bushing Removal and Installation, RS

7.2 Center the shop-made adapter (refer to **Specifications, 400**) on the center bushing. Press the bushing from the beam eye.

Installation

1. Using emery cloth, remove all scale, rust, or corrosion from the beam eyes. Inspect the equalizer beam eyes for cracks, gouges, or damage. Replace the equalizer beam if any of these conditions exist.
2. Using emery cloth, clean the outer sleeves of the new equalizer beam center bushings. Apply a thin coating of Texaco Compound L, or an equivalent rust preventive lubricant, to the surface of the outer sleeves on the new bushing, and to the inside surface of the beam eye.
3. Position the bushing on the equalizer beam eye.
4. If using Owatonna tools, install the bronze center bushings as follows (**see Fig. 2**):

   4.1 Center the hydraulic ram and slide the pulling screw through the beam eye.



1. Speed Nut
2. Bushing
3. Installing Adapter
4. Removing/Installing Adapter
5. Hexnut
6. Pulling Screw

Fig. 2, Bronze Center Bushings Installation

4.2 Position the bushing on the inboard side of the beam eye. Check that the grooves of the bushing are aligned with the vertical centerline of the equalizer beam (see **Fig. 3**).

4.3 Fit the installing adapter and the removing/installing adapter against the outer sleeve of the bushing. Make sure the deep ridge on the installing adapter is positioned against the bronze bushing (see **Fig. 4**).

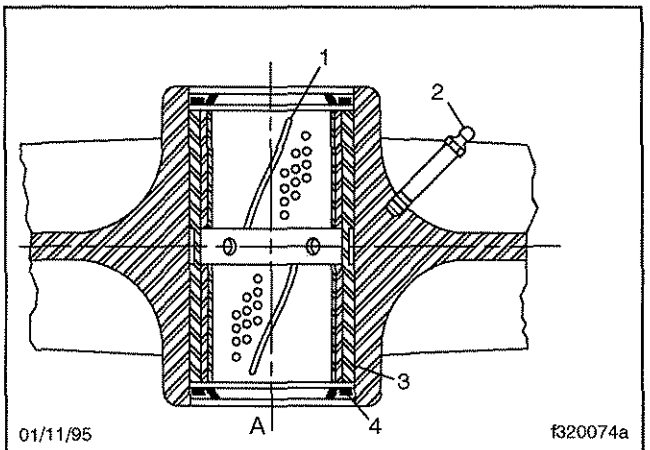
4.4 Install the hexnut on the pulling screw. Full thread engagement is needed.

4.5 Install spacers between the ram cylinder and the speed nut. Tighten the speed nut and remove any slack in the assembly.

4.6 Connect a hydraulic pumping unit to the ram and apply force until the ram cylinder reaches its stroke limit.

4.7 Release the pressure, add spacers, and tighten the speed nut. About three adjustments are needed to completely install the center bushing.

NOTE: The pressure gauge on the pumping unit should read 4000 to 5500 psi (27 560 to 37 895 kPa) during installation. If the reading reaches the

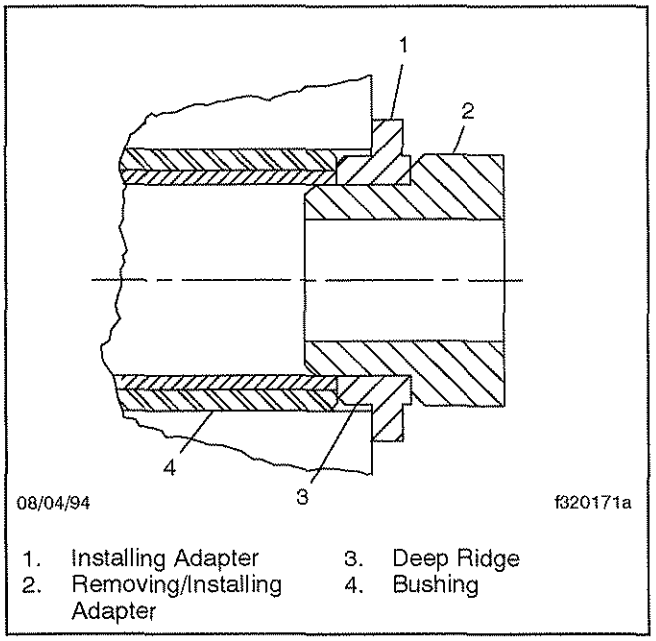


A. Vertical Centerline of Beam

1. Bushing Lube Grooves
2. Grease Fitting
3. Center Bushing Assembly
4. Seal

Fig. 3, Bushing Groove Alignment

Equalizer Beam Bronze Center Bushing Removal and Installation, RS



1. Installing Adapter
2. Removing/Installing Adapter
3. Deep Ridge
4. Bushing

Fig. 4, Installing Adapter Positioning

operating limit of 10,000 psi (68 900 kPa) and the bushing is not going into the beam, check the alignment of the bushing, tooling, and hydraulic equipment. Installation is complete when the installing adapter is flush against the beam.

4.8 On the inboard side of the beam, position a grease seal and installing adapter against the center bushing. Make sure the shallow end of the adapter is against the grease seal (see **Fig. 5**). Using a hammer, tap the installing adapter until it is flat against the beam. Using the same procedure, install a grease seal on the outboard side of the beam.

5. If using shop-made adapters, position the equalizer beam on a 50-ton hydraulic press.

5.1 Center the new bushing in the beam eye. Using a standard bushing driver, press the bushing in until there is equal spacing between both bushing ends and the sides of the beam eye.

5.2 Install the new grease seals (with the seal lips facing out).

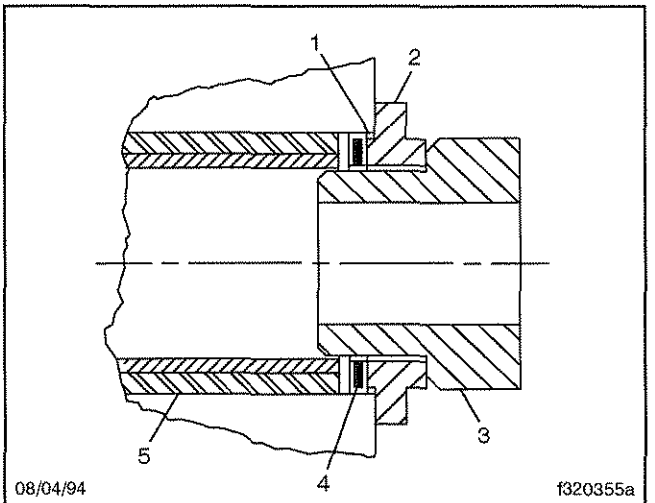
NOTE: Check that the new seals are 1/6 inch (4 mm) inside the beam hub surface to ensure clearance and protection of the seals when the saddle cap is installed.

6. Apply a thin coating of multipurpose chassis grease to the inside surface of the center bushing. Slide the bushing center sleeve into the bushing.

7. Install the grease fitting into the beam hub. Rotate the center sleeve and apply multipurpose chassis grease in the grease fitting. Lubricate until clean grease appears at both ends of the grease seals.

8. Install the crosstube.

9. Install the saddle caps or the equalizer beam (if removed) on the axle beam hangers. For instructions, refer to **Subject 130**.



1. Shallow Ridge
2. Installing Adapter
3. Removing/Installing Adapter
4. Seal
5. Bushing

Fig. 5, Adapter and Grease Seal Positioning

Torque Rod Removal, Bushing Replacement, and Installation, RS

Removal

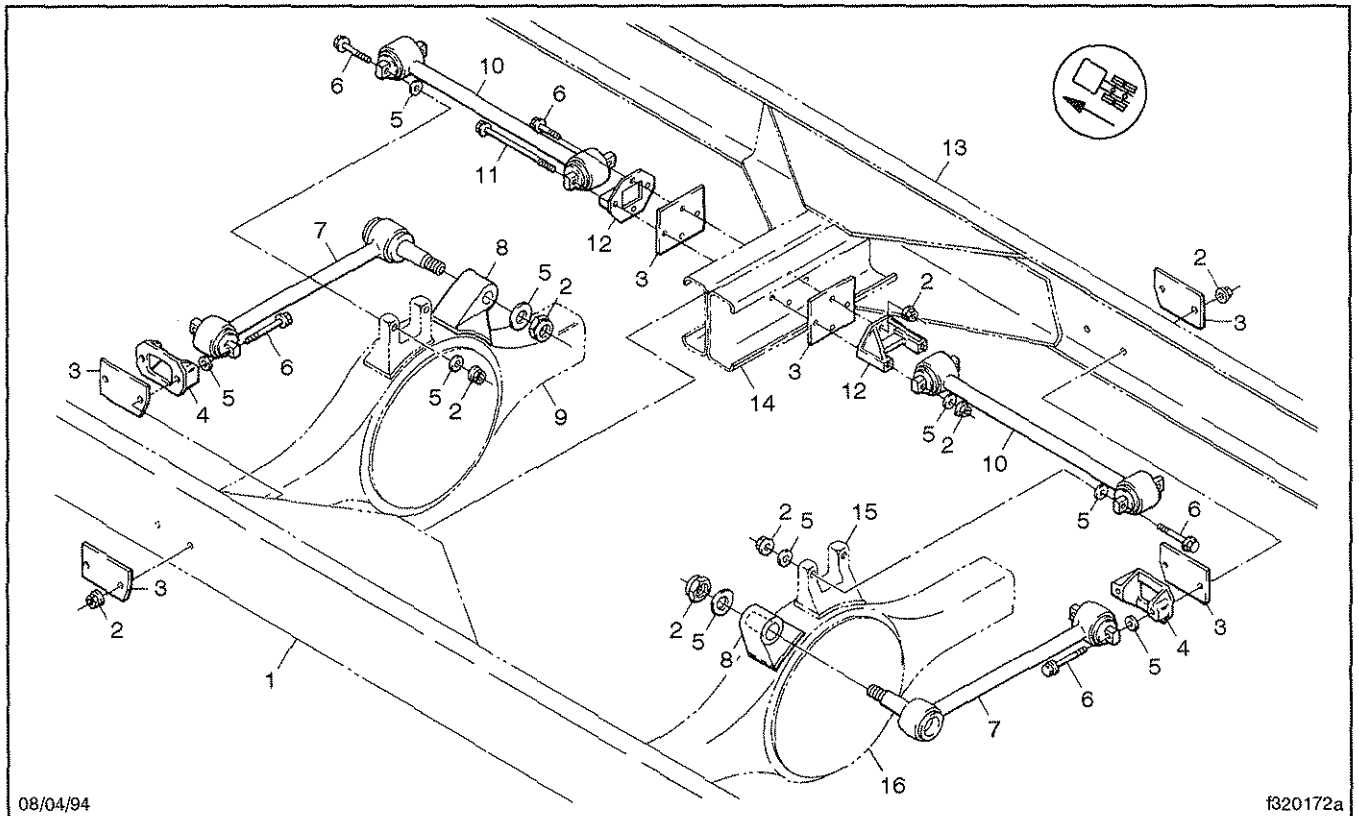
IMPORTANT: To ensure that the required tools are available, see **Specifications, 400** , before beginning these procedures. Special tools are available from the Owatonna Tool Company, Owatonna, Minnesota, or an affiliated dealer.

WARNING: When the torque rods are disconnected from the axle brackets, the axles become free to pivot on the equalizer beam end bushings. Keep clear of the beam hangers and beam ends to avoid possible injury.

1. On fore and aft torque rods, remove the flanged bolts and nuts from the torque rod axle brackets, and the crossmember mounting brackets **(see Fig. 1)**. Remove the torque rods.

   On transverse torque rods, remove the nuts and washers from the axle brackets, and remove the flanged bolts and nuts from the frame rail mounting brackets **(see Fig. 1)**. Remove the torque rods.

NOTE: If necessary, use an impact hammer and tap the top of the axle bracket to disengage the rod stud from the axle bracket.



1. Left-Hand Frame Rail
2. Flanged Hexnut
3. Spacer
4. Transverse Torque Rod Mounting Bracket
5. Hardened Washer
6. Flanged Hex Bolt
7. Transverse Torque Rod
8. Transverse Torque Rod Axle Mounting Bracket
9. Forward Rear-Axle
10. Fore and Aft Torque Rod
11. Capscrew
12. Fore and Aft Torque Rod Crossmember Mounting Bracket
13. Right-Hand Frame Rail
14. Crossmember
15. Fore and Aft Torque Rod Axle Mounting Bracket
16. Rearmost Axle

Fig. 1, Torque Rod Mounting Assembly

Torque Rod Removal, Bushing Replacement, and Installation, RS

2. Inspect the torque rods. If bent or cracked, replace. Check the torque rod bushings. If one of the bushings is loose or damaged, replace both of the bushings.

3. Position the press plate on the hydraulic press. Check that the small counterbore of the plate hole is facing up.

NOTE: Some tapered stud torque rod bushings have a large non-removable washer on the stud that will not fit though the press place hole. Loosen the press plate capscrews and separate the halves **(see Fig. 2)** until the washer clears the counterbore, and the torque rod sets on the press plate. Tighten the capscrews until the press plate halves are closed.

4. Position the tapered stud removal tool (using the end with the larger inside diameter) on the torque rod stud. Apply lubricating oil **(see Fig. 3)**, then press the stud out of the bushing.

5. Position the bushing remover/replacer tool (using the end with the larger outside diameter) on the bushing. Install the cap, then apply lubricating oil to the torque rod bushing.

6. Press the rubber bushing out of the torque rod eye.

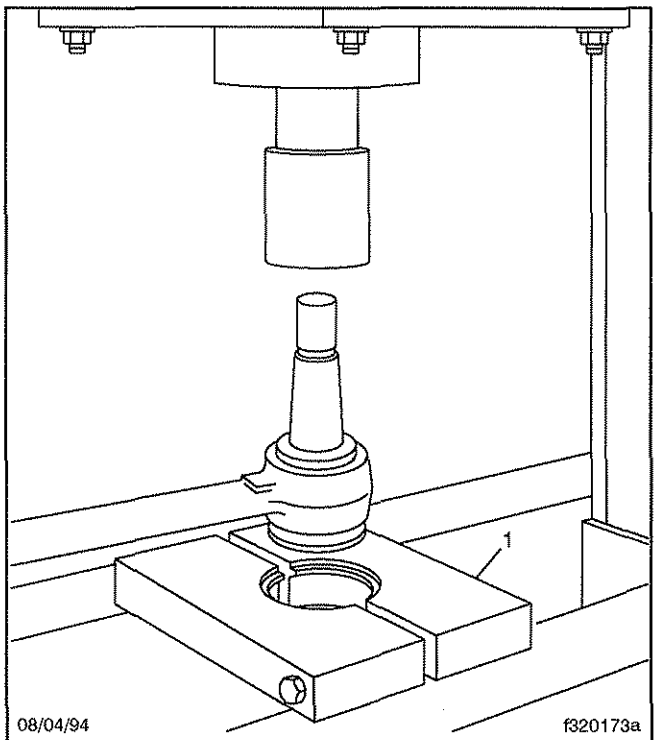
7. Position the straddle mount end of the torque rod into the hole of the press plate. Tighten the press plate capscrews.

8. Position the straddle mount pin remover on the straddle mount pin **(see Fig. 4)**.

9. Apply lubricating oil to the straddle mount pin. Press the straddle mount pin out of the bushing.

10. Position the end of the rubber bushing remover/replacer tool (using the end that has the larger outside diameter) on the bushing. Install the cap, then apply lubricating oil to the torque rod bushing.

11. Press the rubber bushing out of the torque rod eye.



1. Clamping Tool

Fig. 2, Positioning the Torque Rod

Installation

1. Remove all dirt and grease from the torque rod ends. Apply lubricant on the new bushings and in the torque rod eyes.

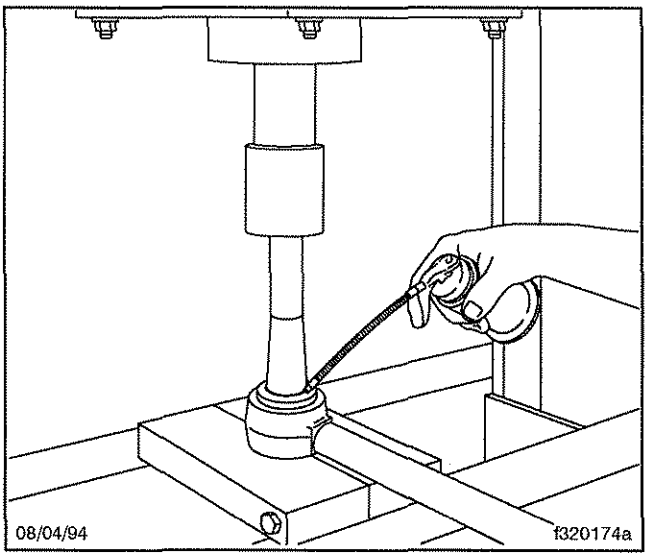


Fig. 3, Applying Lubricating Oil

Torque Rod Removal, Bushing Replacement, and Installation, RS

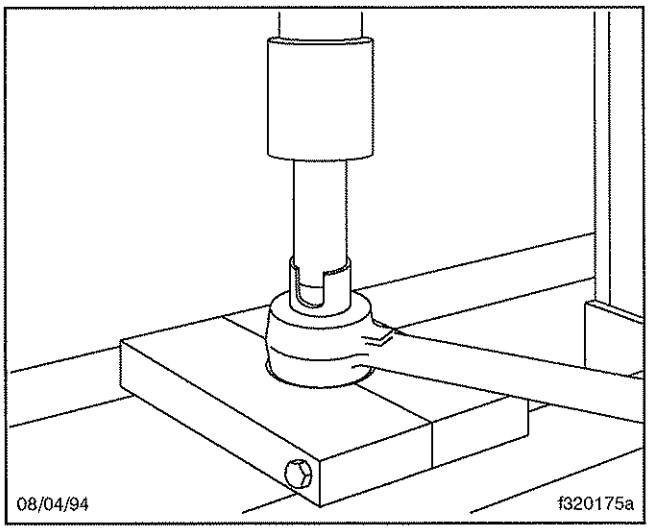
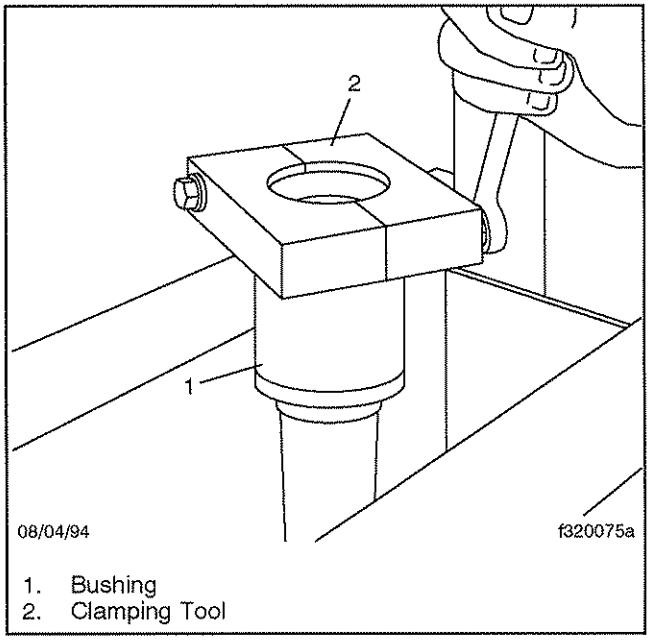


Fig. 4, Straddle Mount Pin Position

2. Position the press plate on the hydraulic press. Check that the small counterbore of the plate hole is facing up.
3. Position the new bushing on the tapered stud of transverse torque rods. Position the clamp and tighten it to compress the rubber **(see Fig. 5)**.
4. Place the torque rod end, the bushing, and the clamp on the press plate.



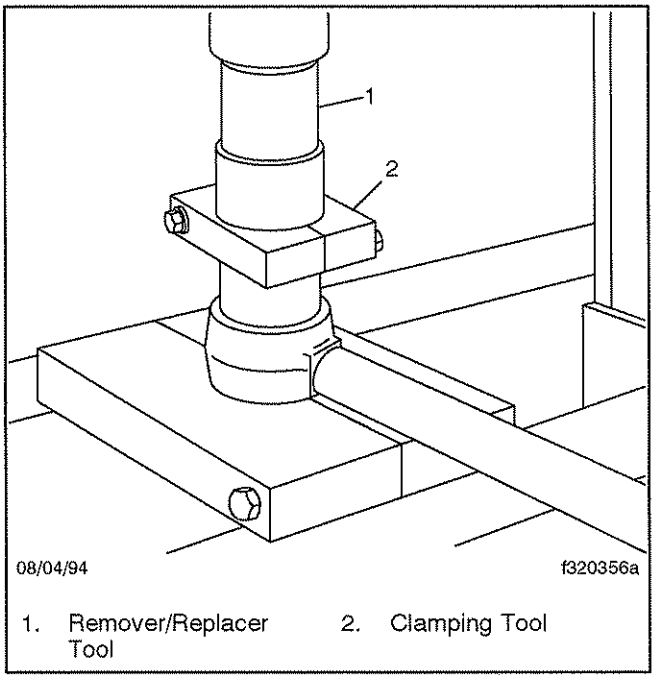
1. Bushing
2. Clamping Tool

Fig. 5, Tighten Clamping Tool

5. Place the remover/replacer tool **(see Fig. 6)** and cap on top of the clamping tool and press the bushing in the torque rod end. Check that the bushing sleeve protrudes equally on each side of the torque rod end.
6. On straddle mount end assemblies, align the clamping tool on the bushing as shown in **Fig. 7**. Tighten the clamp to compress the rubber of the new straddle mount bushing.

NOTE: When tightening the clamp, make sure that the position of the bushing pin is at a right angle to the center line of the torque rod shank **(see Fig. 8)**.

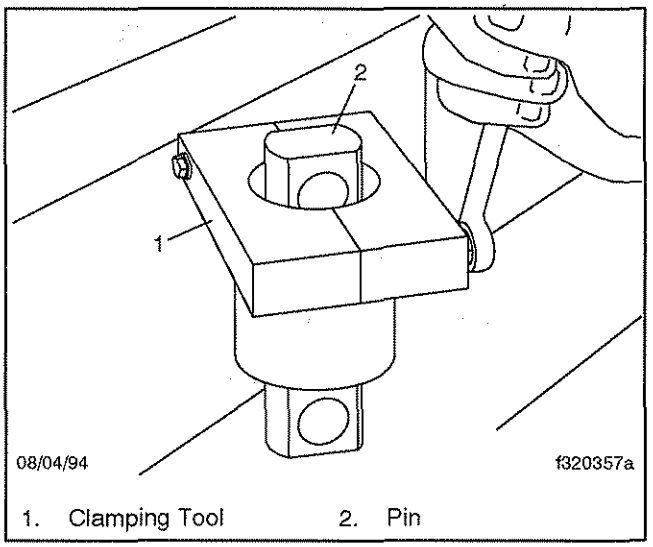
7. Place the torque rod end, the bushing, and the clamp on the press plate.
8. Using the larger end of the remover/replacer tool, position the tool and cap on top of the clamp assembly.
9. Press the bushing in the torque rod end. Check that the bushing's outer sleeve protrudes equally on each side of the torque rod end.
10. Install the fore and aft torque rods as follows **(refer to Fig. 1)**:



1. Remover/Replacer Tool
2. Clamping Tool

Fig. 6, Remover/Replacer Tool Positioning

Torque Rod Removal, Bushing Replacement, and Installation, RS



1. Clamping Tool 2. Pin

Fig. 7, Clamping Tool Alignment

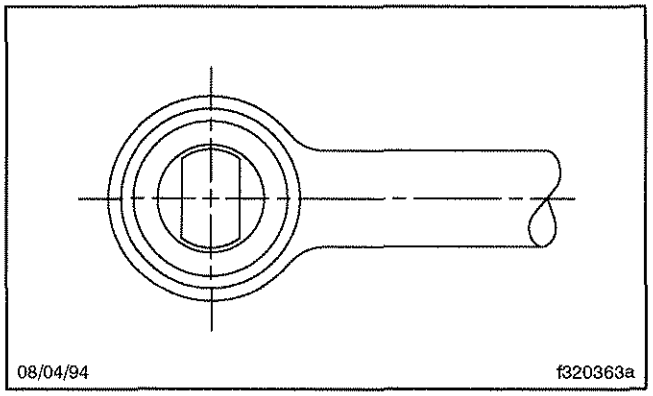


Fig. 8, Bushing Pin Alignment

10.1 Position a torque rod straddle mount pin in the forward-rear axle bracket. Install the flanged bolts through the axle bracket and the straddle mount pin. Install a spacer and nut on each bolt, and tighten 190 lbf·ft (260 N·m).

10.2 Position a torque rod straddle mount pin in the rearmost axle bracket. Install the flanged bolts through the axle bracket and the straddle mount pin. Install a spacer and nut on each bolt, and tighten 190 lbf·ft (260 N·m).

10.3 Position a torque rod spacer and straddle mount bracket on each side of the cross-member. Insert bolts through the upper and lower holes of the forward mounting bracket. Install nuts and tighten 95 lbf·ft (130 N·m).

10.4 Position the straddle mount pin of the forward torque rod in the mounting bracket. Insert bolts through the forward pin, both bracket assemblies, and the straddle mount pin of the rear torque rod. Install the nuts and bearing washers. Tighten the nuts 190 lbf·ft (260 N·m).

11. Install the transverse torque rods as follows **(refer to Fig. 1)**:

11.1 Check that the tapered stud end and the tapered stud bracket hole are clean. Lubricate the tapered stud ends with SAE 20 oil.

11.2 Install the tapered stud in the axle bracket. Install a washer and nut. Tighten the nut 175 to 225 lbf·ft (235 to 300 N·m).

11.3 Align the straddle mount end, the mounting bracket, and the spacer against the inside frame rail.

11.4 On the inboard side of the frame rail, install the bolts through the mounting assembly and the frame rail.

11.5 On the outboard side of the frame rail, install a spacer over the mounting bolt studs. Install the nuts and tighten them 190 lbf·ft (260 N·m).

12. Check the axle pinion angle. For instructions, **refer to Group 41.**

Part Number	Tool	Usage
1761	Torque Rod Set	Torque Rod Bushing Removal and Installation
28536	Installing Adapter (5-3/4" o.d.)	Bronze Center Bushing and Seal Removal and Installation
44119	Receiving Tube	Center and End Bushing Removal and Installation
51678	80-Ton Hydraulic Ram	All Operations
51695	Jack	All Operations
302018	Spacer (3 qty.)	Center and End Bushing Removal and Installation
302023	Pulling Screw	All Operations
302024	Removing and Installing Adapter	Bronze Center Bushing Removal and Installation
302026	Installing Adapter	Rubber Center Bushing Removal and Installation
302027	Removing Adapter	Rubber Center Bushing Removal and Installation
302028	Hexnut	All Operations
302029	Speed Nut	All Operations

Table 1, Special Tools (Owatonna Tool Company)

Tool Number	Dimensions	Usage
3	4-5/8 inch o.d. by 7 inch	Beam Center Bushing Removal and Installation

Table 2, Shop-Made Adapters

Description	Size	Torque lbf·ft (N·m)
Top Pad to Spring Aligning Setscrew	—	100-150 (135-200)
Top Pad Nut	—	275-400 (375-542)
Spring Pin Locknut	1/2-13	45-63 (61-85)
Torque Rod Straddle Mount Nut	5/8-11	190 (260)
Torque Rod Stud Locknut	1-1/4-12	175-225 (235-305)
Saddle Cap Stud	7/8-14	55-65 (75-90)
Saddle Cap Locknut	7/8-14	225-275 (305-373)
Bar Pin Locknut	1-8	450-600 (610-813)
Spring Center Bolt	7/16-20	50-60 (70-80)
	1/2-20	65-75 (90-100)
Rebound Spacer Locknut	1/2-13	38-45 (51-61)
Spring Alignment Clip	—	15 (20)
Fore and Aft Torque Rod Mount Nut	—	95 (130)

Table 3, Torque Values

Rear Suspension, Hendrickson HAS 32.08

Contents

Subject	Subject Number
General Information	050
Service Operations	
Main Support Member Removal and Installation	100
Axle Seat Removal and Installation	110
Torque Rod Bushing Replacement	115
Height Control Valve Removal and Installation	120
Fifth Wheel/Hanger Clearance	125
Quick Release Valve Replacement	130
Slipper Pad Removal and Installation	135
Cross Channel Removal and Installation	137
Axle Alignment Checking and Adjustment	140
Air Spring Replacement	145
Air Spring Frame Hanger Removal and Installation	150
Shock Absorber Bracket Removal and Installation	160
Transverse Rod Removal and Installation	165
Shock Absorber Replacement	170
Ride Height Adjustment	180
Troubleshooting	300
Specifications	400

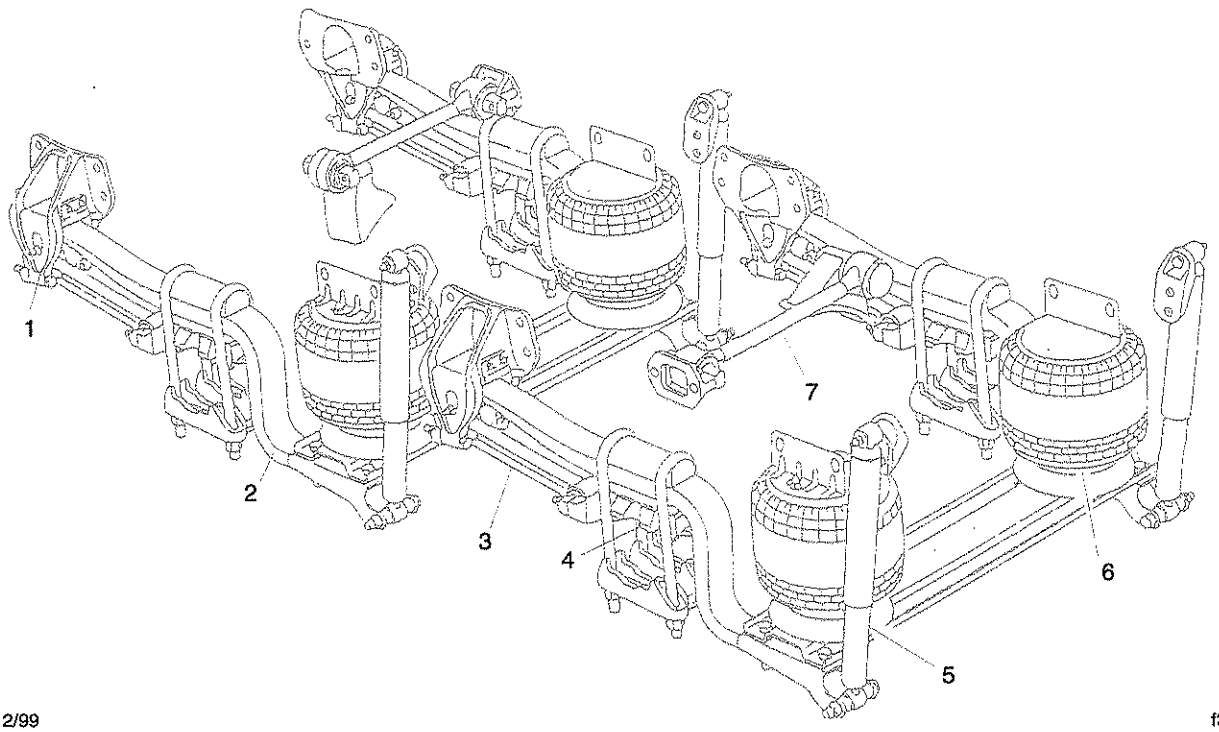
General Description

The Hendrickson HAS suspension (see **Fig. 1**) uses air bags to support the sprung weight on vehicles with both single and tandem axles. The air bags (air springs) mount on a crossmember between the two main support beams that are fastened to the axle housing and pivot on forward-mounted hanger brackets on the frame. Torque rods, running from the hanger brackets to the axle seats, transfer vehicle motion to the frame. Lateral stability is provided by transverse torque rods from the inside of the frame rails to brackets on the axle housings. The shock absorbers help to dampen the oscillations of the air springs and control the torque reaction of the axle housings on acceleration.

AIR CONTROL SYSTEM

The Hendrickson HAS air suspension system allows for a smooth ride while maintaining a constant ride height, even with varying loads. Although most vehicles with the HAS system use only one height control valve for the rear suspension, some vehicles with uneven loading may have a height control valve for each side of the vehicle. An optional suspension dump system permits the driver to temporarily lower the frame for trailer coupling or uncoupling without having to leave the cab. See **Subject 400** for a schematic of the air control system.

The suspension air control system uses air supplied from the secondary air brake system. The air supply line is connected to a secondary air manifold located behind the instrument panel. If a loss of air pressure occurs forward (upstream) of the protection valve, the air spring system will be isolated and maintain the air pressure within the suspension system until repairs can be made. However, if a loss of air occurs rearward (downstream) of the protection valve, the air in the brake system will be protected, but the air pressure in the air springs will be lost.



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1. Hanger Bracket
2. Main Support Beam
3. Torque Rod
4. Axle Seat
5. Shock Absorber
6. Air Spring
7. Transverse Rod

Fig. 1, Rear Suspension, Hendrickson HAS-Series

General Information

The vehicle ride height is maintained by a height control valve mounted on the frame and linkage that connects the valve to the suspension crossmember. (See **Fig. 2**). As the frame-to-axle housing clearance changes due to a change in the vehicle load, the linkage moves the lever on the height control valve, causing air to move in or out of the air bags. A slight delay in the operation of the height control valve prevents the system from trying to adjust the ride height for each suspension movement.

The optional air suspension dump system is used to deflate the rear suspension air springs during trailer coupling and uncoupling operations. The dump control valve is located on the dash in the cab. When the dump control valve is toggled, supply air flows through the dump control valve delivery port and pressurizes the signal line to the relay valve. The pressurization of the signal line closes the relay valve supply port while opening the ports from the air bags to the atmosphere. Air from the air bags exhausts through the relay valve until the dump control valve is released or until the frame rests on the stops inside the air bags. A pressure switch in the signal line to the relay valve senses the signal pressure and switches on an optional red status light on the dash. To allow the air springs to inflate after being dumped, the dump control valve must be first toggled downward to exhaust the pressure in the signal line.

The pilot-operated relay valve is used for rapid deflation of the air bags for trailer coupling and uncoupling. When pilot pressure from the dump control valve is applied to the relay valve, the supply air from the height control valve is stopped from flowing through the relay valve and, simultaneously, the air spring pressure is exhausted directly to the atmosphere through passages in the relay valve.

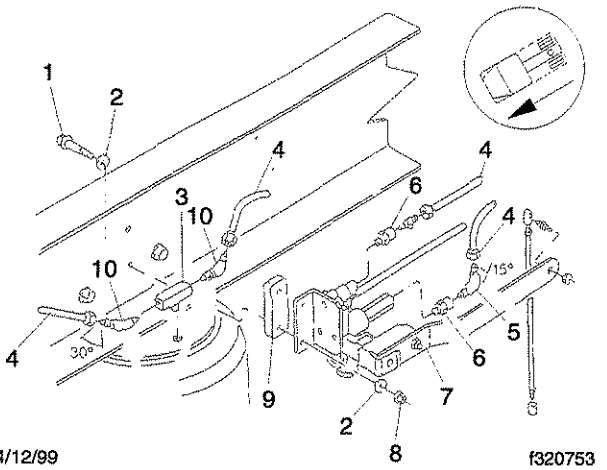
REAR SUSPENSION COMPONENTS

The axle housing, the lower shock mounts and the lower air bag mounts are all solidly attached to the HAS main support arms. See **Fig. 3** and **Fig. 4**. The main support arm hanger brackets, the upper shock mounts and the upper air bag mounts are all solidly mounted to the frame rails. The torque rods, with flexible bushings in each end, connect the hangers to the axle seats. When the vehicle travels over a bump, the axle housing suddenly rises and compresses the air bags. The pressure in the air bags increases immediately, which absorbs most of the energy of the upward-moving axle housing without transferring that movement to the frame. The shock absorbers then help absorb the release of that higher pressure by slowing the downward movement of the axle housing after the bump.

The front of each main support arm is allowed to pivot and slide on replaceable slipper pads in the hanger brackets. A torque rod is attached to each hanger bracket and to each axle seat bracket by rubber bushings with internal pins, installed in the torque rods at specified angles. Shims are used for adjustment at the front of each torque rod to make sure that the wheels run parallel to the frame rails.

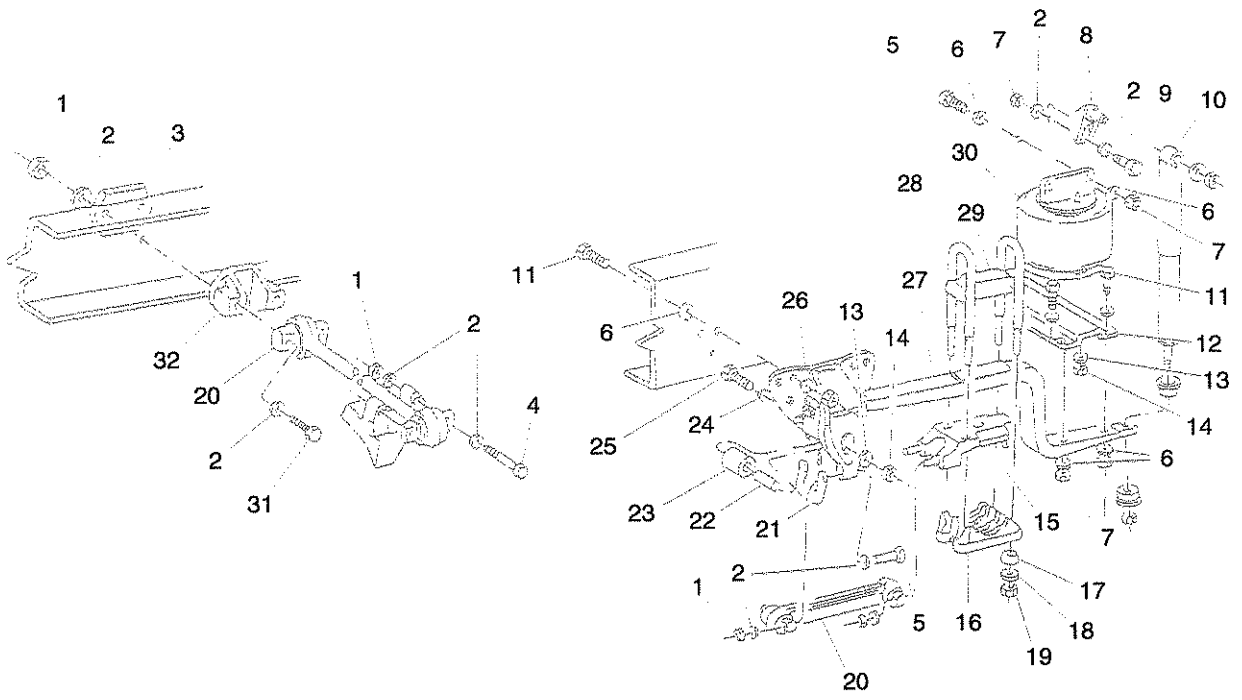
The torque rods control the forward and aft movement of the unsprung pieces during suspension travel. The flexible rubber bushings in the torque rods allow vertical movement of the axle housing while limiting its forward and aft movement. The driveline angles are kept within the specified limits by the torque rods' control of the rotational forces on the axle housings during acceleration and deceleration. The torque rods transfer the forward motion of the axle housing to the frame rails on acceleration and pull back on the frame during braking.

The transverse rods, also with rubber bushings in each end, connect the brackets on the axle housings to the brackets on the frame rails. The transverse rods keep a constant lateral relationship of the frame to the axle



1. Bolt
2. Washer
3. Tee
4. Tube Assembly
5. Elbow
6. Adapter
7. Height Control Valve
8. Nut
9. Bracket
10. Elbow

Fig. 2, Height Control Valve Assembly (typical)



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1. Nut
2. Washer
3. Reinforcement
4. Bolt
5. Bolt
6. Washer
7. Nut
8. Shock Absorber Mounting Bracket
9. Bolt
10. Shock Absorber
11. Bolt
12. Suspension Support
13. Washer
14. Nut
15. Axle Seat
16. Bottom Cap Assembly
17. Spherical Washer
18. Washer
19. Nut
20. Transverse Rod Assembly
21. Alignment Shims
22. Spacer
23. Rebound Roller
24. Washer
25. Bolt
26. Hanger
27. Main Support Beam
28. U-Bolt
29. Top Pad
30. Air Spring Assembly
31. Bolt
32. Bracket

Fig. 3, Rear Suspension Components, Hendrickson HAS-40LH Series

housing, while still allowing vertical movement of the axle housings.

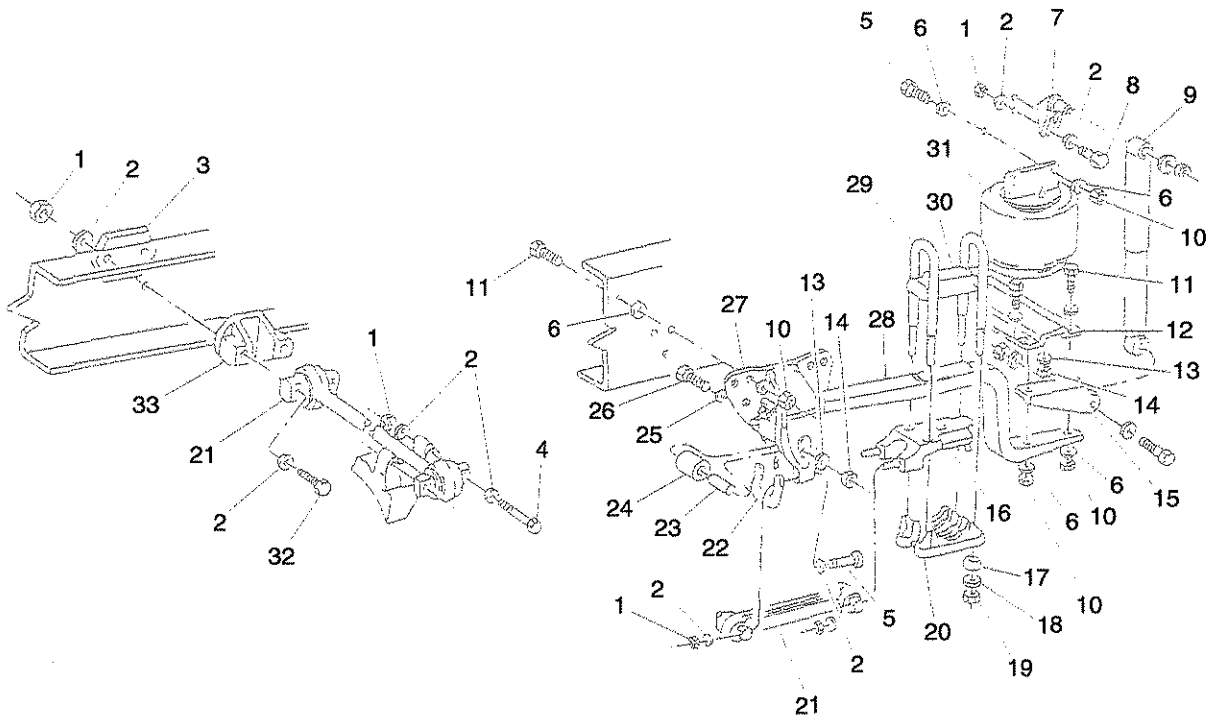
The Hendrickson HAS suspension is available in varying capacities and for limited off-highway use. The heavy-duty or off-highway suspensions have thicker main support arms, heavier crossmembers and torque rods, and heavy-duty air bags and shock absorbers. There are two HAS ride height specifications (measured from the bottom of the frame rail to the bottom of the main support arm at the axle seat) depending on which suspension is used. The HAS suspensions are available for single or tandem axle vehicles and can be ordered with or without the suspension dump feature.

REAR SUSPENSION SERVICE NOTES

⚠ WARNING

A main support member that has been subjected to heat, nicks or gouges can fail, causing loss of vehicle control and possible personal injury or property damage.

General Information



1. Nut
2. Washer
3. Reinforcement
4. Bolt
5. Bolt
6. Washer
7. Shock Absorber Mounting Bracket
8. Bolt
9. Shock Absorber
10. Nut
11. Bolt
12. Suspension Support
13. Washer
14. Nut
15. Shock Absorber Mounting Bracket
16. Axle Seat
17. Spherical Washer
18. Washer
19. Nut
20. Bottom Cap Assembly
21. Transverse Rod Assembly
22. Alignment Shims
23. Spacer
24. Rebound Roller
25. Washer
26. Bolt
27. Hanger
28. Main Support Beam
29. U-Bolt
30. Top Pad
31. Air Spring Assembly
32. Bolt
33. Bracket

Fig. 4, Rear Suspension Components, Hendrickson HAS-400, HAS-402, and HAS-460 Series

⚠ CAUTION

Do not use an arc welder on the suspension parts or use a cutting torch to remove any fasteners. The use of heat on suspension components will adversely affect the strength of these parts. Never reinstall used suspension fasteners. Always use the same part number or an exact equivalent part number when replacing any suspension fastener. All fasteners must be tightened to their specified torque and the U-bolts must be tightened in stages as described in Specifications 400.

Check the axle alignment after replacing components that affect alignment, such as a main support beam, a torque rod or a hanger.

NOTE: During installation, apply Pipe Sealant with Teflon D8AZ–19554–A or equivalent meeting specification WSK–M2G350–A2 or ESR–M18P7–A to the air fitting threads.

NOTE: When replacing the torque rod bushings, lubricate the new bushings with a vegetable-based oil only. Make sure the new bushings are centered in the torque rod bores.

NOTE: A shim pack of three 0.11 inch (2.8 mm) thick spacers are used to adjust axle lateral tracking offset. Install the spacers as required to adjust tracking.

Main Support Member Removal and Installation

Removal

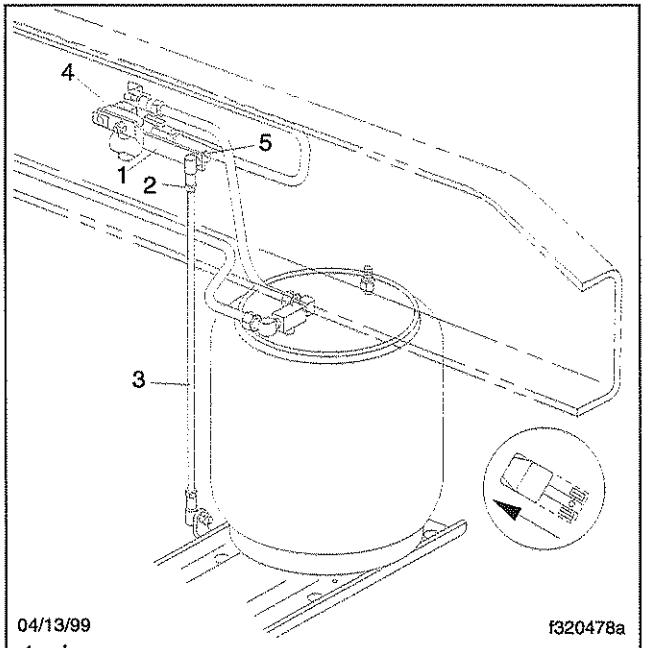
NOTE: Operation of the HAS suspension will result in wear between the main support member and the spring hanger slipper pad. In normal use, these components will function satisfactorily even though they show some wear. Premature wear may occur, however, and requires the replacement of one or both parts. A main support member should be replaced if it has 3/8 inch (9.5 mm) or more wear at the hanger cam contact area.

1. Stop the vehicle on a level surface, shut down the engine and apply the park brakes. Chock the front and rear tires.
2. Support the axle housing with a jack stand under the pinion nose to prevent the axle housing from rotating when the U-bolts are removed.

⚠ WARNING

The air suspension system will start moving the frame when the lever for the ride height control valve is moved from its center position. To avoid injury or property damage, make sure that your hands and all objects are away from any pinch points when the lever is moved.

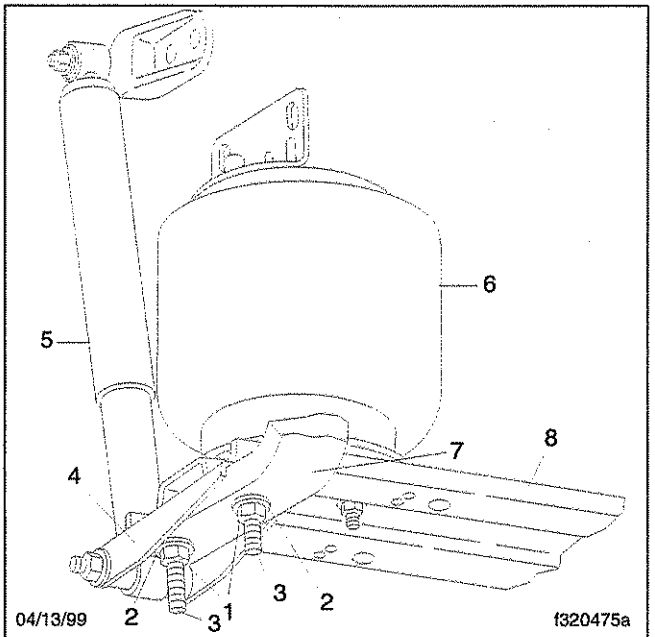
3. Disconnect the vertical linkage for the height control valve at the end of the horizontal lever. See **Fig. 1**. Lift the lever on the height control valve so that the air bags raise the frame about 3 inches (75 mm). Support the frame at that position with jack stands.
4. Remove the locknuts, washers and bolts that connect the cross channel and shock absorber brackets to both main support members. See **Fig. 2**. Remove the lower shock mount fasteners on the HAS–40LH models.
5. Use a floor jack to raise the cross channel about 3 inches (75 mm). Support the cross channel assembly with jack stands.
6. Remove the locknut, washers and bolt from the rebound roller assembly at the front hanger. See **Fig. 3**. Remove the rebound roller and spacer.
7. Remove the U-bolt high nuts and washers, then remove the bottom cap, U-bolts and the top pad and Delrin liner.
8. Slide the main support member out of the hanger and remove the main support assembly from the vehicle.
9. Inspect the main support member for wear. Replace the main support member if worn more than 3/8 inch (9.5 mm) at the hanger end where it contacts the slipper pad or if it has cracks, nicks or signs of the application of heat from a torch or welder.
10. Inspect the slipper pad for wear. Replace the slipper pad if worn. Remove the four bolts and washers that hold the slipper pad to the hanger. If rivets were installed instead of bolts to hold the slipper pad, use a grinder to remove the rivet heads.



1. Lever
2. Ball Joint and Jam Nut
3. Vertical Linkage Rod
4. Height Control Valve
5. Locknut

Fig. 1, Ride Height Control Linkage

Main Support Member Removal and Installation



1. Locknut
2. Washer
3. Bolt
4. Lower Shock Bracket
5. Shock Absorber
6. Air Spring
7. Main Support Member
8. Cross Channel

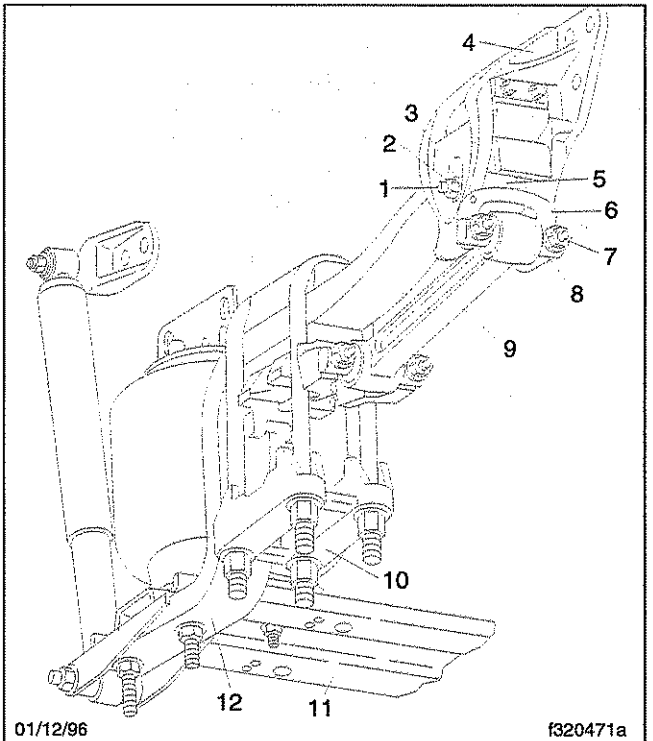
Fig. 2, Main Support Member

Installation

⚠ WARNING

Always use new fasteners when installing suspension components. Reuse of fasteners can lead to component damage and loss of vehicle control, possibly resulting in personal injury or property damage.

1. Install the slipper pad, bolts and washers into the hanger. Tighten the bolts 25 lbf·ft (34 N·m). Install new rivets if so equipped.
2. Slide the main support member into the hanger assembly.
3. Position the main support member on the axle seat, or on the spacer plate if the vehicle is so equipped, with the main support member center dowel sliding into the hole in the axle seat or spacer plate.
4. The Delrin liner must be positioned on the top of the main support member. Install the U-bolt top pad on the Delrin liner. Install the U-bolts over the top pad and liner and around the main support member, the spacer (if so equipped), the axle seat assembly, the axle housing, and the bottom cap. Install the washers and high nuts and tighten with your fingers, but do not fully tighten the U-bolt high nuts at this time.
5. Lower the floor jack under the cross channel until the cross channel is against the main support members. Install the shock absorber bracket (if so equipped) and bolts into the cross channel and main support members. See **Fig. 2**. Install the washers and tighten the locknuts 280 lbf·ft (380 N·m). On the HAS–40LH models, install the lower shock absorber mount bolts, washers and nuts. Tighten the shock absorber nut 60 lbf·ft (82 N·m).



1. Rebound Bolt
2. Locknut
3. Washer
4. Hanger
5. Rebound Roller
6. Alignment Shim(s)
7. Bolt
8. Bar Pin
9. Torque Rod
10. Bottom Cap
11. Cross Channel
12. Main Support Member

Fig. 3, Removing the Rebound Roller

6. Install the rebound roller into the hanger. Install the bolt, washer and locknut. Tighten the locknut 60 lbf·ft (82 N·m).
7. Center the main support member between the hanger legs. Move the lever for the height control valve up to lift the frame from its jack stands. Remove the jack stands from the frame.
8. Tighten the U-bolt locknuts in stages as described in **Specifications 400**. Rap the top of the U-bolts with a hammer and then retighten the high nuts 500 lbf·ft (680 N·m).

IMPORTANT: Do not exceed the specified torque on the U-bolt high nuts. Retighten the U-bolt high nuts after 1000 miles (1600 km).

9. Move the lever for the height control valve down to lower the frame until the upper ball joint stud in the vertical linkage exactly aligns with the hole in the lever when the lever is in the horizontal position. Install the height control valve ball joint stud, washer and locknut. Tighten the locknut 10 lbf·ft (14 N·m).
10. Remove the jack stand from under the nose of the axle housing.
11. Check and adjust the ride height as described in **Subject 180**.
12. Check the alignment after new main support members are installed.

Axle Seat Removal and Installation

Removal

1. Stop the vehicle on a level surface, shut down the engine and apply the park brakes. Chock the front and rear tires.
2. Support the axle housing with a jack stand under the pinion nose to prevent the axle housing from rotating when the U-bolts are removed.

⚠ WARNING

The air suspension system will start moving the frame when the lever for the ride height control valve is moved from its center position. To avoid injury or property damage, make sure that your hands and all objects are away from any pinch points when the lever is moved.

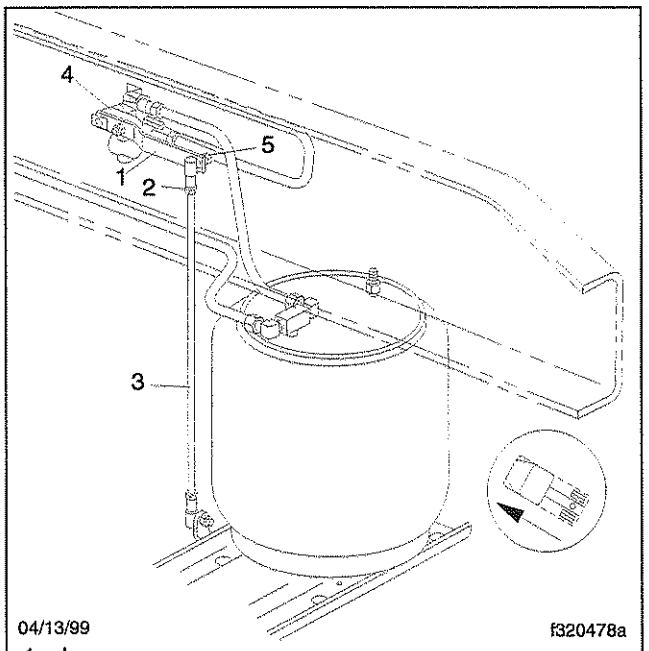
3. Disconnect the vertical linkage for the height control valve at the end of the horizontal lever. See **Fig. 1**. Lift the lever on the height control valve so that the air bags raise the rear of the frame about 3 inches (75 mm). Support the frame at that position with jack stands.
4. Remove the nuts, washers and bolts that hold the torque rod to the hanger legs.
5. Remove the nuts and washers that hold the torque rod to the axle seat. Remove the torque rod.
6. Remove the high nuts from the U-bolts and remove the bottom cap and top pad and Delrin liner.
7. Use a floor jack to raise the cross channel and main support member just enough to remove the axle seat.
8. Remove the axle seat. See **Fig. 2**.
9. If the axle seat studs need replacement, remove them with a hammer and brass drift.

Installation

⚠ WARNING

Always use new fasteners when installing suspension components. Reuse of fasteners can lead to component damage and loss of vehicle control, possibly resulting in personal injury or property damage.

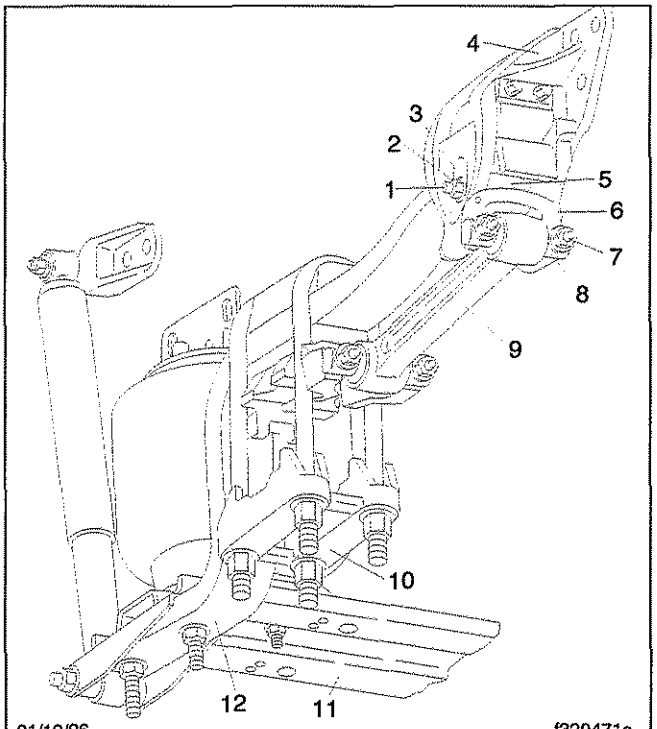
1. Install the new studs with a stud driver. Insert the stud in the hole of the axle seat and tap into position with a hammer and brass drift.
2. Lift the main support member with a floor jack and install the axle seat on the top of the axle housing. Install the spacer (if so equipped) above the axle seat.
3. Position the main support member on the axle seat, or on the spacer plate if the vehicle is so equipped, with the main support member center dowel sliding into the hole in the axle seat or spacer plate.
4. The Delrin liner must be positioned on the top of the main support member. Install the U-bolt top pad on the Delrin liner. Install the U-bolts over the top pad and liner and around the main support member, the spacer (if so equipped), the axle seat assembly, the axle housing, and the bottom cap. Install the washers and high nuts and tighten with your fingers, but do not fully tighten the U-bolt high nuts at this time.



1. Lever
2. Ball Joint and Jam Nut
3. Vertical Linkage Rod
4. Height Control Valve
5. Locknut

Fig. 1, Ride Height Control Linkage

Axle Seat Removal and Installation



1. Rebound Bolt
2. Locknut
3. Washer
4. Hanger
5. Rebound Roller
6. Alignment Shim(s)
7. Bolt
8. Bar Pin
9. Torque Rod
10. Bottom Cap
11. Cross Channel
12. Main Support Member

Fig. 2, Removing the Axle Seat

5. Install the torque rod on the axle seat so that the holes in the bushing pin align with the axle seat studs. Install the washers and nuts, but do not tighten at this time.
6. Install the front end of the torque rod onto the hanger legs and install any shims that were removed. Install the bolts through the hanger legs, shims, and the front bushing pin.
7. Tighten the nuts on the front of the torque rod 175 lbf·ft (237 N·m).
8. Tighten the nuts for the torque rod pin at the axle seat 175 lbf·ft (237 N·m).
9. Move the lever for the height control valve up to lift the frame from its jack stands, Remove the jack stands from the frame.
10. Tighten the U-bolt locknuts in stages as described in **Specifications 400**. Rap the top of the U-bolts with a hammer and then retighten the high nuts 500 lbf·ft (680 N·m).

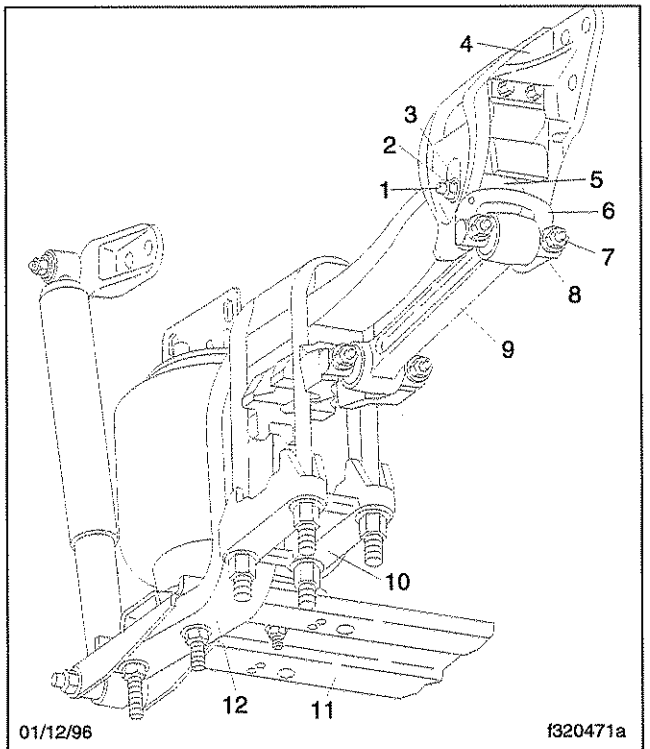
IMPORTANT: Do not exceed the specified torque on the U-bolt high nuts. Retighten the U-bolt high nuts after 1000 miles (1600 km).

11. Move the lever for the height control valve down to lower the frame until the upper ball joint stud in the vertical linkage exactly aligns with the hole in the lever when the lever is in the horizontal position. Install the height control valve ball joint stud, washer and locknut. Tighten the locknut 10 lbf·ft (14 N·m).
12. Remove the jack stand from under the nose of the axle housing.
13. Check and adjust the ride height as described in **Subject 180**.
14. Check the alignment after new axle seats are installed.

Replacement (See Fig. 1)

Use the following procedure to replace the torque rod bushing.

1. Chock the front tires, and the tires of the drive axles.
2. Remove the bushing pin locknuts and washers at the axle end of the torque rod. See **Fig. 1**.
3. Loosen the rebound bolt locknut in the hanger.
4. Remove the bushing pin locknuts, bolts and washers, and any alignment shims at the hanger end of the torque rod. Note the number of shims, as the same thickness shim pack must be reinstalled to avoid affecting the vehicle's alignment.



1. Rebound Bolt
2. Locknut
3. Washer
4. Hanger
5. Rebound Roller
6. Alignment Shim(s)
7. Bolt
8. Bar Pin
9. Torque Rod
10. Bottom Cap
11. Cross Channel
12. Main Support Member

Fig. 1, Torque Rod Installation

5. Push out the old bushings. Use a vertical shop press with a capacity of at least 10 tons. A 5-inch (127 mm) piece of 2-inch by 1/4-inch (50-mm by 6-mm) wall, steel-tubing receiving tool is required. The bushings are not cartridge-type bushings and do not have a metal outer sleeve.
6. Support the torque rod end on the receiving tool with the end tube of the torque rod centered on the tool.

⚠ WARNING

Do not use heat or a cutting torch to remove the bushings from the torque rod. The use of heat will weaken the torque rod, which could cause the rod to break. This could result in a loss of vehicle control, personal injury, or property damage.

7. Push directly on the bushing pin until the bushing is pushed out of the torque rod end tube.
8. Clean and inspect the torque rod ends. Remove any nicks with emery cloth.
9. Lubricate the torque rod ends and the new rubber bushings with a vegetable-based oil. Do not use a petroleum-based or soap-based lubricant.
10. Press in the new bushings while supporting the torque rod end on the receiving tool with the end tube of the torque rod centered on the receiving tool. The bushings must be installed with the mounting flats on the bar pin positioned 90 degrees to the shank of the torque rod. See **Fig. 2**.
11. Press directly on the bar pin of the bushings, which must be centered within the torque rod end tubes. When pressing in the new bushings, overshoot the final position by approximately 3/16 inch (5 mm).
12. Press the bushing again from the opposite side to center the bushing within the torque rod end.
13. Position the torque rod into the axle seat and attach it with the washers and locknuts. Handtighten the locknuts.
14. Position the torque rod onto the forward face of the hanger legs. Assemble the bolts, washers and locknuts, and any alignment shims. Tighten locknut 175 lbf·ft (237 N·m). See **Fig. 1**.
15. Tighten locknuts at the axle end of the torque rods 175 lbf·ft (237 N·m).

Torque Rod Bushing Replacement

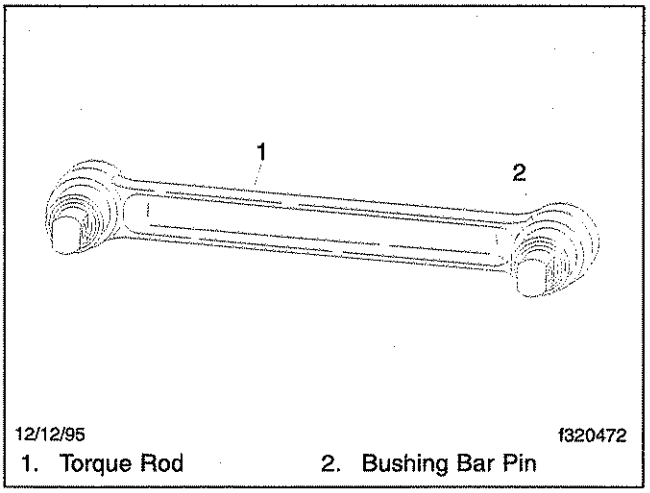


Fig. 2, Positioning the Bar Pin Mounting Flats

16. Tighten rebound bolt locknut 60 lbf·ft (81 N·m).

Height Control Valve Removal and Installation

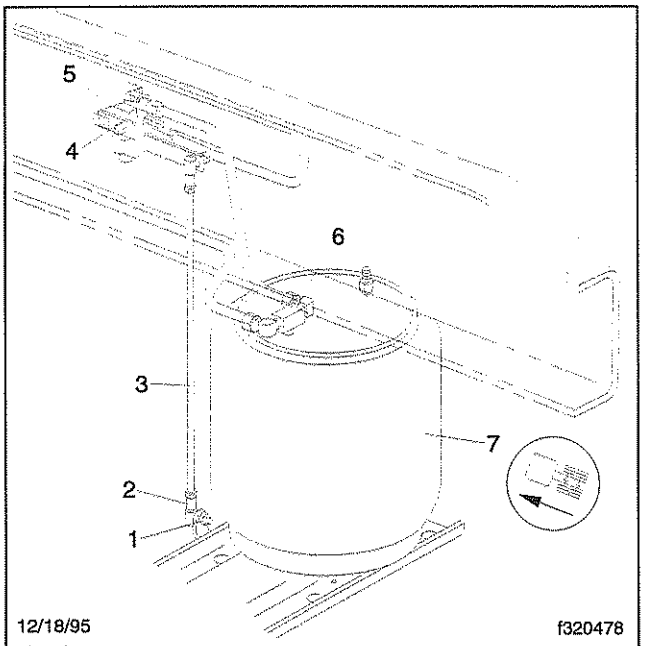
Removal

1. Chock the front tires.
2. Drain the vehicle's air system.

⚠ WARNING

The air suspension system will start moving the frame when the lever for the ride height control valve is moved from its center position. To avoid injury or property damage, make sure that your hands and all objects are away from any pinch points when the lever is moved.

3. Remove the height control valve vertical rod from the valve lever by removing the nut and lock washer. Push down on the lever of the height control valve to exhaust the air from the rear suspension air bags.
4. Remove the air lines attached to the height control valve. See **Fig. 1**.
5. Remove the locknuts, washers, and bolts that attach the height control valve to the frame.
6. Remove the brass air fittings from the height control valve.



1. Lever
2. Ball Joint and Jam Nut
3. Vertical Linkage Rod
4. Height Control Valve
5. Locknut

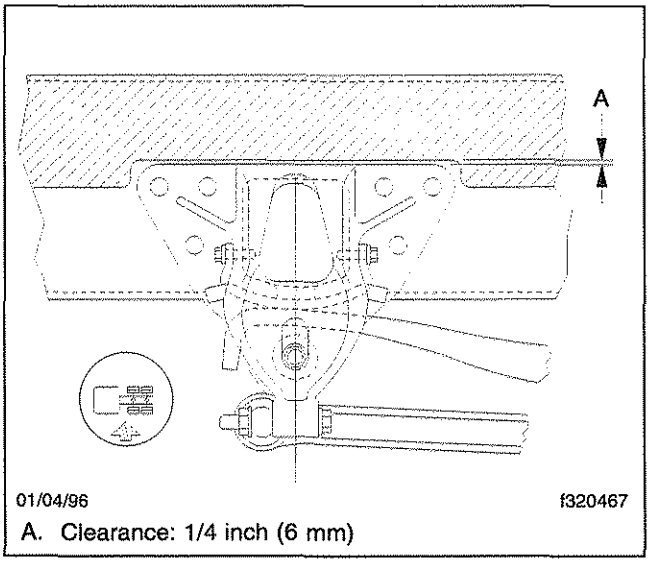
Fig. 1, Height Control Valve System

Installation

1. Install the brass air fittings into the height control valve ports.
2. Install the bolts, washers, and locknuts that attach the valve to the frame rail.
3. Attach the air lines to the height control valve.
4. Attach the height control valve vertical linkage rod to the height control valve lever, and install the lock washer and nut. See **Fig. 1**.
5. Return air to the system.
6. Adjust the height control valve for proper ride height as described in **Subject 180**.

Information

The HAS front hangers must have at least 1/4-inch (6 mm) clearance between the top of the hanger and the bottom of the fifth wheel mounting bracket on the sides of the frame rails. In some cases, the fifth wheel mounting bracket may have to be cut out to provide the correct clearance. See **Fig. 1** for an example of a fifth wheel mounting bracket that has been modified.



A. Clearance: 1/4 inch (6 mm)

Fig. 1, Fifth Wheel Mounting Angle Clearance

Quick Release Valve Replacement

Replacement (See Fig. 1)

1. Chock the front tires.
2. Drain the vehicle's air system.
3. Disconnect the air lines from the quick release valve. Identify the air line at the top of the valve.
4. Remove the quick release valve from the frame or cross member.
5. Remove the brass air fittings from the valve.
6. Attach the brass air fittings to the replacement quick release valve.
7. Attach the valve to the frame or cross member.
8. Connect the air lines to the valve, making sure to attach the identified line to the top of the valve.
9. Build up pressure in the air system.
10. Remove the chocks from the front tires.

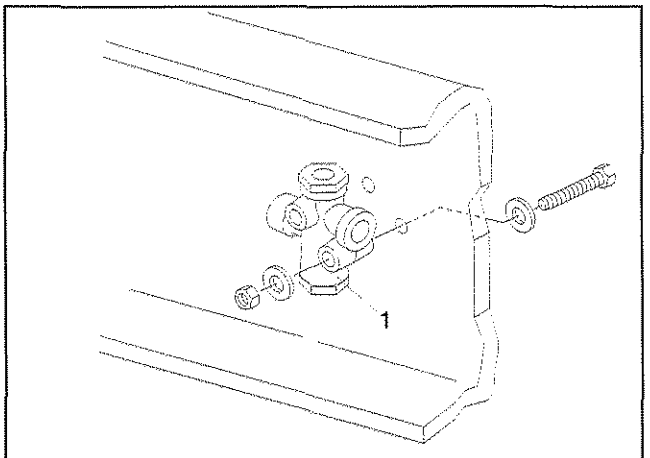


Fig. 1, Quick Release Valve Installation

Slipper Pad Removal and Installation

Removal

NOTE: Operation of the HAS suspension will result in wear between the main support member and the hanger slipper pad. In normal use, these components will function satisfactorily even though the components indicate some wear.

1. Chock the front tires.

⚠ WARNING

The air suspension system will start moving the frame when the lever for the ride height control valve is moved from its center position. To avoid injury or property damage, make sure that your hands and all objects are away from any pinch points when the lever is moved.

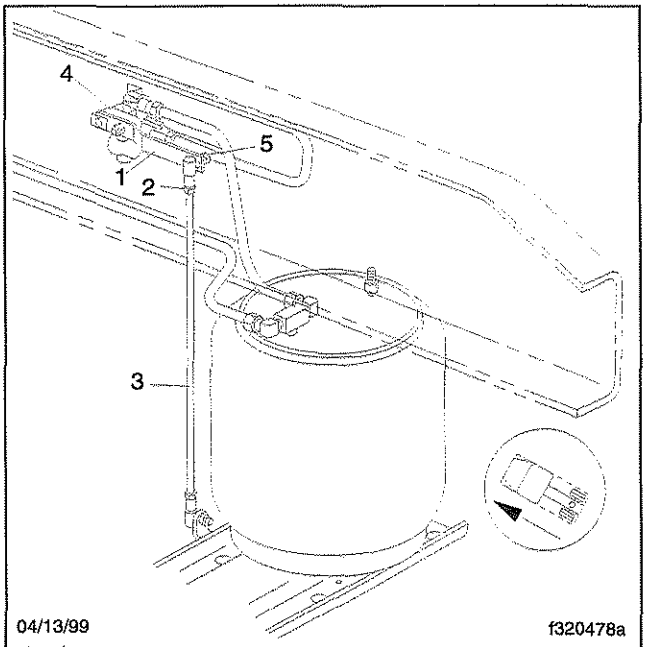
2. Disconnect the vertical linkage from the lever of the height control valve and lift the lever to raise the rear of the frame about 3 inches (75 mm). See **Fig. 1**.
3. Support the frame with jack stands.
4. Apply an upward force on the cross channel with a jack or, on single axles, by pushing down on the height control lever to lift the cross channel. This will cause the tips of the main support members to drop away from the slipper pad. See **Fig. 2**.

IMPORTANT: Do not nick or gouge the cross channel.

5. Remove the fasteners and the slipper pad. In some instances, the screws may have to be drilled out. See **Fig. 3**.
6. In some instances, remove the rebound roller to gain enough clearance to remove the slipper pad. Loosen the rebound bolt locknut, remove the washer, the bolt, and the rebound roller assembly.
7. For rivets, remove the four 1/4-inch (6-mm) rivets by grinding away the rivet heads. With a drift pin, punch the rivets through the holes and remove the slipper pad.

Installation

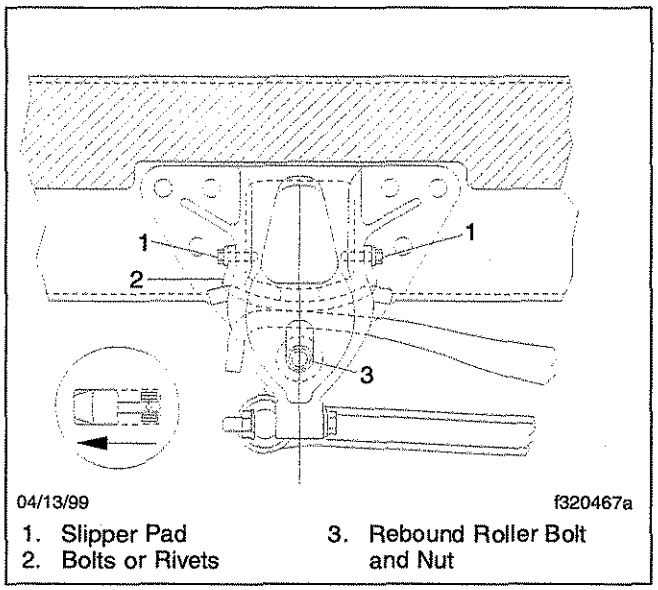
1. Position the slipper pad and retainer plate on the frame hanger.
2. Tighten the hexhead self-tapping screws 25 lbf·ft (34 N·m).
3. Or, install the rivets using a rivet gun.
4. Raise the frame off the jack stands by pulling up on the height control valve lever. Remove the jack stands.
5. Push down on the height control valve lever to lower the frame until the upper ball stud on the vertical linkage rod exactly aligns with the hole in the lever when the lever is horizontal.
6. Install the ball stud into the hole in the lever and install the washer and nut. Tighten the nut 10 lbf·ft (14 N·m).
7. Remove the chocks from the tires.



1. Lever
2. Ball Joint and Jam Nut
3. Vertical Linkage Rod
4. Height Control Valve
5. Locknut

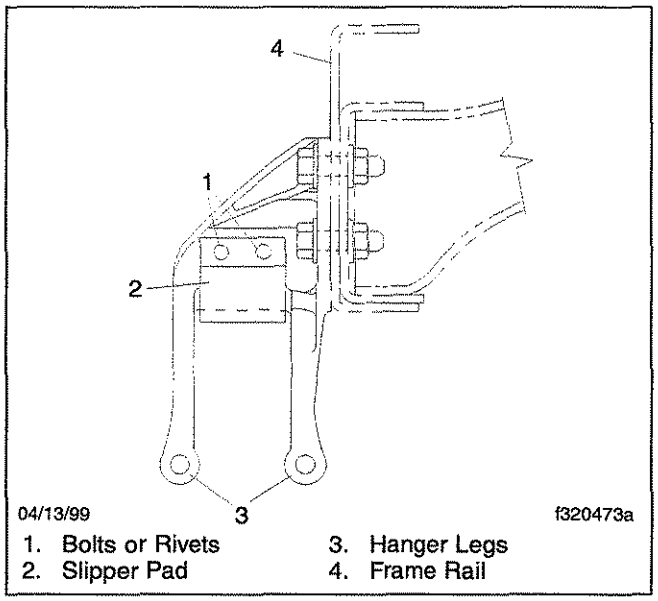
Fig. 1, Ride Height Control Linkage

Slipper Pad Removal and Installation



1. Slipper Pad
2. Bolts or Rivets
3. Rebound Roller Bolt and Nut

Fig. 2, Slipper Pad Installation



1. Bolts or Rivets
2. Slipper Pad
3. Hanger Legs
4. Frame Rail

Fig. 3, Hanger Assembly

Cross Channel Removal and Installation

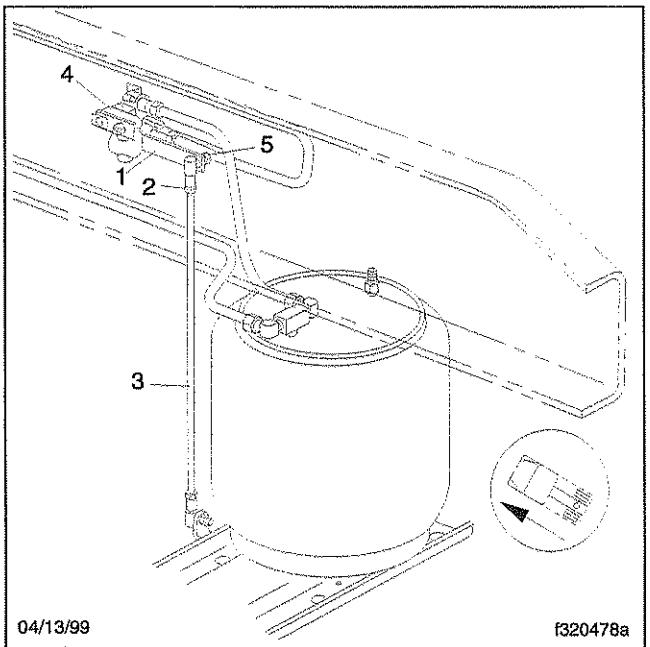
Removal

1. Stop the vehicle on a level surface and shutdown the engine. Chock the front and rear tires.

⚠ WARNING

The air suspension system will start moving the frame when the lever for the ride height control valve is moved from its center position. To avoid injury or property damage, make sure that your hands and all objects are away from any pinch points when the lever is moved.

2. Disconnect the vertical linkage for the height control valve at the end of the horizontal lever. See **Fig. 1**. Lift the lever on the height control valve so that the air bags raise the rear of the frame about 3 inches (75 mm). Support the frame at that position with jack stands.
3. Remove the locknuts and washers that attach both the air springs to the cross channel. See **Fig. 2**.



1. Lever
2. Ball Joint and Jam Nut
3. Vertical Linkage Rod
4. Height Control Valve
5. Locknut

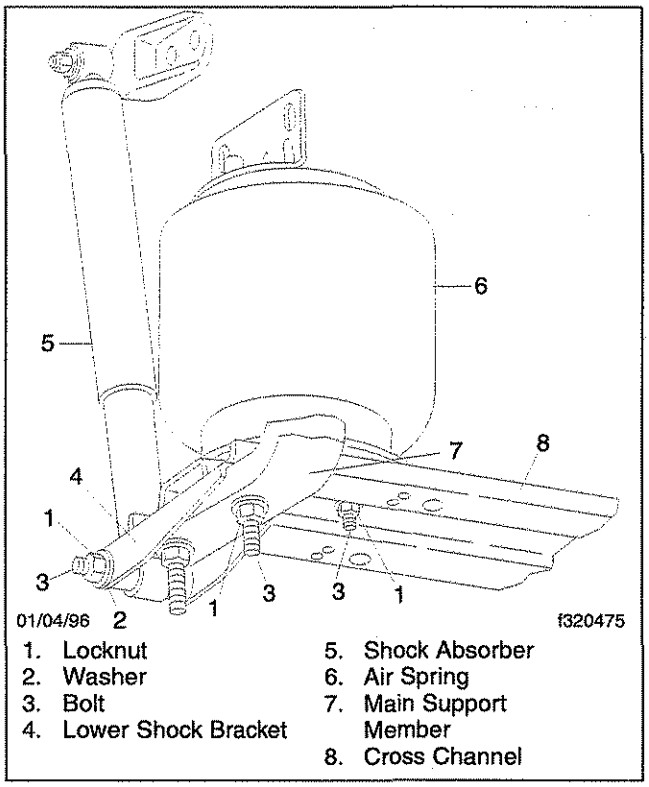
Fig. 1, Height Control Linkage

4. Remove the locknuts, washers, and bolts that attach the cross channel to the main support members and to the shock absorber lower mounting brackets.
5. Raise the cross channel by pushing down on the height control lever to compress the air springs just enough to clear the studs on the bottom of the air springs. Remove the cross channel.

Installation

1. Position the cross channel so that the holes in the cross channel are aligned under the studs of the air springs. Install the washers and nuts. Tighten the nuts on the air spring studs 25 lbf·ft (34 N·m).
2. Lower the cross channel assembly onto the main support members by pushing down on the height control valve lever.
3. Install the bolts, washers and locknuts that connect the cross channel to the main support member and lower shock absorber mounts. Tighten the locknuts 290 lbf·ft (393 N·m).
4. Raise the frame by lifting the height control valve lever and remove the jack stands.
5. Attach the ball joint stud of the vertical linkage rod to the height control valve link, and tighten the locknut on the ball joint stud 10 lbf·ft (14 N·m).
6. Remove the chocks from the tires.

Cross Channel Removal and Installation



1. Locknut
2. Washer
3. Bolt
4. Lower Shock Bracket
5. Shock Absorber
6. Air Spring
7. Main Support Member
8. Cross Channel

Fig. 2, Main Support Member

Axle Alignment Checking and Adjustment

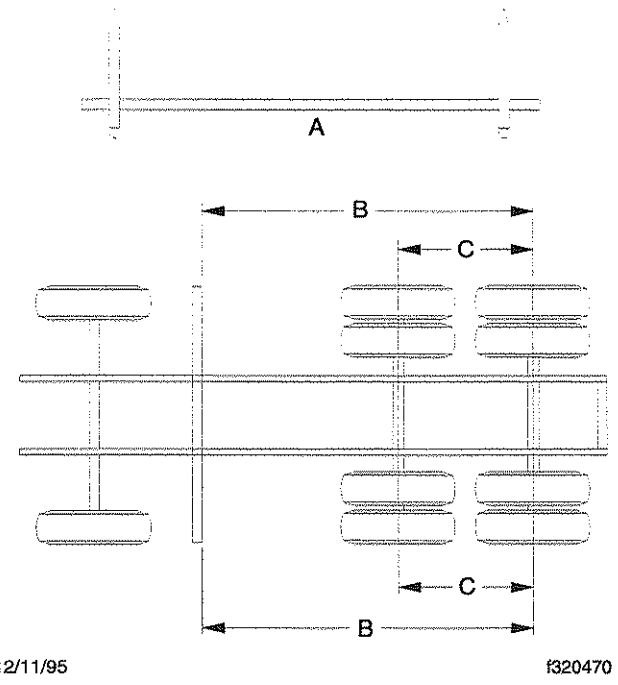
Checking and Adjustment

Use the following procedure after all repairs to the suspension:

1. Park vehicle on a level surface. Free and center all suspension joints by slowly moving the vehicle back and forth several times without applying the brakes.
2. Chock the front tires and the tires of drive axles.
3. C-clamp a nine-foot (2.74-m) piece of straight bar stock or angle iron across the frame. Select a location as far forward of the forward drive axle as possible where components will not interfere. The lower frame flange may be preferred on some vehicles, otherwise use the upper frame flange.
4. Align the straight bar stock or angle iron on the frame using a carpenter's square.
5. Check the rear drive axle first. See **Fig. 1**. Use a trammel bar or its equivalent to measure from the straight edge to the center line of the rear axle on both sides of the vehicle. If both sides measure within 3/16 inch (5 mm) of being the same, the alignment of the rear drive axle is acceptable. If the sides differ by more than 3/16-inch (5 mm), first loosen the rebound locknut, and then adjust the rear drive axle by loosening up the torque rod bar pin locknuts on the hangers. Add or remove drop-in shims as needed.

NOTE: The torque rod bar pin must be mounted to the forward face of the hanger legs. No more than four shims may be used (for a maximum thickness of 1/4 inch (6 mm).

6. Snug the torque rod bar pin locknuts but do not torque to specification.
7. With the rear drive axle properly aligned, the front drive axle alignment can be checked by measuring forward from the center of the axle shafts on the rear drive axle using a trammel bar. If the forward drive axle spacing measurements differ by more than 1/8 inch (3 mm), add or subtract shims at the forward hangers.
8. Following the adjustment of both axles, move the vehicle back and forth several times prior to removing the straight edge from the frame. Recheck the alignment.
9. Tighten the torque rod bar pin locknuts 180 lbf·ft (244 N·m).
10. Remove the chocks from the tires.



A. Trammel Bar
B. Each side must be within 3/16 inch (5 mm) of each other.
C. Distances between axles must be within 1/8 inch (3 mm) of each other.

Fig. 1, Drive Axle Tracking Alignment

Air Spring Replacement

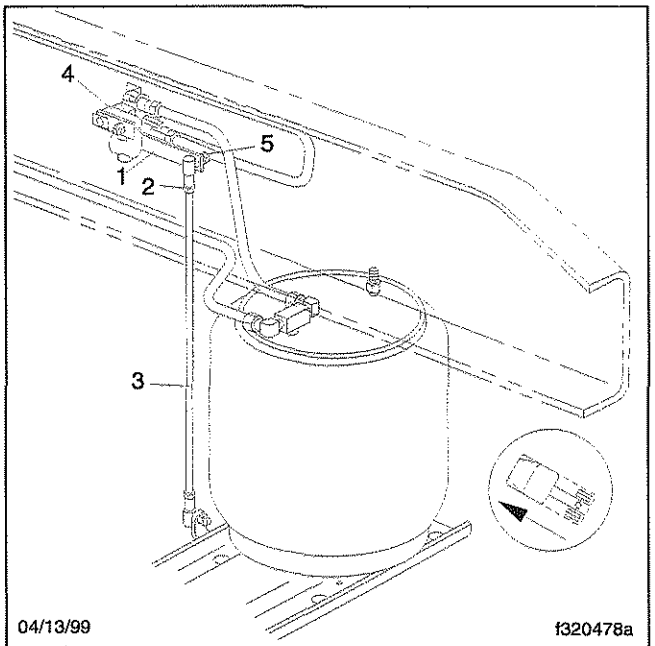
Replacement

1. Chock the front tires.
2. Support the frame with jack stands.
3. Drain the vehicle's air system.

⚠ WARNING

The air suspension system will start moving the frame when the lever for the ride height control valve is moved from its center position. To avoid injury or property damage, make sure that your hands and all objects are away from any pinch points when the lever is moved.

4. Remove the upper ball joint nut and stud from the lever on the height control valve. See **Fig. 1**. Move the height control valve lever down to exhaust all the air from the air bags.
5. Remove the locknuts and washers that attach the air spring to the cross channel. See **Fig. 2**.

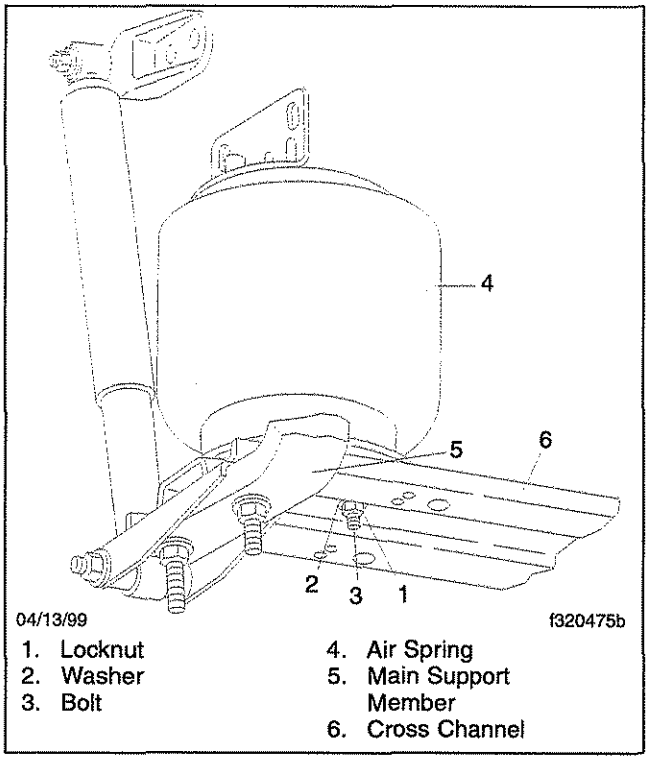


1. Lever
2. Ball Joint and Jam Nut
3. Vertical Linkage Rod
4. Height Control Valve
5. Locknut

Fig. 1, Ride Height Control Linkage

6. Disconnect the air lines to the air spring.
7. Remove the brass air fittings from the air spring.
8. Remove the locknuts and washers that attach the air spring to the upper air spring frame hanger.
9. Remove the air spring.
10. Attach the new air spring to the air spring frame hanger by inserting the studs into the appropriate holes.
11. Attach the air spring to the cross channel. Tighten the nuts 25 lbf·ft (34 N·m).
12. Tighten the outboard locknut that attaches the air spring to the air spring frame hanger 25 lbf·ft (34 N·m).
13. Attach the brass fittings to the air spring using a Teflon thread seal.
14. Connect the air lines to the air spring.
15. Connect the ball stud on the vertical linkage rod to the lever for the height control valve. Install the washer and tighten the nut 10 lbf·ft (14 N·m).
16. Remove the jack stands.
17. Build up pressure in the air system and check the ride height as described in **Subject 180**.
18. Remove the chocks from the tires.

Air Spring Replacement



1. Locknut
2. Washer
3. Bolt
4. Air Spring
5. Main Support Member
6. Cross Channel

Fig. 2, Air Spring Mounting

Air Spring Frame Hanger Removal and Installation

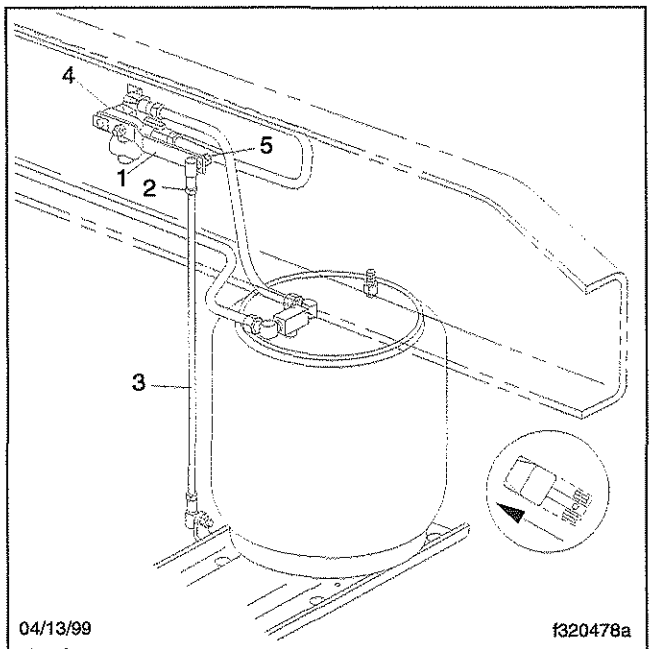
Removal

1. Chock the front tires.

⚠ WARNING

The air suspension system will start moving the frame when the lever for the ride height control valve is moved from its center position. To avoid injury or property damage, make sure that your hands and all objects are away from any pinch points when the lever is moved.

2. Disconnect the vertical linkage for the height control valve at the end of the horizontal lever. See **Fig. 1**. Lift the lever on the height control valve so that the air bags raise the rear of the frame about 3 inches (75 mm). Support the frame at that position with jack stands.
3. Drain the air from the vehicle's air system then lower the lever on the height control valve to exhaust the air from the air springs.



1. Lever
2. Ball Joint and Jam Nut
3. Vertical Linkage Rod
4. Height Control Valve
5. Locknut

Fig. 1, Height Control Valve Linkage

4. Disconnect the air lines from the air spring fittings.
5. Remove the brass air fittings from the air spring.
6. Remove the locknuts and washers that attach the air springs studs to the upper bracket on the frame rail. See **Fig. 2**.
7. Remove the nuts, washers and bolts that hold the upper air spring bracket to the frame rail. Remove the air spring bracket.

Installation

1. Position the air spring upper bracket on the frame rails. Install the bolts through the frame rail and upper bracket and install the washers, and locknuts. Tighten the locknuts 340 lbf·ft (461 N·m).
2. Attach the air spring to the air spring frame bracket. Tighten the outboard locknut 25 lbf·ft (34 N·m).
3. Attach the brass air fittings to the air spring port using Teflon thread sealant.
4. Connect the air lines to the air spring fittings.
5. Build up pressure in the air system and raise the height control lever to lift the frame off the jack stands. Remove the jack stands and lower the vehicle.
6. Align the ball joint stud in the vertical linkage rod with the hole in the height control lever. Install the ball joint stud, the washer and locknut. Tighten the locknut 10 lbf·ft (14 N·m).
7. Remove the chocks from the tires.

Air Spring Frame Hanger Removal and Installation

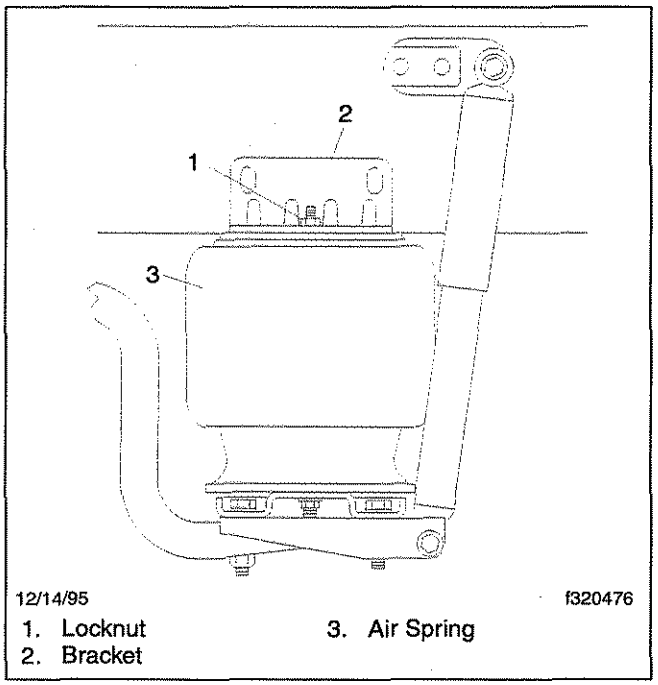


Fig. 2, Air Spring Installation

Shock Absorber Bracket Removal and Installation

Removal

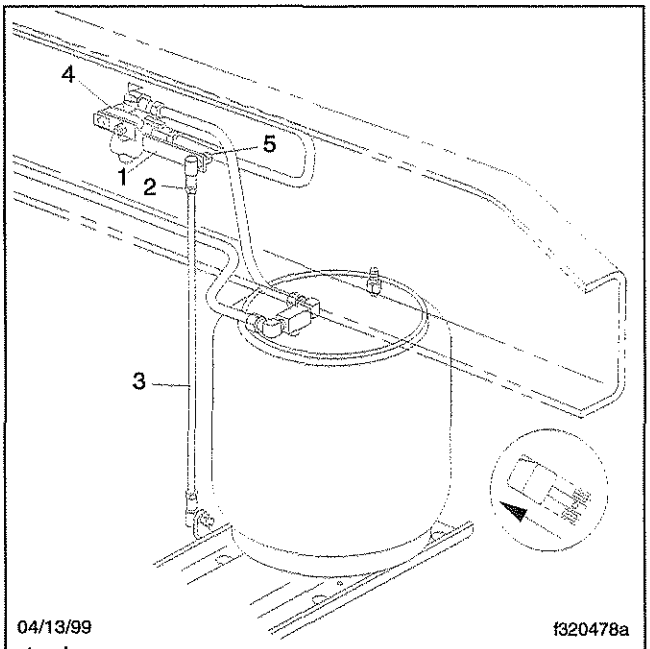
1. Chock the front tires.

⚠ WARNING

The air suspension system will start moving the frame when the lever for the ride height control valve is moved from its center position. To avoid injury or property damage, make sure that your hands and all objects are away from any pinch points when the lever is moved.

2. Remove the locknut and washer and disconnect the ball joint stud on the top of the vertical linkage rod from the height control valve lever. See **Fig. 1**.
3. Lift the height control lever to raise the rear of the frame enough to remove the load from the suspension.

   NOTE: The front of the main support member will move downward as the load is removed. Support the frame in this position with jack stands.



1. Lever
2. Ball Joint and Jam Nut
3. Vertical Linkage Rod
4. Height Control Valve
5. Locknut

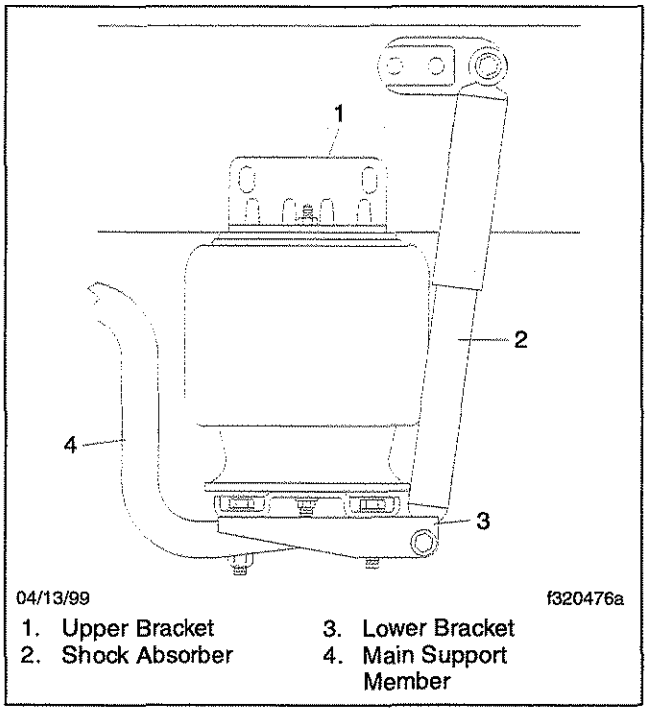
Fig. 1, Height Control Valve Linkage

4. Remove the shock absorber. Refer to **Subject 170**.
5. Remove nuts, washers and bolts from the shock absorber frame hanger bracket. See **Fig. 2**. Remove the top shock absorber bracket from the frame.
6. Remove the nuts, washers and bolts that attach the cross channel and lower shock absorber bracket to the rear of the main support member.
7. Remove the lower bracket by sliding the bracket to the rear.

Installation

1. Install the bolts and washers that attach the frame hanger bracket from the inboard side of the frame. Install the brackets, washers and locknuts. Tighten the nuts 340 lbf·ft (461 N·m).
2. Position the lower bracket between the cross channel and the main support member.
3. Install the bolts and washers from the top of the cross channel, through the shock bracket and main support member. Install the washers and locknuts and tighten the locknuts attaching the cross channel to the main support member 290 lbf·ft (393 N·m).
4. Install the shock absorber. Install the washers at both sides of each shock bushing for a total of four washers per shock absorber.
5. Tighten shock absorber locknuts 60 lbf·ft (81 N·m).
6. Lift the lever of the height control valve to raise the rear of the frame off the jack stands. Remove the jack stands and lower the frame by pushing down on the height control valve lever.
7. Align the ball joint stud in the vertical linkage rod with the hole in the height control valve lever. Install the washer and locknut. Tighten the locknut 10 lbf·ft (14 N·m).
8. Remove the chocks from the tires.

Shock Absorber Bracket Removal and Installation



1. Upper Bracket
2. Shock Absorber
3. Lower Bracket
4. Main Support Member

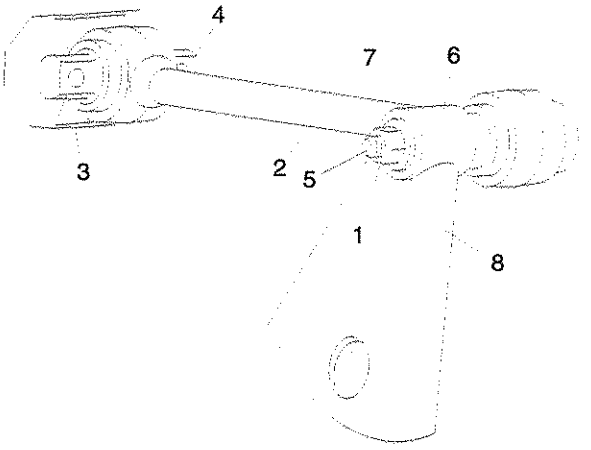
Fig. 2, Shock Absorber Mounts (typical)

Transverse Rod Removal and Installation

Removal (See Fig. 1)

NOTE: This procedure is for replacement of a transverse rod with a tapered stud at the axle connection and a straddle mount pin at the frame bracket end. Some installations have straddle mounts at both ends of the transverse rod.

1. Chock the front and rear tires.
2. Remove the nuts and washers from the bolts that fasten the pin in the transverse rod bushing to the frame bracket. Disconnect the transverse rod where it is attached to the frame bracket bracket.
3. Remove the nut from the tapered stud in the tube bracket on the axle housing. Hit the top of the axle bracket tube hard with a large hammer to momentarily distort the tube and loosen the tapered stud. Remove the stud and transverse rod from the bracket on the axle housing.



1. Locknut
2. Transverse Rod
3. Frame Bracket
4. Straddle Mount Pin
5. Tapered Stud End
6. Axle Bracket Tube
7. Washer
8. Axle Bracket

Fig. 1, Transverse Rod Assembly

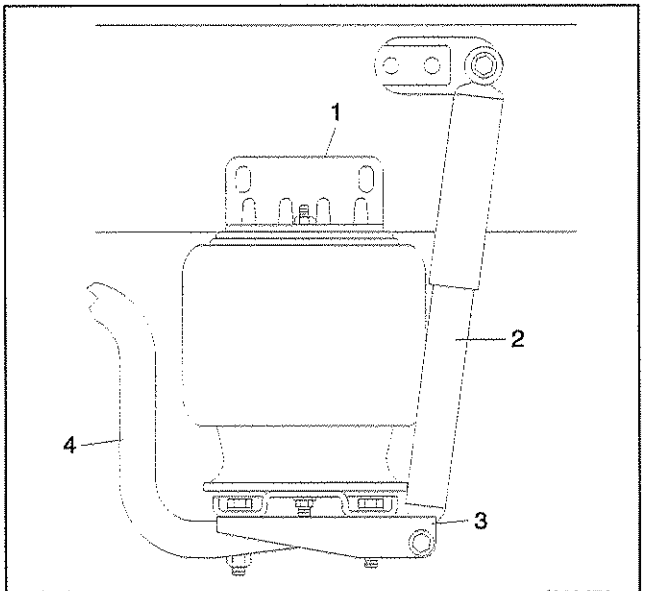
Installation

1. Clear the tapered hole in the axle bracket of all foreign matter.
2. Insert the tapered stud and torque rod bushing into the bracket.
3. Attach the washer and locknut to the stud. Tighten 200 lbf·ft (271 N·m).
4. After tightening, hit the top of the axle bracket tube with a hammer to seat the tapered stud. Retighten.
5. Position the straddle mount end of the transverse rod at the frame bracket, and tighten 200 lbf·ft (271 N·m).
6. Remove the chocks from the tires.

Replacement

NOTE: Shock absorbers are 1 3/8 inches (35 mm) in diameter with a compressed length of 18 1/3 inches (466 mm) and an extended length of 30 inches (762 mm).

1. Chock the front tires.
2. Remove the nut, washer and bolts that attach the shock absorber to the frame hanger bracket. See **Fig. 1**.
3. Remove the fasteners that attach the shock absorber to the lower bracket.
4. Remove the shock absorber.
5. Install the new shock absorber with the rod and shield tube at the top. Install the bolts, washers and nuts in the lower bracket and the frame hanger bracket. Install washers at both sides of each shock bushing, that is four washers per shock absorber.
6. Tighten the fasteners 60 lbf·ft (81 N·m).



1. Upper Bracket
2. Shock Absorber
3. Lower Bracket
4. Main Support Member

Fig. 1, Shock Absorber Mounts (typical)

General Information

NOTE: This subject applies only to Hendrickson series HAS 190/210/230/40LH/400/402/460 suspensions.

Adjust the vehicle ride height with the unloaded vehicle on a level surface. The frame slope, driveline angles, and axle mounting alignment should be checked after the ride height has been changed.

⚠ CAUTION

Failure to adjust the vehicle ride height could adversely affect driveline angles. Also, if the air springs are set too high, the driver may have difficulty (or be prevented from) backing the vehicle under a trailer. If the air springs are set too low, rapid wear of driveline parts will result.

Ride Height Adjustment

The vehicle ride height for Hendrickson HAS air suspension systems is changed by adjusting the length of the vertical linkage at the ride height control valve. Use the following procedure to adjust the ride height of the frame rails.

IMPORTANT: Before checking the ride height, make sure there is no load on the chassis. For tractors, unhitch the trailer. Trucks must be empty when checking the ride height.

1. Stop the vehicle on a level surface, using a light application of the brakes. Slowly move the vehicle forward and back several times without using the brakes to center the suspension joints. Do not apply the parking brakes.
2. Put the transmission in neutral. Build the secondary air pressure to at least 100 psi (690 kPa). Shut down the engine.

   NOTE: Allow several minutes for the air pressure to equalize in the system before checking the ride height.
3. Mark the location of the front and rear tires on the floor so that the vehicle can be checked in the same location after a test drive. Chock the front tires.

IMPORTANT: Any difference in height between the two sides of the vehicle must be corrected using spacers between the main support arm and the rear axle housing before setting the vehicle ride height. See the appropriate section in Group 32 in the vehicle's service manual for the alignment procedure.

4. Measure the distance from the bottom of the frame rail to the bottom of the main support arm at the rear axle U-bolts. See **Fig. 1**. The correct measurement for Hendrickson HAS suspension systems is 4-1/4±1/8 inches (108±3 mm) for vehicles with a specified ride height of 8-1/2 inches (215 mm) or greater. For vehicles with less than an 8-1/2-inch (215 mm) ride height, the distance between the bottom of the frame rail and the bottom of the main support arm must be 2-3/8 inches (60 mm).

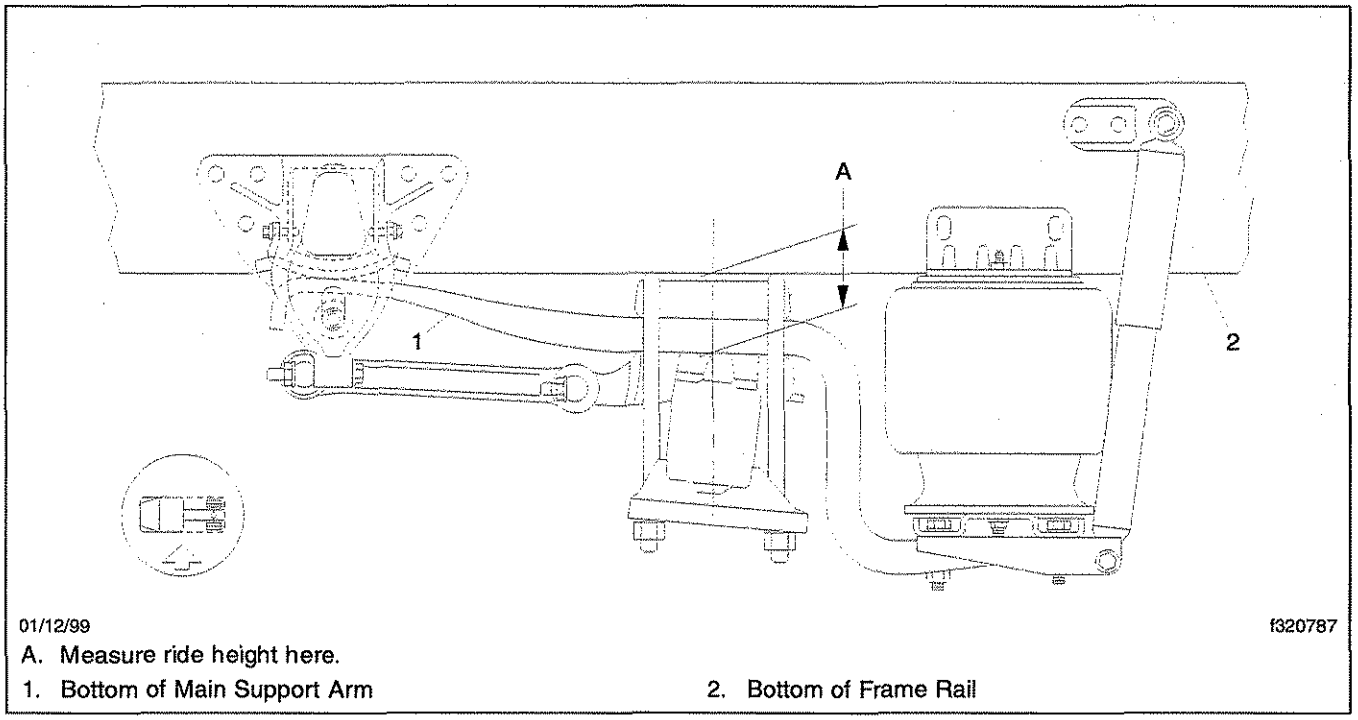
   If the measurement is the same as the specification at each support arm, the ride height is correctly adjusted. If the distance measured is not the same at each rear axle mount on the vehicle, correct this alignment problem before attempting to adjust the ride height.

⚠ WARNING

The air suspension system will start moving the frame when the lever for the ride height control valve is moved from its center position. To avoid injury or property damage, make sure that your hands and all objects are away from any pinch points when the lever is moved.

5. Remove the nut and lockwasher from the ball joint stud at the end of the lever on the ride height control valve. See **Fig. 2**. Separate the vertical rod assembly from the lever, being careful to avoid moving the lever while disconnecting the ball joint.
6. Push the lever down to lower the frame by removing the air in the suspension air bags.
7. Slowly pull the lever up to raise the frame until the ride height measurement is exactly correct for the specified ride height.
8. Make sure that the centering hole in the lever near its pivot aligns with the centering hole in the height control valve body. Check the height control valve to make sure that no air flows through the ride height control valve when the lever is in the centered position.
9. Loosen the jam nuts a few turns at the top and bottom ball joints on the vertical rod that attaches

Ride Height Adjustment

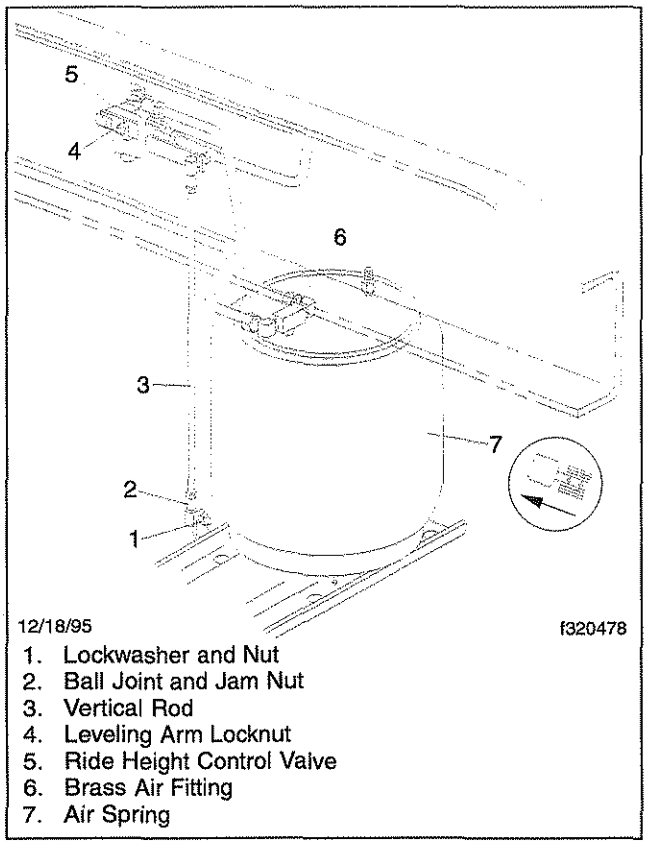


A. Measure ride height here.
1. Bottom of Main Support Arm
2. Bottom of Frame Rail

Fig. 1, Measuring the Ride Height

to the height control lever. Note that one of the ball joints and jam nuts has left-hand threads. Hold the top ball joint with your hand and turn the vertical rod with a wrench until the top ball joint stud exactly aligns with the hole in the end of the lever when the lever is centered horizontally on the control valve.

10. Install the ball joint stud in the lever and install the lockwasher and nut on the stud. Tighten the nut on the stud to 125 lbf·inch (11 N·cm).
11. Tighten the jam nut on each ball joint without changing the length of the vertical rod.
12. Apply the parking brakes; then remove the chocks from the tires. Drive the vehicle unloaded for about 1/4 mile (1/2 km); then stop the vehicle in the exact location (as previously marked) of the original measurement.
13. Park the vehicle using only a light brake application. Chock the tires on one axle only and put the transmission in neutral. Do not apply the parking brakes.
14. Check the adjusted distance between the bottom of the frame and the bottom of the main support arm at the U-bolts. See **Fig. 1**.
15. If the distance is still not correct, loosen the ball joint jam nuts on the vertical rod and turn the rod to adjust the ride height. Lengthen the vertical rod to raise the frame or shorten the rod to lower the frame to the correct ride height. Drive the vehicle and again check the ride height.
16. Apply the parking brakes; then remove the chocks from the tires.



1. Lockwasher and Nut
2. Ball Joint and Jam Nut
3. Vertical Rod
4. Leveling Arm Locknut
5. Ride Height Control Valve
6. Brass Air Fitting
7. Air Spring

Fig. 2, Ride Height Control System

Problem—All Air Bags Are Deflated

Problem—All Air Bags Are Deflated	
Possible Cause	**Remedy**
The vehicle air system pressure is too low.	Run the engine until the air gauge indicates 100 psi (690 kPa).
Air is leaking from the vehicle air system.	Listen for air leakage at the air fittings, tanks, and brake componenets. Repair or replace fittings as needed.
The linkage for the height control valve is disconnected or maladjusted.	Connect the linkage and adjust as described in **Subject 180**.
The suspension dump valve is activated.	Toggle the dump control valve to the normal position.
The relay valve is stuck open.	Check and repair the relay valve.
The air bags have a leak.	Listen for leaks at the air bags, tubes, and fittings.
The height control valve is not operating correctly.	Disconnect the linkage and raise and lower the lever to check the operation of the height control valve. Make sure that no air flows through the valve when the lever is in the center position. Replace the valve if it is bad.
There is a obstruction in the lines to the height control valve.	Check the air pressure at the height control valve supply port. Remove any obstruction or restriction to air flow to the valve.
The pressure protection valve is not allowing air to flow to the height control valve.	Check the operation of the pressure protection valve between the secondary air tank and the height control valve. Replace the valve if it is not operating correctly.

Problem—One Side of the Vehicle Is Higher Than the Other

Problem—One Side of the Vehicle Is Higher Than the Other	
Possible Cause	**Remedy**
The axle seat spacer thickness is not the same on each side.	Adjust the spacers so that the frame is level before adjusting the ride height.
The load on the vehicle is not distributed evenly.	Change the position of the load to ensure equal weight on each side.
There is an obstruction to air flow to the air bags on one side of the vehicle.	Disconnect the fittings and test the flow to the air bags on the lower side of the vehicle.
The height control valve or relay valve has an internal restriction.	Check for the same pressure at the ports on each side of the valve. Replace the valve if the pressure is not the same.
The air bags or fittings have a leak.	Listen for leaks at the air bags, tubes, and fittings. Tighten the fittings, if loose, or replace any bad parts.

Problem—The Ride Height Is Not Constant

Problem—The Ride Height Is Not Constant	
Possible Cause	**Remedy**
Air is leaking from the air bags or lines.	Listen or use soap bubbles to find air leaks. Tighten or replace leaking fittings or air bags.
The height control valve is not working correctly.	Make sure that no air is exhausted from the height control valve when the lever is in the horizontal position and that the air bags inflate when the lever is raised. The bags must deflate when the lever is pushed down. There must be a slight delay between the lever movement and the valve operation. Check for fluid leaks from the height control valve. Replace the valve if damaged.

Troubleshooting

Problem—The Ride Height Is Not Constant	
Possible Cause	**Remedy**
There is an obstruction to air flow to the air bags.	Disconnect the fittings and test the flow to the air bags.
The height control valve has a restriction at the exhaust port.	Check for air exhausting from the valve when the height control lever is pushed down.
The height control linkage is loose.	Make sure that all the jam nuts are tight and that the ball sockets are not worn.

Problem—The Ride Height Measurement Is Not Correct

Problem—The Ride Height Measurement Is Not Correct	
Possible Cause	**Remedy**
The vehicle is loaded.	The ride height of a loaded vehicle will be slightly lower than that of an unloaded vehicle. Adjust the ride only when the vehicle is unloaded.
The ride height adjustment is not correct.	Adjust the ride height as described in **Subject 180.**
Air is leaking from the air bags or lines.	Listen or use soap bubbles to find air leaks. Tighten or replace leaking fittings or air bags.
The height control valve is not working correctly.	Make sure that no air is exhausted from the height control valve when the lever is in the horizontal position and that the air bags inflate when the lever is raised. The bags must deflate when the lever is pushed down. There must be a slight delay between the lever movement and the valve operation. Check for fluid leaks from the height control valve. Replace the valve if damaged.
There is an obstruction to air flow to the air bags.	Disconnect the fittings and test the flow to the air bags.
The height control valve has a restriction at the exhaust port.	Check for air exhausting from the valve when the height control lever is pushed down.
The height control linkage is loose.	Make sure that all the jam nuts are tight and that the ball sockets are not worn.

Problem—The Air Springs Have Cuts

Problem—The Air Springs Have Cuts	
Possible Cause	**Remedy**
The ride height is adjusted too high.	Adjust the ride height so that the air bags are not continually overinflated.
The tires are too wide and are rubbing the air bags.	Install the correct tires.
A shock absorber or mount is broken.	Replace any broken components.

Problem—The Vehicle Does Not Track Straight

Problem—The Vehicle Does Not Track Straight	
Possible Cause	**Remedy**
The axle alignment is not correct.	Adjust the alignment with shims at the front of the torque rods.
The bushings in the torque rods are worn.	Replace the worn bushings.
The bushings in the transverse rods are worn.	Replace the worn bushings.
A shock absorber or mount is broken.	Replace any broken components.

Problem—The Vehicle Does Not Track Straight	
Possible Cause	**Remedy**
The U-bolt high nuts are loose.	Periodically tighten the nuts as described in **Specifications 400**.
The suspension fasteners are loose or damaged.	Tighten or replace the fasteners.

Problem—The Vehicle Vibrates When Driven

Problem—The Vehicle Vibrates When Driven	
Possible Cause	**Remedy**
The ride height is not correct.	Adjust the ride height as described in **Subject 180**.
The axle housing rotational alignment is not correct.	Adjust the rotational alignment of the axle housing with wedge-shaped shims at the axle seats. The driveline U-joint angles must be with 1% of each other.
The shock absorbers are worn or disconnected.	Replace the shock absorbers, if worn, or tighten the mounting fasteners.
The bushings in the torque rods are worn.	Replace the worn bushings.
The U-bolt high nuts are loose.	Periodically tighten the nuts as described in **Specifications 400**.
The suspension fasteners are loose or damaged.	Tighten or replace the fasteners.
The frame is not level from front to rear.	Check and adjust the ride height at the front suspension and each rear axle. The frame should not slope more than 1/2 inch (13 mm). Correct the ride height if not at specifications.

Specifications

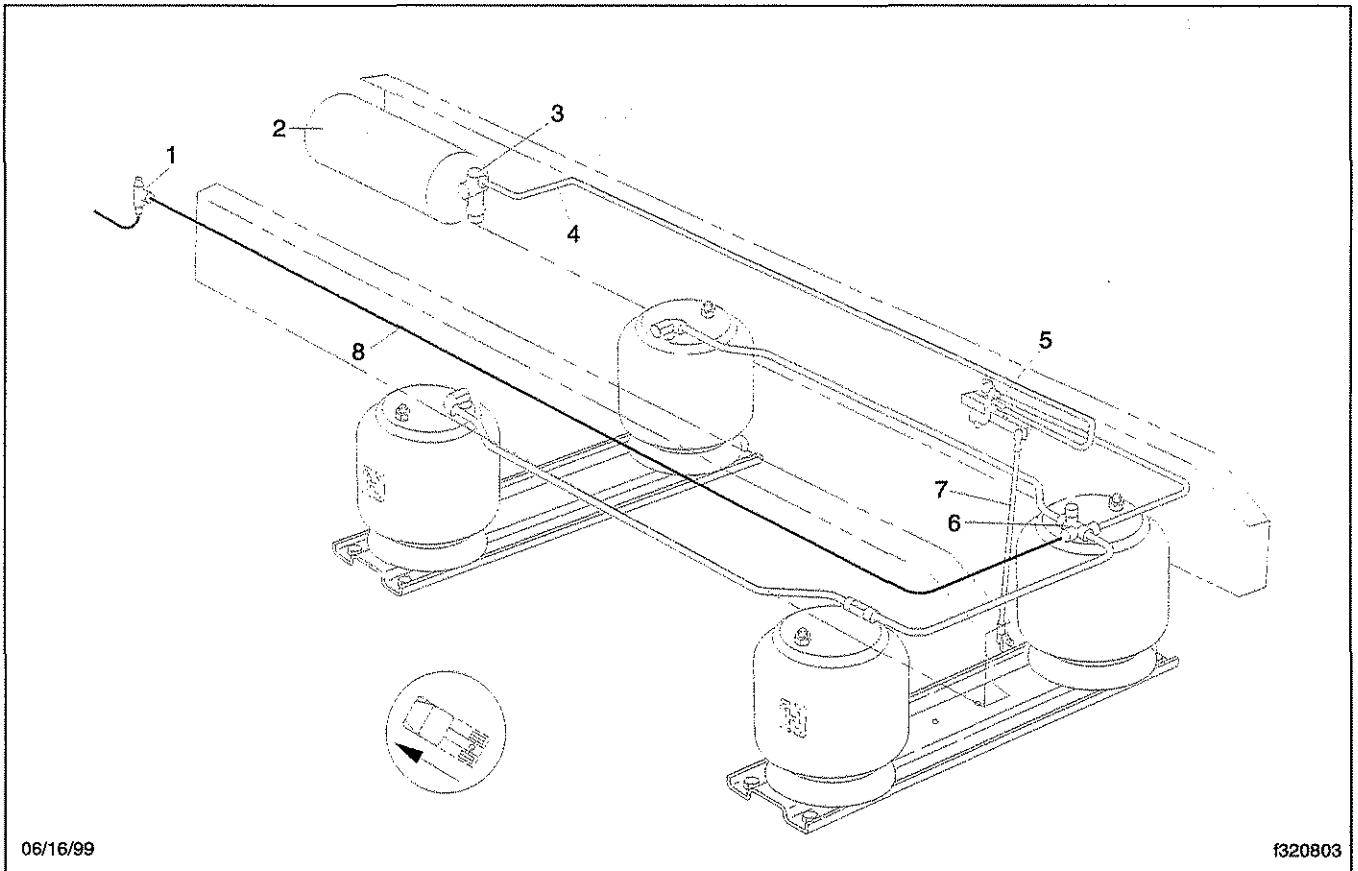
For an overview of the Hendrickson HAS air system plumbing, see **Fig. 1** and **Fig. 2**.

Torque Values		
Description	**Size**	**Torque: lbf·ft (N·m)**
U-bolt High Nuts	7/8–14	Stage 1: Hand tighten Stage 2: 60 (81)* Stage 3: 200 (271)* Stage 4: 420 to 500 (571 to 680)*
	1–14	Stage 1: Hand tighten Stage 2: 60 (81)* Stage 3: 200 (271)* Stage 4: 520 to 600 (707 to 816)*
Torque Rod Bar Pin Locknut	5/8–11	180 (244)
Axle Seat Stud	5/8–11	65 (88)
Rebound Bolt Locknut	1/2–13	60 (81)
Shock Absorber Locknut, Upper	1/2–13	60 (81)
Shock Absorber Locknut, Lower	3/4–10	60 (81)
Cross Channel to Main Support Member Locknut	3/4–10	290 (393)
Air Spring to Frame Hanger Locknut	1/2–13	25 (34)
Air Spring to Cross Channel Locknut	1/2–13	25 (34)
Transverse Rod Locknut	1-1/4–12	200 (271)
Extension Arm Jam Nut	5/16–24	125 (169)
Extension Arm Locknut	5/16–24	125 (169)

* Tighten in a diagonal pattern as shown in **Fig. 3**.

Table 1, Torque Values

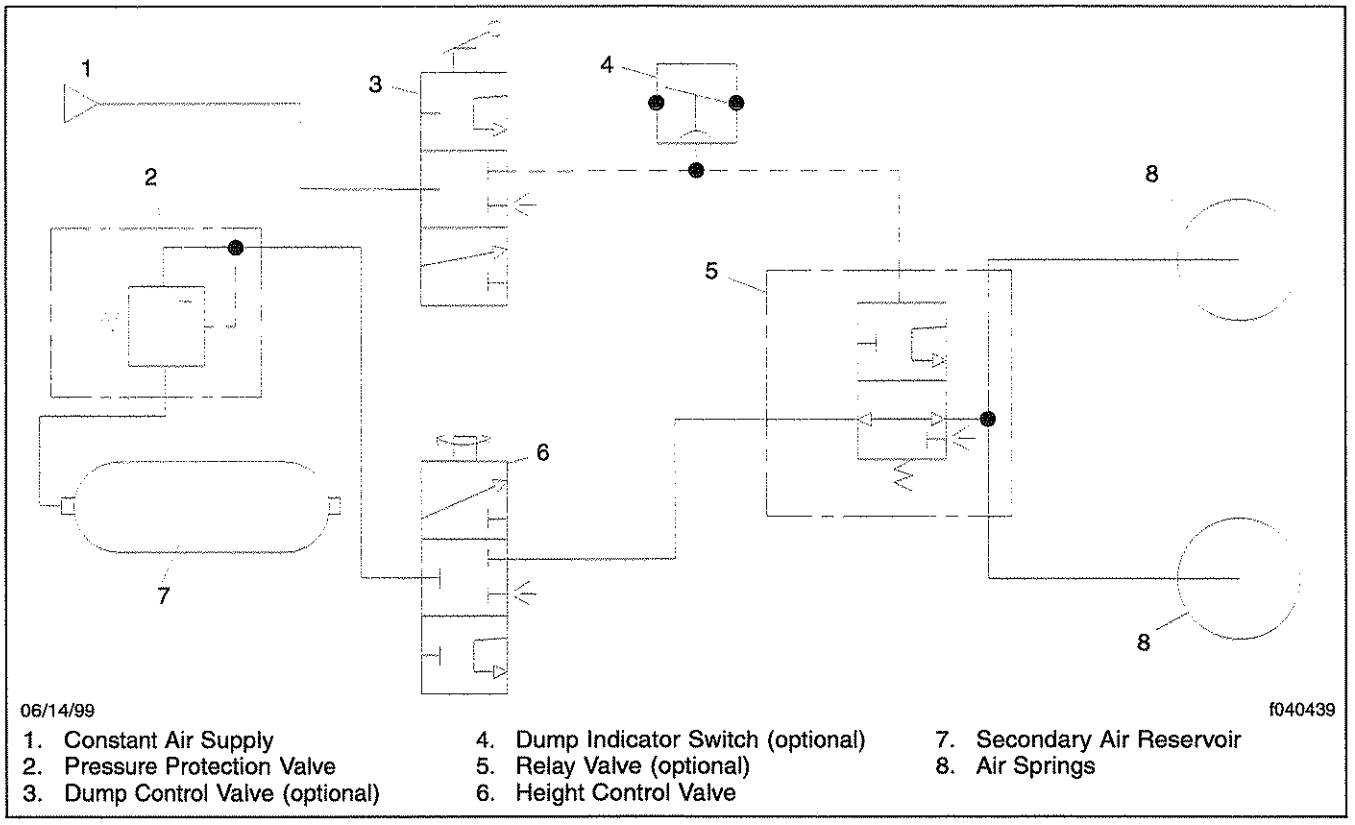
Specifications



NOTE: The height control valve was moved to the forward axle on later HAS systems.

1. Switch Control Valve
2. Air Tank
3. Pressure Protection Valve
4. Air Supply Line
5. Height Control Valve
6. Quick Release Valve
7. Leveling Valve Extension Arm
8. Air Signal Line

Fig. 1, Suspension Air Plumbing



1. Constant Air Supply
2. Pressure Protection Valve
3. Dump Control Valve (optional)
4. Dump Indicator Switch (optional)
5. Relay Valve (optional)
6. Height Control Valve
7. Secondary Air Reservoir
8. Air Springs

Fig. 2, Air Suspension Dump System Schematic (typical)

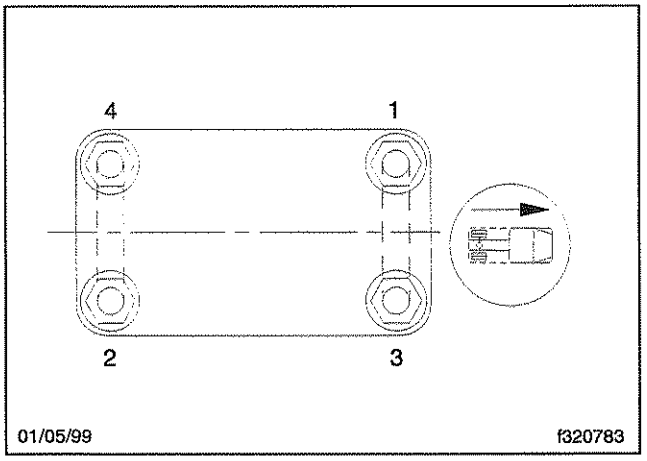


Fig. 3, Tightening Pattern for U-bolt High Nuts

Contents

Subject	Subject Number
General Information	050
Service Operations	
ECU Removal and Installation	100
Solenoid Valve Replacement	110
Height Sensor Replacement	120
Troubleshooting	300
Specifications	400

General Information

The AirLiner Plus suspension is used on vehicles with pusher or tag axles to improve traction performance.

The system maintains an accurate leveling of frame height through the use of the Rockwell WABCO ECAS (Electronically Controlled Air Suspension) system with sensors and an electronic control unit. A height sensor mounted between the frame and the drive axle housing provides the ECAS control unit with frame height information. Other sensors provide additional information, which the control unit uses to quickly lower or raise the frame height as necessary. The operation occurs while the vehicle is in motion or while parked.

The vehicle must be equipped with a rear axle air suspenion, and requires ABS with Automatic Traction Control to trigger the optional load transfer function automatically.

AirLiner Plus components include:

- A cab-mounted electronic control unit that uses information about the vehicle's rear frame height to adjust the air pressure of the air spring bags;
- A frame rail-mounted solenoid valve that adjusts the air pressure;
- An axle- and frame-mounted height sensor that provides the control unit with frame-height information;
- A brake light switch that informs the control unit when the brakes are applied;
- A dash-mounted warning light that indicates a system fault;
- A load transfer light that displays automatic load transfer status;
- A three-position dash switch that allows automatic load transfer, driver-activated load transfer, or no load transfer.
- An optional hand-held remote control unit that is used to alter the chassis height for loading and unloading.

SYSTEM OPERATION

Indicator Lights

ECAS FAIL: Lights for approximately two seconds when the ignition key is turned on, then the light goes out and remains out during vehicle operation. If the ECAS FAIL light does not go out after two seconds, or if it comes on during vehicle operation, there is a failure in the ECAS system.

LOAD X-FER: Lights for approximately two seconds when the igition key is turned on, then the light goes out. Lights whenever there is a manual or an automatic load transfer.

Frame Height Control

ECAS will maintain the vehicle frame to a pre-set height within a 3/16-inch (5 mm) range. The optional remote control unit allows frame height adjustment within operating limits if the vehicle is parked or moving less than 7 mph.

Load Transfer Activation

If the load weight is transferred from the tag axle to the drive axle, it will remain shifted for 20 seconds and is then slowly transferred back to a normal condition. The complete load cycle takes approximately 45 seconds.

Slippage of the driving wheels (usually when starting out on a slick surface) will activate the automatic load transfer. The load transfer will activate after the Automatic Traction Control activates.

Pressing the MOM ON (momentary on) side of the LOAD X-FER dash switch will activate the load transfer system. Manual activation works, however, only at vehicle speeds less than 30 mph.

Load Transfer Termination

The load transfer cycle will immediately terminate if the service brakes are applied when the vehicle speed is more than 30 mph, when the STOP button on the remote control (if equipped) is pressed, or when the vehicle speed exceeds 75 mph.

The STOP button on the remote control will terminate the load transfer at any speed.

ECU Removal and Installation

Removal

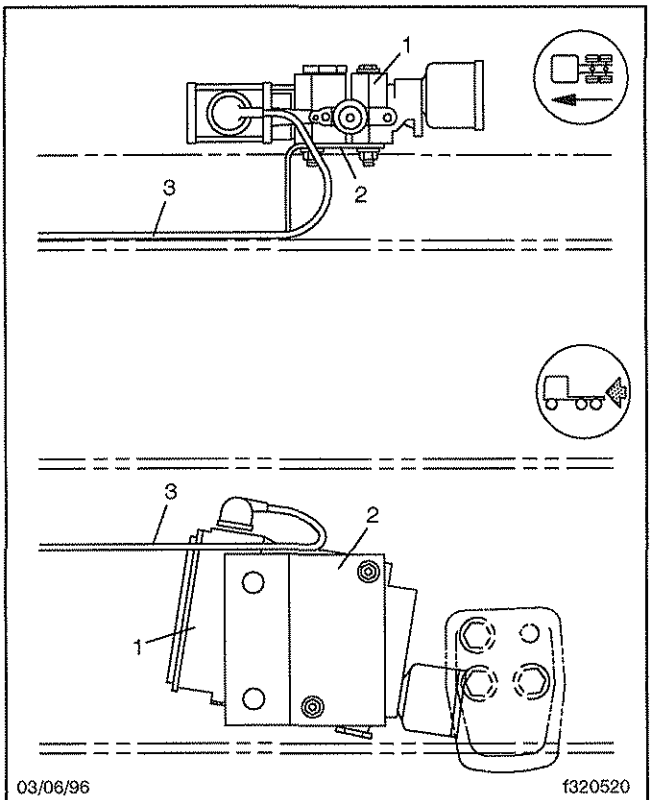
1. Shut down the engine and set the parking brake.
2. Chock the front tires.
3. Remove the lower cover at the base of the left B-pillar.
4. Disconnect the electrical connections at the base of the B-pillar.
5. Remove the grab handle.
6. Remove the shoulder harness adjustable D-loop mechanism mounted to the B-pillar.
7. Detach the plastic channel that attaches the upholstery to the door frame. This will provide slack in the upholstery to allow access to the ECU mounted inside the B-pillar.
8. Remove the fasteners that attach the B-pillar upholstery to the cab wall.
9. Reach inside the B-pillar and remove the fasteners that attach the ECU.
10. Disconnect the electrical connections on the unit, and remove the ECU from the B-pillar.

Installation

1. Install the ECU inside the B-pillar. Connect the electrical connections.
2. Install the B-pillar upholstery.
3. Attach the plastic channel around the door frame and upholstery.
4. Install the shoulder harness adjustable D-loop mechanism.
5. Install the grab handle.
6. Connect the electrical connections at the base of the B-pillar.
7. Install the lower panel at the base of the B-pillar.
8. Remove the chocks from the tires.

Replacement

1. Shut down the engine and set the parking brake.
2. Chock the front tires.
3. Drain air from the suspension system.
4. At the ECAS solenoid valve (see **Fig. 1**), which is mounted to the frame rail, disconnect the electrical connector.
5. Mark the air lines for later reference.
6. Disconnect the air lines from the solenoid valve.
7. Remove the two bolts attaching the solenoid valve to the valve bracket.
8. Remove the valve from the bracket.
9. Attach the new valve to the bracket. Install the bolts.
10. Connect the air lines to the valve as marked earlier.
11. Connect the electrical connector to the valve.
12. Remove chocks from tires.

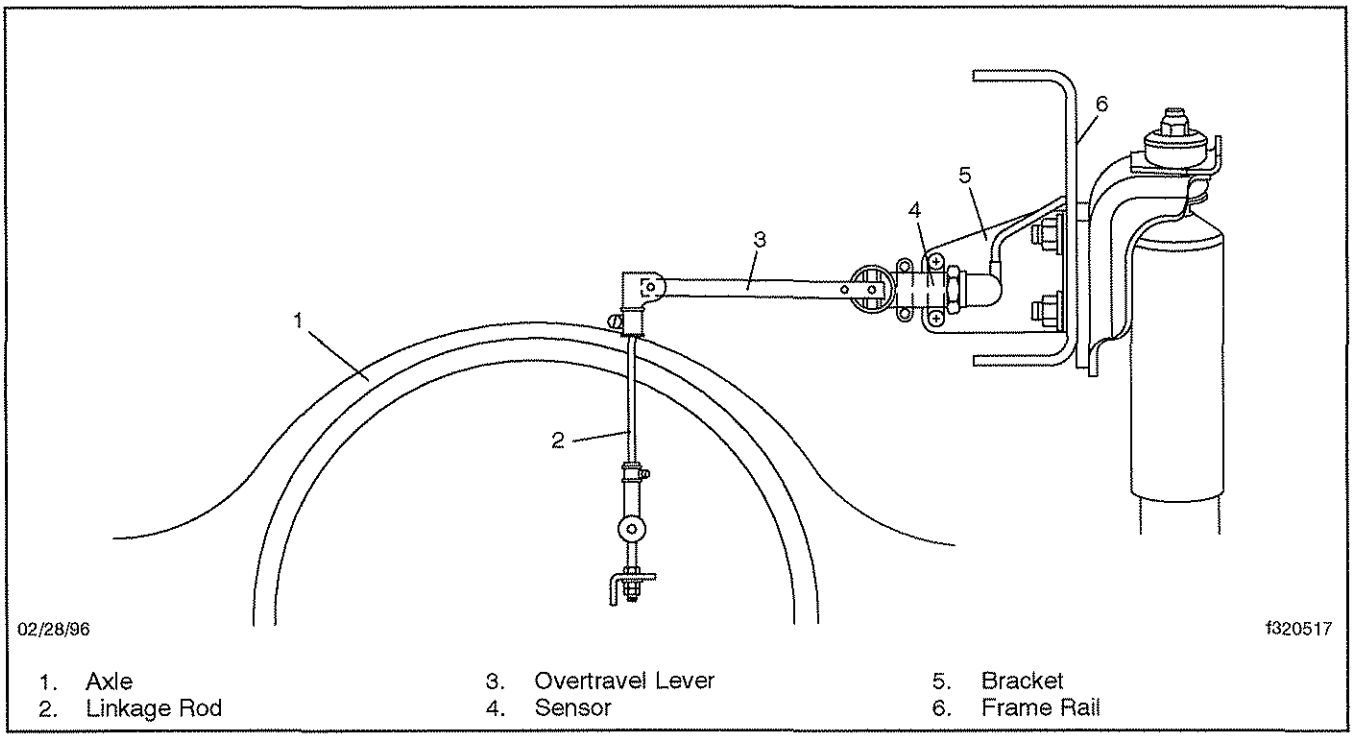


1. Solenoid Valve
2. Bracket
3. Wire

Fig. 1, Solenoid Valve Assembly

Replacement

1. Shut down the engine and set the parking brake.
2. Chock the front tires.
3. At the ECAS height sensor (see **Fig. 1**), which is mounted between the frame rail and the drive axle housing, disconnect the electrical plug on the back of the sensor.
4. Remove the bolts attaching the sensor to the frame rail bracket.
5. Disconnect the linkage rod from the axle housing.
6. Remove the overtravel lever from the height sensor.
7. Remove the sensor.
8. To install the sensor, attach the overtravel lever to the height sensor.
9. Attach the linkage rod to the axle housing.
10. Fasten the sensor to the frame rail bracket.
11. Connect the electrical plug to the back of the height sensor.
12. Remove the chocks from the tires.



1. Axle
2. Linkage Rod
3. Overtravel Lever
4. Sensor
5. Bracket
6. Frame Rail

Fig. 1, Height Sensor Assembly

Troubleshooting Information

1. Indicator Lights:
   - ECAS FAIL lights up if there is a failure in the ECAS system.
   - Load XFER lights up whenever there is a manual or automatic load transfer.
2. Frame Height Control: ECAS will maintain the vehicle frame height to a preset value within 3/16-inch (4.7 mm) by adjusting the pressure in the rear suspension air bags. With the remote-control unit, the operator can adjust the frame height within the operating limits if the vehicle is parked or traveling less than 7 mph (15 km/h).
3. Load Transfer Activation: The weight is transferred from the tag axle to the drive axle by adjusting the pressure in the air bags. The load is shifted for 20 seconds, then is slowly equalized back to the normal condition. The complete load transfer cycle takes approximately 45 seconds. The load transfer occurs under the following conditions.
   - Automatic activation: The drive wheels slipping (usually when staring out on a slick surface) will activate the load transfer. If the vehicle is equipped with Automatic Traction Control, the load transfer will activate just after the ATC.
   - Manual activation: Pressing the MOM ON (Momentary On) side of the ECAS XFER dash switch will activate the load transfer. Manual activation works only at vehicle speeds less than 30 mph (50 km/h).
4. Load Transfer Termination: The load transfer cycle will terminate under the following conditions.
   - Applying the service brakes with a vehicle speed of more than 30 mph (50 km/h).
   - Vehicle speed exceeds 75 mph (120 km/h).
   - Pressing the STOP button on the remote control or disconnecting the remote control. This will terminate the load transfer at any speed.

Troubleshooting Tables

Before performing any diagnostics, make sure there are no ABS faults. Because of the interaction of the ABS and the ECAS systems, a fault in one system may cause a malfunction in the other system.

The following types of failures cause the "ECAS FAIL" indicator light to remain on:

- Grounded "ECAS FAIL" light wire;
- No power at ECAS electronic control unit (ECU) pin 1;
- Electrical fault in ECAS height sensor;
- Electrical fault in ECAS valve;
- Failure of J1587 data bus;
- Internal ECU fault;
- Faulty calibration of ECAS height control;
- Frame height cannot be adjusted within five minutes after ignition or within 30 seconds during normal service.

See **Table 1** for troubleshooting problems when the "ECAS FAIL" light remains on. This would include problems where the wrong action occurs, such as the air bags inflating rather than deflating, or the drive axle air bags deflating rather than the tag axle air bags. The causes may be crossed electrical wiring or air supply plumbing.

See **Table 2** for frame height problems.

See **Table 3** for incorrect ECAS functionality.

See **Table 4** for indicator lamp problems.

See **Table 5** for manual load transfer problems.

NOTE: All lamps are activated by the ECU for approximately two seconds after the ignition is switched on. The ignition must be switched off for at least 6.4 seconds before restarting to determine lamp condition.

Troubleshooting

Electrical Systems Testing

Electrical Systems Testing				
System Tested	**Ignition**	**Test these pins on ECAS ECU harness 35-pin connector (disconnected unless otherwise noted)**	**Acceptable Value**	**Remedy (if not within specification)**
ECAS FAIL light	On	—	Light is out	Find short to ground in wire between ECAS FAIL light and ECU.
Ground	Off	27 and Battery Ground	0 ohms	Trace wire between pin 27 and ground to find cause of high resistance.
Ground	Off	1 and 27	System voltage	Find open circuit or cause of high resistance in wiring.
Ignition and constant power	On	1 and 27 9 and 27	System voltage	Find open circuit or cause of high resistance in wiring.
Height sensor	Off	25 and 27	100 to 140 ohms	If resistance is infinite (open circuit), find open circuit in wires to height sensor and repair. If there is continuity but resistance is out of specification, check resistance at height sensor. If sensor is not within specification, replace sensor.
ECAS valve electrical checks	Off	13 and 27 15 and 27 30 and 27	15 to 25 ohms	If resistance is infinite (open circuit), find open circuit in wires to ECAS valve and repair. If there is continuity but resistance is out of specification, check resistance at ECAS valve. If valve is not within specification, replace valve.
Data bus connectivity (ECAS reads vehicle speed and other data from J1587 data bus)	On	Connect harness to ECU, and run Service Link to see if ECU is connected to data bus.	—	If other ECUs are identified with Service Link, check data bus wires to ECU for open, grounded, or crossed wires (pins 4 and 2). If no other ECUs are identified with Service Link, there is a main data bus problem, not a specific ECAS problem.
Internal ECU fault	—	There is no test for ECU. If all other tests are within specifications, ECU is probably bad.	—	Replace ECU.

Table 1, Electrical Systems Testing

Frame Height Systems Testing

Frame Height Systems Testing		
System Tested	**Test Procedure**	**Remedy (if not within specification)**
ECAS height calibration	Using the remote control unit, raise or lower the vehicle frame. Press the Normal key, and the frame should return to normal height.	Install the height sensor arm in the correct position relative to the height sensor rotating spool.
Frame height adjust time	Check air suspension system for leaks or restrictions in lines or valve ports. Check air supply system for proper charge time.	Repair as required.

Table 2, Frame Height Systems Testing

ECAS Functionality Testing

ECAS Functionality Testing				
System Tested	**Ignition**	**Test these pins on ECAS ECU harness 35-pin connector (disconnected)**	**Acceptable Value**	**Remedy (if not within specification)**
Inflate function	On	Connect 9 to 15. Alternately connect 13 to 9 and to 15. CAUTION: Do not over-inflate air bags. This may extend the shock absorbers to their limits and cause damage.	All rear suspension air bags inflate when (and only when) 13 is connected	Make sure there is adequate air in the supply tanks to inflate the air bags. Check for crossed wiring to the ECAS valve. Check for correct air plumbing between the ECAS valve and the air bags.
Deflate function	On	Connect 9 to 13	All rear suspension air bags deflate	Make sure there is adequate air in the supply tanks to inflate the air bags. Check for crossed wiring to the ECAS valve. Check for correct air plumbing between the ECAS valve and the air bags.
Load transfer function	On	Connect 9 to 30	Tag axle air bags deflate	Make sure there is adequate air in the supply tanks to inflate the air bags. Check for crossed wiring to the ECAS valve. Check for correct air plumbing between the ECAS valve and the air bags.
		Disconnect 9 from 30 Connect 9 to 15	Pressure will equalize between drive and tag axle air bags.	Check for crossed wiring to the ECAS valve. Check for correct air plumbing between the ECAS valve and the air bags.

Table 3, ECAS Functionality Testing

Troubleshooting

Indicator Light Testing

Indicator Light Testing				
System Tested	**Ignition**	**Test these pins on ECU harness 35-pin connector (disconnected)**	**Acceptable Value**	**Remedy (if not within specification)**
ECAS FAIL light	On	Connect 33 and 27	Light on	Replace bulb. If bulb still does not light, check the wiring between the bulb and the 35-pin connector.
ECAS XFER light	On	Connect 18 and 27	Light on	Replace bulb. If bulb still does not light, check the wiring between the bulb and the 35-pin connector.

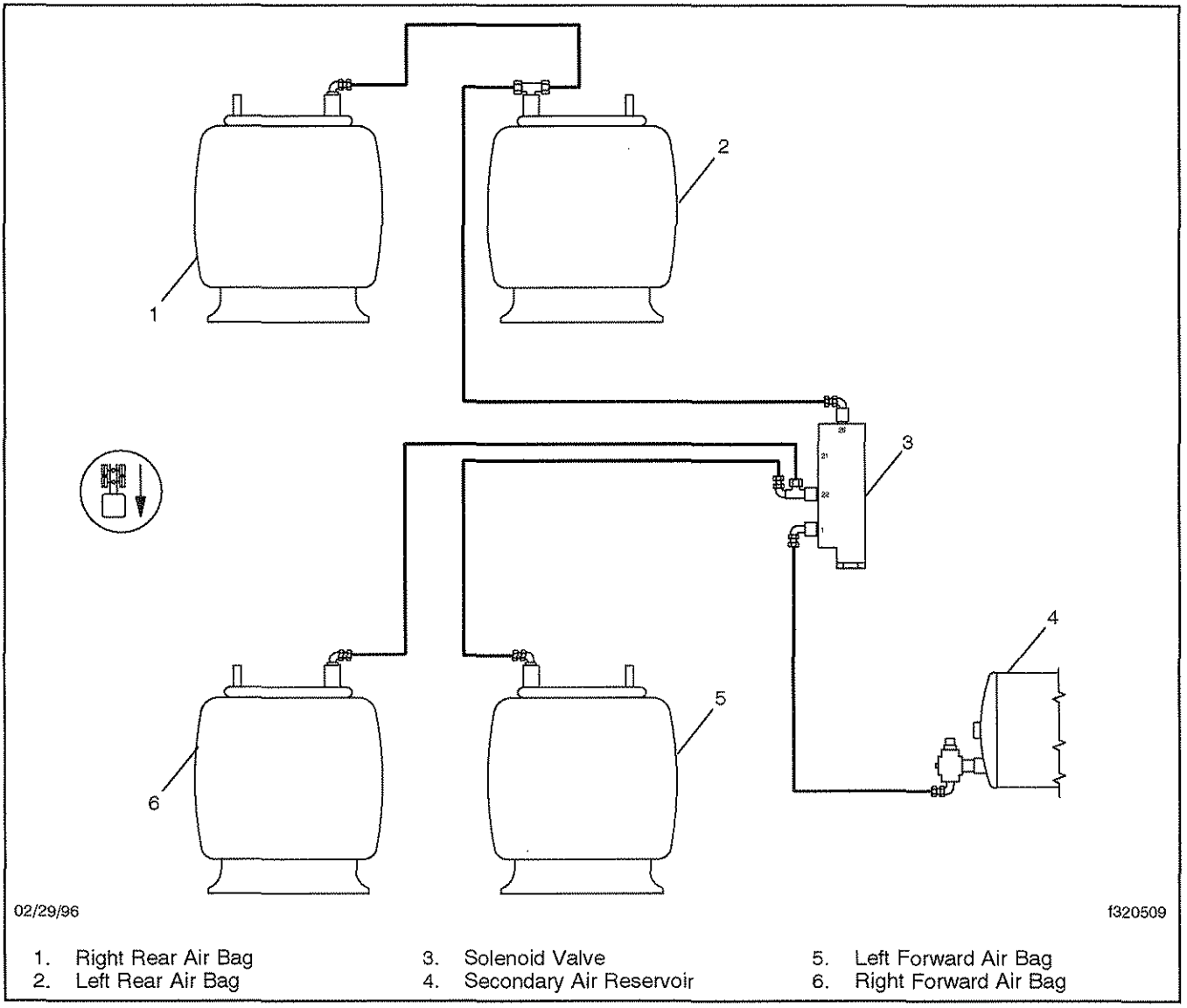
Table 4, Indicator Light Testing

Manual Load Transfer Testing

Manual Load Transfer Testing				
System Tested	**Ignition**	**Test These Pins On ECAS ECU harness 35-pin connector**	**Acceptable Value**	**Remedy (if not within specification)**
Manual load transfer switch	Off	17 and 27, MOM ON switch released (with harness disconnected)	>30k ohms	Locate and repair ground (wire pin to pin 17).
		17 and 27, MOM ON switch pressed (with harness disconnected)	0 to 2 ohms	Locate and repair high resistance in switch circuit.
	On	ECAS ECU harness; Jump pin 17 to ground (with harness connected to ECU	Load transfer cycle will occur	Perform air bag functionality tests. If air bags function correctly as described, manual load transfer function of ECU is malfunctioning. Replacement of ECU is probably necessary.

Table 5, Manual Load Transfer Testing

See **Fig. 1** for the AirLiner Plus air system plumbing diagram, and see **Fig. 2**, **Fig. 3** and **Fig. 4** for diagrams of the AirLiner Plus electrical system.



1. Right Rear Air Bag
2. Left Rear Air Bag
3. Solenoid Valve
4. Secondary Air Reservoir
5. Left Forward Air Bag
6. Right Forward Air Bag

Fig. 1, AirLiner Plus ECAS Air System Plumbing Diagram

Specifications

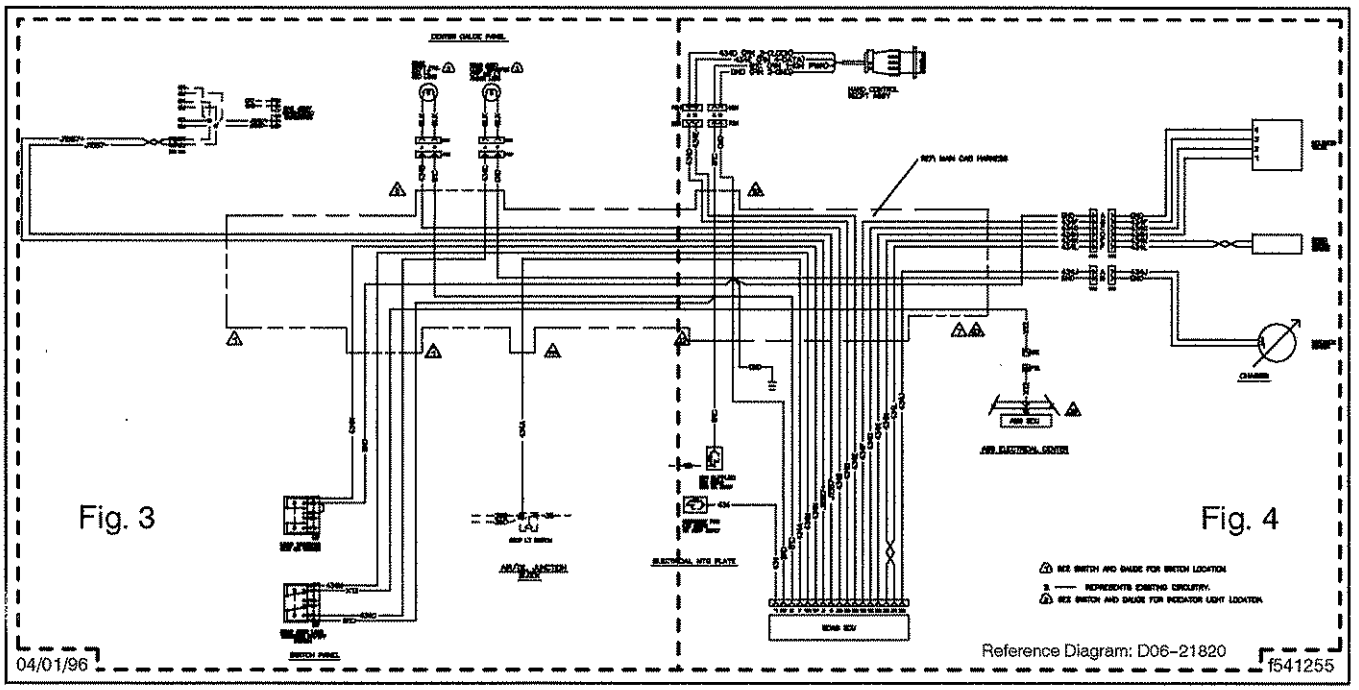


Fig. 2, AirLiner Plus ECAS Electrical Diagram (complete view)

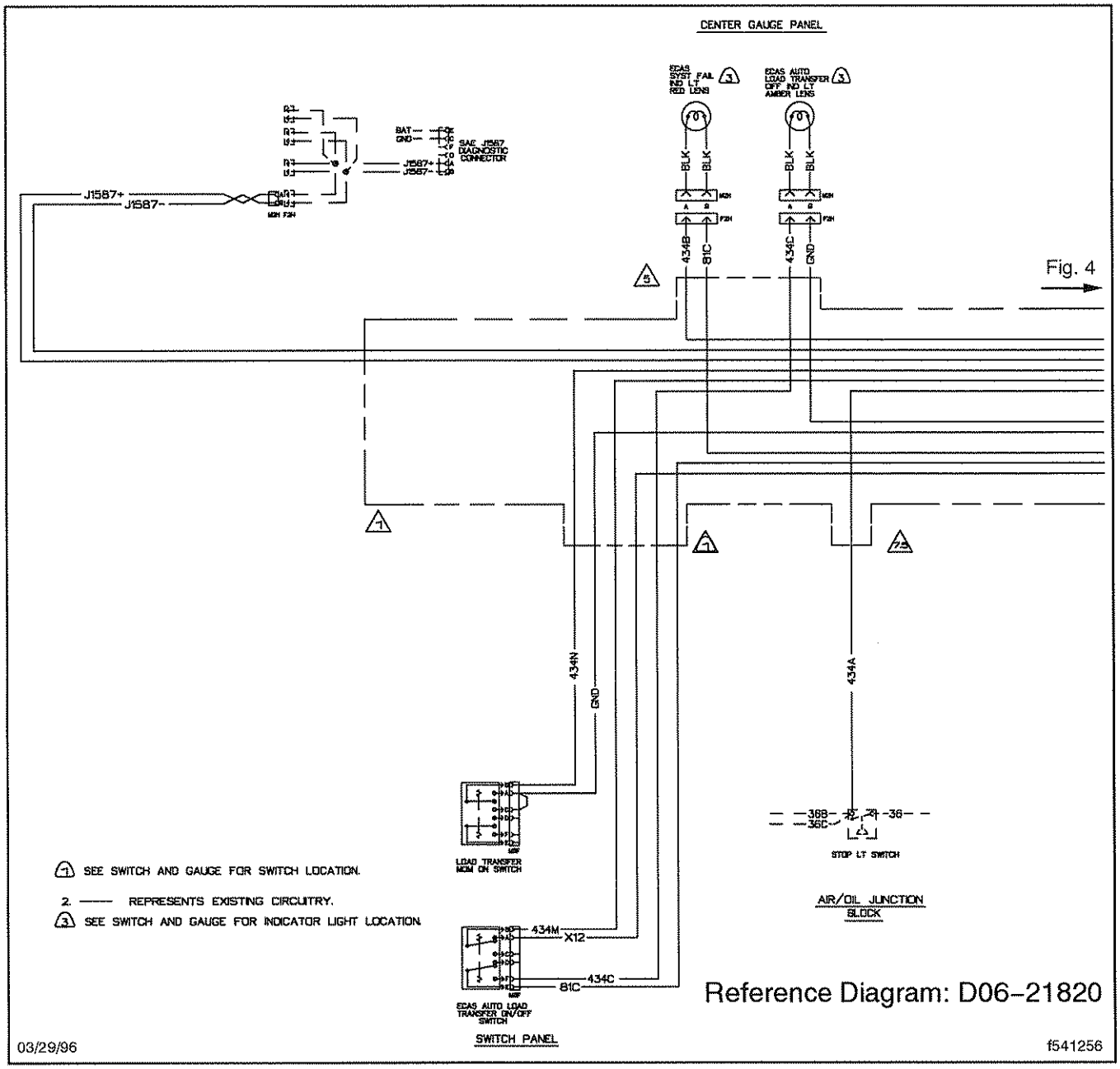


Fig. 3, AirLiner Plus ECAS Electrical Diagram (partial view)

Specifications

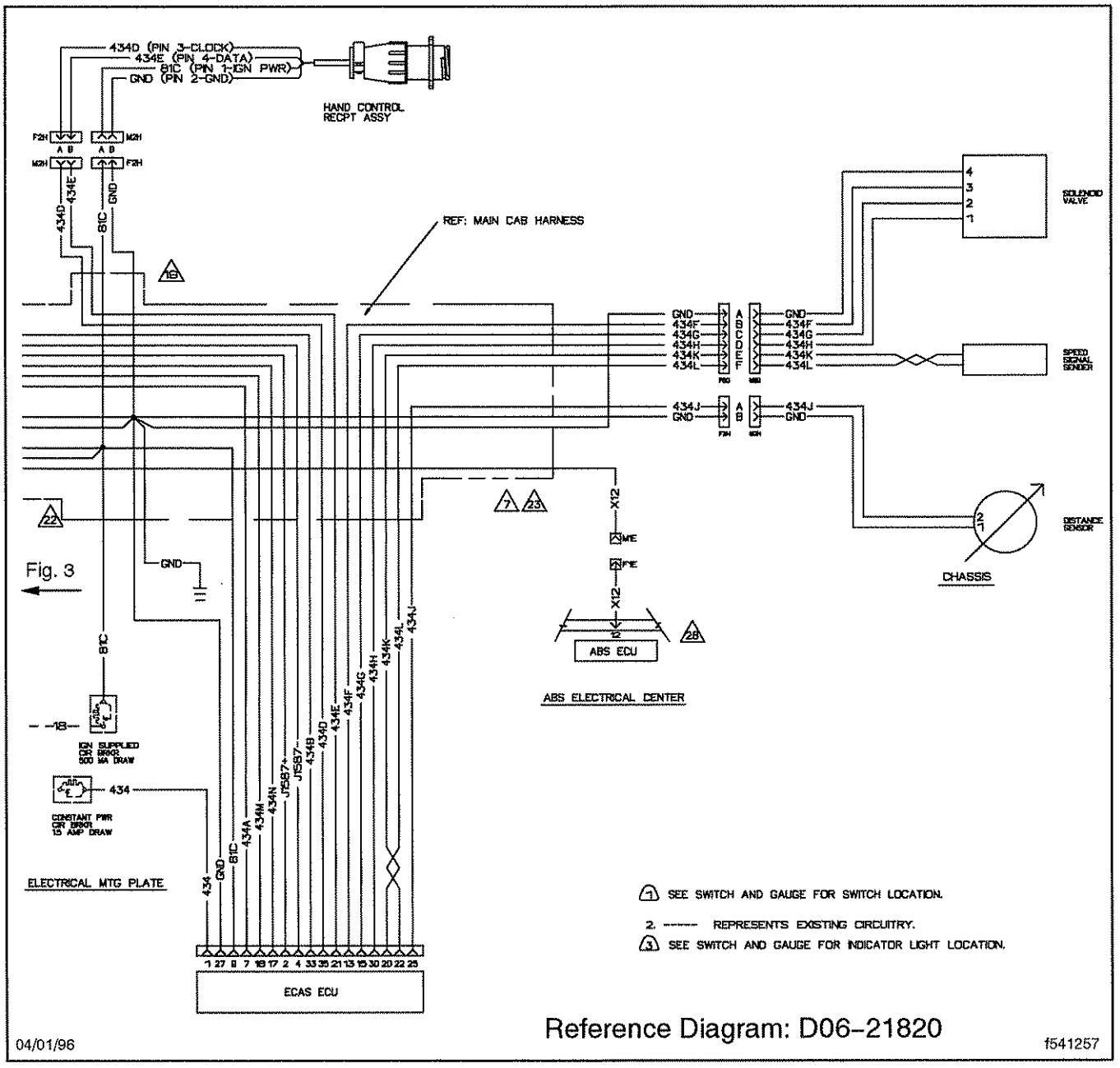


Fig. 4, AirLiner Plus ECAS Electrical Diagram (partial view)

Contents

Subject	Subject Number
General Information	050
Service Operations	
Height Control Valve Adjustment	100
Air Spring Replacement	110
Shock Absorber Replacement	120
Equalizing Beam Removal and Installation	130
Equalizing Beam Bushing Replacement	140
Control Rod Removal, Inspection, and Installation	150
Torque Rod Removal, Inspection, and Installation	160
Torque Rod Bushing Replacement	170
Rear Axle Lateral Alignment	180
Rear Axle Parallel Alignment	190
Troubleshooting	300
Specifications	400

General Description

The Neway Air Ride Suspension is a single axle (Model AD-123; see **Fig. 1**) or tandem axle (Model AD-246; see **Fig. 2**) suspension that uses air springs. The top of each air spring is bolted to a frame-rail bracket, and the bottom of each spring is attached to a suspension crossmember. The suspension crossmember is attached to the rear ends of two equalizing beams which carry the axle. The forward ends of the equalizing beams are journaled to brackets bolted on the frame rail.

Both models of the suspension allow for vertical travel. The maximum loading capacity of the single axle model is 22,500 pounds (10 000 kg); and the maximum loading capacity for the tandem axle model is 44,000 pounds (20 000 kg).

The Neway suspension maintains a stable, level ride by adjusting the air spring height according to vehicle load and road conditions. A height control valve mounted inside the frame rail is linked to the suspension crossmembers and monitors ride height in relation to the crossmember. See **Fig. 3**. If the load is riding too high, the suspension crossmember pulls the valve's control lever down, and the valve lowers the load by venting air from the springs. See **Fig. 4**. If the load rides too low, the suspension crossmember pushes the valve's control lever up, and the valve raises the load by delivering air to the springs. The air springs and the shocks mounted between the axle and the frame rails absorb road shock.

The design of the height control valve allows a several second delay between delivering air to and venting air from the air springs. This prevents the valve from reacting to abrupt axle movements caused by the condition of the road surface.

A torque rod (**Fig. 3**) connects each axle housing to a frame crossmember to prevent torque-induced rotation of the axle. A similar control rod (**Fig. 3**) connects each axle housing to a frame rail to prevent the axle from moving laterally.

If the air springs lose pressure, a solid rubber bumper inside the spring will support the vehicle until it can be repaired. Do not drive the vehicle over 30 mph (50 km/h) with the air springs deflated, and drive it only as far as the nearest service facility. To deflate the air springs, disconnect the control lever arm from the linkage rod, and press the valve's control lever down to simulate overinflated air springs. The valve will vent the air from the springs.

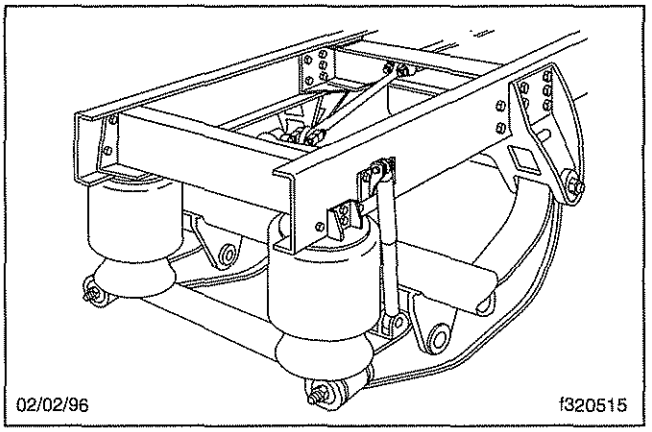


Fig. 1, Single Axle Suspension, Model AD-123

General Information

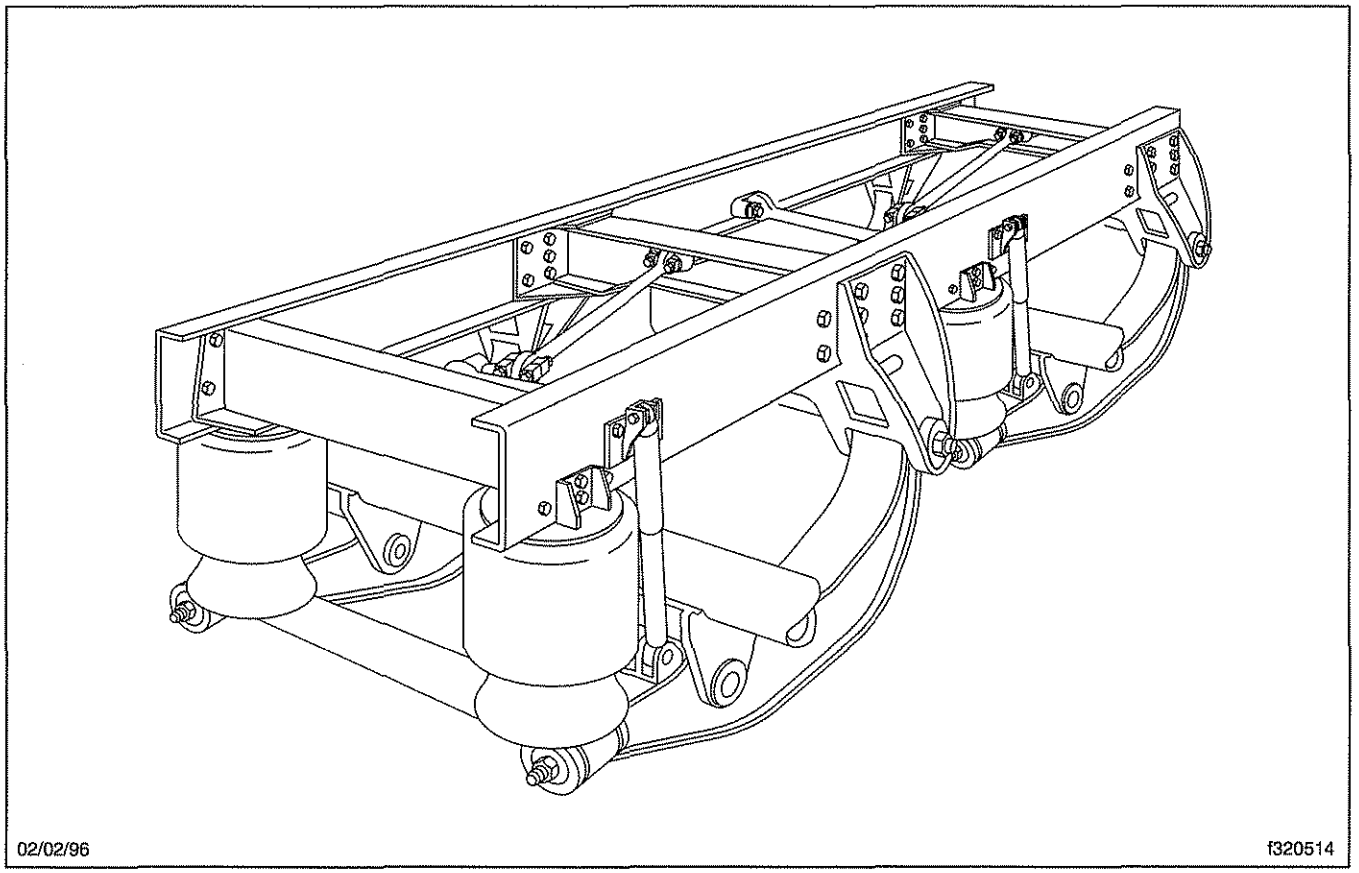
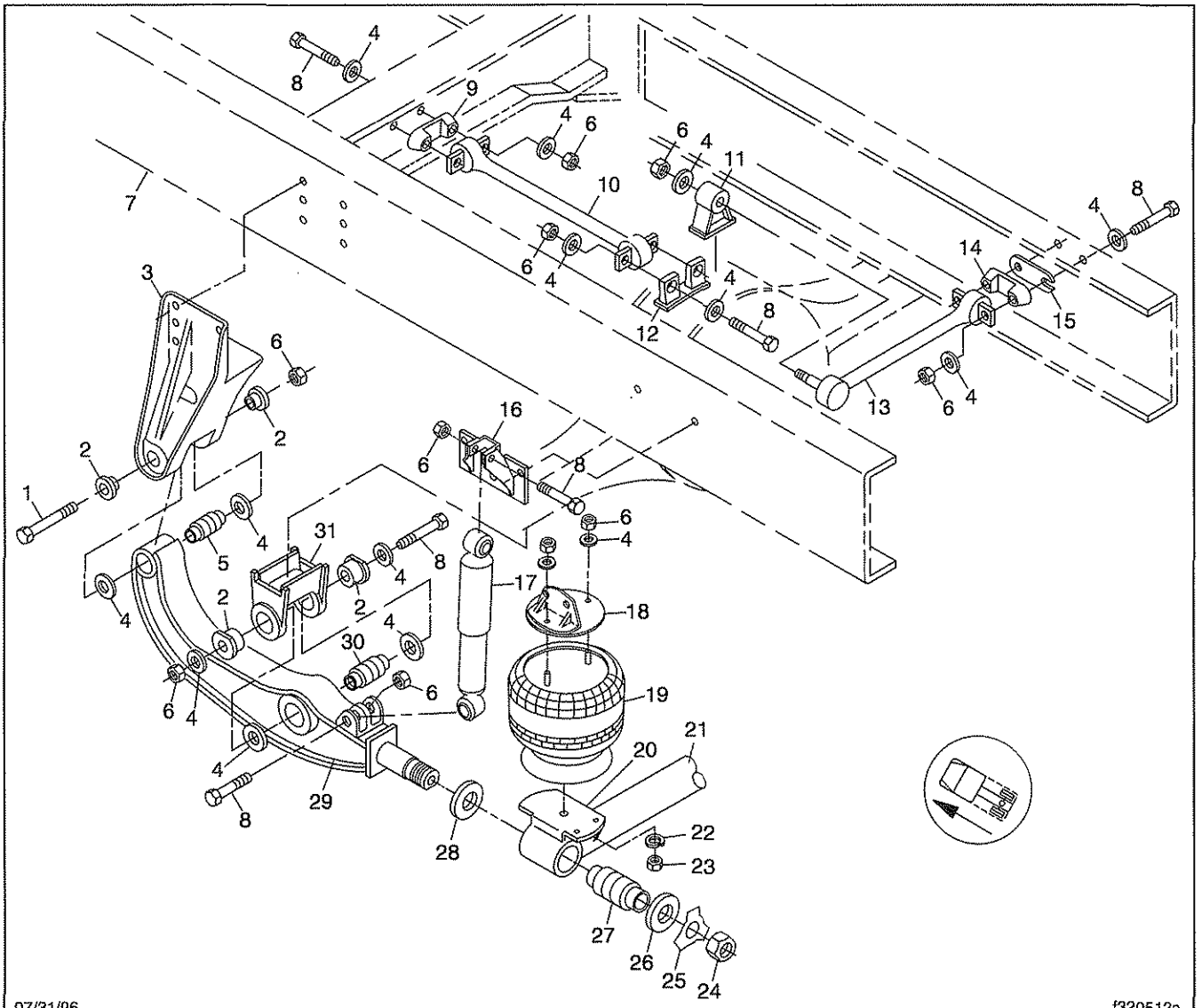


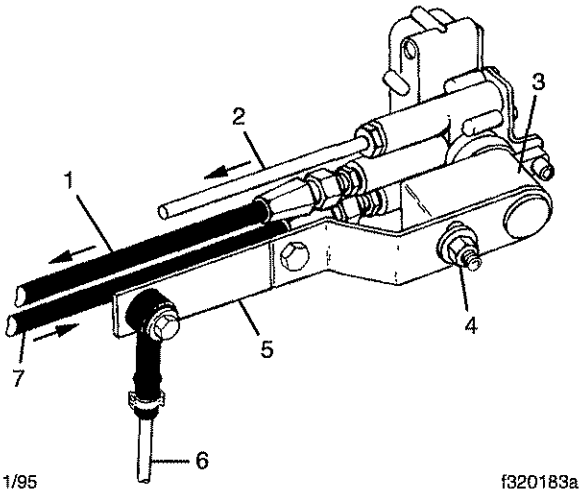
Fig. 2, Tandem Axle Suspension, Model AD-246



1. Rod Bolt, 1-1/8–7 x 9-1/4
2. Adaptor Bushing
3. Frame Bracket
4. Spacer Washer
5. Equalizing Beam Front Bushing
6. Locknut
7. Frame Rail
8. Rod Bolt, 3/4–10 x 7-1/2
9. Torque Rod Crossmember Bracket
10. Torque Rod
11. Control Rod Axle Bracket
12. Torque Rod Axle Bracket
13. Control Rod
14. Control Rod Frame Bracket
15. Axle Alignment Shim(s)
16. Shock Absorber Frame Bracket
17. Shock Absorber
18. Air Spring Upper Mounting Plate
19. Air Spring
20. Air Spring Lower Mounting Plate
21. Transverse Beam
22. Lock Washer
23. Hexnut, 1/2–13
24. Hexnut, 2-1/4–8
25. Tab Washer
26. Spacer Washer
27. Transverse Beam Bushing
28. Spacer Washer
29. Equalizing Beam
30. Equalizing Beam Center Bushing
31. Beam Hanger Bracket

Fig. 3, Neway Suspension Components

General Information



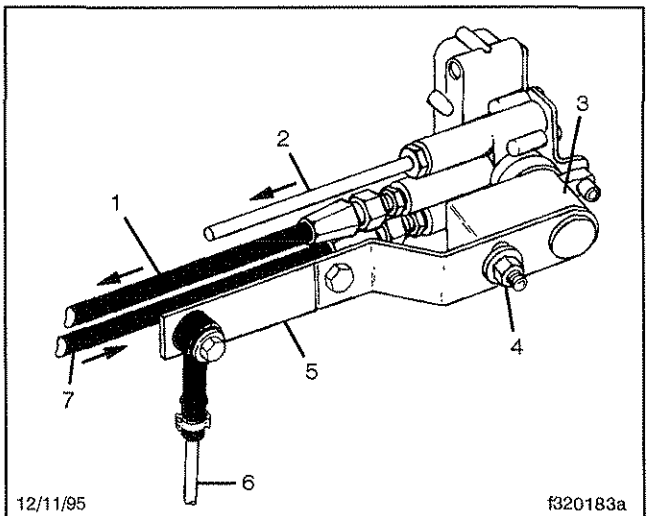
1. Airflow to Spring
2. Exhaust to Atmosphere
3. Nylon Block
4. Adjustment Locknut
5. Control Lever
6. Linkage
7. Airflow from Air Reservoir

Fig. 4, Height Control Valve

Height Control Valve Adjustment

Adjustment

1. Park the unloaded or evenly loaded vehicle on a level surface. Run the engine until the air brake system is fully charged. Chock the tires.
2. Remove the bolt that secures the height control valve linkage to the control lever of each valve. **See Fig. 1.** Disconnect the linkages from the control levers.
3. Exhaust all air from the air springs by pushing the control levers down to the vertical position.
4. Connect one of the control levers to its respective linkage, and allow the air spring(s) controlled by the lever to fill until the valve shuts off.
5. Measure the distance from the underside of the frame rail to the centerline of the axle nearest the inflated spring. This dimension should be 10 inches (25 cm). Adjust the height control valve by loosening the adjustment locknut (**see Fig. 1**) and moving the control lever slightly, relative to the nylon block. When the 10-inch (25-cm) height dimension is achieved, retighten the adjustment locknut.
6. Disconnect the control lever from the linkage, and press it down to deflate the air springs about halfway. Reconnect the linkage to inflate the air springs, then check the height dimension. Repeat the step above and this step until the height dimension measures 10 inches (25 cm).
7. When the height control valve is adjusted, disconnect the control lever from the height control valve linkage, and push it down to the vertical position to fully deflate the air spring.
8. Repeat the previous four steps on the other height control valve(s).
9. Connect all linkage assemblies to the control levers. All height dimensions should now be equal. If they aren't, check for loose mounting bolt nuts on the height control valves. Tighten any loose nuts or capscrews. Repeat the adjustment procedures until all height dimensions are 10 inches (25 cm).



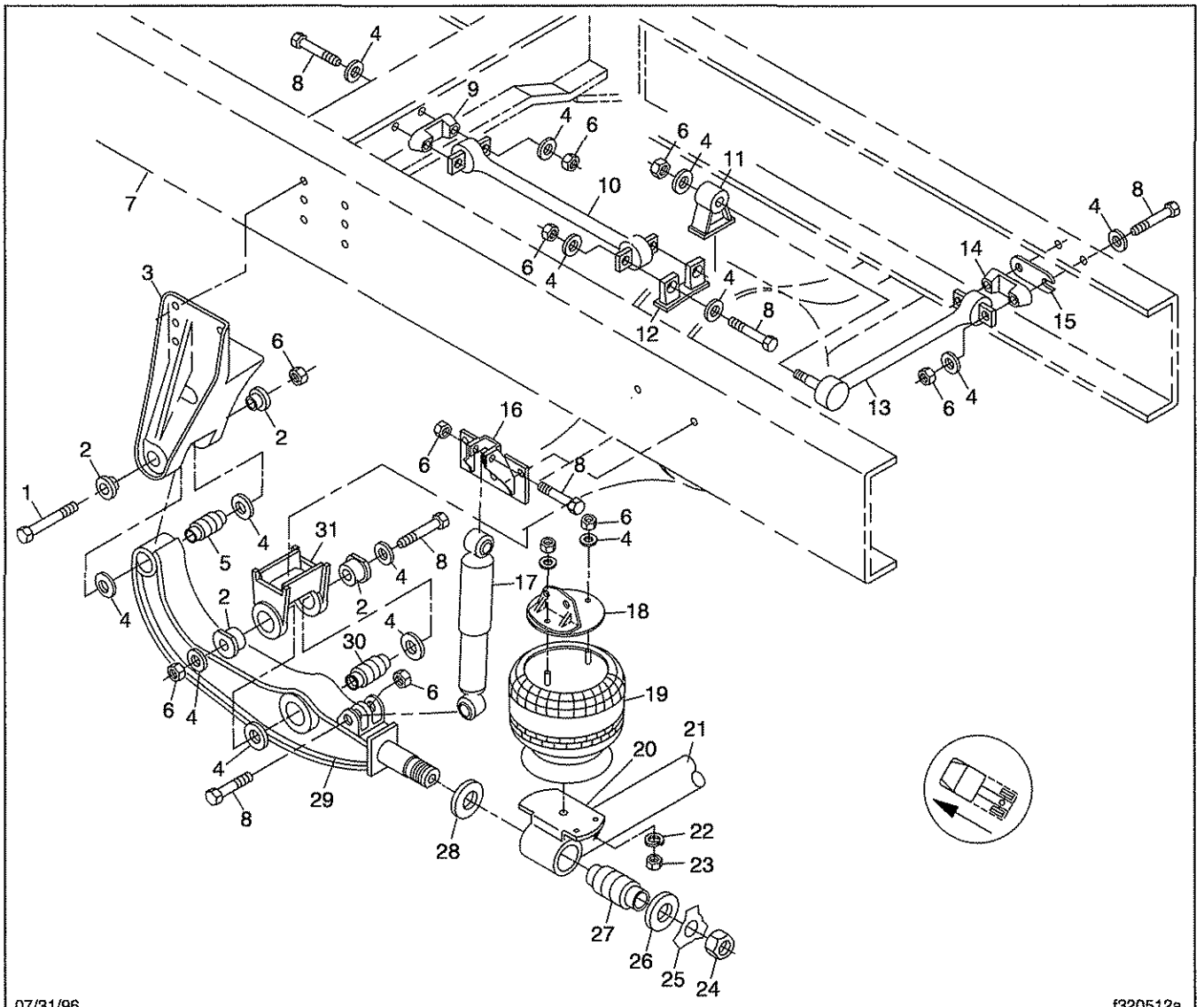
1. Airflow to Spring
2. Exhaust to Atmosphere
3. Nylon Block
4. Adjustment Locknut
5. Control Lever
6. Linkage
7. Airflow from Air Reservoir

Fig. 1, Height Control Valve

Replacement (See Fig. 1)

1. Chock the front tires to prevent vehicle movement. Open the stopcocks on the air tanks to drain the air system.
2. Raise the rear of the vehicle to remove all weight from the rear axles, and place safety stands to secure the vehicle in its raised position. When raised, the height control valves will vent all air from the air springs.
3. Taking care to prevent foreign substances from entering the line or fitting, disconnect the air supply line from the air spring.
4. Remove the locknut (see **Fig. 1**), hexnut, and washers that secure the air spring to the air spring upper mounting plate.
5. Remove the capscrews and lockwashers that connect the air spring to the air spring lower mounting plate on the transverse beam. Remove the air spring.
6. Position the new air spring on the air spring lower mounting plate, then install the capscrews and lockwashers to secure the air spring to the lower mounting plate. Tighten the capscrews to the torque under **Specifications, 400.**
7. Install the locknut, hexnut, and washers previously removed, to connect the air spring to the air spring upper mounting plate. Tighten the nuts to the torque under **Specifications, 400**.
8. Connect the air supply line to the air spring.
9. Remove the safety stands from under the vehicle, then lower the vehicle.
10. There must be 10 inches (25 cm) between the bottom of the frame rail and the centerline of the axle. Adjust the height control valve adjustment; for instructions, refer to **Subject 100**.

Air Spring Replacement



1. Rod Bolt, 1-1/8–7 x 9-1/4
2. Adaptor Bushing
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4. Spacer Washer
5. Equalizing Beam Front Bushing
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24. Hexnut, 2-1/4–8
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26. Spacer Washer
27. Transverse Beam Bushing
28. Spacer Washer
29. Equalizing Beam
30. Equalizing Beam Center Bushing
31. Beam Hanger Bracket

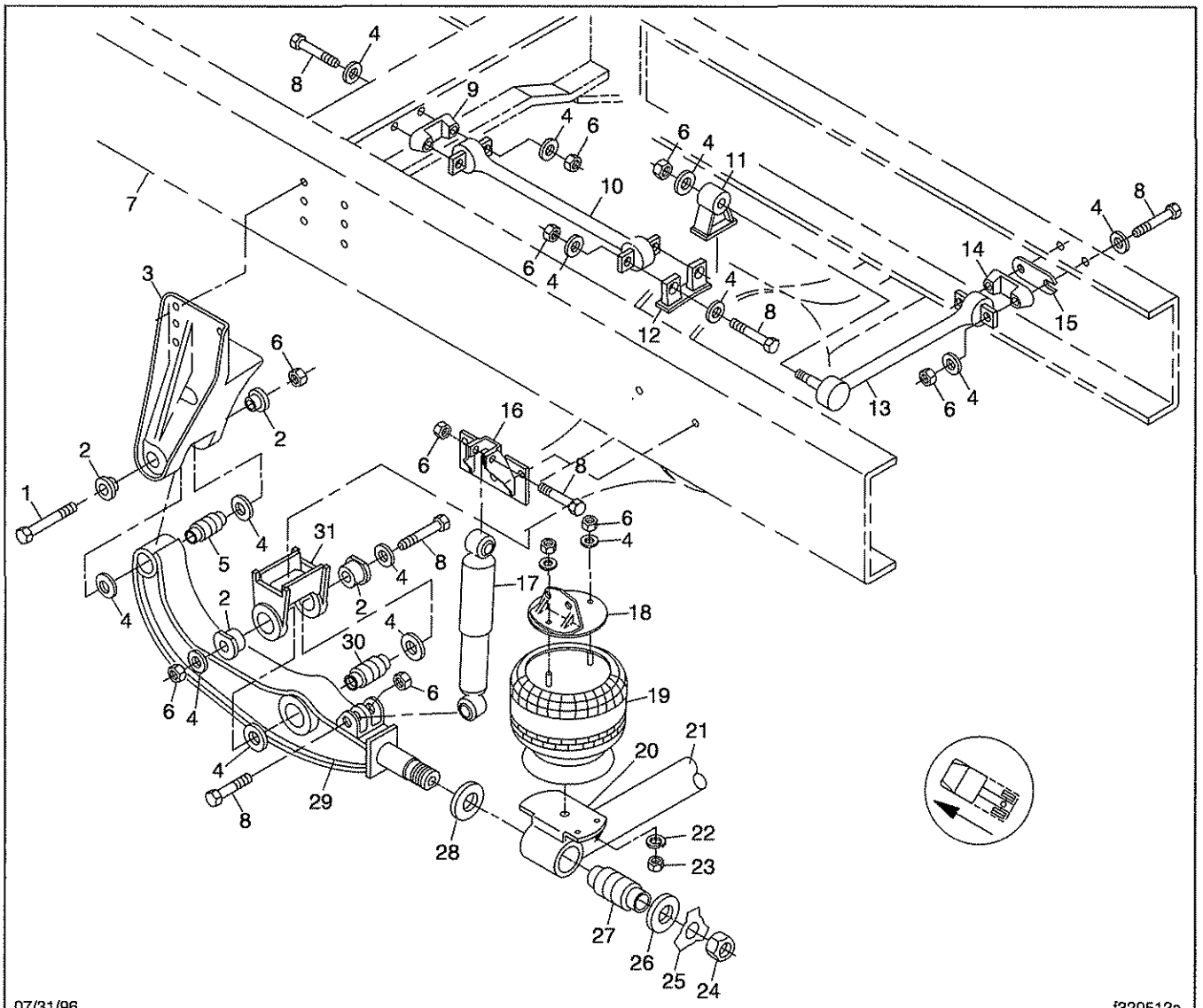
Fig. 1, Neway Suspension Components

Shock Absorber Replacement

Replacement (See Fig. 1)

1. Remove the locknuts from the shock absorber upper and lower mounting brackets.
2. If the shock absorber is fully extended, chock the vehicle wheels and jack up the axle to relieve tension from the shock. Remove the shock absorber. If the inner metal sleeve is rusted to the mounting pin, use a small, sharp chisel to force the sleeve from the pin.
3. Install the new shock absorber on the mounting pins and secure it with the locknuts and washers previously removed. Tighten the locknuts to the torque under **Specifications, 400**.

Shock Absorber Replacement



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24. Hexnut, 2-1/4–8
25. Tab Washer
26. Spacer Washer
27. Transverse Beam Bushing
28. Spacer Washer
29. Equalizing Beam
30. Equalizing Beam Center Bushing
31. Beam Hanger Bracket

Fig. 1, Neway Suspension Components

Equalizing Beam Removal and Installation

Removal (See Fig. 1)

1. Chock the front tires.
2. Raise the rear of the vehicle to remove all weight from the rear suspension, and place safety stands to secure the vehicle in its raised position.
3. Remove the rear wheels and tires for access to the suspension. Block the axle securely to prevent it from dropping away from the vehicle as the equalizing beam is removed.
4. With the weight removed from the suspension, the air springs should be fully deflated. If they aren't, disconnect the height control valve linkage from the height control valve control lever. Push the lever down to the vertical position to deflate the air springs.
5. Remove the capscrews and lockwashers that secure the air springs to the air spring lower mounting plates on both ends of the transverse beam. See **Fig. 1**.
6. Remove the cotter pins, locknuts, flatwashers, and retainer washers from the studs in the ends of the equalizing beams. Tap the transverse beam back from the ends of the equalizing beams.

NOTE: In some cases, the transverse beam bushings will stick, making it difficult to remove the transverse beam from the equalizing beams. Use a Porta-Power, or equivalent tool, between the axle housing and the transverse beam at a point as near to the end of the transverse beam as possible to remove the beam.

7. Remove the locknut and washer from the outboard end of the rod bolt. Support the equalizing beam on a floor jack, then extract the equalizing beam center bushing bolt from the beam hanger bracket.
8. Use a drift to tap the adaptor bushings from the beam hanger bracket. Lower the equalizing beam to the floor.
9. Remove the locknut from the inboard end of the bolt. Note the positions of the spacer washers at either side of the equalizing beam so they can be reassembled in their original positions. Use a drift to drive the rod bolt out of the frame bracket. Remove the equalizing beam from the vehicle.

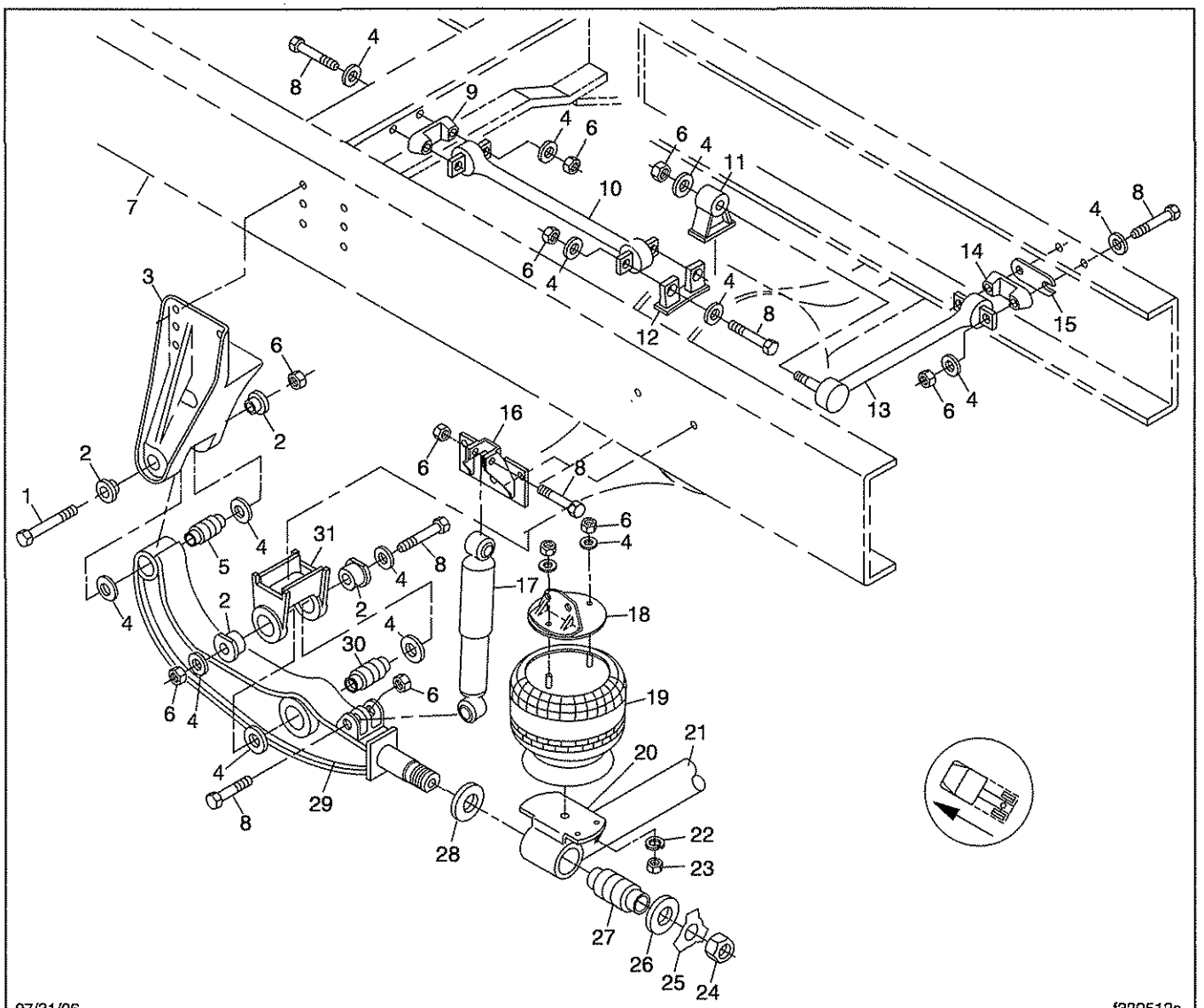
Installation

1. Make sure the adaptor bushings are installed in the frame bracket.
2. Position the equalizing beam with its front bushing centered in the frame bracket. Push the rod bolt into the frame bracket while inserting the spacer washers into their original positions between the equalizing beam and the frame bracket.

NOTE: Refer to **Subject 190** for placement of the spacer washers if their positions were not recorded during removal of the equalizer beam.

3. Lubricate the threads of the rod bolt with SAE-20 oil, then install the locknut. Tighten the locknut to the torque under **Specifications 400**.
4. Raise the equalizing beam so the center bushing is centered in the beam hanger bracket. Insert the beam hanger adaptor bushings through the beam hanger bracket and into the equalizing beam center bushing.
5. With a flatwasher under the head,insert the rod bolt through the beam hanger adaptor bushings with the threaded end on the outboard side of the suspension.
6. Lubricate the center bushing bolt threads with SAE-20 oil, then install the flatwasher and locknut on the bolt. Tighten the locknut to the torque under **Specifications 400**.
7. Lubricate the transverse beam bushings with rubber lubricant, soap and water solution, or a waterless hand cleaner. Install the inner halves of the bushings with their thicker ends toward the front of the vehicle.
8. Install the transverse beam on the equalizing beams, with the air spring lower mounting plates tilted toward the rear of the vehicle. Install the outer halves of the transverse beam bushings on the equalizer beam journals.
9. Apply SAE-20 oil to the threads on the studs at the rear of the equalizing beams. Install the retainer washers, flatwashers and locknuts on the studs. Tighten the locknuts to the low end of the torque ranges under **Specifications 400**. Install the cotter pins and lock them in place. Tighten the locknuts further if it's necessary in order to install the cotter pins.

Equalizing Beam Removal and Installation



1. Rod Bolt, 1-1/8–7 x 9-1/4
2. Adaptor Bushing
3. Frame Bracket
4. Spacer Washer
5. Equalizing Beam Front Bushing
6. Locknut
7. Frame Rail
8. Rod Bolt, 3/4–10 x 7-1/2
9. Torque Rod Crossmember Bracket
10. Torque Rod
11. Control Rod Axle Bracket
12. Torque Rod Axle Bracket
13. Control Rod
14. Control Rod Frame Bracket
15. Axle Alignment Shim(s)
16. Shock Absorber Frame Bracket
17. Shock Absorber
18. Air Spring Upper Mounting Plate
19. Air Spring
20. Air Spring Lower Mounting Plate
21. Transverse Beam
22. Lock Washer
23. Hexnut, 1/2–13
24. Hexnut, 2-1/4–8
25. Tab Washer
26. Spacer Washer
27. Transverse Beam Bushing
28. Spacer Washer
29. Equalizing Beam
30. Equalizing Beam Center Bushing
31. Beam Hanger Bracket

Fig. 1, Neway Suspension Components

10. Apply SAE-20 oil to the threads of the capscrews that secure the air springs to the air spring lower mounting plates. Position the air springs on the plates and install the capscrews and lockwashers. Tighten the capscrews to the torque under **Specifications 400**.

Replacement (See Fig. 1)

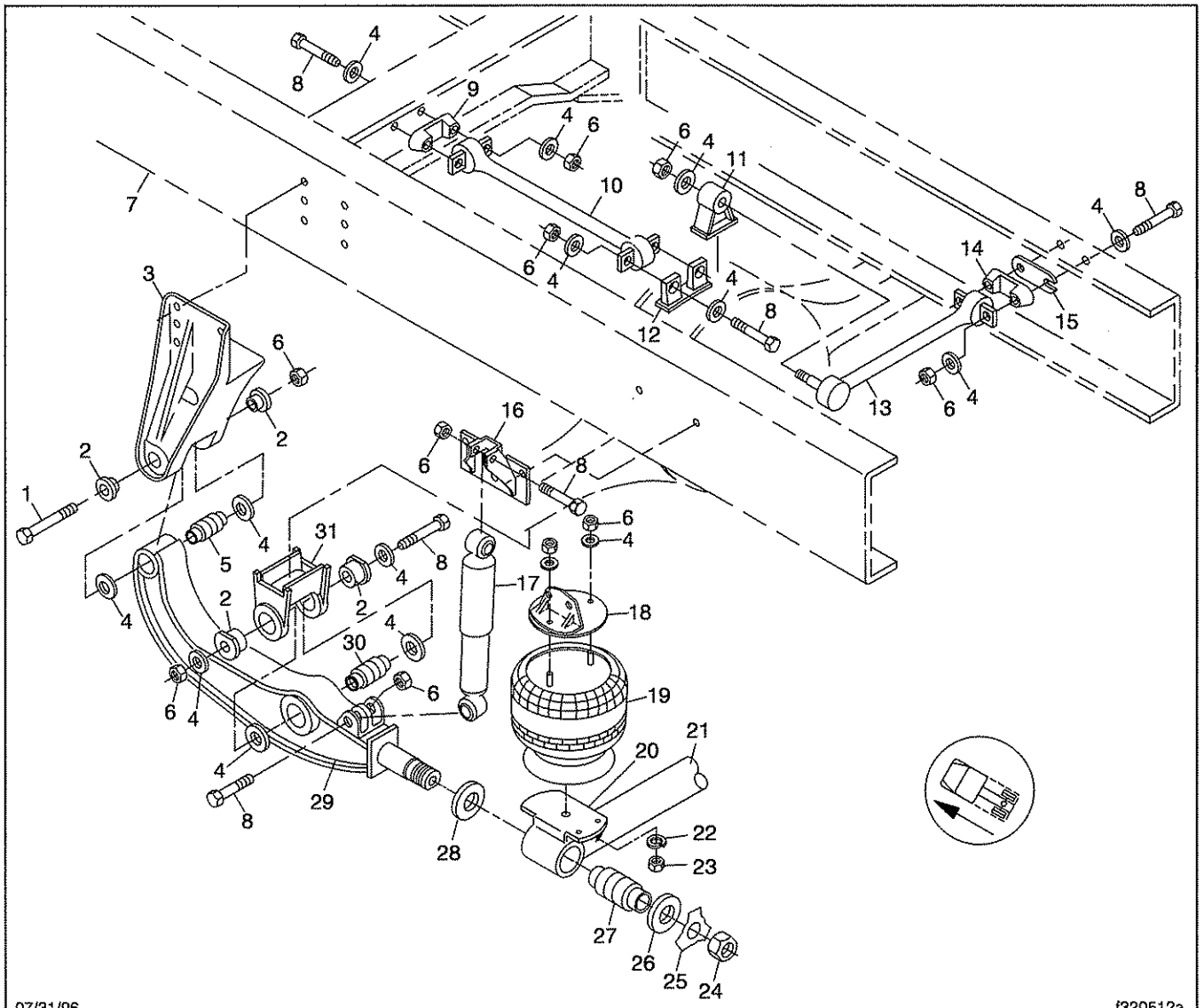
1. Remove the equalizing beam. Refer to **Subject 130**.

⚠ WARNING

Do not use a torch to cut the bushing sleeve out of the equalizing beam. To do so could weaken the casting, possibly resulting in loss of vehicle control and personal injury.

2. Using a hydraulic press, apply 2000 to 3000 pounds (metric) pressure to remove the equalizing beam front and center bushings. See **Fig. 1**.
3. Using a wire brush and solvent, clean out the equalizing beam bushing receptacles. Inspect the entire beam for cracks or bends. Replace any damaged equalizing beam with a new one.
4. Lubricate the replacement bushings and the bushing receptacles with a non-mineral lubricant. If standard rubber lubricant is not available, use a soap and water solution or a waterless hand cleaner.
5. Press the replacement bushings into the bushing receptacles with a hydraulic press. Press the bushings slightly past center, then turn the equalizing beam over and press the bushings back to a centered position.
6. Install the equalizing beam. Refer to **Subject 130**.

Equalizing Beam Bushing Replacement



1. Rod Bolt, 1-1/8–7 x 9-1/4
2. Adaptor Bushing
3. Frame Bracket
4. Spacer Washer
5. Equalizing Beam Front Bushing
6. Locknut
7. Frame Rail
8. Rod Bolt, 3/4–10 x 7-1/2
9. Torque Rod Crossmember Bracket
10. Torque Rod
11. Control Rod Axle Bracket
12. Torque Rod Axle Bracket
13. Control Rod
14. Control Rod Frame Bracket
15. Axle Alignment Shim(s)
16. Shock Absorber Frame Bracket
17. Shock Absorber
18. Air Spring Upper Mounting Plate
19. Air Spring
20. Air Spring Lower Mounting Plate
21. Transverse Beam
22. Lock Washer
23. Hexnut, 1/2–13
24. Hexnut, 2-1/4–8
25. Tab Washer
26. Spacer Washer
27. Transverse Beam Bushing
28. Spacer Washer
29. Equalizing Beam
30. Equalizing Beam Center Bushing
31. Beam Hanger Bracket

Fig. 1, Neway Suspension Components

Control Rod Removal, Inspection, and Installation

Removal

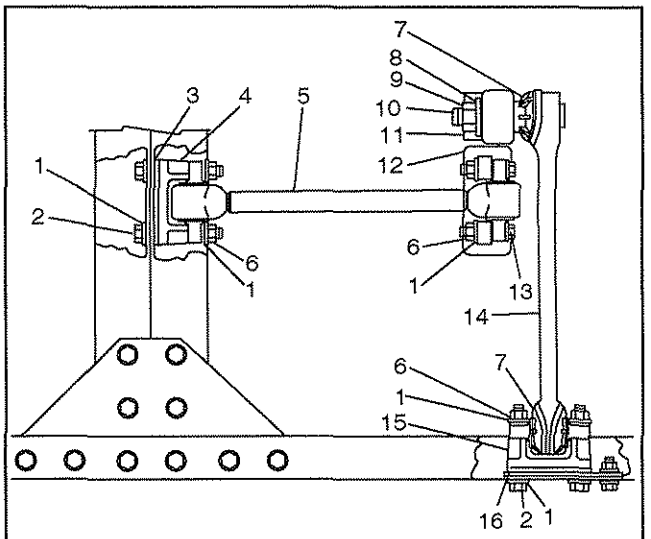
1. Apply the parking brakes.
2. Remove the locknuts and flatwashers (**see Fig. 1**) from the bolts that secure the control rod frame bracket to the frame rail. To ease reassembly, note the order of the axle alignment shims between the control rod frame bracket and the backing plate.
3. Remove the control rod frame bracket bolts. Swing the control rod clear, and remove the axle alignment shims and the bracket.
4. Remove the locknut and flatwasher from the ball stud on the inboard end of the control rod. Rap the ball stud eye on the control rod axle bracket with a hammer to loosen the ball stud. If this fails to break it loose, use a tie-rod separator tool to remove the ball stud from the control rod axle bracket. Remove the control rod.
5. Remove the seals from both ends of the control rod. Clean the seals and rod to remove all dirt and grease.

Inspection

Inspect the seals for dryness, cracks, or other signs of deterioration and wear. Replace damaged seals with new ones. Visually inspect the control rod for cracks or bends. Work the ball joint and control rod pin to check for looseness in the bushings. If the control rod is bent, cracked, or otherwise damaged, or if there is any slack in either of the bushings, replace the control rod with a new one.

Installation

1. Lubricate all control rod and fastener threads with SAE-20 oil, and install the seals (**see Fig. 1**) removed from the rod ends.
2. Insert the control rod ball stud through the control rod axle bracket, then install the flatwasher and locknut on the stud. Tighten the locknut to the torque under **Specifications, 400**, then rap the control rod axle mount with a hammer. Tighten the locknut again to the torque under **Specifications, 400.**
3. Position the control rod frame bracket and the axle alignment shims against the backing plate on the inside of the frame rail. Move the control rod into position on the control rod frame bracket.
4. Install flatwashers on the control rod frame bracket bolts, then install the bolts through the frame rail, the shims, the control rod frame bracket, and the control rod. Install the flatwashers and locknuts on the bolts, and tighten the locknuts to the torque under **Specifications, 400.**
5. Check the alignment of the axle. Refer to **Subject 180** for instructions.



1. Flatwasher, 5/8-inch
2. Bolt, 5/8-11 x 5-1/2 Inch
3. Axle Plane Shim(s)
4. Torque Rod Crossmember Bracket
5. Torque Rod
6. Locknut, 5/8-18
7. Seal
8. Flatwasher, 1-1/4 Inch
9. Locknut, 1-1/4-12
10. Ball Stud
11. Control Rod Axle Bracket
12. Torque Rod Axle Bracket
13. Bolt, 5/8-11 x 4 Inch
14. Control Rod
15. Control Rod Frame Bracket
16. Axle Alignment Shim(s)

Fig. 1, Control Rod Mounting

Torque Rod Removal, Inspection, and Installation

Removal

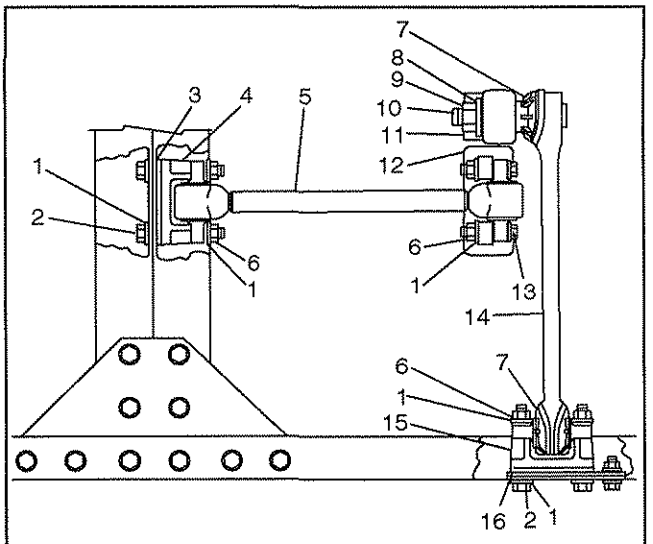
1. Apply the parking brakes.

WARNING: When the torque rods are disconnected from the axle brackets, the axles become free to pivot on the equalizer beam end bushings. Keep clear of the beam hangers and beam ends to avoid possible injury.

2. Remove the locknuts and the flatwashers (**see Fig. 1**) from the bolts that secure the torque rod crossmember bracket to the vehicle frame crossmember. For ease of installation, note the order of the axle plane shims between the torque rod crossmember bracket and the frame crossmember.

3. Remove the torque rod crossmember bracket bolts. Swing the torque rod clear of the torque rod crossmember bracket, and remove the axle plane shims together with the torque rod crossmember bracket.

4. Remove the locknuts and flatwashers from the bolts that secure the torque rod to the torque rod axle bracket . Remove the bolts. Remove the torque rod from the vehicle.



1. Flatwasher, 5/8-inch
2. Bolt, 5/8-11 x 5-1/2 Inch
3. Axle Plane Shim(s)
4. Torque Rod Crossmember Bracket
5. Torque Rod
6. Locknut, 5/8-18
7. Seal
8. Flatwasher, 1-1/4 Inch
9. Locknut, 1-1/4-12
10. Ball Stud
11. Control Rod Axle Bracket
12. Torque Rod Axle Bracket
13. Bolt, 5/8-11 x 4 Inch
14. Control Rod
15. Control Rod Frame Bracket
16. Axle Alignment Shim(s)

Fig. 1, Torque Rod Mounting

Inspection

Inspect the torque rod for bends or cracks. Work the torque rod pins to check for looseness in the polyurethane bushings. If the torque rod is bent, cracked, or otherwise damaged, replace it with a new one. If either of the polyurethane bushings is loose, replace the bushing with a new one. For instructions, refer to **Subject 170**.

Installation

1. Lubricate all torque rod and fastener threads with SAE-20 oil.

2. Position the torque rod against the torque rod axle bracket (**see Fig. 1**). Slip a flatwasher over each of the two bolts, then insert the bolts through the torque rod axle bracket and the torque rod.

3. Install the flatwashers and locknuts on the torque rod axle bracket bolts. Tighten the locknuts to the torque under **Specifications, 400**.

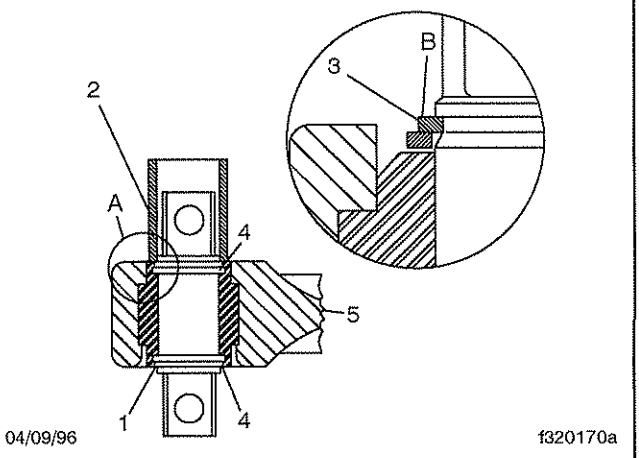
4. Position the torque rod crossmember bracket and the axle plane shims against the frame crossmember, and move the torque rod into place on the torque rod crossmember bracket.

5. Install flatwashers on the bolts, and install the bolts through the frame crossmember, the shims, the torque rod crossmember bracket, and the torque rod. Install flatwashers and locknuts on the bolts, and tighten the locknuts to the torque under **Specifications, 400**.

Replacement

NOTE: In order to replace the torque rod polyurethane bushings, you need special installation tool kit P-097-009. This tool kit can be purchased from Freightliner, or it can be machined, using the dimensions given in **Specifications, 400.**

1. Remove the snap ring and washer from each side of the bushing to be removed. **See Fig. 1.** Note that the torque rod eye has a smaller shoulder on one side than on the other, and the larger shoulder has a rounded edge around the inside of the eye. The polyurethane bushing must be pressed in and out through the larger side.
2. Using the plunger from the special tool kit on a hydraulic press, press the old bushing out of the torque rod eye. Clean all dirt, grease, or foreign matter from the torque rod.
3. Coat the replacement bushing with a non-mineral lubricant, such as rubber lubricant or waterless hand cleaner. Position the bushing in the larger end of the insertion sleeve from the tool kit, then fit the beveled (smaller) end of the sleeve into the larger side of the torque rod eye.



A. Detail
B. Install washer and snap ring with sharp edges to outside.

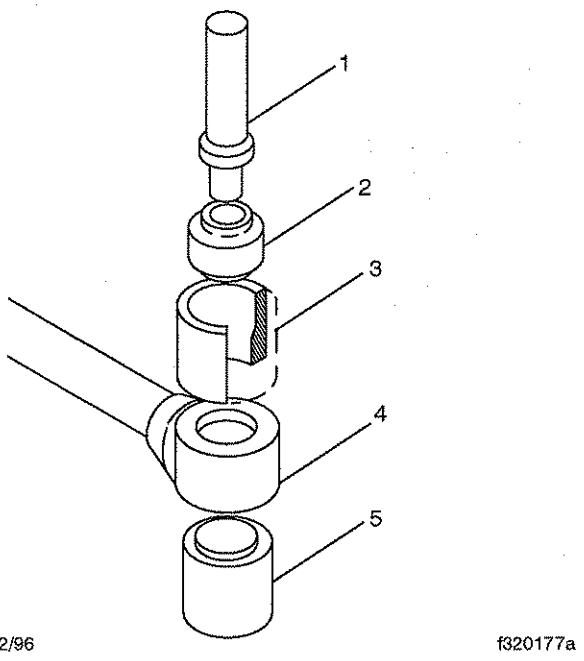
1. Snap Ring
2. Pressing Sleeve
3. Snap Ring
4. Washer
5. Torque Rod

Fig. 1, Bushing Snap Ring Installation

4. Center the torque rod eye on the tool base, and insert the plunger tool into the polyurethane bushing. **See Fig. 2.** Press the bushing into the torque rod eye.
5. Install the snap ring and flatwasher on one end of the torque rod pin, with the sharp edges of the washer and the snap ring facing the outward end of the pin. **See Fig. 1.**
6. Press the torque rod pin into the torque rod bushing from the same side as the bushing was pressed into the torque rod eye. Make sure the snap ring seats. Do not lubricate the torque rod pin.
7. Turn the torque rod over and install a flatwasher, with the sharp edge facing away from the bushing; then install the other snap ring onto the outer shoulder of the pin, with the sharp edge facing outward.
8. Place a pressing sleeve over the end of the torque rod pin, then seat the snap ring. **See Fig. 1.**
9. After assembly, press the torque rod pin slightly to center it in the torque rod eye.

   There should be no slack on either side of the polyurethane bushing, and the bushing should be compressed by about half the thickness of the snap ring. If necessary, install a second washer under one of the snap rings to compress the bushing.

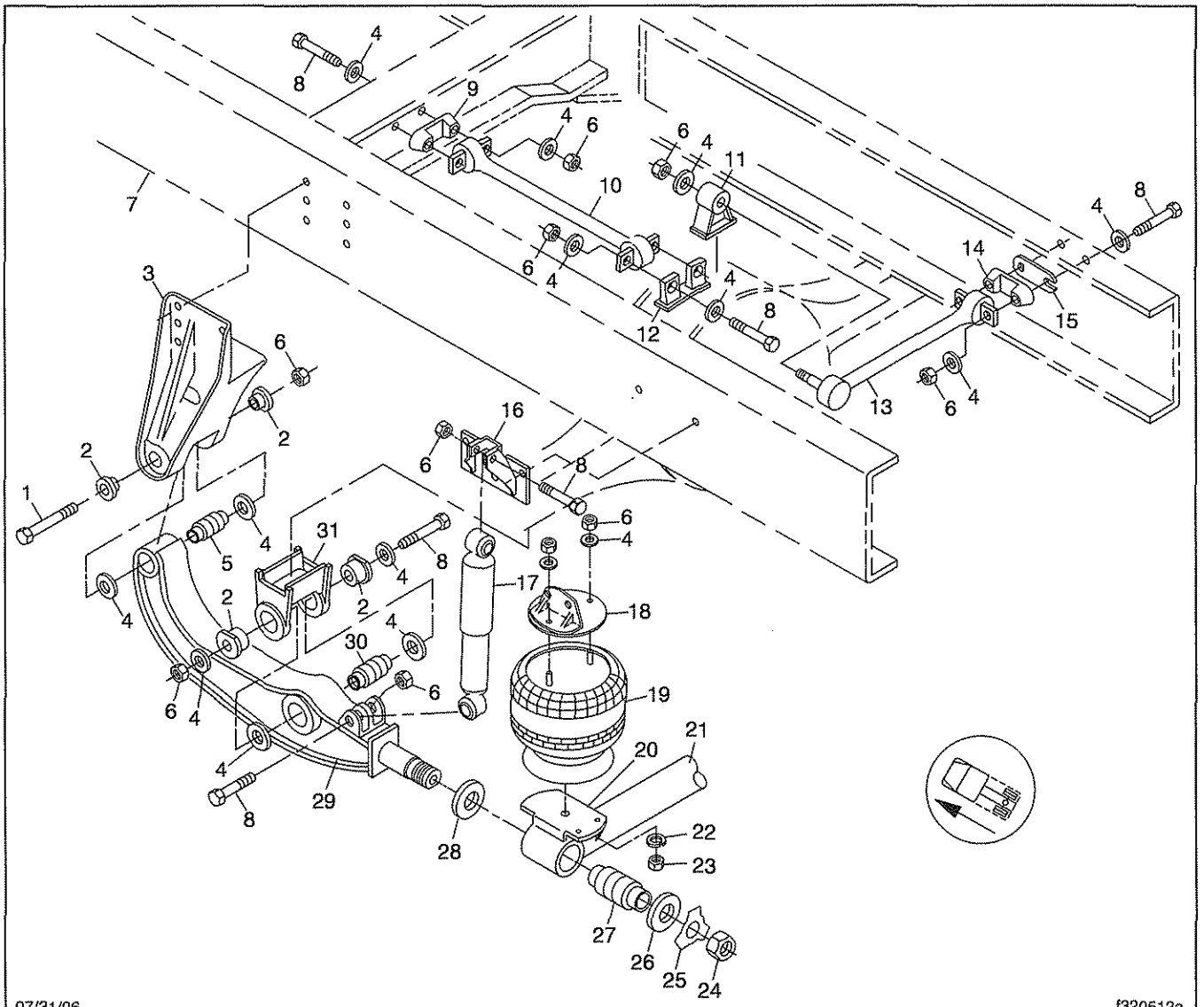
Torque Rod Bushing Replacement



1. Plunger
2. Polyurethane Bushing
3. Insertion Sleeve
4. Torque Rod
5. Base

Fig. 2, Torque Rod Bushing Installation

Lateral Alignment (See Fig. 1)



1. Rod Bolt, 1-1/8–7 x 9-1/4
2. Adaptor Bushing
3. Frame Bracket
4. Spacer Washer
5. Equalizing Beam Front Bushing
6. Locknut
7. Frame Rail
8. Rod Bolt, 3/4–10 x 7-1/2
9. Torque Rod Crossmember Bracket
10. Torque Rod
11. Control Rod Axle Bracket
12. Torque Rod Axle Bracket
13. Control Rod
14. Control Rod Frame Bracket
15. Axle Alignment Shim(s)
16. Shock Absorber Frame Bracket
17. Shock Absorber
18. Air Spring Upper Mounting Plate
19. Air Spring
20. Air Spring Lower Mounting Plate
21. Transverse Beam
22. Lock Washer
23. Hexnut, 1/2–13
24. Hexnut, 2-1/4–8
25. Tab Washer
26. Spacer Washer
27. Transverse Beam Bushing
28. Spacer Washer
29. Equalizing Beam
30. Equalizing Beam Center Bushing
31. Beam Hanger Bracket

Fig. 1, Neway Suspension Components

Rear Axle Lateral Alignment

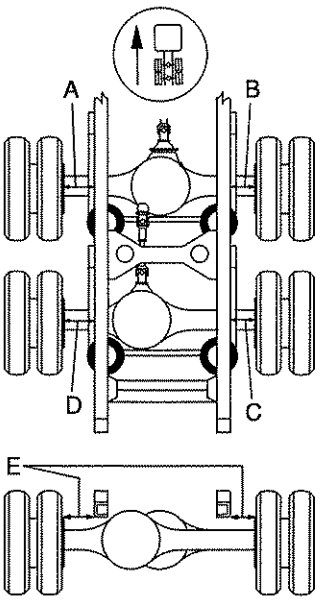
1. Park the vehicle on a level surface; then position the front tires straight ahead and chock them. Release the parking brakes, and place the transmission in neutral.
2. Raise the rear of the vehicle until the tires clear the ground, then place safety stands under the rear of the vehicle to hold it in this position.
3. Check the wheel bearing adjustment. Refer to the rear axle section in this manual for instructions. Adjust or replace the wheel bearings as needed.
4. Measure the lateral runout of the rear wheels. If the runout on any wheel exceeds 0.18 inch (4.6 mm), replace the wheel before proceeding with the axle alignment check.
5. Remove the safety stands and lower the rear of the vehicle. Relieve any internal stresses in the suspension by jacking the axles up and letting them down; or, remove the tire chocks, then move the vehicle back and forth (with the interaxle differential disengaged).
6. On either rear axle, measure the distance between the left frame rail and the nearest point on the inside wheel rim. See **Fig. 2**, Dimension A.
7. On the same axle, measure the distance between the right frame rail and the nearest point on the inside wheel rim (**Fig. 2**, Dimension B).
8. Compare Dimension A with Dimension B. If they're within 1/8 inch (3.25 mm) of being equal, alignment is not necessary. However, if they're different by more than 1/8 inch (3.25 mm), adjust the lateral alignment.

   8.1 Loosen the locknuts on the bolts that secure the lateral rod mount to the frame rail.

   8.2 Add or remove one axle alignment shim for each 1/8 inch (3.25 mm) difference between Dimensions A and B. Adding shims will decrease the measurement on the side of the vehicle to which the lateral rod is attached, and removing shims will increase the measurement.

   8.3 After installing the shims, lubricate the threads on the lateral rod mount bolts with engine oil; tighten the locknuts to the torque under **Specifications 400**.
9. On tandem axle installations, do the previous three steps on the other axle.
10. On suspensions equipped with an axle alignment feature (alignment bushings welded to slotted frame brackets), proceed to **Subject 190**.

    On suspensions not equipped with an axle alignment feature, no further checking is required. Apply the parking brakes; then remove the chocks from the tires.



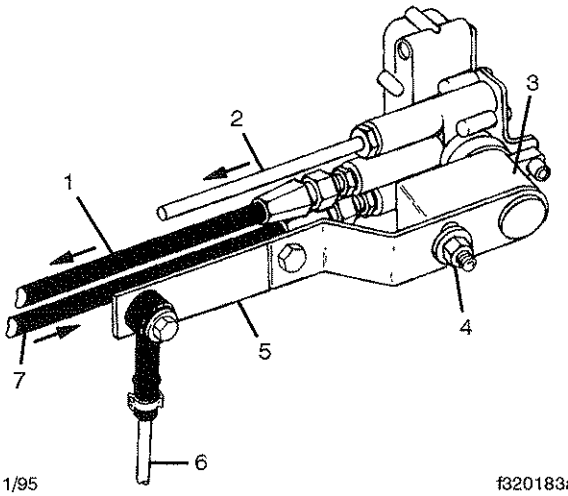
NOTE: Dimension A equals Dimension B plus or minus 1/8-inch (3.25 mm)

A. Dimension A (forward rear axle)
B. Dimension B (forward rear axle)
C. Dimension C (rearmost axle)
D. Dimension D (rearmost axle)
E. Measure Here

Fig. 2, Rear Axle Lateral Alignment

Parallel Alignment

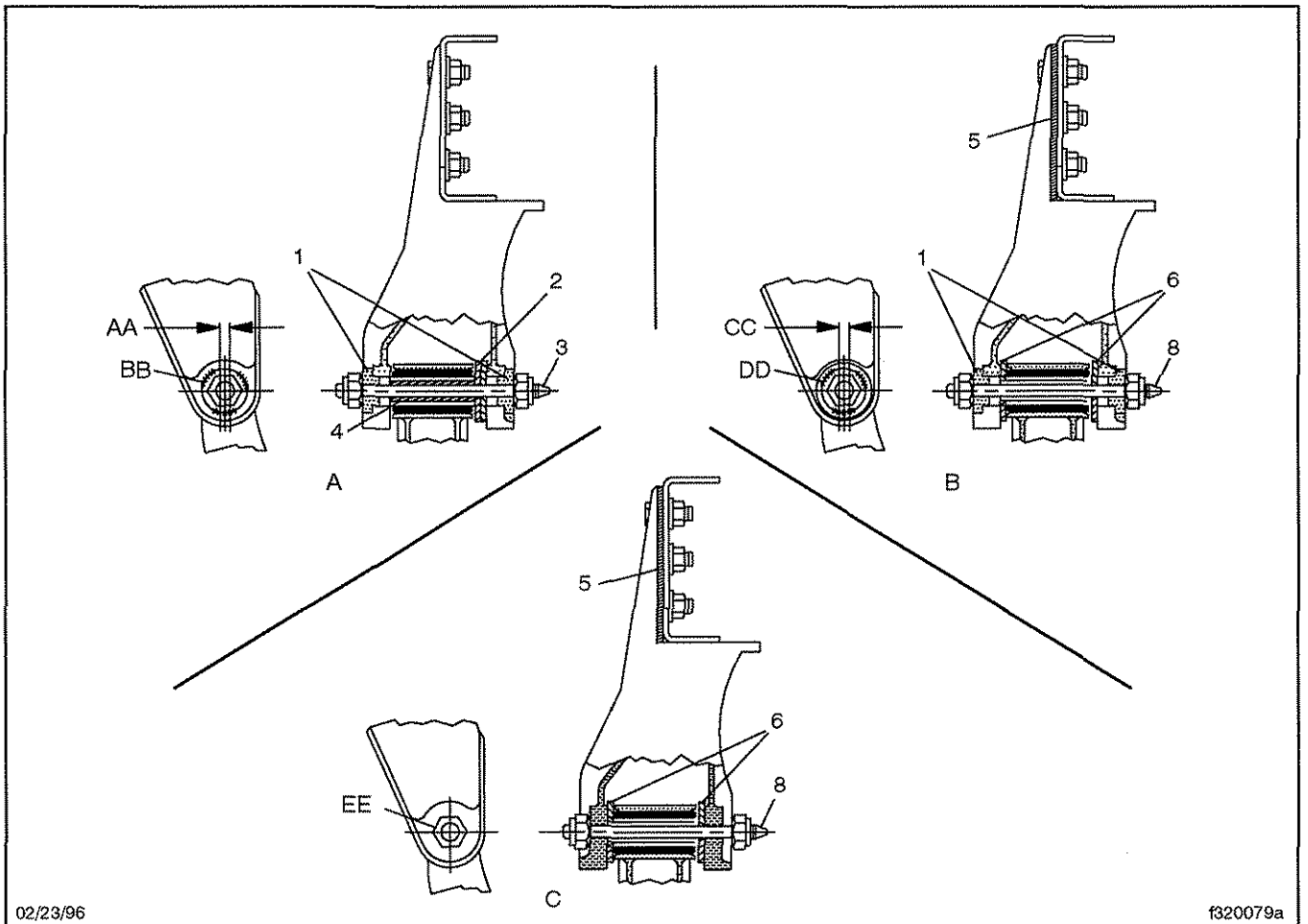
1. Check and, if needed, adjust the lateral alignment of the rear axle(s) before checking parallel alignment. **Refer to Subject 180** for instructions.
2. Check the axles for parallel alignment. Refer to the rear axle section in this manual for instructions.
3. Adjust the rear axle, if necessary.
   - 3.1 Using jack stands, support the vehicle frame at normal ride height. Disconnect both height control valve linkages from their respective control levers. **See Fig. 1.** Then exhaust all air from all air springs by pushing the valve control levers down.
   - 3.2 Remove the equalizing beam pivot connection locknut and bolt, and both spacer washers. **See Fig. 2.** Lower the equalizing beam from the frame bracket.
   - 3.3 Cut the welds off of the alignment bushings on both sides of the frame bracket. Remove the alignment bushings; then grind any remaining weld material off of the frame bracket and alignment bushings.
   - 3.4 Position the alignment bushings in the frame bracket; then raise the equalizing beam until the front eye is aligned with the frame bracket. Install the spacer washers and pivot connection bolt and locknut. Position the spacer washers. **See Fig. 2.** Suspension installations which have a 1/4-inch (6-mm) frame-rail spacer between the forward frame-rail bracket and the frame rail will require one spacer washer on each side of the equalizing beam. Installations without a frame-rail spacer require two spacer washers on the inboard side of the equalizing beam.
   - 3.5 Move the axle forward or backward by rolling the wheels on that side of the vehicle (only that side), until the correct axle alignment is obtained.
   - 3.6 With the axle aligned and the vehicle frame supported at normal ride height, torque the equalizing beam front bushing locknut to the torque under **Specifications, 400**.
   - 3.7 Weld both of the alignment bushings to the frame bracket, using AWS spec E7018 welding rod or Linde 3/32 FC 72 wire weld, or an equivalent. Weld (1/4-inch fillet) each bushing with three, 3/4-inch (19-mm) long welds. **See Fig. 2.**
4. Connect the linkages to their respective control levers.
5. Apply the parking brakes; then remove the jack stands from the frame and the chocks from the tires.



1. Airflow to Spring
2. Exhaust to Atmosphere
3. Nylon Block
4. Adjustment Locknut
5. Control Lever
6. Linkage
7. Airflow from Air Reservoir

Fig. 1, Height Control Valve

Rear Axle Parallel Alignment



A. Without Frame Rail Spacer, With Alignment Bushings
B. With Frame Rail Spacer, With Alignment Bushings
C. With Frame Rail Spacer, Without Alignment Bushings

1. Alignment Bushings
2. Two Spacer Washers on the Inboard Side of the Beam
3. Rod Bolt, 1-1/8-12
4. Delrin Spacer
5. 1/4-inch Frame Rail Spacer
6. One Spacer Washer on Each Side of the Beam
7. Rod Bolt, 1-1/4-12

AA. Measurement: 0.50" (12.7 mm) Axle Alignment Adjustment
BB. Weld: Three places approximately 3/4" (19 mm) long
CC. Measurement: 0.25" (6.4 mm) Axle Alignment Adjustment
DD. Weld: Three places approximately 3/4" (19 mm) long
EE. No Axle Alignment Adjustment

Fig. 2, Spacer Washer Installation and Alignment Bushing Welding

Troubleshooting

Problem—Air Springs Are Flat

Problem—Air Springs Are Flat	
Possible Cause	**Remedy**
Low air pressure in the vehicle brake system.	Check the air pressure gauge on the instrument panel. If the air pressure is low, run the engine until a minimum pressure of 70 psi (483 kPa) is shown on the gauge.
Air leaking from the suspension air system or the air brake system.	Listen for leakage due to loose fittings or damaged air lines, air springs, brake actuators or control valves. Tighten loose fittings or replace work or damaged air lines with new ones.

Problem—Air Spring(s) Flat on One Side of the Vehicle

Problem—Air Spring(s) Flat on One Side of the Vehicle	
Possible Cause	**Remedy**
Air leakage between the pressure holding valve and the air spring(s).	Listen for leakage due to loose fittings or damaged air lines. Tighten loose fittings or replace damaged lines with new ones.
Air spring leaking.	Inspect the air spring for leaks caused by damage, wear, or deterioration. If any air spring is leaking, install a new one.
Bent, broken, or disconnected height control valve linkage.	Inspect the linkage for damaged or loose parts. Reconnect loose linkage parts or replace damaged parts with new ones.
Height control valve out of adjustment.	Disconnect the height control valve linkage from the height control valve control lever. Move the lever upward. If the air spring then inflates, adjust the height control valve.
Inoperative height control valve.	If movement of the control lever in the previous step fails to inflate the air spring, the height control valve is damaged. Replace the valve.

Problem—Tractor Leans Due to Unequal Inflation of the Air Springs

Problem—Tractor Leans Due to Unequal Inflation of the Air Springs	
Possible Cause	**Remedy**
Damaged height control valve linkage.	Inspect the height control valves and linkages for damage. Repair or replace damaged parts.
Loose or missing height control valve bolts or adjustment locknut.	Inspect for damage to the height control valve mounting bolts or adjustment locknut. Replace any missing bolts or nuts, then adjust the height control valve.
Height control valve out of adjustment.	Adjust the height control valve.

Troubleshooting

Problem—Air Springs Deflate Rapidly When the Vehicle Is Parked

Problem—Air Springs Deflate Rapidly When the Vehicle Is Parked	
Possible Cause	**Remedy**
Air leakage from the suspension air system.	Listen for leakage due to loose fittings or damaged air lines, air springs, or height control valves. Tighten loose fittings and replace worn or damaged parts with new ones.

Problem—Tractor Rides Too High or Too Low

Problem—Tractor Rides Too High or Too Low	
Possible Cause	**Remedy**
Height control valve out of adjustment.	Disconnect the height control valve linkage from the height control valve control lever. Move the lever upward. If the air spring then inflates, adjust the height control valve.

Problem—Air Spring Blown Out

Problem—Air Spring Blown Out	
Possible Cause	**Remedy**
Air spring cut or punctured.	Locate large leaks by listening for escaping air, and locate small leaks by applying a soap and water solution to the suspected air spring and watching for bubbles. Temporarily repair punctures or cuts less than 1/8-inch (3-mm) long by applying hot patches on both sides of the hole. If the cut is more than 1/8-inch (3-mm) long, install a new air spring.
Tires, rims, or chains rubbing the air spring.	Check the clearance between the air spring and the tire. If the tire, rim, or chains contact the inflated air spring, change to narrower tires and rims to provide clearance for tires with chains.
Air brake actuator rubbing against the air spring.	Relocate the brake actuator with factory approved parts to provide adequate clearance.

Problem—Air Spring Deflated Due to Fatigue

Problem—Air Spring Deflated Due to Fatigue	
Possible Cause	**Remedy**
Driving the vehicle too long or too fast with the air springs deflated.	If the vehicle must be driven with the air springs deflated, maintain a speed of less than 30 mph (48 km/h), and drive only as far as the nearest repair facility.
Continual or repeated overextension of the air springs.	Inspect for broken or loose shock absorbers or shock absorber mounting brackets. Reconnect loose parts and replace any damaged parts. Check the adjustment on the height control valve.

Problem—Air Spring Doesn't Fully Deflate When All Weight Is Removed from the Suspension

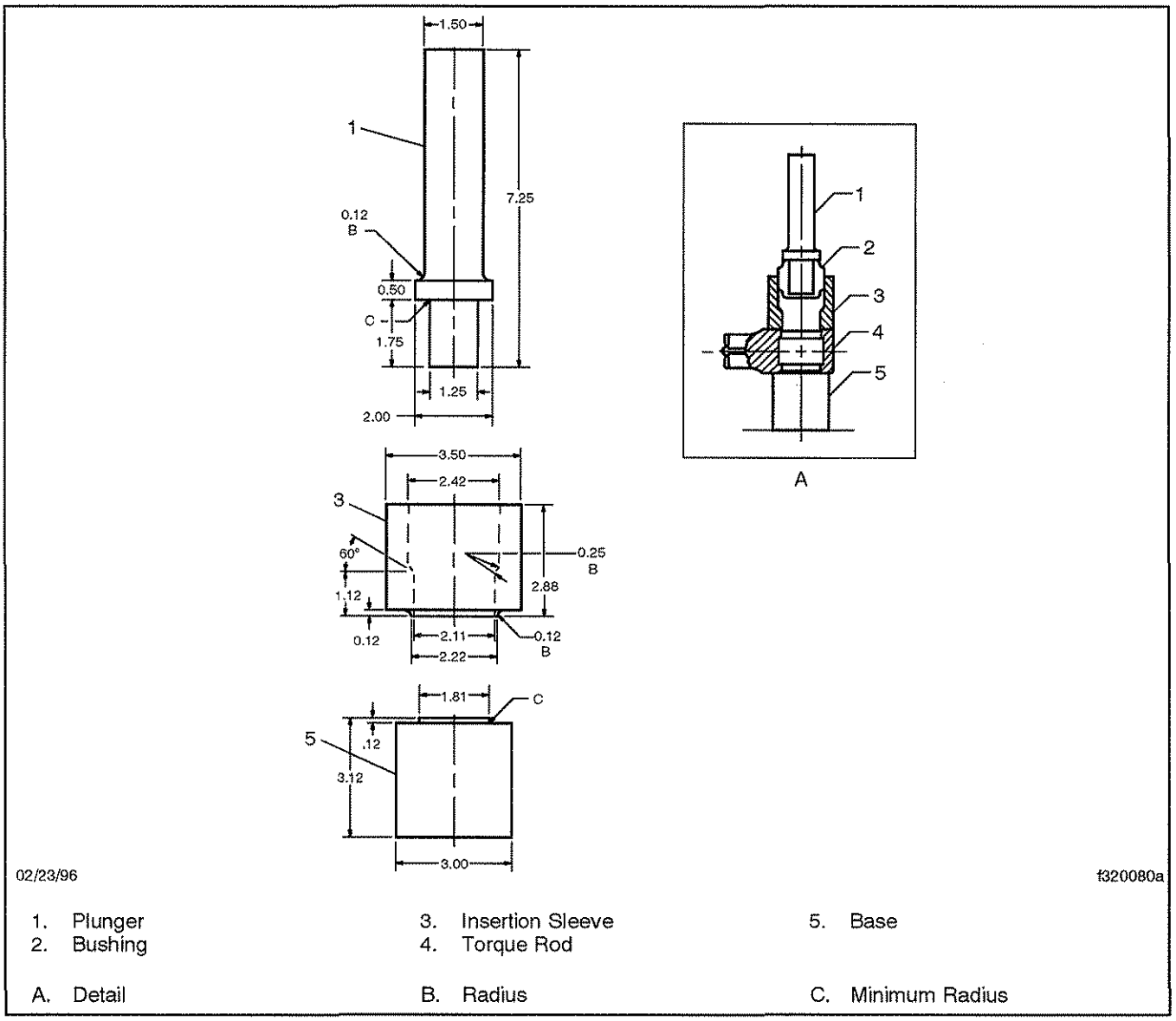
Problem—Air Spring Doesn't Fully Deflate When All Weight Is Removed from the Suspension	
Possible Cause	**Remedy**
Restricted air line between the height control valve and the air spring.	Disconnect the height control valve linkage, and push the control lever down. If the air spring remains inflated, check for a pinched or blocked line. Clean out any plugged line and replace any damaged line.

Description	Size	Torque: lbf·ft (N·m)
Shock Absorber Mount Locknut	3/4–16	110-150 (149-203)
Air Spring Upper Mounting Plate Locknut	3/4–16	31-42 (42-57)
Air Spring Upper Mounting Plate Capscrew	1/2–13	31-42 (42-57)
Air Spring Lower Mounting Plate Capscrew	1/2–13	31-42 (42-57)
Transverse Beam Bushing Locknuts	1-1/4–12	600-700 (814-950)
Equalizing Beam Center Bushing Locknut	3/4–16	150-200 (203-271)
Equalizing Beam Front Bushing Locknut	1-1/8–12	600-700 (814-950)
	1-1/4–12	
Control Rod Ball Stud Locknut	1-1/8–12	550-650 (746-880)
Control and Torque Rod Mounting Locknuts	5/8–18	110-150 (149-203)

Table 1, Suspension Torque Specifications (lubricated threads)

See **Fig. 1** and **Table 2** for the bushing installation tool.

Specifications



1. Plunger
2. Bushing
3. Insertion Sleeve
4. Torque Rod
5. Base

A. Detail
B. Radius
C. Minimum Radius

Fig. 1, Bushing Installation Tool

Tool	Dimensions	Material
A	Bar, 2.00" Diameter (51 mm)	Mild Steel
B	Tube, 3.50" (89 mm) o.d. x 0.75" (19 mm) wall	Mild Steel
C	Bar, 3.00" Diameter (76 mm)	Mild Steel

Table 2, Bushing Installation Tool Materials

Contents

Subject	Subject Number
General Description	050
Service Operations	
Restrictor Can Removal, Inspection, and Installation	100
Rubber Spring Replacement	110
Shock Absorber Replacement	120
Walking Beam Removal, Inspection, and Installation	130
Walking Beam Repair	140
Torque Rod Removal and Installation	150
Torque Rod Bushing Inspection and Replacement	160
Rear Axle Alignment Adjustment	170
Specifications	400

General Description

The Chalmers 800 Series Rear Suspension is a walking beam-type tandem axle suspension that uses hollow rubber springs instead of leaf springs or air bags. Each hollow rubber spring is mounted between a frame-rail plate and the center (front-to-rear) of the steel walking beam. A sawhorse bracket assembly is attached to the frame and provides mounting points for the lower torque rods that tie the axles to the frame. The upper torque rods are fastened to brackets that bolt to the frame side rails and to tower assemblies that are welded to the top of the differential housings. **See Fig. 1.**

The 800 Series Rear Suspension allows a high degree of both parallel and diagonal articulation, while maintaining wheel load equalization to within 3 percent.

The Chalmers suspension design separates the rear suspension's responsibility for supporting/cushioning the load from that of locating/guiding the axles. The suspension is very light, relative to its load carrying capacity, but requires very little maintenance. In fact, there are no lubrication fittings since grease and oil are never needed.

The 800 Series Rear Suspension is available in three different maximum load capacities: 40,000 lb. (18 000 kg), 46,000 lb. (21 000 kg), and 50,000 lb. (23 000 kg). The 40,000 lb. version is easily distinguished from the other two versions since the upper torque rods do not cross over one another on the 40,000 lb. version.

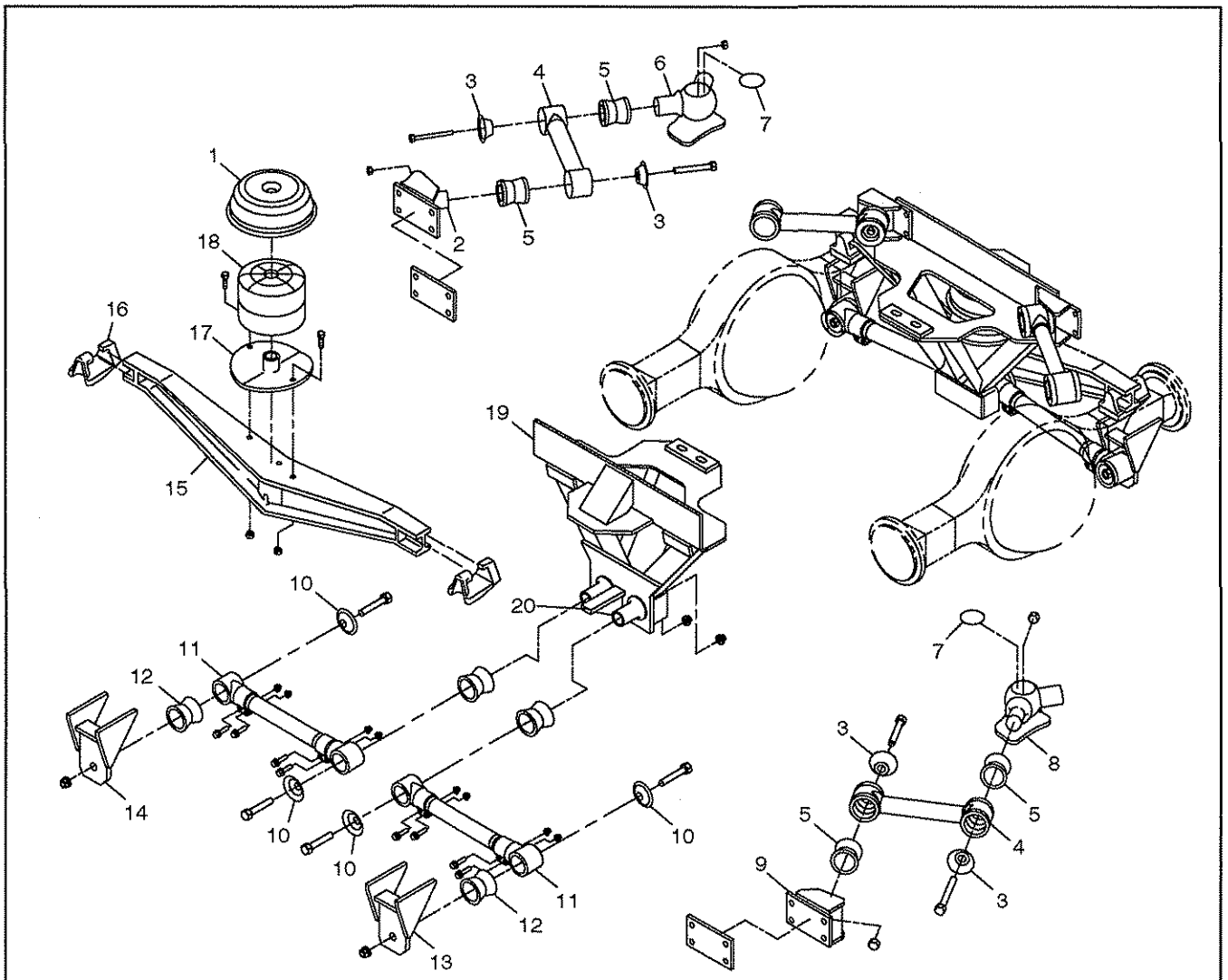
The 800 Series is also available in three different axle spacings: 54-inch, 60-inch, and 72-inch axle-to-axle. The axle-to-axle spacing dimension is often included as part of the suspension name, e.g. "Chalmers 854 Rear Suspension" or "Chalmers 860 Suspension."

Shock absorbers are optional on all versions of the suspension, and available in two styles: beam-mounted and axle housing-mounted.

Other variations depend on whether the suspension is installed on a truck (high-mount) or a tractor (low-mount) and whether high center-of-gravity or low center-of-gravity is desired.

The rear suspension may be precision-aligned by adjusting the length of the lower torque rods. These rods have both left- and right-hand threads cut on the same tube so rotating the tube changes the effective length of the tube.

General Description

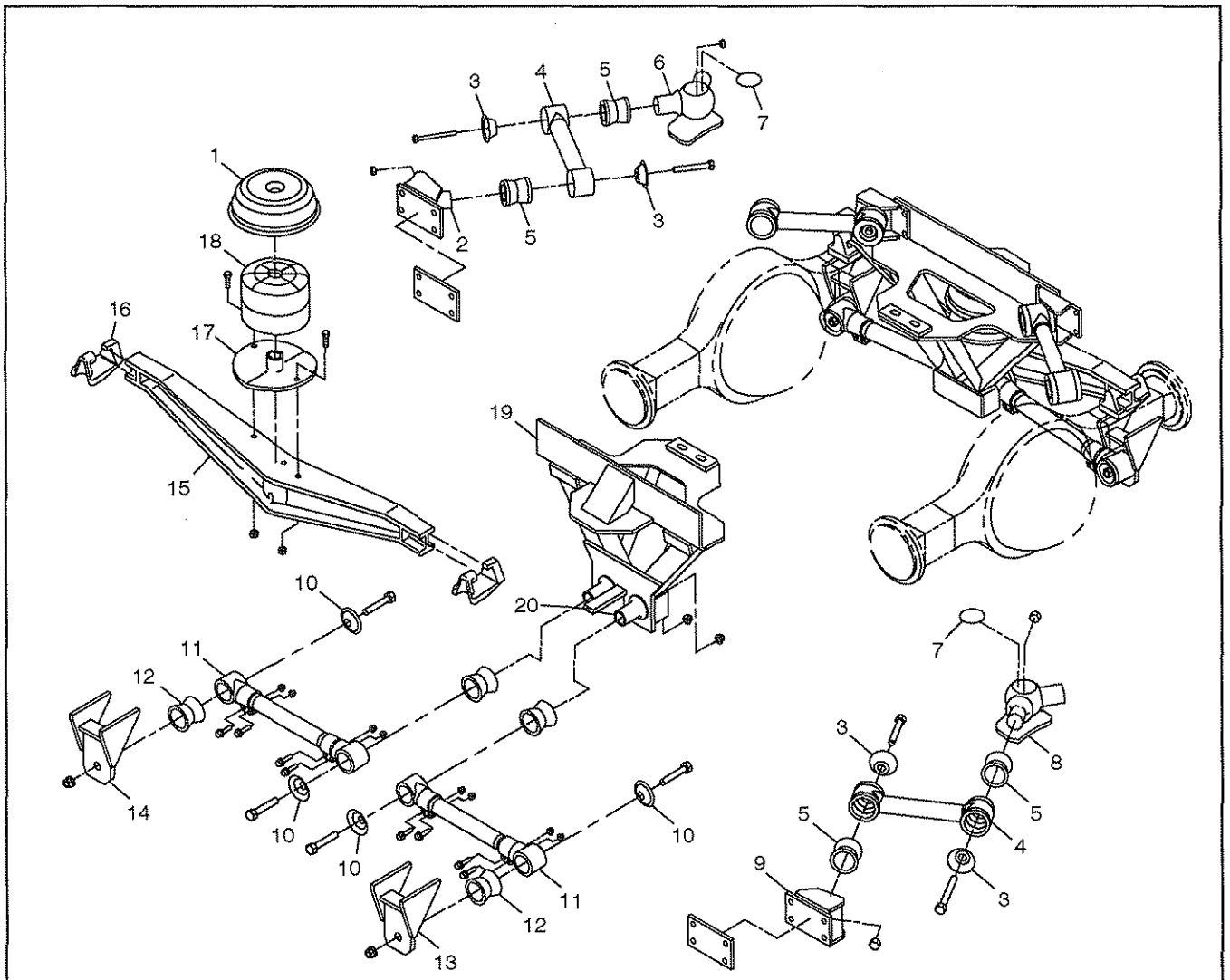


1. Restrictor Can
2. Upper Torque Rod Frame Bracket (LH forward)
3. Spigot Cap (upper)
4. Upper Torque Rod
5. Torque Rod Bushing (upper)
6. Forward Rear Axle Tower
7. Rear Axle Tower Plug
8. Rearmost Rear Axle Tower
9. Upper Torque Rod Frame Bracket (LH rear)
10. Spigot Cap (lower)
11. Lower Torque Rod (adjustable)
12. Torque Rod Bushing (lower)
13. Lower Torque Rod Axle Housing Bracket (LH rear)
14. Lower Torque Rod Axle Housing Bracket (LH forward)
15. Beam
16. Axle Housing Beam Saddle Bracket
17. Beam Spring Plate
18. Hollow Rubber Spring
19. Sawhorse Bracket Assembly
20. Beam Stop

Fig. 1, Chalmers 800 Series Tandem Axle Suspension (40,000-pound capacity without shock absorbers shown)

Restrictor Can Removal, Inspection, and Installation

Removal (See Fig. 1)



1. Restrictor Can
2. Upper Torque Rod Frame Bracket (LH forward)
3. Spigot Cap (upper)
4. Upper Torque Rod
5. Torque Rod Bushing (upper)
6. Forward Rear Axle Tower
7. Rear Axle Tower Plug
8. Rearmost Rear Axle Tower
9. Upper Torque Rod Frame Bracket (LH rear)
10. Spigot Cap (lower)
11. Lower Torque Rod (adjustable)
12. Torque Rod Bushing (lower)
13. Lower Torque Rod Axle Housing Bracket (LH rear)
14. Lower Torque Rod Axle Housing Bracket (LH forward)
15. Beam
16. Axle Housing Beam Saddle Bracket
17. Beam Spring Plate
18. Hollow Rubber Spring
19. Sawhorse Bracket Assembly
20. Beam Stop

Fig. 1, Chalmers 800 Series Tandem Axle Suspension (40,000-pound capacity without shock absorbers shown)

Restrictor Can Removal, Inspection, and Installation

1. If necessary, power wash the spring restrictor can area to remove road dirt accumulation.
2. Chock the front tires to prevent vehicle movement.
3. Raise the rear of the vehicle just enough to remove all weight from the rear axles, and place safety stands under the frame to support the vehicle in its raised position.
4. Remove the two bolts and nuts that secure the walking beam spring plate (**see Fig. 1**, Ref. 17) to the walking beam assembly. Discard the fasteners.

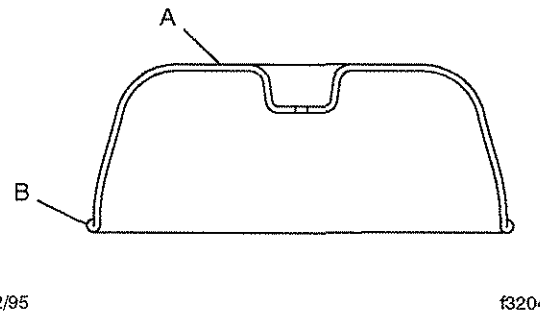
NOTE: On 54-inch spread suspensions, it may be necessary to remove either the front or rear tires to allow spring assembly removal.

5. Pull the lower spring plate, rubber spring, and restrictor can as one assembly outward, off the beam assembly. **See Fig. 1**, Refs. 1, 17, 18.
6. Separate the restrictor can, spring, and spring plate.

Inspection

1. Carefully inspect the restrictor can for cracks or severe corrosion. Pay special attention to the top surface of the can and the can rim. **See Fig. 2.**

NOTE: It is recommended that both restrictor cans be replaced at the same time to ensure evenness of ride and handling characteristics.



A. Inspect top surface for cracks or severe corrosion.
B. Carefully inspect can rim for cracks.

Fig. 2, Restrictor Can Inspection Areas

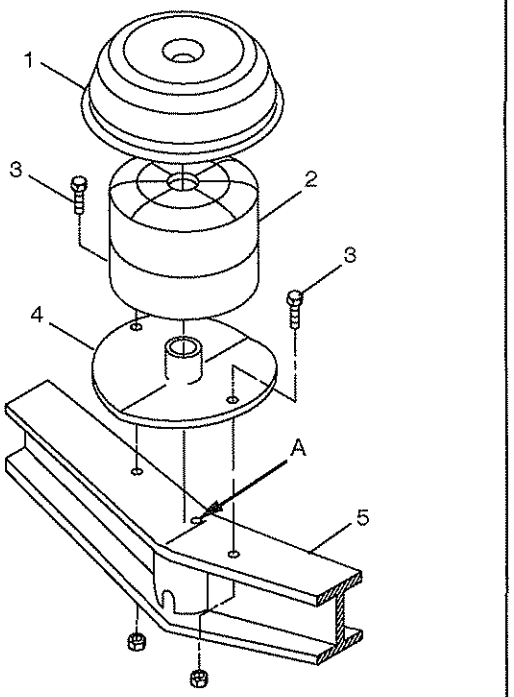
2. Replace a cracked or severely corroded restrictor can.

Installation

1. Using a stiff wire brush or gasket scraper, clean rust and road dirt from the spring plate. Also, make sure that the center vent holes in the plate and in the walking beam are free of rust and debris. **See Fig. 3.**
2. Inspect the spring plate for cracks; replace it if any are present.

IMPORTANT: Never use any mineral based oils, greases, jellies, or solvent soaps to aid in the assembly of rubber suspension parts. Use only lubricants specifically designed for use with rubber compounds.

3. Position the rubber spring on the spring plate so it is upside down, relative to its original orientation. Make sure that the spring vent hole is centered on the spring plate tube. Place the new restrictor can over the spring; make sure the can is centered on the spring.
4. Slide, as one assembly, the spring plate, spring, and restrictor cap, into position on the walking beam.
5. Install and tighten the spring plate fasteners 35 lbf·ft (47 N·m).
6. Check the gap between the spring and the restrictor can to make sure it is even, all the way around the can. Rotate the spring and/or can as necessary to make the gap even.
7. Remove the safety stands from under the vehicle, then lower the vehicle.
8. Remove the chocks from the tires.

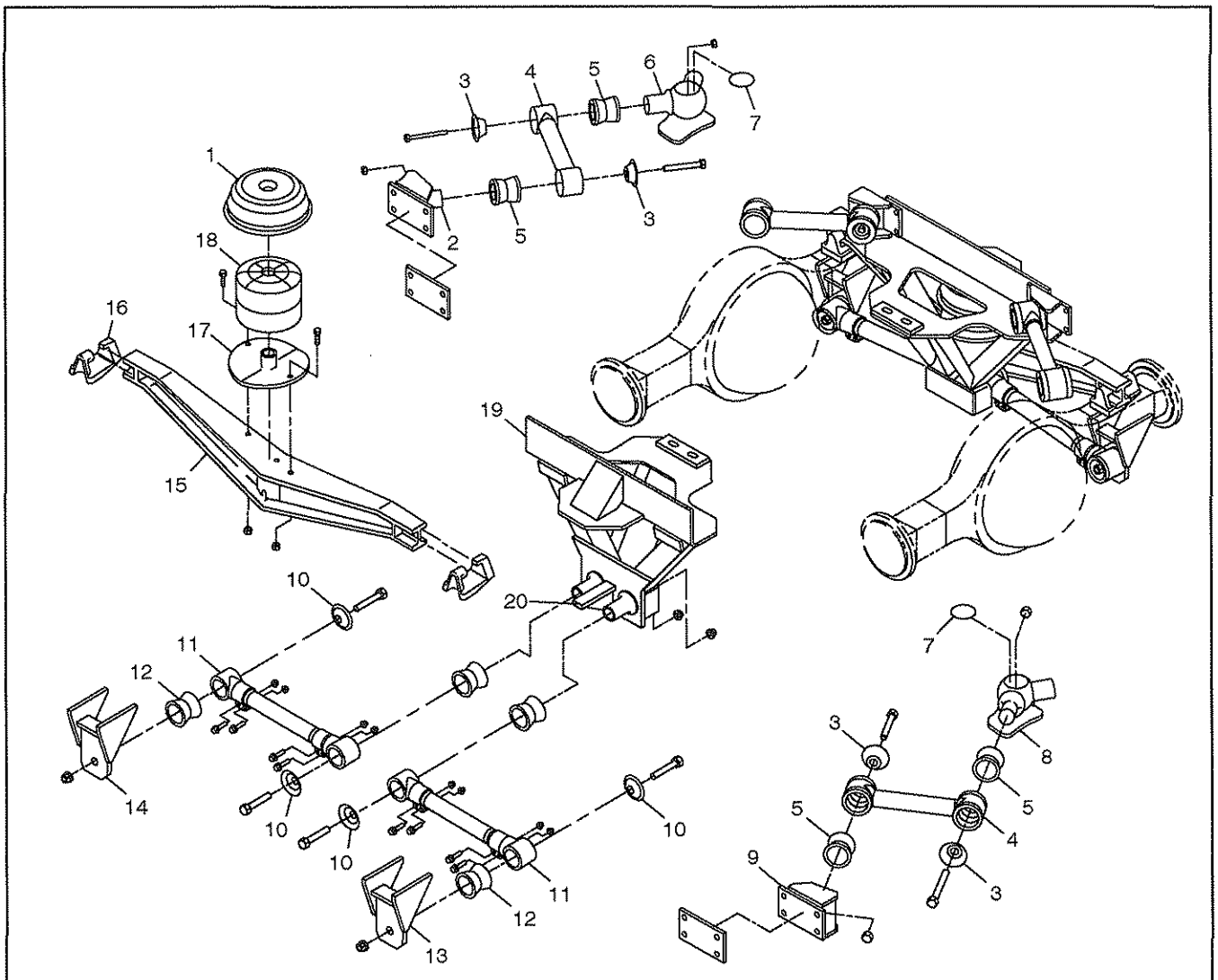


A. Make sure that the vent hole in the walking beam is free of rust and debris.

1. Spring Restrictor Can
2. Hollow Rubber Spring
3. Spring Plate Bolt
4. Spring Plate
5. Walking Beam

Fig. 3, Spring Assembly Components

Replacement (See Fig. 1)



1. Restrictor Can
2. Upper Torque Rod Frame Bracket (LH forward)
3. Spigot Cap (upper)
4. Upper Torque Rod
5. Torque Rod Bushing (upper)
6. Forward Rear Axle Tower
7. Rear Axle Tower Plug
8. Rearmost Rear Axle Tower
9. Upper Torque Rod Frame Bracket (LH rear)
10. Spigot Cap (lower)
11. Lower Torque Rod (adjustable)
12. Torque Rod Bushing (lower)
13. Lower Torque Rod Axle Housing Bracket (LH rear)
14. Lower Torque Rod Axle Housing Bracket (LH forward)
15. Beam
16. Axle Housing Beam Saddle Bracket
17. Beam Spring Plate
18. Hollow Rubber Spring
19. Sawhorse Bracket Assembly
20. Beam Stop

Fig. 1, Chalmers 800 Series Tandem Axle Suspension (40,000-pound capacity without shock absorbers shown)

Rubber Spring Replacement

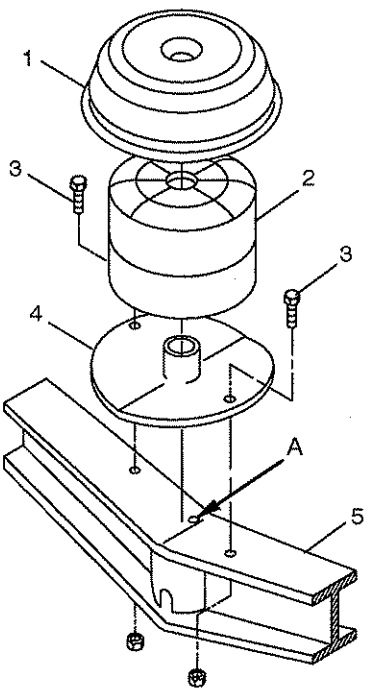
1. If necessary, power wash the spring restrictor can area to remove road dirt accumulation.
2. Chock the front tires to prevent vehicle movement.
3. Raise the rear of the vehicle just enough to remove all weight from the rear axles, and place safety stands under the frame to support the vehicle in its raised position.
4. Remove the two bolts and nuts that secure the walking beam spring plate (**see Fig. 1**, Ref. 17) to the walking beam assembly. Discard the fasteners.

NOTE: On 54-inch spread suspensions, it may be necessary to remove either the front or rear tires to allow spring assembly removal.

5. Pull the lower spring plate, rubber spring, and restrictor can as one assembly outward, off the beam assembly. **See Fig. 1**, Refs. 1, 17, 18.
6. Separate the restrictor can, spring, and spring plate; discard the spring.
7. Using a stiff wire brush or gasket scraper, clean rust and road dirt from the spring plate. Also, make sure that the center vent holes in the plate and in the walking beam are free of rust and debris. **See Fig. 2.**
8. Inspect the spring plate for cracks; replace it if any are present.

IMPORTANT: Never use any mineral based oils, greases, jellies, or solvent soaps to aid in the assembly of rubber suspension parts. Use only lubricants specifically designed for use with rubber compounds.

9. Position the new rubber spring on the spring plate, making sure that the vent hole is centered on the spring plate tube. Place the restrictor can over the spring; make sure the can is centered on the spring.
10. Slide, as one assembly, the spring plate, spring, and restrictor cap, into position on the walking beam.
11. Install and tighten the spring plate fasteners 35 lbf·ft (47 N·m).
12. Remove the safety stands from under the vehicle, then lower the vehicle.
13. Remove the chocks from the tires.



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A. Make sure that the vent hole in the walking beam is free of rust and debris.

1. Spring Restrictor Can
2. Hollow Rubber Spring
3. Spring Plate Bolt
4. Spring Plate
5. Walking Beam

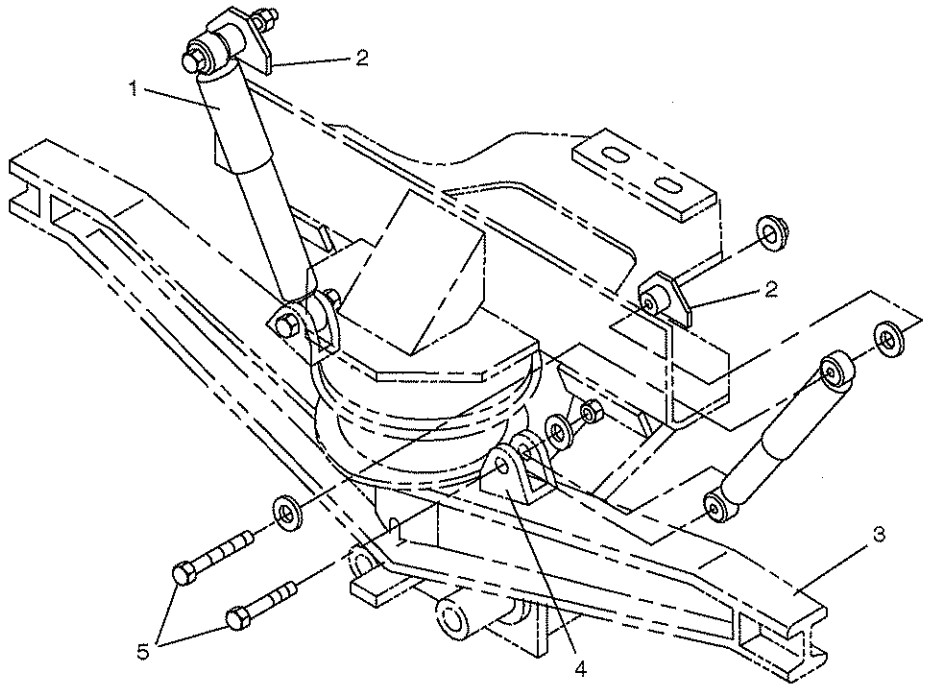
Fig. 2, Spring Assembly Components

Replacement

The Chalmers 800 Series Suspension may be fitted with either beam-mounted or axle-mounted shock absorbers. **See Fig. 1** and **Fig. 2.** The replacement procedure is essentially the same for both types of shock absorber.

1. If necessary, power wash the rear suspension to remove road dirt accumulation.
2. Chock the front tires to prevent vehicle movement.
3. Remove the shock absorber mounting fasteners.
   - 3.1 On beam-mounted shocks, remove the upper and lower bolts. **See Fig. 1**, Ref. 5. Discard the fasteners.
   - 3.2 On axle-mounted shocks, remove the upper and lower locknuts and hardened washers. **See Fig. 2**, Refs. 4 and 5. Discard the fasteners.
4. Remove and discard the shock absorber.
5. On axle-mounted shock absorber installations, the compression sleeve (**see Fig. 2**, Ref. 3) may be rusted to the shock mounting pin and remain on the pin when the shock is removed. If this occurs, drive the sleeve off of the pin using a small, sharp chisel.
6. On axle-mounted shock absorber installations, clean the shock mounting pin threads using a stiff wire brush or, if necessary, a thread-chaser die.

   Lubricate the threads with a small amount of engine oil.
7. Install the new shock absorbers.



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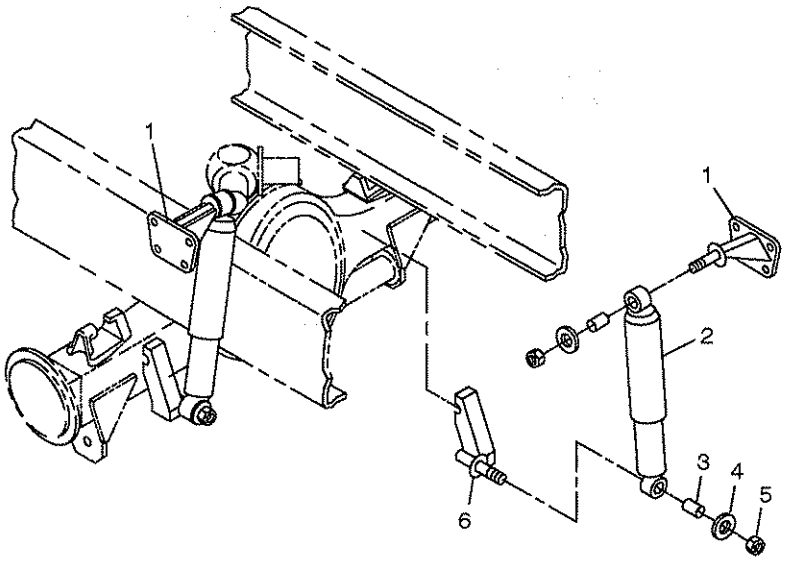
1. Shock Absorber
2. Frame-Mounted Bracket
3. Walking Beam
4. Beam-Mounted Bracket
5. 3/4" Mounting Bolts

Fig. 1, Shock Absorbers, Beam-Mounted

Shock Absorber Replacement



1. Frame-Mounted Bracket
2. Shock Absorber
3. Compression Sleeve
4. Hardened Washer
5. 7/8" Mounting Locknut
6. Axle-Mounted Bracket

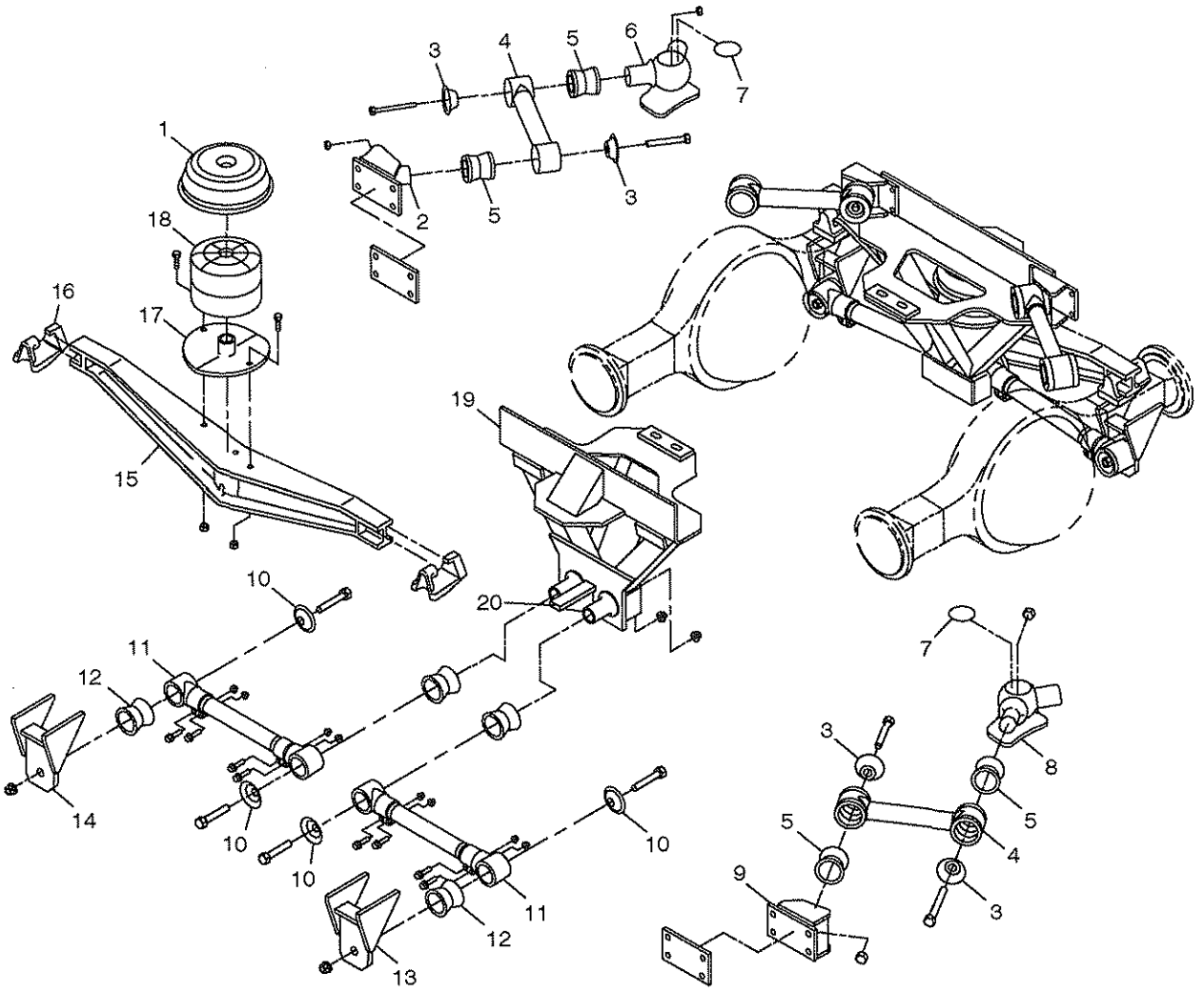
Fig. 2, Shock Absorbers, Axle-Mounted

7.1 On beam-mounted shock absorber installations, extend or compress the shock absorber as necessary to install the mounting bolts. Install the locknuts and tighten the fasteners 170 lbf·ft (230 N·m).

7.2 On axle-mounted shock absorber installations, extend or compress the shock absorber as necessary to fit it on the mounting pins. Install the locknuts and tighten them 270 lbf·ft (366 N·m).

8. Remove the chocks from the tires.

Removal (See Fig. 1)



1. Restrictor Can
2. Upper Torque Rod Frame Bracket (LH forward)
3. Spigot Cap (upper)
4. Upper Torque Rod
5. Torque Rod Bushing (upper)
6. Forward Rear Axle Tower
7. Rear Axle Tower Plug
8. Rearmost Rear Axle Tower
9. Upper Torque Rod Frame Bracket (LH rear)
10. Spigot Cap (lower)
11. Lower Torque Rod (adjustable)
12. Torque Rod Bushing (lower)
13. Lower Torque Rod Axle Housing Bracket (LH rear)
14. Lower Torque Rod Axle Housing Bracket (LH forward)
15. Beam
16. Axle Housing Beam Saddle Bracket
17. Beam Spring Plate
18. Hollow Rubber Spring
19. Sawhorse Bracket Assembly
20. Beam Stop

Fig. 1, Chalmers 800 Series Tandem Axle Suspension (40,000-pound capacity without shock absorbers shown)

Walking Beam Removal, Inspection, and Installation

1. If necessary, power wash the walking beams and axle housing ends to remove road dirt accumulation.
2. Chock the front tires to prevent vehicle movement.
3. Relieve all drive axle brake or wind-up loads by placing the transmission in neutral and releasing the spring or driveline brakes.
4. Raise the rear of the vehicle to remove all weight from the rear axles, and place safety stands under the frame to secure the vehicle in its raised position.
5. If equipped, disconnect beam-mounted shock absorbers from the walking beam being replaced. Refer to **Subject 120**, if necessary.
6. Remove the two bolts and nuts that secure the walking beam spring plate (**see Fig. 1**, Ref. 17) to the walking beam assembly. Discard the fasteners.

NOTE: On 54-inch spread suspensions, it may be necessary to remove the front or rear tires to allow spring assembly removal.

7. Pull the lower spring plate, rubber spring, and restrictor can as one assembly outward, off the beam assembly. **See Fig. 1**, Refs. 1, 17, 18.

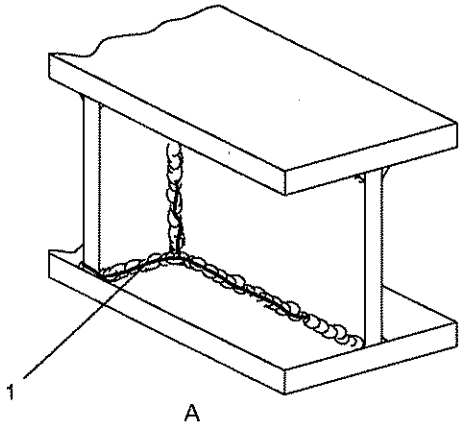
NOTE: Tag or otherwise mark each torque rod to ensure that it can be re-installed in the same position and orientation.

8. Disconnect the rearmost axle's upper torque rods from the rear axle tower and the lower torque rods from the rear axle housing brackets. **See Fig. 1**, Refs. 4, 8, 11, 13.
9. Roll the rear axle rearward just enough to disengage the axle saddles (Ref. 16) from the walking beam ends.
10. Lift up the free end of the walking beam and slide the beam rearward to disengage it from the front axle saddle; remove the walking beam.

Inspection

1. Inspect the beam ends carefully, looking for cracks. Cracks along weld lines may be repairable, while cracks in or across the beam flanges require walking beam replacement. **See Fig. 2.**

NOTE: Take flange thickness measurements at least 1/2" (12 mm) from the flange edges. Measurements taken at the flange edges are not an accurate indication of beam wear and may lead to unnecessary beam repair/replacement.



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A. Repairable Walking Beam
B. Non-repairable Walking Beam

1. Cracks

Fig. 2, Repairable/Non-repairable Beam Cracks

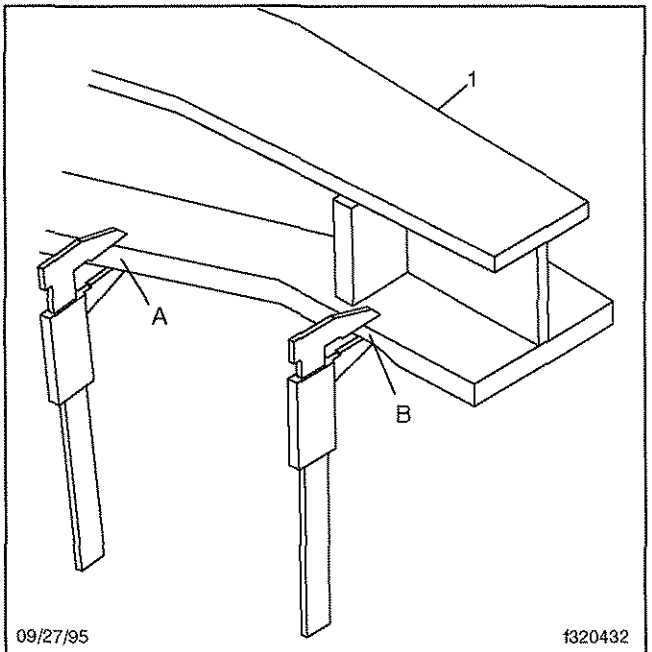
2. Check for excessive wear on the beam flanges, where they contact the axle housing saddle brackets.

   If flange wear is significant, use a micrometer or vernier calipers to take measurements at both unworn and worn areas. The maximum allowable difference between unworn and worn areas is 0.062" (1.5 mm). **See Fig. 3.**

3. Beams showing excessive wear must be repaired or replaced. Refer to **Subject 140** for beam repair information.

Installation

1. Position the new or repaired walking beam over the rearmost rear axle, with the front end of the beam tilted downward.



A. Flange thickness measurement taken at unworn area for reference.
B. Flange thickness measurement taken at wear area to assess beam condition.

1. Walking Beam

Fig. 3, Beam Wear Measurement

2. Slide the beam forward and downward so the front end of the beam enters the axle housing saddle bracket. **See Fig. 4.** Let the middle of the beam rest on the sawhorse bracket beam stop.

NOTE: On 54-inch spread suspensions, it may be necessary to install the spring assembly before the rearmost axle is rolled into place.

3. Carefully roll the rearmost rear axle forward, while lifting the rear end of the walking beam enough so the beam end enters the axle housing saddle bracket.

4. Connect the rearmost axle's upper and lower torque rods to the axle housing brackets. Install and tighten the torque rod bushing through-bolts 135 lbf·ft (183 N·m).

5. Slide, as one assembly, the spring plate, rubber spring, and restrictor cap, into position on the walking beam.

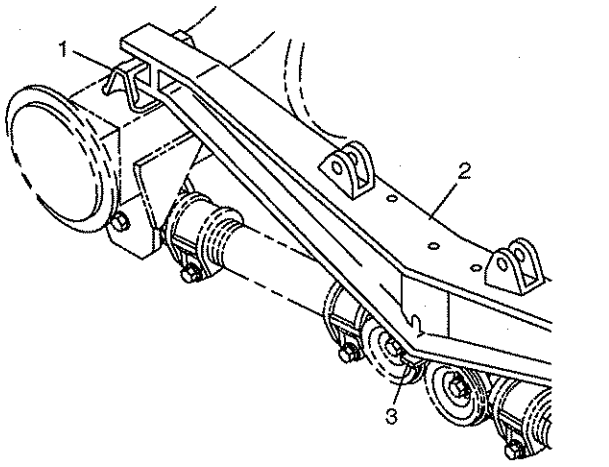
6. Install and tighten the spring plate fasteners 35 lbf·ft (47 N·m).

7. If so equipped, connect the beam-mounted shock absorbers to the beam brackets and tighten the fasteners 170 lbf·ft (230 N·m).

8. Remove the safety stands from under the vehicle, then lower the vehicle.

9. Remove the chocks from the tires.

Walking Beam Removal, Inspection, and Installation



1. Front Axle Housing, Beam Saddle Bracket
2. Walking Beam
3. Beam Stop

Fig. 4, Beam/Saddle Bracket Alignment

Repair

NOTE: This subject addresses only instances where excessive beam flange wear occurs, but cracks in the web or flange are not present.

Cracked webs and/or flanges require walking beam replacement.

Walking beams with excessive flange wear, however, can be repaired by welding a Chalmers Wear Plate over the worn areas as described below.

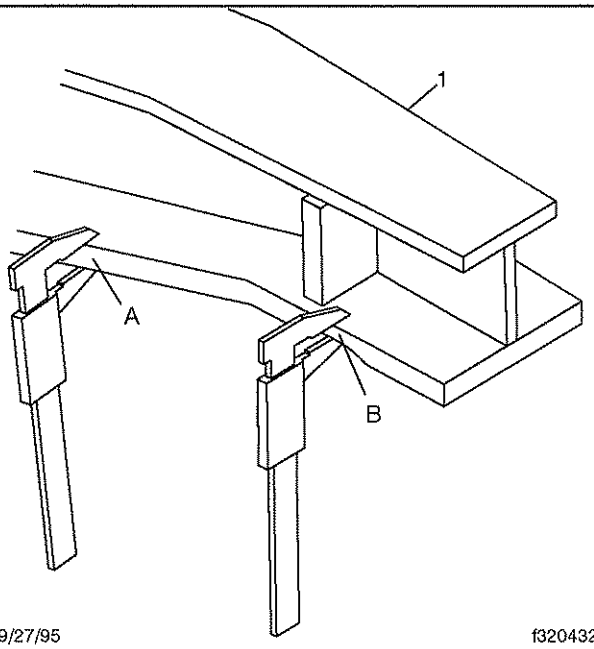
1. Remove the walking beam assembly. Refer to **Subject 130** for information.

NOTE: Take flange thickness measurements at least 1/2" (12 mm) from the flange edges. Measurements taken at the flange edges are not an accurate indication of beam wear and may lead to unnecessary beam repair/replacement.

2. Confirm that flange wear is severe enough to warrant repairs. Use a micrometer or vernier calipers to take flange thickness measurements at both unworn and worn areas. The maximum allowable difference between unworn and worn areas is 0.062" (1.5 mm). **See Fig. 1.**
3. If repair is required, clean the worn area of the beam thoroughly. Make sure that any oil or grease is removed, as well as rust or road dirt accumulation. If necessary, slight grinding of the beam is allowed to smooth raised areas.
4. Clamp Chalmers Wear Plate #700313 to the bottom flange of the beam. Make sure the plate is centered and has good surface-to-surface contact with the beam. Slight grinding is allowable to obtain good plate-to-beam contact.
5. Tack weld the plate to the beam, welding on the sides of the plate only.

CAUTION: Weld at the sides of the wear plate and beam only. Never weld at the ends of the wear plate. Welding the ends of the wear plate does not allow the wear plate to properly slightly expand nor contract, an action which, if the ends are welded, can cause cracks in the welds.

6. Remove the clamps and weld the plate to the beam, again, welding on the sides of the plate only. **See Fig. 2.**
7. Prime and paint the repaired area.
8. Install the repaired walking beam assembly. Refer to **Subject 130** for information.

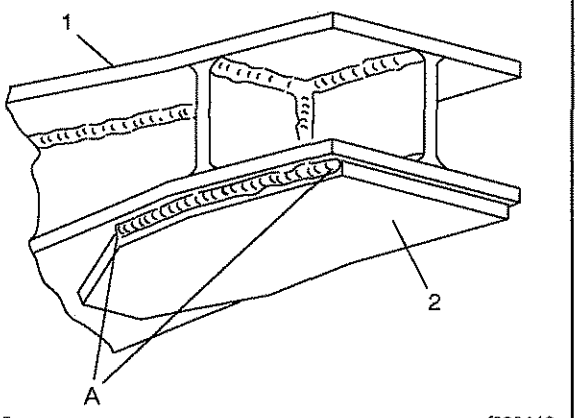


A. Flange thickness measurement taken at unworn area for reference.
B. Flange thickness measurement taken at wear area to assess beam condition.

1. Walking Beam

Fig. 1, Beam Wear Measurement

Walking Beam Repair



A. Limit weld to this area only.

1. Walking Beam 2. Wear Plate

Fig. 2, Chalmers Wear Plate Welding

Torque Rod Removal and Installation

The torque rods hold the rear axles in place, maintaining both axle alignment and pinion nose angle. When servicing the torque rods, it is good practice to remove and install them one at a time to avoid the possibility of mixing them up and affecting the alignment or pinion nose angle.

Several different styles of torque rods and bushing spigots exist. On the 40,000-pound version of the 800 Series suspension, the torque rods have tubular steel bodies and the upper rods do not cross over one another. On the 46,000- and 50,000-pound versions, the lower torque rods have tubular steel bodies, but the upper torque rods are made of "I-beam" shaped ductile iron. These upper torque rods do cross over one another. **See Fig. 1** and **Fig. 2.**

Removal

NOTE: Inspect torque rod bushings for free play before removing the torque rods. See **Subject 160** for torque rod bushing inspection information.

1. If necessary, power wash the rear suspension to remove road dirt accumulation.
2. Chock the front tires to prevent vehicle movement.
3. Relieve all drive axle brake or wind-up loads by placing the transmission in neutral and releasing the spring or driveline brakes.
4. Raise the rear of the vehicle to remove all weight from the rear axles, and place safety stands under the frame to secure the vehicle in its raised position.
5. Working on one torque rod at a time, remove the torque rod bolts and spigot caps. Discard the bolts. Set the spigot caps aside for cleaning and inspection.

   Remove the torque rods by prying between the torque rod eye and the spigot base or frame bracket.

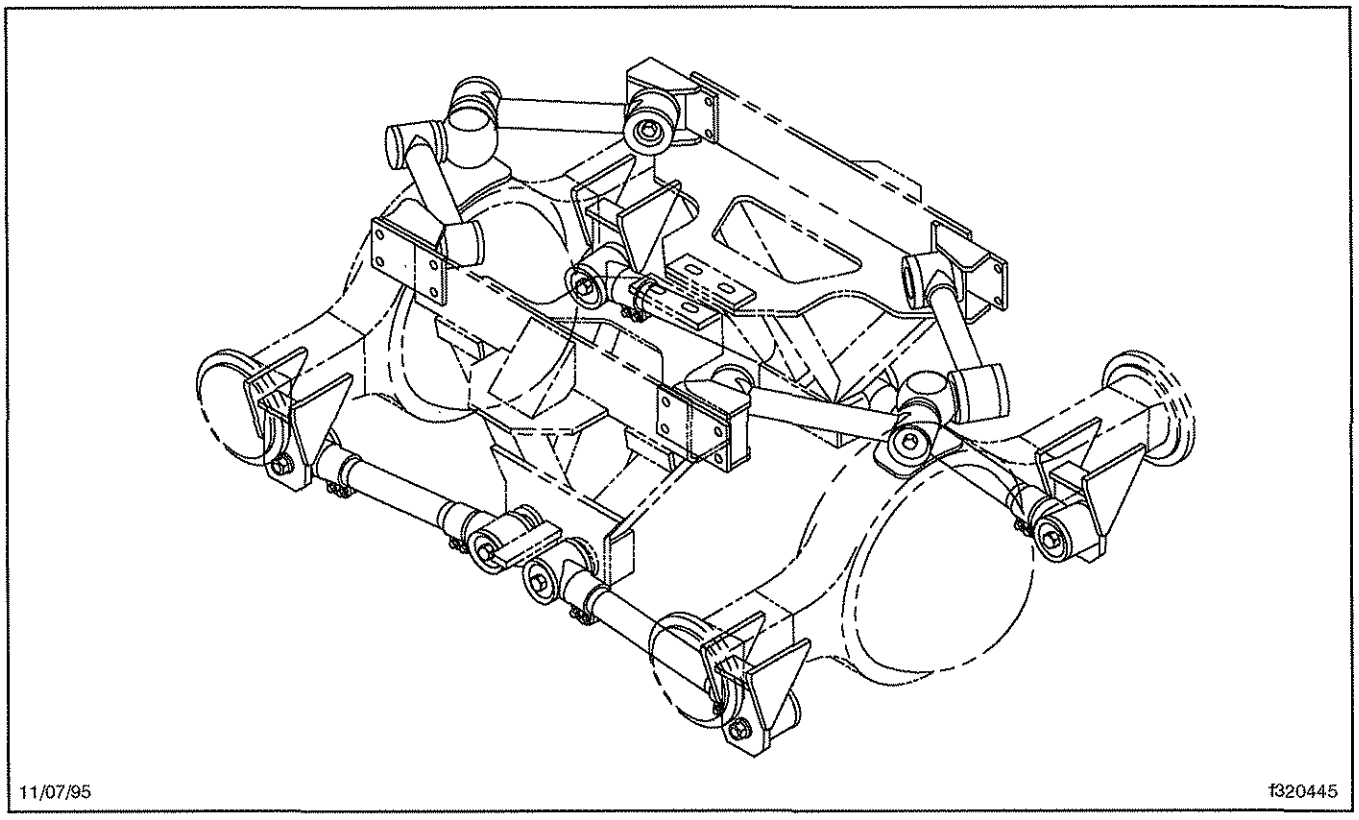


Fig. 1, Torque Rod Arrangement, 40,000-Pound Capacity Suspension

Torque Rod Removal and Installation

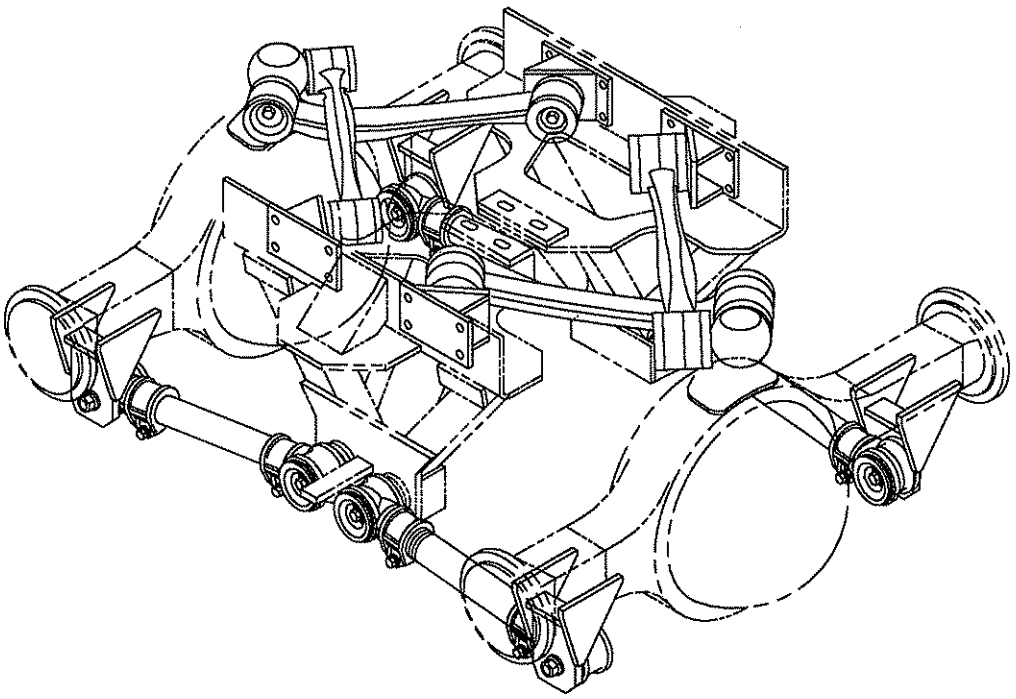


Fig. 2, Torque Rod Arrangement, 46,000- and 50,000-Pound Capacity Suspensions

NOTE: At the axle housing towers, pry off the tower cap to access the torque rod fasteners.

6. Replace worn or damaged bushings following the instructions in **Subject 160.**

7. Inspect the spigots for damage, severe corrosion, or extensive wear. Replace damaged or severely corroded spigots. To determine whether or not a spigot is worn enough to warrant replacement, see **Fig. 3** and **Table 1.**

   The smaller of the two measurements should be used as the spigot diameter.

Installation

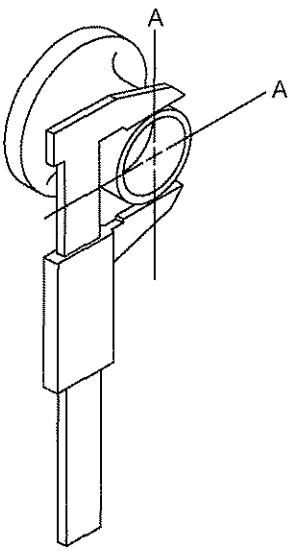
1. Check the torque rod bushings to make sure they are properly installed. They must be centered within the torque rod eye. **See Fig. 4.**

IMPORTANT: Never use any mineral-based oils, greases, jellies, or solvent soaps to aid in the assembly of rubber suspension parts. Use only lubricants specifically designed for use with rubber compounds.

2. Lubricate the outside of the spigots and the inside of the rubber bushings with a generous amount of rubber lubricant such as Rimslip® or equivalent.

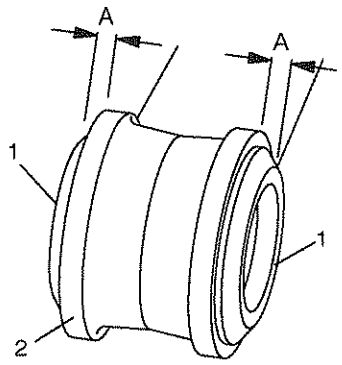
Spigot Size	Spigot Part #	Usage	Minimum Spigot Diameter With Standard Bushing: inch (mm)	Minimum Spigot Diameter With Oversize Bushing: inch (mm)
1	800200	40,000 lb. capacity — all	2.350 (60)	2.320 (59)
2	800021	46,000 & 50,000 lb. capacity — all	2.530 (64)	2.500 (63)

Table 1, Spigot Wear Limits



A. Measure outside diameter at two locations, 90 degrees apart.

Fig. 3, Spigot Measurement Points



A. The amount of rubber protruding from each side of the torque rod eye must be equal.

1. Torque Rod Bushing 2. Torque Rod Eye

Fig. 4, Torque Rod Bushing Protrusion

3. Push the torque rod into position on its spigots. After the torque rod is partially installed, use a heavy soft-faced mallet to drive the torque rod into position until the bushing contacts the spigot bottom face.

NOTE: For easier installation, alternate mallet blows between ends of the torque rod to drive it onto the spigots evenly.

4. Install the spigot caps.
5. Install and tighten the torque rod bushing through-bolts 135 lbf·ft (183 N·m).
6. Remove the safety stands from under the vehicle, then lower the vehicle. Remove the chocks.

Torque Rod Bushing Inspection and Replacement

Inspection

1. If necessary, power wash the upper and lower torque rods to remove road dirt accumulation.
2. Chock the front tires to prevent vehicle movement.
3. Relieve all drive axle brake or wind-up loads by placing the transmission in neutral and releasing the spring or driveline brakes.
4. Using your hands only, attempt to move the torque rod ends, checking for free play. Some movement as the bushings "give" is normal, but only free play is cause for bushing replacement.

NOTE: Never use a lever or pry bar to check for torque rod bushing free play. To do so may result in unnecessary bushing replacement.

5. If free play is detected, replace the bushing as described below.

Replacement

1. Remove the torque rod containing the worn out bushing. Refer to **Subject 150**, if necessary.

NOTE: Remove only one torque rod at a time to avoid mixing-up torque rod positions.

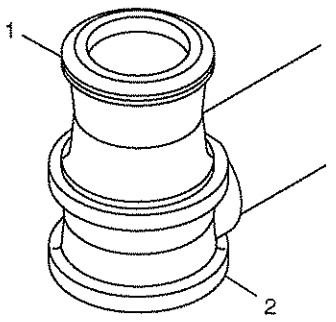
2. Place the torque rod on the floor or a workbench with a bushing open end facing upward. Push the tip of a large screwdriver down between the torque rod eye and the bushing and pry out the bushing. Discard removed bushings.
3. Use a wire brush and/or scraper to clean the torque rod eyes, removing all rust, scale, and rubber accumulations.
4. Inspect the torque rod eyes looking for cracks, distortion, or severe corrosion. Replace torque rods with damaged bushing eyes.

IMPORTANT: Never use any mineral based oils, greases, jellies, or solvent soaps to aid in the assembly of rubber suspension parts. Use only lubricants specifically designed for use with rubber compounds.

5. Lubricate both the inside of the torque rod eye and the outside of the new bushing with a generous amount of rubber lubricant, such as Rimslip® or equivalent.
6. Place the torque rod on a solid level floor with an open end of the eye facing upward. Position a lubricated bushing on the eye, making sure that the tapered shoulder of the bushing is centered on the eye. **See Fig. 1.**
7. Using a heavy, soft-faced mallet, strike the bushing squarely to drive it into the torque rod eye. Then, flip the torque rod over 180 degrees and tap on the torque rod shaft with the mallet while the bushing rests on the floor.

NOTE: If available, a small press may be used instead of a mallet for bushing installation.

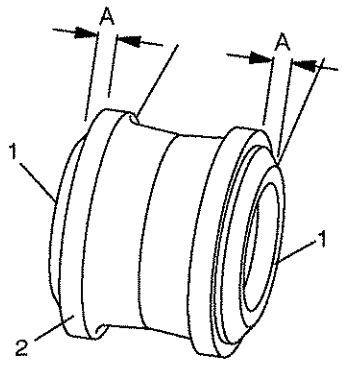
8. The bushing is completely installed when it is centered within the torque rod eye. **See Fig. 2.**
9. Install the re-bushed torque rod. Refer to **Subject 150**, if necessary.



1. Torque Rod Bushing 2. Torque Rod Eye

Fig. 1, Torque Rod Bushing Installation

Torque Rod Bushing Inspection and Replacement



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A. The amount of rubber protruding from each side of the torque rod eye must be equal .

1. Torque Rod Bushing 2. Torque Rod Eye

Fig. 2, Torque Rod Bushing Protrusion

Rear Axle Alignment Adjustment

On the Chalmers 800 Series Rear Suspension, the lower torque rods provide the only means for adjusting rear axle alignment. The upper torque rods play no part in the axle alignment process.

The lower torque rod bodies consist of steel tubes, with fine threads cut into the ends of the tube. Left-hand threads are cut into one end of the tube, right-hand threads into the other end. Therefore, by simply twisting the tube body while restraining the ends, the effective length of the tube is changed.

One type of torque rod end is used. A #1 size, two 1/2-inch clamp bolt secured the rod end to the tube. On the #2 size, a single 5/8-inch bolt is used. See **Fig. 1.**

Adjustment

1. Ensure that the torque rod bushings are in a fully relaxed, neutral state by slowly moving the vehicle back and forth a few times. Apply the service brakes, *not the parking brakes.*
2. Chock the front tires to prevent vehicle movement.

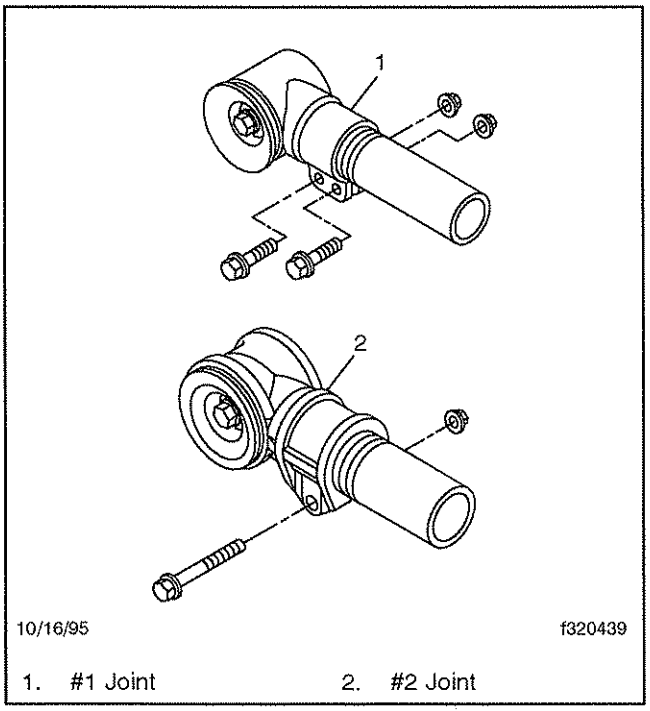


Fig. 1, Adjustable Torque Rod Ends

3. Relieve drive axle brake or wind-up loads by placing the transmission in neutral and releasing the brakes.
4. Using a straightedge and a tape measure, determine the amount of adjustment needed to align the forward-rear axle at right angles to the frame. For instructions, see **Group 35**. The difference in measurements between the sides of the vehicle is the approximate amount that the trailing end of the forward-rear axle will have to be brought forward, or the leading end will have to be moved back to align it at a right angle to the frame. See **Fig. 2.**

   If the forward-rear axle alignment is within specifications, go to the step that begins "Using a center-point bar, determine...".
5. On the side of the vehicle that is to be adjusted forward or rearward, loosen the torque rod end pinch bolts at both ends of the torque rod.

NOTE: If the pinch bolts are badly corroded or otherwise damaged, remove and discard them. Install new Chalmers fasteners.

6. Attach a pipe wrench to the tube body (chain type preferred) and rotate the tube to shorten or lengthen the torque rod. Continue to rotate the tube until the forward-rear axle is square to the frame.

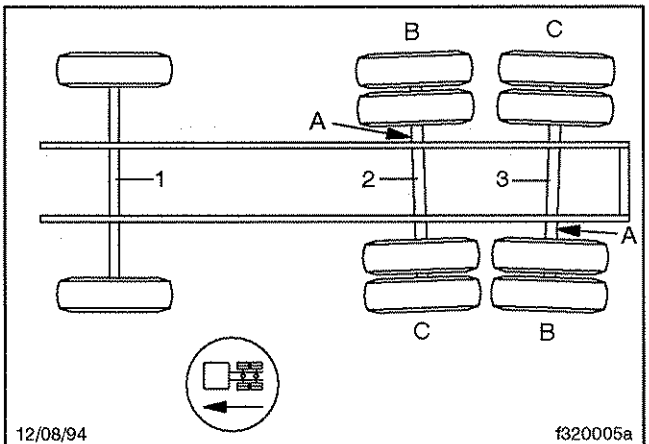
NOTE: If the torque rod tube is difficult to rotate, apply penetrating oil to the tube threads. If this does not help, remove the pinch bolts and drive wedges between the eye lugs to relieve the clamping effect.

7. When the forward-rear axle is square with the frame, tighten the pinch bolts.

   7.1 Tighten 1/2-inch UNC bolts on #1 joints 65 lbf·ft (88 N·m).

   7.2 Tighten 5/8-inch UNC bolts on #2 joints 135 lbf·ft (183 N·m).
8. Using a center-point bar, determine the difference between the forward-rear and the rearmost axles' center-to-center measurements on each side of the vehicle. For instructions, refer to **Group 35.** This difference is the approximate distance that the leading end of the rearmost axle will have to be adjusted rearward, or that the trailing end will have to be adjusted forward, to align it at a right

Rear Axle Alignment Adjustment



A. Axle Out of Alignment
B. Leading End
C. Trailing End

1. Front Axle
2. Forward Rear Axle
3. Rearmost Axle

Fig. 2, Tandem Axle, Shown Out of Alignment

angle to the frame, and to align it parallel to the forward-rear axle. See **Fig. 2.**

9. On the side of the vehicle that is to be adjusted forward or rearward, loosen the torque rod end pinch bolts at both ends of the torque rod.

NOTE: If the pinch bolts are badly corroded or otherwise damaged, remove and discard them. Install new Chalmers fasteners.

10. Attach a pipe wrench to the tube body (chain type preferred) and rotate the tube to shorten or lengthen the torque rod. Continue to rotate the tube until the rearmost axle is square to the frame.

NOTE: If the torque rod tube is difficult to rotate, apply penetrating oil to the tube threads. If this does not help, remove the pinch bolts and drive wedges between the eye lugs to relieve the clamping effect.

11. When the rearmost axle is square with the frame, tighten the pinch bolts.

    11.1 Tighten 1/2-inch UNC bolts on #1 joints 65 lbf·ft (88 N·m).

    11.2 Tighten 5/8-inch UNC bolts on #2 joints 135 lbf·ft (183 N·m).

12. Remove the safety stands, and lower the vehicle. Remove the chocks from the front tires.

13. Using the center-point bar, check the rearmost axle alignment. If alignment is not within specifications, repeat the applicable steps above.

CAUTION: Failure to periodically torque the suspension fasteners can result in abnormal tire wear, and damage to the suspension.

IMPORTANT: All suspension fasteners require periodic torquing. For suspension component inspecting and fastener torque checking intervals and instructions, refer to **Group 32** in the *vehicle maintenance manual.*

Specifications

Description	Bolt Size	IFI Grade	Torque lbf·ft (N·m)
Beam Spring Plate Bolt	3/8 UNC	8	35 (47)
Torque Rod End Through Bolts	5/8 UNC	8	135 (183)
Shock Absorber (beam-mounted) Bolt	3/4	8	170 (230)
Shock Absorber (axle-mounted) Nut	7/8	G	270 (366)
#1 Torque Rod End Pinch Bolts	1/2 UNC	8	65 (88)
#2 Torque Rod End Pinch Bolts	5/8 UNC	8	135 (183)

Table 1, Fastener Torques, 800 Series Suspension

Contents

Subject	Subject Number
General Information	050
Service Operations	
Shock Absorber Replacement	100
Center Bearing Replacement	110
Spring Assembly Replacement	120
Lower Control Rod And V-Rod Replacement	130
Axle Clamp and Retainer Replacement	140
Rear Axle Alignment Adjustments	150
Specifications	400

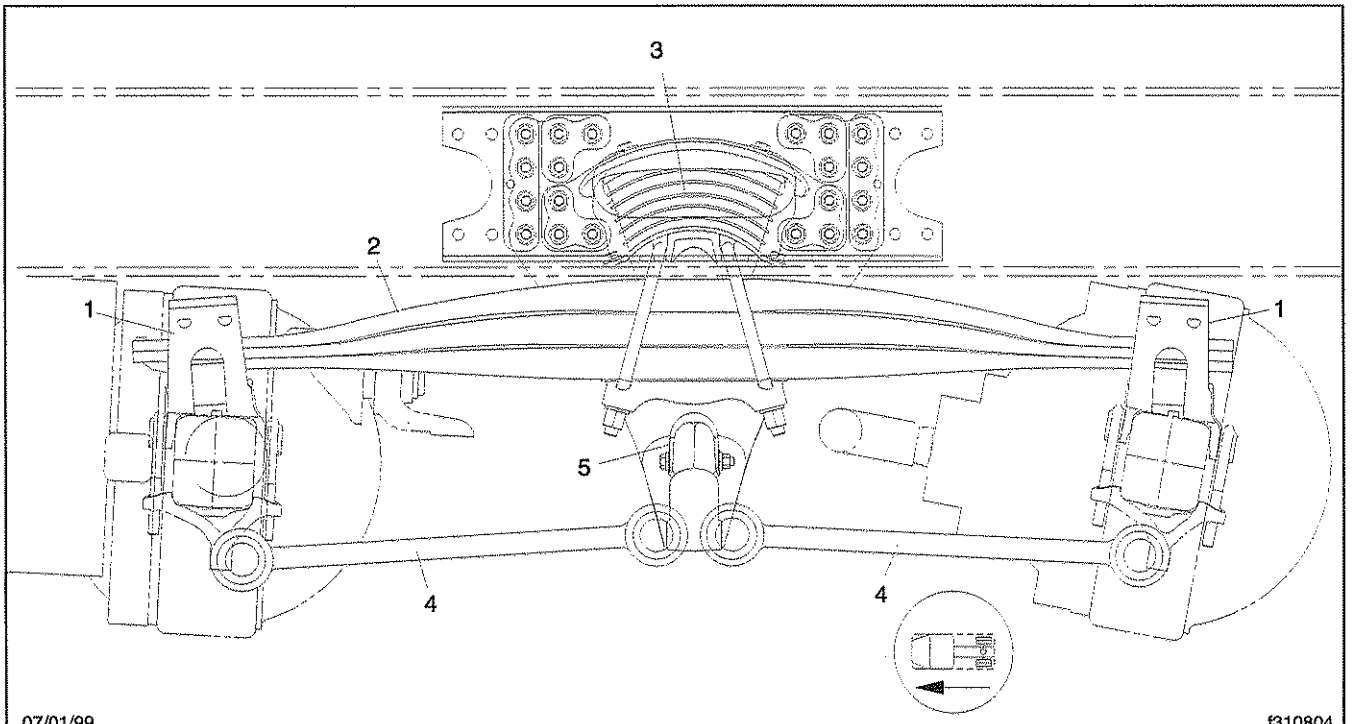
General Description

The TufTrac Suspension (**Fig. 1**) is heavy-duty "six rod" tandem-axle suspension option for trucks built for severe on/off highway work. The TufTrac design allows a truck to maneuver over bumps, ridges and washboard roads that typically generate high rates of axle articulation, without bottoming out the suspension or losing traction.

The TufTrac suspension is available in three weight ratings – 40,000-, 46,000- and 52,000-pound (18 144-, 20 865-, 23 586-kilogram) capacities. The 40,000-pound (18 144-kilogram) capacity suspension uses two taper leaf springs and has an axle spacing of 54 inches. The 46,000-pound (20 865-kilogram) capacity suspension has three leaf springs (shown in this section), while the 52,000-pound (23 586-kilogram) suspension features four leaf springs. Both the 46,000-pound (20 865-kilogram) and the 52,000-pound (23 586-kilogram) suspensions have a standard axle spacing of 56 inches.

Principles of Operation

Six functional links in the TufTrac suspension maintain the positions of the axles. Side-to-side axle movement is controlled by two v-rods from the frame to the axles at the top of the suspension. Four bar links from the frame to the axles at the bottom control the forces of driving and braking as well as fore-and-aft road shocks. Vertical loads are carried by the rubber-isolated parabolic taper leaf spring packs.



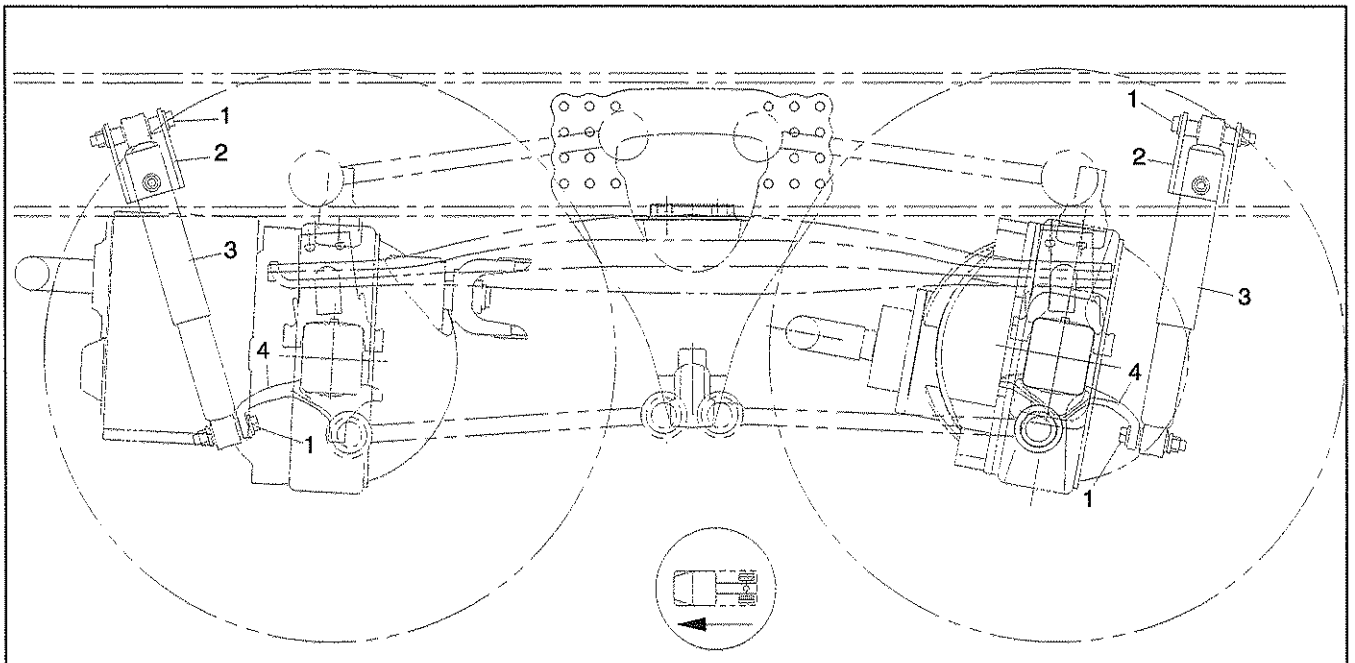
1. Axle Clamps
2. Leaf Springs
3. Center Bearing
4. Lower Control Rods
5. Rebound Stop

Fig. 1, TufTrac Suspension (46,000-pound [20 865-kilogram] version shown)

Shock Absorber Replacement

Replacement (See Fig. 1)

1. Park the vehicle on a level surface, shut down the engine and apply the parking brakes. Chock the tires.
2. Remove the lower shock mounting nut and washer.
3. Remove the upper shock mounting nut and washer.
4. Remove the upper and lower mounting bolts and remove the shock absorber.
5. Position the new shock absorber in place and install the mounting bolts.
6. Loosely fasten the bolts with the nuts and washers removed from the old shock absorber.
7. Torque each mounting nut 241 lbf·ft (327 N·m).
8. Remove the chocks from the tires.



1. Mounting Bolt
2. Upper Mounting Bracket
3. Shock Absorber
4. Lower Mounting Bracket

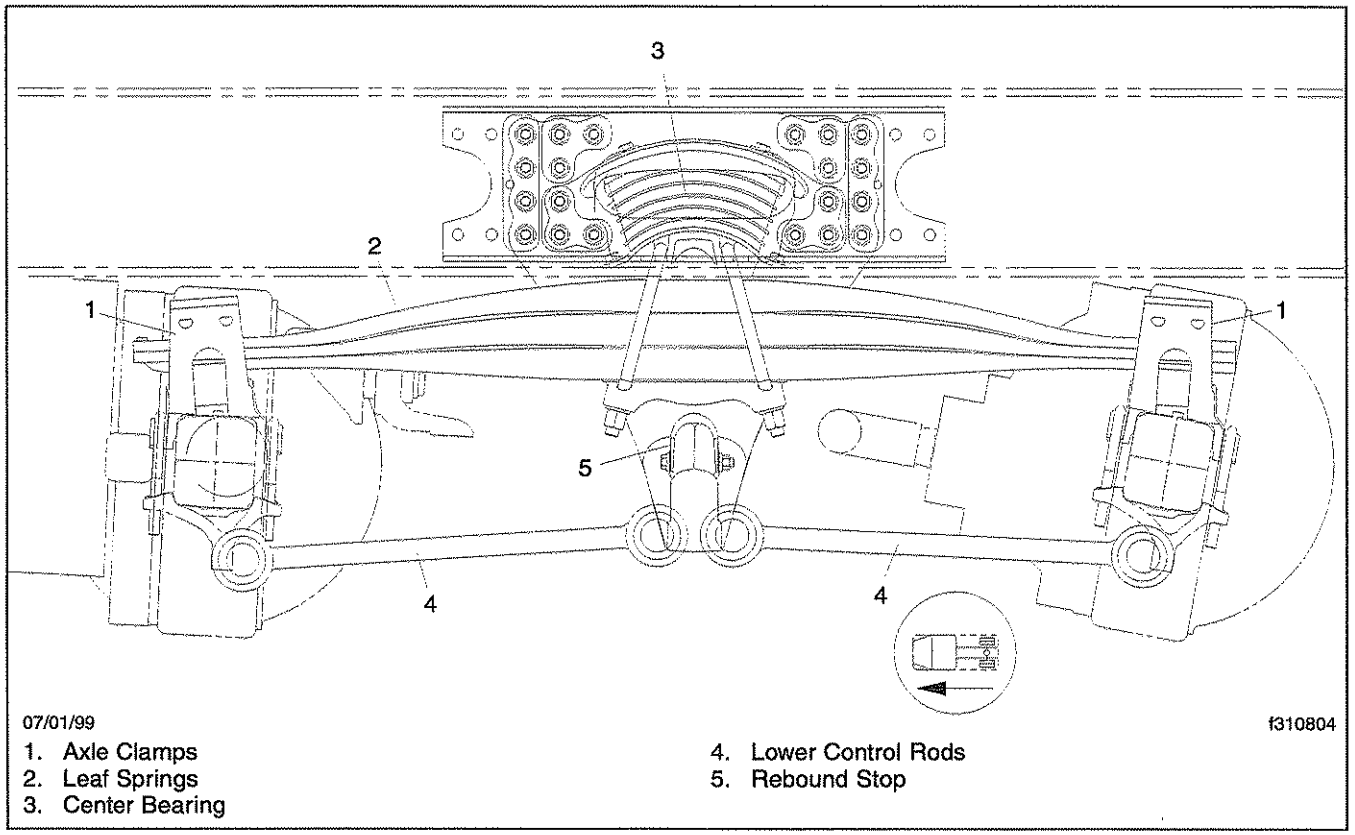
Fig. 1, Shock Absorber Replacement

Replacement

1. Park the vehicle on a level surface, shut down the engine and apply the parking brakes. Chock the tires.
2. Remove the rebound stop from the suspension. See **Fig. 1**.
   - 2.1 Remove the nut and bolt securing the rebound stop to the mounting bracket.
   - 2.2 Slide the rebound stop from the mounting bracket.
3. Remove the upper two fasteners on the center bearing.
4. Jack up the vehicle under the rear axle.
5. Support the rear frame rails with jack stands, then lower the jack. This will clear the center bearing from the top of the mounting bracket. See **Fig. 2**.
6. Remove the lower center bearing bolts attached to the spring assembly casting. Discard the bolts.
7. Remove the center bearing. See **Fig. 3**.
8. Position the new center bearing in the mounting bracket.
9. Install the upper mounting bolts and tighten 68 lbf·ft (92 N·m).
10. With the jack, raise the rear axle until bottom of the center bearing meets the mounting bracket on the leaf springs.

IMPORTANT: Be sure to use new bolts with loctite (p/n 23–12576–125) when attaching the center bearing to the leaf spring casting.

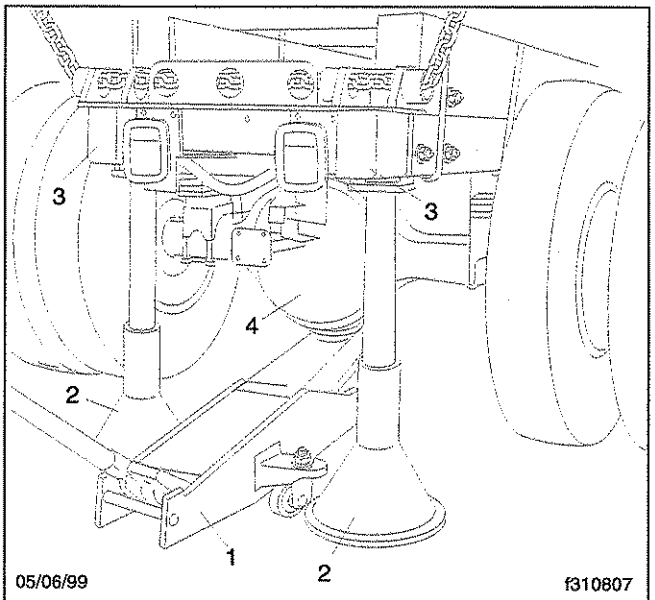
11. Install new lower mounting bracket bolts (p/n 23–12576–125). Tighten the bolts 155 lbf·ft (210 N·m).
12. Return the vehicle to its normal operating position.
13. Install the rebound stop.



1. Axle Clamps
2. Leaf Springs
3. Center Bearing
4. Lower Control Rods
5. Rebound Stop

Fig. 1, TufTrac Suspension (46,000-pound [20 865-kilogram] version shown)

Center Bearing Replacement



1. Jack
2. Jack Stand
3. Frame Rail
4. Rear Axle

Fig. 2, Jack and Jack Stand Placement

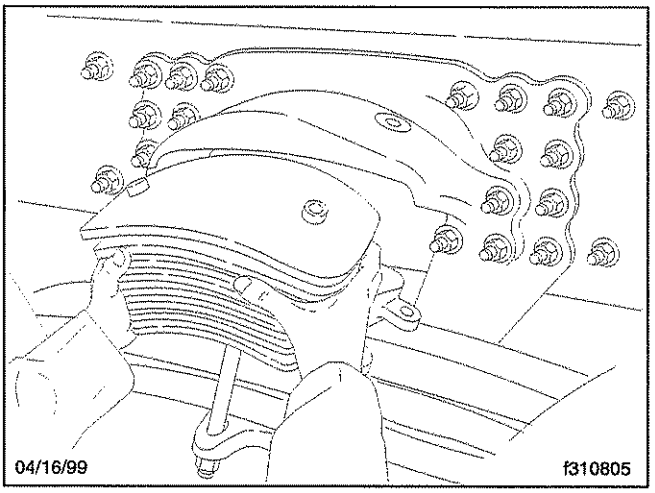


Fig. 3, Center Bearing Removal

14. Remove the chocks from the tires.

Spring Assembly Removal, Assembly and Installation

IMPORTANT: The spring pack assembly is not available as an assembled unit in the aftermarket. If the spring pack assembly is to be replaced with a new assembly, the springs, center bearing seat and retainer bracket must be assembled before installation on the vehicle.

Removal

1. Park the vehicle on a level surface. Shut down the engine and apply the parking brakes. Chock the tires.
2. Remove the tip pad bolts above each axle on the axle clamp. There are four bolts on each pad. See **Fig. 1**.
3. Remove the center bearing. See **Subject 110**.
4. With the vehicle still raised, remove the wheels on both rear axles on the side the spring assembly will be replaced. For instructions, see **Group 40**.

⚠ WARNING

Do not attempt to remove the spring assembly by hand. The assembly is very heavy and attempting to lift it could result in bodily injury.

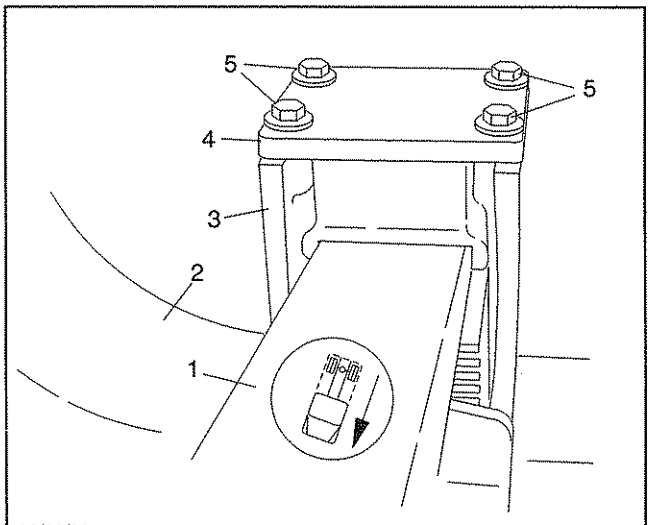


Fig. 1, Tip Pad Installation

5. Using a lift (i.e. engine hoist), remove the leaf spring assembly from the vehicle. See **Fig. 2**.

Assembly

IMPORTANT: Leaf springs in a spring pack assembly cannot be replaced individually. The entire spring pack assembly must be replaced.

1. Support both sides of the new spring pack assembly on jack stands. Make sure all the leaf springs are interlocking with the studs and dimples at the centers of the leaf springs.
2. If the assembly contains a spacer, place it on the center of the top leaf spring. Make sure the dimple in the spacer is aligned with the stud in the center of the top leaf spring.
3. Place the center bearing seat on the top of the spacer or leaf spring, as applicable. Make sure the dimple in the middle of the center bearing seat aligns with the stud in the middle of the leaf spring or the spacer.
4. Install the two 3/4-inch U-bolts over the center bearing seat. Make sure the U-bolts rest in the grooves of the center bearing seat.
5. At the bottom of the spring pack, install the U-bolt retainer bracket over the threaded ends of the U-bolts.
6. Holding the retainer bracket in place, install a hardened washer and hexnut over the threaded end of each U-bolt.
7. Tighten the U-bolts in a diagonal sequence as follows:
   - Stage 1: 60 lbf·ft (81 N·m)
   - Stage 2: 200 lbf·ft (271 N·m)
   - Stage 3: 300 lbf·ft (407 N·m)

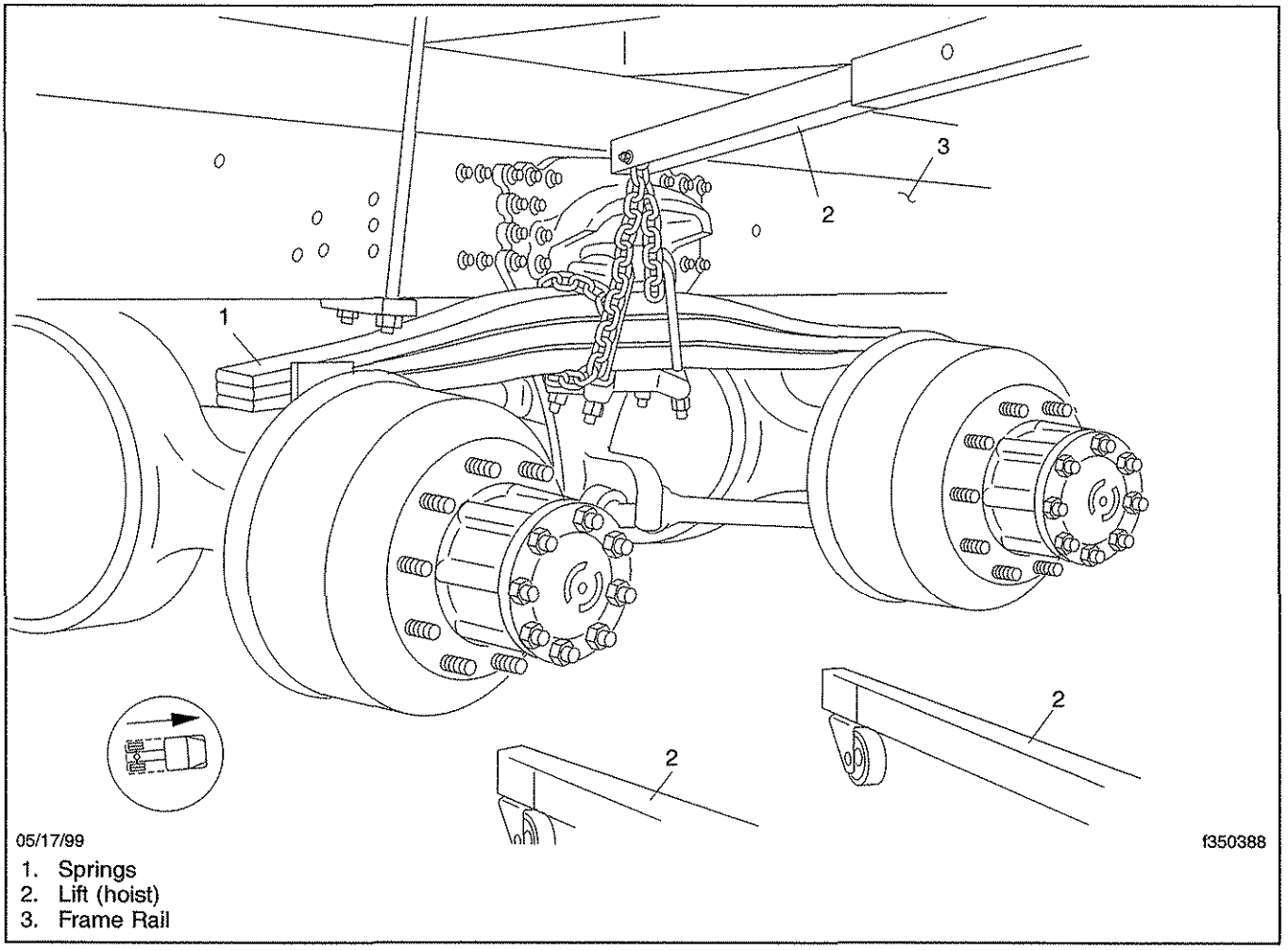
Installation

⚠ WARNING

Do not attempt to install the spring assembly by hand. The assembly is very heavy and attempting to lift it could result in bodily injury.

1. Place the new spring assembly on the vehicle.

Spring Assembly Removal, Assembly and Installation



1. Springs
2. Lift (hoist)
3. Frame Rail

Fig. 2, Leaf Spring Replacement

1.1 Attach the new assembly to the lift.

1.2 Using the lift (hoist), lift the assembly into place on the axle clamps.

2. Install the center bearing. For instructions, see **Subject 110**.
3. Install the tip pad and bolts on each axle clamp. Tighten the bolts 37 lbf·ft (50 N·m). See **Fig. 1**.
4. If not already installed, install the rebound stop and mounting bolt. Tighten the nut 68 lbf·ft (92 N·m).
5. Install the wheels. For instructions, see **Group 40**.
6. Return the vehicle to its normal operating position.
7. Remove the chocks from the tires.

Lower Control Rod and V-Rod Replacement

Lower Control Rod Replacement

(See Fig. 1)

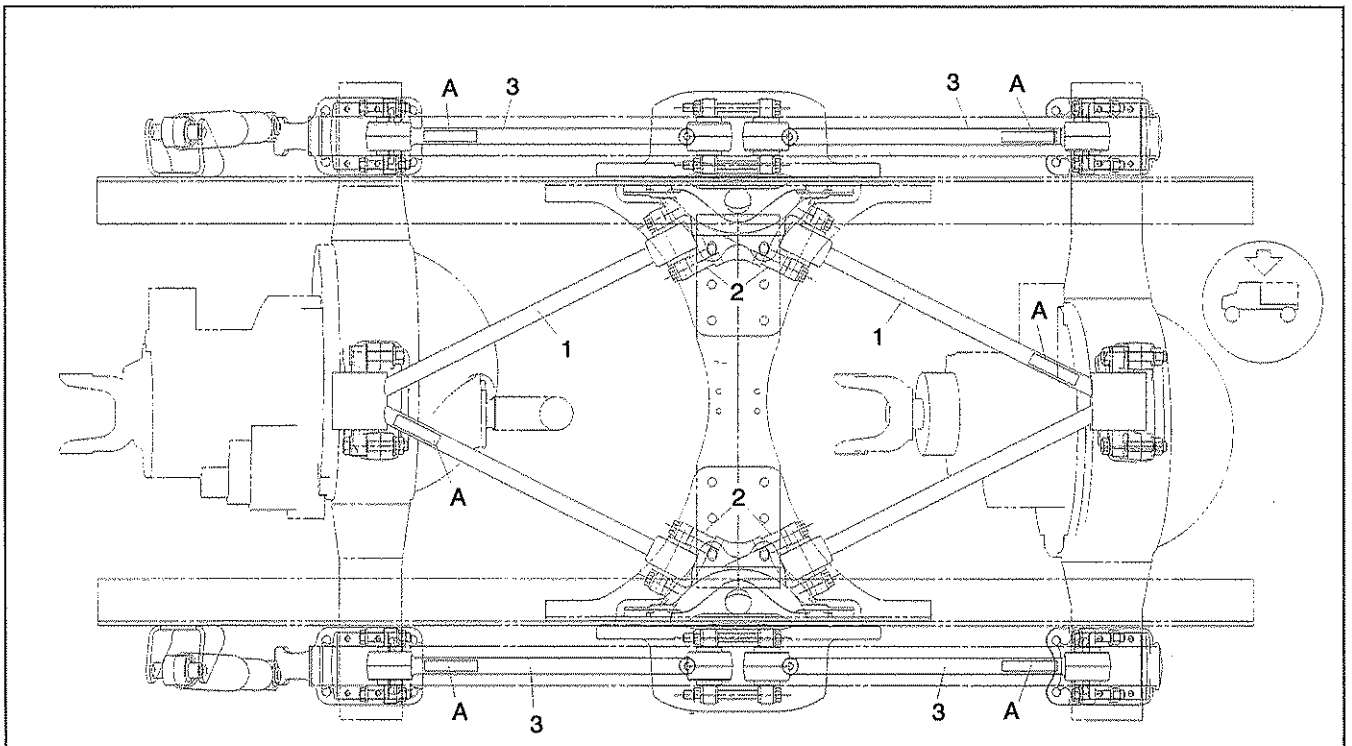
1. Park the vehicle on a level surface, shut down the engine, and apply the parking brakes. Chock the front tires.
2. Raise the rear axle and support the frame rails with jack stands.
3. Lower the jack under the axle. See **Fig. 2**.
4. Remove the bolts holding both rods between the rear axles, below the rebound stop. See **Fig. 3**.
5. Remove the nut and bolt from the axle clamp.
6. Remove the control rod from the vehicle.

IMPORTANT: When installing the rods make sure the labels on the rods are facing upward. Forward axle rods are marked "FDA" and rear axle rods "RDA."

7. Fasten the new control rod to the axle clamp. Tighten the nut 136 lbf·ft (184 N·m).
8. Fasten the other end of the rod to the bracket below the rebound stop. Tighten the nut 136 lbf·ft (184 N·m).
9. Return the vehicle to the normal operating position.

V-Rod Replacement

1. Park the vehicle on a level surface, shut down the engine, and apply the parking brakes. Chock the tires.
2. Raise the rear axle and support the frame rails with jack stands.
3. Lower the jack under the axle. See **Fig. 2**.
4. Remove all six mounting bolts securing the v-rod to the chassis and axle.



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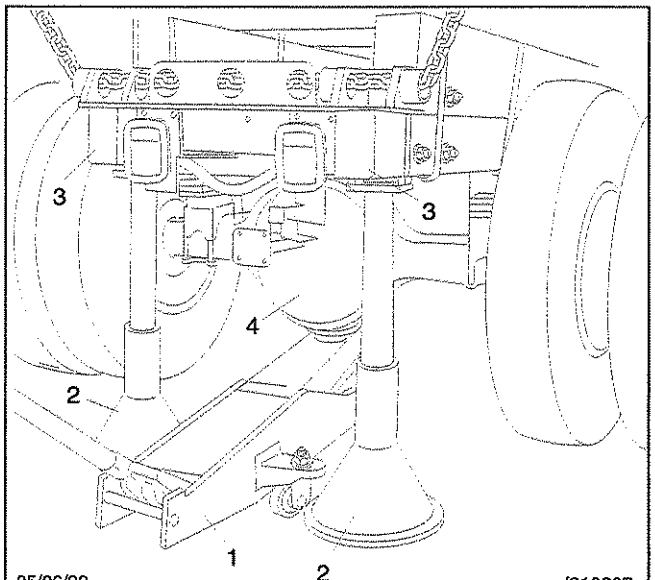
A. Label
1. V-Rod
2. Spacer
3. Lower Control Rod

Fig. 1, Control and V-Rod Replacement

Lower Control Rod and V-Rod Replacement



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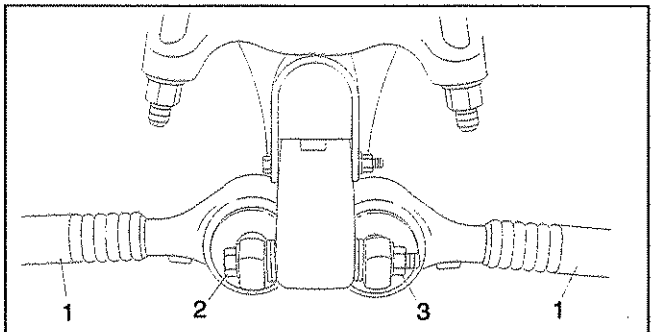
1. Jack
2. Jack Stand
3. Frame Rail
4. Rear Axle

Fig. 2, Jack and Jack Stand Placement



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1. Lower Control Rod
2. Mounting Bolt
3. Mounting Nut

Fig. 3, Lower Control Rods

5. Remove the v-rod from the chassis.

IMPORTANT: When installing the rods make sure the labels on the rods are facing upward. Forward axle rods are marked "FDA" and rear axle "RDA."

6. Install the v-rod. See **Fig. 4**.

   6.1 Place the new rod in position between the frame rails.

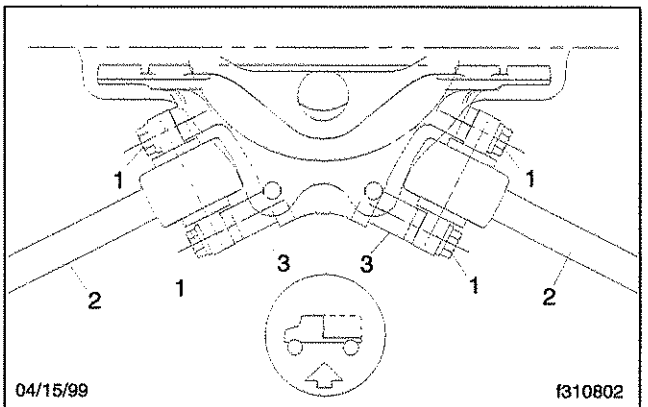
   6.2 Install the bolts and spacers and loosely tighten all connections.

   6.3 After all fasteners and spacers are installed, torque as follows:

   - Tighten the bolts at the frame bracket 136 lbf·ft (184 N·m).
   - Tighten the bolts at the axle bracket 427 lbf·ft (579 N·m).

7. Return the vehicle to normal operating position.

8. Remove the chocks from the tires.



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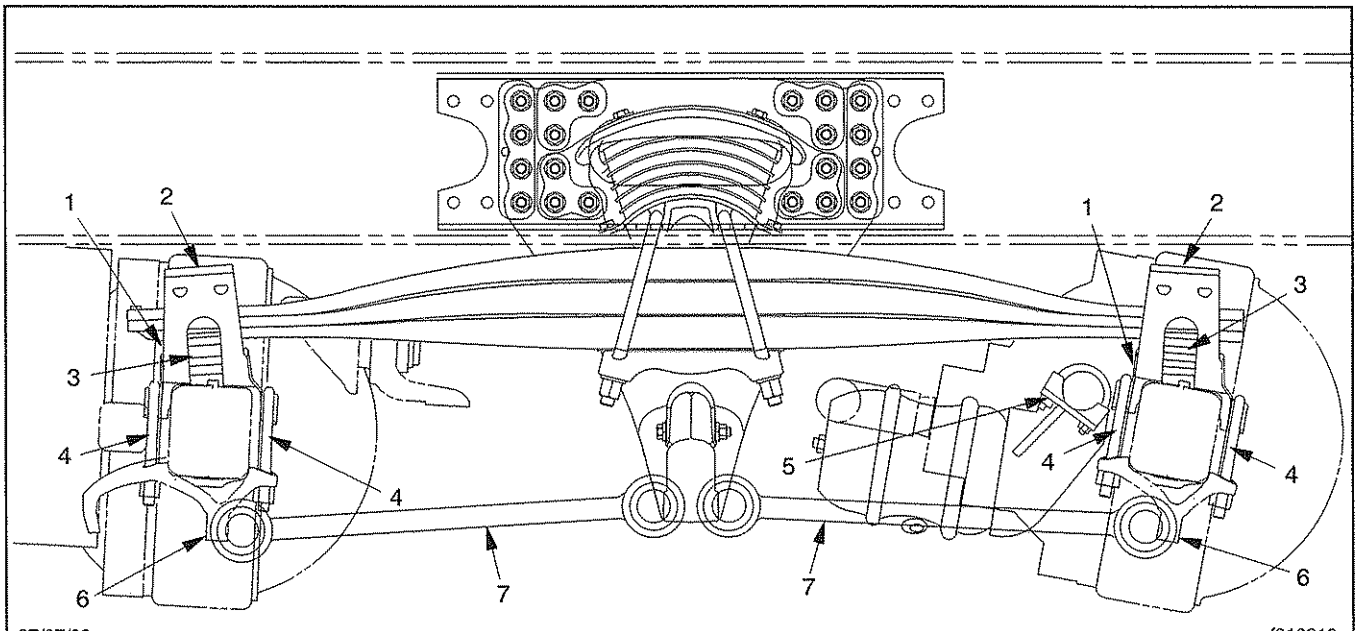
1. Mounting Bolt
2. V-Rod
3. Spacer

Fig. 4, V-Rod Replacement

Axle Clamp and Retainer Replacement

Replacement (See Fig. 1)

1. Park the vehicle on a level surface, shut down the engine and chock the tires.
2. Remove the two upper spring tip pads and bolts from the left suspension spring.
3. Disconnect the shock absorbers from the lower axle retainer on the left suspension spring.
   - 3.1 Remove the lower shock mounting nuts and washers.
   - 3.2 Remove the lower shock absorber mounting bolts.
4. Disconnect the two lower torque control rods from the lower axle retainers on the left side of the vehicle.
5. Loosen and remove the U-bolt nuts and washers, and discard.
6. Remove the brake cam tube support bracket from the left rear axle.
7. Remove the lower axle retainers from the left forward and left rear drive axles, and discard.
8. Remove the axle U-bolts from the left forward drive axle and the left rear drive axle, and discard.
9. Jack up the center of the left suspension spring (at the center bearing, between the tandem) and support with the jack stands at the frame. See **Fig. 2**. Make sure that all of the weight has been relieved from the axle clamp group and that there is sufficient clearance to remove the upper axle clamp.
10. Remove the lower spring tip pads from the left forward and left rear drive axles.
11. Remove the upper axle clamps from the left forward and left rear drive axles. Discard the clamps.
12. Install the new upper axle clamps from the applicable warranty kit to the left forward and left rear drive axles. Locate the dowel pin through the hole in the bottom of each axle clamp to confirm proper alignment



1. Upper Axle Clamp
2. Upper Spring Tip Pad
3. Lower Spring Tip Pad
4. U-Bolt
5. Brake Cam Tube Support Bracket
6. Lower Axle Retainer
7. Lower Control Rods

Fig. 1, TufTrac Suspension (left-side view)

Axle Clamp and Retainer Replacement

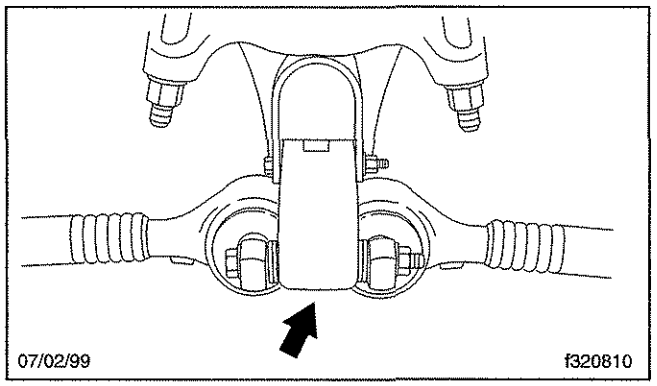


Fig. 2, Jack the Vehicle Here

NOTE: Confirm that you are installing the correct upper axle clamps before continuing. You are able to visually identify the new upper axle clamp because the step has been removed from the area directly above the U-bolt saddles. See **Fig. 3**.

13. Install the lower spring tip pads into the left front and rear axle clamps.
14. Jack up the left suspension spring, remove the jack stands, and lower the suspension spring. Ensure while the spring is being lowered that it is seated correctly onto the lower spring tip pads.
15. Install the new lower axle retainers onto the left forward and rear drive axles.
16. Install the brake cam tube support bracket onto the left rear axle.
17. Install the U-bolts on the left forward and rear drive axles.

    IMPORTANT: Install two washers for each U-bolt nut.

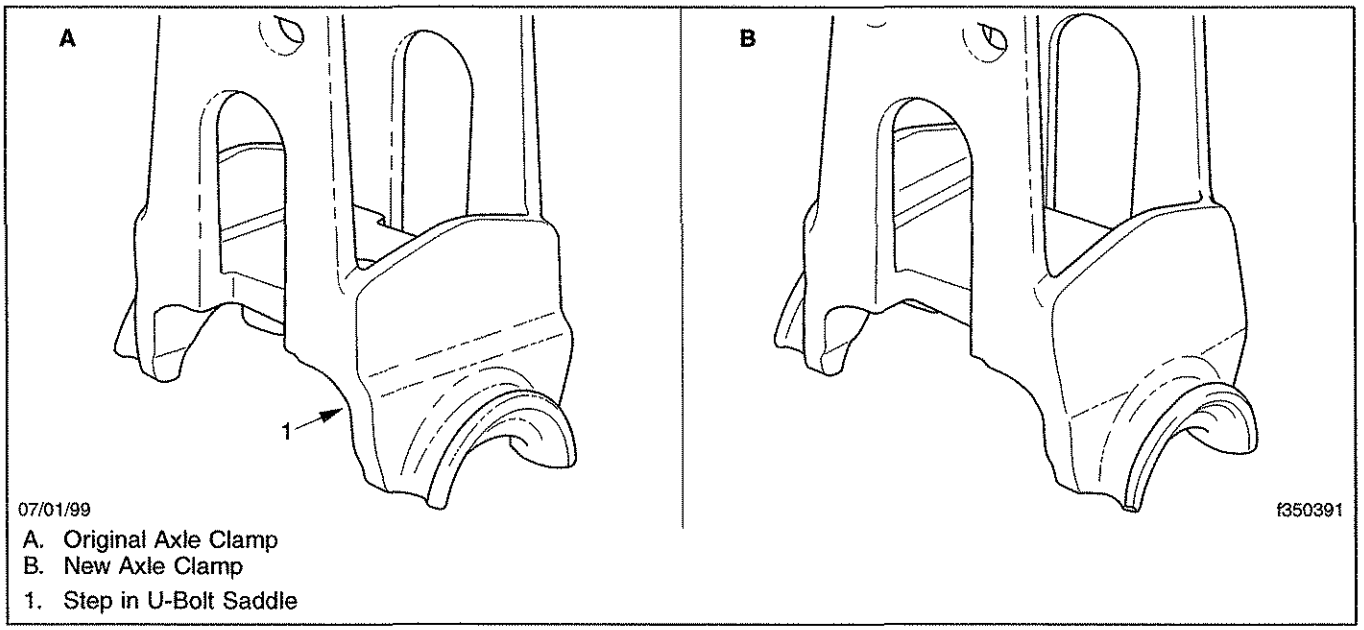
    17.1 Install each U-bolt over the U-bolt saddle in the upper axle clamp and through the holes in the lower axle retainer.

    17.2 Install the washers and finger-tighten the nuts in the order shown in **Fig. 4**.

    Make sure all brackets are snug against the axle housing before proceeding to the next step.

    IMPORTANT: U-bolt nuts must be tightened in the order shown in **Fig. 4**.

    17.3 Tighten the nuts 60 lbf·ft (81 N·m) and then to 200 lbf·ft (271 N·m) in two separate rotations following the order shown in **Fig. 4**.
18. Install the lower torque control rods to the lower axle retainers on the left side of the vehicle and tighten 136 lbf·ft (184 N·m).



A. Original Axle Clamp
B. New Axle Clamp
1. Step in U-Bolt Saddle

Fig. 3, Upper Axle Clamps

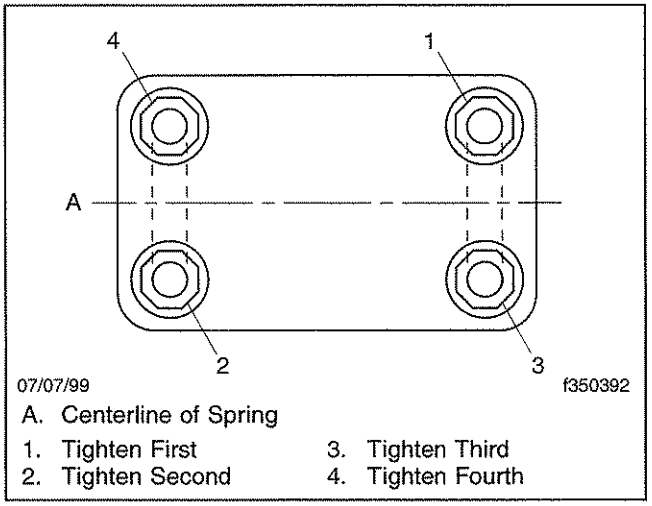


Fig. 4, U-Bolt Nut Tightening Sequence

19. Install the shock absorbers to the lower axle retainers.
    - 19.1 Install the lower shock mounting bolts.
    - 19.2 Install the lower shock absorber mounting washers and nuts and tighten by hand.
    - 19.3 Tighten the lower shock absorber mounting nuts to 241 lbf·ft (327 N·m).
20. Install the spring tip pads to the left suspension spring.
    - 20.1 Install the spring tip pads to the upper axle clamps.
    - 20.2 Install the bolts to secure each upper spring tip pad and tighten 37 lbf·ft (50 N·m).
21. Repeat the above steps for the right suspension spring.
22. Remove the chocks from the tires.

Adjustments

Rear axle positioning and alignment on a vehicle equipped with the TufTrac suspension is determined by the length of the lower control rods and the V-rods. See **Fig. 1**. The length of the control rods and V-rods can be controlled by the addition or removal of shims at the mounting points of the control rods and/or V-rods. The addition of shim(s) between the control rod or V-rod and its mounting will effectively lengthen the rod moving the axle relative to the frame. Conversely, the removal of shim(s) will shorten the length of the rod, moving the axle in the opposite direction.

The lower control rods use a horse-shoe style of shim (**Fig. 2**) while the V-rods use hardened washers for shims.

Control rod shimming is performed at the center bracket. See **Fig. 3**. The purpose of this shim adjustment is to provide axle alignment and planing adjustment (angle of the axle from vertical in the side view).

Axle tracking (lateral axle positioning) is performed by inserting or removing hardened washers at the V-rod mounting at the frame end. See **Fig. 4**.

Lower Control Rods

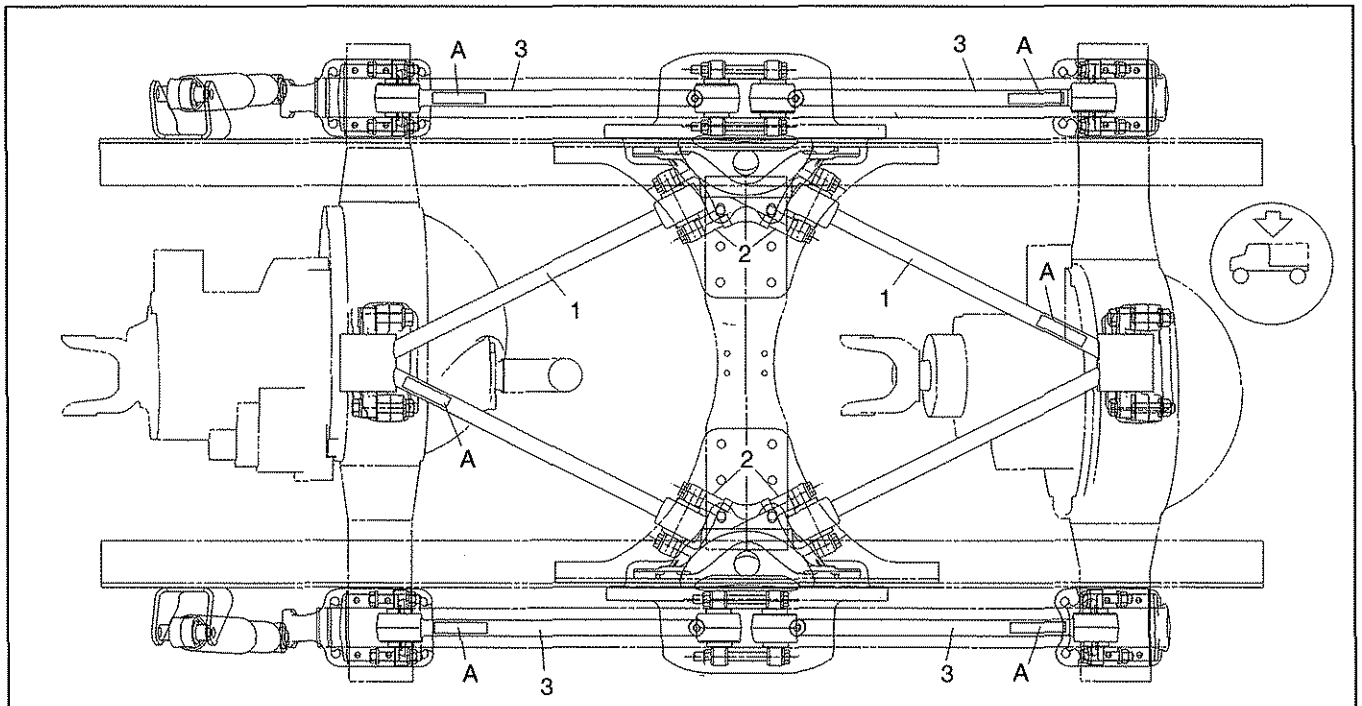
Alignment Adjustments

NOTE: Alignment refers to the squareness of the axles to each other and the frame rails viewed from the top of the vehicle.

Add or remove shims at the center bracket to achieve proper alignment. See **Fig. 3**. To minimize the effect on planing angles, if possible, add or remove shims from both sides of the vehicle.

When one 3mm thick shim is added and one removed (from the opposite side) the axle position is affected as follows:

- Angle of the axle in the plan view: 0.33 degrees



A. Label
1. V-Rod
2. Spacer
3. Lower Control Rod

Fig. 1, Control Rod and V-Rod Installation

Rear Axle Alignment Adjustments

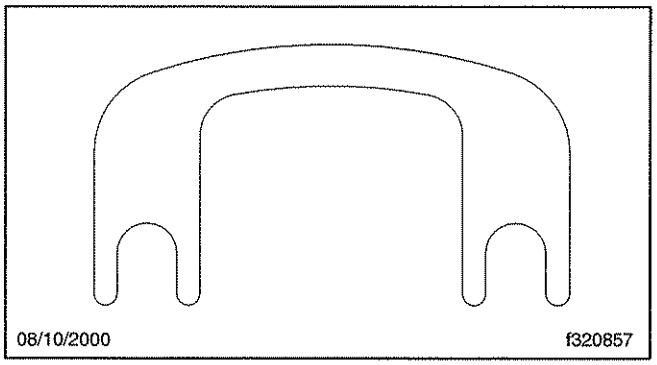


Fig. 2, Lower Control Rod Shim

- Fore-aft movement of the wheel at the outside (assuming 97.6 in. (2480 mm) wheel to wheel distance): 0.283 in. (7.2 mm)

Planing Adjustments

NOTE: planing refers to the angle of the axle from vertical in the side view.

Add or remove shims at the center bracket to change the planing angle. See **Fig. 3**. Unless alignment is required, an equal number of shims should be used left and right for a given axle; example, when adding one shim to the left forward rod add one shim to right forward rod. A shim 0.12 inch thick changes the planing angle 0.3 degrees.

V-Rods

Axle Tracking Adjustments

The tracking adjustment of the forward and rear axles is done by adding and/or removing hardened washers between the V-rod bar pin and the frame-mounted bracket. See **Fig. 4**.

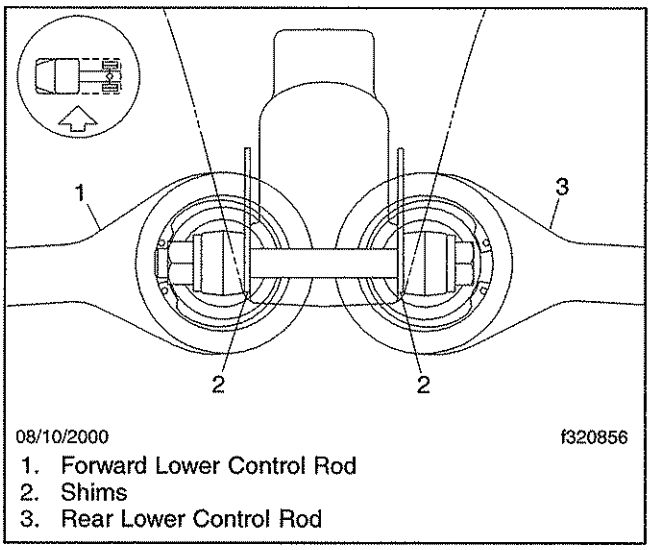


Fig. 3, Lower Control Rod Shim Installation

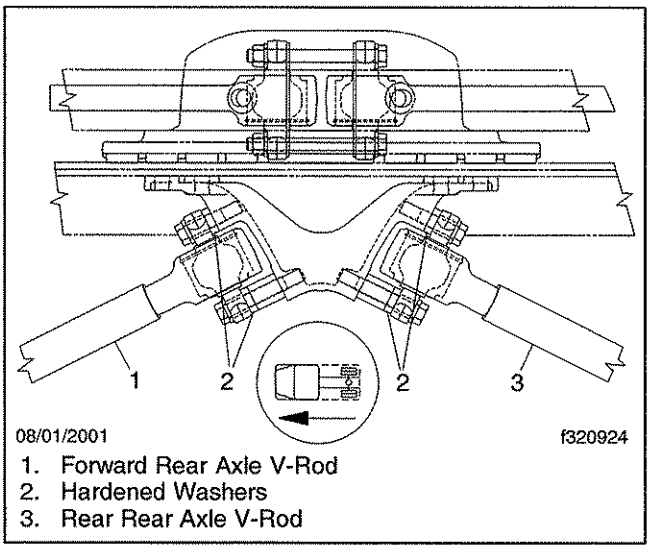
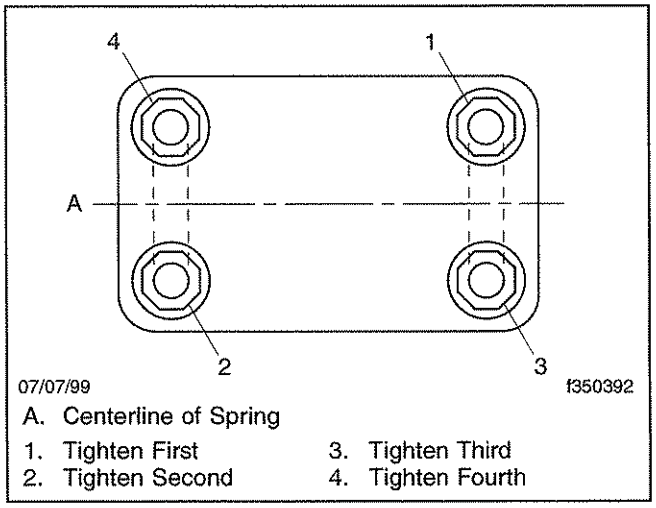


Fig. 4, V-Rod Hardened Washer Installation

Specifications

Torque Specifications	
Description	**Torque Value lbf·ft (N·m)**
Shock Absorber Mounting Bolt	241 (327)
Center Bearing Upper Mounting Bolts	68 (92)
Center Bearing Lower Mounting Bolts	155 (210)
Tip Pad Bolts	37 (50)
Rebound Stop Mounting Bolt	68 (92)
Lower Control Rod Mounting Bolts	136 (184)
V-Rod Frame Bracket Mounting Bolts	136 (184)
V-Rod Axle Bracket Mounting Bolts	427 (579)
5/8–18 Axle Clamp U-Bolt Nuts (Tighten as shown in **Fig. 1**.)	Stage 1: Hand-Tighten Stage 2: 60 (81) Stage 3: 200 (271)
3/4-Inch Spring Pack U-Bolt Nuts	Stage 1: 60 (81) Stage 2: 200 (271) Stage 3: 300 (407)

Table 1, Torque Specifications



A. Centerline of Spring
1. Tighten First
2. Tighten Second
3. Tighten Third
4. Tighten Fourth

Fig. 1, U-Bolt Nut Tightening Sequence

Group Index, Alphabetical

Section	Section Number
Front Axle	33.00
Front Axle Oil Seals	33.02
Front Axle Wheel Hubs, Brake Drums, and Wheel Bearings	33.01

Contents

Subject	Subject Number
General Description	050
Service Operations	
Preliminary Checks	100
Steering Angle Checking and Adjusting	110
Measuring and Adjusting Front Axle Wheel Alignment Angles	120
Camber Angle Checking	130
Caster Angle Checking and Adjusting	140
Wheel Toe-In Checking and Adjusting	150
Front Axle Removal and Installation	160
Specifications	400

NOTE: For front axle troubleshooting procedures, refer to **Section 33.01**.

General Description

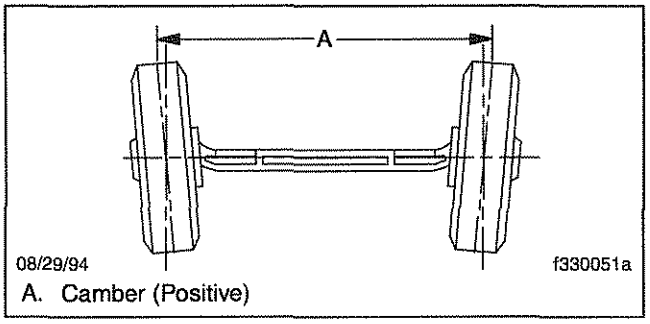
The front axle requires periodic servicing to maintain accurate wheel alignment. If the front axle is damaged enough to affect the camber angle it must be replaced. For axle removal and installation instructions, see **Subject 160.**

Correct front axle wheel alignment is needed to ensure long tire life, ease of handling, and steering stability.

Three factors are involved in wheel alignment: camber angle, caster angle, and wheel toe-in.

Camber angle **(Fig. 1)** is the vertical tilt of the wheel as viewed from the front of the vehicle. Camber angle is measured in degrees, and is not adjustable. Positive camber is the outward tilt of the wheel at the top. Excessive positive camber in one wheel causes the vehicle to pull in the opposite direction, rapidly wearing the outboard side of the tire tread. Negative camber is the inward tilt of the wheel at the top. Excessive negative camber in one wheel causes the vehicle to pull in the same direction that the negative-camber wheel is on, wearing the inboard side of the tire tread. If camber angles are not correct, the tires will wear smooth around the edge on one side. **See Fig. 2.**

Caster angle **(Fig. 3)** is the tilt of the knuckle pin (or kingpin) as viewed from the side. Caster angle is measured in degrees and it is adjustable. A positive caster angle is the tilt of the top of the knuckle pin toward the rear of the vehicle. A negative caster angle is the tilt of the top of the knuckle pin toward the front of the vehicle. Caster angles are based on the design load of the vehicle. An incorrect caster angle does not cause tire wear. However, a positive caster angle that exceeds specifications could cause vehicle shimmy, road shock, and an increased steering effort. A negative caster angle that does not meet specifications could cause unstable steering. The vehicle may wander and weave, and extra steering effort may be necessary. After leaving a turn, the tendency to return to and maintain a straight-ahead position is reduced. Too much or too little caster in one wheel can cause erratic steering when the service brakes are applied to stop the vehicle.



A. Camber (Positive)

Fig. 1, Camber Angle

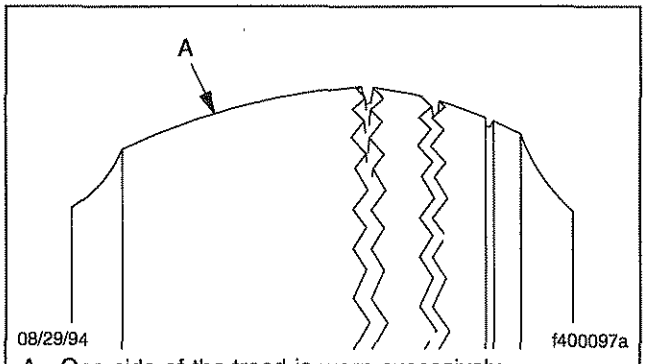
Wheel toe-in **(Fig. 4)** is the distance in inches that the front of the wheels are closer together than the rear of the wheels, as viewed from the top. Wheel toe-in is adjustable. If it is not adjusted correctly, the vehicle could pull to one side while driving. Wheel shimmy and cupped tire treads (indentations on the road contact surface of the treads) could occur. Also, rapid or severe tire wear on the steering axle could occur, usually in a feather-edged pattern. **See Fig. 5.**

Advanced wear patterns can be seen, but less severe wear patterns are detected only by rubbing the palm of your hand flat across the tire tread.

Feather-edging more often affects the front tire on the passenger's side of the vehicle, and is usually more apparent on the outside grooves of the tire.

If any of the conditions listed above occur, the vehicle could need a front end wheel alignment, and possibly, drive axle alignment. However, in some cases these conditions are not wheel alignment related; refer to **Section 33.01** for other possible causes.

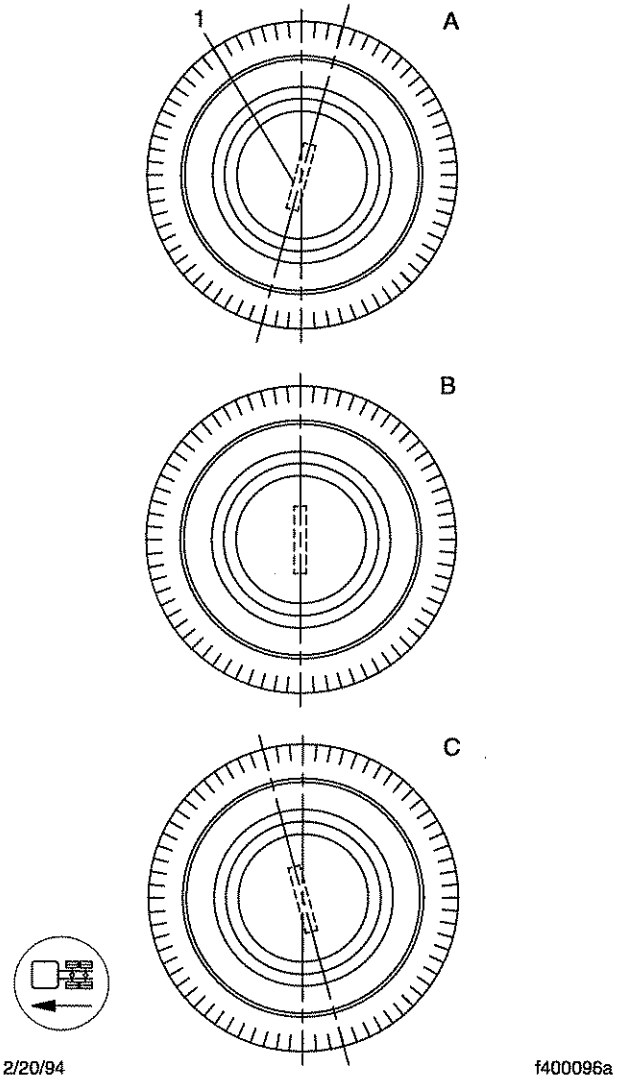
If excessive tire tread wear has resulted from incorrect wheel alignment, replace the damaged tires. For minimum tread wear specifications, refer to the wheels and tires section in the vehicle maintenance manual.



A. One side of the tread is worn excessively.

Fig. 2, Tire Damage Due to Excessive Camber

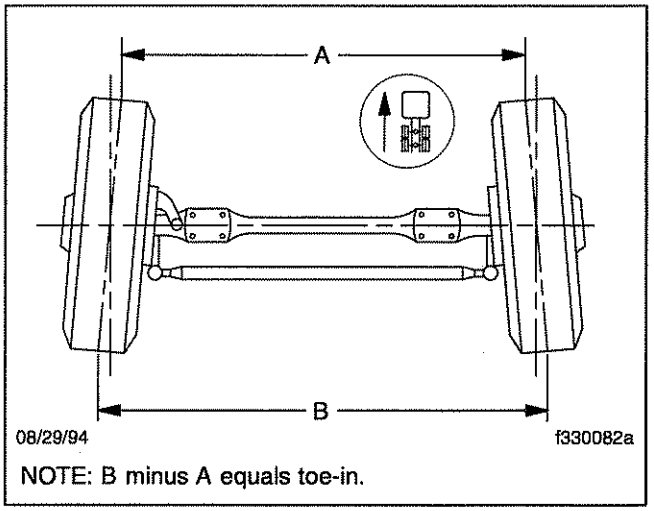
General Description



1. Knuckle Pin (King Pin)

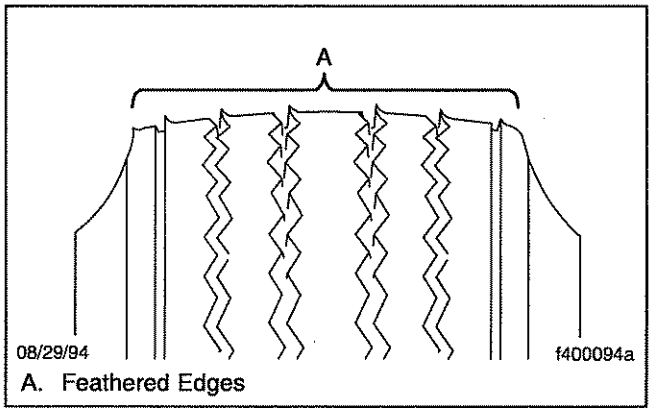
A. Positive Caster
B. Zero Caster
C. Negative Caster

Fig. 3, Caster Angle



NOTE: B minus A equals toe-in.

Fig. 4, Wheel Toe-In (overhead view)



A. Feathered Edges

Fig. 5, Tire Damage Due to Excessive Toe-In or Incorrect Drive Axle Alignment

Preliminary Checks

1. Steering axle wheel assemblies should be balanced, especially for vehicles that travel at sustained speeds of more than 50 mph (80 km/h). Off-balance wheel assemblies cause vibrations that result in severely shortened life for tires, and steering suspension parts.
2. Do not mix tires of different size, type, or weight. Tire wear should be even and not worn to limits exceeding government specifications. Refer to **Group 40** in this manual and the vehicle maintenance manual for more information. Replace any tire that is excessively worn.
3. Check the inflation pressure of the tires. Refer to the wheels and tires section in this manual for recommended pressures. An underinflated tire causes tread wear completely around both tire shoulders. An overinflated tire causes tread wear in the center of the tire. **See Fig. 1.**
4. Check for out-of-round wheels, rims, or wheel stud holes. Replace the wheel if any of these conditions exist.
5. On each side of the vehicle, check the height of the chassis above the ground. Sagging, fatigued, or broken suspension springs create a lopsided vehicle appearance. This causes an unbalanced weight distribution. Anything that changes the ratio of weight on the springs affects the alignment angles and also the tire tread contact area. Replace damaged springs as instructed in the suspension section in this manual.
6. Inspect the front axle beam (also called the axle center) for bends or twists. If the axle beam is bent or twisted over 1/2 degree, replace it before aligning the front axle wheels.
7. Check for damaged, worn, or bent steering gear or linkage parts. Make sure the steering gear is centered. Replace damaged components, and adjust the steering gear, using the instructions in the steering section in this manual.
8. Check the steering angle, and adjust the axle steering stops, as needed. Refer to **Subject 110.**

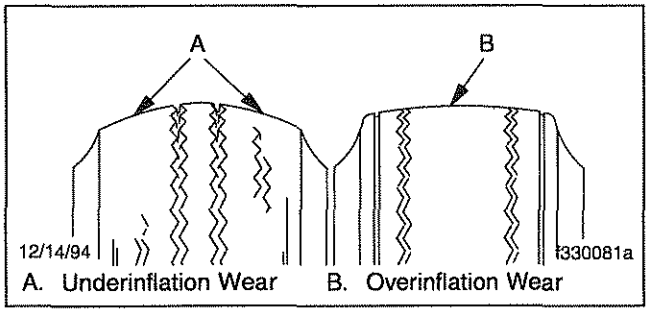


Fig. 1, Tire Damage Due to Underinflated or Overinflated Tires

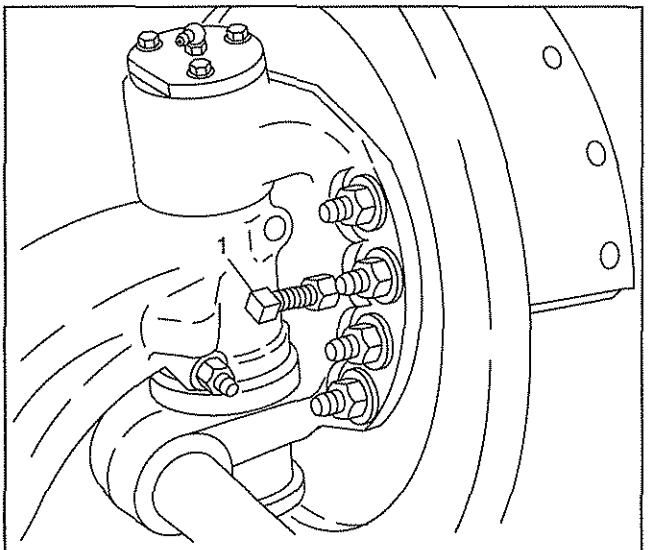
Steering Angle Checking and Adjusting

Checking and Adjusting

Steering (or turning) angle is the degree of front wheel movement from a straight-ahead position to either an extreme right or left position. Although front wheel movement can be limited by the amount of internal travel in the steering gear, it generally depends on how much clearance there is between chassis components and the tire and wheel assemblies. All axles have adjustable stopscrew-and locknut-type axle stops (**Fig. 1**), which are located on the rear side of each front axle spindle.

IMPORTANT: For vehicle alignment to be accurate, the shop floor must be level in every direction. The turn plates for the front wheels must rotate freely without friction, and the alignment equipment must be calibrated every three months by a qualified technician from the equipment manufacturer. Freightliner dealers must have proof of this calibration history.

1. Make sure the steering gear is in the center of travel when the wheels are in a straight-ahead position. Center the gear, using the instructions in the steering section in this manual. Bottoming of the steering gear must not occur when making an extreme right or left turn.



1. Stopscrew and Locknut

Fig. 1, Axle Stop

2. If using stationary turn-plates or turntables (**Fig. 2**), drive the vehicle on the plates; the tires must be exactly straight ahead. Apply the parking brakes.

   If using portable gauges, apply the parking brakes, chock the rear tires, and raise the front of the vehicle. Place a turn-plate or turntable under each tire. With the tires exactly straight ahead, lower the vehicle so that the tires rest on the center of the gauges.

3. Remove the lockpins from the gauges, and adjust the dials so that the pointers on both gauges read zero.

4. With the brakes fully applied, turn the steering wheel clockwise to the end of travel. Have someone check both sides of the vehicle for interference at the tires and wheels. There must be at least 0.50 inch (13 mm) clearance from any fixed object, and 0.75 inch (19 mm) from any moving object.

   If necessary, loosen the stopscrew locknut; adjust the stopscrew to contact the axle when the maximum turning angle of the wheels is determined.

   Tighten the locknut to the value in the torque table under **Specifications, 400**.

5. Repeat the step above with the steering wheel turned counterclockwise. Adjust the axle stop, as needed.

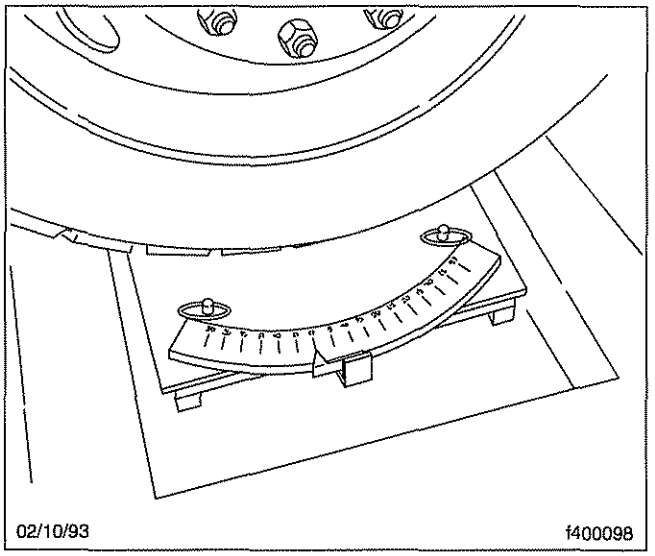


Fig. 2, Turn-Plate (Turntable), Stationary Type

Steering Angle Checking and Adjusting

6. If equipped with power steering, adjust the steering gear so that pressure is released ahead of the axle stop. This will prevent possible damage to the steering or axle components. For poppet valve adjustment instructions, refer to **Group 46** in this manual.
7. Drive the vehicle off the turn-plates or turntables, or remove them from under the tires and lower the vehicle.

Measuring and Adjusting Front Axle Wheel Alignment Angles

Measuring and Adjusting

IMPORTANT: For vehicle alignment to be accurate, the shop floor must be level in every direction. The turn plates for the front wheels must rotate freely without friction, and the alignment equipment must be calibrated every three months by a qualified technician from the equipment manufacturer. Freightliner dealers must have proof of this calibration history.

Precision instruments and equipment are needed for accurately measuring and adjusting wheel alignment. Refer to the operating instructions provided by the wheel alignment equipment manufacturer.

Before checking or correcting wheel alignment, make sure the vehicle is at curb weight. Curb weight is the weight of the unloaded vehicle complete with accessories and full fuel tanks.

If a road test is necessary, the route should be one that allows full left and right turns and full stops. It should also include a length of straight, level road to check the steering wheel position during straight-ahead driving.

During the road test, note any steering effort and possible roughness. Check for looseness, too much wheel play, any tendency for the vehicle to lead in one direction, and for pull during stopping.

Note the position of the steering wheel while driving on a straight, level road. When the steering gear is centered, the steering wheel spokes should be at the 4 and 8 o'clock positions, or within 10 degrees of that position. **See Fig. 1.**

If there are any problems, refer to **Section 33.01**.

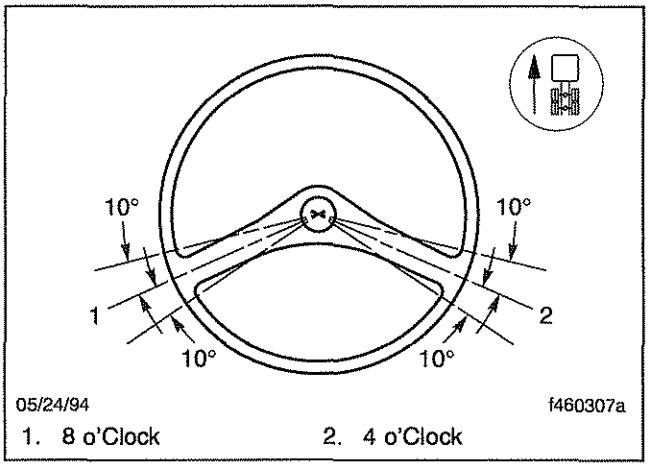


Fig. 1, Steering Wheel Position

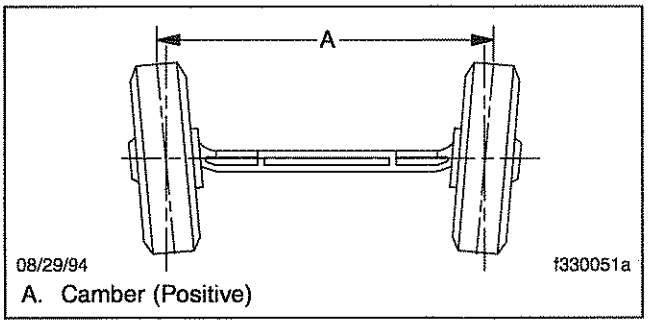
Camber Angle Checking

Checking (See Fig. 1)

IMPORTANT: For vehicle alignment to be accurate, the shop floor must be level in every direction. The turn plates for the front wheels must rotate freely without friction, and the alignment equipment must be calibrated every three months by a qualified technician from the equipment manufacturer. Freightliner dealers must have proof of this calibration history.

1. Apply the parking brakes, and chock the rear tires.
2. Raise the front of the vehicle until the tires clear the ground. Place safety stands under the axle; make sure the stands will support the weight of the cab, frame, and front axle.
3. Before measuring camber, check the front wheel bearings for wear and incorrect adjustment. Try moving the wheel on the axle spindle (steering knuckle) either by grasping the front tire on the top and bottom, or by using a bar for leverage. If movement between the brake drum and the backing plate or other axle-mounted reference point is 0.05 inch (1 mm) or more, the bearings may be worn or incorrectly adjusted. Inspect the wheel bearings for damage using the instructions in **Section 33.01**. If needed, replace or adjust the bearings.
4. Remove the safety stands, and lower the vehicle to the ground.
5. Using the alignment equipment manufacturer's instructions, measure the front wheel camber.
6. Compare the camber angles with those shown in the appropriate table in **Specifications, 400**. Differences between the measurements taken in the step above and the angles in the table are caused by damaged (bent) axle components.

   Incorrect camber angles could be caused by damage in one or more of the following front axle components: the knuckle pin, the knuckle pin bushings, the axle spindle, or the axle beam. Replace twisted or otherwise damaged components. Don't try to straighten twisted or bent components; replace them with new components. If a bent or twisted front axle knuckle pin, axle spindle, or axle beam has been straightened, the axle warranty will be voided.



A. Camber (Positive)

Fig. 1, Camber Angle

⚠ WARNING

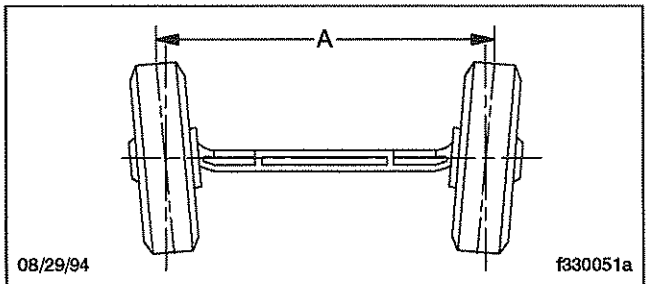
WARNING: Do not attempt to straighten any twisted or bent front axle component. This could crack or weaken the component, possibly resulting in a collapsed front axle, loss of a wheel, and serious personal injury.

7. Remove the chocks from the tires.

Checking (See Fig. 1)

IMPORTANT: For vehicle alignment to be accurate, the shop floor must be level in every direction. The turn plates for the front wheels must rotate freely without friction, and the alignment equipment must be calibrated every three months by a qualified technician from the equipment manufacturer. Freightliner dealers must have proof of this calibration history.

1. Apply the parking brakes, and chock the rear tires.
2. Raise the front of the vehicle until the tires clear the ground. Place safety stands under the axle; make sure the stands will support the weight of the cab, frame, and front axle.
3. Before measuring camber, check the front wheel bearings for wear and incorrect adjustment. Try moving the wheel on the axle spindle (steering knuckle) either by grasping the front tire on the top and bottom, or by using a bar for leverage. If movement between the brake drum and the backing plate or other axle-mounted reference point is 0.05 inch (1 mm) or more, the bearings may be worn or incorrectly adjusted. Inspect the wheel bearings for damage using the instructions in **Section 33.01**. If needed, replace or adjust the bearings.
4. Remove the safety stands, and lower the vehicle to the ground.
5. Using the alignment equipment manufacturer's instructions, measure the front wheel camber.
6. Compare the camber angles with those shown in the appropriate table in **Specifications, 400.**



A. Camber (Positive)

Fig. 1, Camber Angle

Differences between the measurements taken in the step above and the angles in the table are caused by damaged (bent) axle components.

Incorrect camber angles could be caused by damage in one or more of the following front axle components: the knuckle pin, the knuckle pin bushings, the axle spindle, or the axle beam. Replace twisted or otherwise damaged components. Don't try to straighten twisted or bent components; replace them with new components. If a bent or twisted front axle knuckle pin, axle spindle, or axle beam has been straightened, the axle warranty will be voided.

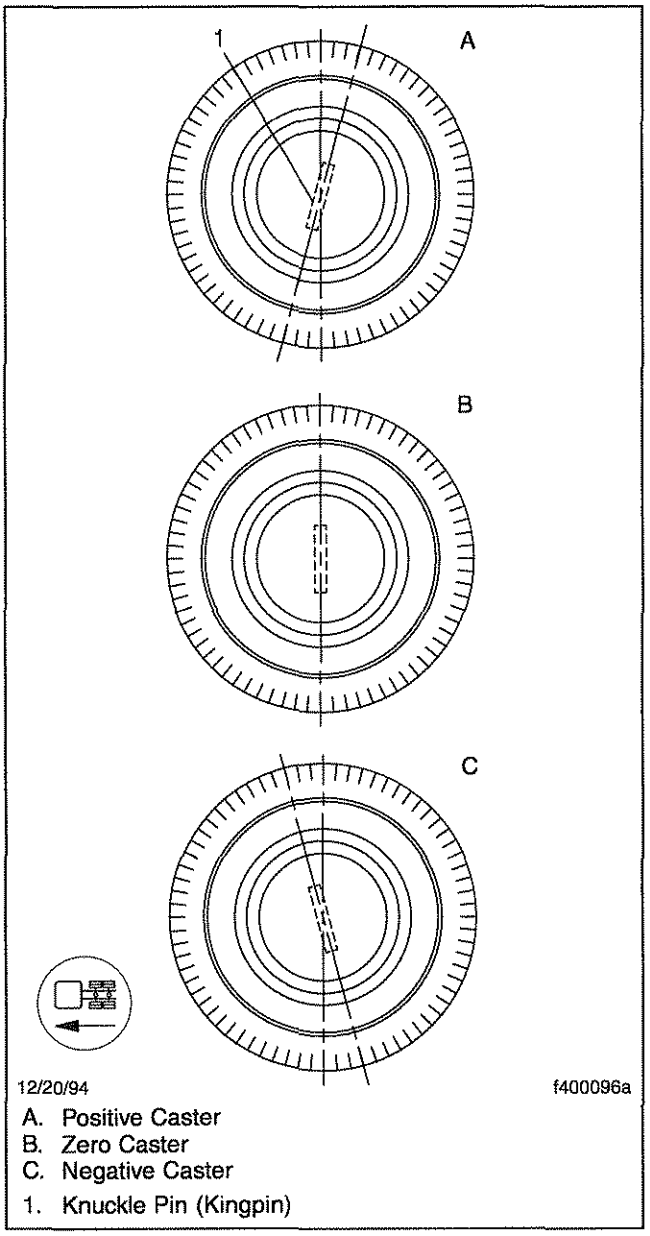
WARNING: Do not attempt to straighten any twisted or bent front axle component. This could crack or weaken the component, possibly resulting in a collapsed front axle, loss of a wheel, and serious personal injury.

7. Remove the chocks from the tires.

Caster Angle Checking and Adjusting

Checking and Adjusting (See Fig. 1)

IMPORTANT: For vehicle alignment to be accurate, the shop floor must be level in every direction. The turn plates for the front wheels must rotate freely without friction, and the alignment equipment must be calibrated every three months by a qualified technician from the equipment manufacturer. Freightliner dealers must have proof of this calibration history.



A. Positive Caster
B. Zero Caster
C. Negative Caster
1. Knuckle Pin (Kingpin)

Fig. 1, Caster Angle

Using the alignment equipment manufacturer's operating instructions, measure the front wheel caster.

Compare the caster angles with those shown the appropriate table in **Specifications, 400**. If needed, adjust the caster angle by placing wedge-shaped shims between the axle spacer and the axle beam, as follows **(see Fig. 2)**:

IMPORTANT: Extreme angle shims cannot be used to correct caster angles that vary by more than 2 degrees from the values in the table. Weak or broken leaf springs, or worn shackle bushings, can cause extreme deviations to caster angles. Replace damaged parts before doing caster adjustments.

1. Apply the parking brakes, and chock the front and rear tires.
2. Back off the U-bolt nuts from the U-bolts on one side of the front axle. **See Fig. 2.**
3. Raise the spring away from the axle enough to allow removal of the front caster shim.
4. Remove the shim, and install one that will provide the correct caster angle, as specified in the table in **Specifications, 400**. Install the dowel pin and check penetration.

IMPORTANT: Place front caster shims between the axle beam and the axle spacer, or between the axle beam and the shock absorber bracket. **See Fig. 2.**

5. Lower the vehicle onto the axle.
6. Coat the threaded ends of the U-bolts with chassis lube or an antiseize compound, such as Loctite® 242. Tighten the U-bolt nuts to the value in the appropriate table in **Specifications, 400**.

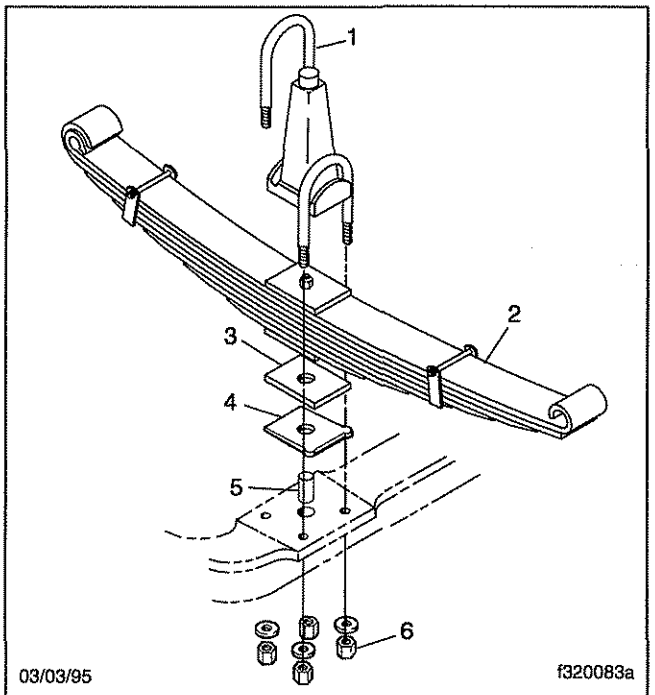
   U-bolt nuts need periodic retightening. Refer to the suspension section in the vehicle maintenance manual for recommended intervals.

⚠ CAUTION

CAUTION: Failure to periodically retighten the U-bolt nuts could result in spring breakage and abnormal tire wear.

7. Using the steps above, replace the shim on the other side of the axle.

Caster Angle Checking and Adjusting



1. Axle Spring U-Bolt
2. Leaf Spring Assembly
3. Spacer
4. Front Caster Shim
5. Dowel Pin
6. U-Bolt High Nut

Fig. 2, Axle Spring Installation

8. Remove the chocks from the tires. Do a final caster angle check.

Wheel Toe-In Checking and Adjusting

Checking and Adjusting (See Fig. 1)

Using the alignment equipment manufacturer's operating instructions, measure the wheel toe-in. Compare the measurement with that shown in the appropriate table in **Specifications, 400**. If corrections are needed, go to the applicable (tie rod adjustment) step below.

IMPORTANT: For vehicle alignment to be accurate, the shop floor must be level in every direction. The turn plates for the front wheels must rotate freely without friction, and the alignment equipment must be calibrated every three months by a qualified technician from the equipment manufacturer. Freightliner dealers must have proof of this calibration history.

1. Apply the parking brakes, and chock the rear tires.
2. Raise the front of the vehicle until the tires clear the ground. Place safety stands under the axle. Make sure the stands will support the weight of the cab, axle, and frame.
3. Using spray paint or a piece of chalk, mark the entire center rib of each front tire.
4. Place a scribe or pointed instrument against the marked center rib of each tire, and turn the tires. The scribes must be held firmly in place so that a single straight line is scribed all the way around each tire.
5. Place a turn-plate or turntable under each tire. Remove the safety stands from under the axle, then lower the vehicle. Remove the lockpins from the gauges; make sure the tires are exactly straight ahead.

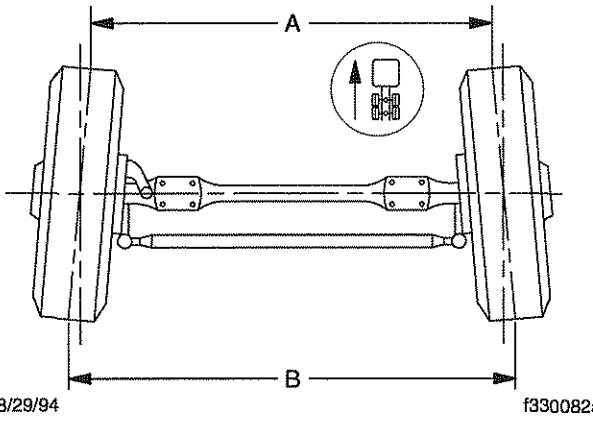
NOTE: If turn-plates or turntables are not available, lower the vehicle. Remove the chocks from the rear tires and release the parking brakes. Move the vehicle backward and then forward about six feet (2 meters).

6. Place the trammel bar at the rear of the front tires; locate the trammel pointers at spindle height, and adjust the pointers to line up with the scribe lines. Lock in place. Make sure that the scale is set on zero.
7. Place the trammel bar at the front of the tires as shown in **Fig. 2**. Adjust the scale end so that the pointers line up with the scribe lines. **See Fig. 3.**
8. Read the toe-in from the scale. Compare the toe-in with the value in the appropriate table in **Specifications, 400**. If corrections are needed, go to the next step.
9. Loosen the tie rod (cross tube) clamp nuts, and turn the tie rod as needed.

   If the vehicle is not on turn-plates or turntables, move the vehicle backward and then forward about six feet (two meters). This is important when setting the toe-in on vehicles equipped with radial tires.

   Do a final wheel toe-in check to make sure that it is correct.

   Tighten the clamp nuts to the values in the appropriate table in **Specifications, 400**.
10. If not already done, remove the chocks from the rear tires. Road test the vehicle.



NOTE: B minus A equals toe-in.

Fig. 1, Wheel Toe-In (Overhead View)

Wheel Toe-In Checking and Adjusting

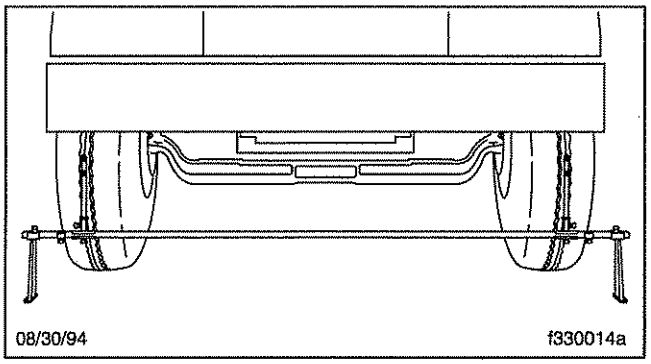


Fig. 2, Trammel Bar Positioning

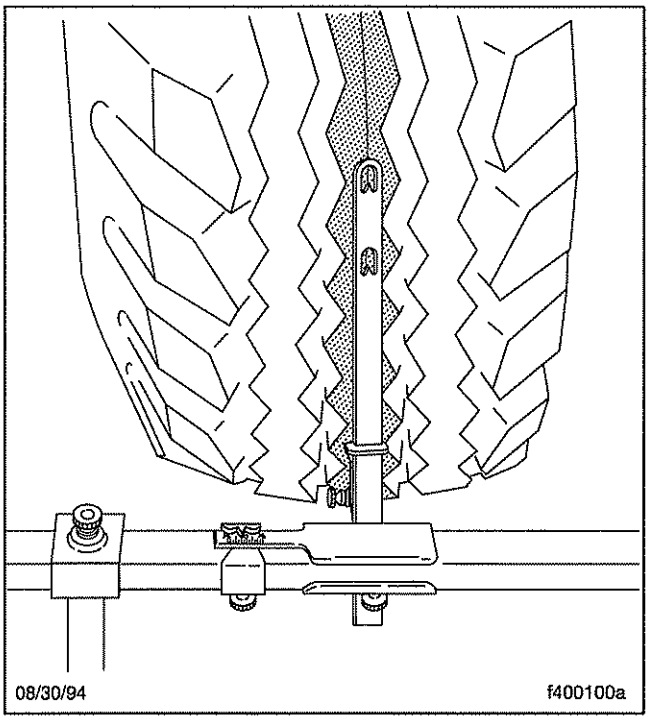


Fig. 3, Calculating Wheel Toe-In

Front Axle Removal and Installation

Removal

NOTE: This procedure involves removing the axle from underneath the front of the vehicle. If you cannot support the vehicle high enough for the axle to clear the bumper, then you will need to remove the bumper.

1. Park the vehicle on a level surface, set the parking brakes, then chock the rear tires.
2. Tilt the hood or cab. For cab tilt instructions, see **Group 60**.
3. Raise the vehicle, then support the frame rails with safety stands.
4. Remove the front tires.
5. If so equipped, disconnect the ABS sensors from the axle knuckles. Pull the sensors straight out.

⚠ WARNING

When draining the air system, don't look into the air jets or direct them toward another person, as dirt or sludge particles may be in the airstream. Don't disconnect pressurized hoses because they may whip as air escapes from the line. Failure to take all necessary precautions while working on the air brake system can cause personal injury.

6. Drain the air tanks.
7. Disconnect the air lines from the front brake chambers.
8. Remove the brake drums. See **Group 42** for instructions.
9. Remove the hubs. Refer to the applicable subject in **Section 33.01** for instructions.
10. Disconnect the steering drag link from the axle steering arm. See **Group 46** for instructions.
11. If needed, remove the front bumper. See **Group 31** for instructions.
12. Remove the U-bolts and nuts holding the axle to the leaf springs.
    - 12.1 Take the weight off the leaf springs by raising the axle.
    - 12.2 On one side of the axle, remove all the U-bolt nuts and washers, then remove the two U-bolts.
    - 12.3 Repeat the procedure on the other side of the axle.
13. Remove the axle stops from the top of the leaf springs.
14. Remove the axle spacers from the top of the axle beam.
15. Using a suitable axle jack, remove the axle by sliding it out from the front of the vehicle.
16. Remove the brake shoes, cam, and spider. See **Group 42** for instructions.

Installation

1. From the front of the vehicle, and using a suitable axle jack, roll the axle into place under the leaf springs.
2. Install the axle spacers.
3. Slowly raise the axle up to the bottom of the leaf springs, making sure the dowels on top of the axle beam line up with the holes in the axle spacers.
4. Install the axle stops onto the tops of the leaf springs.
5. Install the U-bolts.
    - 5.1 Using a suitable clamp (such as a large C-clamp) compress one of the U-bolts, then install it on one side of the axle. Do the same for the second U-bolt.
    - 5.2 Install the U-bolt nuts and washers. Tighten the nuts finger-tight.
    - 5.3 Repeat the procedure on the other side of the axle.
6. Tighten the U-bolt nuts.

    For 3/4–16 U-bolt nuts: In a diagonal pattern, tighten the U-bolt nuts successively 80 lbf·ft (108 N·m), 200 lbf·ft (270 N·m), then 300 lbf·ft (406 N·m).

    For 7/8–16 U-bolt nuts: In a diagonal pattern, tighten the U-bolt nuts successively 60 lbf·ft (81

Front Axle Removal and Installation

N·m), 200 lbf·ft (270 N·m), then 460 lbf·ft (624 N·m).

7. Install the brake spider, cam, and brake shoes. See **Group 42** for instructions.
8. If so equipped, install the ABS sensors in the axle knuckles.
9. Connect the air lines to the brake chambers.
10. Connect the drag link to the steering arm. See **Group 46** for instructions.
11. Install the tires.
12. If it was removed, install the bumper. See **Group 31** for instructions.
13. Raise the vehicle, then remove the safety stands.
14. Lower the vehicle.
15. Lower the hood or return the cab to the operating position. For cab tilt instructions, see **Group 60**.
16. Remove the chocks from the rear tires.

Specifications

IMPORTANT: When aligning the front axle, it is essential that the rear axle(s) be checked for correct alignment at the same time. Alignment of the rear axle(s) has a direct impact on how the vehicle tracks. See **Section 35.00**, Specifications 400.

Left-Hand-Drive Camber and Toe-In					
Axle Manufacturer	**Axle Model**	**Left Camber* Degrees**	**Right Camber* Degrees**	**Toe-In Limits inch (mm)**	**Toe-In Target inch (mm)**
Meritor	FF–981 FF–961 FG–941	–1/4 ± 7/16	–1/4 ± 7/16	0 to +1/8† (0 to +3.2)	+1/16 (+1.6)
Dana Spicer	1200I, 1320I, 1460I	+3/16 ± 7/16	–1/16 ± 7/16		

* Camber angle under axle rated load with axle installed in vehicle.
† If adjustment is required, set the toe-in as close as possible to +1/16 inch.

Table 1, Left-Hand-Drive Camber and Toe-In

Left-Hand-Drive Caster					
Axle Manufacturer	**Beissbarth Degrees**	**Bee Line**		**Hunter Degrees**	**Target, All Models Degrees**
		Except LC 4000 Degrees	**LC 4000 Degrees**		
Meritor, Freightliner, and Dana Spicer	+3 to +6-1/2	+3 to +6-1/2	+2-1/4 to +4-3/4	+1-1/2 to +5	Left +3-1/2; Right +4
IMPORTANT: Caster settings for the left and right sides *must* be within 1/2 degree of each other. It is necessary for only one side to be within the specifications given in this table.					

Table 2, Left-Hand-Drive Caster

Tie Rod Clamp Nut Torque Values				
Axle Manufacturer	**Axle Model**	**Tie Rod Clamp Nut Size**	**Plain Nut Torque* lbf.ft (N.m)**	**Locknut Torque* lbf.ft (N.m)**
Meritor	FF–981 FF–961 FG–941	5/8-11	40-60 (54-81)	40-60 (54-81)
Dana Spicer	1200I 1320I 1460I	5/8-18	—	45-60 (61-81)

* All torque values in this table apply to parts lightly coated with rust-preventive type oil.

Table 3, Tie Rod Clamp Nut Torque Values

Specifications

Miscellaneous Torque Values	
Description	**Torque lbf.ft (N·m)**
U-Bolt Nuts 7/8-14	400 (542)
Meritor Stopscrew Locknut	50-65 (68-88)
Dana Spicer Stopscrew Locknut	90-120 (122-163)

Table 4, Miscellaneous Torque Values

Right-Hand-Drive Bias Camber and Toe-In					
Axle Manufacturer	**Axle Model**	**Curb Side Camber* Degrees**	**Driver Side Camber* Degrees**	**Toe-In Limits inch (mm)**	**Toe-In Target inch (mm)**
Meritor	FG–941	–1/2 ± 7/16	3/4 ± 7/16	0 to +1/8† (0 to +3.2)	+1/16 (+1.6)

* Camber angle under axle rated load with axle installed in vehicle.
† If adjustment is required, set the toe-in as close as possible to +1/16 inch.

Table 5, Right-Hand-Drive Bias Camber and Toe-In

Right-Hand-Drive Caster					
Axle Manufacturer	**Beissbarth Degrees**	**Bee Line**		**Hunter Degrees**	**Target, All Models Degrees**
		Except LC 4000 Degrees	**LC 4000 Degrees**		
Meritor	+3 to +6-1/2	+3 to +6-1/2	+2-1/4 to +4-3/4	+1-1/2 to +5	Left +4; Right +3-1/2
IMPORTANT: Caster settings for the left and right sides *must* be within 1/2 degree of each other. It is necessary for only one side to be within the specifications given in this table.					

Table 6, Right-Hand-Drive Caster

Contents

Subject	Subject Number
General Information	050
Service Operations	
Hub Assembly Removal and Installation	100
Outboard-Mounted Drum Removal and Installation	105
Axle Components Cleaning and Inspection	110
Wheel Bearing Cup Removal and Installation, Aluminum Hubs	115
Wheel Bearing Cup Removal and Installation, Ferrous Hubs	120
Wheel Stud Replacement	125
Four-Piece Wheel Bearing System Installation and Adjustment	130
Con Met PreSet® Hub Installation and Adjustment	135
Meritor Unitized Wheel-End Installation and Adjustment	140
Meritor Unitized Wheel-End End Play Checking	145
Pro-Torq Nut® Wheel Bearing System Installation and Adjustment	150
Troubleshooting	300
Specifications	400

General Information

These vehicles are equipped with one of four different wheel end assemblies:

- The Con Met PreSet® Hub

  This wheel end has the bearings and oil seal pre-installed in a hub. To install a new hub, mount it on the axle spindle, and secure it with an Axi-Lok® nut. For instructions, see **Subject 135.** A spacer between the inner and outer bearings adjusts the bearings to near zero end-play and preload when you tighten the retaining nut.

- The Meritor Easy Steer Plus® Axle, Model FF-981

  This axle has the hubs, bearings, and oil seals factory-installed on the axle spindles. The hubs can be removed and installed on the axle, and the studs can be replaced, but the wheel bearings and oil seal are not serviceable in the field. To install a new hub, mount it on the axle spindle, and secure it. For instructions, refer to **Subject 140.**

- The traditional hub and bearings

  With traditional wheel ends, the bearings and oil seal must be assembled with the hub when the hub is installed on the axle spindle. First the oil seal is placed on the spindle (some brands of oil seal are installed in the hub bore), then the inner bearing and the hub are mounted on the axle spindle. Then, the outer bearing is mounted in the hub bore. A nut is installed on the axle spindle end and tightened and loosened to adjust the bearings. Finally, a locking device and jam nut are installed to secure the hub and bearings on the axle. For instructions, refer to **Subject 130.**

- Pro-Torq® nut system. This system has one adjusting nut and a lockring device. For instructions, see **Subject 150.**

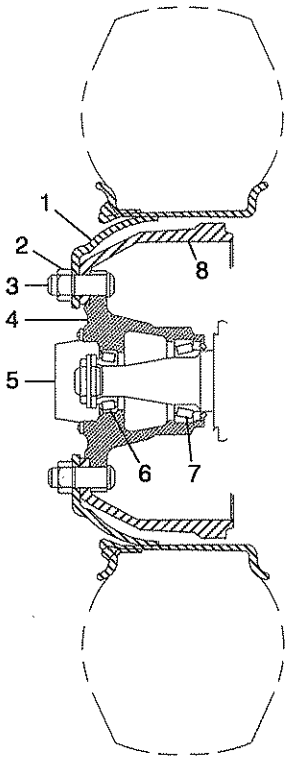
All wheel hub assemblies consist of the following components (see **Fig. 1**):

- Wheel Bearings
- Wheel Hub
- Wheel Studs
- Brake Drum

TAPERED WHEEL BEARINGS

A traditional tapered wheel bearing assembly consists of a cone, tapered rollers, a roller cage, and a separate cup that is press-fit in the hub. See **Fig. 2**. All components carry the load, with the exception of the cage, which spaces the rollers around the cone.

Each hub has a set of inner and outer tapered wheel bearing assemblies. On traditional hub and bearing assemblies, the bearing setting is locked in place on the axle spindle (steering knuckle) by an adjusting nut, a locking device such as a lockring or nut-lock, and a jam nut, or a Pro-Torq nut. See **Fig. 3**.



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1. Disc Wheel
2. Wheel Nut
3. Wheel Stud
4. Hub
5. Hub Cap
6. Outer Wheel Bearing
7. Inner Wheel Bearing
8. Brake Drum

Fig. 1, Wheel Assembly, Cutaway View

General Information

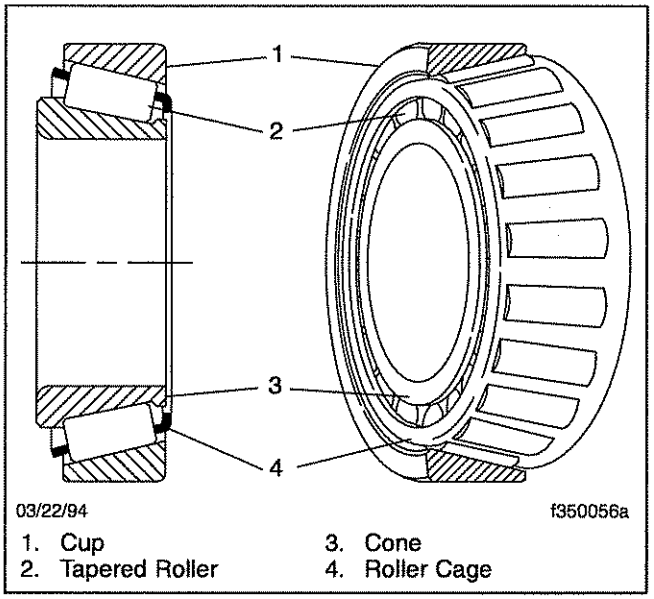


Fig. 2, Tapered Wheel Bearing Assembly

WHEEL HUB

The wheel and the brake drum are mounted on an aluminum or iron wheel hub (**Fig. 4**).

Both the inner and outer wheel bearing cups and the wheel studs are press-fit in the hub.

WHEEL STUDS

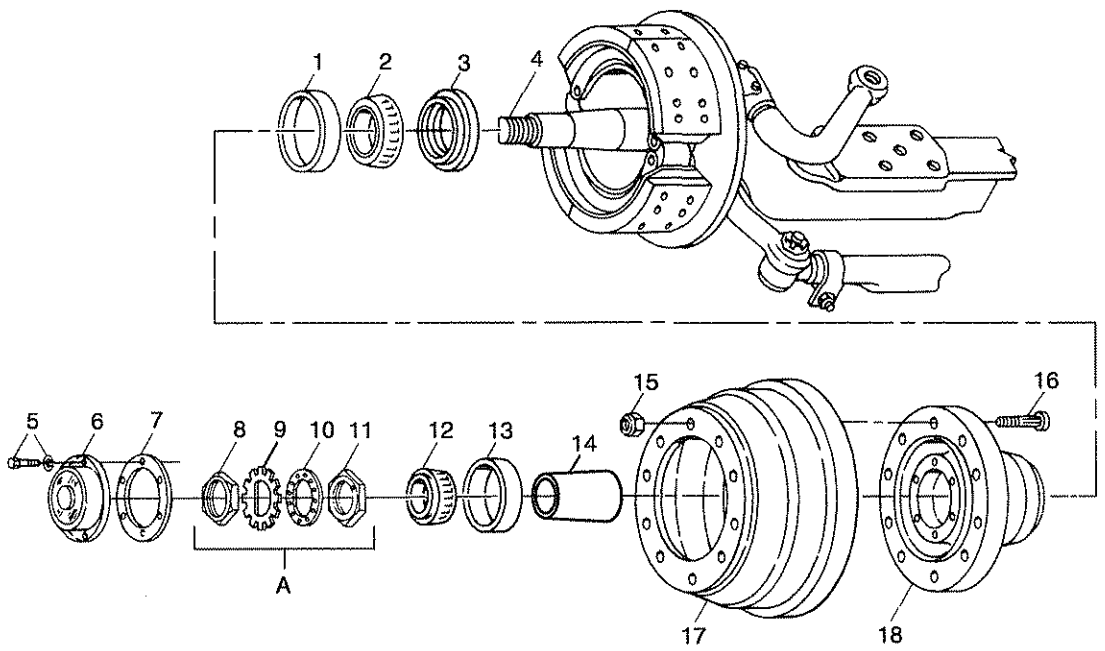
A headed wheel stud (**Fig. 5**) is used on front axle disc wheel hub assemblies and has either serrations on the stud body or a flat area on the stud's head to prevent the stud from turning in the wheel hub.

The end of the stud that faces away from the vehicle is stamped with an "L" or "R," depending on which side of the vehicle the stud is installed. Studs stamped with an "L" are left-hand threaded and are installed on the left side of the vehicle. Studs stamped with an "R" are right-hand threaded and are installed on the right side of the vehicle.

BRAKE DRUM

The brake drum and lining work together as a mated friction pair, with the drum responsible for both heat absorption and dissipation. Lining performance and life largely depend on the condition of the drum and whether it can adequately absorb and dissipate heat generated by braking action.

The brake drum is mounted on the outboard face of the hub and fits over the wheel studs. See **Fig. 3.**



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NOTE: On Meritor FF-981 Easy Steer Plus axles, the hub, wheel bearings, studs, and oil seal are assembled at Meritor and installed as an assembly.

A. Four-piece bearing system shown; Pro-Torq or Axi-Lok locking nuts could be used.

1. Inner Wheel Bearing Cup
2. Inner Wheel Bearing
3. Oil Seal
4. Axle Spindle
5. Hub Cap Capscrew
6. Hub Cap
7. Gasket
8. Jam Nut
9. Nut-Lock
10. Lockring
11. Adjusting Nut
12. Outer Wheel Bearing
13. Outer Bearing Cup
14. Bearing Spacer (used only with Con Met PreSet hubs)
15. Wheel Nut
16. Wheel Stud
17. Brake Drum
18. Hub

Fig. 3, Typical Wheel and Axle Assembly

General Information

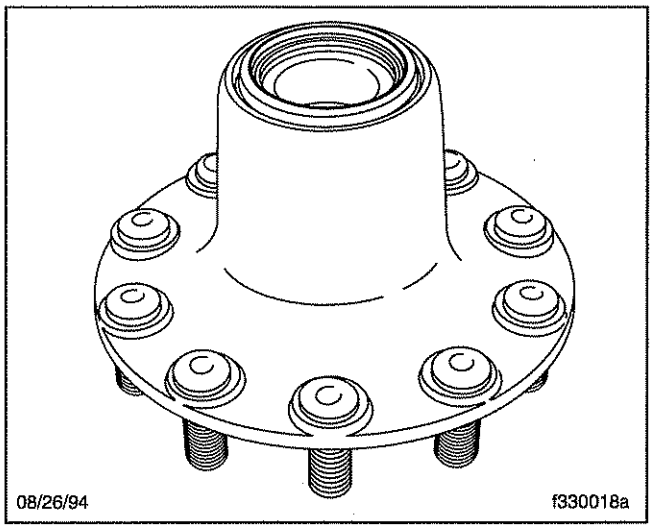
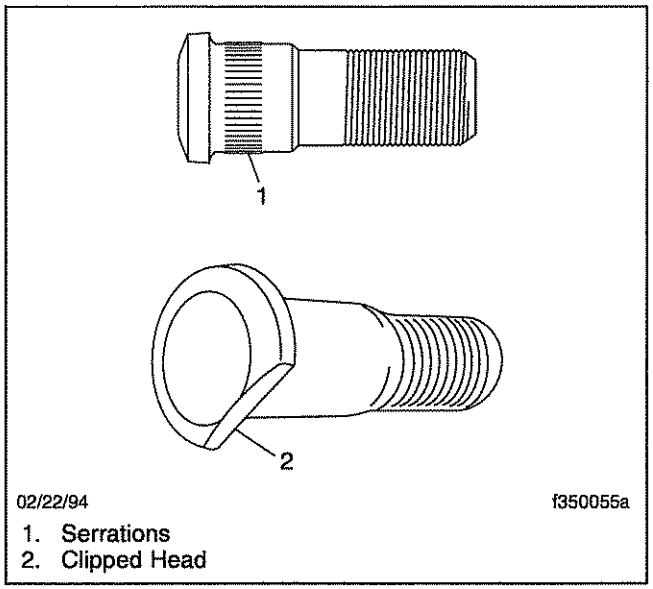


Fig. 4, Front Axle Wheel Hub



1. Serrations
2. Clipped Head

Fig. 5, Typical Wheel Studs

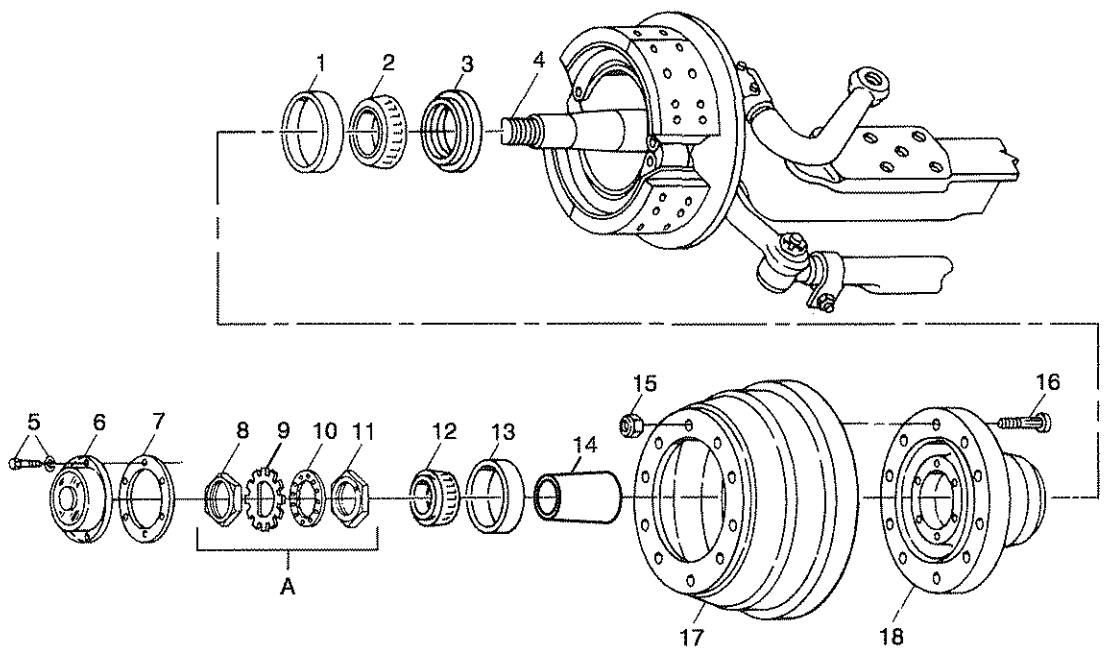
Hub Assembly Removal and Installation

Removal (See Fig. 1)

1. Chock the rear tires.
2. Raise the front of the vehicle until the tires clear the ground. Then place safety stands under the axle.
3. Back off the slack adjuster to release the front axle brake shoes.
4. Remove the wheel and tire assembly. Refer to **Group 40** in this manual for instructions.
5. Remove the brake drum. For instructions, refer to **Subject 105**.

NOTE: Oil will spill as the hub cap and wheel hub are removed. Place a suitable container under the axle spindle to catch any spilled oil, and avoid contaminating the brake shoes with oil. Discard the oil.

6. Remove the capscrews, washers, and hub cap. Remove and discard the hub cap gasket.
7. If working with Con Met PreSet® or Meritor Easy Steer Plus® hubs, remove the nut(s) and locking device and remove the wheel end (hub, bearings and oil seal) as a unit.



NOTE: On Meritor FF-981 Easy Steer Plus axles, the hub, wheel bearings, studs, and oil seal are assembled at Meritor and installed as an assembly.

A. Four-piece bearing system shown; Pro-Torq® or Axi-Lok® locking nuts could be used.

1. Inner Wheel Bearing Cup
2. Inner Wheel Bearing
3. Oil Seal
4. Axle Spindle
5. Hub Cap Capscrew
6. Hub Cap
7. Gasket
8. Jam Nut
9. Nut-Lock
10. Lockring
11. Adjusting Nut
12. Outer Wheel Bearing
13. Outer Bearing Cup
14. Bearing Spacer (used only with Con Met PreSet® hubs)
15. Wheel Nut
16. Wheel Stud
17. Brake Drum
18. Hub

Fig. 1, Typical Wheel and Axle Assembly

Hub Assembly Removal and Installation

If working with a traditional hub and bearing assembly, remove the jam nut, locking device(s), and adjusting nut.

If working with a Pro-Torq® nut system, remove the lockring, then remove the nut.

⚠ CAUTION

When moving the hub, be careful not to let the outer wheel bearing drop from the axle spindle. If the wheel bearing is dropped, cage warpage or roller damage can occur. On vehicles equipped with WABCO ABS, use care when working with the hubs. The ABS tone wheel is permanently pressed onto the hub and cannot be repaired. The tone wheel and the hub must be replaced as a unit if either is damaged. To prevent damage to the tone wheel, do not drop the hub or lay it down in a way that would damage the tone wheel.

7.1 If working with a traditional hub and bearing assembly, move the hub about 1/2 inch (13 mm) to jar loose the outer wheel bearing (allow the hub-only assembly to rest on the axle spindle; be careful not to damage the axle spindle threads).

7.2 Carefully remove the outer wheel bearing; handle the bearings with clean, dry hands. Wrap the bearings in either clean oil-proof paper or lint-free rags.

⚠ CAUTION

Do not spin bearing rollers at any time. Dirt or grit can scratch the roller surface and cause rapid wear of the bearing assembly. Treat used bearings as carefully as new ones.

7.3 Remove the hub from the axle spindle. Be careful not to damage the axle spindle threads as the assembly is removed.

7.4 Remove the inner wheel bearing from the axle; handle the bearings with clean, dry hands. Wrap the bearings in clean, oil-proof paper or lint-free rags. Occasionally, the inner wheel bearing will remain in the hub after the hub is removed. In those cases, place a protective cushion where it will catch the bearings. Use a hardwood drift and a light hammer to gently tap the bearing (and seal, if necessary) out of the cup.

7.5 Remove the oil seal from the axle spindle, if not already removed. Refer to **Section 33.02** for additional information.

Installation

⚠ WARNING

Breathing brake lining dust (asbestos or non-asbestos) could cause lung cancer or lung disease. OSHA has set maximum levels of exposure and requires workers to wear an air purifying respirator approved by MSHA or NIOSH. Wear a respirator at all times when servicing the brakes, starting with removal of the wheels and continuing through assembly.

1. Using cleaning solvent, remove the old oil from the axle spindle (steering knuckle) and the disassembled parts. Allow the parts to dry, or dry them with a clean, absorbent, and lint-free cloth or paper. Wrap a protective layer of friction tape on the axle spindle threads.
2. On brake drum assemblies with an aluminum hub, coat the hub and drum contact surfaces with Alumilastic® compound or an equivalent.

⚠ CAUTION

Make sure that both bearing assemblies are coated with fresh oil. Use only fresh oil on the bearing assemblies; old oil could be contaminated with dirt or water (both are corrosives) and could cause damage to both wheel bearing assemblies and the wheel hub.

3. If working with traditional hub and bearing assemblies, coat both bearing assemblies with fresh oil. Install the inner wheel bearings and oil seal. Handle the bearings with clean, dry hands. Refer to **Section 33.02** for oil seal installation instructions.
4. Wipe a film of axle oil on the axle spindle to prevent rust from forming behind the inner wheel bearing.

Hub Assembly Removal and Installation

⚠ CAUTION

On vehicles equipped with WABCO ABS, use care when installing the hubs. The ABS tone wheel is permanently pressed onto the hub and cannot be repaired. The tone wheel and the hub must be replaced as a unit if either is damaged. To prevent damage to the tone wheel, do not drop the hub or lay it down in a way that would damage the tone wheel.

5. Mount the hub assembly on the axle spindle.
6. Adjust the wheel bearings according to the instructions in the applicable wheel bearing subject in this section.

   For traditional hub and bearing assemblies, refer to **Subject 130**.

   For Con-Met PreSet hubs, refer to **Subject 135**.

   For Meritor Easy Steer Plus axle ends, refer to **Subject 140**.

   For the Pro-Torq nut system, see **Subject 150**.
7. Place the hub cap and a new gasket in position, then install the washers and capscrews. Tighten the capscrews to the torque values in the torque table in **Specifications, 400**.
8. If applicable, add fresh oil to the wheel hub to the level indicated on the hub cap. For the recommended axle lubricants, see **Specifications, 400**.

⚠ WARNING

Failure to add oil to the wheel hub after the hub has been serviced will cause the wheel bearings to overheat and seize during vehicle operation. Seized bearing rollers can cause sudden damage to the tire or axle, possibly resulting in personal injury.

9. Install the brake drum on the wheel hub. For instructions, refer to **Subject 105** in this section.

⚠ WARNING

If the wheel nuts cannot be tightened to minimum torque values, the wheel studs have lost their locking action, and the wheel hub flange is probably damaged. In this case, replace it with a new wheel hub assembly. Failure to replace the wheel hub assembly when the conditions described above exist could result in the loss of a wheel or loss of vehicle control, and possible personal injury.

10. Install the wheel and tire assembly. Refer to **Group 40** for instructions.
11. Adjust the front axle brakes. Refer to the brake section in the vehicle maintenance manual.
12. Remove the safety stands from under the axle; lower the vehicle.
13. Remove the chocks from the rear tires.

Outboard-Mounted Drum Removal and Installation

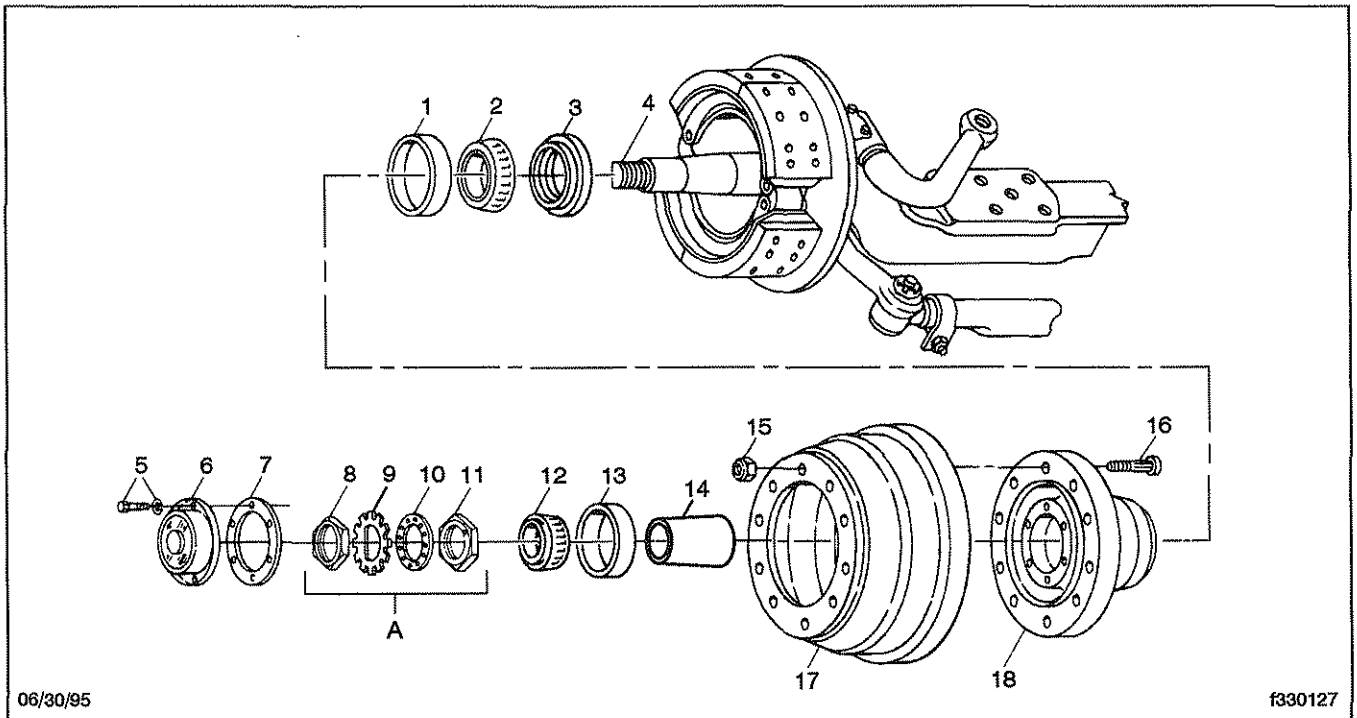
Removal (See Fig. 1)

1. Chock the rear tires to prevent vehicle movement. Apply the parking brakes.
2. Raise the front of the vehicle until the tires clear the ground. Then place safety stands under the axle.
3. Back off the slack adjuster to release the front axle brake shoes.

WARNING: Breathing brake lining dust (asbestos or non-asbestos) could cause lung cancer or lung disease. OSHA has set maximum levels of exposure and requires workers to wear an air purifying respirator approved by MSHA or NIOSH. Wear a respirator at all times when servicing the brakes, starting with removal of the wheels and continuing through assembly.

4. Remove the wheel and tire assembly. Refer to **Group 40** for instructions.

   To minimize the possibility of creating airborne brake lining dust, clean the dust from the brake



NOTE: On Rockwell FF-981 Easy Steer Plus axles, the hub, wheel bearings, studs, and oil seal are assembled at Rockwell and installed as an assembly.

A. Four-piece bearing system shown, Pro-Torq or Axi-Lok locking nuts could be used.

1. Inner Wheel Bearing Cup
2. Inner Wheel Bearing
3. Oil Seal
4. Axle Spindle
5. Hub Cap Capscrew
6. Hub Cap
7. Gasket
8. Jam Nut
9. Nut-Lock
10. Lockring
11. Adjusting Nut
12. Outer Wheel Bearing
13. Outer Bearing Cup
14. Bearing Spacer (used only with Con-Met integral wheel bearing packs)
15. Wheel Nut
16. Wheel Stud
17. Brake Drum
18. Hub

Fig. 1, Typical Wheel and Axle Assembly

Outboard-Mounted Drum Removal and Installation

drum, brake backing plate, and brake assembly, using an industrial-type vacuum cleaner equipped with a high-efficiency filter system. Then, using a rag soaked in water and wrung until nearly dry, remove any remaining dust. Don't use compressed air or dry brushing to clean the brake assembly.

5. Remove the brake drum.
6. Inspect the drum. Refer to **Subject 110** for instructions.

Installation

1. On brake drum assemblies with an aluminum hub, coat the hub and drum contact surfaces with Alumilastic® compound or an equivalent.
2. Install the brake drum on the wheel hub.

   2.1 On hub-piloted drums, position the brake drum on the top step of the pilot pad. One of the hub's pilot pads should be at the twelve o'clock (top center) position. **See Fig. 2.**

   IMPORTANT: If the drum is not positioned correctly, the pilot pad could be damaged when the wheel nuts are torqued.

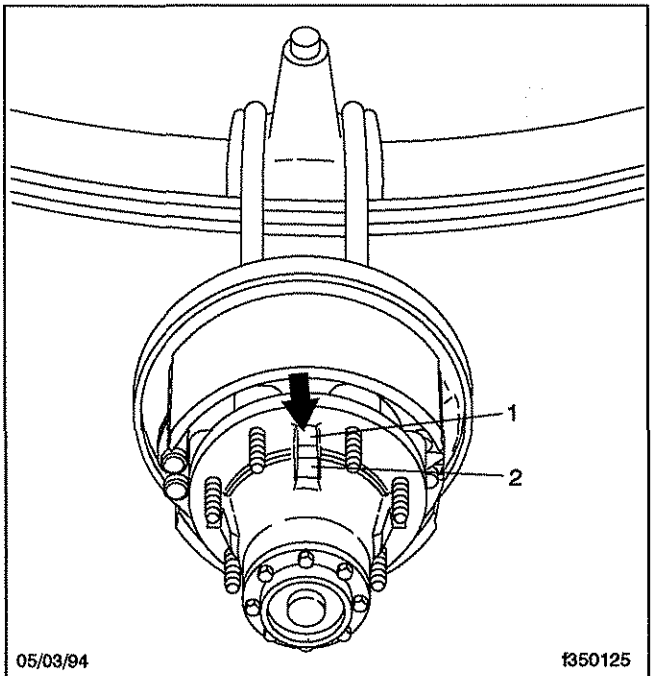
   2.2 Make sure that the pilot pads securely center the drum (space between drum and hub is equal all around the hub).

   IMPORTANT: If damage to the pads prevents the drum from centering, replace the hub. If necessary to hold the drum in position, adjust the brakes before installing the wheels.

3. Install the wheel and tire assembly. To ensure that the drum does not slip off the pilot pad, follow the proper nut tightening sequence. For instructions, refer to **Group 40.**

WARNING: If the wheel nuts cannot be tightened to minimum torque values, the wheel studs have lost their locking ability, and the hub flange is probably damaged. In this case, replace it with a new wheel hub assembly. Failure to replace the wheel hub assembly when the conditions described above exist, could result in the loss of a wheel or loss of vehicle control, and possible personal injury.

4. Adjust the front axle brakes. Refer to the brake section in the vehicle maintenance manual.
5. Remove the safety stands from under the axle; lower the vehicle.
6. Remove the chocks from the rear tires.



NOTE: Pilot pad at 12 o'clock position

1. Drum Pilot
2. Wheel Pilot

Fig. 2, Hub Pilot Pads

Wheel Hub Assembly Inspection

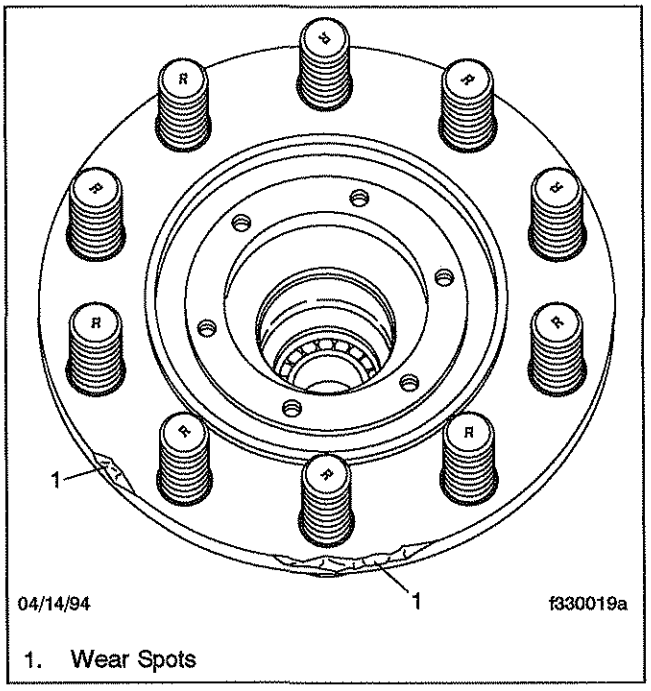
1. Inspect the wheel hub mounting flange. A loose wheel assembly will cause the flange to be worn, jagged, or warped. **See Fig. 1.** Replace the wheel hub if any of these conditions exist.

   Inspect the flange surface around the wheel studs. Improperly torqued wheel nuts will cause worn or cracked stud grooves on the hub. **See Fig. 2.** If wear spots or cracks appear anywhere on the hub, or if the hub is otherwise damaged, replace it with a new one.

2. Remove all the old oil from the wheel hub cavity. Inspect the inner surface of the hub for cracks, dents, wear, or other damage. Replace the wheel hub if damage exists.

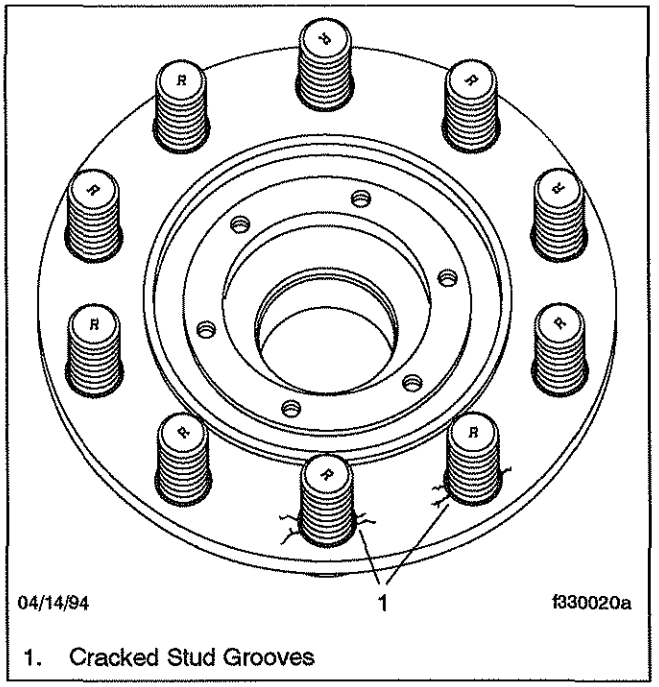
3. Remove all the old grease or oil from the surfaces of the wheel bearing cups. Inspect the wheel bearing cups for cracks, wear, spalling, or flaking. **See Fig. 3.** Replace the cups if damaged in any way. Refer to **Subject 115** or **Subject 120.**

4. Inspect the wheel nuts on disc wheel installations, or the rim nuts on spoke-wheel installations. Damaged nuts (**Fig. 4**), usually caused by inadequate tightening, must be replaced with new ones.



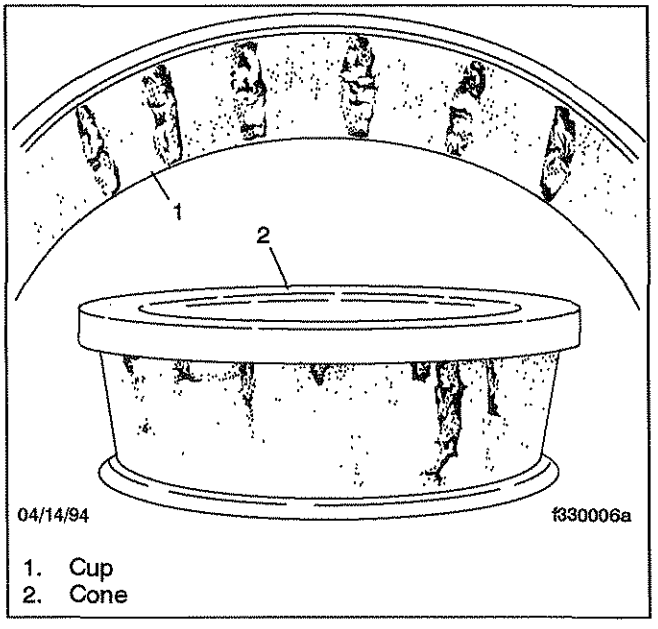
1. Wear Spots

Fig. 1, Damaged Front Axle Wheel Hub



1. Cracked Stud Grooves

Fig. 2, Damaged Front Axle Wheel Hub



1. Cup
2. Cone

Fig. 3, Spalling (Flaking) of Wheel Bearing Assembly

Axle Components Cleaning and Inspection

5. Inspect the wheel or rim studs. Replace studs that are stripped, broken, bent, or otherwise damaged. Refer to **Subject 125**.

Wheel Bearing Inspection

Wheel bearings should be very closely inspected at the time of disassembly. Optimal inspection conditions are possible only after the bearings have been thoroughly cleaned using kerosene or diesel fuel oil, and a stiff brush. Before inspecting, clean the bearings.

1. Remove the wheel hub and bearing cones. Refer to **Subject 100**.
2. Clean all old oil from the bearings and hub cavity with kerosene or diesel fuel and a stiff brush. Don't use gasoline or heated solvent.
3. Allow the cleaned parts to dry, or dry them with a clean absorbent cloth or paper. Clean and dry your hands and all tools used in the maintenance operation. Oil will not stick to a surface which is wet with kerosene or diesel fuel, and the kerosene or diesel fuel may dilute the lubricant.

CAUTION: Do not spin the bearing rollers at any time. Dirt or grit can scratch the roller surface and cause premature wear of the bearing assembly. Treat a used bearing as carefully as a new one.

4. After the bearings are cleaned, inspect the assemblies, which include the rollers, cones, cups, and cages. If any of the following conditions exist, replace the bearing assemblies:

   4.1 Large ends of rollers worn flush to the recess, or radii at the large ends of the rollers worn sharp. These are indications of advanced wear. **See Fig. 5.**

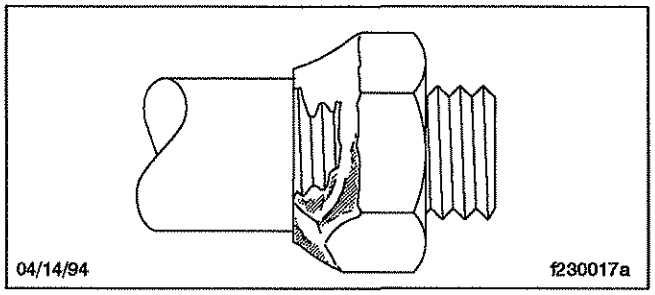
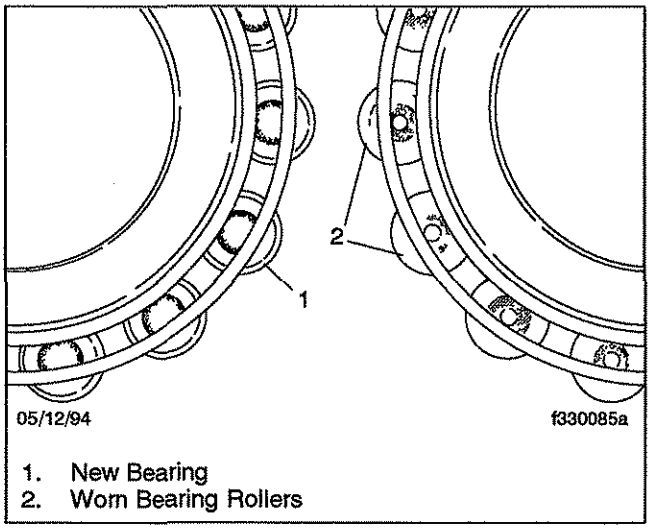


Fig. 4, Damaged Wheel Stud Nut

   4.2 Visible step wear, particularly at the small end of the roller track. Deep indentations, cracks, or breaks in the cone surfaces. **See Fig. 6.**

   4.3 Bright rubbing marks on the dark phosphate surfaces of the bearing cage. **See Fig. 7.**

   4.4 Water etch on any bearing surface. Water etch appears as gray or black stains on the steel surface, and it greatly weakens



1. New Bearing
2. Worn Bearing Rollers

Fig. 5, Wheel Bearing Roller Wear

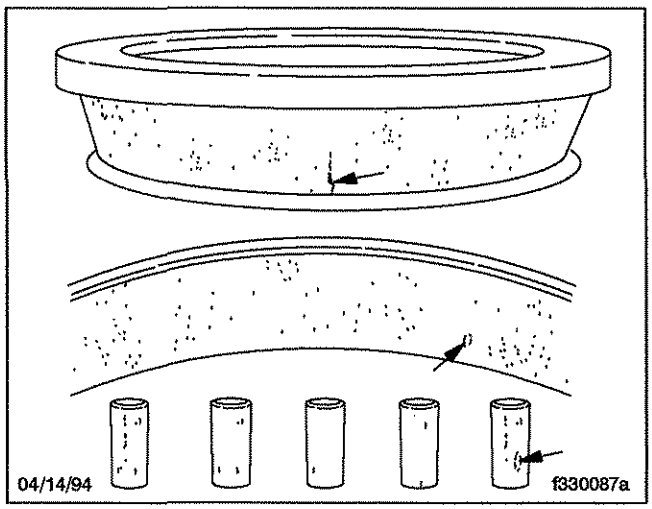


Fig. 6, Indentations, Cracks, or Breaks in Bearing Surfaces

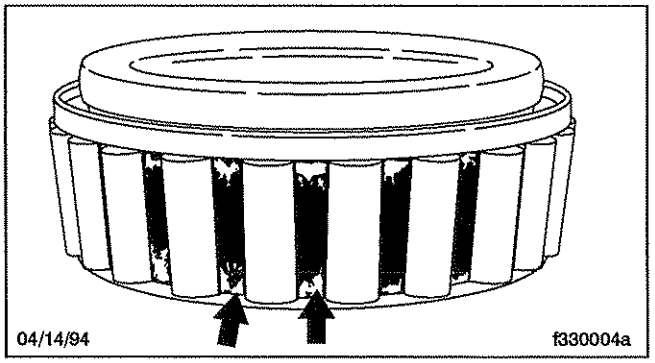


Fig. 7, Rubbing Marks on Bearing Cage

the affected area. If water etch is present, replace the bearing seals.

4.5 Etching or pitting on functioning surfaces. **See Fig. 8.**

4.6 Spalling (flaking) of the bearing cup, roller, or cone surfaces. **See Fig. 3.**

After inspection, brush the bearings with fresh axle lubricant.

Brake Drum Inspection

New brake drums are purposely undersized to allow for turning (remachining), since in mounting drums on the hub, there can be some eccentricity. If a new drum is installed, the protective coating on the inner friction surface must be removed with a solvent, prior to drum installation, then rinsed with a hot water wash. Use a clean rag to remove any oily residue or metal chips from the friction surface.

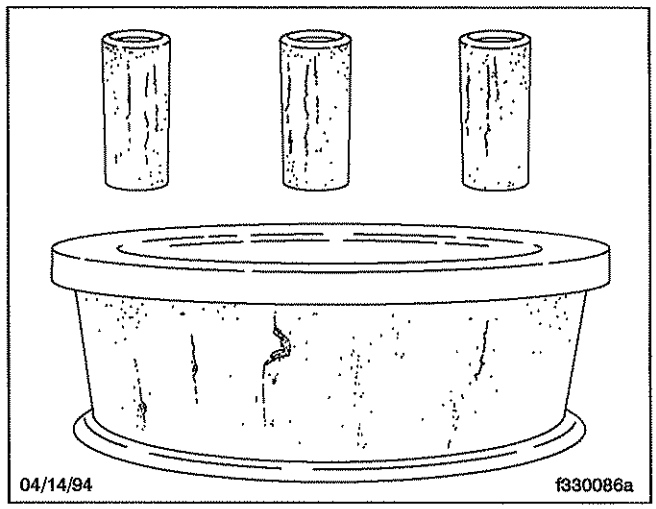


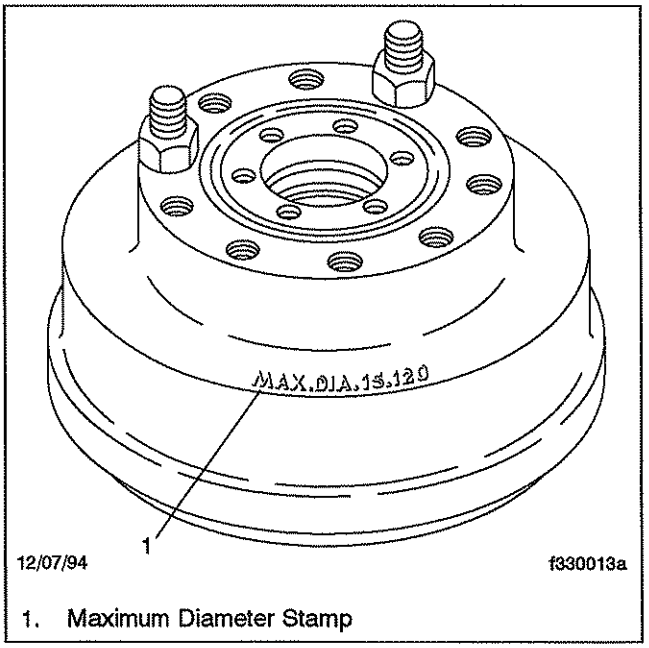
Fig. 8, Etching (Pitting) on Bearing Surfaces

If a drum must be turned or replaced, the other same-axle drum must be similarly turned or replaced to provide the same braking power on both wheels. Turned drums should not exceed the maximum allowable diameter, which is stamped on the outside surface of the drum. **See Fig. 9** for a typical location of this stamp.

NOTE: Drums that have been turned should then be cleaned by using fine emery cloth followed with a hot water wash. Drums that have been renewed using emery cloth should also be followed with a hot water wash.

CAUTION: Failure to replace drums when worn or turned to limits exceeding the maximum allowable diameter will cause drum weakness and reduced braking capacity, which can lead to distortion, higher drum temperatures, and ultimate drum breakage.

If the drums are turned or replaced, replace the brake linings. Refer to **Group 42** in this manual for instructions.



1. Maximum Diameter Stamp

Fig. 9, Outboard Mounted Hub and Drum Assembly

Axle Components Cleaning and Inspection

1. Inspect the inner friction surface. If a veneered (highly glossed) or glazed surface exists, renew the drum by using 80–grit emery cloth or by turning the drums.
2. Inspect for heat checking, which is a form of buckling (cracking) resulting from a temperature differential in the drum wall between a relatively cool exterior and a hot friction surface. Heat checking is normal on all drums and may not impair performance and lining life if the network of fine hairline cracks remains small. Examine heat checks of drums frequently to be certain the checks have not widened into drum weakening cracks (substantial cracks extending to the open edge of the drum). Replace the same-axle drums if substantial cracks are present, or if widening of the fine hairline cracks occurs.

NOTE: If normal heat checking as described above is present, inspect the drums at least every 12,000 miles (19 300 km) thereafter. Inspect the drums (using a flashlight from the inboard side of the wheels) every 6000 miles (9700 km). Inspect more often under adverse operating conditions.

3. Check for a contaminated inner friction surface. If fluids are present, such as oil or grease, remove the contaminants. Locate and correct the source of the contamination. If the brake drums are contaminated with fluids, the brake linings will also be affected. Since oil or grease saturated linings cannot be salvaged, they must be replaced. For brake lining replacement procedures, refer to **Group 42** in this manual.

WARNING: If the brake drums are contaminated with fluids, replace the brake linings. Failure to replace fluid contaminated brake linings could result in a partial loss of braking capacity, which could lead to personal injury or property damage.

4. Measure the inside diameter of the drum. If the measured diameter is greater than the maximum allowable diameter, replace the same-axle drums and linings.
5. Check for a variation in gauge readings at different points on the radius of the drum's working surface. If the variation is more than 0.010 inch (0.25 mm) at any point, the drum is out-of-round to unacceptable limits. Remachine or replace the same-axle drums.
6. Inspect the outside surface of the drum. Remove any accumulation of mud, dirt, or rust; foreign matter acts as an insulator, trapping heat within the drum.
7. Check for hard, slightly raised dark-colored spots on the inner friction surface or for a bluish cast on the brake parts, both of which are caused by high temperatures. If the drums' maximum allowable diameters have not been exceeded, remachine both same-axle drums. If the spots or discoloration cannot be removed, or if remachining is not possible, replace the drums. Also replace the brake shoe return springs.

Wheel Bearing Cup Removal and Installation, Aluminum Hubs

Removal (See Fig. 1)

To insure a tight fit, wheel bearing cups are purposely larger than the wheel hub bores they occupy. To remove the bearing cups, aluminum hub bores must be temporarily expanded by heating the hub in an oven (the bearing cups will also expand, but to a considerably lesser extent). If adequate heating facilities are not available, replace the hub, wheel stud, and bearing cup assembly.

1. Using a solvent, completely remove all grease, oil, and other debris from the outer and inner surfaces of the wheel hub assembly.
2. Oven-heat the hub to a temperature range of 240° to 280°F (116° to 138°C). Make sure the oven thermostat is accurately set; if unsure, use an oven thermometer to check the temperature of the oven before placing the hub inside.

   If adequate heating facilities are not available, replace the hub, wheel stud, and bearing cup assembly.

WARNING: Do not use oxyacetylene equipment or similar equipment to heat the hub. Oxyacetylene equipment or similar equipment will cause cracks in the hub which could cause loss of a wheel and loss of vehicle control, leading to personal injury or property damage.

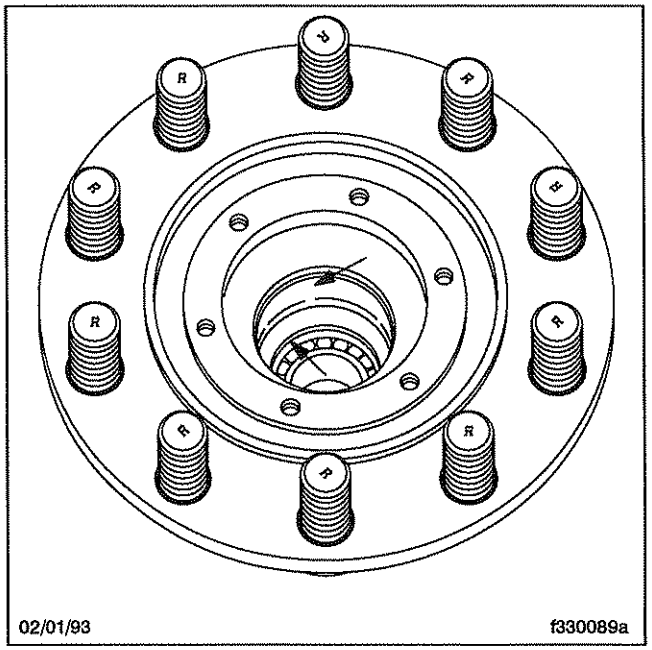


Fig. 1, Wheel Bearing Cup Locations

3. Wearing heavy protective gloves, remove the hub from the oven. Place the hub on a suitable press so that the base is fully supported. Quickly press out the bearing cups.

Installation

To install the bearing cups, aluminum hubs must again be temporarily expanded using oven heating. When the hub is properly heated, the bearing cup and hub can be press-fit together, using a suitable press.

1. Using a solvent, completely remove all grease, oil, and other debris from the outer and inner surfaces of the wheel hub assembly, including the bearing cup bores.
2. Inspect the bearing cup bores of the hub for warpage or uneven surfaces. If a bearing cup bore is damaged, replace the wheel hub assembly.
3. Oven-heat the hub to a temperature range of 240° to 280°F (116° to 138°C). Make sure the oven thermostat is accurately set; if unsure, use an oven thermometer to check the temperature of the oven before placing the hub inside.

WARNING: Do not use oxyacetylene equipment or similar equipment to heat the hub. Oxyacetylene equipment or similar equipment will cause cracks in the hub which could cause loss of a wheel and loss of vehicle control, leading to personal injury or property damage.

4. Coat the replacement bearing cup hub contact surface with a film of grease.
5. Wearing heavy protective gloves, remove the hub from the oven.
6. Place the hub on a suitable press so that the base is fully supported. Quickly press-fit the bearing cup into the wheel hub until it is completely and evenly seated. Be careful not to shave the sides of the bearing cup bore as the bearing cup is seated. The accumulation of debris will prevent the cup from being seated and will also cause permanent damage to the wheel hub. If the sides of the bearing cup bore are damaged during installation, replace the wheel hub assembly.

Wheel Bearing Cup Removal and Installation, Aluminum Hubs

7. Allow the wheel hub to cool before handling. Then, using a 0.0015–inch feeler gauge, check at several places for the seating of the bearing cup in the bearing cup bore. The gauge should not enter beneath the cup. If it does, there is probably dirt or debris preventing the cup from seating. Using the instructions above, remove the cup, then remove the foreign matter. Reinstall the cup.
8. Wipe off the accumulation of grease left after the bearing cup has been seated. Then, using a clean, lint-free cloth dampened with kerosene or diesel fuel oil, clean the inner surface of the bearing cup. Wipe the surface dry using a clean, absorbent, and lint-free cloth or paper.

Wheel Bearing Cup Removal and Installation, Ferrous Hubs

Removal

Wheel bearing cups on ferrous hubs are removed and installed by driving them out and pressing them in without heating the hub.

1. Using a solvent, completely remove all grease, oil, and other debris from the outer and inner surfaces of the wheel hub assembly.
2. Using a mild-steel rod through the opposite end of the hub, drive against the inner edge of the bearing cup. Alternately drive on opposite sides of the cup to avoid cocking the cup and damaging the inside of the hub.

Installation

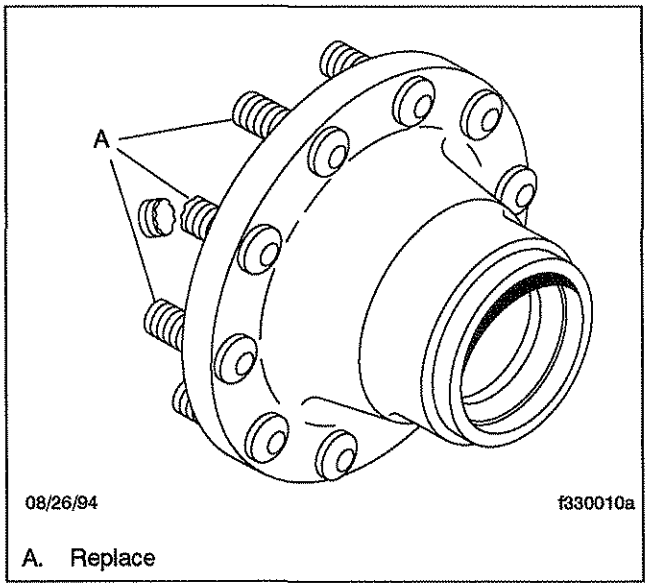
1. Using a solvent, completely remove all grease, oil, and other debris from the outer and inner surfaces of the wheel hub assembly, including the bearing cup bores.
2. Inspect the bearing cup bores of the hub for warpage or uneven surfaces. If a bearing cup bore is damaged, replace the wheel hub assembly.
3. Coat the replacement bearing cup hub contact surface with a film of grease.
4. Position the cup in the hub and press it into place, using a suitable driving tool. Cups must seat against the shoulder in the hub.
5. Wipe off the accumulation of grease left after the bearing cup has been seated. Then, using a clean lint-free cloth dampened with kerosene or diesel fuel oil, clean the inner surface of the bearing cup. Wipe the surface dry using a clean, absorbent, and lint-free cloth or paper.

Replacement

WARNING: If a wheel stud breaks, the remaining studs are subjected to undue strain and could fail due to fatigue. When a broken stud is replaced, replace the stud on each side of it. See Fig. 1. If more than one stud is broken, replace all of the studs. Failure to replace the studs could result in the loss of a wheel or loss of vehicle control, possibly resulting in personal injury.

1. Remove the wheel hub from the axle. For instructions, refer to **Subject 100.**
2. If a bent portion of a wheel stud will have to pass through the wheel stud bore, cut off the bent portion before removing the wheel stud.
3. Place the wheel hub on a suitable press; make sure the hub flange is supported evenly around and next to the stud being removed. With steady movement, press the damaged stud out of the hub.

CAUTION: Do not use a drift and hammer or concentrated heat for removing and installing the wheel studs. Constant, smooth movement of the wheel stud is necessary to ensure the least amount of metal removal from the wheel stud bore. Concentrated heat will damage the hub. If the hub is damaged during wheel stud removal or installation, replace it.



A. Replace

Fig. 1, Wheel Stud Replacement

4. Apply a coating of clean axle grease to the entire shaft on headed studs.
5. With the hub on a suitable press, make sure the hub flange is supported evenly around and next to the stud being installed.
6. Position the stud in its hole. *Be sure the flat edge of the head flange on clipped studs is in line with the shoulder on the hub.*

CAUTION: If headed studs with serrations are being installed, position the teeth of the serrated portion in the notches carved by the original wheel studs during factory installation. If additional metal is scraped from the wheel stud bores, the locking action provided by the serrations will be greatly weakened. Loss of locking action will prevent achieving final torque of the wheel nuts during wheel installation. If final wheel nut torques during wheel installation cannot be achieved, replace the wheel hub assembly.

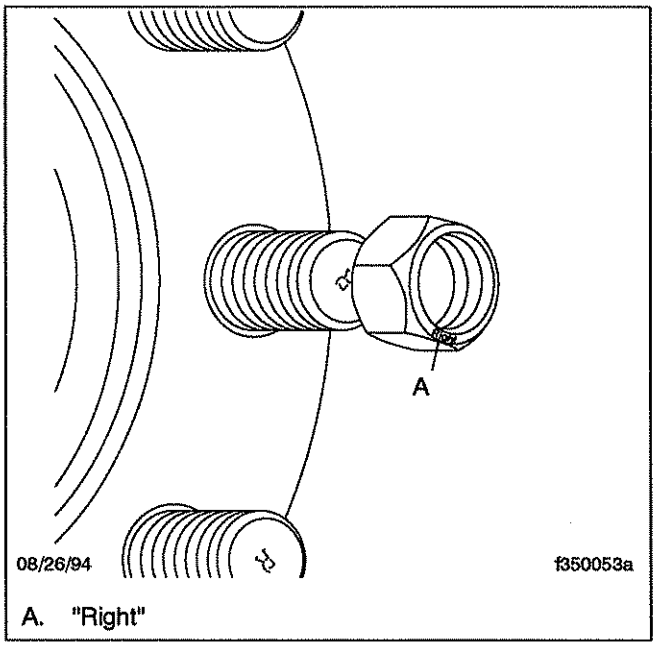
NOTE: If the left side of the vehicle is being serviced, the replacement wheel stud must be stamped with an "L" (left-hand threaded), and the nut's face must be stamped "Left" If the right side of the vehicle is being serviced, the replacement stud must be stamped with an "R" (right-hand threaded), and the nut's face must be stamped "Right" (**Fig. 2**).

7. With steady movement, press the new stud all the way into the hub.
8. Make sure the stud is fully seated and that its head (flange) is not embedded into the hub. If the head of the stud is embedded into the hub, replace the hub.

WARNING: Don't embed the wheel stud heads in the wheel hub. Wheel studs with heads embedded in the wheel hub will weaken the wheel hub flange. Weakness in the wheel hub can result in the loss of a wheel or loss of steering control, possibly resulting in personal injury.

9. Wipe off any grease on the wheel studs and wheel hub. Install wheel nuts on dry wheel studs only.
10. Install the wheel hub on the axle. For instructions, refer to **Subject 100.**

Wheel Stud Replacement



A. "Right"

Fig. 2, Thread Stamp Location

Four-Piece Wheel Bearing System Installation and Adjustment

Installation and Adjustment (See Fig. 1)

1. Carefully mount the hub and inner wheel bearing assembly on the axle spindle. Be careful not to unseat the inner wheel bearing or seal.
2. Fill the hub cavity with oil, then install the outer wheel bearing; handle the bearings with clean, dry hands. Use care not to damage the bearings as they are seated in the bearing cups.
3. Install the wheel bearing adjusting nut. Tighten the nut finger-tight. Adjust the bearings.

   3.1 After the wheel hub and bearings are assembled on the spindle, tighten the inner (adjusting) nut 200 lbf·ft (271 N·m) while rotating the wheel hub assembly.

   3.2 Back off the inner nut one full turn.

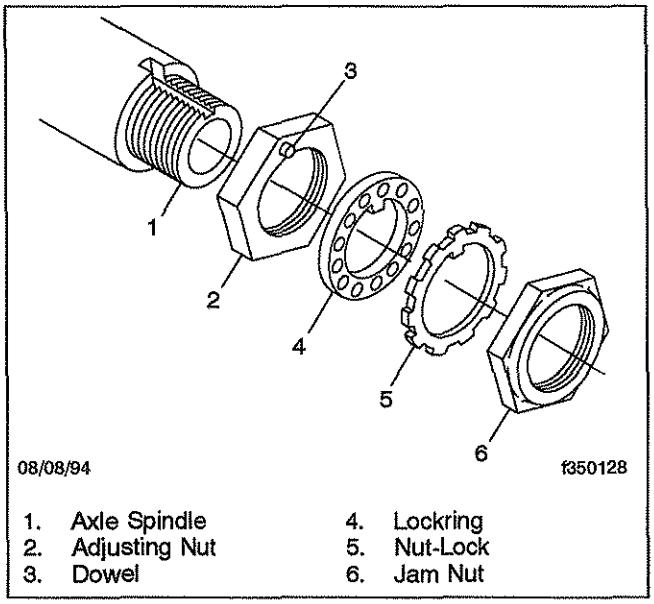
   3.3 Tighten the inner nut 50 lbf·ft (68 N·m) while rotating the wheel hub assembly.

   3.4 Back off the inner nut one quarter turn.

   NOTE: If no hole in the lockring aligns with the dowel on the adjusting nut, remove the lockring, turn it over and install it, again. If a hole still doesn't align with the dowel, loosen the adjusting nut, but only enough to align the dowel with a hole in the lockring.

   3.5 Install the lockring and nut-lock.

   Then install the jam nut, and tighten it to the applicable torque in **Table 1.**



1. Axle Spindle
2. Adjusting Nut
3. Dowel
4. Lockring
5. Nut-Lock
6. Jam Nut

Fig. 1, Four-Piece Wheel Bearing Assembly

Locking Device	Torque lbf·ft (N·m)	
	1-1/8 to 2-1/2 Inch Jam Nuts	2-5/8 Inch or Larger Jam Nuts
Tanged Nut-Lock and Lockring	200 to 300 (271 to 407)	250 to 400 (339 to 542)

Table 1, Jam Nut Torques

IMPORTANT: Do not adjust the wheel bearings with the wheel mounted on the hub. You cannot accurately adjust or measure bearing end play with the wheel mounted on the hub.

3.6 With the jam nut installed and tightened, attach a dial indicator to the hub and set the point of the indicator in line with the end of the axle spindle.

If using aluminum hubs, you may have to install the brake drum on the hub to provide a steel base for the magnet of the dial indicator. Mount the drum on the hub's drum pilot, then adjust the brake or have someone apply the brakes to hold the drum securely while you secure the drum using the stud at the 12 o'clock position, then the studs at about the 4 o'clock and 8 o'clock positions.

NOTE: If using a stud-piloted hub and a steel drum, install 1–1/4 inch washers between the nuts and the drum.

3.7 Release the brakes if you used them to hold the drum while installing it.

Grip the sides of the hub at the three o'clock and nine o'clock positions, then push the hub (and drum, if applicable), to seat the inboard bearing set. Zero the dial indicator.

Grip the sides of the hub at the three o'clock and nine o'clock positions, then

Four-Piece Wheel Bearing System Installation and Adjustment

pull the hub (and drum, if applicable). Read the dial indicator, and note the end play.

Push the hub back in to confirm that the needle of the dial indicator returns to zero.

The end play must be between 0.001 and 0.005 inch (0.025 and 0.127 mm).

4. If the end play is not within this range, remove the jam nut and locking device, and back off or tighten the inner (adjusting) nut to adjust the end play.

   Install the locking device and jam nut as described earlier, and measure the end play. If the end play is not between 0.001 and 0.005 inch (0.025 and 0.127 mm), adjust the inner (adjusting) nut, again.

5. Once the end play is correct, bend two tabs of the nut-lock over opposing flats on the jam nut.

6. Rotate the wheel in both directions. It should turn freely with no dragging or binding. End play should be between 0.001 and 0.005 inch (0.03 to 0.13 mm).

Con Met PreSet® Hub Installation and Adjustment

General Information

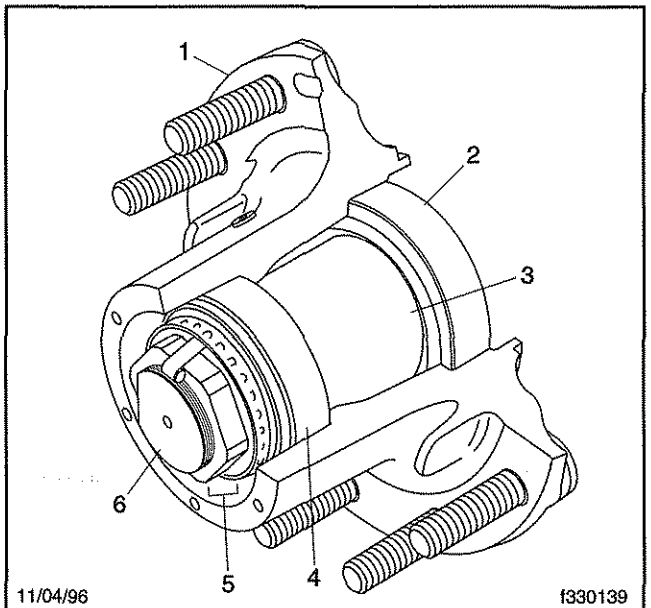
Con Met PreSet® steer axle hubs are equipped with a special tubular spacer inside the hub, between the inner and outer bearings. See **Fig. 1**.

Wheel bearing adjustment is unnecessary when installing these hubs, because the spacer, together with specially toleranced bearings, automatically sets the bearing end-play to zero. Front axle PreSet hubs can be identified by the part number NP874005 stamped on the outer bearing cone. The outer bearing cone is visible when the retaining nut is removed. See **Fig. 2.**

NOTE: If you are replacing the bearings for a PreSet hub, and the required bearings are not available, use standard wheel bearings. Remove the bearing spacer and adjust the bearings manually. See the installation instructions for "Standard Bearings," under "Installation."

⚠ CAUTION

Do not use the bearing spacer with standard wheel bearings. To do so may result in too much bearing end-play, which could damage the wheel bearings, oil seals, the axle spindle, and the hub.

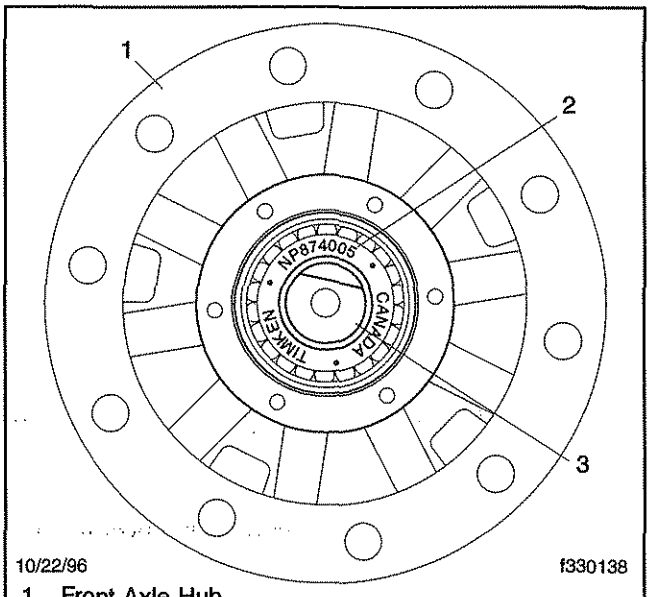


1. Hub
2. Inner Bearing
3. Bearing Spacer
4. Outer Bearing
5. Axilok® Retaining Nut
6. Axle Spindle

Fig. 1, Con Met PreSet Hub, Cut-Away View

Con Met PreSet hubs use Axilok® retaining nuts. See **Fig. 3** and **Fig. 4**. Axilok retaining nuts can be damaged if they are not removed or installed correctly. Use the following guidelines when removing and installing Axilok retaining nuts.

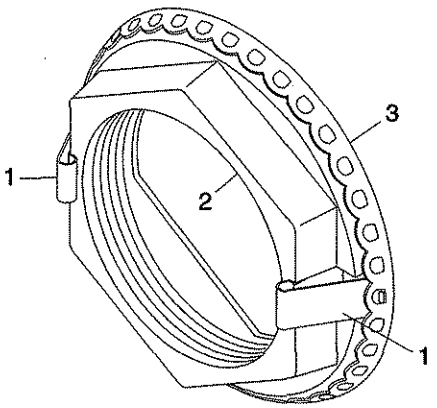
- Use only the correct size, *six-point* socket to remove or install Axilok retaining nuts. Do not use a worn or loose-fitting socket. *Do not use a 12-point socket.*
- Do not use hammers, chisels, pliers, wrenches, or power tools to remove or install Axilok nuts.
- Do not use an Axilok nut if the locking clips are damaged or missing, or if the retainer cage tab or D-flat is damaged or missing.
- Never try to repair a damaged Axilok nut; always replace it with a new one.
- Always start an Axilok installation by hand. A good-fitting six-point socket will completely disengage the nut's locking clips, allowing it to spin freely by hand. See **Fig. 5**. Use an accurately calibrated torque wrench to tighten the nut to its final torque value.

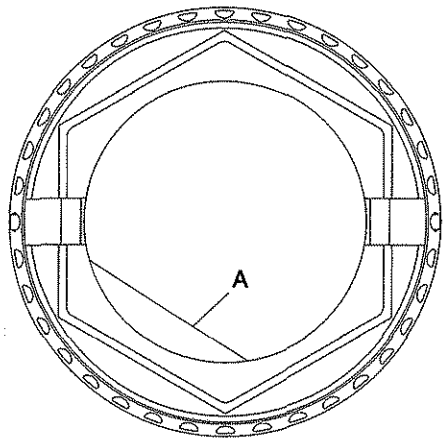


1. Front Axle Hub
2. Outer Bearing Cone and Part Number
3. Axle Spindle

Fig. 2, Identifying a Con Met PreSet Hub

Con Met PreSet® Hub Installation and Adjustment





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A. The flat side of the retainer must engage the flat side of the axle spindle.
1. Locking Clip
2. Nut
3. Retainer

Fig. 3, Axilok Retaining Nut, Meritor Front Axle

- After the nut is installed, always make sure that both locking clips are present and engaged in the retainer cage. See **Fig. 5**. If the locking clips are not engaged, the nut is not locked in position and can rotate freely.

Installation

Using PreSet Bearings

1. Wipe a film of axle oil on the axle spindle to prevent rust from forming behind the inner wheel bearing.
2. If present, remove the temporary plastic bearing cover from the front of the hub.
3. Install the PreSet hub assembly all the way onto the axle spindle. A temporary plastic alignment sleeve may be installed in the center of a new hub. It will be pushed out when the hub is installed on the axle spindle. If it is present, remove and discard this sleeve.

⚠ CAUTION

Do not remove the outer wheel bearing once the hub is installed on the axle. Removing the outer bearing could cause the oil seal to become misaligned, which could cause damage to the wheel bearings, the hub, and the axle spindle

⚠ WARNING

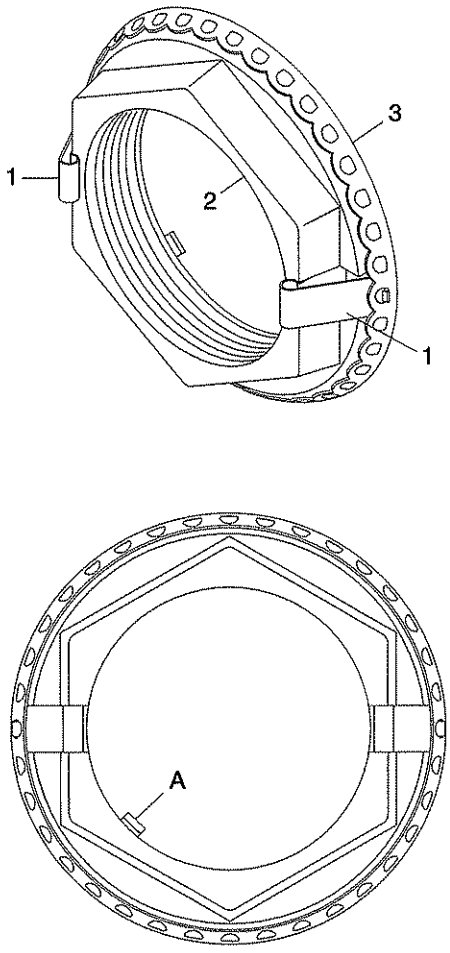
Follow the guidelines at the beginning of this subject when installing an Axilok nut. Axilok retaining nuts secure the hub assemblies on the axle. If the Axilok nut is not correctly installed, the hub could separate from the axle, resulting in severe personal injury or death.

4. Install the Axilok retaining nut (see **Fig. 3** or **Fig. 4**) onto the axle spindle.
5. Tighten the retaining nut 300 lbf·ft (407 N·m). Do not back off the retaining nut. The nut should lock in place when you remove the wrench. If it does not, advance it until it does.
6. Install the hub cap, using a new gasket. Tighten the capscrews 15 lbf·ft (20 N·m).

⚠ WARNING

Failure to add oil to the wheel hub after the hub has been serviced will cause the wheel bearings to overheat and seize during vehicle operation. Seized bearing rollers can cause sudden damage

Con Met PreSet® Hub Installation and Adjustment



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A. This retainer tab must engage the keyway of the axle spindle.
1. Locking Clip
2. Nut
3. Retainer Cage

Fig. 4, Axilok Retaining Nut, Eaton Front Axle

to the tire or axle, possibly resulting in personal injury.

7. Fill the hub with fresh oil to the level shown on the hub cap. Do not overfill.

Using Standard Bearings

NOTE: Save the spacer for use when converting the hub back to the PreSet system.

⚠ CAUTION

Do not use the spacer with standard wheel bearings. To do so may result in too much bearing end-play, which could damage the wheel bearings, oil seals, the axle spindle, and the hub.

1. If not already done, remove the tubular spacer from inside the hub. Save it for future use to convert the hub back to the PreSet system.
2. Wipe a film of axle oil on the axle spindle to prevent rust from forming behind the inner wheel bearing.
3. Coat both bearing assemblies with fresh oil. Install the inner wheel bearing and oil seal in the hub. See **Section 33.02** for instructions on installing the various types of oil seals.
4. Install the hub with the inner bearing and oil seal onto the axle spindle. Be careful not to unseat the inner bearing or oil seal.
5. Fill the hub cavity with oil, and install the outer wheel bearing.

⚠ CAUTION

Do not remove the outer wheel bearing once the hub is installed on the axle. Removing the outer bearing could cause the oil seal to become misaligned, which could cause damage to the wheel bearings, the hub, and the axle spindle.

6. Adjust the wheel bearings.

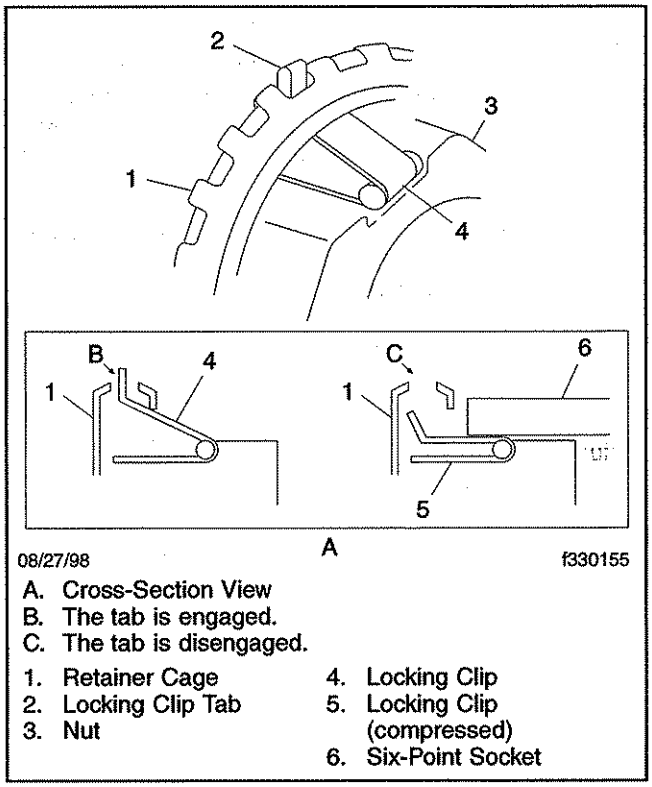
⚠ WARNING

Follow the guidelines at the beginning of this subject when installing an Axilok nut. Axilok retaining nuts secure the hub assemblies on the axle. If the Axilok nut is not correctly installed, the hub could separate from the axle, resulting in severe personal injury or death.

6.1 Install the Axilok nut (see **Fig. 3** or **Fig. 4**) and turn it against the bearing while spinning the wheel.

6.2 Tighten the nut 90 to 110 lbf·ft (122 to 149 N·m) while spinning the wheel in both directions.

Con Met PreSet® Hub Installation and Adjustment



A. Cross-Section View
B. The tab is engaged.
C. The tab is disengaged.

1. Retainer Cage
2. Locking Clip Tab
3. Nut
4. Locking Clip
5. Locking Clip (compressed)
6. Six-Point Socket

Fig. 5, Axilok Nut, Checking the Position of the Locking Clip

6.3 Loosen the nut to zero torque and spin the wheel a few turns.

6.4 Tighten the nut 50 lbf·ft (68 N·m) while spinning the wheel in both directions. Back off the nut one-eighth to one-sixth turn.

6.5 Remove the wrench from the nut. The Axilok nut should automatically lock in place. If it does not, advance it until it does.

7. Install the hub cap, using a new gasket. Tighten the capscrews 15 lbf·ft (20 N·m).

⚠ WARNING

Failure to add oil to the wheel hub after the hub has been serviced will cause the wheel bearings to overheat and seize during vehicle operation. Seized bearing rollers can cause sudden damage to the tire or axle, possibly resulting in personal injury.

8. Fill the hub with fresh oil to the level shown on the hub cap. Do not overfill.

Meritor Unitized Wheel-End Installation and Adjustment

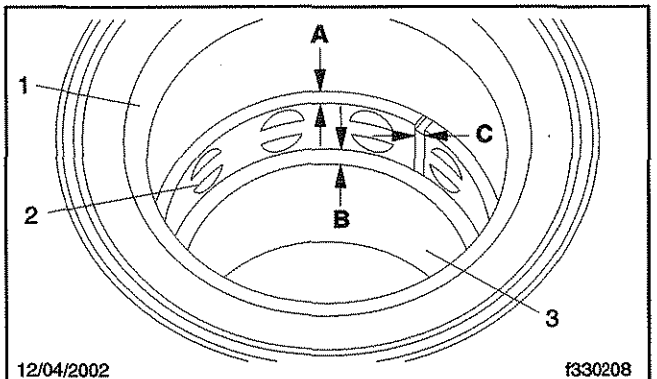
IMPORTANT: The following information is based on a Meritor technical bulletin for unitized wheel ends, and has been formatted for this Freightliner workshop manual. Contact Meritor if you wish to refer to the original technical bulletin.

Installation

⚠ WARNING

Do not service the bearings on Meritor unitized wheel ends. Disassembling the wheel end (hub) and bearings could contaminate the bearing lubricant, possibly damaging the bearings. This could result in the eventual loss of the wheel end (hub), which could cause an accident resulting in serious personal injury and property damage.

1. If not already done, clean the axle spindle and inner surfaces of the wheel bearings with a clean, lint-free cloth.
2. If installing a new wheel end (hub), inspect it as follows:
   - The inner clip ring is present and is aligned correctly between the inner and outer bearings. See **Fig. 1**.
   - The gaps between the inner and outer bearings and the clip ring are equal. See **Fig. 1**. If necessary, adjust by hand.



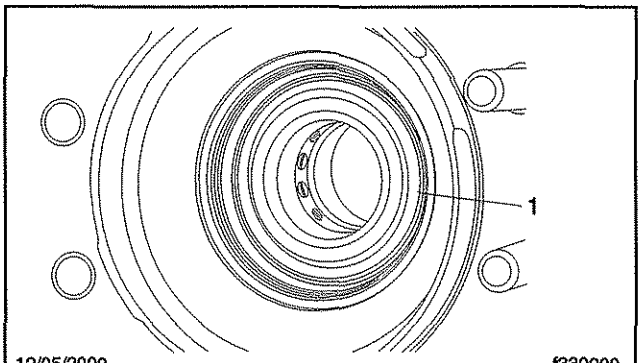
A. This gap must be equal to the "B" gap.
B. This gap must be equal to the "A" gap.
C. This gap must not exceed 1/4-inch (6 mm).
1. Inner Bearing
2. Clip Ring
3. Outer Bearing

Fig. 1, Checking the Inner Clip Ring

- The bearing face is clean, with no seal coating, dirt, or rust
- The inboard or outboard seals are undamaged and the bearings are seated correctly. See **Fig. 2** and **Fig. 3**.
- The tone wheel teeth are all present and undamaged. See **Fig. 3**.

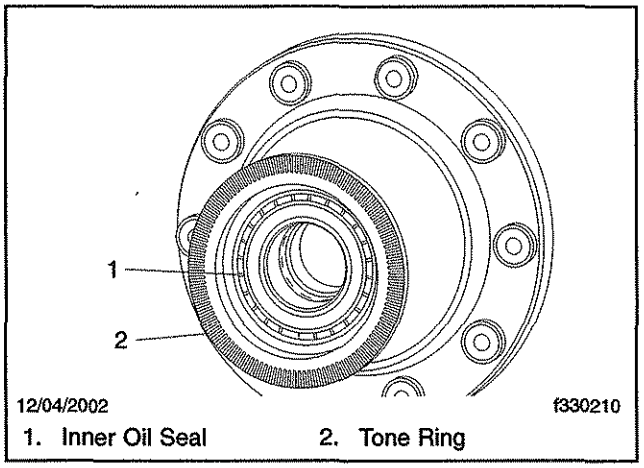
⚠ WARNING

Do not apply anti-seize compound to the axle spindle threads. This could result in the axle nuts losing their clamping ability, which could cause the loss of the hub and wheel assembly, which could cause an accident resulting in serious personal injury and property damage.



1. Outer Oil Seal

Fig. 2, Outboard Side of Wheel End (hub)



1. Inner Oil Seal
2. Tone Ring

Fig. 3, Inboard Side of Wheel End (hub)

Meritor Unitized Wheel-End Installation and Adjustment

3. Apply anti-seize compound to the new O-ring, spindle, and inner surfaces of the wheel bearings.

   Use Meritor compound part number 2297-C-8297 or Dow Corning Molykote® D.

   If any of the compound gets on the axle spindle threads, wipe it off.

4. Install the O-ring onto the axle spindle.

5. Install the wheel end (hub) straight onto the axle spindle, being careful not to damage the spindle threads.

6. With the wheel end (hub) mounted on the axle spindle, install the inner D-ring, then the inner locknut. Tighten 600 lbf·ft (813 N·m) while rotating the wheel end (hub) at least five times.

NOTE: The inner and outer locknuts are identical, but their torque values are different.

7. Install the tabbed washer.

8. Bend one of the tabs over the flat of the inner locknut.

9. Install the outer locknut and tighten it 250 lbf·ft (339 N·m).

10. Bend an opposing tab of the tabbed washer over a flat of the outer locknut.

11. Install the brake drum. If necessary, adjust the slack adjuster. For instructions, see **Group 42** of this manual.

12. Install the wheel and tire assembly. Hand tighten the wheel nuts.

13. Raise the vehicle, remove the jackstands, then lower the vehicle.

14. Tighten the wheel nuts 500 lbf·ft (678 N·m).

NOTE: Plastic and metal hub caps are interchangeable; however, the installation procedure is different for each type.

15. If installing a metal hub cap, go to the next step.

    If installing a plastic hub cap, do the following:

    15.1 Using a wire brush, remove any grease or mud from the inner threads of the hub. Wipe the threads with a clean shop cloth.

    15.2 Apply a continuous 1/8-inch (3 mm) bead of RTV silicone sealant to the outside first thread of the hub cap. Apply the sealant around the entire circumference.

    IMPORTANT: Use only the following RTV sealants on the hub cap:

    - Meritor part number 2297-Z-7098
    - Three Bond®
    - Loctite® Ultra Grey Adhesive Sealant 18581

    15.3 Install the hub cap by hand until it is seated.

    IMPORTANT: Disregard the torque value embossed on the hub cap.

    15.4 Using a torque wrench, tighten the hub cap 75 lbf·ft (102 N·m).

    If you cannot tighten the hub cap to the correct torque value, or if it makes a popping sound while being tightened, replace it with a new one.

16. If installing a metal hub cap, do the following:

    16.1 Using a wire brush, clean the inner threads of the hub and the hub cap threads. Wipe the inner threads of the hub with a clean shop cloth.

    16.2 Apply Loctite® 17430 (Meritor part number 2297-D-7076) gasket sealant to the hub cap threads.

    16.3 Install the hub cap by hand until it is seated.

    16.4 Using a torque wrench, tighten the hub cap 350 lbf·ft (475 N·m).

    IMPORTANT: If you cannot tighten the hub cap to the correct torque value, or if it makes a popping sound while being tightened, replace it with a new one.

17. Remove the chocks from the tires.

Meritor Unitized Wheel-End End Play Checking

End Play Checking

IMPORTANT: The following information is based on a Meritor technical bulletin for unitized wheel ends, and has been formatted for this Freightliner workshop manual. Contact Meritor if you wish to refer to the original technical bulletin.

⚠ WARNING

Do not service the bearings on Meritor unitized wheel ends. Disassembling the wheel end and bearings could contaminate the bearing lubricant, possibly damaging the bearings. This could result in the eventual loss of the wheel end (hub), which could cause an accident resulting in serious personal injury and property damage.

1. Park the vehicle on a level surface, set the parking brakes, shut down the engine, and chock the rear tires.
2. Raise the vehicle until the front tires are clear of the ground. Support the vehicle with safety stands.

⚠ WARNING

Never work under a vehicle that is supported only by a jack. Jacks can slip, causing the vehicle to fall. This could result in serious injury or death.

3. Rotate the tire and wheel assembly. It should rotate smoothly and without any noise.
4. Remove the tire and wheel assembly.
5. Remove the brake drum. If needed, back off the slack adjuster.
6. Remove the hub cap.
7. Attach the magnetic base of a dial indicator to the end of the axle spindle.
8. Touch the dial indicator stem to the surface of the wheel end (hub), making sure the stem is perpendicular to the surface of the wheel end.
9. Set the dial indicator to zero.
10. Without rotating the wheel end, grasp it at the 3 and 9 o'clock positions, and push it straight in. Note the reading on the dial indicator.

    Pull the wheel end straight out. Note the reading on the dial indicator.

    The difference between the two readings is the end play.
11. If the end play is less than 0.003-inch (0.08 mm), go to the step for installing the hub cap.

    If the end play is 0.003-inch (0.08 mm) or greater, go to the next step.
12. Remove the outer locknut and tabbed washer from the axle spindle.
13. Loosen, but don't remove, the inner locknut.
14. While rotating the wheel end a minimum of five rotations, tighten the inner locknut 600 lbf·ft (813 N·m).
15. Install the tabbed washer and the outer locknut. Tighten 250 lbf·ft (339 N·m).
16. Repeat the procedure for checking the end play.
17. If the end play is greater than 0.003-inch (0.08 mm) but less than 0.006-inch (0.15 mm), the end play is correct. Go to the next step.

    If the end play is 0.006-inch (0.15 mm) or greater, replace the entire wheel end assembly. For instructions, see **Subject 140**.
18. Check the rotation of the wheel end. If it doesn't rotate smoothly and without noise, replace it. For instructions, see **Subject 140**.

    If the wheel end rotates smoothly and without noise, go to the next step.
19. Bend an opposing tab of the tabbed washer over a flat of the inner locknut. Do the same for the outer locknut. Make sure that a tab of the washer is bent over a flat of both the inner and outer locknuts.
20. Install the wheel and tire assembly. Hand tighten the wheel nuts.
21. Raise the vehicle, remove the jackstands, then lower the vehicle.
22. Tighten the wheel nuts 500 lbf·ft (678 N·m).
23. Install the hub cap.

    If installing a metal hub cap, go to the next step.

    If installing a plastic hub cap, do the following:

Meritor Unitized Wheel-End End Play Checking

23.1 Using a wire brush, remove any grease or mud from the inner threads of the hub. Wipe the threads with a clean shop cloth.

23.2 Apply a continuous 1/8-inch (3 mm) bead of RTV silicone sealant to the outside first thread of the hub cap. Apply the sealant around the entire circumference.

IMPORTANT: Use only the following RTV sealants on the hub cap:

- Meritor part number 2297-Z-7098
- Three Bond®
- Loctite® Ultra Grey Adhesive Sealant 18581

23.3 Install the hub cap by hand until it is seated.

IMPORTANT: Disregard the torque value embossed on the hub cap.

23.4 Using a torque wrench, tighten the hub cap 75 lbf·ft (102 N·m).

If you cannot tighten the hub cap to the correct torque value, or if it makes a popping sound while being tightened, replace it with a new one.

24. If installing a metal hub cap, do the following:

24.1 Using a wire brush, clean the inner threads of the hub and the hub cap threads

24.2 Apply Loctite® 17430 (Meritor part number 2297-D-7076) gasket sealant to the hub cap threads.

24.3 Install the hub cap by hand until it is seated.

24.4 Using a torque wrench, tighten the hub cap 350 lbf·ft (475 N·m).

IMPORTANT: If you cannot tighten the hub cap to the correct torque value, or if it makes a popping sound while being tightened, replace it with a new one.

25. Remove the chocks from the tires.

Pro-Torq® Nut Wheel Bearing System Installation and Adjustment

Installation and Adjustment (See Fig. 1)

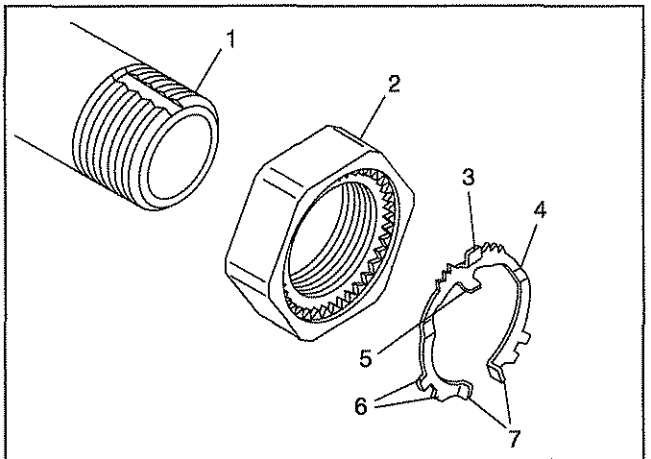
1. Carefully mount the hub and inner wheel bearing assembly on the axle spindle. Be careful not to unseat the inner wheel bearing or seal.
2. Fill the hub cavity with oil, then install the outer wheel bearing; handle the bearings with clean, dry hands. Use care not to damage the bearings as they are seated in the bearing cups.
3. Install the Pro-Torq nut, and turn it against the bearing while spinning the wheel.

IMPORTANT: Be sure there is enough clearance between the brake shoes and the brake drum, so brake shoe drag won't interfere with the bearing adjustment.

4. Tighten the adjusting nut 200 lbf·ft (270 N·m) while spinning the wheel in both directions.

   Loosen the nut to zero torque and spin the wheel a few turns.

5. *For Meritor axles:* Tighten the nut 100 lbf·ft (136 N·m), then back off the nut 1/4 turn.



1. Axle Spindle
2. Pro-Torq Nut
3. Keeper Tab
4. Lockring
5. Keyway Tab
6. Keeper Arms
7. Keeper Projections

Fig. 1, Pro-Torq Nut Wheel Bearing Assembly, Eaton Front Axle Shown

   For Eaton axles: Tighten the nut 75 lbf·ft (102 N·m), then back off the nut 1/3 turn.

6. Hold the lockring with the keeper projections facing outboard. See **Fig. 2**.
7. *For Meritor axles:* Insert the keeper tab in the undercut groove of the Pro-Torq nut, while pressing the keyway tabs on the flat surface of the axle spindle, engaging the mating teeth.

   For Eaton axles: Insert the keeper tab in the undercut groove of the Pro-Torq nut, while pressing the keyway tab into the keyway of the axle spindle, engaging the mating teeth.

8. Insert a screwdriver, or similar tool, in the undercut groove of the nut, between the keeper arms. See **Fig. 3**. Using the tool, compress the lockring to lock in place.

   Using the screwdriver, press around the edges of the lockring to be sure it is locked in place. See **Fig. 4**.

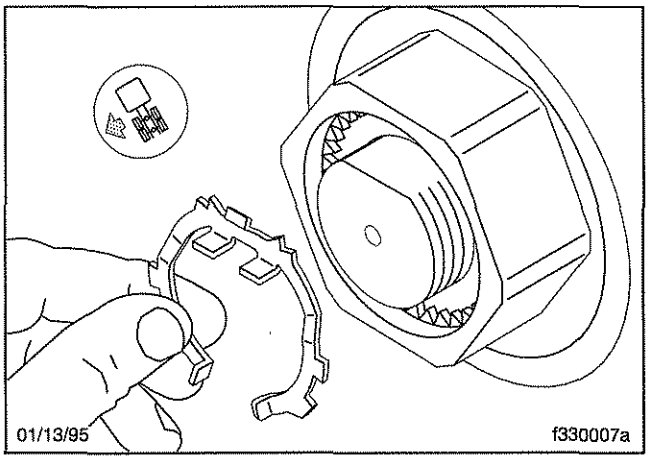


Fig. 2, Lockring Position, Meritor Front Axle Shown

Pro-Torq® Nut Wheel Bearing System Installation and Adjustment

⚠ CAUTION

Do not use pliers or similar devices on the keeper projections to compress the lockring. This could result in damage or breakage of the lockring.

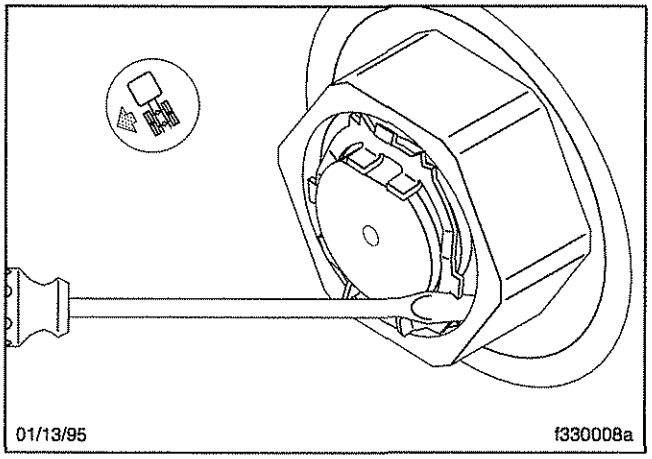


Fig. 3, Compressing the Lockring, Meritor Front Axle Shown

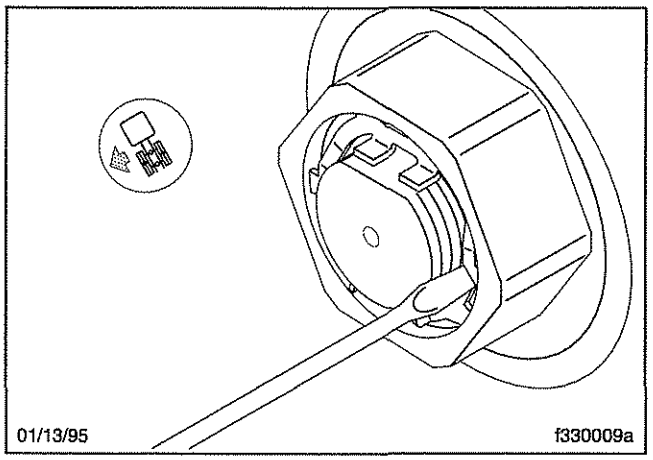


Fig. 4, Making Sure the Lockring is Locked, Meritor Axle Shown

Troubleshooting Tables

Problem—Noisy Bearings or Excessive Bearing Replacement Intervals

Possible Cause	Remedy
Not enough oil was used on the bearings, or the wrong type of oil was used.	Clean, then inspect the bearings for wear. Replace worn seals. Coat the bearing assemblies with fresh oil.
Foreign matter or corrosive agents entered the bearing assembly. Dirt or metallic debris from the bearings was not removed.	Clean, then inspect the bearings for wear. Replace worn seals. Also clean the wheel hub, the axle spindle, and any other component in contact with the bearing lubricant.
An incorrect adjustment of the wheel bearings is causing noise and wear.	Adjust the wheel bearings following the applicable instructions in this section.
Flat spots or dents on the roller surface were caused by skidding of the roller or improper handling of the wheel bearing during installation.	Clean, then inspect the bearing rollers. Replace the bearing if damaged. Coat the replacement bearings with fresh oil. For lubricant specifications, refer to **Specifications, 400**.

Problem—Broken Wheel or Rim Studs

Possible Cause	Remedy
The wheel or rim nuts were overtightened.	Replace the wheel or rim studs. Refer to **Group 40** for the wheel or rim nut tightening sequence.
An incorrect nut tightening sequence was used.	
The wrong brake drums were installed.	Install new brake drums.
Wheels are mismatched (hub-piloted wheels are mixed with stud-piloted wheels).	Install properly matched wheels.
The vehicle is being overloaded.	Do not exceed the maximum load-carrying capacity of the vehicle.

Problem—Damaged Hub

Possible Cause	Remedy
(Cracked hub) Local surface of an aluminum hub was heated higher than 350°F (177°C) during bearing cup removal.	Replace the hub assembly. When removing the bearing cup, oven-heat the hub.
(Bent flange) Incorrect installation of the wheel studs, such as using a hammer and drift, or the hub flange was not fully supported on the press during wheel stud replacement.	Replace the hub assembly. Replace the wheel studs.
The wrong brake drums were installed.	Install new brake drums.
Insufficient tightening of the wheel nuts to the wheel hub.	Replace the hub assembly and tighten the wheel nuts to the values in the torque table in **Specifications, 400**.

Problem—Loss of Lubricant from the Wheel Hubs

Possible Cause	Remedy
The seals or gaskets are worn or damaged.	Replace worn or damaged parts.

Troubleshooting

Problem—Vehicle Does Not Slow Down Quickly Enough When Brakes Are Applied

Possible Cause	Remedy
Dirt or grease has built up on the brake linings (glazing), or the brake linings have worn excessively.	Install new brake linings on both sets of axle brake shoes. Clean, turn, or replace the drums.
The brake drums are worn, heat-checked or cracked.	Install new brake drums.

Problem—Service Brakes Grab or Pull

Possible Cause	Remedy
For detailed information, refer to **Group 42.**	

Problem—Poor Lining-to-Drum Contact

Possible Cause	Remedy
The inside surface of the brake drum is scored or grooved.	Install new brake linings on both sets of axle brake shoes. Install new brake drums or turn the drums.
The brake shoes are stretched or bent.	Replace the brake shoes.
Undersized linings were installed.	Install new brake linings on both sets of axle brake shoes.
An incorrect grind was used on the brake linings.	
The wrong brake drums were installed.	Install new brake drums.
An incorrect adjustment of the wheel bearings is causing wheel instability.	Adjust the wheel bearings following the applicable instructions in this section.

Problem—Brake Linings Are Tapered Across the Width

Possible Cause	Remedy
The inside surface of the brake drum is scored or grooved.	Install new brake linings on both sets of axle brake shoes. Turn or replace the drums.
The brake shoes are bent.	Replace the brake shoes.
An incorrect adjustment of the wheel bearings is causing wheel instability.	Adjust the wheel bearings following the applicable instructions in this section

Problem—Brake Shoes on the Same Brake Are Wearing Unequally

Possible Cause	Remedy
The brake linings are not a matched set. Different friction codes or different brands of brake linings are installed.	Install a new matched set of brake linings on both sets of axle brake shoes. Clean, turn, or replace the drums.
The brake shoes are stretched.	Replace the brake shoes.

Problem—Shoes on Each Side of the Axle (Side-to-Side Brakes) Are Wearing Unequally

Possible Cause	Remedy
The brake linings are not a matched set. Different friction codes or different brands of brake linings are installed.	Install a new matched set of brake linings on both sets of axle brake shoes. Clean, turn, or replace the drums.
The inside surface of the brake drum is in poor condition.	Turn or replace the drums.
The wheel bearings are out of adjustment.	Adjust the wheel bearings following the applicable instructions in this section.

Problem—Edge of the Lining Is Showing Wear

Possible Cause	Remedy
The brake lining is too wide.	Install new brake linings on both sets of axle brake shoes.
The brake linings are misaligned because of incorrectly drilled brake lining holes.	
Undersized brake drums were installed.	Install new brake drums.
The wheel bearings are out of adjustment.	Adjust the wheel bearings following the applicable instructions in this section.
There is an incorrect fit of the wheel onto the spindle due to the wrong wheel bearings.	Install new wheel bearings and adjust them following the applicable instructions in this section.
The brake shoes are bent.	Replace the brake shoes.

Problem—Brake Linings Are Scored or Grooved

Possible Cause	Remedy
Worn or scored brake drums have been causing poor contact with the brake linings.	Install new brake linings on both sets of axle brake shoes. Turn or replace the brake drums.
There is abrasive material between the lining and the drum.	

Problem—Brake Linings Are Loose

Possible Cause	Remedy
The rivet holes in the brake shoes are to large.	Replace the brake shoes.
Incorrectly crimped rivets are working loose and allowing the linings to move.	Replace the rivets.
Rust has built up on the shoe table.	Clean the brake shoe table of all rust, dirt, scale, and paint.

Troubleshooting

Problem—Brake Lining Is Cracked at the Rivet Holes or Bolt Holes

Possible Cause	Remedy
Overtightening of the lining bolts is causing cracks.	Install new brake linings. Replace the rivets or bolts with the correct size.
The wrong size counter bore for the rivet holes was made.	
The wrong rivets or bolts were used.	Replace the rivets or bolts with the correct size.
Incorrectly crimped rivets are working loose and allowing the linings to move.	Replace the rivets.
Rust has built up on the shoe table.	Clean the brake shoe table of all rust, dirt, scale, and paint.

Problem—Out-of-Round Rivet Holes or Bolt Holes

Possible Cause	Remedy
The rivets or bolts are loose.	Replace the brake shoes or linings.

Problem—Brake Drums Are Heat-Checked

Possible Cause	Remedy
The brake drums are out-of-round.	Turn or replace the brake drums.
The wrong brake drums were installed.	Install new brake drums.
The wheel bearings are out of adjustment.	Adjust the wheel bearings following the applicable instructions in this section.
The brake linings are glazed (dirt or grease build-up) or are worn unevenly.	Install new brake linings on both sets of axle brake shoes. Clean, turn, or replace the drums.
The lining friction material for the operation of the vehicle is incorrect.	
There is a brake imbalance between the tractor and the trailer.	Do a brake balance test (tractor versus trailer). Contact the District Service Manager if help is needed.

Problem—Brake Drums Are Heavily Scored

Possible Cause	Remedy
The brake linings are damaged.	Install new brake linings on both sets of axle brake shoes. Clean, turn, or replace the drums.
There is excessive wear on the linings.	
On the last brake reline, the drums were not turned.	Turn the brake drums.

Problem—Excessive Brake Lining Wear

Possible Cause	Remedy
There is a brake imbalance between the tractor and the trailer.	Do a brake balance test (tractor versus trailer). Contact the District Service Manager if help is needed.

Problem—Hard Steering

Possible Cause	Remedy
Tire pressure is low in one or both front tires.	Inflate tires to the correct pressure.
Binding in the steering gear due to a lack of lubrication.	Test the steering system for binding with the front tires off the ground. For instructions, refer to **Group 46**.
Too much caster angle in the front wheels.	Check the caster angle and adjust as needed.
The front suspension is sagging due to a damaged spring.	Repair or replace the spring as needed. For instructions, refer to **Group 32**.
The axle spindle is bent.	Replace the spindle.
The frame is misaligned.	Check the frame alignment; correct, as needed.

Problem — Erratic Steering When the Brakes are Applied

Possible Cause	Remedy
Tire pressure is low in one or both front tires.	Inflate the tires to the correct pressure.
One or more front axle spring U-bolt nuts are loose.	Check the U-bolt nuts for looseness. If loose, check the U-bolt for damage. Replace damaged parts; tighten loose nuts.
The brakes are not adjusted evenly.	Adjust the brakes on all axles. Also, check the operation of the slack adjusters.
Grease or oil contamination of the brake linings is reducing brake effectiveness.	Replace the brake linings and clean the drums. Find and correct the cause of grease or oil contamination.
The caster angle is wrong.	Check, and adjust as needed.
An axle spindle is bent.	Replace the axle spindle.
The front axle wheel bearings are worn or were incorrectly adjusted.	Check the bearings for wear or damage; replace as needed.

Problem—Vehicle Pulls to One Side During Operation

Possible Cause	Remedy
Tire pressure is low in one or both front tires.	Inflate the tires to the correct pressure.
One or more of the alignment measurements are incorrect.	Check all the alignment measurements. Correct as needed.
The wheels or tires are out-of-round.	Inspect the wheels and tires. Replace out-of-round parts.
The front axle wheel bearings are too tightly adjusted.	Check the bearings for wear or other damage. Replace the bearings if needed.
The front suspension is sagging due to a damaged spring.	Repair or replace the spring as needed. For instructions, refer to **Group 32**.
The axle spindle is bent.	Replace the spindle.
The frame is misaligned.	Check the frame alignment; correct as needed.
The rear axle(s) is out of alignment.	Check, and if needed, adjust the rear axle alignment.

Troubleshooting

Problem—Front Wheel Wander

Possible Cause	Remedy
One or more wheels or brake drums are out-of-balance.	Balance the wheels. Check for out-of-round brake drums; correct as needed.
One of the front springs is weak or broken.	Repair or replace the spring as needed. For instructions, refer **Group 32.**

Problem—Front Wheel Shimmy

Possible Cause	Remedy
Tire pressure is low in one or both front tires.	Inflate the tires to the correct pressure.
One or more wheels or brake drums are out-of-balance.	Balance the wheels. Check for out-of-round brake drums, correct or replace as needed.
One or more tires are out-of-round or bulged.	Replace the tire.
The front axle wheel bearings are worn or were incorrectly adjusted.	Check the bearings for wear or other damage. Replace the bearings if needed.
Parts of the steering gear or linkage are worn.	Test for play in the steering gear and linkage with the front tires off the ground. Replace parts as needed.
The axle spindle is bent.	Replace the spindle.
One or more of the alignment measurements are incorrect.	Check all alignment measurements and correct as needed.
The knuckle pin is loose due to worn bushings.	Inspect the knuckle pin and bushings for damage. Replace worn or damaged parts as needed.
Shock absorbers are worn or damaged.	Check the shock absorbers and replace if needed.

Problem—Vehicle Wanders

Possible Cause	Remedy
Tire pressure is low in one or both front tires.	Inflate the tires to the correct pressure.
One or more of the alignment measurements are incorrect.	Check all of the alignment measurements; correct as needed.
The rear axle(s) is out of alignment.	Check the rear axle alignment and adjust as needed.
Parts of the steering gear or linkage are worn.	Test for play in the steering gear and linkage with the front tires off the ground. Replace parts as needed.
A knuckle pin is loose due to worn bushings.	Inspect the knuckle pin and bushings for damage. Replace worn or damaged parts.
The axle spindle is bent.	Replace the spindle.

Problem—Cupped Tires

Possible Cause	Remedy
Tire pressure is too low or too high in one or both front tires.	Inflate or deflate the tires to the correct pressure.
One or more wheels or brake drums are out-of-balance.	Balance the wheels. Check for eccentric brake drums; correct or replace as needed.
The wheel toe-in in not correct.	Adjust the wheel toe-in.
The brakes are not adjusted evenly.	Adjust the brakes on all axles. Also, check the operation of the slack adjusters.
The front axle wheel bearings are worn or were not adjusted correctly.	Check the bearings for wear or other damage; replace them if needed.
The camber angle is not within specifications.	Check the front wheel camber angle. If not correct, find and replace the damaged axle component.

Problem—Steering Wheel Spokes Do Not Point at the 4 and 8 O'clock Positions

Possible Cause	Remedy
The steering gear is not centered.	Center the steering gear.
If adjustable, the drag link is out of adjustment.	Adjust the drag link.
The steering wheel was not installed (positioned) correctly on the steering column.	Reposition the steering wheel on the steering column.
The pitman arm is not correctly aligned with the timing mark on the steering gear output shaft.	Reposition the pitman arm on the steering gear output shaft. For instructions, refer to **Group 46.**

Specifications

Application	Size (grade 8)	Torque lbf·ft (N·m)
Hub Cap Capscrews	5/16–18	15 (20)

Table 1, Torque Values

Lubricant Type	Condition	Lubricant SAE Viscosity Grade
Eaton® Roadranger® Synthetic Drive Axle Lubricants, or Equivalent with Military Specification MIL–L–2105D	Over-the-Road Service	75W–90
	Off-Highway Equipment, or Under Extra Heavy Loads	80W–140

Table 2, Eaton Drive Axle Recommended Lubricant

Recommended Lubricant Type	Ambient Temperature	Lubricant SAE Viscosity Grade	Rockwell Specification
Hypoid Gear Oil API Service Classification GL–5	+10°F (–12.2°C) and up*	85W–140	0–76–A
	–15°F (–26.1°C) and up*	80W–140	0–76–B
	–15°F (–26.1°C) and up*	80W–90	0–76–D
	–40°F (–40°C) and up*	75W–90	0–76–E
	–40°F (–40°C) to +35°F (+2°C)	75W	0–76–J
	–40°F (–40°C) and up*	75W–140	0–76–L
Synthetic Gear Oil	–40°F (–40°C) and up*	75W–90	0–76–N
	–40°F (–40°C) and up*	75W–140	0–76–M

* There is no upper limit on these ambient temperatures, but axle sump temperature must never exceed 250°F (121°C).

Table 3, Rockwell Drive Axle Recommended Lubricant

Contents

Subject	Subject Number
General Information	050
Service Operations	
Seal Replacement, Chicago Rawhide	100
Seal Replacement, Dana Spicer® Outrunner™	110
Seal Replacement, National®	120
Seal Replacement, Stemco®	130
Specifications	400

General Information

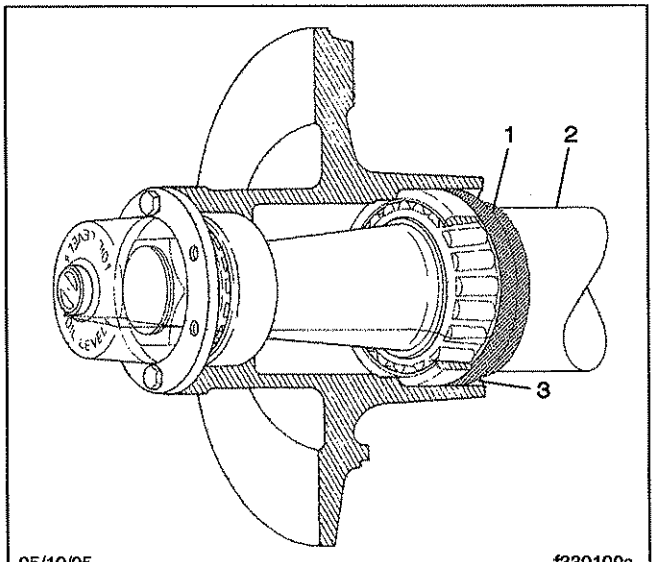
Wheel oil seals (also called "oil bath seals" or "hub seals") work as a dam to keep oil in the hub cavity so that it constantly "bathes" the wheel bearings. The seals also protect the wheel bearings by keeping dirt, dust, and water out of the hub.

The oil seal fits between the hub bore and the axle spindle (**See Fig. 1**), and the sealing element either turns with the wheel (*hub-mounted seals*) and seals against the axle spindle, or the sealing element stays stationary with the axle spindle (*spindle-mounted seals*) and seals against the turning hub.

Until the late 1950's, truck wheel bearings were packed in grease. To retain this type of lubricant, the axle oil seal was pressed into the hub bore and turned with the wheel. Since the late 1950's, truck wheel bearings have been bathed in oil.

But oil bath lubrication created a problem.

With hub-mounted seals, the turning wheel created enough centrifugal force to pull the sealing element off the axle spindle. This broke the seal, and oil escaped. To keep lube oil inside the hub cavity, the inner edge, or sealing lip, of the seal had to be strong and tight enough that the centrifugal force of the turning wheel would not pull it away from the axle spindle. However, these new, stronger, tighter seals would wear a groove into the spindle sealing surface.



1. Wheel Oil Seal
2. Axle Spindle
3. Wheel Hub Bore

Fig. 1, Spindle-Mounted Wheel Oil Seal, Stemco Seal Shown

To prevent damage to the spindle, wear sleeves (also called "axle rings") are pressed onto the spindle to absorb the wear from the sealing lip. Later, these wear sleeves were designed to also deflect dirt. These sleeves are called "deflector rings."

Some seal designs avoid the problem of centrifugal force by having the seal pressed onto the axle spindle. This way, centrifugal force drives the sealing element out toward the hub to create the seal.

Most wheel oil seals consist of four basic parts (**Fig. 2**):

- The outside edge (also called the outer "cup" or "case")
- The inside edge (also called the inner "cup" or "case")
- The sealing element
- The garter spring

The outside edge is usually metal coated with rubber or another sealing agent so that it grips the hub bore tightly enough to prevent oil escaping between the outer edge of the seal and the hub bore.

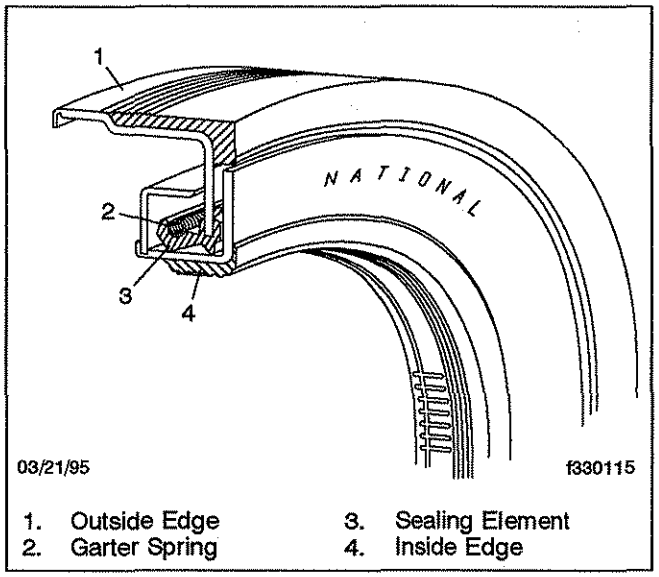
The inside edge is usually metal or rubber with a metal ring within it to prevent the sealing element from wearing a groove in the axle spindle.

The sealing element is usually molded rubber, leather, or a synthetic such as nitrile or silicone. The element is molded into lips which will seal against the axle spindle or against the outside or inside edge described above. The innermost lip, called the "primary lip," keeps the oil inside the hub cavity. The outermost lip, called the "secondary lip," keeps dirt out of the hub cavity.

The garter spring is a coiled wire spring with its ends connected to make a loop. On hub-mounted seals, the spring runs around the outside of the sealing element to press the element inwards against the sealing surface. On spindle-mounted seals, the spring runs around the inside of the sealing element to press the element outward against the sealing surface.

Freightliner uses four brands of axle oil seals:

General Information



1. Outside Edge
2. Garter Spring
3. Sealing Element
4. Inside Edge

Fig. 2, Wheel Oil Seal Parts, National Oil Seal, Advanced Design

- Chicago Rawhide (Scotseal® and Scotseal Plus®)
- Eaton (Outrunner™)
- National (5-Star Gold® and Advanced Design®)
- Stemco (Guardian® and SS4®)

Chicago Rawhide (See Fig. 3)

The Chicago Rawhide Scotseal is a unitized, one-piece design consisting of a sealing element (packing) that is assembled between metal outer and inner cups. The sealing element consists of three sealing lips; a spring-loaded primary sealing lip that is factory pre-lubed and two dirt exclusion lips. The seal is press fit into the hub bore using Scotseal service installation tools. *Do not install the Scotseal directly onto the axle spindle.*

Although you install the Scotseal into the hub bore, the seal's element grips the axle spindle tightly enough that the sealing element stays stationary with the spindle and seals against the outer cup which turns with the hub.

The Chicago Rawhide Scotseal maintains a metal-to-metal contact between the outer cup and the hub bore surface as well as a metal-to-metal contact between the sealing element inside edge and the axle spindle.

Eaton (See Fig. 4)

The Eaton Outrunner has a rubber-coated outside edge and is installed in the hub bore using Eaton installation tools.

National (See Fig. 2 and Fig. 5)

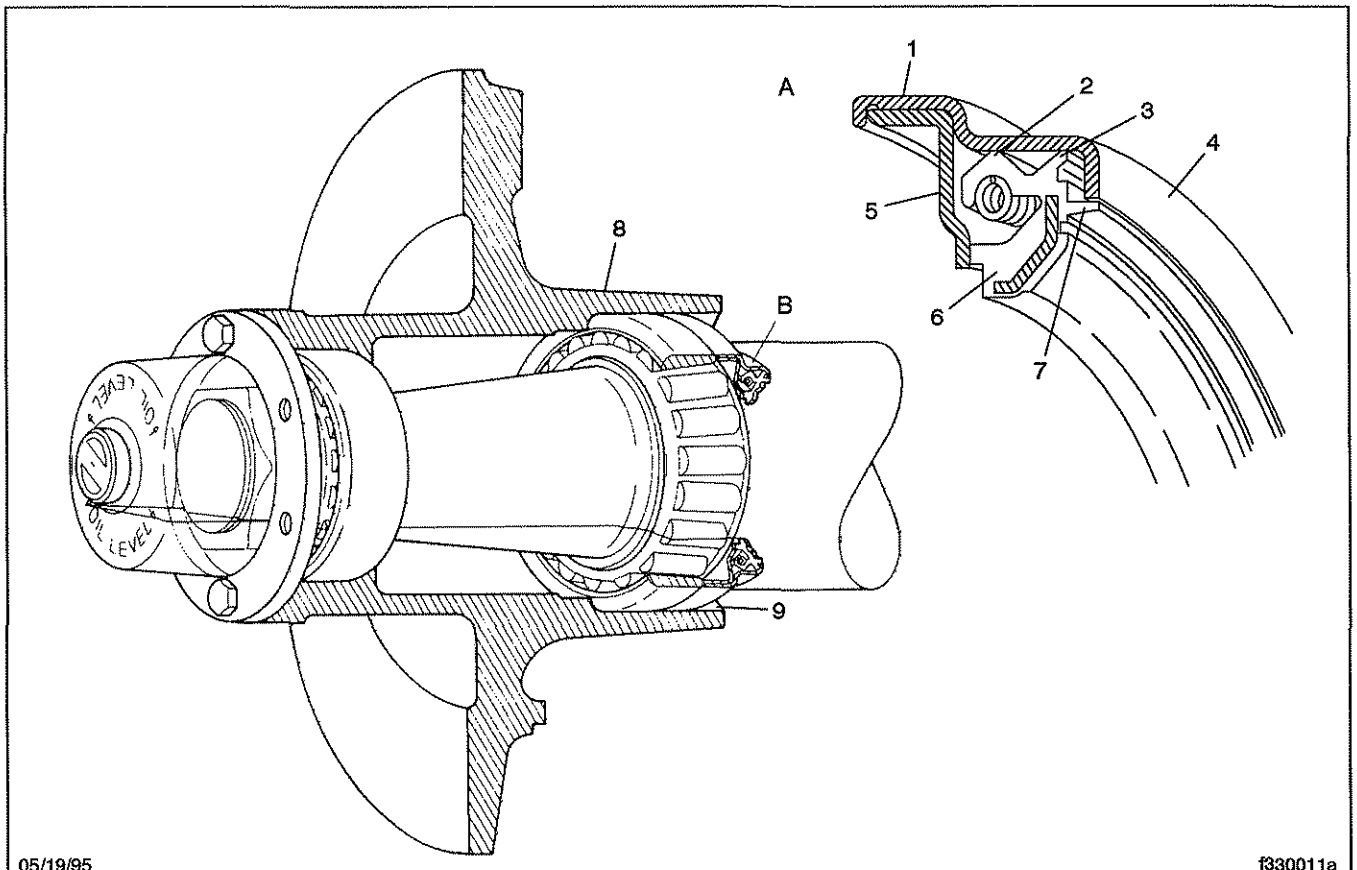
National wheel oil seals are hub-mounted, with a rubber-coated outside edge that grips inside the hub bore and also holds the sealing element. The element turns with the hub and seals against the inside edge of the seal which grips the axle spindle and acts as a wear sleeve. The shield protects the sealing element, and holds the two parts (the outside and inside edges) together.

The 5-Star Gold seal features a Teflon® lay-down sealing lip compatible with any combination of mineral and/or synthetic gear lubricants and/or greases.

Stemco (See Fig. 6 and Fig. 7)

The Stemco wheel oil seals are spindle-mounted, with a rubber-coated outside edge that grips inside the hub bore and also holds the sealing element.

Although you install the Stemco seal onto the axle spindle, the outside edge grips the hub bore tight enough that the sealing element turns with the hub and seals against the inside edge which grips the axle spindle and acts as a wear sleeve.



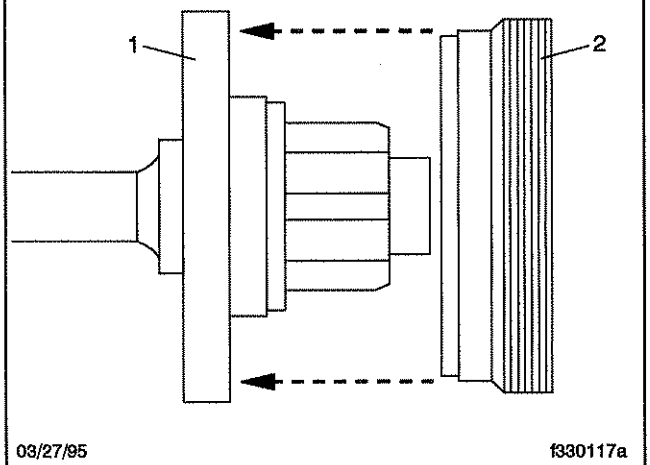
A. Detail A

B. Oil Seal (See detail A.)

1. Bore-Tite® Coating
2. Primary Sealing Lip
3. Dirt Lip
4. Outer Cup
5. Inner Cup
6. Sealing Element (Packing)
7. Bumper Lip
8. Hub
9. Hub Bore

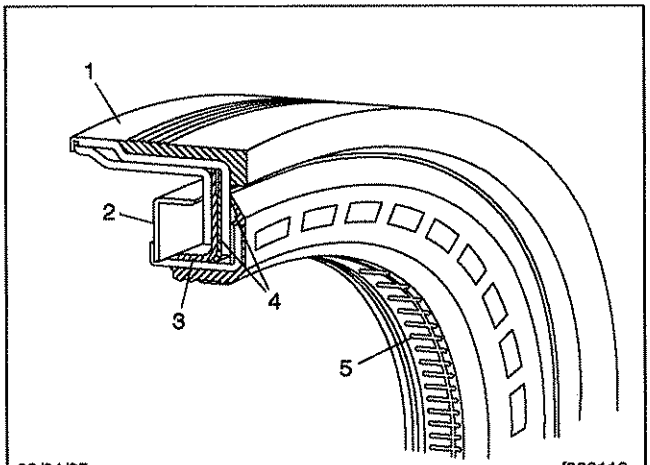
Fig. 3, Chicago Rawhide Scotseal

General Information



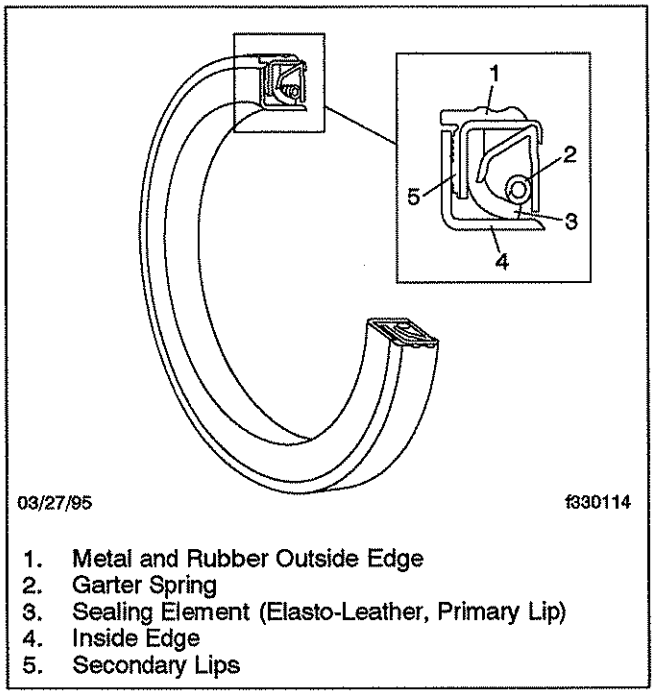
1. Eaton Outrunner Installation Tool
2. Eaton Outrunner Seal

Fig. 4, Eaton Outrunner Seal



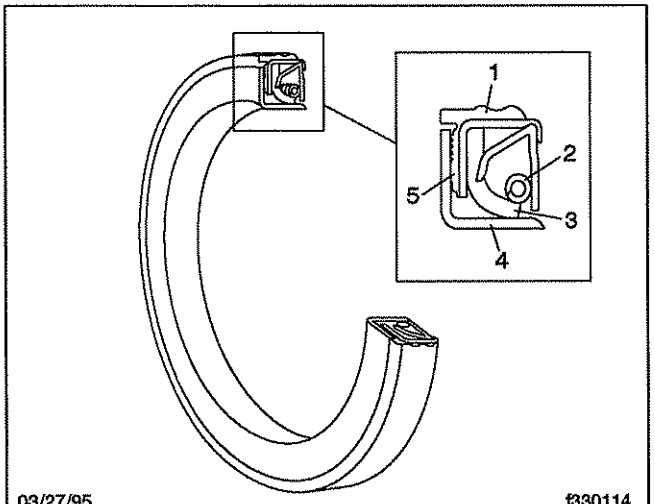
1. Metal and Rubber Outside Edge
2. Shield
3. Teflon Lay-Down Primary Sealing Lip
4. Dual Secondary Sealing Lips
5. Rubber Inside Edge

Fig. 5, National 5-Star Gold Axle Oil Seal



1. Metal and Rubber Outside Edge
2. Garter Spring
3. Sealing Element (Elasto-Leather, Primary Lip)
4. Inside Edge
5. Secondary Lips

Fig. 6, Stemco Guardian Wheel Oil Seal



1. Metal and Rubber Outside Edge
2. Garter Spring
3. Sealing Element (Teflon, Primary Lip)
4. Inside Edge
5. Secondary Lips

Fig. 7, Stemco SS4 Wheel Oil Seal

Seal Replacement, Chicago Rawhide

IMPORTANT: Make sure the required tools are available before beginning the service procedures described here. See the "Bearing Centering Tool Interchange" and "Adapter Plates" tables in **Specifications, 400**.

Replacement

NOTE: This procedure applies to the Chicago Rawhide Scotseal®.

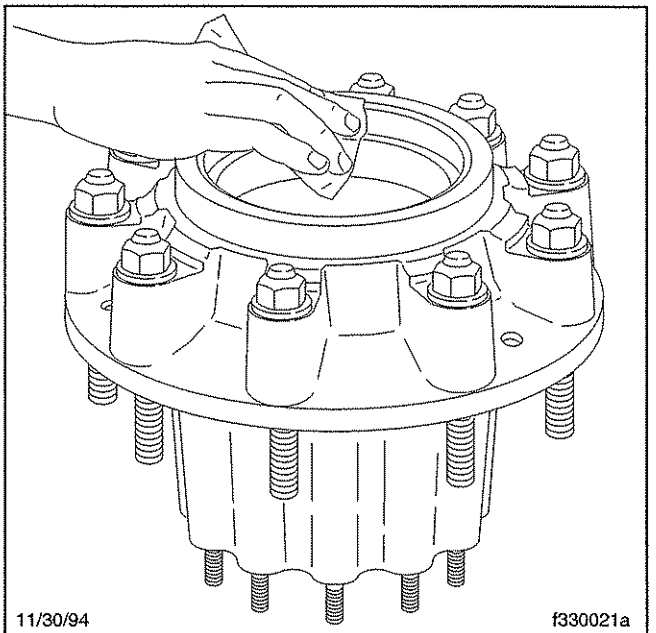
1. Remove the wheel, drum, and hub from the axle. For instructions, see **Section 33.01**.
2. Remove the inner wheel bearing assembly from the axle. Handling the bearings with clean dry hands, wrap the bearings in clean oil-proof paper or lint-free cloths. Occasionally, the inner wheel bearing cone assembly will remain in the hub after the hub is removed from the axle. In those cases, place a protective cushion to catch the bearing assembly. Using a hardwood drift and a light hammer, gently tap the bearing and seal out of the inner wheel bearing cup.
3. Clean the spindle, spindle threads, seal bore, and the hub cavity. See **Fig. 1** and **Fig. 2**.
4. Remove all burrs from the shoulder and the seal bore with an emery cloth or a file. Clean any metal filings from the components.

⚠ CAUTION

Do not spin bearing rollers at any time. Dirt or grit can scratch the roller surface and cause rapid wear of the bearing assembly. Treat used bearings as carefully as new ones.

IMPORTANT: Use extreme care in cleaning the wheel hub cavity and axle spindle. Dirt, metal filings, or other contaminants can scratch the bearing roller surfaces, and cause premature wear of the bearing assembly.

5. Inspect the bearings and hub components for wear or damage. Replace any worn or damaged components as necessary.
6. Coat the wheel bearing cones with oil.
7. Install the inner wheel bearing cone in the inner wheel bearing cup.
8. Seat the small outside edge of the seal in the recess of the tool adapter. See **Fig. 3**. The correct adapter is identified on the box.



NOTE: Rear hub shown.

Fig. 1, Clean the Hub

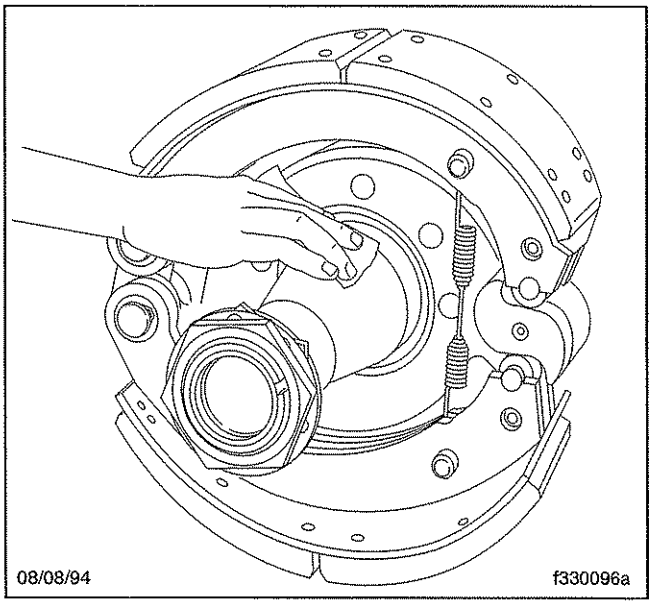
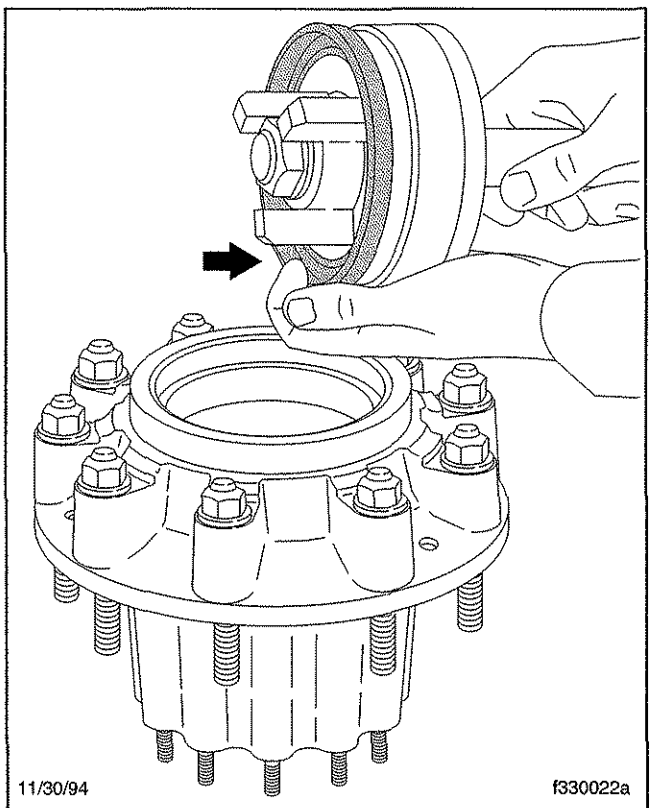


Fig. 2, Clean the Spindle

Seal Replacement, Chicago Rawhide

9. Insert the centering plug of the tool in the bore of the inner bearing cone. See **Fig. 4**. The plug prevents cocking of the seal in the bore.
10. Hold the tool handle firmly, and strike it until the sound of the impact changes as the seal bottoms out. See **Fig. 5**. Hold the tool firmly to avoid bounce or unseating of the seal from the adapter.
11. After the seal is bottomed in the bore, check for freedom of movement by manually moving the interior rubber part of the seal back and forth. A slight movement indicates a damage-free installation.
12. Install the wheel hub on the axle, and adjust the wheel bearings. For instructions, see **Section 33.01**.

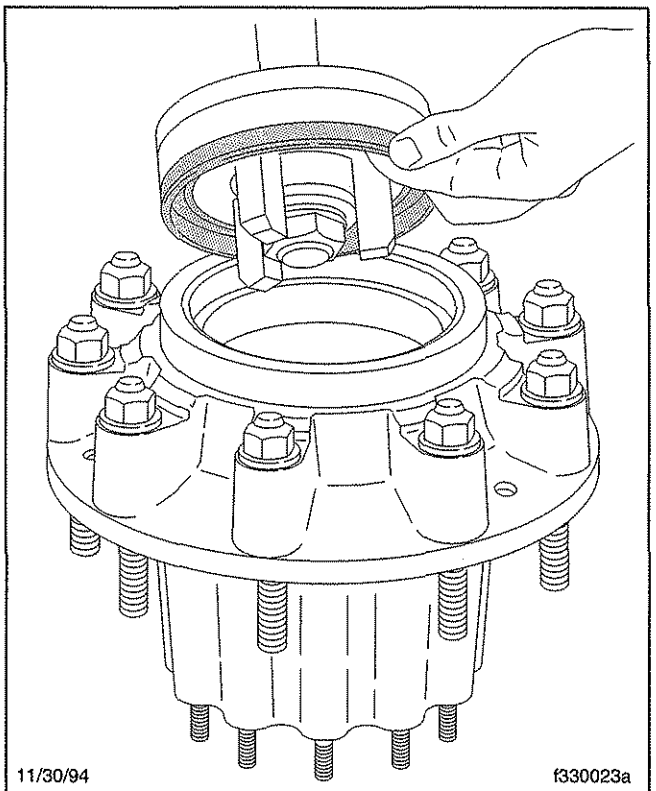
IMPORTANT: When starting the wheel on the spindle, center the hub carefully to avoid seal damage from the leading edge of the spindle.



NOTE: Rear hub shown.

Fig. 3, Place the Seal on the Installation Tool

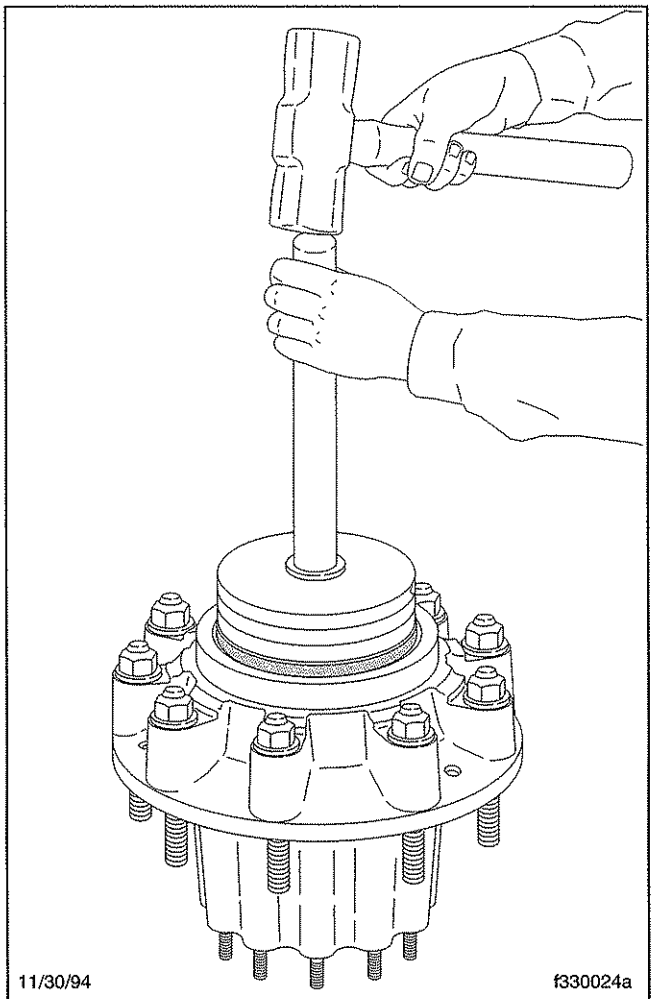
13. Place the hubcap and a new gasket in position. Install the capscrews. Tighten the capscrews 15 lbf·in (20 N·m).
14. Fill the hub with oil to the level shown on the hubcap. See **Fig. 6**. Do not overfill.
15. Spin the wheel and check the oil level.
16. Adjust the brake shoe-to-drum clearance. For instructions, see **Group 42**.



NOTE: Rear hub shown.

Fig. 4, Insert the Tool in the Hub Bore

Seal Replacement, Chicago Rawhide



NOTE: Rear hub shown.

Fig. 5, Strike the Tool

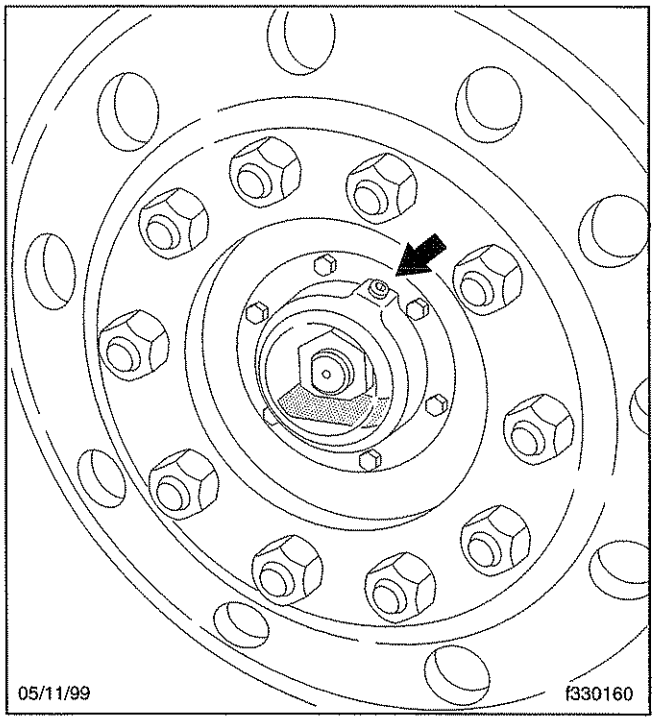


Fig. 6, Hub Filler Plug

Seal Replacement, Dana Spicer® Outrunner™

IMPORTANT: Make sure the required tools are available before beginning the service procedures described here. See the "Bearing Centering Tool Interchange" and "Adapter Plates" tables in **Specifications, 400**.

Replacement

NOTE: This procedure applies to the Dana Spicer Outrunner seal.

1. Remove the wheel, drum, and hub from the axle. For instructions, see **Section 33.01**.
2. Remove the inner wheel bearing assembly from the axle. Handling the bearings with clean dry hands, wrap the bearings in clean oil-proof paper or lint-free cloths. Occasionally, the inner wheel bearing cone assembly will remain in the hub after the hub is removed from the axle. In those cases, place a protective cushion to catch the bearing assembly. Using a hardwood drift and a light hammer, gently tap the bearing and seal out of the inner wheel bearing cup.

⚠ CAUTION

Never use a sharp chisel to cut through an axle ring (wear sleeve). A sharp chisel could damage the spindle or shoulder.

3. Remove the steel axle ring (wear sleeve) by striking the ring surface several times with a ball-peen hammer. See **Fig. 1**. Remove the stretched axle ring from the spindle.
4. Clean and inspect the bearings, the spindle, spindle threads, seal bore, and the hub cavity.

   IMPORTANT: Use extreme care in cleaning the wheel hub cavity and axle spindle. Dirt, metal filings, or other contaminants can scratch the bearing roller surfaces, and cause premature wear of the bearing assembly.

   4.1 Inspect the inner hub bore. Remove dirt and contaminants from all recesses and corners. Smooth any sharp edges with emery cloth, and fill in any grooves with filler. See **Fig. 2**.

   4.2 Wipe the hub area with a clean shop cloth.

   4.3 After removing the wear sleeve, inspect the spindle. Remove any sharp edges and burrs from the leading edges and the shoulder area. Repair deep gouges with filler and smooth with an emery cloth. See **Fig. 3**.

   4.4 Wipe the seal and shoulder area with a clean shop cloth.

⚠ CAUTION

Do not spin bearing rollers at any time. Dirt or grit can scratch the roller surface and cause rapid wear of the bearing assembly. Treat used bearings as carefully as new ones.

   4.5 Inspect the bearings and hub components for wear or damage. Replace any worn or damaged components as necessary.

   4.6 Coat the wheel bearing cones with oil.

5. Install the inner wheel bearing cone in the inner wheel bearing cup.

IMPORTANT: Use the Dana Spicer Outrunner installation tool *with the centering tool* when installing the seal. See **Fig. 4**.

6. Install the oil seal in the hub bore.

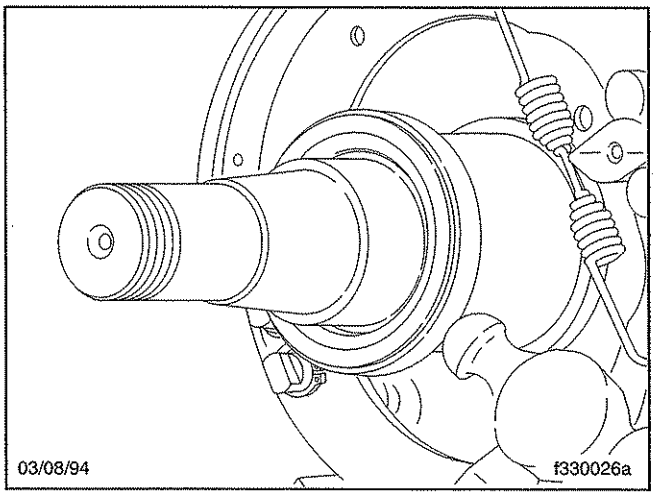
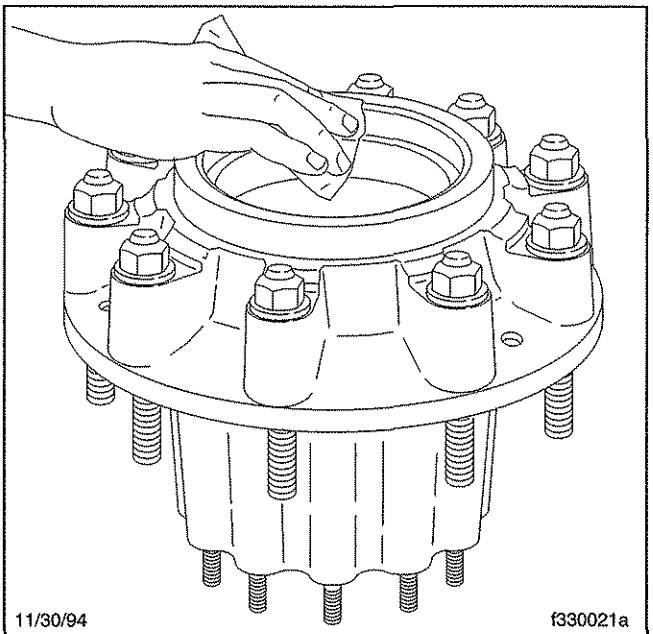


Fig. 1, Removing the Axle Ring

Seal Replacement, Dana Spicer® Outrunner™



NOTE: Rear hub shown.

Fig. 2, Clean and Inspect the Hub Bore

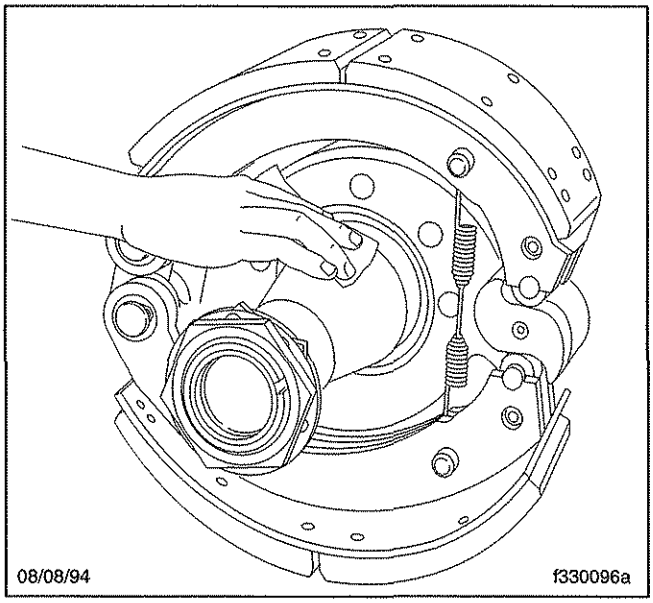


Fig. 3, Clean and Inspect the Axle Spindle

⚠ CAUTION

Do not use any silicone or permatex type bore sealant with this seal. The Dana Spicer Corporation recommends a light coating of bearing oil on the outer circumference of the seal.

Do not mix lubricants of different grades. Do not mix mineral and synthetic lubricants. Do not pack the bearings with grease when using an oil bath system. Failure to follow these installation guidelines will result in less than desired performance of the Outrunner seal, and installation-related failures are not covered under warranty.

6.1 Place the Outrunner seal tool with the words "air side" facing the adapter plate of the installation tool. See **Fig. 5**. Lubricate the seal outer circumference with wheel bearing oil.

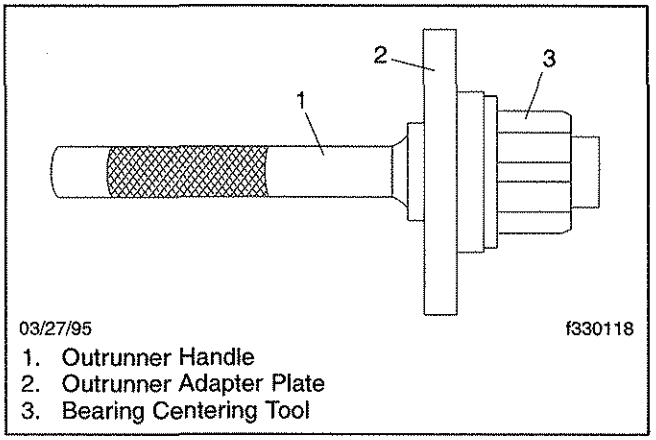
IMPORTANT: Install the seal in the hub bore with the hub lying flat. Do not install the seal with the hub in the vertical (upright) position.

6.2 With the hub and the wheel assembly lying flat on the floor, place the inner bearing cone in the cup.

6.3 Position the oil seal in the hub bore. Before striking the handle of the installation tool, tap the adapter plate around the outer edge to position the seal. See **Fig. 6**.

6.4 Hit the handle of the installation tool *gently*. See **Fig. 7**.

Because of the rubber outer circumference, the Outrunner seal is easier to install than seals with metal outer circumferences. When the adapter plate bottoms out on the



1. Outrunner Handle
2. Outrunner Adapter Plate
3. Bearing Centering Tool

Fig. 4, Outrunner Installation Tool

Seal Replacement, Dana Spicer® Outrunner™

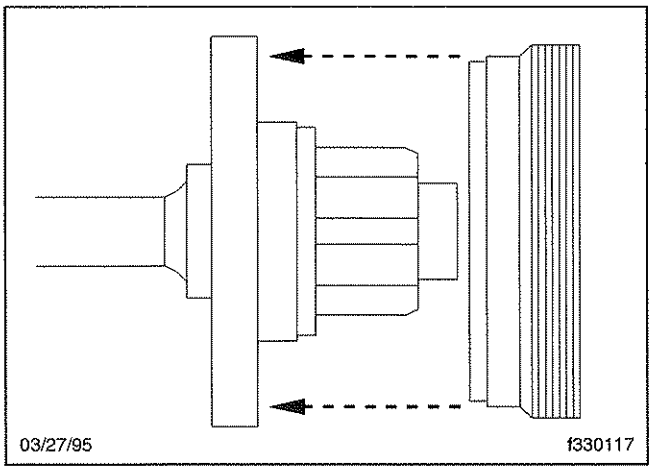


Fig. 5, Seal Placement on Tool

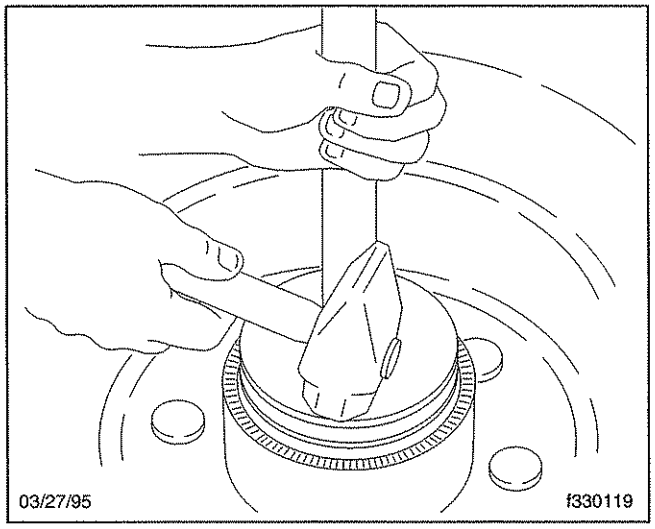


Fig. 6, Position the Seal

hub surface, the seal is installed correctly. You will hear a metal-to-metal sound.

6.5 Check that the seal is not cocked, and that the unitized seal inner circumference and inner bearing turn freely.

6.6 Lubricate the inner circumference of the seal with a light film of clean bearing oil.

7. Install the wheel hub on the axle, and adjust the wheel bearings. For instructions, see **Section 33.01**.

IMPORTANT: When starting the wheel on the spindle, center the hub carefully to avoid seal damage from the leading edge of the spindle.

8. Place the hubcap and a new gasket in position. Install the capscrews. Tighten the capscrews 15 lbf·ft (20 N·m).
9. Fill the hub with oil to the level shown on the hubcap. See **Fig. 8**. Do not overfill.
10. Spin the wheel and check the oil level.
11. Adjust the brake shoe-to-drum clearance. For instructions, see **Group 42**.

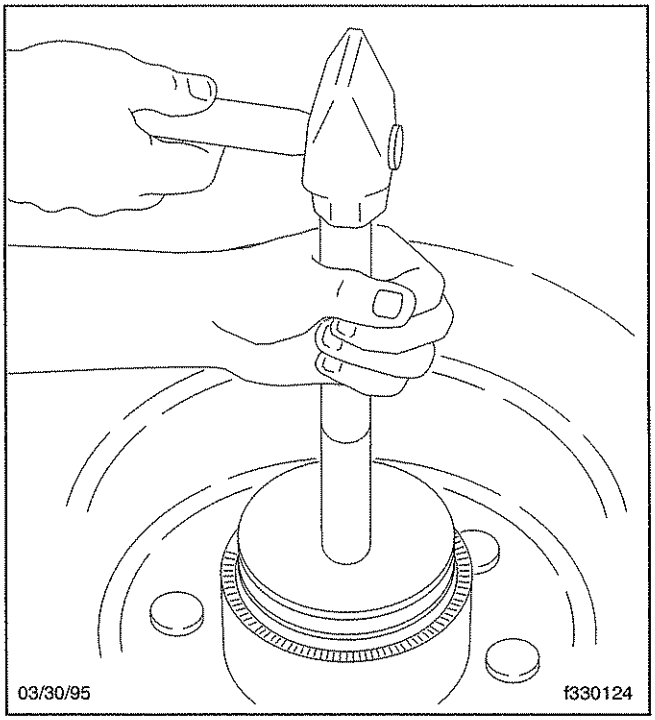


Fig. 7, Install the Seal

Seal Replacement, Dana Spicer® Outrunner™

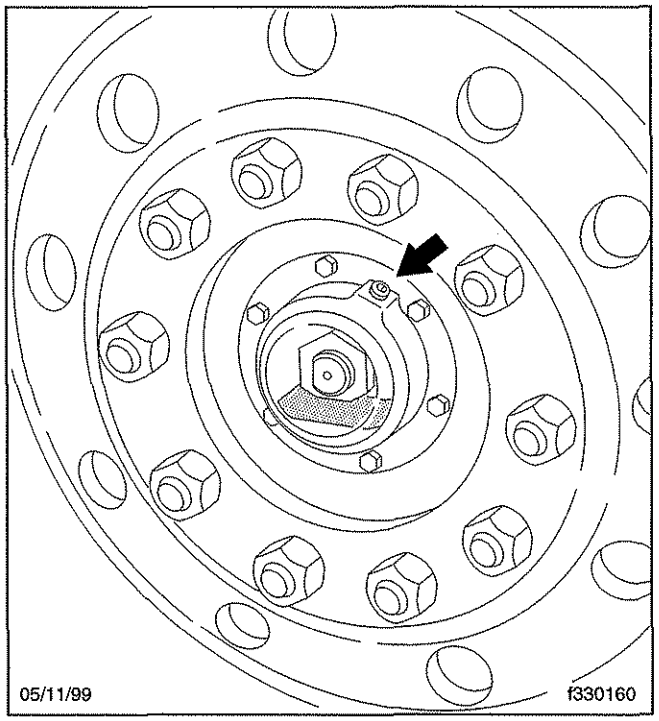


Fig. 8, Hub Filler Plug

Seal Replacement, National®

IMPORTANT: Make sure the required tools are available before beginning the service procedures described here. See the "Bearing Centering Tool Interchange" and "Adapter Plates" tables in **Specifications, 400**.

Replacement

1. Remove the wheel, drum, and hub from the axle. For instructions, see **Section 33.01**.
2. Remove the old oil seal from the hub or spindle.
3. Clean the spindle, spindle threads, seal bore, and the hub cavity.

⚠ CAUTION

Never use a sharp chisel to cut through an axle ring. A sharp chisel could damage the spindle or shoulder.

4. Remove the steel axle ring by striking the ring surface several times with a ball-peen hammer. See **Fig. 1**. Remove the stretched axle ring from the spindle.
5. Inspect the spindle shoulder and hub bore.
   - 5.1 If necessary, use a file to remove burrs from the leading edges and shoulder area.

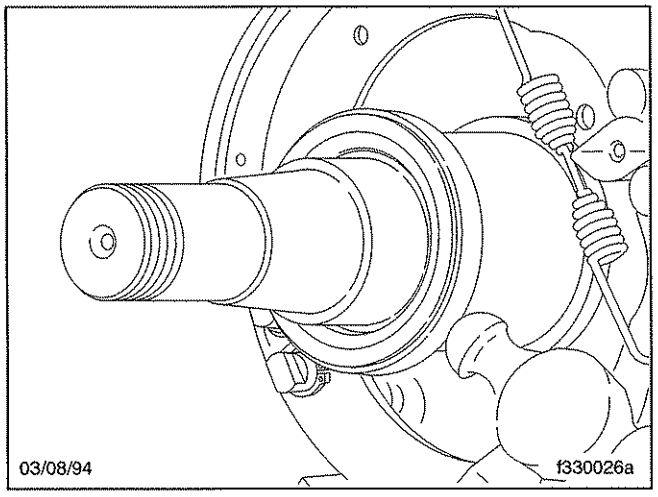


Fig. 1, Remove the Axle Ring

   - 5.2 Fill any deep scratches with a hardening compound and smooth it with an emery cloth. See **Fig. 2**.
   - 5.3 Use a clean cloth to remove all dirt, grit, and metal filings.
   - 5.4 Check the seal for a correct fit by placing the seal on the axle spindle, up to the first rubber rib. The correct seal will not go any farther.

   IMPORTANT: Clean the wheel hub cavity and axle spindle. Dirt, metal filings, or other contaminants can scratch the bearing roller surfaces, and cause rapid wear of the bearing assembly.

   - 5.5 Inspect the hub bore, and remove any burrs from the leading edge with an emery cloth.
6. Select the seal installation tools designed for use with National oil bath seals. These should include a universal handle, an adapter plate, and a bearing pilot. See **Fig. 3**.
7. Install the seal in the hub.

⚠ CAUTION

Do not spin bearing rollers at any time. Dirt or grit can scratch the roller surface and cause rapid wear of the bearing assembly. Treat used bearings as carefully as new ones.

   - 7.1 Prelube the inner bearing cone with clean oil and place it in the hub. See **Fig. 4**.

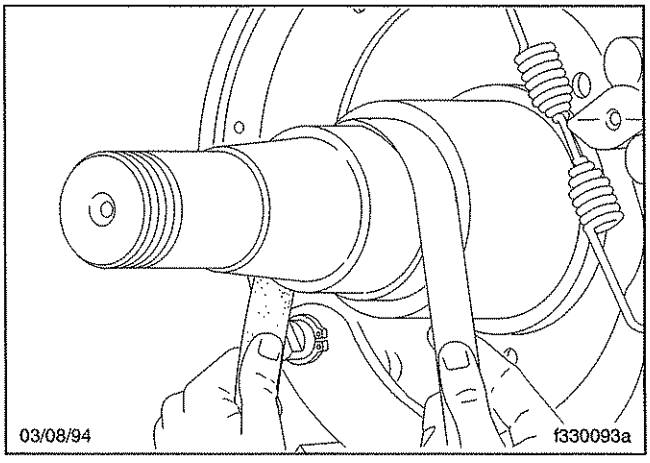


Fig. 2, Clean the Axle Spindle

Seal Replacement, National®

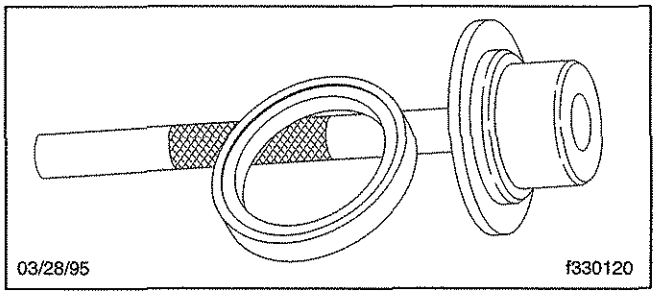


Fig. 3, Installation Tools

7.2 Place the oil bath seal on the installation tool with the words "air side" facing the adapter plate. Lubricate the outside diameter of the seal with clean oil to ease the installation. See **Fig. 5**.

7.3 Hold the tool straight, and drive the seal with a firm hit until the sound of the impact changes. See **Fig. 6**. Make sure the seal is squarely in position and the inner wheel bearing rotates freely.

7.4 Lubricate the inside diameter of the seal with clean oil.

8. Install the hub, and adjust the wheel bearings. For instructions, see **Section 33.01**. Fill the hub cavity with clean oil.

9. Install the hub cap with a new gasket. Tighten the hub cap nuts 15 lbf·ft (20 N·m). Add oil to the level shown on the window. See **Fig. 7**. Turn the hub and allow the oil to settle. Recheck the hub and fill to a level between the oil line and about 1/4 inch (6 mm) above the oil line. Do not overfill the hub. Install the vent plug or threaded filler plug.

10. Spin the wheel and check the oil level.

11. Adjust the brake shoe-to-drum clearance. For instructions, see **Group 42**.

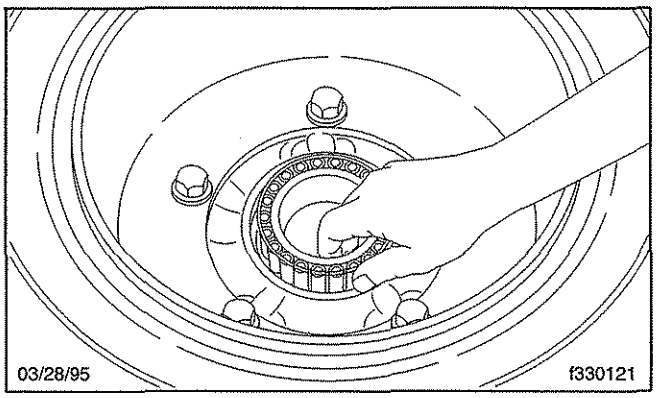


Fig. 4, Place the Bearings in the Hub

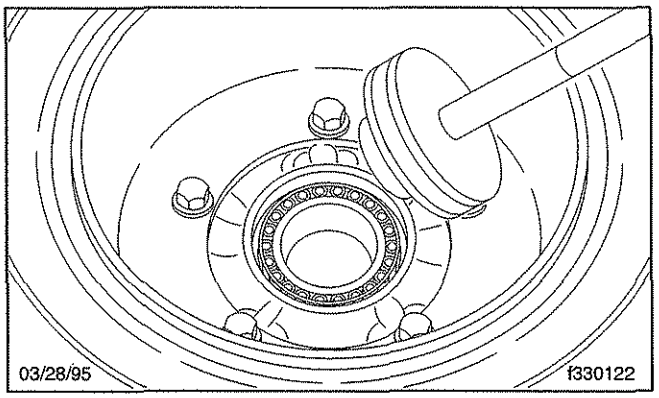


Fig. 5, Place the Seal on the Tool

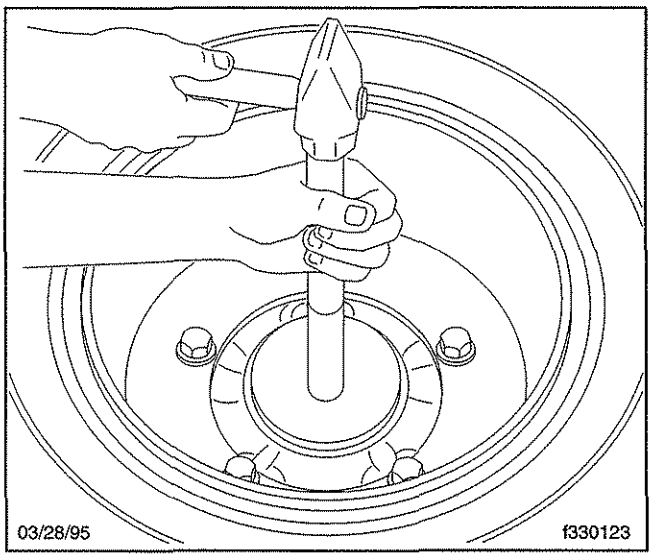


Fig. 6, Drive the Seal Into the Hub

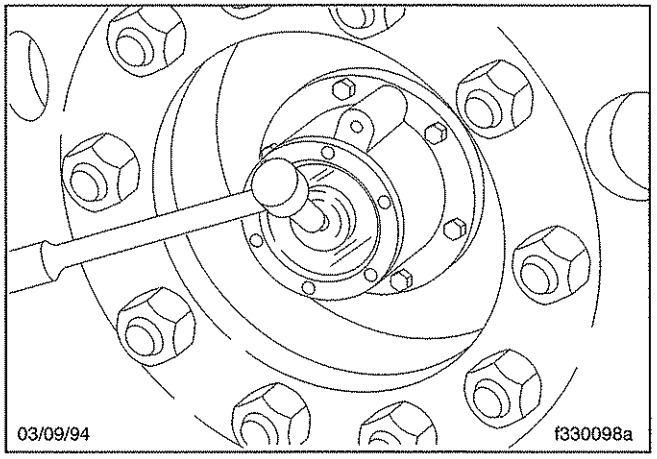


Fig. 7, Fill the Hub With Oil

Seal Replacement, Stemco®

IMPORTANT: Make sure the required tools are available before beginning the service procedures described here. See the "Bearing Centering Tool Interchange" and "Adapter Plates" tables in **Specifications, 400**.

Replacement

1. Remove the wheel, drum, and hub from the axle. For instructions, see **Section 33.01**.
2. Remove the old oil seal from the hub or spindle.
3. Clean the spindle, spindle threads, seal bore, and the hub cavity.

⚠ CAUTION

Never use a sharp chisel to cut through an axle ring. A sharp chisel could damage the spindle or shoulder.

4. Remove the steel axle ring by striking the ring surface several times with a ball-peen hammer. See **Fig. 1**. Remove the stretched axle ring from the spindle.
5. Using a wire brush, remove any old sealant and corrosion from the axle spindle and shoulder. Remove any burrs with an emery cloth. See **Fig. 2**. Wipe the spindle and shoulder clean with safety solvent.

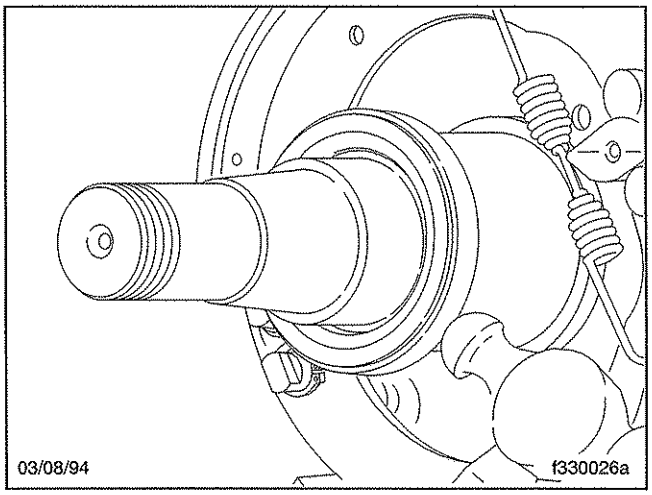


Fig. 1, Remove the Axle Ring

6. Remove any burrs from the inside of the hub bore. See **Fig. 3**. The hub bore must be free of burrs that will scratch the outer surface of the seal and allow oil to escape from the hub. Remove any spacer rings or washers, if so equipped.

IMPORTANT: Clean the wheel hub cavity and axle spindle. Dirt, metal filings, or other contaminants can scratch the bearing roller surfaces, and cause rapid wear of the bearing assembly.

7. Inspect the bearings and hub components for wear or damage. Replace any worn or damaged parts as necessary.

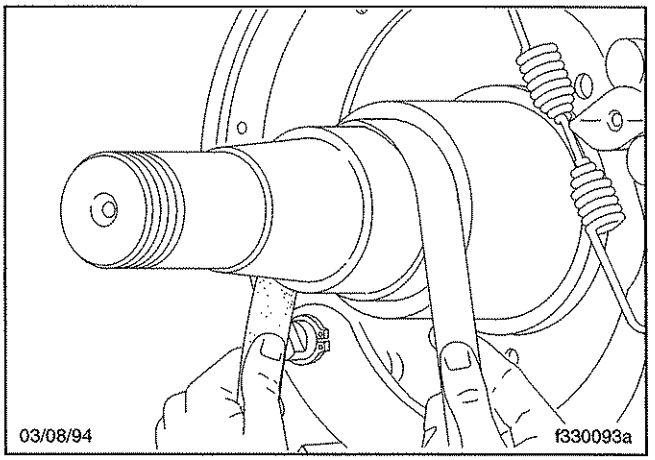
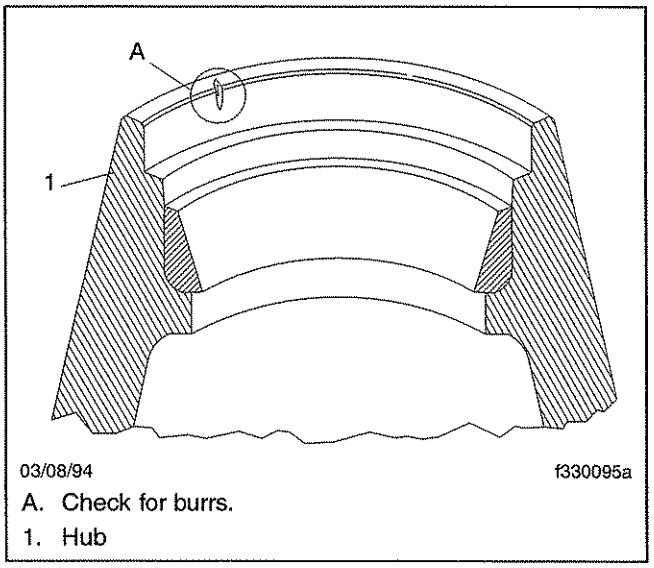


Fig. 2, Clean the Axle Spindle



A. Check for burrs.
1. Hub

Fig. 3, Inspect the Hub Bore

Seal Replacement, Stemco®

⚠ CAUTION

Do not spin bearing rollers at any time. Dirt or grit can scratch the roller surface and cause rapid wear of the bearing assembly. Treat used bearings as carefully as new ones.

8. If burrs were removed from the spindle shoulder, apply a thin layer of non-hardening sealant to the spindle shoulder. See **Fig. 4**.

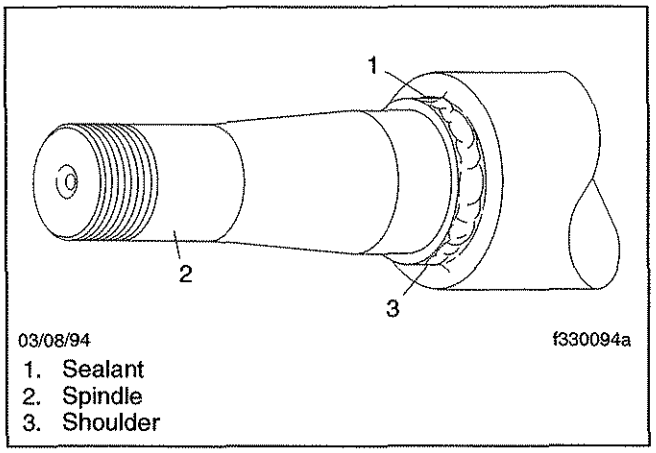
NOTE: Use a non-hardening sealant such as Permatex® Number-2 or Loctite® 515.

9. Place the oil seal on the spindle so the words "oil-bearing side" are exposed to the oil. A slight step on the inside circumference of the seal ring will allow it to be placed by hand about 1/8 inch (3 mm) onto the shoulder. See **Fig. 5**.

⚠ CAUTION

Do not install the oil seal in the hub bore. Incorrect seal installation will damage the seal and lead to possible spindle, hub, and bearing damage.

10. Position the Stemco installation tool over the spindle. See **Fig. 6**. Using a 3 to 5 lb (1 to 2 kg) hammer, drive the seal on the spindle until the tool bottoms against the shoulder. After the tool bottoms, turn it while applying several light taps with the hammer to ensure the seal ring is flush with the face of the shoulder. Wipe off all excess sealant.



1. Sealant
2. Spindle
3. Shoulder

Fig. 4, Apply Sealant to the Spindle Shoulder

IMPORTANT: Use only the tool specified by Stemco for the vehicle's axle. In order for the Stemco warranty to apply, the product must be correctly installed using the correct tool made by Stemco or a tool approved by Stemco.

11. Make sure there are no gaps between the ring and shoulder. See **Fig. 7**.

12. Coat the inner wheel bearing with oil and install it on the spindle. See **Fig. 8**. No additional oil is needed on the outside of the seal. The seals are lubed at the factory.

13. Install the hub and wheel bearings. For instructions, see **Section 33.01**.

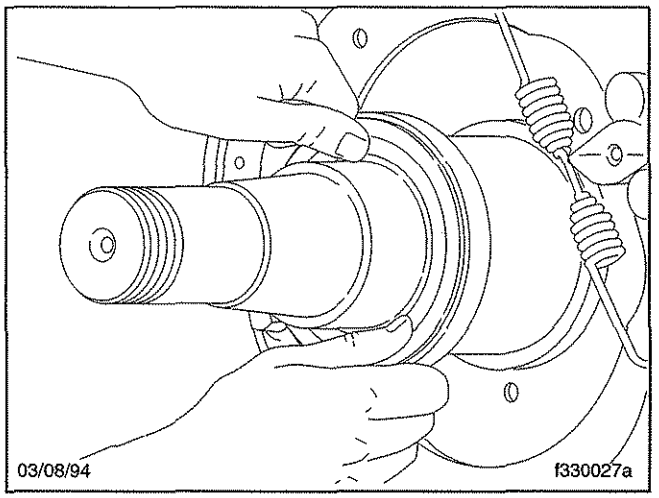


Fig. 5, Place the Seal on the Spindle

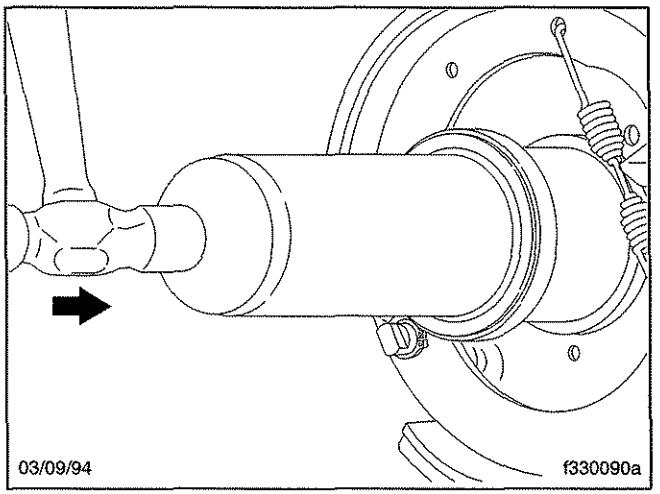


Fig. 6, Drive the Seal onto the Spindle

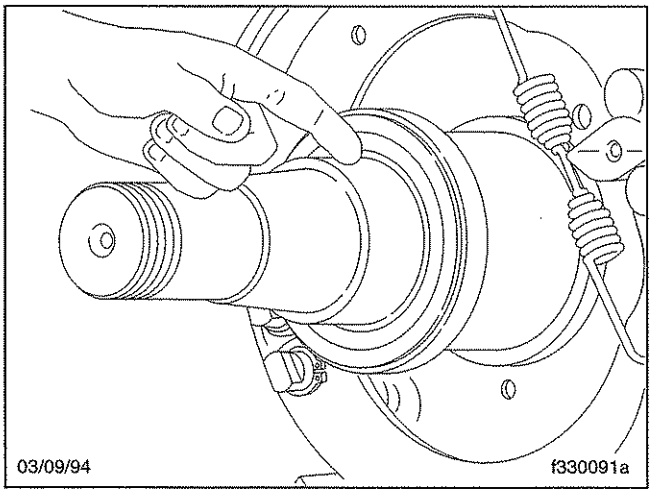


Fig. 7, Check the Ring for Gaps

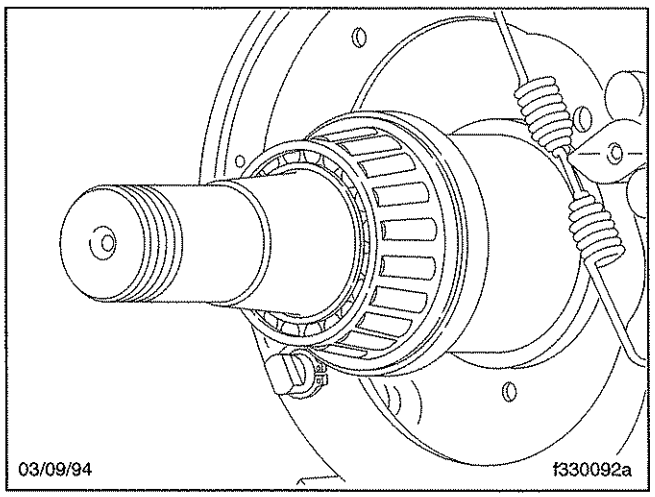


Fig. 8, Install the Inner Bearings

IMPORTANT: Do not force the wheel onto the seal. The wheel will seat on the seal when the adjustment nut is tightened.

14. Adjust the wheel bearings. For instructions, see **Section 33.01**.

15. Install the hub cap with a new gasket. Tighten the hub cap nuts 15 lbf·ft (20 N·m). Add oil to the level shown on the window. See **Fig. 9**. Turn the hub and allow the oil to settle. Recheck the hub and fill to a level between the oil line and about 1/4 inch (6 mm) above the oil line. Do not overfill the hub. Install the vent plug or threaded filler plug.

16. Spin the wheel and check the oil level.

17. Adjust the brake shoe-to-drum clearance. For instructions, see **Group 42**.

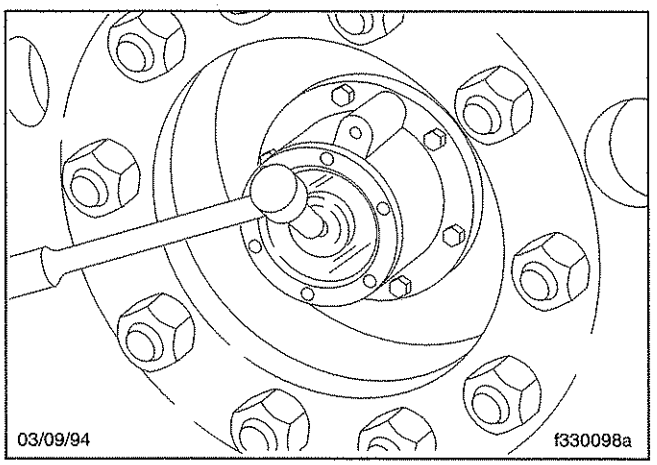


Fig. 9, Fill the Hub with Oil

Specifications

Bearing Centering Tool Interchange				
Spindle Type	Bearing Cone	Centering Tool Number		
		Dana Spicer® Outrunner™	Chicago Rawhide	National®
—	641	BCT-6	706	RD-406
—	39581	BCT-2	702	RD-402
—	557A	BCT-3	703	RD-403
FL	6461A	BCT-8	708	RD-418
—	H715345	BCT-16	716	RD-407
—	HM212044	BCT-3	703	RD-403
—	HM212047	BCT-4	704	RD-404
FF	HM212049	BCT-6	706	RD-406

Table 1, Bearing Centering Tool Interchange

Adapter Plates		
Seal	Adapter Plate	Color
847	847-T	Blue
855	855-T	
857	857-T	
863	863-T	

Table 2, Adapter Plates

Group Index, Alphabetical

Section **Section Number**

Rear Axle Alignment 35.00
Rear Axle Wheel Hubs, Brake Drums, and Wheel Bearings 35.01
Rear Axle Oil Seals 35.02

Rear Axle Alignment

35.00

Contents

Subject	Subject Number
General Information	050
Service Operations	
Manual Alignment Checking, Single Axle	100
Manual Alignment Checking, Tandem Axle	110
Center Point Bar Construction	120
Specifications	400

General Information

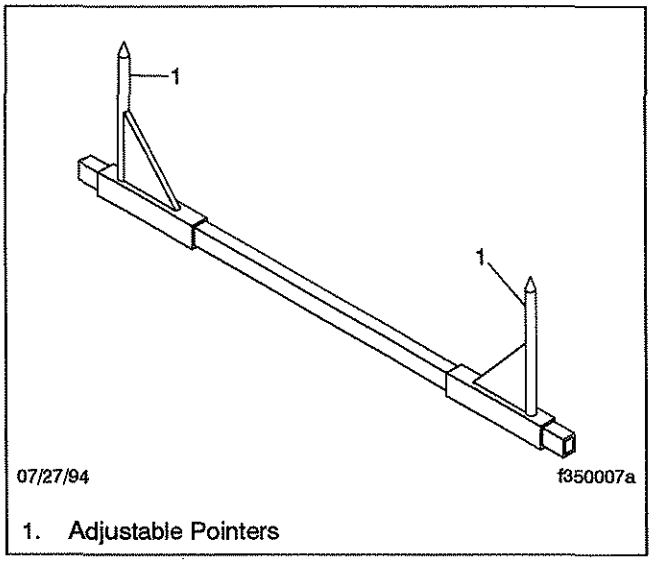
Rear axle alignment should be checked whenever rear axle or suspension components are replaced. It should also be checked when there is excessive front and rear tire wear or hard or erratic steering.

Manufacturers of axle alignment equipment offer a variety of systems to precisely measure and correct rear axle alignment. If this type of equipment is not available, the basic tools needed for checking rear axle alignment on tandem axles are a straightedge (which is nonflexible and at least as long as the axle), a steel tape rule, and a center point bar. On single axle vehicles, a straightedge, trammel bar, and steel tape rule are needed.

The straightedge is used to see if a single axle, or a forward-rear axle of a tandem axle installation, is in alignment with the frame. The distance from the straightedge to the center of the wheel hub is measured on each side of the vehicle; any difference in the measurements means that the axle is out of alignment.

The center point bar (**Fig. 1**) is used to see if the forward-rear axle and rearmost axle of a tandem installation are aligned with each other (parallel). The center point bar has adjustable pointers at each end, which are inserted into the axle cap holes of each axle. By comparing the distance between the two axles on one side to the distance on the other side, it can be determined if the axles are parallel.

Instructions and a list of materials for making the center point bar are in **Subject 120**.



1. Adjustable Pointers

Fig. 1, Center Point Bar

Manual Alignment Checking, Single Axle

Checking

NOTE: Before checking the axle alignment, make sure the wheel bearings are adjusted. For instructions, refer to **Section 35.01** in this manual. Make sure that no wheel rims are bent and that all rims are correctly seated. Check the frame rail alignment following the instructions in **Group 31** in this manual. Correct the frame rail alignment if necessary.

IMPORTANT: For vehicle alignment to be accurate, the shop floor must be level in every direction. The turn plates for the front wheels must rotate freely without friction, and the alignment equipment must be calibrated every three months by a qualified technician from the equipment manufacturer. Freightliner dealers must have proof of this calibration history.

1. Park the vehicle on a level surface. Relieve internal stresses in the suspension by driving the vehicle back and forth in a straight line, or by jacking the axle up and letting it down.
2. Chock the front tires and place the transmission in neutral. Release the parking brakes.

⚠ CAUTION

Do not use scribe lines for marking on frame rails. Scribe lines, which cut or scratch the metal, can develop into starting points for structural damage to the frame.

3. Select a point on the frame rail forward of the rear axle. Using a pencil or soapstone, mark two other points, exactly four inches (102 mm) forward and to the rear of the original point. Make sure that all three marks are aligned and of equal distance from the outside edge of the frame rail. Using a trammel bar, place one trammel pointer on the forwardmost point, and make an arc with a pencil or soapstone on the opposite frame rail. Then place the trammel pointer on the rearmost point and make an arc on the opposite frame rail intersecting the first arc. See **Fig. 1**. The point where the two arcs intersect and the original (or middle) point on the opposite frame rail have matching locations.
4. Line up the straightedge with the two matching points. Check that the straightedge extends out about the same distance on each side of the frame rail. Using C-clamps, clamp the straightedge to the frame. See **Fig. 2**. The straightedge must line up exactly with the points.
5. Measuring from the outside edge of each frame rail, mark the straightedge on both sides of the frame.The marks (**Fig. 2**, Ref. A) must be of equal distance from the frame and as far from the frame rail as the tires are at their farthest point from the frame.

IMPORTANT: The distance between the mark on the straightedge and the frame rail must be equal on both sides of the vehicle.

6. On each side of the vehicle, measure the distance from the mark on the straightedge to the center of the wheel hub. See **Fig. 2**.

   The difference between these measurements should be 1/4 inch (6 mm) or less. See **Fig. 3**. If the difference is more than 1/4 inch (6 mm), adjust the axle alignment. For instructions, refer to the applicable suspension section in this manual, or to the suspension manufacturer's service literature.

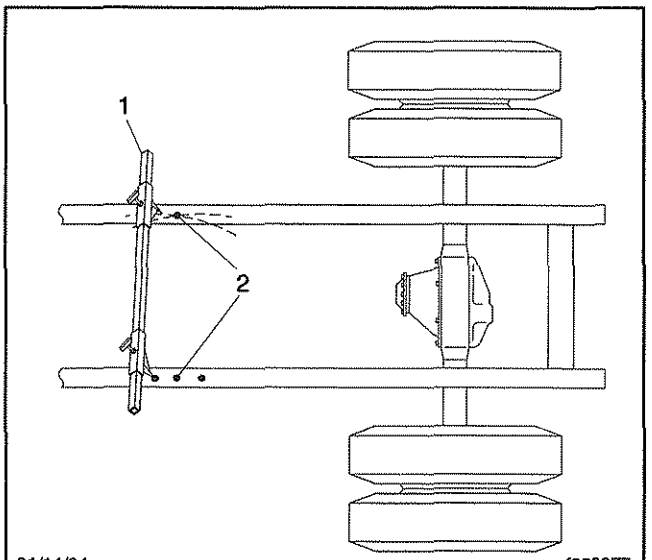
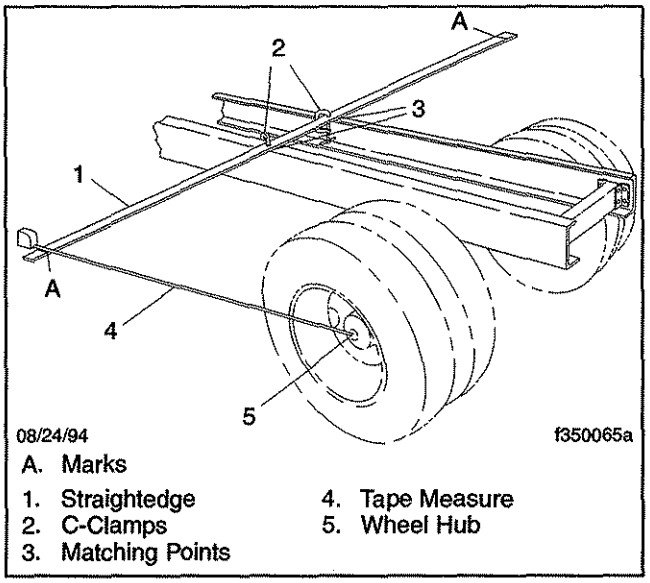


Fig. 1, Marking an Arc With the Trammel Bar

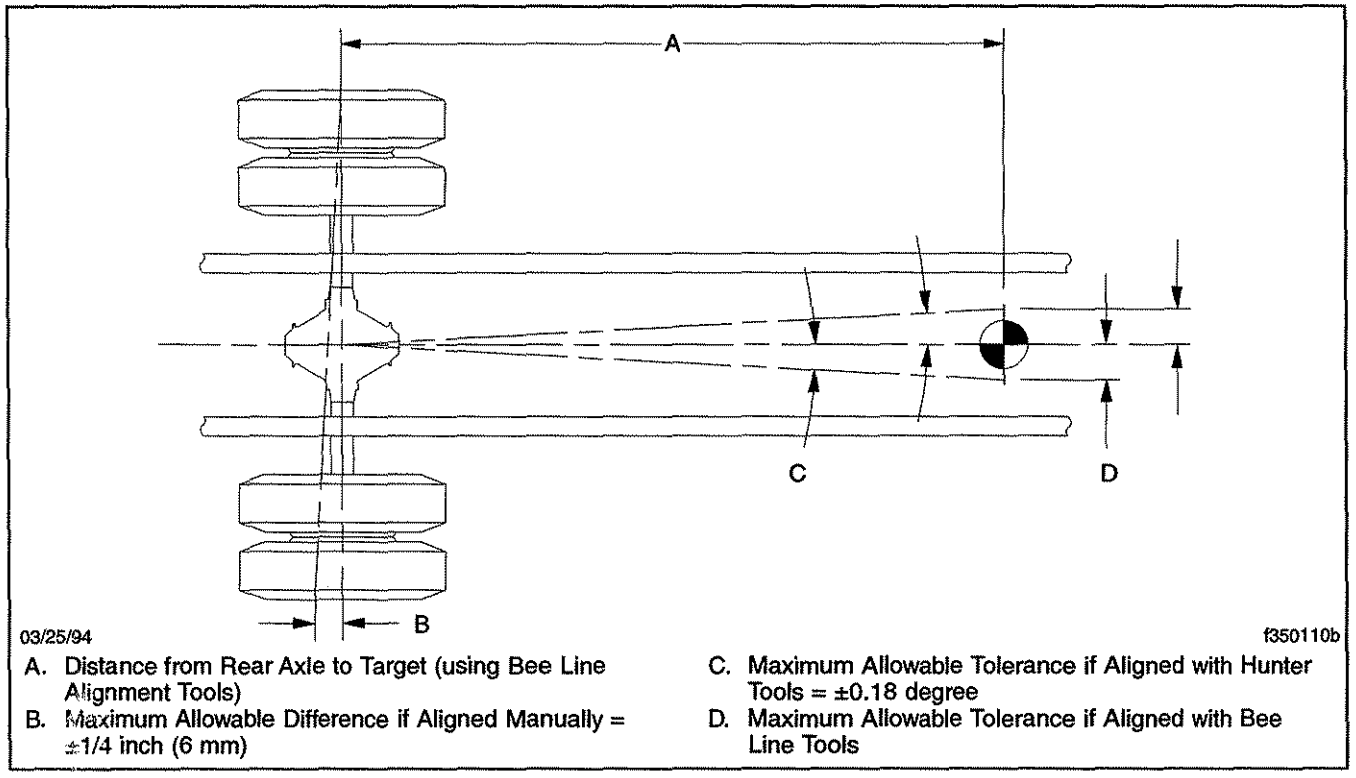
Manual Alignment Checking, Single Axle



A. Marks

1. Straightedge
2. C-Clamps
3. Matching Points
4. Tape Measure
5. Wheel Hub

Fig. 2, Straightedge to Wheel Hub Measurement



A. Distance from Rear Axle to Target (using Bee Line Alignment Tools)
B. Maximum Allowable Difference if Aligned Manually = ±1/4 inch (6 mm)
C. Maximum Allowable Tolerance if Aligned with Hunter Tools = ±0.18 degree
D. Maximum Allowable Tolerance if Aligned with Bee Line Tools

Fig. 3, Alignment Measurements

Manual Alignment Checking, Tandem Axle

Checking

A straightedge and a center point bar are needed to align a tandem axle. First, a straightedge and trammel bar are used to check and, if needed, align the rearmost axle. Then, the center point bar is used to check and, if needed, align the forward-rear axle.

Use the instructions in **Subject 100** to check and align the rearmost axle. Then, check the alignment of the forward-rear axle as follows:

IMPORTANT: Align the rearmost axle before checking the forward-rear axle.

For vehicle alignment to be accurate, the shop floor must be level in every direction. The turn plates for the front wheels must rotate freely without friction, and the alignment equipment must be calibrated every three months by a qualified technician from the equipment manufacturer. Freightliner dealers must have proof of this calibration history.

1. Using the center point bar, set the two points into the axle cap holes as shown in **Fig. 1**. Lock them in place by tightening the setscrews.
2. With the points still locked in place, move the center point bar to the other side of the vehicle, set the two points into the axle cap holes, and compare the axle spacing. If there is a difference of 1/8 inch (3 mm) or less between the spacing on one side of the vehicle compared to the other, no further action is necessary.

   If the difference is more than 1/8 inch (3 mm), adjust the forward-rear axle alignment. **See Fig. 2.** For instructions, refer to the suspension section in this manual, or to the suspension manufacturer's service literature.

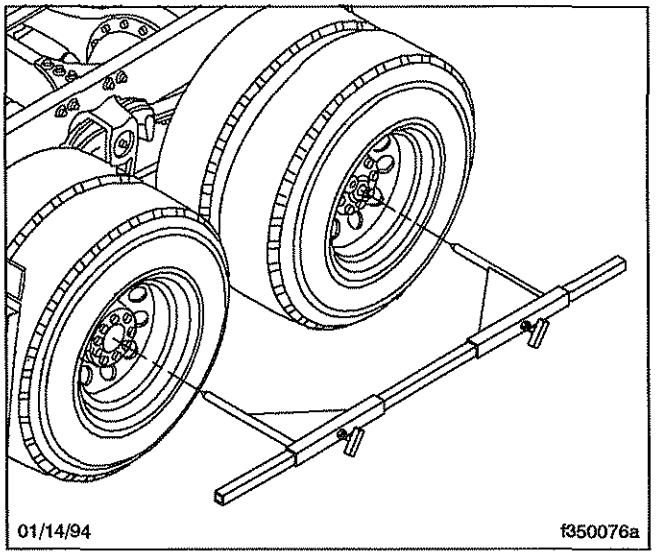
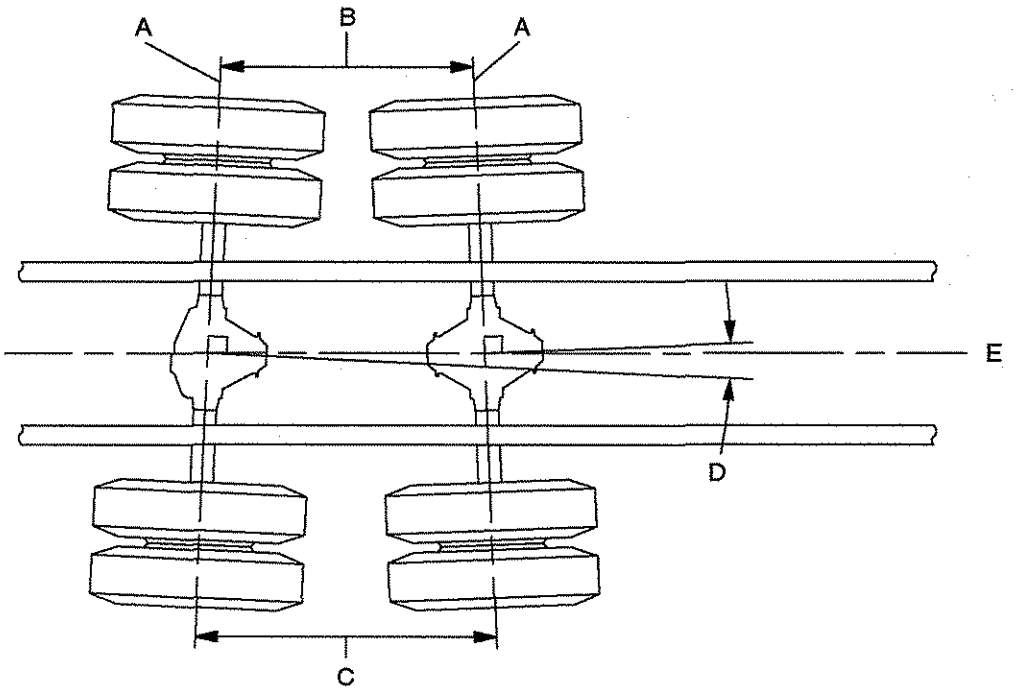


Fig. 1, Centerpoint Bar Placement

Manual Alignment Checking, Tandem Axle



A. Axle Centerline
B. Left-Hand Axle End Spacing, Measured Manually or with Bee Line Alignment Tools
C. Right-Hand Axle End Spacing, Measured Manually or with Bee Line Alignment Tools
D. Maximum Tolerance as Measured with Hunter Alignment Tools = ±0.08 degree
E. Vehicle Centerline

Fig. 2, Tandem Axle Measurements

Center Point Bar Construction

Materials Required

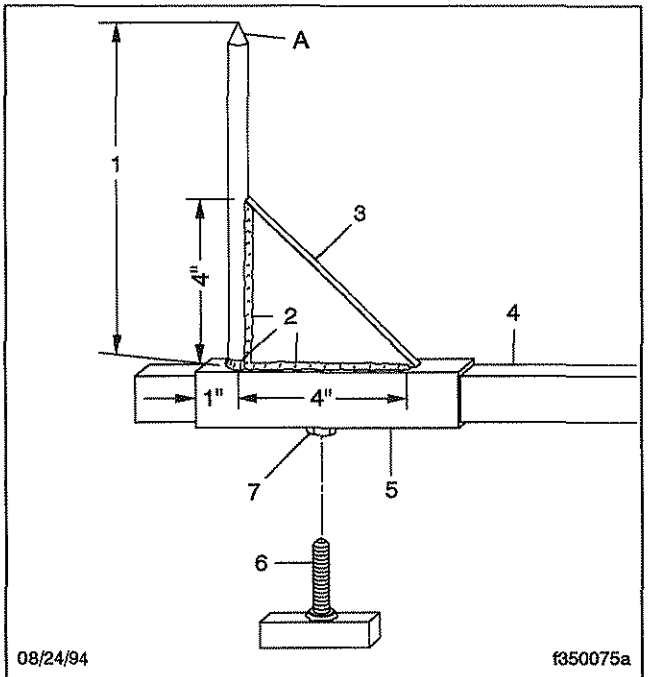
NOTE: To obtain metric conversions (millimeters), multiply the number of inches by 25.4.

Required materials are listed below.

- 62" of square steel tube (1" o.d.)
- 12" of square steel tube (1-1/8" i.d.)
- 20" of 3/8" steel rod
- Two 1/2" x 3" pieces of steel square-bar stock
- One 4" x 4" steel plate, 1/8" thick
- Two 3/8–16 capscrews (grade 5), 2" long
- Two 3/8–16 hexnuts (equivalent to grade 5)

Construction Procedures

1. Cut the 1-1/8 inch i.d. square steel tube in half to obtain two pieces 6 inches long. These will be the sliding members (slides) of the center point bar.
2. Cut the 4-inch by 4-inch steel plate diagonally into two pieces (gussets). Weld one gusset to each slide, as shown in **Fig. 1**.
3. Cut the steel rod in half to obtain two 10-inch rods. Grind one end of each to form a point.
4. Weld the pointed steel rods to the slides and gussets, as shown in **Fig. 1**.
5. Drill a 1/2-inch hole in the center of each slide, on the side opposite where the pointer was welded. Drill through only one side of the tube.
6. Directly over each hole drilled in the step above, weld a 3/8–16 nut (equivalent to grade 5).
7. Weld a piece of steel stock, about 1/2-inch wide by 3-inches long, over the head of each of two 3/8–16 by 2-inch long capscrews.
8. Place a slide over each end of the 60-inch piece of steel tube, with the pointed rods to the outside. Screw the handscrews (made in the step above) into the slides until they are clamped tightly to the cross tube.



A. Grind to a point.

1. 3/8-Inch Diameter Rod
2. Weld
3. Gusset
4. 1-Inch Square Steel Tube
5. 1–1/8 Inch Square Steel Tube
6. 3/8–16 Bolt
7. 3/8–16 Nut

Fig. 1, Center Point Bar Construction

Specifications

Maximum Tolerance from Perpendicular, Manual Method	
Method	**Maximum Tolerance ± from Perpendicular**
Manual	1/4-inch (6 mm)

Table 1, Maximum Tolerance from Perpendicular, Manual Method

Maximum Tolerance from Perpendicular, Hunter Equipment	
Method	**Maximum Tolerance ± from Perpendicular**
Hunter *	0.18 degree

* To use Hunter alignment equipment, refer to the applicable Hunter service literature.

Table 2, Maximum Tolerance from Perpendicular, Hunter Equipment

Maximum Tolerance from Perpendicular at Target, Bee Line Equipment	
Distance from the Forward or Rear Drive Axle to Target inches (mm)	**Maximum Tolerance± from Perpendicular inches (mm)**
100 (2540)	5/16 (8)
120 (3048)	3/8 (10)
140 (3556)	7/16 (11)
160 (4064)	1/2 (13)
180 (4572)	9/16 (14)
200 (5080)	5/8 (16)
220 (5588)	11/16 (17)
240 (6096)	3/4 (19)
260 (6604)	13/16 (21)

Table 3, Maximum Tolerance from Perpendicular at Target, Bee Line Equipment

Rear Axle Parallelism Specifications	
Method	**Maximum Tolerance**
Hunter	±0.08 degree maximum axle-to-axle difference; reference "C" in **Fig. 1.**
Bee Line or Manual	±1/8-inch max. difference in axle end-spacing; reference "B" minus "A" in **Fig. 1.**

Table 4, Rear Axle Parallelism Specifications

Specifications

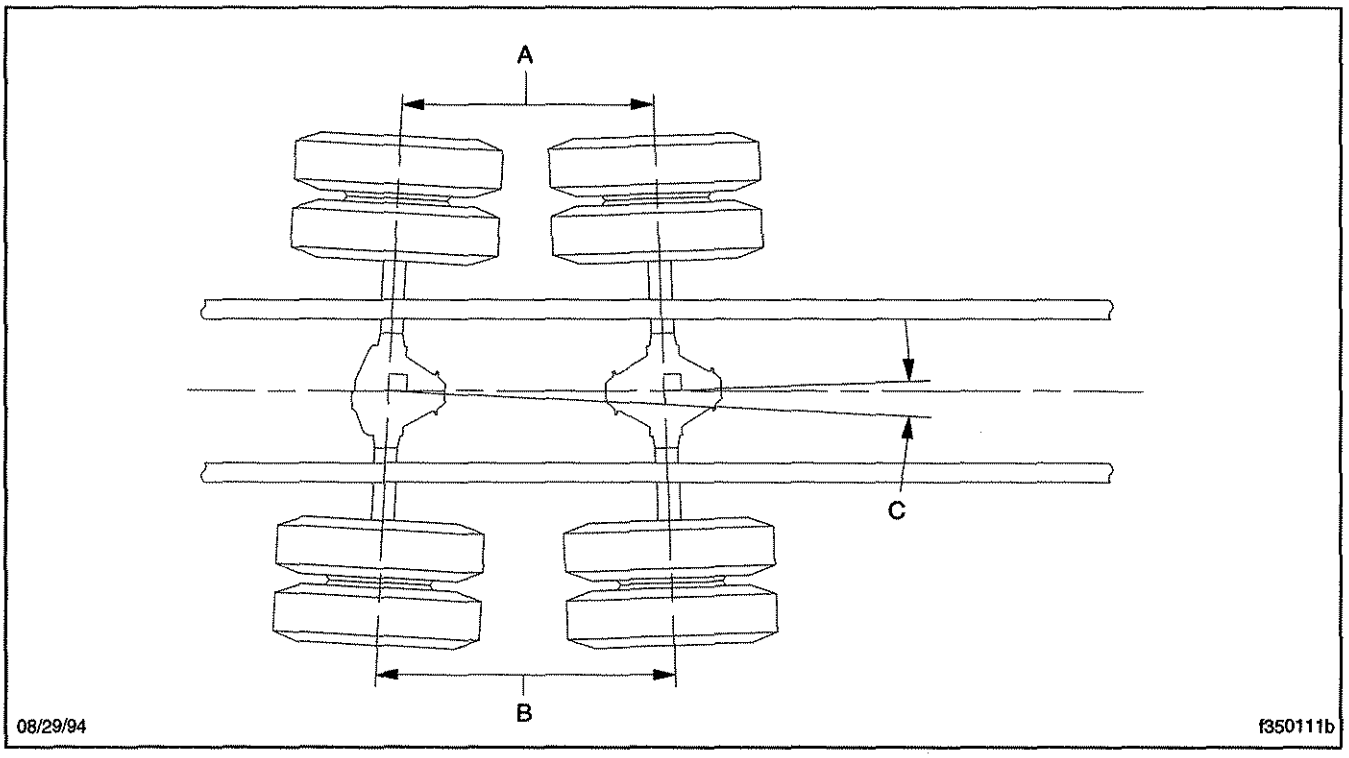


Fig. 1, Tandem Axle Measurements

Contents

Subject	Subject Number
General Information	050
Service Operations	
Hub Assembly Removal and Installation	100
Outboard-Mounted Drum Removal and Installation	105
Axle Components Cleaning and Inspection	110
Wheel Bearing Cup Removal and Installation, Aluminum Hubs	115
Wheel Bearing Cup Removal and Installation, Ferrous Hubs	120
Wheel Stud Replacement	125
Drive Axle Stud Replacement	130
Con Met PreSet® Hub Installation and Adjustment	135
Four-Piece Wheel Bearing System Installation and Adjustment	140
Pro-Torq® Nut Wheel Bearing System Installation and Adjustment	150
Troubleshooting	300
Specifications	400

General Information

These vehicles are equipped with one of three different wheel end assemblies:

- The Con Met PreSet® hub

  This wheel end has the bearings and oil seal pre-installed in a hub. To install a new hub, mount it on the axle spindle, and secure it with an Axi-Lok® nut. For instructions, see **Subject 135**. A spacer between the inner and outer bearings adjusts the bearings to near zero end-play and preload when you tighten the retaining nut.

- The traditional hub and bearings

  With traditional wheel ends, the bearings and oil seal must be assembled with the hub when the hub is installed on the axle spindle. First the oil seal is placed on the spindle (some brands of oil seal are installed in the hub bore), then the inner bearing and the hub are mounted on the axle spindle. Then, the outer bearing is mounted in the hub bore. A nut is installed on the axle spindle end and tightened and loosened to adjust the bearings. Finally, a locking device and jam nut are installed to secure the hub and bearings on the axle. For instructions, see **Subject 140**.

- The Pro-Torq® nut system.

  This system has one adjusting nut and a lockring device. For instructions, see **Subject 150**.

All wheel end assemblies consist of the following components (see **Fig. 1**):

- Wheel Bearings
- Axle Spindle
- Wheel Hub
- Brake Drum
- Wheel Studs

TAPERED WHEEL BEARINGS

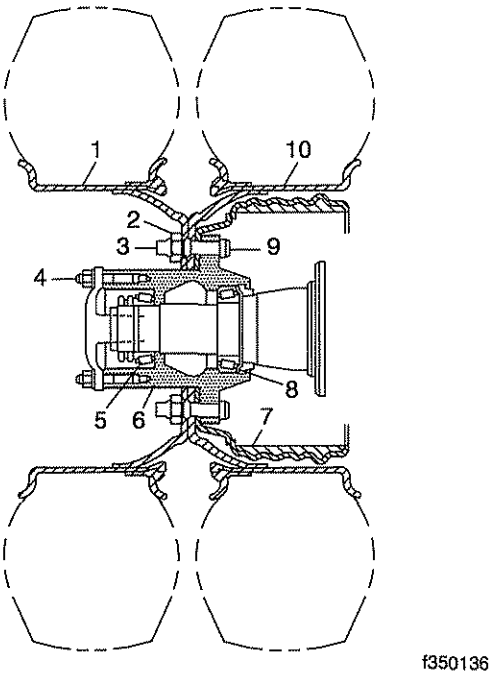
A typical tapered wheel bearing assembly consists of a cone, tapered rollers, a roller cage, and a separate cup that is press-fit in the hub. See **Fig. 2**. All components carry the load, with the exception of the cage, which spaces the rollers around the cone.

Each hub has a set of inner and outer tapered wheel bearing assemblies. On traditional hub and bearing assemblies, the bearing setting is locked in place on the axle spindle (steering knuckle) by an adjusting nut, a locking device such as a lockring or nut-lock, and a jam nut, or a Pro-Torq nut. See **Fig. 3**.

DRIVE AXLE SPINDLE ASSEMBLY

The drive axle spindle assembly is made up of a drive axle flange and shaft, drive axle studs and stud nuts, a flange gasket, an axle spindle, an oil seal, and the locking assembly described above

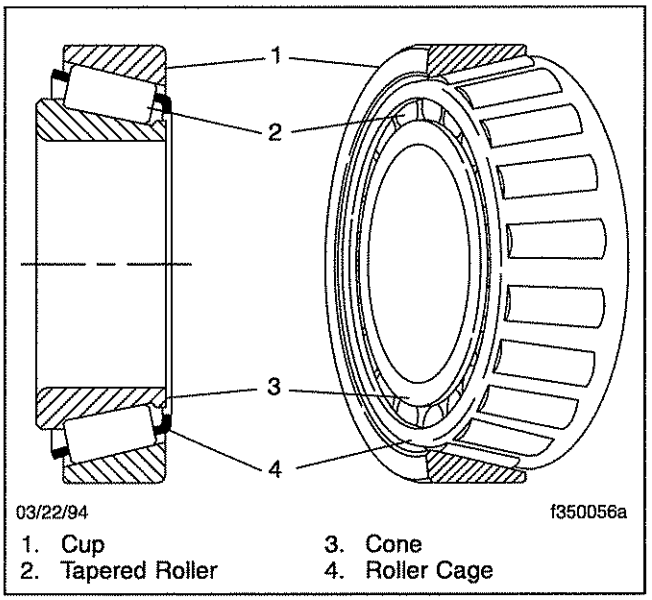
The surfaces of the spindle and the nut threads are machined. When these surfaces become damaged, repairs are necessary. There are standard methods for performing those repairs that preserve the proper alignment of the axle spindle assembly. Refer to the axle manufacturer for instructions.



1. Outer Wheel
2. Outer Wheel Nut
3. Wheel Stud
4. Drive Axle Stud
5. Outer Wheel Bearing
6. Hub
7. Brake Drum
8. Inner Wheel Bearing
9. Wheel Stud
10. Inner Wheel

Fig. 1, Wheel Hub and Brake Drum Assembly

General Information



1. Cup
2. Tapered Roller
3. Cone
4. Roller Cage

Fig. 2, Tapered Wheel Bearing Assembly

⚠ CAUTION

The National Highway Traffic Safety Administration (NHTSA) has warned against repairs that involve cutting off a portion of a damaged spindle and welding on a replacement part. The heat of welding can reduce the strength of spindles made with heat-treated materials and lead to spindle failure. After the cutting and welding operations, the replacement part may not be correctly aligned on the spindle. This can cause damage to the spindle nut.

WHEEL HUB

The inner disc wheel and/or brake drum is mounted on an aluminum or iron wheel hub (**Fig. 3**). Both the inner and outer bearing cups and certain types of wheel studs are press-fit in the hub. The hub is also the interconnecting point for the drive axle shaft and wheels.

BRAKE DRUM

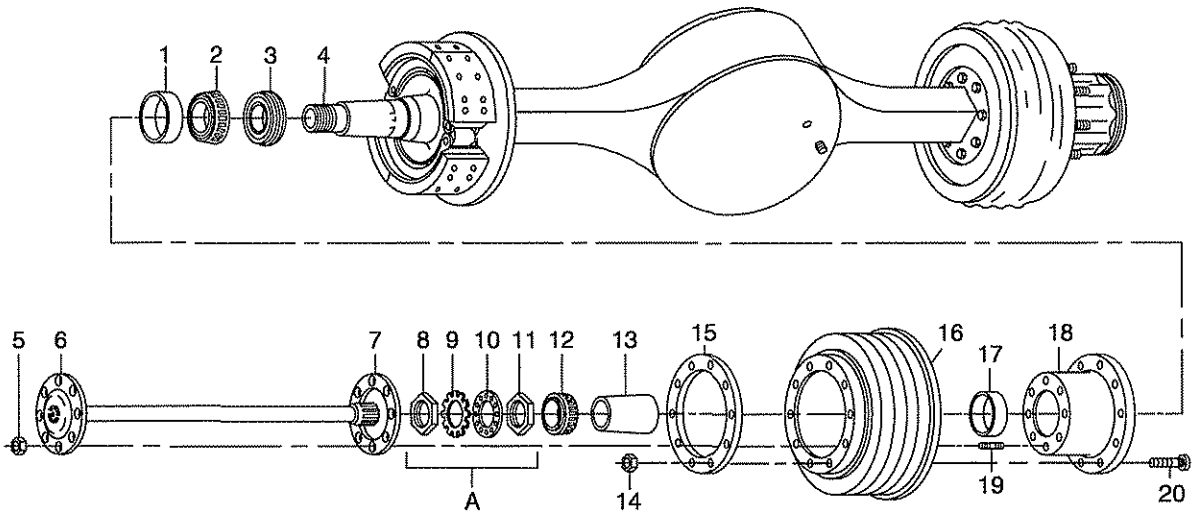
The brake drum and lining work together as a mated friction pair, with the drum responsible for both heat absorption and dissipation. Lining performance and life largely depend on the condition of the drum and whether it can adequately absorb and dissipate heat generated by braking action.

The brake drum is mounted on the outboard face of the hub and fits over the wheel studs. See **Fig. 3**.

WHEEL STUDS

A headed wheel stud (**Fig. 4**) is used on rear axle disc wheel hub assemblies and has either serrations on the stud body or a flat area on the stud's head to prevent the stud from turning in the wheel hub.

The end of the stud that faces away from the vehicle is stamped with an "L" or "R," depending on which side of the vehicle the stud is installed. Studs stamped with an "L" are left-hand threaded and are installed on the left side of the vehicle. Studs stamped with an "R" are right-hand threaded and are installed on the right side of the vehicle.



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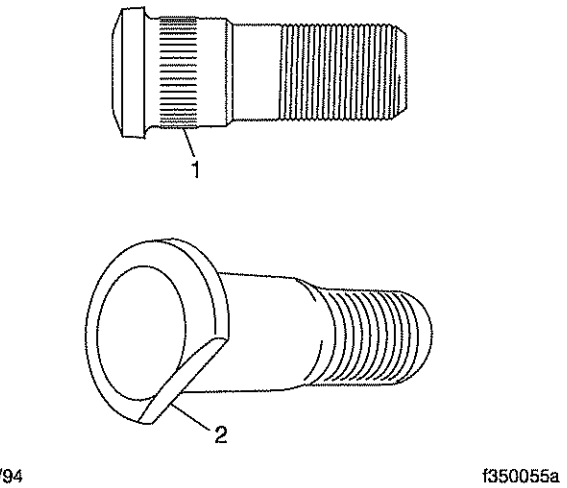
A. Four-piece bearing system shown; Pro-Torq or Axi-Lok locking nuts could be used.

1. Inner Wheel Bearing Cup
2. Inner Wheel Bearing
3. Oil Seal
4. Axle Spindle
5. Drive Axle Stud Nut
6. Drive Axle Flange and Shaft
7. Gasket
8. Jam Nut
9. Nut-Lock
10. Lockring
11. Adjusting Nut
12. Outer Wheel Bearing
13. Bearing Spacer (used only with Con-Met PreSet hubs)
14. Brake Drum Nut
15. Hub Spacer
16. Brake Drum
17. Outer Wheel Bearing Cup
18. Hub
19. Drive Axle Stud
20. Wheel Stud

Fig. 3, Typical Drive Axle and Hub Assembly (exploded view)



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1. Serrations
2. Clipped Head

Fig. 4, Typical Headed Wheel Studs

Hub Assembly Removal and Installation

Removal (See Fig. 1)

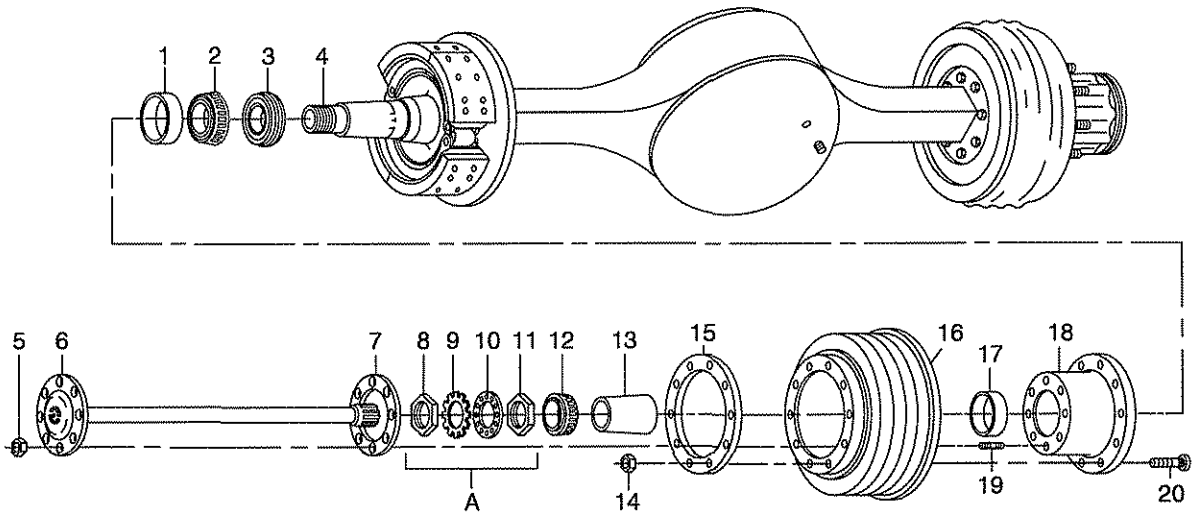
1. Park the vehicle, shut down the engine, and chock the front tires. Release the parking brakes.
2. Raise the rear of the vehicle until the tires clear the ground. Then place safety stands under the axle.
3. Back off the slack adjuster to release the rear axle brake shoes.
4. Remove both wheel and tire assemblies. For instructions, refer to **Group 40**.
5. Remove the brake drum. For instructions, refer to **Subject 105**.

NOTE: Oil will spill as the drive axle shaft (or hub cap) and the wheel hub are removed. Place a suitable container under the drive axle flange or hub cap to catch any spilled oil. Discard the oil.

6. Remove the drive axle stud nuts and washers. See **Fig. 2**.
7. Using a hammer and a soft drift, such as one made of brass, sharply tap the center portion of the drive axle flange. The shaft will usually spring slightly outward after the seal has broken. Remove the drive axle shaft.

⚠ CAUTION

When tapping the drive axle flange, avoid striking the drive axle studs. If struck, the studs may bend or break, or the stud threads can be damaged. Replace damaged studs.



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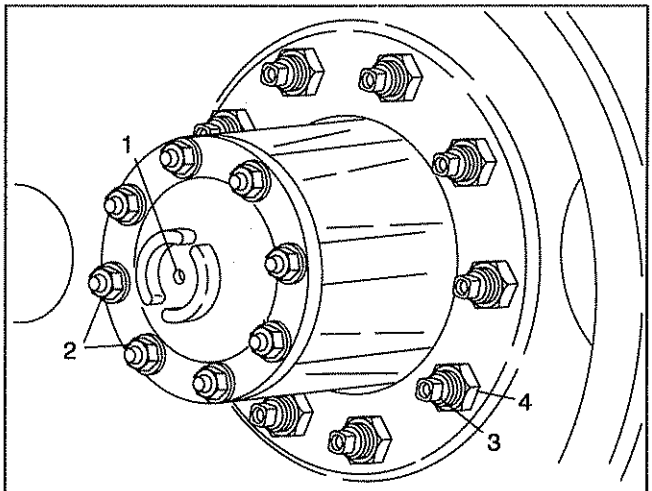
A. Four-piece bearing system shown; Pro-Torq® or Axi-Lok® locking nuts could be used.

1. Inner Wheel Bearing Cup
2. Inner Wheel Bearing
3. Oil Seal
4. Axle Spindle
5. Drive Axle Stud Nut
6. Drive Axle Flange and Shaft
7. Gasket
8. Jam Nut
9. Nut-Lock
10. Lockring
11. Adjusting Nut
12. Outer Wheel Bearing
13. Bearing Spacer (used only with Con Met PreSet® hubs and bearings)
14. Brake Drum Nut
15. Hub Spacer
16. Brake Drum
17. Outer Wheel Bearing Cup
18. Hub
19. Drive Axle Stud
20. Wheel Stud

Fig. 1, Typical Drive Axle and Hub Assembly (exploded view)

Hub Assembly Removal and Installation



1. Center Portion of Drive Axle Flange
2. Drive Axle Studs and Nuts
3. Inner Wheel Nut
4. Outer Wheel Nut

Fig. 2, Wheel Assembly and Hub

NOTE: Even if the drive axle shaft doesn't spring outward, the seal may have loosened enough to allow the shaft to be pulled from the axle housing. If the seal has not broken, repeat the step above.

8. If so equipped, remove the tapered dowels and washers from the drive axle flange.
9. Remove and discard the gasket.
10. Remove the wheel bearing locking device.

    If the axle is equipped with Con Met PreSet hubs, refer to **Subject 135**.

    If the axle is equipped with a four-piece wheel bearing system, refer to **Subject 140**.

    If the axle is equipped with a Pro-Torq nut system, remove the lockring, then remove the nut.

11. Move the hub about 1/2 inch (13 mm) to jar loose the outer wheel bearing (allow the hub-only assembly to rest on the axle spindle; be careful not to damage the axle spindle threads).

⚠ CAUTION

When moving the hub, be careful not to let the outer wheel bearing drop from the axle spindle. If the wheel bearing is dropped, cage warpage or roller damage can occur. On vehicles equipped with WABCO ABS, use care when working with the hubs. The ABS tone wheel is permanently pressed onto the hub and cannot be repaired. The tone wheel and hub must be replaced as a unit if either is damaged. To prevent damage to the tone wheel, do not drop the hub or lay it down in a way that would damage the tone wheel.

12. Carefully remove the outer wheel bearing; handle the bearings with clean, dry hands. Wrap the bearings in either clean oil-proof paper or lint-free rags.

⚠ CAUTION

Do not spin bearing rollers at any time. Dirt or grit can scratch the roller surface and cause rapid wear of the bearing assembly. Treat used bearings as carefully as new ones.

13. Remove the hub. Be careful not to damage the axle spindle threads as the assembly is removed.
14. Remove the inner wheel bearing from the axle. Handle the bearings with clean, dry hands, then wrap the bearings in either clean oil-proof paper or lint-free rags. Occasionally, the inner wheel bearing will remain in the hub after the hub is removed from the axle. In those cases, place a protective cushion where it will catch the bearings. Then use a hardwood drift and a light hammer to gently tap the bearing (and seal, if necessary) out of the cup.
15. Remove the oil seal from the axle spindle, if not already removed. Refer to the applicable oil seal section in this group for additional information.

Installation

⚠ WARNING

Breathing brake lining dust (asbestos or non-asbestos) could cause lung cancer or lung disease. OSHA has set maximum levels of exposure and requires workers to wear an air purifying respirator approved by MSHA or NIOSH. Wear a respirator at all times when servicing the brakes, starting

with removal of the wheels and continuing through assembly.

1. Using cleaning solvent, remove the old oil from the axle spindle and the disassembled parts. Allow the parts to dry, or dry them with a clean, absorbent, and lint-free cloth or paper. Wrap a protective layer of friction tape on the axle spindle threads.
2. On brake drum assemblies with an aluminum hub, coat the hub and drum contact surfaces with Alumilastic compound or an equivalent.
3. Coat both bearing assemblies with fresh oil. Install the inner wheel bearing and oil seal. Handle the bearings with clean, dry hands. Refer to **Section 35.02** for oil seal installation instructions.

⚠ CAUTION

Use only fresh oil on the bearing assemblies; old oil could be contaminated with dirt or water (both are corrosives) and could cause damage to both wheel bearing assemblies and the wheel hub.

4. Wipe a film of axle oil on the axle spindle to prevent rust from forming behind the inner wheel bearing.

⚠ CAUTION

On vehicles equipped with WABCO ABS, use care when installing the hubs. The ABS tone wheel is permanently pressed onto the hub and cannot be repaired. The tone wheel and the hub must be replaced as a unit if either is damaged. To prevent damage to the tone wheel, do not drop the hub or lay it down in a way that would damage the tone wheel.

5. Mount the bearings and hub on the spindle. Then adjust and secure the bearings.

   If the axle is equipped with Con Met PreSet hubs, refer to **Subject 135**.

   If the axle is equipped with a four-piece wheel bearing system, refer to **Subject 140**.

   If the axle is equipped with a Pro-Torq nut system, refer to **Subject 150**.

6. Install a new gasket on the drive axle studs.
7. Install the drive axle shaft or, on non-drive axles, the hub cap. The splined end of the axle shaft must seat before the drive axle flange will fit over the studs.
8. If equipped, install the dowels and washers on the drive axle studs. Install the drive axle nuts. Using the sequence shown in **Fig. 3**, tighten the nuts to the torque values in the torque table in **Specifications, 400**.
9. Install the brake drum on the wheel hub. For instructions, refer to **Subject 105**.

⚠ WARNING

If the inner wheel nuts cannot be tightened to minimum torque values, the wheel studs have lost their locking action, and the hub flange is probably damaged. In this case, replace it with a new wheel hub assembly. Failure to replace the wheel hub assembly when the conditions described above exist, could result in loss of a wheel or loss of vehicle control, and possible personal injury.

10. Install the inner and outer wheel and tire assemblies. For instructions, refer to **Group 40**.

⚠ WARNING

Add oil to the axle housing bowl or the wheel hub after the drive axle shaft and wheel hub have been serviced. Failure to add oil will damage the wheel

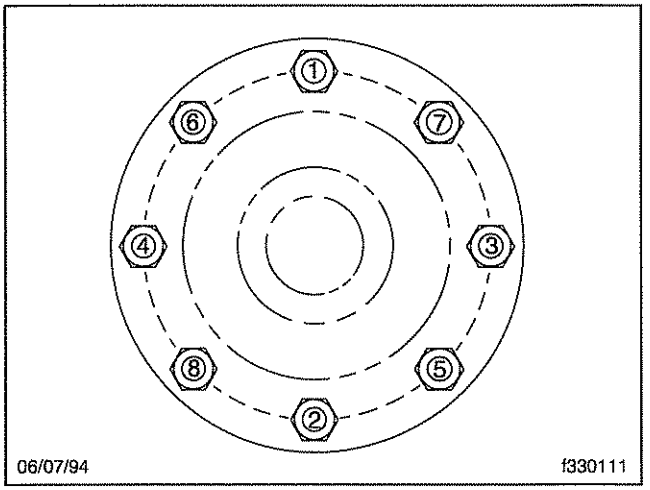


Fig. 3, Axle Shaft Flange Nut-Tightening Sequence

Hub Assembly Removal and Installation

bearings and cause them to seize during vehicle operation. Seized bearing rollers can cause sudden damage to the tire or axle, possibly resulting in personal injury.

11. For drive axles, pour the recommended drive axle lubricant through the axle housing filler hole.

    On Eaton axles, tighten the oil filler plug 40 to 60 lbf·ft (54 to 81 N·m).

    On Meritor axles, tighten the oil filler plug 35 lbf·ft (47 N·m).

12. Tilt the axle to the left and right, by jacking the opposite side. Hold the tilted position for one minute on each side, to allow oil to run into the wheel end. Return the axle to a level position, and add oil through the axle housing filler hole. About two extra pints (1 L) of lubricant will be needed, to bring the oil level even with the base of the filler hole.

NOTE: Drive axle wheel bearings are lubricated by oil drawn from the axle housing bowl section. This method ensures good exchange of heat, prevents stagnation, and minimizes the maintenance required on bearings and hub assemblies.

13. For non-drive axles, add about 1 to 1-1/2 pints (0.5 to 0.7 L) of oil to the level shown on the hub cap. Do not overfill. Install the vent plug or threaded filler plug.

14. Turn the wheels, and check the lubricant level.

15. Adjust the rear axle brakes. For instructions, see **Group 42** in the vehicle maintenance manual.

16. Remove the safety stands from under the axle, then lower the vehicle.

17. Apply the parking brakes, then remove the chocks from the front tires.

Outboard-Mounted Drum Removal and Installation

Removal (See Fig. 1)

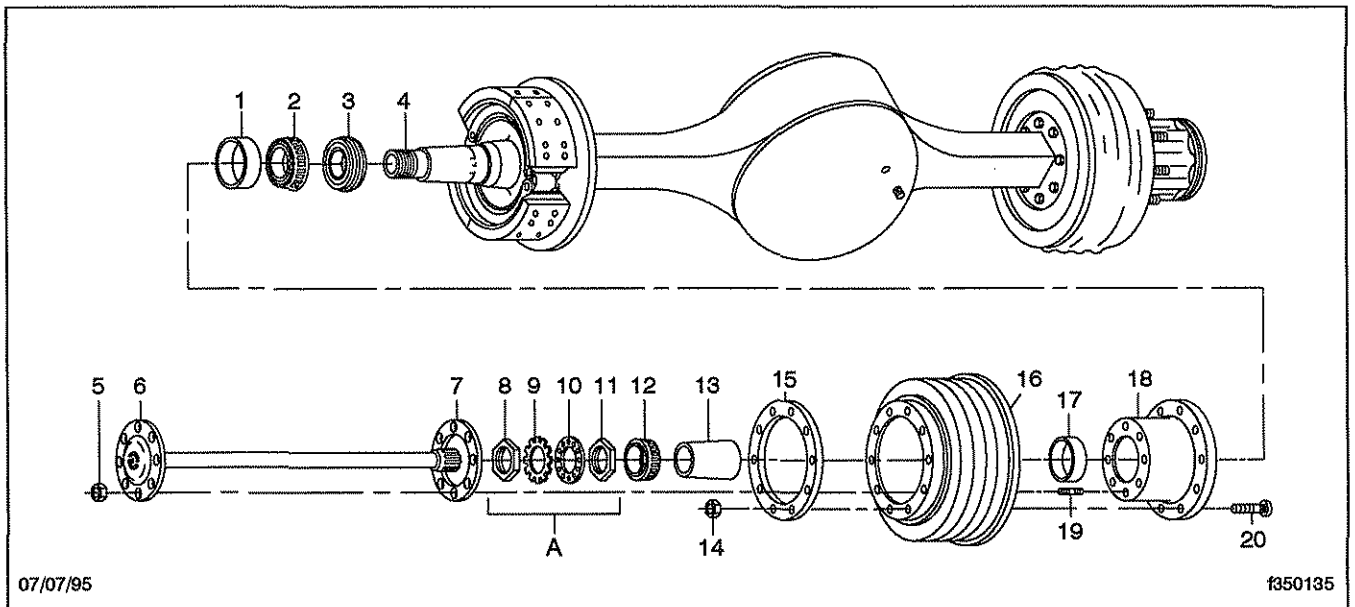
1. Park the vehicle, shut down the engine, apply the parking brakes and chock the front tires.
2. Raise the rear of the vehicle until the tires clear the ground. Then place safety stands under the axle.
3. Back off the slack adjuster to release the rear axle brake shoes.

WARNING: Breathing brake lining dust (asbestos or non-asbestos) could cause lung cancer or lung disease. OSHA has set maximum levels of exposure and requires workers to wear an air purifying respirator approved by MSHA or NIOSH. Wear a respirator at all times when servicing the brakes, starting with removal of the wheels and continuing through assembly.

4. Remove the wheel and tire assembly. Refer to **Group 40** for instructions.

   To minimize the possibility of creating airborne brake lining dust, clean the dust from the brake drum, brake backing plate, and brake assembly, using an industrial-type vacuum cleaner equipped with a high-efficiency filter system. Then, using a rag soaked in water and wrung until nearly dry, remove any remaining dust. Don't use compressed air or dry brushing to clean the brake assembly.

5. Remove the brake drum.



A. Four-piece bearing system shown, Pro-Torq or Axi-Lok locking nuts could be used.

1. Inner Wheel Bearing Cup
2. Inner Wheel Bearing
3. Oil Seal
4. Axle Spindle
5. Drive Axle Stud Nut
6. Drive Axle Flange and Shaft
7. Gasket
8. Jam Nut
9. Nut-Lock
10. Lockring
11. Adjusting Nut
12. Outer Wheel Bearing
13. Bearing Spacer (used only with Con-Met integral wheel bearing packs)
14. Brake Drum Nut
15. Hub Spacer
16. Brake Drum
17. Outer Wheel Bearing Cup
18. Hub
19. Drive Axle Stud
20. Wheel Stud

Fig. 1, Typical Drive Axle and Hub Assembly (exploded view)

Outboard-Mounted Drum Removal and Installation

Installation

1. On brake drum assemblies with an aluminum hub, coat the hub and drum contact surfaces with Alumilastic® compound or an equivalent.
2. Install the brake drum on the wheel hub.

   2.1 On hub-piloted drums, position the brake drum on the top step of the pilot pad. One of the hub's pilot pads should be at the twelve o'clock (top center) position. **See Fig. 2.**

   IMPORTANT: If the drum is not positioned correctly, the pilot pad could be damaged when the wheel nuts are torqued.

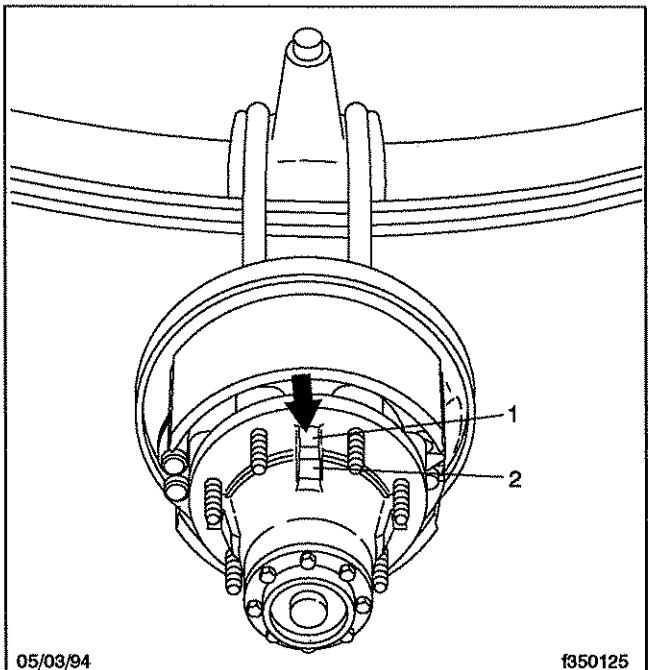
   2.2 Make sure that the pilot pads securely center the drum (space between drum and hub is equal all around the hub).

   IMPORTANT: If damage to the pads prevents the drum from centering, replace the hub. If necessary to hold the drum in position, adjust the brakes before installing the wheels.

3. Install the wheel and tire assembly. To ensure that the drum does not slip off the pilot pad, follow the correct nut tightening sequence. For instructions, refer to **Group 40.**

WARNING: If the wheel nuts cannot be tightened to minimum torque values, the wheel studs have lost their locking ability, and the hub flange is probably damaged. In this case, replace it with a new wheel hub assembly. Failure to replace the wheel hub assembly when the conditions described above exist, could result in the loss of a wheel or loss of vehicle control, and possible personal injury.

4. Adjust the rear axle brakes. Refer to the brake section in the vehicle maintenance manual.
5. Remove the safety stands from under the axle; lower the vehicle.
6. Remove the chocks from the tires.



NOTE: Pilot pad at 12 o'clock position

1. Drum Pilot
2. Wheel Pilot

Fig. 2, Hub Pilot Pads

Wheel Hub Assembly Inspection

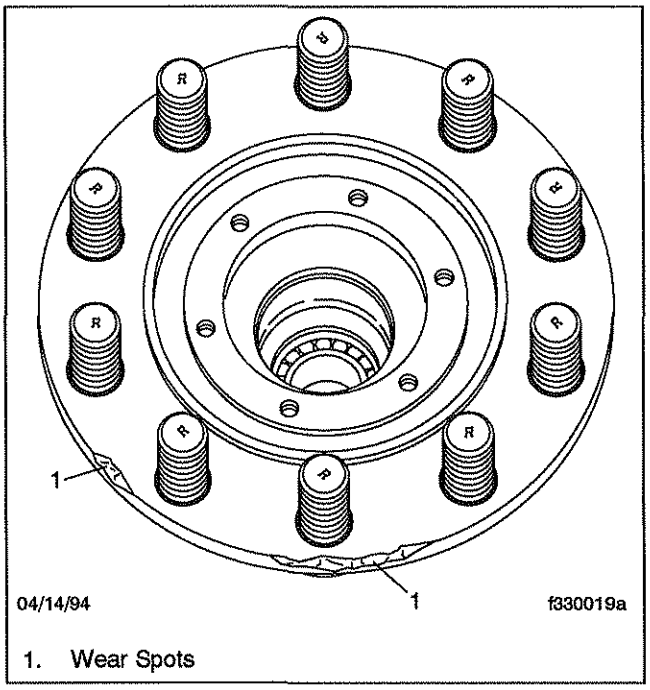
1. Inspect the wheel hub mounting flange. A loose wheel assembly will cause the flange to be worn, jagged, or warped. **See Fig. 1.** Replace the wheel hub if any of these conditions exist.

   Inspect the flange surface around the wheel studs. Improperly torqued wheel nuts will cause worn or cracked stud grooves on the hub. **See Fig. 2.** If wear spots or cracks appear anywhere on the hub, or if the hub is otherwise damaged, replace it with a new one.

2. Remove all the old oil from the wheel hub cavity. Inspect the inner surface of the hub for cracks, dents, wear, or other damage. Replace the wheel hub if damage exists.

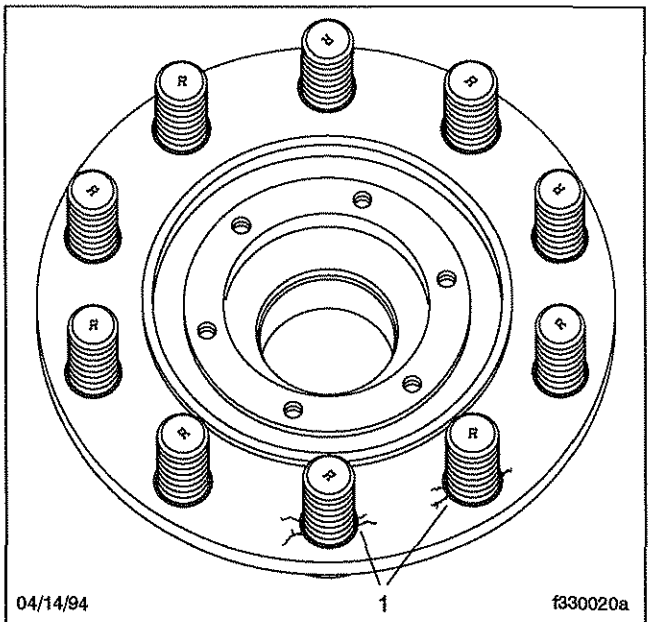
3. Remove all the old grease or oil from the surfaces of the wheel bearing cups. Inspect the wheel bearing cups for cracks, wear, spalling, or flaking. **See Fig. 3.** Replace the cups if damaged in any way. Refer to **Subject 115** or **Subject 120.**

4. Inspect the wheel nuts on disc wheel installations, or the rim nuts on spoke-wheel installations. Damaged nuts (**Fig. 4**), usually caused by inadequate tightening, must be replaced with new ones.



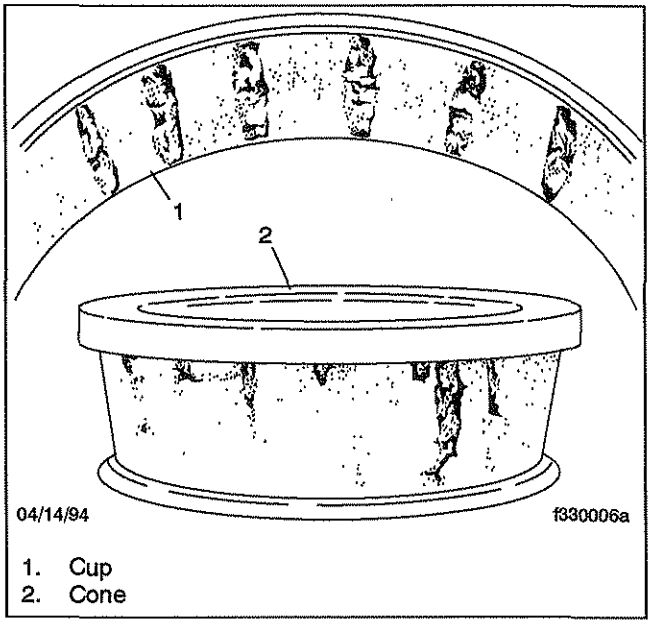
1. Wear Spots

Fig. 1, Damaged Front Axle Wheel Hub



1. Cracked Stud Grooves

Fig. 2, Damaged Front Axle Wheel Hub



1. Cup
2. Cone

Fig. 3, Spalling (Flaking) of Wheel Bearing Assembly

Axle Components Cleaning and Inspection

5. Inspect the wheel or rim studs. Replace studs that are stripped, broken, bent, or otherwise damaged. Refer to **Subject 125** or **Subject 130**.

Wheel Bearing Inspection

Wheel bearings should be very closely inspected at the time of disassembly. Optimal inspection conditions are possible only after the bearings have been thoroughly cleaned using kerosene or diesel fuel oil, and a stiff brush. Before inspecting, clean the bearings.

1. Remove the wheel hub and bearing cones. Refer to **Subject 100**.
2. Clean all old oil from the bearings and hub cavity with kerosene or diesel fuel and a stiff brush. Don't use gasoline or heated solvent.
3. Allow the cleaned parts to dry, or dry them with a clean absorbent cloth or paper. Clean and dry your hands and all tools used in the maintenance operation. Oil will not stick to a surface which is wet with kerosene or diesel fuel, and the kerosene or diesel fuel may dilute the lubricant.

CAUTION: Do not spin the bearing rollers at any time. Dirt or grit can scratch the roller surface and cause premature wear of the bearing assembly. Treat a used bearing as carefully as a new one.

4. After the bearings are cleaned, inspect the assemblies, which include the rollers, cones, cups, and cages. If any of the following conditions exist, replace the bearing assemblies:

   4.1 Large ends of rollers worn flush to the recess, or radii at the large ends of the rollers worn sharp. These are indications of advanced wear. **See Fig. 5**

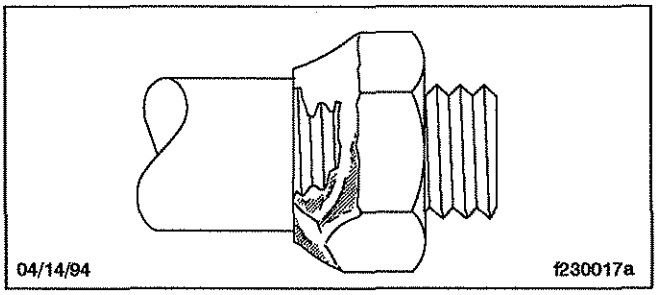
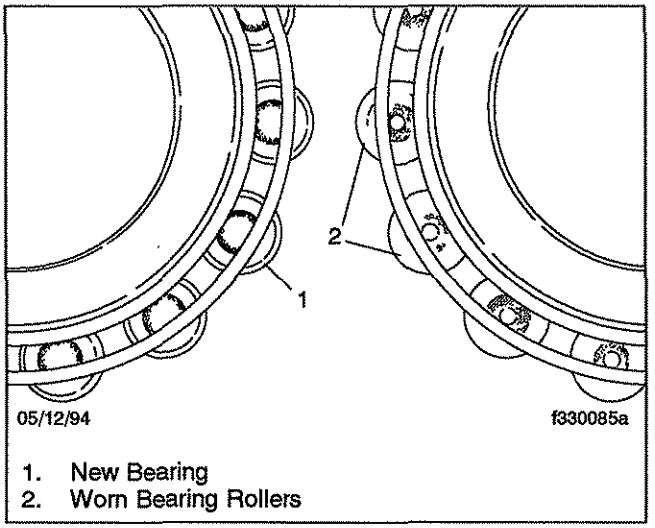


Fig. 4, Damaged Wheel Stud Nut

   4.2 Visible step wear, particularly at the small end of the roller track. Deep indentations, cracks, or breaks in the cone surfaces. **See Fig. 6.**

   4.3 Bright rubbing marks on the dark phosphate surfaces of the bearing cage. **See Fig. 7.**

   4.4 Water etch on any bearing surface. Water etch appears as gray or black stains on the steel surface, and it greatly weakens



1. New Bearing
2. Worn Bearing Rollers

Fig. 5, Wheel Bearing Roller Wear

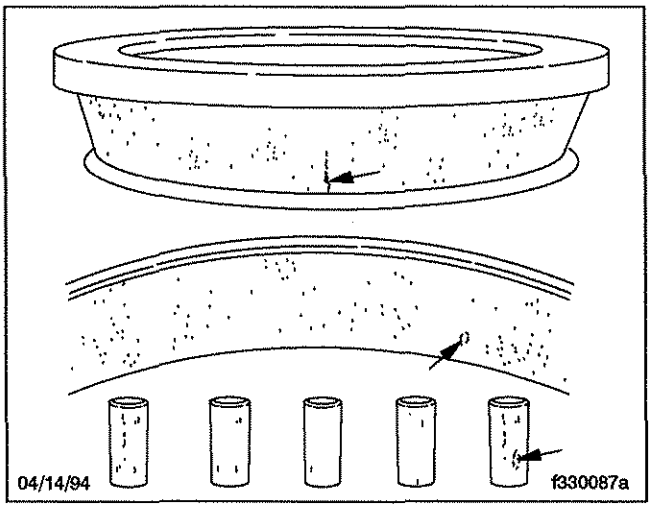


Fig. 6, Indentations, Cracks, or Breaks in Bearing Surfaces

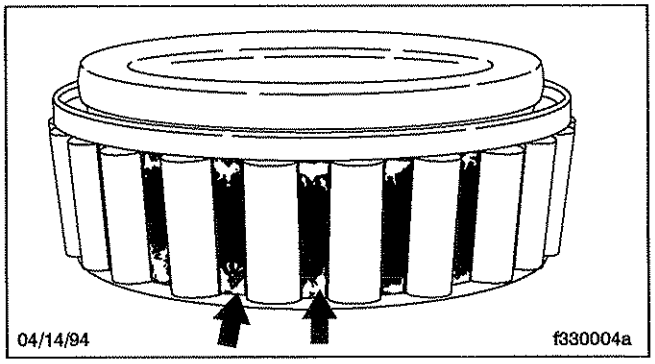


Fig. 7, Rubbing Marks on Bearing Cage

the affected area. If water etch is present, replace the bearing seals.

4.5 Etching or pitting on functioning surfaces. **See Fig. 8.**

4.6 Spalling (flaking) of the bearing cup, roller, or cone surfaces. **See Fig. 3.**

After inspection, brush the bearings with fresh axle lubricant.

Brake Drum Inspection

New brake drums are purposely undersized to allow for turning (remachining), since in mounting drums on the hub, there can be some eccentricity. If a new drum is installed, the protective coating on the inner friction surface must be removed with a solvent, prior to drum installation, then rinsed with a hot water wash. Use a clean rag to remove any oily residue or metal chips from the friction surface.

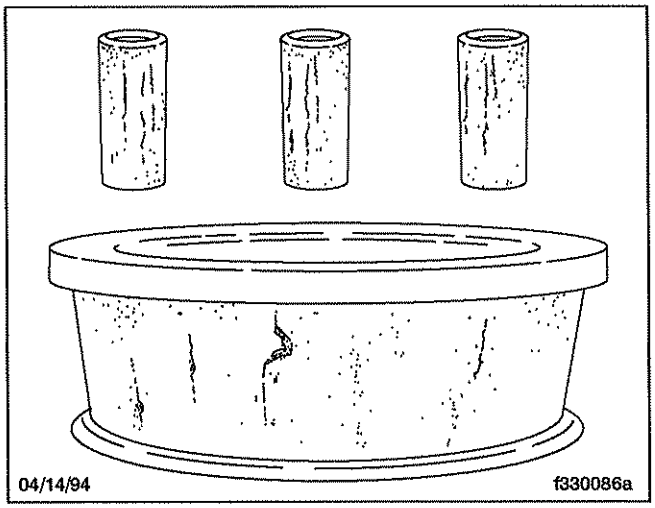


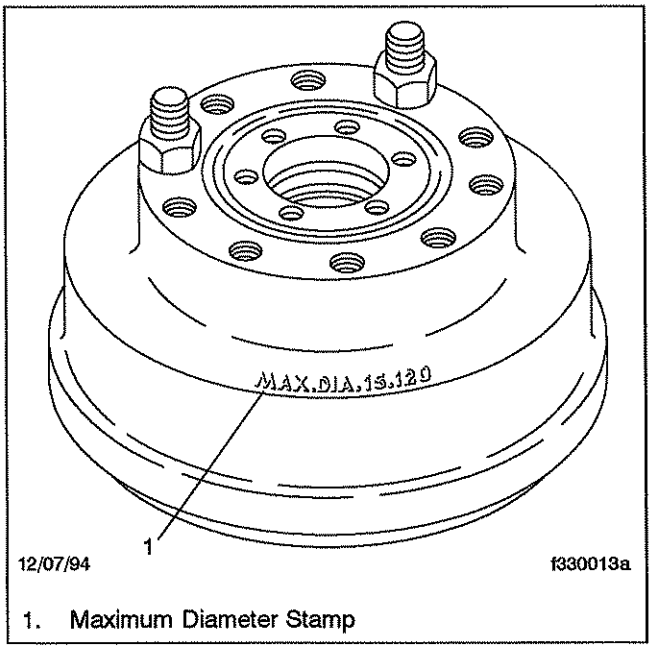
Fig. 8, Etching (Pitting) on Bearing Surfaces

If a drum must be turned or replaced, the other same-axle drum must be similarly turned or replaced to provide the same braking power on both wheels. Turned drums should not exceed the maximum allowable diameter, which is stamped on the outside surface of the drum. **See Fig. 9** for a typical location of this stamp.

NOTE: Drums that have been turned should then be cleaned by using fine emery cloth followed with a hot water wash. Drums that have been renewed using emery cloth should also be followed with a hot water wash.

CAUTION: Failure to replace drums when worn or turned to limits exceeding the maximum allowable diameter will cause drum weakness and reduced braking capacity, which can lead to distortion, higher drum temperatures, and ultimate drum breakage.

If the drums are turned or replaced, replace the brake linings. Refer to **Group 42** in this manual for instructions.



1. Maximum Diameter Stamp

Fig. 9, Outboard Mounted Hub and Drum Assembly

Axle Components Cleaning and Inspection

1. Inspect the inner friction surface. If a veneered (highly glossed) or glazed surface exists, renew the drum by using 80–grit emery cloth or by turning the drums.
2. Inspect for heat checking, which is a form of buckling (cracking) resulting from a temperature differential in the drum wall between a relatively cool exterior and a hot friction surface. Heat checking is normal on all drums and may not impair performance and lining life if the network of fine hairline cracks remains small. Examine heat checks of drums frequently to be certain the checks have not widened into drum weakening cracks (substantial cracks extending to the open edge of the drum). Replace the same-axle drums if substantial cracks are present, or if widening of the fine hairline cracks occurs.

NOTE: If normal heat checking as described above is present, inspect the drums at least every 12,000 miles (19 300 km) thereafter. Inspect the drums (using a flashlight from the inboard side of the wheels) every 6000 miles (9700 km). Inspect more often under adverse operating conditions.

3. Check for a contaminated inner friction surface. If fluids are present, such as oil or grease, remove the contaminants. Locate and correct the source of the contamination. If the brake drums are contaminated with fluids, the brake linings will also be affected. Since oil or grease saturated linings cannot be salvaged, they must be replaced. For brake lining replacement procedures, refer to **Group 42** in this manual.

WARNING: If the brake drums are contaminated with fluids, replace the brake linings. Failure to replace fluid contaminated brake linings could result in a partial loss of braking capacity, which could lead to personal injury or property damage.

4. Measure the inside diameter of the drum. If the measured diameter is greater than the maximum allowable diameter, replace the same-axle drums and linings.
5. Check for a variation in gauge readings at different points on the radius of the drum's working surface. If the variation is more than 0.010 inch (0.25 mm) at any point, the drum is out-of-round to unacceptable limits. Remachine or replace the same-axle drums.
6. Inspect the outside surface of the drum. Remove any accumulation of mud, dirt, or rust; foreign matter acts as an insulator, trapping heat within the drum.
7. Check for hard, slightly raised dark-colored spots on the inner friction surface or for a bluish cast on the brake parts, both of which are caused by high temperatures. If the drums' maximum allowable diameters have not been exceeded, remachine both same-axle drums. If the spots or discoloration cannot be removed, or if remachining is not possible, replace the drums. Also replace the brake shoe return springs.

Wheel Bearing Cup Removal and Installation, Aluminum Hubs

Removal

To insure a tight fit, wheel bearing cups are purposely larger than the wheel hub bores they occupy. To remove the bearing cups, aluminum hub bores must be temporarily expanded by heating the hub in an oven (the bearing cups will also expand, but to a considerably lesser extent). If adequate heating facilities are not available, replace the hub, wheel stud, and bearing cup assembly.

1. Using a solvent, completely remove all grease, oil, and other debris from the outer and inner surfaces of the wheel hub assembly.
2. Oven-heat the hub to a temperature range of 240° to 280°F (116° to 138°C). Make sure the oven thermostat is accurately set; if unsure, use an oven thermometer to check the temperature of the oven before placing the hub inside.

   If adequate heating facilities are not available, replace the hub, wheel stud, and bearing cup assembly.

WARNING: Do not use oxyacetylene equipment or similar equipment to heat the hub. Oxyacetylene equipment or similar equipment will cause cracks in the hub which could cause loss of a wheel and loss of vehicle control, leading to personal injury or property damage.

3. Wearing heavy protective gloves, remove the hub from the oven. Place the hub on a suitable press so that the base is fully supported. Quickly press out the bearing cups.

Installation

To install the bearing cups, aluminum hubs must again be temporarily expanded using oven heating. When the hub is properly heated, the bearing cup and hub can be press-fit together, using a suitable press.

1. Using a solvent, completely remove all grease, oil, and other debris from the outer and inner surfaces of the wheel hub assembly, including the bearing cup bores.
2. Inspect the bearing cup bores of the hub for warpage or uneven surfaces. If a bearing cup bore is damaged, replace the wheel hub assembly.
3. Oven-heat the hub to a temperature range of 240° to 280°F (116° to 138°C). Make sure the oven thermostat is accurately set; if unsure, use an oven thermometer to check the temperature of the oven before placing the hub inside.

WARNING: Do not use oxyacetylene equipment or similar equipment to heat the hub. Oxyacetylene equipment or similar equipment will cause cracks in the hub which could cause loss of a wheel and loss of vehicle control, leading to personal injury or property damage.

4. Coat the replacement bearing cup hub contact surface with a film of grease.
5. Wearing heavy protective gloves, remove the hub from the oven.
6. Place the hub on a suitable press so that the base is fully supported. Quickly press-fit the bearing cup into the wheel hub until it is completely and evenly seated. Be careful not to shave the sides of the bearing cup bore as the bearing cup is seated. The accumulation of debris will prevent the cup from being seated and will also cause permanent damage to the wheel hub. If the sides of the bearing cup bore are damaged during installation, replace the wheel hub assembly.
7. Allow the wheel hub to cool before handling. Then, using a 0.0015–inch feeler gauge, check at several places for the seating of the bearing cup in the bearing cup bore. The gauge should not enter beneath the cup. If it does, there is probably dirt or debris preventing the cup from seating. Using the instructions above, remove the cup, then remove the foreign matter. Reinstall the cup.
8. Wipe off the accumulation of grease left after the bearing cup has been seated. Then, using a clean, lint-free cloth dampened with kerosene or diesel fuel oil, clean the inner surface of the bearing cup. Wipe the surface dry using a clean, absorbent, and lint-free cloth or paper.

Wheel Bearing Cup Removal and Installation, Ferrous Hubs

Removal

Wheel bearing cups on ferrous hubs are removed and installed by driving them out and pressing them in without heating the hub.

1. Using a solvent, completely remove all grease, oil, and other debris from the outer and inner surfaces of the wheel hub assembly.
2. Using a mild-steel rod through the opposite end of the hub, drive against the inner edge of the bearing cup. Alternately drive on opposite sides of the cup to avoid cocking the cup and damaging the inside of the hub.

Installation

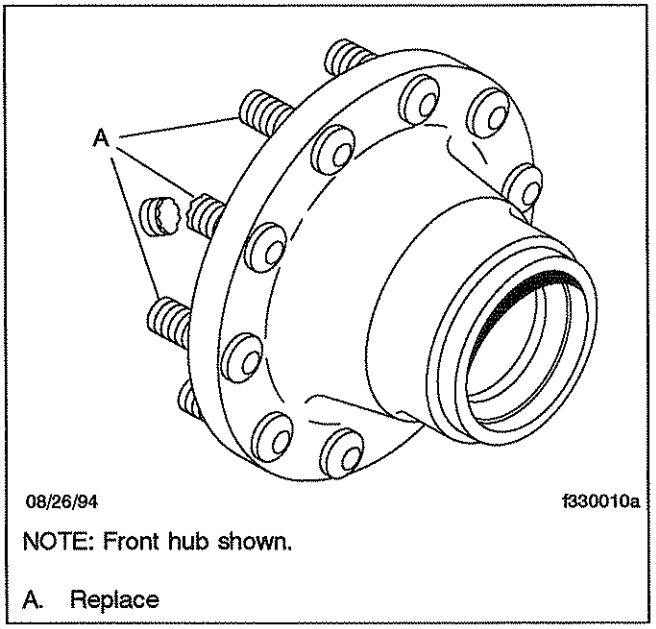
1. Using a solvent, completely remove all grease, oil, and other debris from the outer and inner surfaces of the wheel hub assembly, including the bearing cup bores.
2. Inspect the bearing cup bores of the hub for warpage or uneven surfaces. If a bearing cup bore is damaged, replace the wheel hub assembly.
3. Coat the replacement bearing cup hub contact surface with a film of grease.
4. Position the cup in the hub and press it into place, using a suitable driving tool. Cups must seat against the shoulder in the hub.
5. Wipe off the accumulation of grease left after the bearing cup has been seated. Then, using a clean lint-free cloth dampened with kerosene or diesel fuel oil, clean the inner surface of the bearing cup. Wipe the surface dry using a clean, absorbent, and lint-free cloth or paper.

Replacement

WARNING: If a wheel stud breaks, the remaining studs are subjected to undue strain and could fail due to fatigue. When a broken stud is replaced, replace the stud on each side of it. See Fig. 1. If more than one stud is broken, replace all of the studs. Failure to replace the studs could result in the loss of a wheel or loss of vehicle control, possibly resulting in personal injury.

1. Remove the wheel hub from the axle. For instructions, refer to **Subject 100.**
2. If a bent portion of a wheel stud will have to pass through the wheel stud bore, cut off the bent portion before removing the wheel stud.
3. Place the wheel hub on a suitable press; make sure the hub flange is supported evenly around and next to the stud being removed. With steady movement, press the damaged stud out of the hub.

CAUTION: Do not use a drift and hammer or concentrated heat for removing and installing the wheel studs. Constant, smooth movement of the wheel stud is necessary to ensure the least amount of metal removal from the wheel stud bore. Concentrated heat will damage the hub. If the hub is damaged during wheel stud removal or installation, replace it.



NOTE: Front hub shown.

A. Replace

Fig. 1, Wheel Stud Replacement

4. Apply a coating of clean axle grease to the entire shaft on headed studs.
5. With the hub on a suitable press, make sure the hub flange is supported evenly around and next to the stud being installed.
6. Position the stud in its hole. *Be sure the flat edge of the head flange on clipped studs is in line with the shoulder on the hub.*

CAUTION: If headed studs with serrations are being installed, position the teeth of the serrated portion in the notches carved by the original wheel studs during factory installation. If additional metal is scraped from the wheel stud bores, the locking action provided by the serrations will be greatly weakened. Loss of locking action will prevent achieving final torque of the wheel nuts during wheel installation. If final wheel nut torques during wheel installation cannot be achieved, replace the wheel hub assembly.

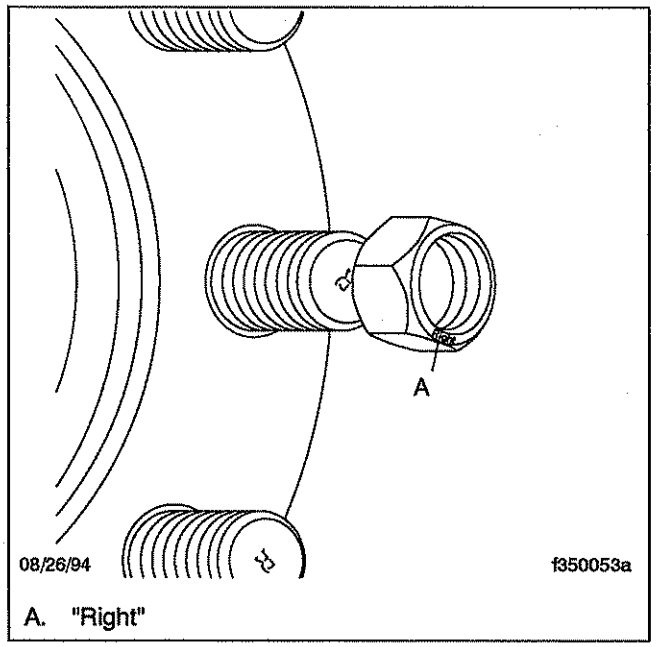
NOTE: If the left side of the vehicle is being serviced, the replacement wheel stud must be stamped with an "L" (left-hand threaded), and the nut's face must be stamped "Left" If the right side of the vehicle is being serviced, the replacement stud must be stamped with an "R" (right-hand threaded), and the nut's face must be stamped "Right" **(Fig. 2)**.

7. With steady movement, press the new stud all the way into the hub.
8. Make sure the stud is fully seated and that its head (flange) is not embedded into the hub. If the head of the stud is embedded into the hub, replace the hub.

WARNING: Don't embed the wheel stud heads in the wheel hub. Wheel studs with heads embedded in the wheel hub will weaken the wheel hub flange. Weakness in the wheel hub can result in the loss of a wheel or loss of steering control, possibly resulting in personal injury.

9. Wipe off any grease on the wheel studs and wheel hub. Install wheel nuts on dry wheel studs only.
10. Install the wheel hub on the axle. For instructions, refer to **Subject 100.**

Wheel Stud Replacement



A. "Right"

Fig. 2, Thread Stamp Location

Drive Axle Stud Replacement

Replacement

1. Remove the wheel hub from the axle. For instructions, refer to **Subject 100.**
2. If enough threads remain on the damaged stud, remove it by double-nutting the stud. Turn the inner nut with a wrench in order to remove the stud. Then, proceed to the next step.

   If the drive axle stud is broken near the surface of the hub, the stud should be center-drilled using a high-speed drill, and then removed with an easy-out tool. If needed, grind off a flat surface on the damaged stud, then center-punch the surface as a starting point for drilling. Follow these recommendations:

   2.1 Determine the correct drill diameter by referring to the easy-out tool manufacturer's guidelines. At no time should it be large enough to penetrate the threads of the stud; if the stud threads in the wheel hub are damaged, replace the hub.

   2.2 Do not drill more than 1.25 inches (32 mm) into the broken stud, as measured at the stud's entrance into the wheel hub. Drilling through the bottom of the drive axle stud could damage the hub. If the wheel hub is drilled into, replace it.

   2.3 While drilling, keep the cutting surfaces of the drill well lubricated with oil, which acts as a coolant. Allow the drill and drill bit to cool frequently.
3. After the damaged stud is removed, tap out the drive axle stud hole in the wheel to rid the threads of old stud-locking compound. Use an appropriate sized tap, depending on the original drive axle stud installation size.
4. Be sure the threads of the new stud are clean and dry. Then, coat the insertion end of the drive axle stud (the coarse threads) with an anaerobic thread-lock compound.
5. Using double nuts on the fine-thread portion of the stud, install the new stud. Seat the drive axle stud using the torque values in the torque table in **Specifications, 400.**
6. Allow sufficient time for the thread-lock compound to set, as suggested by the manufacturer.
7. If the hub was removed from the axle, proceed to for installation instructions.

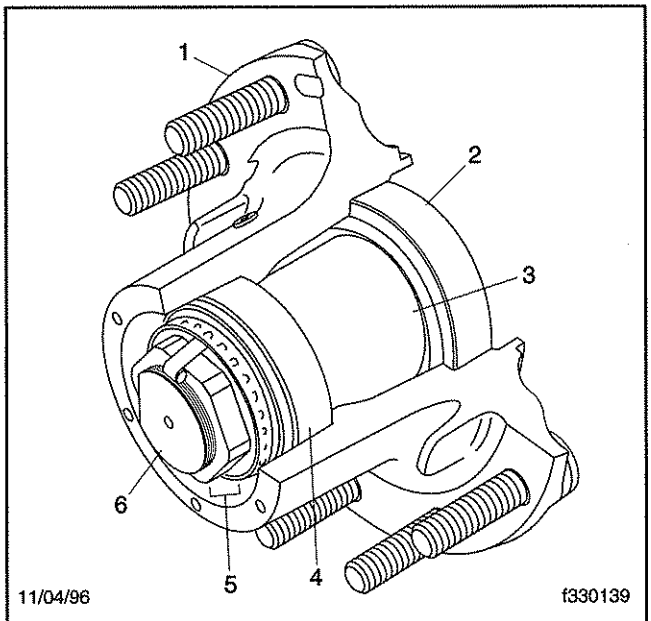
Con Met PreSet® Hub Installation and Adjustment

General Information

Con Met PreSet® drive axle hubs are equipped with a special tubular spacer inside the hub, between the inner and outer bearings. See **Fig. 1.**

Wheel bearing adjustment is unnecessary when installing these hubs, because the spacer, together with specially toleranced bearings, automatically sets the bearing end-play to zero. Rear axle PreSet hubs can be identified by the part number NP840302 stamped on the outer bearing cone. The outer bearing cone is visible when the retaining nut is removed. See **Fig. 2.**

NOTE: If you are replacing the bearings for a PreSet hub, and the required bearings are not available, use standard wheel bearings. Remove the bearing spacer and adjust the bearings manually. See the installation instructions for "Standard Bearings," under "Installation."



NOTE: Front axle hub shown.

1. Hub
2. Inner Bearing
3. Bearing Spacer
4. Outer Bearing
5. Axilok® Retaining Nut
6. Axle Spindle

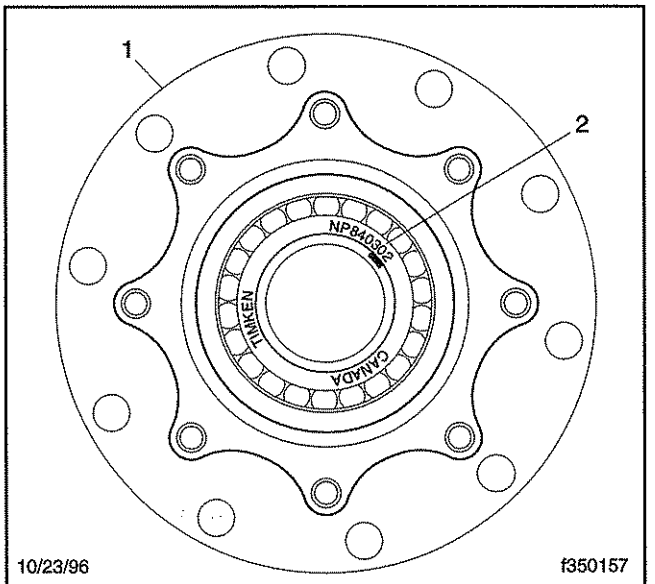
Fig. 1, Con Met PreSet Hub, Cut-Away View

⚠ CAUTION

Do not use the bearing spacer with standard wheel bearings. To do so may result in too much bearing end-play, which could damage the wheel bearings, oil seals, the axle spindle, and the hub.

Con Met PreSet hubs use Axilok® retaining nuts. See **Fig. 3.** Axilok retaining nuts can be damaged if they are not removed or installed correctly. Use the following guidelines when removing and installing Axilok retaining nuts.

- Use only the correct size, *six-point* socket to remove or install Axilok spindle nuts. Do not use a worn or loose-fitting socket. *Do not use a 12-point socket.*
- Do not use hammers, chisels, pliers, wrenches, or power tools to remove or install Axilok nuts.
- Do not use an Axilok nut if the locking clips are damaged or missing, or if the retainer cage tab or D-flat is damaged or missing.
- Never try to repair a damaged Axilok nut; always replace it with a new one.
- Always start an Axilok installation by hand. A good-fitting six-point socket will completely



1. Rear Axle Hub
2. Outer Bearing Cone and Part Number

Fig. 2, Identifying a Con Met PreSet Hub

Con Met PreSet® Hub Installation and Adjustment

disengage the nut's locking clips, allowing it to spin freely by hand. See **Fig. 4.** Use an accurately calibrated torque wrench to tighten the nut to its final torque value.

- After the nut is installed, always make sure that both locking clips are present and engaged in the retainer cage. See **Fig. 4.** If the locking clips are not engaged, the nut is not locked in position and can rotate freely.

Installation

Using PreSet Bearings

1. Wipe a film of axle oil on the axle spindle to prevent rust from forming behind the inner wheel bearing.
2. If present, remove the temporary plastic bearing cover from the front of the hub.
3. Install the PreSet hub assembly all the way onto the axle spindle. A temporary plastic alignment sleeve may be installed in the center of a new hub. It will be pushed out when the hub is installed on the axle spindle. If it is present, remove and discard this sleeve.

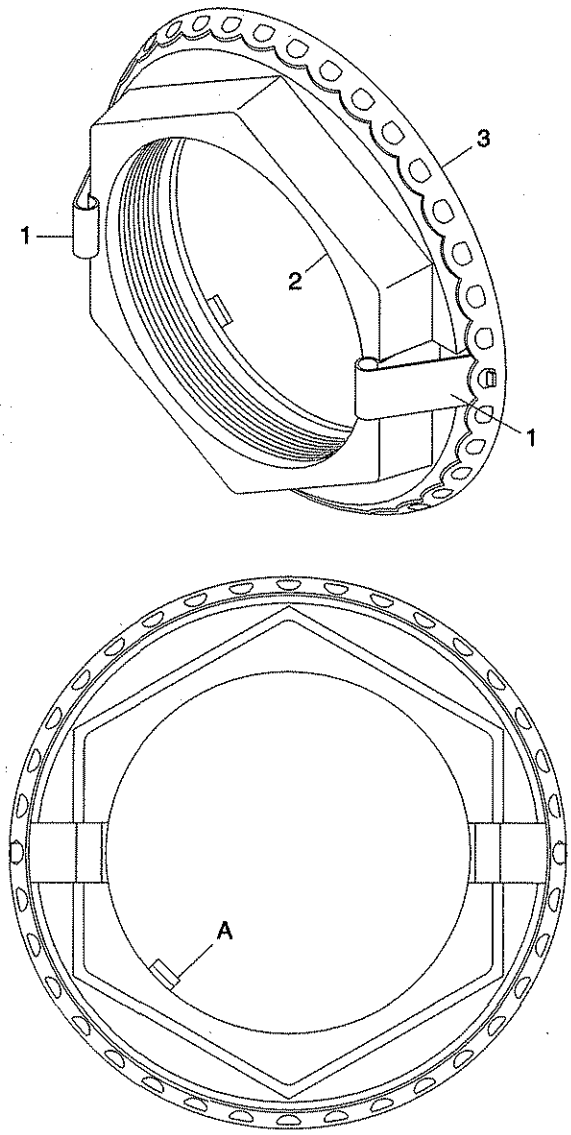
⚠ CAUTION

Do not remove the outer wheel bearing once the hub is installed on the axle. Removing the outer bearing could cause the oil seal to become misaligned, which could cause damage to the wheel bearings, the hub, and the axle spindle.

⚠ WARNING

Follow the guidelines at the beginning of this subject when installing an Axilok nut. Axilok retaining nuts secure the hub assemblies on the axle. If the Axilok nut is not correctly installed, the hub could separate from the axle, resulting in severe personal injury or death.

4. Install the Axilok retaining nut (see **Fig. 3**) onto the axle spindle.
5. Tighten the retaining nut 300 lbf·ft (407 N·m). Do not back off the retaining nut. The nut should lock in place when you remove the wrench. If it does not, advance it until it does.
6. Install the axle shaft, using a new gasket. See **Subject 100** for instructions.



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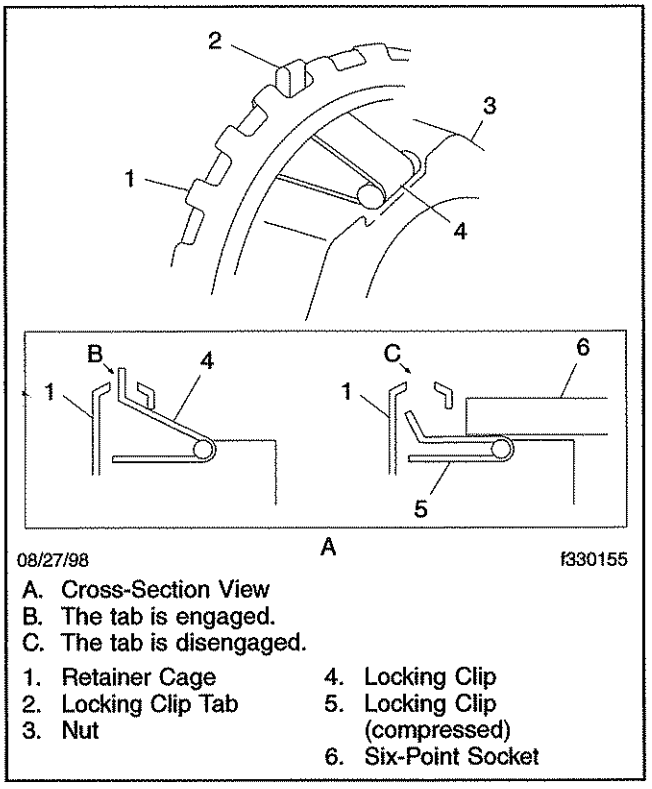
A. The retainer tab must engage the keyway of the axle spindle.
1. Locking Clip
2. Nut
3. Retainer

Fig. 3, Rear Axle Axilok Nut

Con Met PreSet® Hub Installation and Adjustment



A. Cross-Section View
B. The tab is engaged.
C. The tab is disengaged.

1. Retainer Cage
2. Locking Clip Tab
3. Nut
4. Locking Clip
5. Locking Clip (compressed)
6. Six-Point Socket

Fig. 4, Axilok Nut, Checking the Position of the Locking Clip

⚠ WARNING

Add oil to the axle housing bowl or the wheel hub after the drive axle shaft and wheel hub have been serviced. Failure to add oil will damage the wheel bearings and cause them to seize during vehicle operation. Seized bearing rollers can cause sudden damage to the tire or axle, possibly resulting in personal injury.

7. Pour the recommended drive axle oil through the axle housing filler hole.

Using Standard Bearings

1. If not already done, remove the tubular spacer from inside the hub. Save it for future use to convert the hub back to the PreSet system.
2. Wipe a film of axle oil on the axle spindle to prevent rust from forming behind the inner wheel bearing.
3. Coat both bearing assemblies with fresh oil. Install the inner wheel bearing and oil seal in the hub. See **Section 35.02** for instructions on installing the various types of oil seals.
4. Install the hub with the inner bearing and oil seal onto the axle spindle. Be careful not to unseat the inner bearing or oil seal.
5. Fill the hub cavity with oil, and install the outer wheel bearing.

⚠ CAUTION

Do not remove the outer wheel bearing once the hub is installed on the axle. Removing the outer bearing could cause the oil seal to become misaligned, which could cause damage to the wheel bearings, the hub, and the axle spindle.

⚠ WARNING

Follow the guidelines at the beginning of this subject when installing an Axilok nut. Axilok retaining nuts secure the hub assemblies on the axle. If the Axilok nut is not correctly installed, the hub could separate from the axle, resulting in severe personal injury or death.

6. Adjust the wheel bearings.
   - 6.1 Install the Axilok nut (see **Fig. 3**) and turn it against the bearing while spinning the wheel.
   - 6.2 Tighten the nut 90 to 110 lbf·ft (122 to 149 N·m) while spinning the wheel in both directions.
   - 6.3 Loosen the nut to zero torque and spin the wheel a few turns.
   - 6.4 Tighten the nut 50 lbf·ft (68 N·m) while spinning the wheel in both directions. Back off the nut one-eighth to one-sixth turn.
   - 6.5 Remove the wrench from the nut. The Axilok nut should automatically lock in place. If it does not, advance it until it does.
7. Install the axle shaft, using a new gasket. See **Subject 100** for instructions

Con Met PreSet® Hub Installation and Adjustment

⚠ WARNING

Add oil to the axle housing bowl or the wheel hub after the drive axle shaft and wheel hub have been serviced. Failure to add oil will damage the wheel bearings and cause them to seize during vehicle operation. Seized bearing rollers can cause sudden damage to the tire or axle, possibly resulting in personal injury.

8. Remove the fill plug from axle housing, then pour the recommended drive axle oil through the axle housing filler hole. Install the filler plug.

Four-Piece Wheel Bearing System Installation and Adjustment

Installation and Adjustment (See Fig. 1)

1. Carefully mount the hub and inner wheel bearing assembly on the axle spindle. Be careful not to unseat the inner wheel bearing or seal.
2. Fill the hub cavity with oil, then install the outer wheel bearing; handle the bearings with clean, dry hands. Use care not to damage the bearings as they are seated in the bearing cups. Remove the friction tape from the axle spindle threads.
3. Install the wheel bearing adjusting nut. Tighten the nut finger-tight. Adjust the bearings.

   3.1 After the wheel hub and bearings are assembled on the spindle, tighten the inner (adjusting) nut 200 lbf·ft (271 N·m) while rotating the wheel hub assembly.

   3.2 Back off the inner nut one full turn.

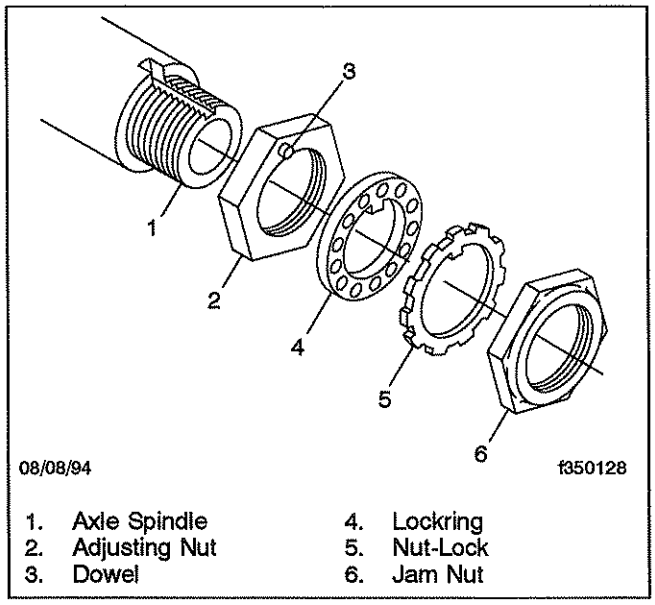
   3.3 Tighten the inner nut 50 lbf·ft (68 N·m) while rotating the wheel hub assembly.

   3.4 Back off the inner nut one quarter turn.

   NOTE: If no hole in the lockring aligns with the dowel on the adjusting nut, remove the lockring, turn it over and install it, again. If a hole still doesn't align with the dowel, loosen the adjusting nut, but only enough to align the dowel with a hole in the lockring.

   3.5 Install the lockring and nut-lock.

   Then install the jam nut, and tighten it to the applicable torque in **Table 1**.



1. Axle Spindle
2. Adjusting Nut
3. Dowel
4. Lockring
5. Nut-Lock
6. Jam Nut

Fig. 1, Four-Piece Wheel Bearing Assembly

Locking Device	Torque lbf·ft (N·m)	
	1-1/8 to 2-1/2 Inch Jam Nuts	2-5/8 Inch or Larger Jam Nuts
Tanged Nut-Lock and Lockring	200 to 300 (271 to 407)	250 to 400 (339 to 542)

Table 1, Jam Nut Torques

IMPORTANT: Do not adjust the wheel bearings with the wheel mounted on the hub. You cannot accurately adjust or measure bearing end play with the wheel mounted on the hub.

3.6 With the jam nut installed and tightened, attach a dial indicator to the hub and set the point of the indicator in line with the end of the axle spindle.

If using aluminum hubs, you may have to install the brake drum on the hub to provide a steel base for the magnet of the dial indicator. Mount the drum on the hub's drum pilot, then adjust the brake or have someone apply the brakes to hold the drum securely while you secure the drum using the stud at the 12 o'clock position, then the studs at about the 4 o'clock and 8 o'clock positions.

NOTE: If using a stud-piloted hub and a steel drum, install 1–1/4 inch washers between the nuts and the drum.

3.7 Release the brakes if you used them to hold the drum while installing it.

Grip the sides of the hub at the three o'clock and nine o'clock positions, then push the hub (and drum, if applicable), to seat the inboard bearing set. Zero the dial indicator.

Four-Piece Wheel Bearing System Installation and Adjustment

Grip the sides of the hub at the three o'clock and nine o'clock positions, then pull the hub (and drum, if applicable). Read the dial indicator, and note the end play.

Push the hub back in to confirm that the needle of the dial indicator returns to zero.

The end play must be between 0.001 and 0.005 inch (0.025 and 0.127 mm).

4. If the end play is not within this range, remove the jam nut and locking device, and back off or tighten the inner (adjusting) nut to adjust the end play.

   Install the locking device and jam nut as described earlier, and measure the end play. If the end play is not between 0.001 and 0.005 inch (0.025 and 0.127 mm), adjust the inner (adjusting) nut, again.

5. Once the end play is correct, bend two tabs of the nut-lock over opposing flats on the jam nut.

6. Rotate the wheel in both directions. It should turn freely with no dragging or binding. End play should be between 0.001 and 0.005 inch (0.03 to 0.13 mm).

Pro-Torq® Nut Wheel Bearing System Installation and Adjustment

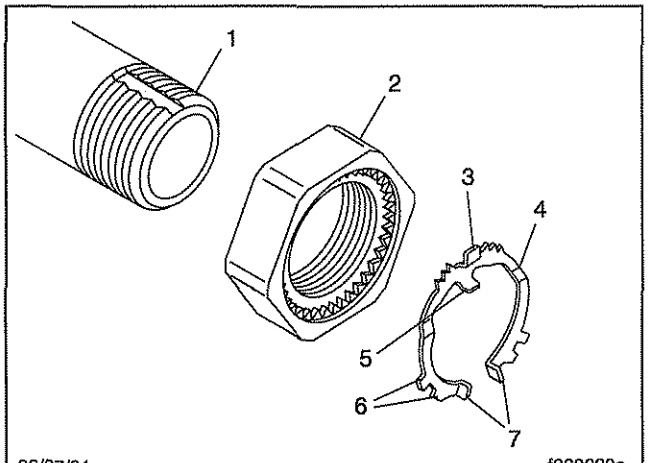
Installation and Adjustment (See Fig. 1)

1. Carefully mount the hub and inner wheel bearing assembly on the axle spindle. Be careful not to unseat the inner wheel bearing or seal.
2. Fill the hub cavity with oil, then install the outer wheel bearing; handle the bearings with clean, dry hands. Use care not to damage the bearings as they are seated in the bearing cups.
3. Install the Pro-Torq nut, and turn it against the bearing while spinning the wheel.

IMPORTANT: Be sure there is enough clearance between the brake shoes and the brake drum, so brake shoe drag won't interfere with the bearing adjustment.

4. Tighten the adjusting nut 200 lbf·ft (270 N·m) while spinning the wheel in both directions.

   Loosen the nut to zero torque and spin the wheel a few turns.
5. Tighten the nut 100 lbf·ft (136 N·m) while spinning the wheel in both directions. Back off the nut one-eighth turn.



1. Axle Spindle
2. Pro-Torq Nut
3. Keeper Tab
4. Lockring
5. Keyway Tab
6. Keeper Arms
7. Keeper Projections

Fig. 1, Pro-Torq Nut Wheel Bearing Assembly, Eaton Front Axle Shown

6. Hold the lockring with the keeper projections facing outboard. See **Fig. 2**.
7. *For Meritor axles:* Insert the keeper tab in the undercut groove of the Pro-Torq nut, while pressing the keyway tabs on the flat surface of the axle spindle, engaging the mating teeth.

   For Eaton axles: Insert the keeper tab in the undercut groove of the Pro-Torq nut, while pressing the keyway tab into the keyway of the axle spindle, engaging the mating teeth.
8. Insert a screwdriver, or similar tool, in the undercut groove of the nut, between the keeper arms. See **Fig. 3**. Using the tool, compress the lockring to lock in place.

   Using the screwdriver, press around the edges of the lockring to be sure it is locked in place. See **Fig. 4**.

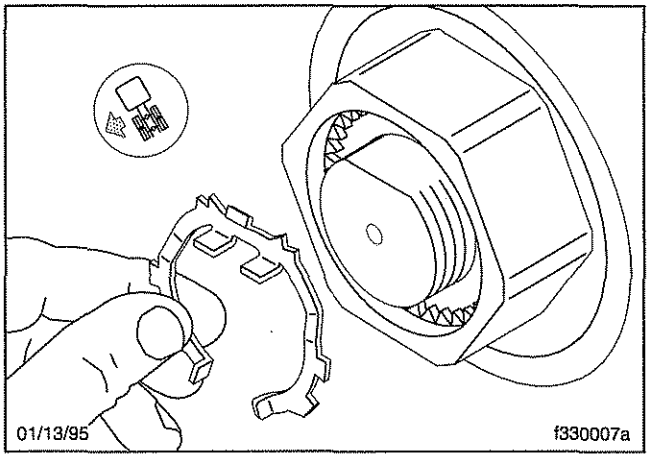


Fig. 2, Lockring Position, Meritor Front Axle Shown

Pro-Torq® Nut Wheel Bearing System Installation and Adjustment

⚠ CAUTION

Do not use pliers or similar devices on the keeper projections to compress the lockring. This could result in damage or breakage of the lockring.

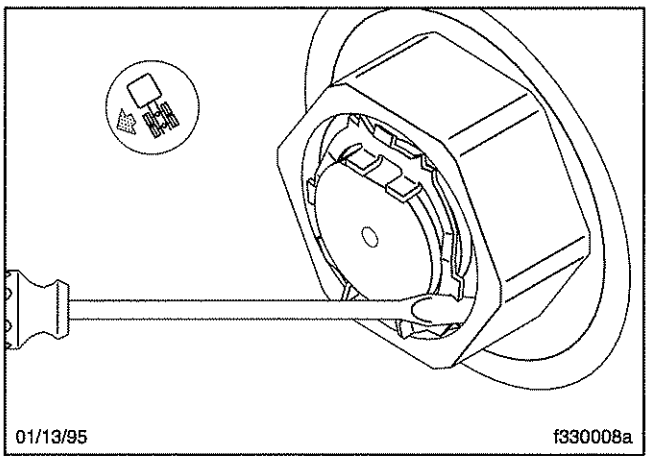


Fig. 3, Compressing the Lockring, Meritor Front Axle Shown

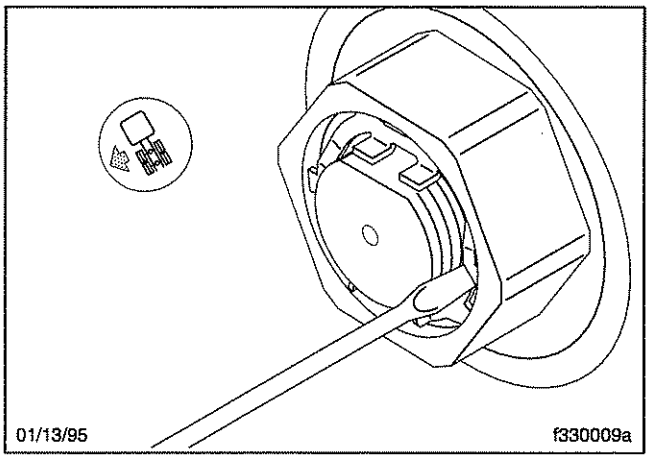


Fig. 4, Making Sure the Lockring is Locked, Meritor Axle Shown

Problem—Noisy Bearings or Excessive Bearing Replacement Intervals

Possible Cause	Remedy
Not enough oil was used on the bearings, or the wrong type of oil was used.	Clean, then inspect the bearings for wear. Replace worn seals. Coat the bearing assemblies with fresh oil. For lubricant specifications, refer to the rear axle section in the vehicle maintenance manual.
Foreign matter or corrosive agents entered the bearing assembly. Dirt or metallic debris from the bearings was not removed.	Clean, then inspect the bearings for wear. Replace worn seals. Also clean the wheel hub, the axle spindle, and any other component in contact with the bearing lubricant.
An incorrect adjustment of the wheel bearings is causing noise and wear.	Adjust the wheel bearings following the instructions in **Subject 135** or **Subject 140** in this section.
Flat spots or dents on the roller surface were caused by skidding of the roller or improper handling of the wheel bearing during installation.	Clean, then inspect the bearing rollers. Replace the bearing if damaged. Coat the replacement bearings with fresh oil. For lubricant specifications, refer to the rear axle section in the vehicle maintenance manual.

Problem—Broken Wheel or Rim Studs

Possible Cause	Remedy
The wheel or rim nuts were overtightened.	Replace the wheel or rim studs. Refer to the wheels and tires section in this manual for the wheel or rim nut tightening sequence.
An incorrect nut tightening sequence was used.	
The wrong brake drums were installed.	Install new brake drums.
Wheels are mismatched (hub-piloted wheels are mixed with stud-piloted wheels).	Install properly matched wheels.
The vehicle is being overloaded.	Do not exceed the maximum load-carrying capacity of the vehicle.

Problem—Damaged Hub

Possible Cause	Remedy
(Cracked hub) Local surface of an aluminum hub was heated higher than 350°F (177°C) during bearing cup removal.	Replace the hub assembly. When removing the bearing cup, oven-heat the hub.
(Bent flange) Incorrect installation of the wheel studs, such as using a hammer and drift, or the hub flange was not fully supported on the press during wheel stud replacement.	Replace the hub assembly. Replace the wheel studs as instructed under **Subject 125**.
The wrong brake drums were installed.	Install new brake drums.
Insufficient tightening of the wheel nuts to the wheel hub.	Replace the hub assembly and tighten the wheel nuts to the values in the torque table in **Specifications, 400**.

Troubleshooting

Problem—Loss of Lubricant From the Wheel Hubs

Possible Cause	Remedy
The drive axle studs are loose.	Tighten the nuts to the torque values in the torque table in **Specifications, 400.** Add lubricant to the axle housing or to the wheel hub.
The seals or gaskets are worn or damaged.	Replace worn or damaged parts.
Minor burrs or rough spots are on the inboard portion of the drive axle flange.	Use fine-grit emery cloth to remove the burrs or rough spots. If they cannot be removed, replace the drive axle shaft.

Problem—Vehicle Does Not Slow Down Quickly Enough When Brakes Are Applied

Possible Cause	Remedy
The brake linings are glazed (dirt or grease build-up) or are worn unevenly.	Install new brake linings on both sets of axle brake shoes. Clean, turn, or replace the drums.
The brake drums are worn, heat-checked, or cracked.	Install new brake drums.

Problem—Service Brakes Grab or Pull

Possible Cause	Remedy
The drum could be out of round if it was not correctly positioned on the drum pilot tabs before the wheel was installed.	Position one of the hub-piloted tabs in the top position before placing the drum on the hub. When doing so, be sure the drum is located flat against the hub and on the largest-diameter portion of the pilot tabs. After placing the wheel(s) on the studs, firmly hand-tighten the nut on the stud closest to the top position. Proceed with the other nuts.
Also refer to the air brake system troubleshooting section of this manual.	

Problem—Poor Lining-to-Drum Contact

Possible Cause	Remedy
The inside surface of the brake drum is scored or grooved.	Install new brake linings on both sets of axle brake shoes. Turn or replace the brake drums.
The brake shoes are stretched or bent.	Replace the brake shoes.
Undersized linings were installed.	Install new brake linings on both sets of axle brake shoes.
An incorrect grind was used on the brake linings.	
The wrong brake drums were installed.	Install new brake drums.
An incorrect adjustment of the wheel bearings is causing wheel instability.	Adjust the wheel bearings following the instructions in **Subject 135** or **Subject 140** in this section.

Problem—Brake Linings Are Tapered Across the Width

Possible Cause	Remedy
The inside surface of the brake drum is scored or grooved.	Install new brake linings on both sets of axle brake shoes. Turn or replace the brake drums.
The brake shoes are bent.	Replace the brake shoes.
An incorrect adjustment of the wheel bearings is causing wheel instability.	Adjust the wheel bearings following the instructions in **Subject 135** or **Subject 140** in this section.

Problem—Brake Shoes on the Same Brake Are Wearing Unequally

Possible Cause	Remedy
The brake linings are not a matched set. Different friction codes or different brands of brake linings are installed.	Install a new matched set of brake linings on both sets of axle brake shoes. Clean, turn, or replace the drums.
The inside surface of the brake drum is in poor condition.	Turn or replace the brake drums.
The wheel bearings are out of adjustment.	Adjust the wheel bearings following the instructions in **Subject 135** or **Subject 140** in this section.

Problem—Edge of the Lining Is Showing Wear

Possible Cause	Remedy
The brake lining is too wide.	Install new brake linings on both sets of axle brake shoes.
The brake linings are misaligned because their holes were incorrectly drilled.	
Undersized brake drums were installed.	Install new brake drums.
The wheel bearings are out of adjustment.	Adjust the wheel bearings following the instructions in **Subject 135** or **Subject 140** in this section.
There is an improper fit of the wheel onto the spindle due to the wrong wheel bearings or cone.	Install and adjust the new wheel bearings and cone.
The brake shoes are bent.	Replace the brake shoes.

Problem—Brake Linings Are Scored or Grooved

Possible Cause	Remedy
Worn or scored brake drums have been causing poor contact with the brake linings.	Install new brake linings on both sets of axle brake shoes. Turn or replace the brake drums.
There is abrasive material between the lining and the drum.	

Troubleshooting

Problem—Brake Linings Are Loose

Possible Cause	Remedy
The rivet holes in the brake shoes are too large.	Replace the brake shoes.
Improperly crimped rivets are working loose and allowing the linings to move.	Replace the rivets.
Rust has built up on the shoe table.	Clean the brake shoe table of all rust, dirt, scale, and paint.

Problem—Brake Lining is Cracked at the Rivet Holes or Bolt Holes

Possible Cause	Remedy
Overtightening of the lining bolts is causing cracks.	Replace the brake linings. Replace the rivets or bolts with the correct size.
The wrong size counter bore for the rivet holes was made.	
The wrong rivets or bolts were used.	Replace the rivets or bolts with the correct size.
Improperly crimped rivets are working loose and allowing the linings to move.	Replace the rivets.
Rust has built up on the shoe table.	Clean the brake shoe table of all rust, dirt, scale, and paint.

Problem—Out-of-Round Rivet Holes or Bolt Holes

Possible Cause	Remedy
The rivets or bolts are loose.	Replace the brake shoes or linings.

Problem—Brake Drums Are Heat-Checked

Possible Cause	Remedy
The brake drums are out-of-round.	Turn or replace the brake drums.
The wrong brake drums were installed.	Install new brake drums.
The wheel bearings are out of adjustment.	Adjust the wheel bearings following the instructions in **Subject 135** or **Subject 140** in this section.
The brake linings are glazed (dirt or grease build-up) or are worn unevenly.	Install new brake linings on both sets of axle brake shoes. Clean, turn, or replace the drums.
The lining friction material for the operation of the vehicle is incorrect.	
There is a brake imbalance between the tractor and the trailer.	Do a brake balance test (tractor versus trailer). Contact the District Service Manager if help is needed.

Problem—Brake Drums Are Heavily Scored

Possible Cause	Remedy
The brake linings are damaged.	Install new brake linings on both sets of axle brake shoes. Turn or replace the drums.
There is excessive wear on the linings.	
On the last brake reline, the drums were not turned.	Turn the brake drums.

Problem—Excessive Brake Lining Wear

Possible Cause	Remedy
There is a brake imbalance between the tractor and the trailer.	Do a brake balance test (tractor versus trailer). Contact the District Service Manager if help is needed.

Specifications

Torque Values		
Description	**Size (grade 8)**	**Torque lbf·ft (N·m)**
Hub Cap Capscrews	5/16–18	15 (20)
Drive Axle Studs-to-Hub	1/2–13	70 (95)
	5/8–11	135 (185)
Drive Axle Stud Nuts	1/2–20	75–115 (102–156)
	5/8–18	185–230 (250–312)

Table 1, Torque Values

Rear Axle Oil Seals

35.02

Contents

Subject	Subject Number
General Information	050
Service Operations	
Seal Replacement, Chicago Rawhide	100
Seal Replacement, Dana Spicer® Outrunner™	110
Seal Replacement, National®	120
Seal Replacement, Stemco®	130
Specifications	400

General Information

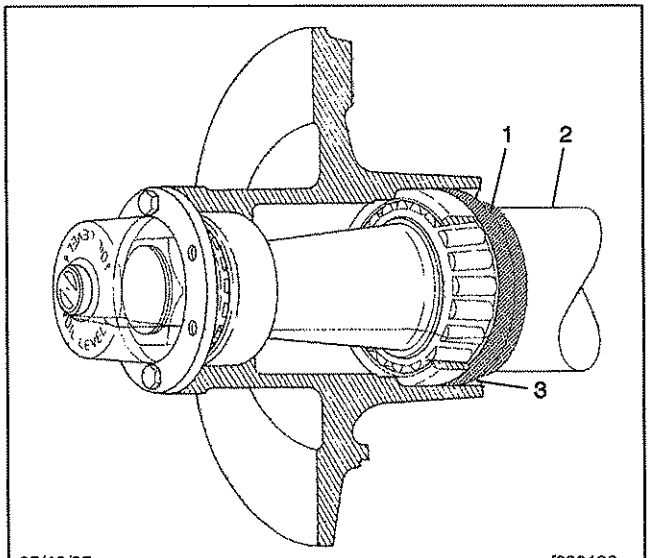
Wheel oil seals (also called "oil bath seals" or "hub seals") work as a dam to keep oil in the hub cavity so that it constantly "bathes" the wheel bearings. The seals also protect the wheel bearings by keeping dirt, dust, and water out of the hub.

The oil seal fits between the hub bore and the axle spindle (**See Fig. 1**), and the sealing element either turns with the wheel (*hub-mounted seals*) and seals against the axle spindle, or the sealing element stays stationary with the axle spindle (*spindle-mounted seals*) and seals against the turning hub.

Until the late 1950's, truck wheel bearings were packed in grease. To retain this type of lubricant, the axle oil seal was pressed into the hub bore and turned with the wheel. Since the late 1950's, truck wheel bearings have been bathed in oil.

But oil bath lubrication created a problem.

With hub-mounted seals, the turning wheel created enough centrifugal force to pull the sealing element off the axle spindle. This broke the seal, and oil escaped. To keep lube oil inside the hub cavity, the inner edge, or sealing lip, of the seal had to be strong and tight enough that the centrifugal force of the turning wheel would not pull it away from the axle spindle. However, these new, stronger, tighter seals would wear a groove into the spindle sealing surface.



1. Wheel Oil Seal
2. Axle Spindle
3. Wheel Hub Bore

Fig. 1, Spindle-Mounted Wheel Oil Seal, Stemco Seal Shown

To prevent damage to the spindle, wear sleeves (also called "axle rings") are pressed onto the spindle to absorb the wear from the sealing lip. Later, these wear sleeves were designed to also deflect dirt. These sleeves are called "deflector rings."

Some seal designs avoid the problem of centrifugal force by having the seal pressed onto the axle spindle. This way, centrifugal force drives the sealing element out toward the hub to create the seal.

Most wheel oil seals consist of four basic parts (**Fig. 2**):

- The outside edge (also called the outer "cup" or "case")
- The inside edge (also called the inner "cup" or "case")
- The sealing element
- The garter spring

The outside edge is usually metal coated with rubber or another sealing agent so that it grips the hub bore tight enough to prevent oil escaping between the outer edge of the seal and the hub bore.

The inside edge is usually metal or rubber with a metal ring within it to prevent the sealing element from wearing a groove in the axle spindle.

The sealing element is usually molded rubber, leather, or a synthetic such as nitrile or silicone. The element is molded into lips which will seal against the axle spindle or against the outside or inside edge described above. The innermost lip, called the "primary lip," keeps the oil inside the hub cavity. The outermost lip, called the "secondary lip," keeps dirt out of the hub cavity.

The garter spring is a coiled wire spring with its ends connected to make a loop. On hub-mounted seals, the spring runs around the outside of the sealing element to press the element inwards against the sealing surface. On spindle-mounted seals, the spring runs around the inside of the sealing element to press the element outward against the sealing surface.

Freightliner uses four brands of axle oil seals:

General Information

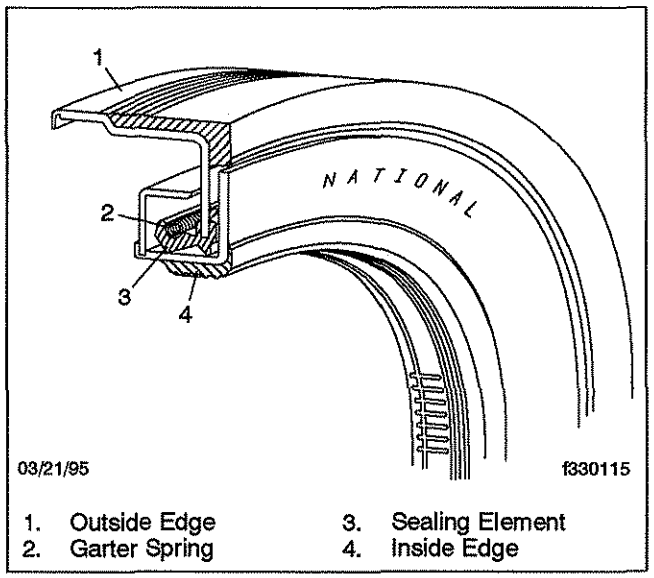


Fig. 2, Wheel Oil Seal Parts, National Oil Seal, Advanced Design

- Chicago Rawhide (Scotseal® and Scotseal Plus®)
- Eaton (Outrunner™)
- National (5-Star Gold® and Advanced Design®)
- Stemco (Guardian® and SS4®)

Chicago Rawhide (See Fig. 3)

The Chicago Rawhide Scotseal is a unitized, one-piece design consisting of a sealing element (packing) that is assembled between metal outer and inner cups. The sealing element consists of three sealing lips; a spring-loaded primary sealing lip that is factory pre-lubed and two dirt exclusion lips. The seal is press fit into the hub bore using Scotseal service installation tools. *Do not install the Scotseal directly onto the axle spindle.*

Although you install the Scotseal into the hub bore, the seal's element grips the axle spindle tightly enough that the sealing element stays stationary with the spindle and seals against the outer cup which turns with the hub.

The Chicago Rawhide Scotseal maintains a metal-to-metal contact between the outer cup and the hub bore surface as well as a metal-to-metal contact between the sealing element inside edge and the axle spindle.

Eaton (See Fig. 4)

The Eaton Outrunner has a rubber-coated outside edge and is installed in the hub bore using Eaton installation tools.

National (See Fig. 2 and Fig. 5)

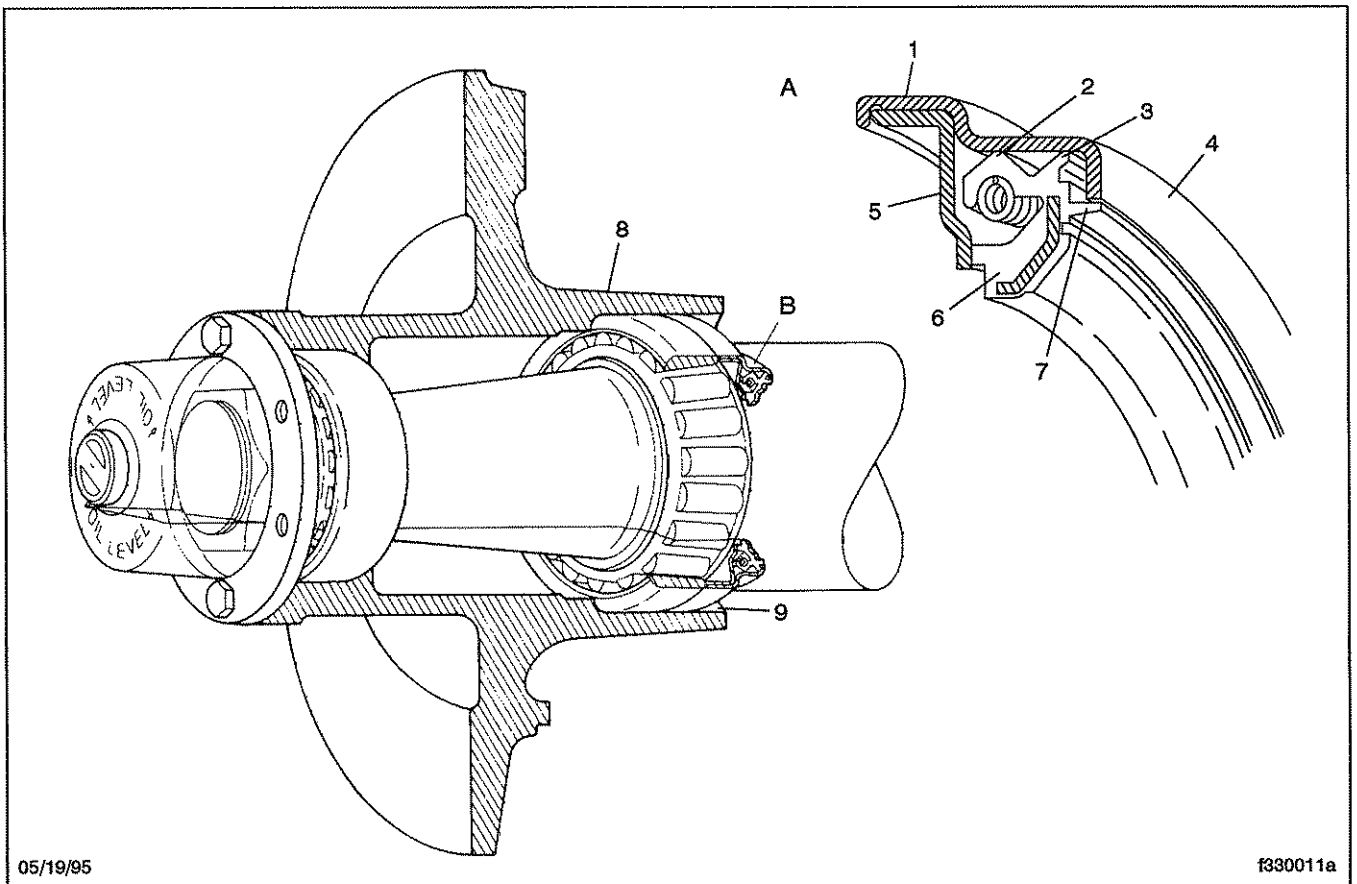
National wheel oil seals are hub-mounted, with a rubber-coated outside edge that grips inside the hub bore and also holds the sealing element. The element turns with the hub and seals against the inside edge of the seal which grips the axle spindle and acts as a wear sleeve. The shield protects the sealing element, and holds the two parts (the outside and inside edges) together.

The 5-Star Gold seal features a Teflon® lay-down sealing lip compatible with any combination of mineral and/or synthetic gear lubricants and/or greases.

Stemco (See Fig. 6 and Fig. 7)

The Stemco wheel oil seals are spindle-mounted, with a rubber-coated outside edge that grips inside the hub bore and also holds the sealing element.

Although you install the Stemco seal onto the axle spindle, the outside edge grips the hub bore tight enough that the sealing element turns with the hub and seals against the inside edge which grips the axle spindle and acts as a wear sleeve.



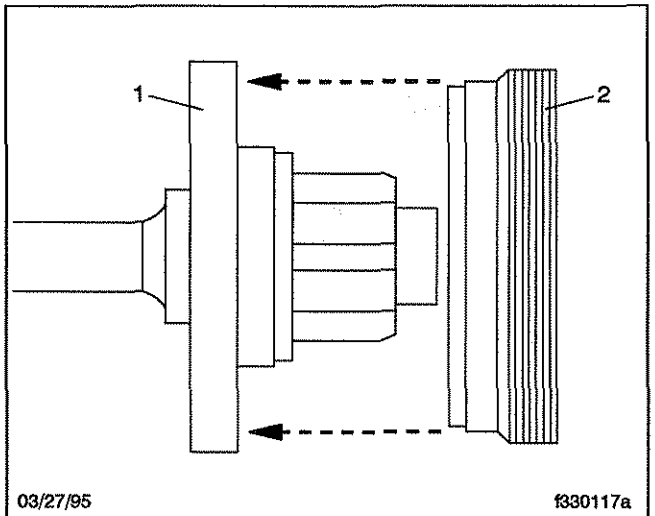
A. Detail A

B. Oil Seal (See detail A.)

1. Bore-Tite® Coating
2. Primary Sealing Lip
3. Dirt Lip
4. Outer Cup
5. Inner Cup
6. Sealing Element (Packing)
7. Bumper Lip
8. Hub
9. Hub Bore

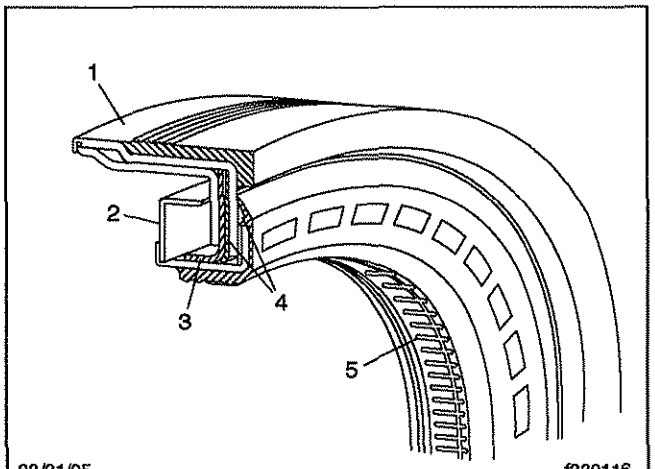
Fig. 3, Chicago Rawhide Scotseal

General Information



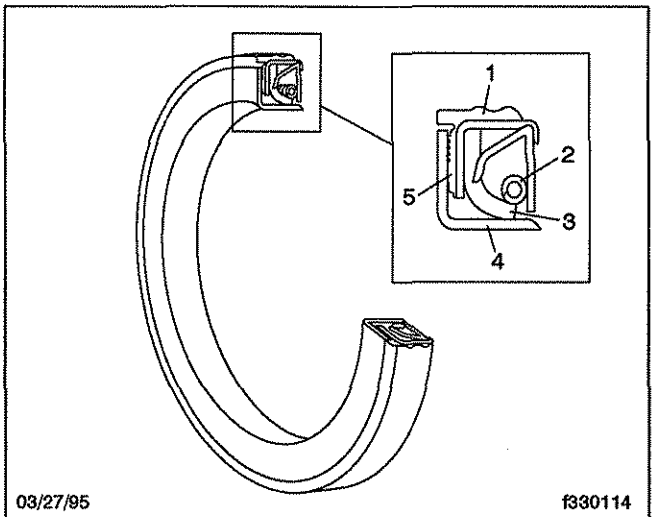
1. Eaton Outrunner Installation Tool
2. Eaton Outrunner Seal

Fig. 4, Eaton Outrunner Seal



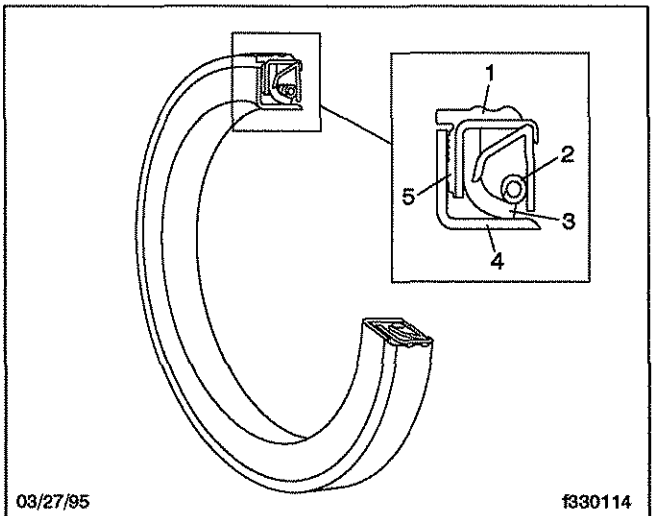
1. Metal and Rubber Outside Edge
2. Shield
3. Teflon Lay-Down Primary Sealing Lip
4. Dual Secondary Sealing Lips
5. Rubber Inside Edge

Fig. 5, National 5-Star Gold Axle Oil Seal



1. Metal and Rubber Outside Edge
2. Garter Spring
3. Sealing Element (Elasto-Leather, Primary Lip)
4. Inside Edge
5. Secondary Lips

Fig. 6, Stemco Guardian Wheel Oil Seal



1. Metal and Rubber Outside Edge
2. Garter Spring
3. Sealing Element (Teflon, Primary Lip)
4. Inside Edge
5. Secondary Lips

Fig. 7, Stemco SS4 Wheel Oil Seal

Seal Replacement, Chicago Rawhide

IMPORTANT: Make sure the required tools are available before beginning the service procedures described here. See the "Bearing Centering Tool Interchange" and "Adapter Plates" tables in **Specifications, 400**.

Replacement

NOTE: This procedure applies to the Chicago Rawhide Scotseal®.

1. Remove the wheel, drum, and hub from the axle. For instructions, see **Section 35.01**.
2. Remove the inner wheel bearing assembly from the axle. Handling the bearings with clean dry hands, wrap the bearings in clean oil-proof paper or lint-free cloths. Occasionally, the inner wheel bearing cone assembly will remain in the hub after the hub is removed from the axle. In those cases, place a protective cushion to catch the bearing assembly. Using a hardwood drift and a light hammer, gently tap the bearing and seal out of the inner wheel bearing cup.
3. Clean the spindle, spindle threads, seal bore, and the hub cavity. See **Fig. 1** and **Fig. 2**.
4. Remove all burrs from the shoulder and the seal bore with an emery cloth or a file. Clean any metal filings from the components.

⚠ CAUTION

Do not spin bearing rollers at any time. Dirt or grit can scratch the roller surface and cause rapid wear of the bearing assembly. Treat used bearings as carefully as new ones.

IMPORTANT: Use extreme care in cleaning the wheel hub cavity and axle spindle. Dirt, metal filings, or other contaminants can scratch the bearing roller surfaces, and cause premature wear of the bearing assembly.

5. Inspect the bearings and hub components for wear or damage. Replace any worn or damaged components as necessary.
6. Coat the wheel bearing cones with oil.
7. Install the inner wheel bearing cone in the inner wheel bearing cup.
8. Seat the small outside edge of the seal in the recess of the tool adapter. See **Fig. 3**. The correct adapter is identified on the box.

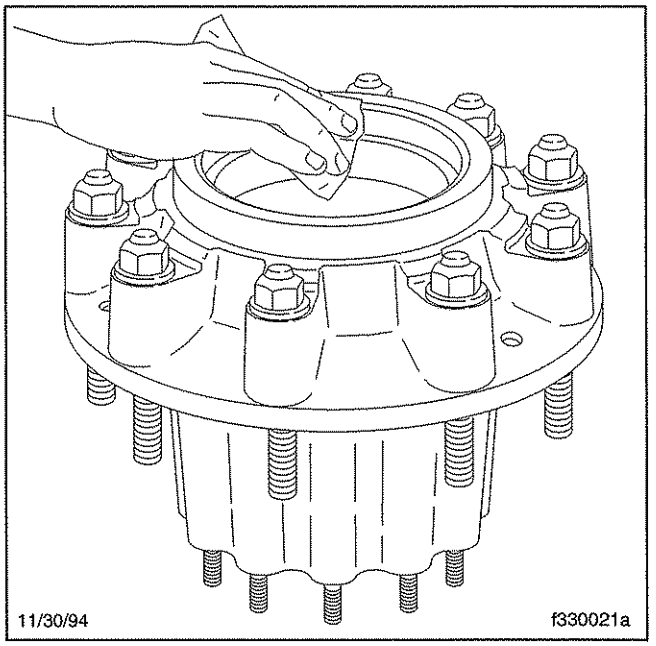
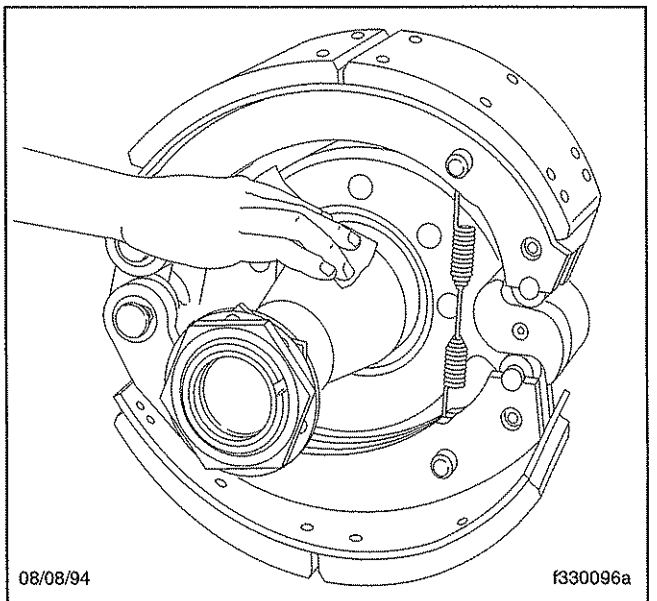


Fig. 1, Clean the Hub



NOTE: Front axle shown.

Fig. 2, Clean the Spindle

Seal Replacement, Chicago Rawhide

9. Insert the centering plug of the tool in the bore of the inner bearing cone. See **Fig. 4**. The plug prevents cocking of the seal in the bore.
10. Hold the tool handle firmly, and strike it until the sound of the impact changes as the seal bottoms out. See **Fig. 5**. Hold the tool firmly to avoid bounce or unseating of the seal from the adapter.
11. After the seal is bottomed in the bore, check for freedom of movement by manually moving the interior rubber part of the seal back and forth. A slight movement indicates a damage-free installation.
12. Install the wheel, drum, and hub on the axle and adjust the wheel bearings. For instructions, see **Section 35.01**.

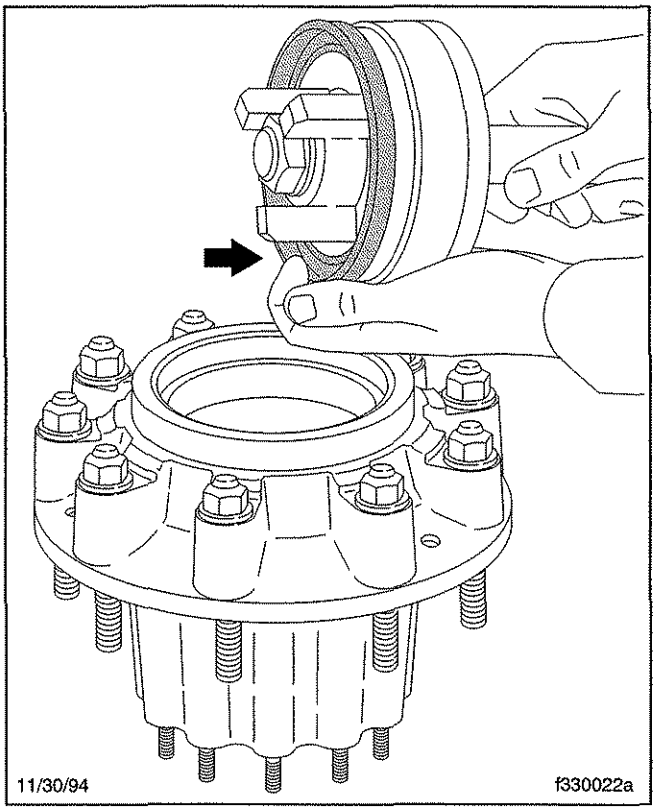


Fig. 3, Place the Seal on the Installation Tool

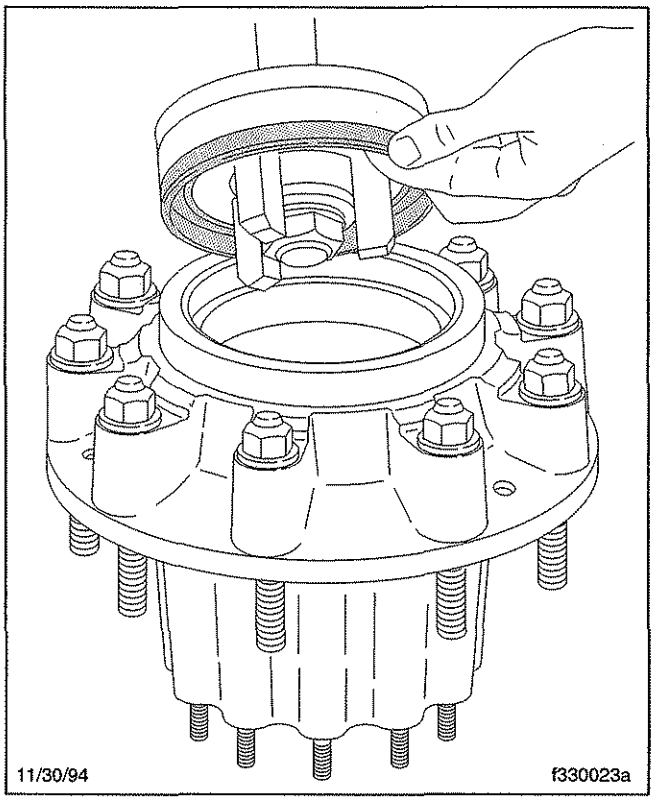


Fig. 4, Insert the Tool in the Hub Bore

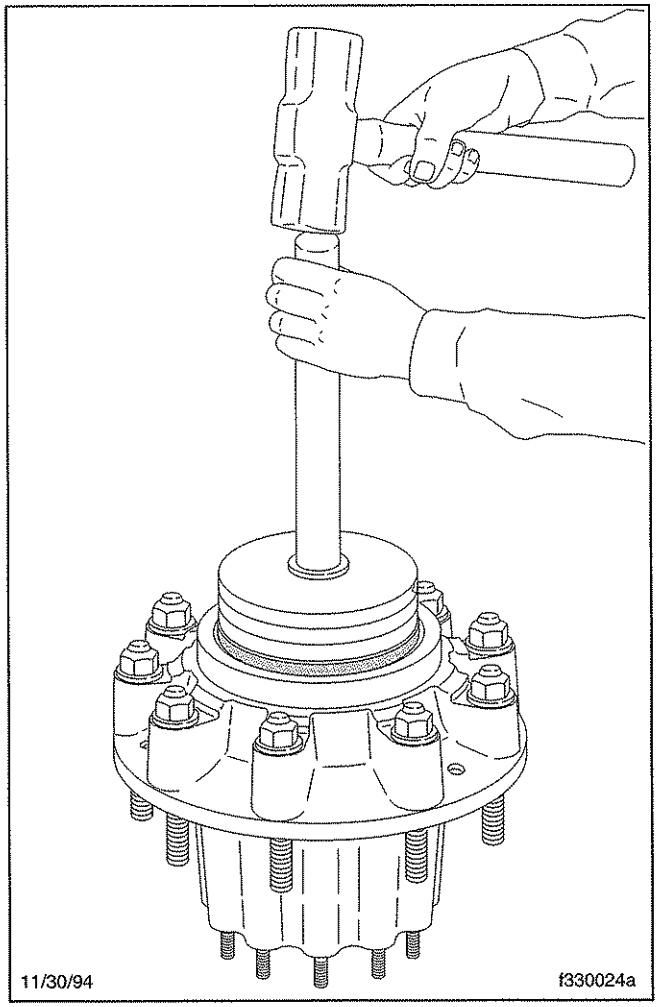


Fig. 5, Strike the Tool

Seal Replacement, Dana Spicer® Outrunner™

IMPORTANT: Make sure the required tools are available before beginning the service procedures described here. See the "Bearing Centering Tool Interchange" and "Adapter Plates" tables in **Specifications, 400**.

Replacement

NOTE: This procedure applies to the Dana Spicer Outrunner seal.

1. Remove the wheel, drum, and hub from the axle. For instructions, see **Section 35.01**.
2. Remove the inner wheel bearing assembly from the axle. Handling the bearings with clean dry hands, wrap the bearings in clean oil-proof paper or lint-free cloths. Occasionally, the inner wheel bearing cone assembly will remain in the hub after the hub is removed from the axle. In those cases, place a protective cushion to catch the bearing assembly. Using a hardwood drift and a light hammer, gently tap the bearing and seal out of the inner wheel bearing cup.

⚠ CAUTION

Never use a sharp chisel to cut through an axle ring (wear sleeve). A sharp chisel could damage the spindle or shoulder.

3. Remove the steel axle ring (wear sleeve) by striking the ring surface several times with a ball-peen hammer. See **Fig. 1**. Remove the stretched axle ring from the spindle.
4. Clean and inspect the bearings, the spindle, spindle threads, seal bore, and the hub cavity.

   IMPORTANT: Use extreme care in cleaning the wheel hub cavity and axle spindle. Dirt, metal filings, or other contaminants can scratch the bearing roller surfaces, and cause premature wear of the bearing assembly.

   4.1 Inspect the inner hub bore. Remove dirt and contaminants from all recesses and corners. Smooth any sharp edges with emery cloth, and fill in any grooves with filler. See **Fig. 2**.

   4.2 Wipe the hub area with a clean shop cloth.

   4.3 After removing the wear sleeve, inspect the spindle. Remove any sharp edges and burrs from the leading edges and the shoulder area. Repair deep gouges with filler and smooth with an emery cloth. See **Fig. 3**.

   4.4 Wipe the seal and shoulder area with a clean shop cloth.

⚠ CAUTION

Do not spin bearing rollers at any time. Dirt or grit can scratch the roller surface and cause rapid wear of the bearing assembly. Treat used bearings as carefully as new ones.

   4.5 Inspect the bearings and hub components for wear or damage. Replace any worn or damaged components as necessary.

   4.6 Coat the wheel bearing cones with oil.

5. Install the inner wheel bearing cone in the inner wheel bearing cup.

IMPORTANT: Use the Dana Spicer Outrunner installation tool *with the centering tool* when installing the seal. See **Fig. 4**.

6. Install the oil seal in the hub bore.

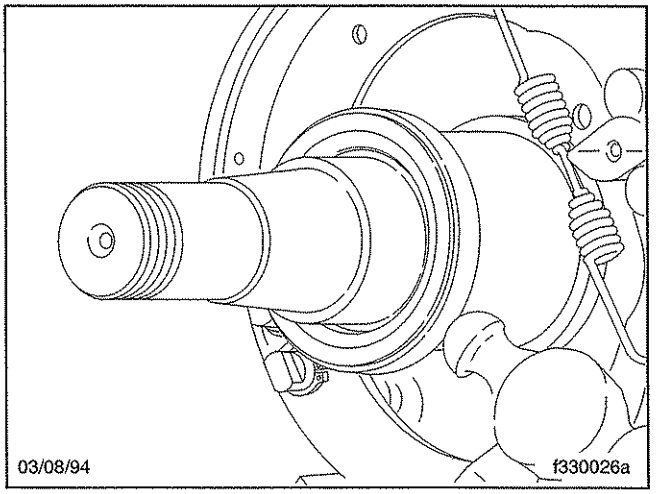


Fig. 1, Removing the Axle Ring

Seal Replacement, Dana Spicer® Outrunner™

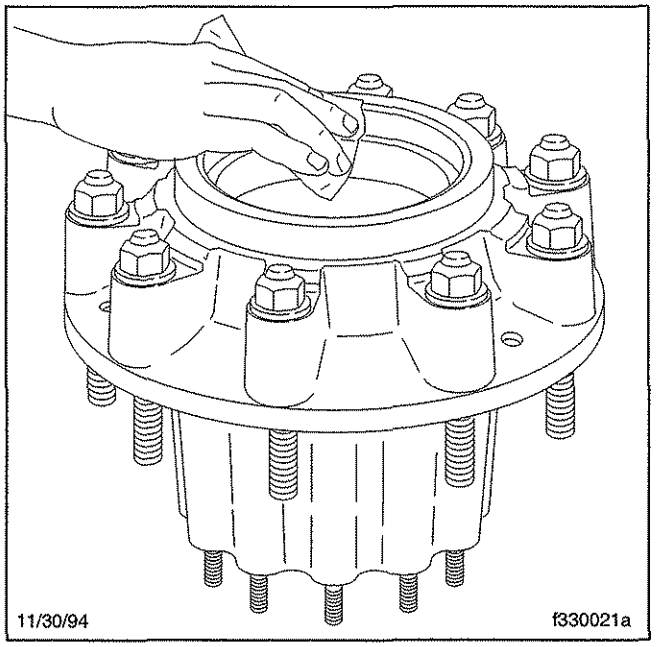


Fig. 2, Clean and Inspect the Hub Bore

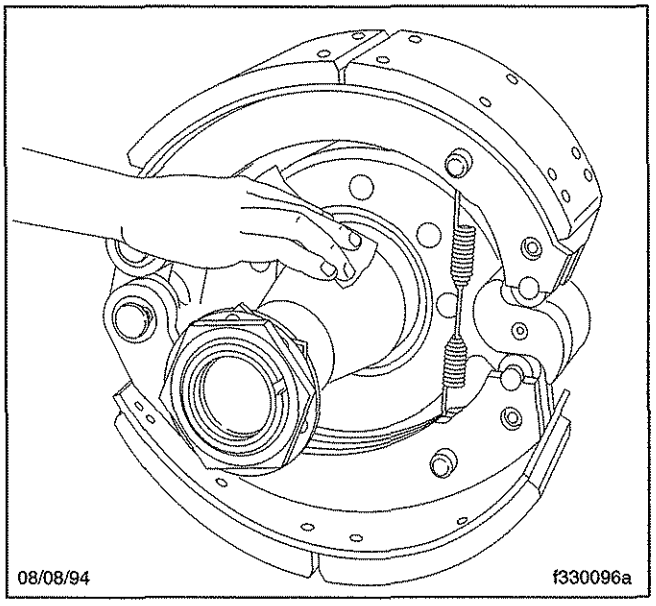


Fig. 3, Clean and Inspect the Axle Spindle

⚠ CAUTION

Do not use any silicone or permatex type bore sealant with this seal. The Dana Spicer Corporation recommends a light coating of bearing oil on the outer circumference of the seal.

Do not mix lubricants of different grades. Do not mix mineral and synthetic lubricants. Do not pack the bearings with grease when using an oil bath system. Failure to follow these installation guidelines will result in less than desired performance of the Outrunner seal, and installation-related failures are not covered under warranty.

6.1 Place the Outrunner seal tool with the words "air side" facing the adapter plate of the installation tool. See **Fig. 5**. Lubricate the seal outer circumference with wheel bearing oil.

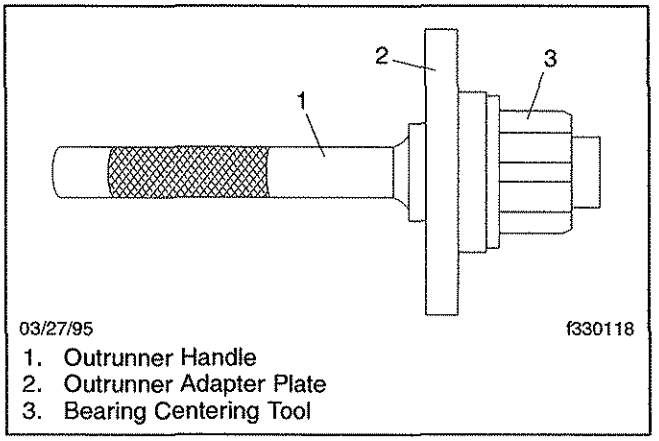
IMPORTANT: Install the seal in the hub bore with the hub lying flat. Do not install the seal with the hub in the vertical (upright) position.

6.2 With the hub and the wheel assembly lying flat on the floor, place the inner bearing cone in the cup.

6.3 Position the oil seal in the hub bore. Before striking the handle of the installation tool, tap the adapter plate around the outer edge to position the seal. See **Fig. 6**.

6.4 Hit the handle of the installation tool *gently*. See **Fig. 7**.

Because of the rubber outer circumference, the Outrunner seal is easier to install than seals with metal outer circumferences. When the adapter plate bottoms out on the



1. Outrunner Handle
2. Outrunner Adapter Plate
3. Bearing Centering Tool

Fig. 4, Outrunner Installation Tool

Seal Replacement, Dana Spicer® Outrunner™

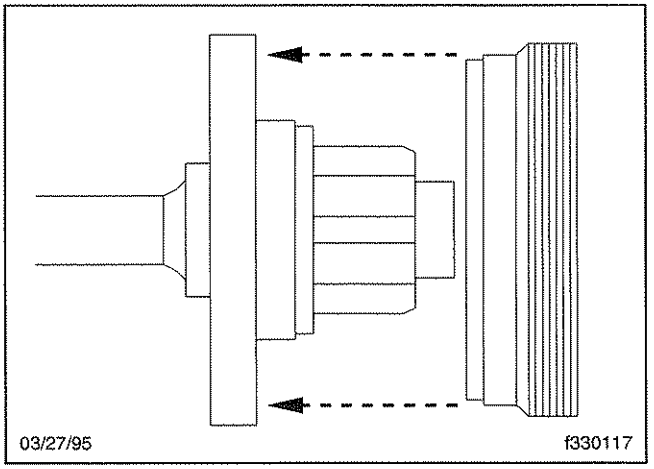


Fig. 5, Seal Placement on Tool

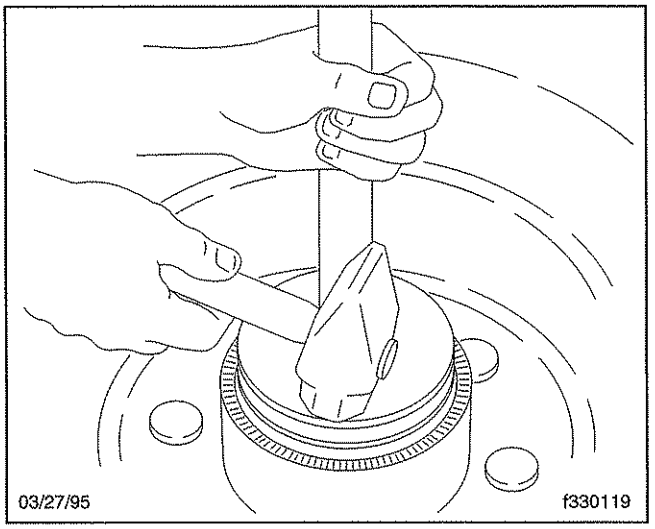


Fig. 6, Position the Seal

hub surface, the seal is installed correctly. You will hear a metal-to-metal sound.

6.5 Check that the seal is not cocked, and that the unitized seal inner circumference and inner bearing turn freely.

6.6 Lubricate the inner circumference of the seal with a light film of clean bearing oil.

7. Install the wheel, drum, and hub on the axle and adjust the wheel bearings. For instructions, see **Section 35.01**.

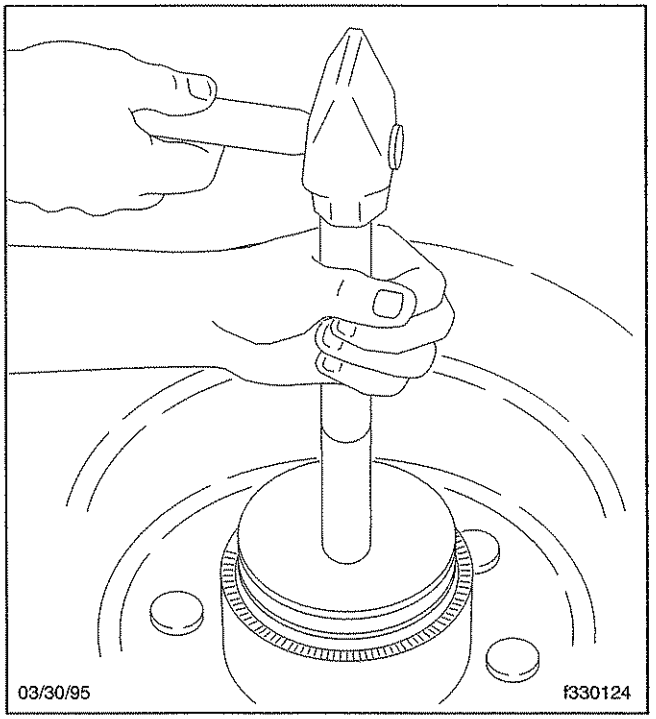


Fig. 7, Install the Seal

Seal Replacement, National®

IMPORTANT: Make sure the required tools are available before beginning the service procedures described here. See the "Bearing Centering Tool Interchange" and "Adapter Plates" tables in **Specifications, 400**.

Replacement

1. Remove the wheel, drum, and hub from the axle. For instructions, see **Section 35.01**.
2. Remove the old oil seal from the hub or spindle.
3. Clean the spindle, spindle threads, seal bore, and the hub cavity.

⚠ CAUTION

Never use a sharp chisel to cut through an axle ring. A sharp chisel could damage the spindle or shoulder.

4. Remove the steel axle ring by striking the ring surface several times with a ball-peen hammer. See **Fig. 1**. Remove the stretched axle ring from the spindle.
5. Inspect the spindle shoulder and hub bore.
   - 5.1 If necessary, use a file to remove burrs from the leading edges and shoulder area.

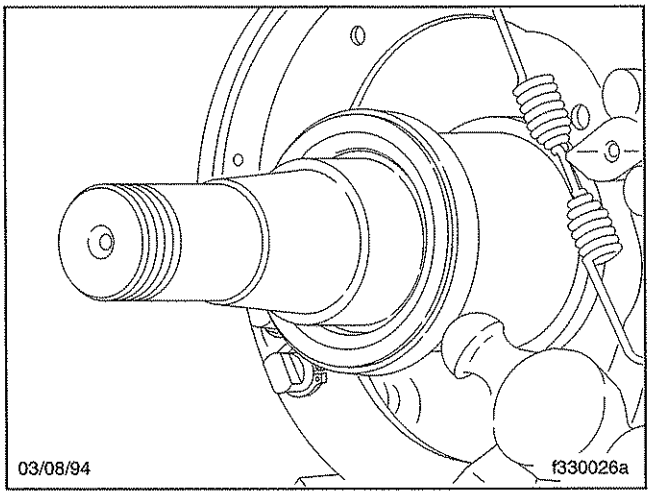


Fig. 1, Remove the Axle Ring

   - 5.2 Fill any deep scratches with a hardening compound and smooth it with an emery cloth. See **Fig. 2**.
   - 5.3 Use a clean cloth to remove all dirt, grit, and metal filings.
   - 5.4 Check the seal for a correct fit by placing the seal on the axle spindle, up to the first rubber rib. The correct seal will not go any farther.

   IMPORTANT: Clean the wheel hub cavity and axle spindle. Dirt, metal filings, or other contaminants can scratch the bearing roller surfaces, and cause rapid wear of the bearing assembly.

   - 5.5 Inspect the hub bore, and remove any burrs from the leading edge with an emery cloth.
6. Select the seal installation tools designed for use with National oil bath seals. These should include a universal handle, an adapter plate, and a bearing pilot. See **Fig. 3**.
7. Install the seal in the hub.

⚠ CAUTION

Do not spin bearing rollers at any time. Dirt or grit can scratch the roller surface and cause rapid wear of the bearing assembly. Treat used bearings as carefully as new ones.

   - 7.1 Prelube the inner bearing cone with clean oil and place it in the hub. See **Fig. 4**.

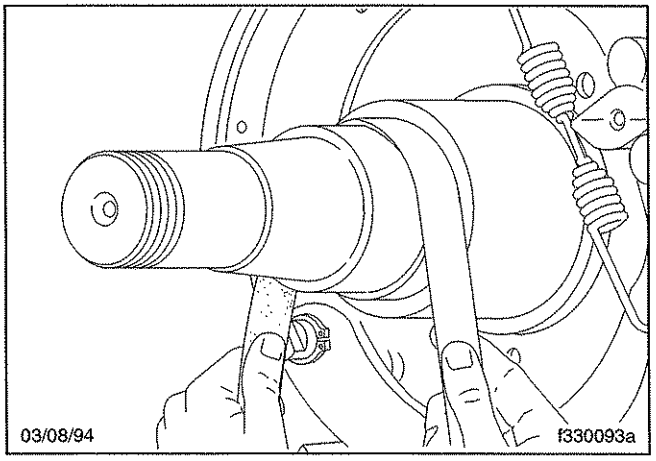


Fig. 2, Clean the Axle Spindle

Seal Replacement, National®

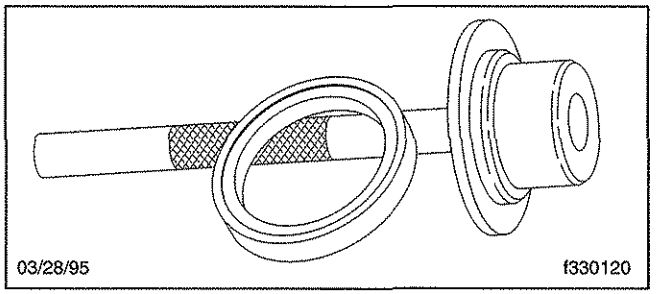


Fig. 3, Installation Tools

7.2 Place the oil bath seal on the installation tool with the words "air side" facing the adapter plate. Lubricate the outside edge of the seal with clean oil to ease the installation. See **Fig. 5**.

7.3 Hold the tool straight, and drive the seal with a firm hit until the sound of the impact changes. See **Fig. 6**. Make sure the seal is squarely in position and the inner wheel bearing rotates freely.

7.4 Lubricate the inside edge of the seal with clean oil.

8. Install the wheel, drum, and hub on the axle and adjust the wheel bearings. For instructions, see **Section 35.01**.

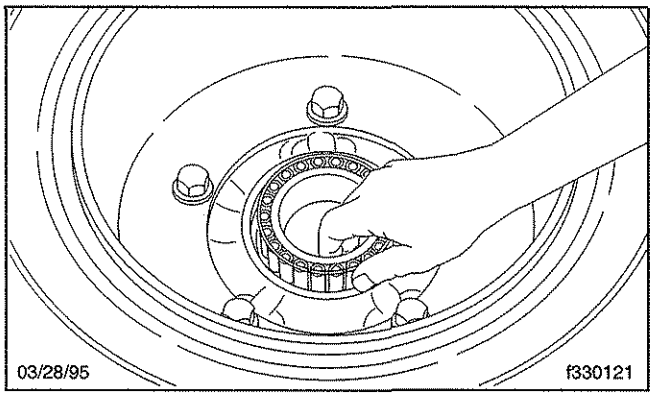


Fig. 4, Place the Bearings in the Hub

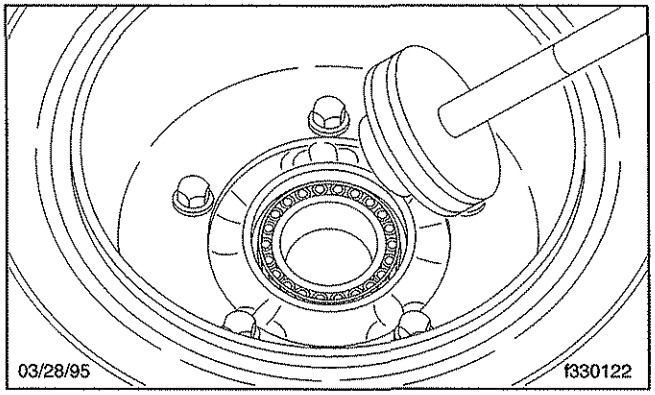


Fig. 5, Place the Seal on the Tool

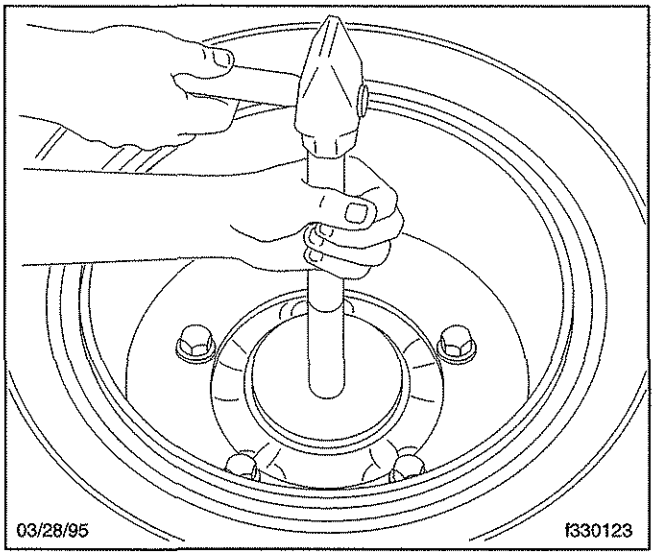


Fig. 6, Drive the Seal Into the Hub

Seal Replacement, Stemco®

IMPORTANT: Make sure the required tools are available before beginning the service procedures described here. See the "Bearing Centering Tool Interchange" and "Adapter Plates" tables in **Specifications, 400**.

Replacement

1. Remove the wheel, drum, and hub from the axle. For instructions, see **Section 35.01**.
2. Remove the old oil seal from the hub or spindle.
3. Clean the spindle, spindle threads, seal bore, and the hub cavity.

⚠ CAUTION

Never use a sharp chisel to cut through an axle ring. A sharp chisel could damage the spindle or shoulder.

4. Remove the steel axle ring by striking the ring surface several times with a ball-peen hammer. See **Fig. 1**. Remove the stretched axle ring from the spindle.
5. Using a wire brush, remove any old sealant and corrosion from the axle spindle and shoulder. Remove any burrs with an emery cloth. See **Fig. 2**. Wipe the spindle and shoulder clean with safety solvent.

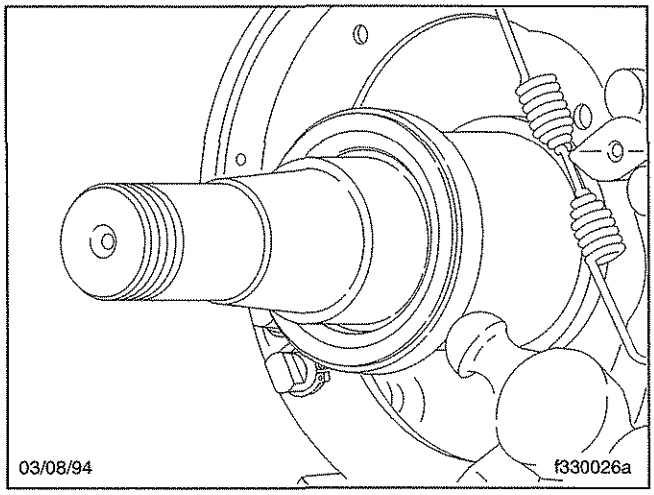


Fig. 1, Remove the Axle Ring

6. Remove any burrs from the inside of the hub bore. See **Fig. 3**. The hub bore must be free of burrs that will scratch the outer surface of the seal and allow oil to escape from the hub. Remove any spacer rings or washers, if so equipped.

IMPORTANT: Clean the wheel hub cavity and axle spindle. Dirt, metal filings, or other contaminants can scratch the bearing roller surfaces, and cause rapid wear of the bearing assembly.

7. Inspect the bearings and hub components for wear or damage. Replace any worn or damaged parts as necessary.

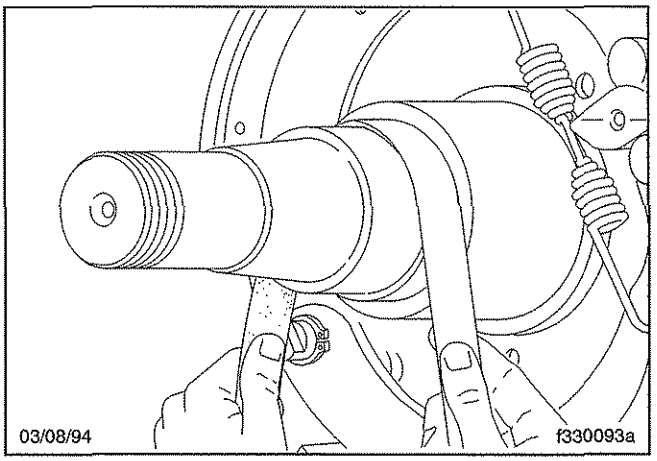
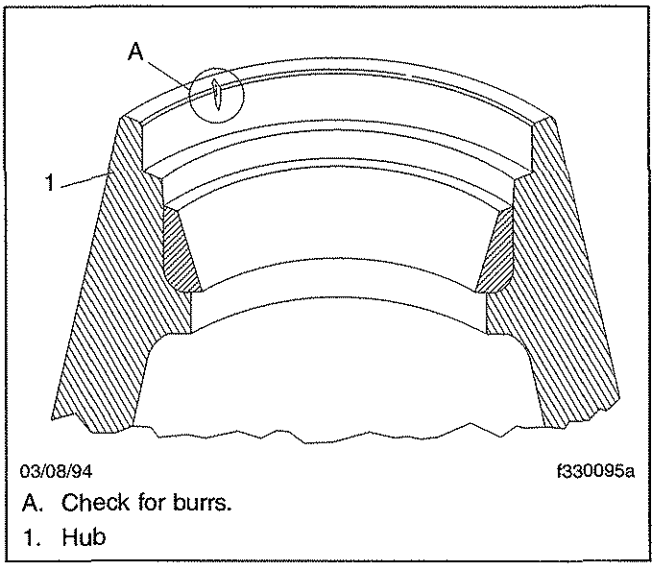


Fig. 2, Clean the Axle Spindle



A. Check for burrs.
1. Hub

Fig. 3, Inspect the Hub Bore

Seal Replacement, Stemco®

⚠ CAUTION

Do not spin bearing rollers at any time. Dirt or grit can scratch the roller surface and cause rapid wear of the bearing assembly. Treat used bearings as carefully as new ones.

8. If burrs were removed from the spindle shoulder, apply a thin layer of non-hardening sealant to the spindle shoulder. See **Fig. 4**.

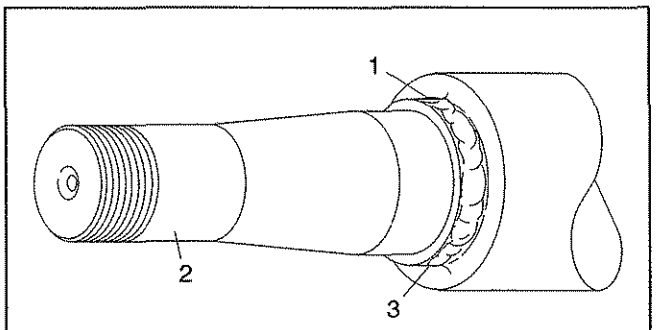
NOTE: Use a non-hardening sealant such as Permatex® Number-2 or Loctite® 515.

9. Place the oil seal on the spindle so the words "oil-bearing side" are exposed to the oil. A slight step on the inside circumference of the seal ring will allow it to be placed by hand about 1/8 inch (3 mm) onto the shoulder. See **Fig. 5**.

⚠ CAUTION

Do not install the oil seal in the hub bore. Incorrect seal installation will damage the seal and lead to possible spindle, hub, and bearing damage.

10. Position the Stemco installation tool over the spindle. See **Fig. 6**. Using a 3 to 5 lb (1 to 2 kg) hammer, drive the seal on the spindle until the tool bottoms against the shoulder. After the tool bottoms, turn it while applying several light taps with the hammer to ensure the seal ring is flush with the face of the shoulder. Wipe off all excess sealant.



1. Sealant
2. Spindle
3. Shoulder

Fig. 4, Apply Sealant to the Spindle Shoulder

IMPORTANT: Use only the tool specified by Stemco for the vehicle's axle. In order for the Stemco warranty to apply, the product must be correctly installed using the correct tool made by Stemco or a tool approved by Stemco.

11. Make sure there are no gaps between the ring and shoulder. See **Fig. 7**.

12. Coat the inner wheel bearing with oil and install it on the spindle. See **Fig. 8**. No additional oil is needed on the outside of the seal. The seals are lubed at the factory.

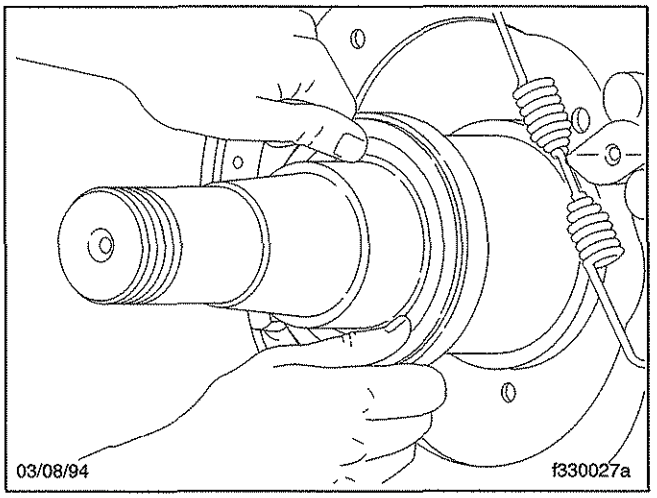


Fig. 5, Place the Seal on the Spindle

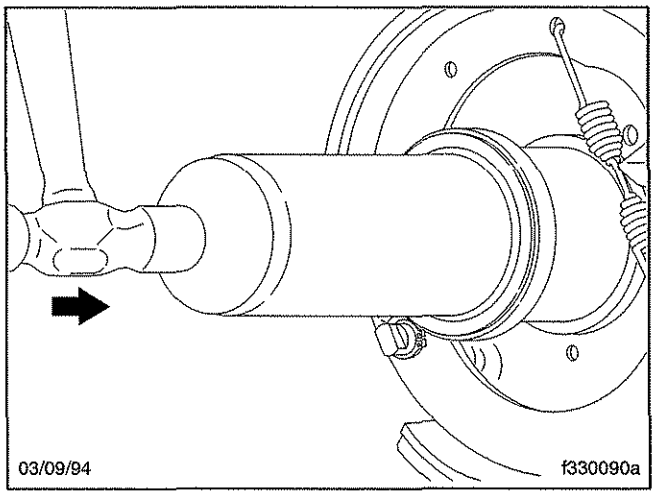


Fig. 6, Drive the Seal onto the Spindle

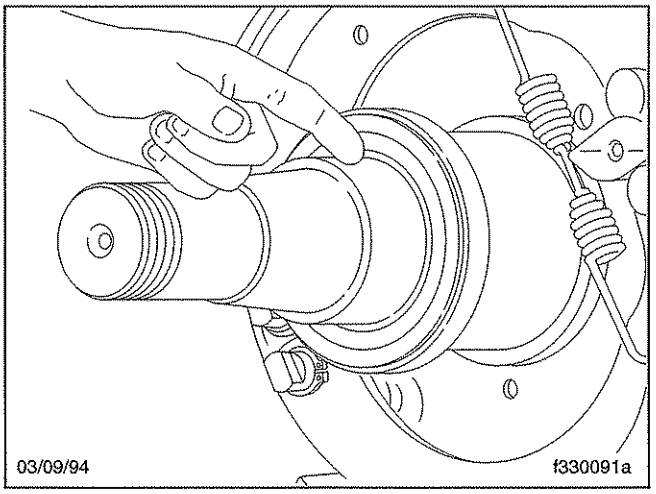


Fig. 7, Check the Ring for Gaps

13. Install the wheel, drum, and hub on the axle and adjust the wheel bearings. For instructions, see **Section 35.01**.

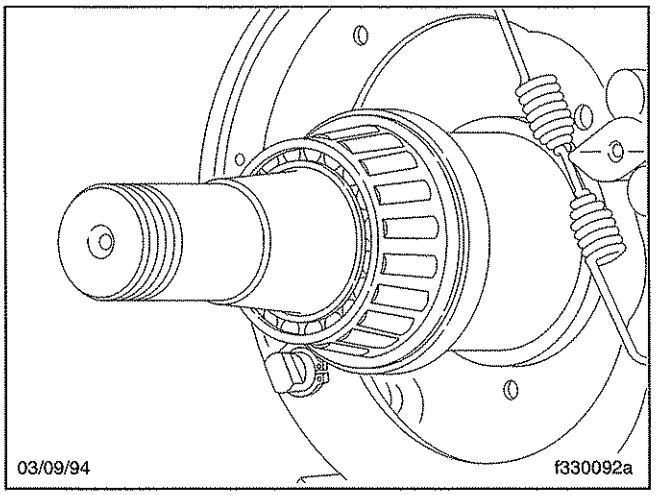


Fig. 8, Install the Inner Bearings

Specifications

Bearing Centering Tool Interchange				
Spindle Type	Bearing Cone	Centering Tool Number		
		Dana Spicer® Outrunner™	Chicago Rawhide	National®
—	580	BCT-10	710	RD-410
—	582	BCT-10	710	RD-410
—	594	BCT-15	715	RD-416
—	595	BCT-10	710	RD-410
—	598	BCT-14	714	RD-415
—	663	BCT-10	710	RD-410
—	665	BCT-11	711	RD-411
—	759	BCT-12	712	RD-412
—	5760	BCT-8	708	RD-418
15K	33287	BCT-7	707	RD-408
—	47678	BCT-8	708	RD-418
L	47686	BCT-10	710	RD-410
—	495AX	BCT-8	708	RD-418
R	594A	BCT-15	715	RD-416
—	598A	BCT-14	714	RD-415
—	HM516449	BCT-10	710	RD-410

Table 1, Bearing Centering Tool Interchange

Adapter Plates		
Seal	Adapter Plate	Color
848	848-T	Gold
849	849-T	
852	852-T	
854	854-T	
856	856-T	
858	858-T	
860	860-T	
861	861-T	

Table 2, Adapter Plates

Group Index, Alphabetical

Section	Section Number
Wheels and Tires	40.00

Contents

Subject	Subject Number
General Information	050
Service Operations	
8-Hole Disc Wheel With Two-Piece Flange Nuts Removal and Installation	100
10-Hole Disc Wheel With Two-Piece Flange Nuts Removal and Installation	110
10-Hole Disc Wheel With Inner and Outer Nuts; Removal and Installation	120
Spoke Wheel, Tire and Rim Assembly; Removal and Installation	130
Tire Demounting and Mounting Service Precautions	140
Demounting and Mounting Tubeless Tires on One-Piece Drop Center Wheels or Rims	150
Demounting and Mounting Tube-Type Tires on Two-Piece Flat Base Wheels or Rims	160
Demounting and Mounting Tube-Type Tires on Three-Piece Flat Base Wheels or Rims	170
Demounting and Mounting Tube-Type Tires on Semi Drop-Center Wheels or Rims	180
Wheel and Components Inspection	190
Tires and Components Inspection	200
Tire Inflation	210
Troubleshooting	300
Specifications	400

General Information

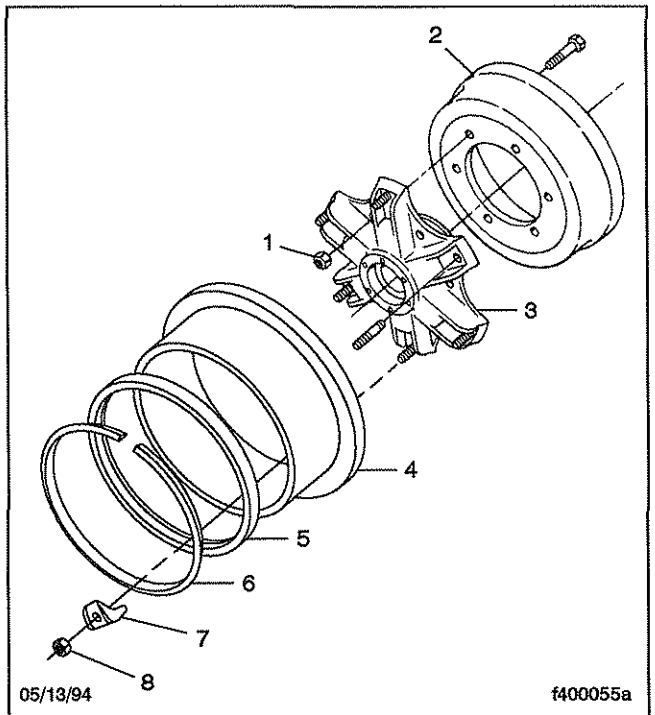
WHEELS AND TIRES

The tires support the weight of the vehicle, and are integral parts of the transmission and braking systems. The wheels serve as load carrying members between the tires and the axle.

There are two types of wheels: spoke and disc.

Spoke wheels consist of a wheel and brake drum assembly installed on the axle **(Fig. 1)**, and a tire and rim assembly that mounts on the wheel. Rim clamps and rim nuts hold the tire and rim assembly in place.

Disc wheels consist of a rim and disc. The rim, the portion of the wheel on which the tire is mounted and supported, is welded to the disc **(Fig. 2)**. After the tire is mounted on the wheel, the assembly is held in place on the hub with wheel studs and nuts.



1. Brake Drum Nut
2. Brake Drum
3. Spoke Wheel
4. Rim Base
5. Continuous Side Ring
6. Split Lockring
7. Rim Clamp
8. Rim Nut

Fig. 1, Spoke Wheel and Brake Drum Assembly (Shown with Three-Piece Rim, for Tube-Type Tires)

Standard ten-hole dual disc wheels are held in place on the hub by self-centering inner and outer wheel nuts. Eight-hole and optional ten-hole (single and dual) disc wheels are centered by pilot pads and are held in place on the hub with cone locknuts.

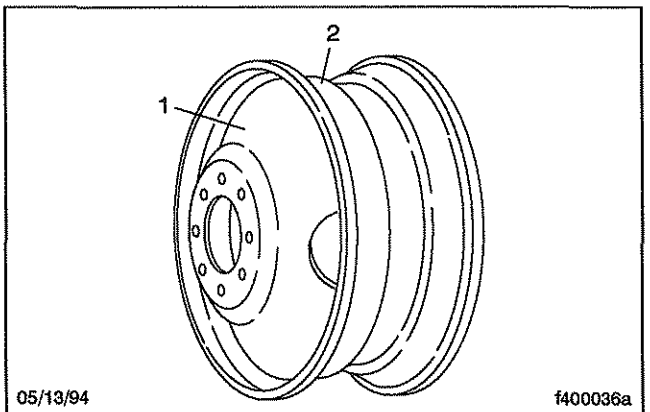
Tires are constructed of either radial or bias plies:

Radial tires have ply cords that run from bead to bead, and at a right angle to the belt plies and tire tread **(Fig. 3)**. The belt plies constrict the radial ply cords and give rigidity to the tread.

Bias ply tires have body ply cords that run diagonally from bead to bead **(Fig. 4)**. The tires may also have narrow plies under the tread, called breakers, with cords that lie in about the same direction as the body ply cords.

Tire body plies, breakers, and belts are made of polyester, rayon, nylon, fiberglass, steel, or aramids (fibrous reinforcements). In radial ply tires, these materials are used in various combinations, including steel body/steel belt, polyester body/fiberglass belt, or nylon body/steel belt.

Wheels and tires operate either with or without tubes. Tube-type tires require a tube and flap for correct assembly on a two-or three-piece rim **(Fig. 1)**. Tubeless tires require only the tire, and a one-piece drop-center wheel or rim. **See Fig. 2.**



1. Disc
2. Rim

Fig. 2, Disc wheel

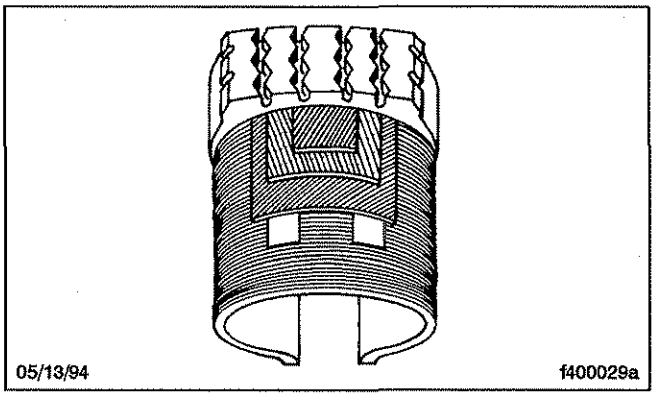


Fig. 3, Radial Ply Tire Construction

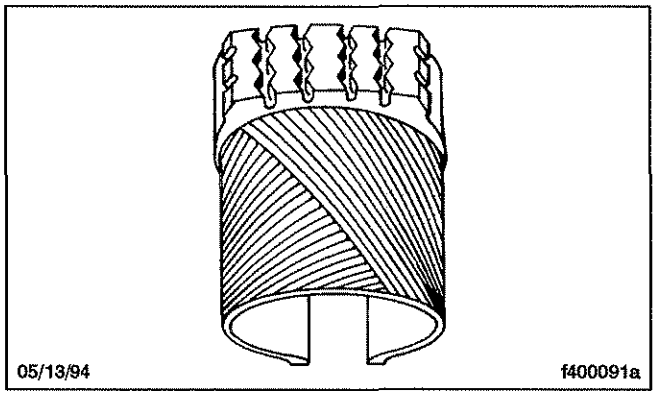


Fig. 4, Bias Ply Tire Construction

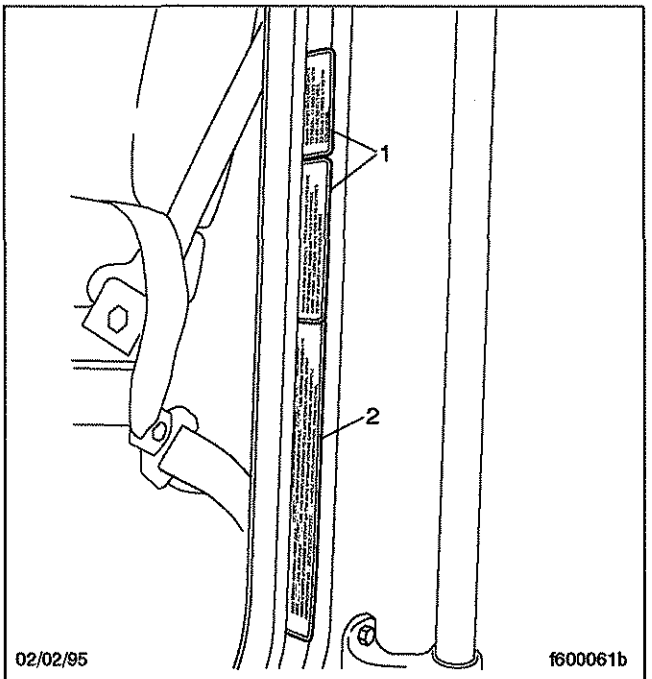
TIRE MATCHING AND MIXING

IMPORTANT: Review and follow these requirements for matching and mixing tires, before installing any tire and wheel or rim assembly on a vehicle.

Before changing wheels and tires, consider the effect that the change may have on the Gross Vehicle Weight Rating (GVWR) of the vehicle. At the time of vehicle certification, the GVWR is calculated by adding the vehicle's Gross Axle Weight Ratings (GAWR). The GVWR and each of the GAWRs are shown on a certification label (U.S.-purchased tractors) or "Statement of Compliance" label (Canadian-purchased tractors) attached to the left rear door post. **See Fig. 5.**

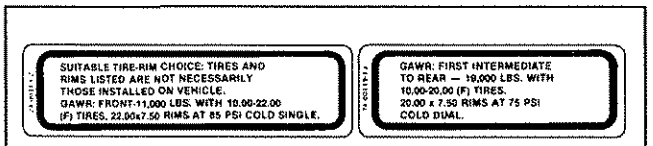
Tire and rim labels (**Fig. 5** and **Fig. 6**) certify the minimum tire and rim combinations that can be installed on the vehicle for the given GAWRs. Each GAWR is determined by considering each component of the axle system, including suspension, axle, wheels, and tires. The lowest component's capacity is the value used for the system. Therefore, the tires and rims installed on the vehicle at the time of vehicle manufacture may have a higher load capacity than that certified by the tire and rim label. Tires and rims of the minimum capacity can be installed without changing the load limitations. If tires and rims are installed that have a lower load capacity than that shown on the tire and rim label, then the tires and rims determine the load limitations (the GAWRs and GVWR will be lower).

When pairing tires in a dual assembly, the tire diameters must not differ by more than 1/4 inch (6.4 mm),



1. Tire and Rim Labels
2. Certification Label

Fig. 5, Certification Label, U.S.



NOTE: Examples only. Actual specifications may vary from vehicle to vehicle.

Fig. 6, Tire and Rim Labels

or the tire circumference by more than 3/4 inch (19 mm). The total tire circumference of one driving rear axle must match, as nearly as possible, the total tire circumference of the other driving rear axle.

CAUTION: Mismatching dual tires overloads the larger diameter tire, causing it to overdeflect and overheat. The smaller diameter tire, lacking proper road contact, wears faster and unevenly. Tread or ply separation, tire body breaks, and blowouts can occur from mismatched duals.

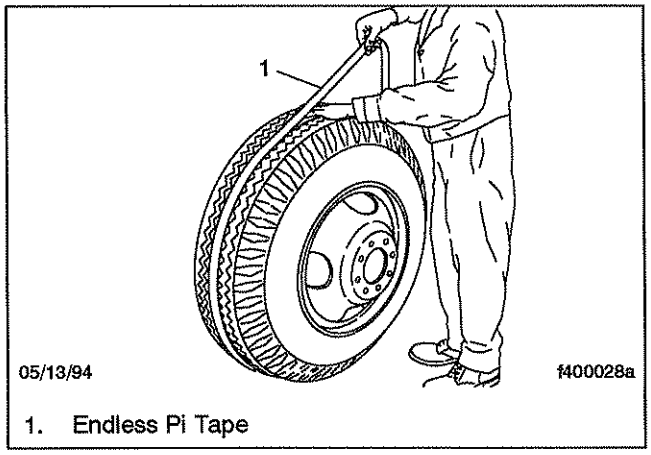
With an endless pi tape **(Fig. 7)** or square **(Fig. 8)**, measure the diameter of the tires 24 hours after inflation. A matching stick **(Fig. 9)**, string gauge **(Fig. 10)**, or tire straight edge **(Fig. 11)** can also be used to determine the difference in tire radius, which is then doubled to calculate the diameter difference.

When pairing tires of unequal diameters (but within the above limits), mount the larger tire on the outside.

CAUTION: Driving a vehicle on one tire of a dual assembly dangerously exceeds the carrying capacity of the single tire and wheel. Operating in this manner can cause damage to the wheel and tire.

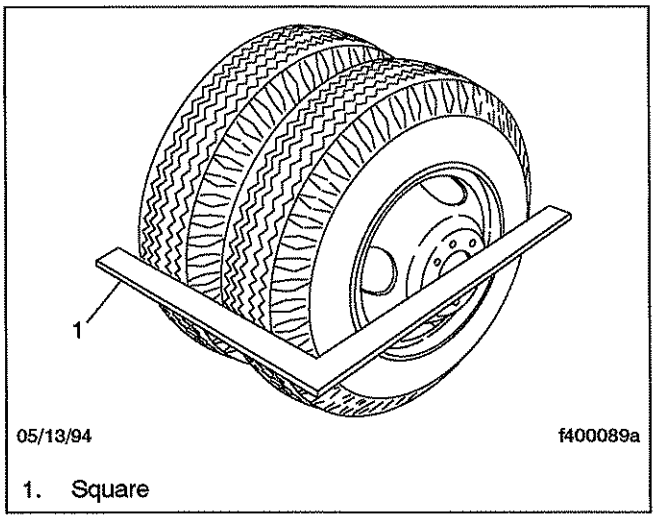
Inflate all tires on an axle, or on both axles of a tandem unit, to within 5 psi (35 kPa) of one another. For tire inflation specifications, refer to **Specifications, 400.**

There must be sufficient space between dual tires for air to flow and cool the tires, and to prevent them from rubbing against one another. Rims and wheels of the same size, but of different makes and types, can have different offsets, which would affect dual spacing. If there is sidewall contact between tires, or



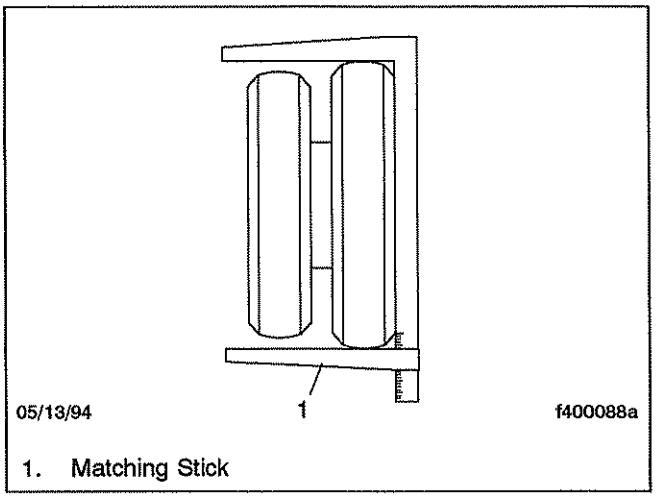
1. Endless Pi Tape

Fig. 7, Endless Pi Tape



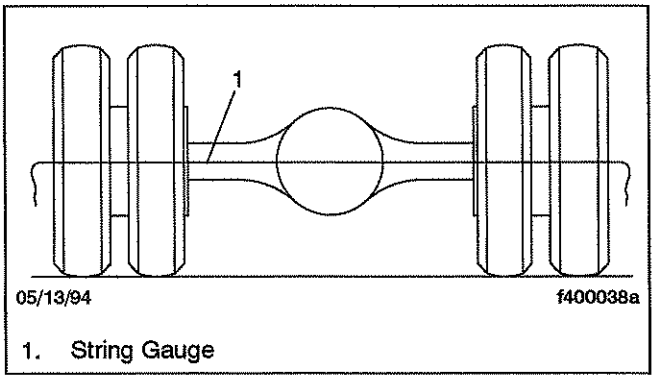
1. Square

Fig. 8, Square



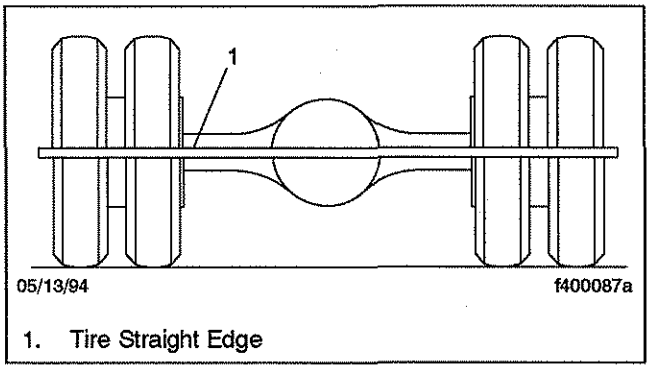
1. Matching Stick

Fig. 9, Matching Stick



1. String Gauge

Fig. 10, String Gauge



1. Tire Straight Edge

Fig. 11, Tire Straight Edge

between the inside tire and the chassis, refer to the tire manufacturer's catalog to determine the minimum dual spacing. Refer to the rim or wheel manufacturer's catalog to determine the correct offset.

Federal Motor Carrier Safety regulations require the removal of all tires with less than 4/32-inch (3 mm) remaining groove depth on a front axle, and tires with less than 2/32-inch (1.5 mm) remaining groove depth on a rear axle. However, tires with the word "Regroovable" on the sidewall, may be regrooved.

Better tire and vehicle performance is usually obtained by using tires of the same size and construction. Using tires of different construction is permitted if the following rules are observed:

- Do not mix radial and bias ply tires on the same axle.
- If both radial and bias ply tires are used, better handling is usually obtained by using the bias ply tires on the front axle.
- Use either all radial or all bias ply tires on the non-driving rear axles of a vehicle. However, all radial or all bias ply tires must be used on vehicles with tandem drive-axles.

CAUTION: Mixing radial and bias ply tires should be done as an emergency measure only. Some loss of steering control and premature tire wear could occur when driving under such conditions.

If installing radial tires on a vehicle formerly equipped with bias ply tires, refer to **Specifications, 400** concerning the inflation needs and load limits of the bias ply tires being removed, and of the radial ply tires being installed. Radial ply tires permit greater loads per tire, but also require higher inflation. They can also cause higher stresses on rims and wheels than bias ply tires. Contact the rim or wheel manufacturer about the compatibility of the rim or wheel with radial ply tires. Also, refer to the front axle section in this manual for information on the possible differences in toe-in setting between radial and bias ply tires.

8-Hole Disc Wheel With Two-Piece Flange Nuts Removal and Installation

Removal

⚠ CAUTION

The wheel center hole and hub pilot have close tolerances. If the wheel is not kept square to the hub, it could bind during removal and damage the stud threads or hub-pilot pads. Keep the wheel square to the hub during removal.

1. Park the vehicle on a level surface and apply the parking brakes. Shut down the engine. Chock all tires that will not be serviced, to prevent vehicle movement.
2. Remove the wheels and tires from the front axle.
   - 2.1 Raise the front of the vehicle until the tires clear the floor. Place safety stands under the front axle.
   - 2.2 If the tire or wheel is damaged (or if there is suspected damage), deflate the tire being serviced by removing the valve core.
   - 2.3 Place a jack or wheel-and-tire dolly under the front wheel assembly being serviced. Turn the wheel until one hub-pilot pad is in the top-center position.
   - 2.4 Leaving the top nut until last, remove all eight two-piece flange nuts.

   IMPORTANT: On both sides of the vehicle, the two-piece flange nuts have right-hand threads.

   - 2.5 Remove the wheel. Do not let it drop on or drag across the stud threads.
3. Remove the wheels and tires from a rear axle:
   - 3.1 Raise the rear of the vehicle until the tires clear the floor. Place safety stands under the axle being serviced.
   - 3.2 If the tire or wheel is damaged (or if there is suspected damage), deflate both tires of the dual assembly being serviced by removing the valve cores.
   - 3.3 Place a jack or wheel-and-tire dolly under the dual wheel assembly being serviced. Turn the wheel until one hub pilot pad is in the top-center position.
   - 3.4 Leaving the top nut until last, remove all eight two-piece flange nuts.

   IMPORTANT: On both sides of the vehicle, the two-piece flange nuts have right-hand threads.

   - 3.5 Remove the wheel. Do not let it drop on or drag across the stud threads.

Installation

NOTE: Before installing a wheel and tire assembly, inspect it using the instructions in **Subject 190**. Also, follow the tire matching and mixing requirements under **Subject 050**.

1. Clean the hub and wheel mounting surfaces, and between the rims of dual wheels. Make sure the tire is correctly inflated. For instructions, see **Subject 210**.
2. Apply a few drops of light engine oil to the wheel studs and the area between the body and the flange of each two-piece flange nut. Wipe off any excess oil.

⚠ CAUTION

The wheel center hole and hub pilot have close tolerances. If the wheel is not kept square to the hub, it could bind during installation and damage the stud threads or hub-pilot pads. Keep the wheel square to the hub during installation.

IMPORTANT: Before installing the wheels, make sure the drum is positioned on the raised step of the pilot pad. One of the hub's pilot pads must be at the top location. To help keep the drum in place, it may be necessary to adjust the brakes before installing the wheels.

3. If installing a rear wheel assembly, go to the next step. Install the front wheel assembly.
   - 3.1 Locate one hub-pilot pad in the top-center position. Using a jack or wheel-and-tire dolly, position the wheel assembly on the hub. Make sure the wheel is square to the hub and that the threads or hub-pilot pads are not damaged by contact with the wheel during installation.
   - 3.2 Make sure the hub-pilot pad is still centered at the top.

8-Hole Disc Wheel With Two-Piece Flange Nuts Removal and Installation

IMPORTANT: Install the wheel assembly so that the balance weight(s) on the wheels are 180 degrees opposite the balance weight(s) on the brake drum.

4. Install the rear wheel assembly:
   - 4.1 Locate one hub-pilot pad in the top center position. Using a jack or wheel-and-tire dolly, position the inner wheel assembly on the hub. Make sure the wheel is square to the hub and that the threads or hub-pilot pads are not damaged by contact with the wheel during installation.
   - 4.2 Using the same procedure, mount the outer wheel against the inner wheel. Make sure the hub-pilot pad is still centered at the top.

IMPORTANT: Install the wheel assembly so that the balance weight(s) on the wheels are 180 degrees opposite the balance weight(s) on the brake drum. If this causes the valve stems to be in the same wheel hole, mount the outer wheel so that the outer wheel balance weight(s) are on the same side as the brake drum balance weight(s).

5. Install and hand-tighten a two-piece flange nut on the top and bottom studs.

⚠ CAUTION

The two-piece flange nuts have right-hand metric threads. Do not try to install a similar size SAE nut on a stud, or the stud and nut will be damaged.

6. Install and hand-tighten the remaining two-piece flange nuts. Tighten the two-piece flange nuts 50 to 100 lbf·ft (68 to 135 N·m) following the sequence in **Fig. 1.**
7. Check that the wheel is correctly seated against the hub and on the hub-pilot pads.
8. Following the sequence in **Fig. 1**, tighten the two-piece flange nuts 450 to 500 lbf·ft (610 to 678 N·m).

⚠ WARNING

Failure to replace damaged parts could result in the loss of a wheel or loss of vehicle control, causing personal injury or property damage. Always replace damaged parts with new parts.

IMPORTANT: If the wheel nuts cannot be tightened to minimum torque values, the studs could be turning in the hub flange, having lost their locking ability. In this situation, the wheel hub assembly is damaged and must be replaced with a new assembly. Failure to reach minimum torque values could also be caused by stripped threads on the wheel studs or wheel nuts. Again, damaged parts must be replaced with new parts.

NOTE: Replace damaged parts following the instructions in the front or rear axle section in this manual.

9. Remove the safety stands, lower the vehicle, and remove the chocks.
10. After operating the vehicle for 50 to 100 miles (80 to 160 km), retighten the wheel nuts 450 to 500 lbf·ft (610 to 678 N·m). Follow the sequence in **Fig. 1.**

⚠ CAUTION

Too little wheel nut torque can cause wheel shimmy, wheel damage, stud breakage, and extreme tire tread wear. Too much wheel nut torque can break studs, damage threads, and crack discs in the stud hole area. Use the specified torque values, and follow the tightening sequence in Fig. 1.

IMPORTANT: The two-piece flange nuts seat during vehicle operation. It is necessary to periodically tighten the wheel nuts to the specified torque. Tighten the two-piece flange nuts to the specified torque 50 to 100

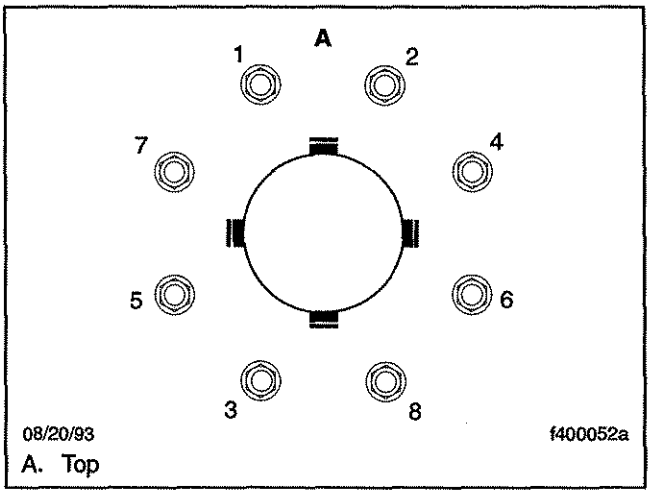


Fig. 1, 8-Stud Disc Wheel Tightening Sequence

miles (80 to 160 km) after service work, and check the torque every 50,000 miles (80 000 km) thereafter.

10-Hole Disc Wheel With Two-Piece Flange Nuts Removal and Installation

Removal

1. Park the vehicle on a level surface and apply the parking brakes. Shut down the engine. Chock all tires that will not be serviced, to prevent vehicle movement.
2. If working on the front axle wheels, raise the front of the vehicle until the tires clear the floor. Place safety stands under the front axle.

   If working on the rear axle wheels, raise the rear of the vehicle until the tires clear the floor. Place safety stands under the axle being serviced.
3. If the tire or wheel is damaged or if there is suspected damage, deflate the tire (or tires, on a dual assembly) being serviced by removing the valve core.
4. Turn the wheel until one hub-pilot pad is in the top-center position.
5. Leaving the top and bottom nuts until last, remove the other eight two-piece flange nuts.
6. Place a jack or wheel-and-tire dolly under the wheel assembly being serviced. Remove the top and bottom nuts.

⚠ CAUTION

The wheel center hole and hub pilot have close tolerances. If the wheel is not kept square to the hub, it could bind during removal and damage the stud threads or hub-pilot pads. Keep the wheel square to the hub during removal.

IMPORTANT: On both sides of the vehicle, the two-piece flange nuts have right-hand metric threads.

7. Remove the wheel. Do not let it drop on or drag across the stud threads.

Installation

IMPORTANT: Before installing the wheels, it is recommended that an anti-seize compound be applied on the 360 degree wheel pilot hubs of Meritor FF-981 "Easy Steer Plus" front axles. After time in service, a small amount of rust or corrosion may make the wheel difficult to remove because of the extended wheel-to-hub contact. Applying an anti-seize compound on the wheel pilot of the hub will ensure easy wheel removal at a later date. Compounds such as the following may be used:

- Armite Led-Plate No. 250
- Loctite Anti-Seize No. 767
- Never-Seez
- Permabond Anti-Seize No. 82-9839

Compounds are available for purchase locally.

IMPORTANT: Freightliner "Turbo" wheel assemblies require directional mounting, as shown in **Fig. 1**.

NOTE: Before installing a wheel and tire assembly, inspect it using the instructions in **Subject 190**. Also, follow the tire matching and mixing requirements in **Subject 050**.

1. Clean the hub and wheel mounting surfaces, and all disc faces of dual wheels. Make sure the tire is correctly inflated. For instructions, see **Subject 210**.
2. Apply a few drops of light engine oil to the wheel studs and the area between the body and the flange of each two-piece flange nut. Wipe off any excess oil.

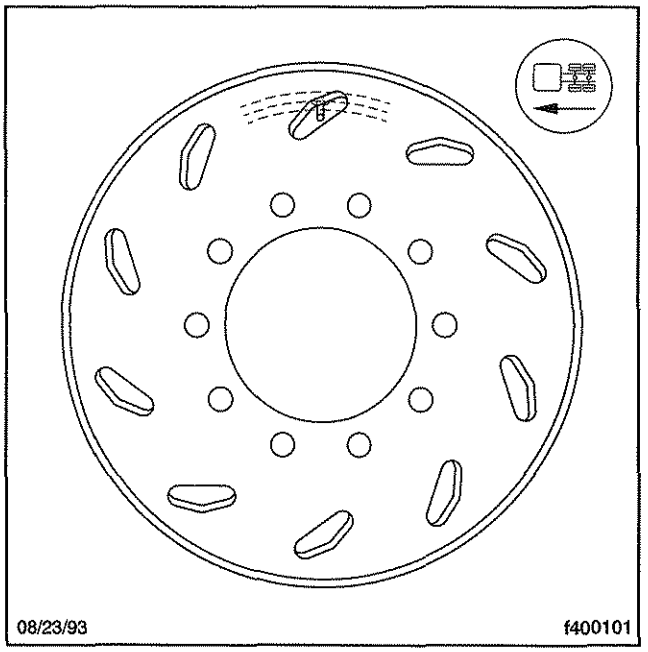


Fig. 1, Side View

10-Hole Disc Wheel With Two-Piece Flange Nuts Removal and Installation

⚠ CAUTION

The wheel center hole and hub pilot have close tolerances. If the wheel is not kept square to the hub, it could bind during installation and damage the stud threads or hub-pilot pads. Keep the wheel square to the hub during installation.

IMPORTANT: Before installing the wheels, make sure the drum is positioned on the raised step of the pilot pad. One of the hub's pilot pads must be at the top location. To help keep the drum in place, it may be necessary to adjust the brakes before installing the wheels.

3. If installing a rear wheel assembly, go to the next step. Install the front wheel assembly.
   - 3.1 Locate one hub-pilot pad in the top-center position. Using a jack or wheel-and-tire dolly, position the wheel assembly on the hub. Make sure the wheel is square to the hub so that the stud threads or hub-pilot pads are not damaged by contact with the wheel during installation.
   - 3.2 Make sure the hub-pilot pad is still centered at the top.

IMPORTANT: Install the wheel assembly so that the balance weight(s) on the wheels are 180 degrees opposite the balance weight(s) on the brake drum.

4. Install the rear wheel assembly:
   - 4.1 Locate one hub-pilot pad in the top-center position. Using a jack or wheel-and-tire dolly, position the inner wheel assembly on the hub. Make sure the wheel is square to the hub so that the stud threads or hub-pilot pads are not damaged by contact with the wheel during installation.
   - 4.2 Using the same procedure, mount the outer wheel against the inner wheel. Make sure the hub-pilot pad is still centered at the top.

IMPORTANT: Install the wheel assembly so that the balance weight(s) on the wheels are 180 degrees opposite the balance weight(s) on the brake drum. If this causes the valve stems to be in the same wheel hole on rear wheel assemblies, mount the outer wheel so that the outer wheel balance weight(s) is on the same side as the brake drum balance weight(s).

5. Install and hand-tighten a two-piece flange nut on the top and bottom studs.

⚠ CAUTION

The two-piece flange nuts have right-hand metric threads. Do not try to install a similar size SAE nut on a stud, or the stud and nut will be damaged.

6. Install and hand-tighten the remaining two-piece flange nuts. Tighten the nuts 50 lbf·ft (68 N·m) following the sequence in **Fig. 2.**
7. Check that the wheel is correctly seated against the hub and on the hub-pilot pads.
8. Following the sequence in **Fig. 2**, tighten the two-piece flange nuts 450 to 500 lbf·ft (610 to 678 N·m).

⚠ WARNING

Failure to replace damaged parts could result in the loss of a wheel or loss of vehicle control, causing personal injury or property damage. Always replace damaged parts with new parts.

IMPORTANT: If the wheel nuts cannot be tightened to minimum torque values, the studs could be turning in the hub flange, having lost their locking ability. In this situation, the wheel hub assembly is damaged and must be replaced with a new assembly. Failure to reach minimum torque values could also be caused by stripped threads on the wheel studs or wheel nuts. Again, damaged parts must be replaced with new parts.

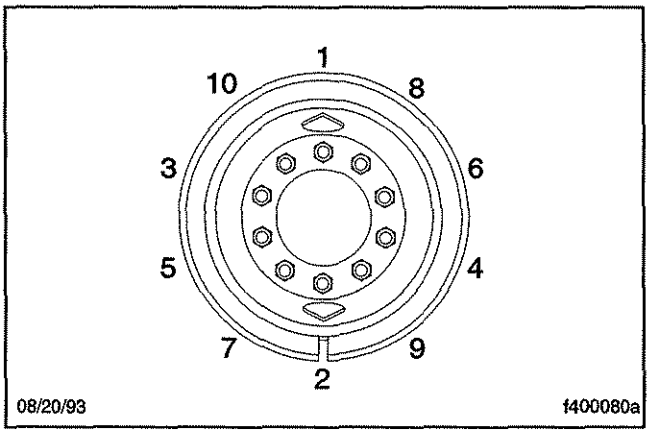


Fig. 2, 10-Stud Disc Wheel Tightening Sequence

9. Remove the safety stands, lower the vehicle, and remove the chocks.

⚠ CAUTION

Too little wheel nut torque can cause wheel shimmy, wheel damage, stud breakage, and extreme tire tread wear. Too much wheel nut torque can break studs, damage threads, and crack discs in the stud hole area. Use the specified torque values, and follow the tightening sequence in Fig. 2.

IMPORTANT: The two-piece flange nuts seat during vehicle operation. It is necessary to periodically tighten the wheel nuts to the specified torque. Tighten the two-piece flange nuts to the specified torque 50 to 100 miles (80 to 160 km) after service work, and check the torque every 10,000 miles (16 000 km) thereafter.

10. After operating the vehicle for 50 to 100 miles (80 to 160 km), retighten the wheel nuts 450 to 500 lbf·ft (610 to 678 N·m). Follow the sequence in **Fig. 2.**

10-Hole Disc Wheel With Inner and Outer Nuts; Removal and Installation

Removal

1. Chock all tires that will not be serviced, to prevent vehicle movement.
2. If removing wheels and tires from a rear axle, go to the next step. Remove the wheels and tires from the front axle.
   - 2.1 Apply the parking brakes.
   - 2.2 Raise the front of the vehicle until the tires clear the floor. Place safety stands under the front axle.
   - 2.3 Deflate the tire being serviced by removing the valve core.
   - 2.4 Place a jack or wheel-and-tire dolly under the front wheel assembly being serviced. Remove the wheel nuts, then raise and remove the wheel assembly. Be careful not to damage the threads of the wheel studs as the wheel is pulled away.
3. Remove the wheels and tires from a rear axle:
   - 3.1 Raise the rear of the vehicle until the tires clear the floor. Place safety stands under the axle being serviced.
   - 3.2 Deflate both tires of the dual assembly being serviced by removing the valve cores.
   - 3.3 Place a jack or wheel-and-tire dolly under the outer wheel assembly. Remove the outer wheel nuts, then raise and remove the outer wheel. Be careful not to damage the threads of the inner wheel nuts as the outer wheel is pulled away.
   - 3.4 Place a jack or wheel-and-tire dolly under the inner wheel assembly. Remove the inner wheel nuts, then raise and remove the inner wheel. Be careful not to damage the threads of the wheel studs as the inner wheel is pulled away.

Installation

IMPORTANT: Before installing the wheels, it is recommended that an anti-seize compound be applied on the 360 degree wheel pilot hubs of Rockwell FF–981 "Easy Steer Plus" front axles. After time in service, a small amount of rust or corrosion may make the wheel difficult to remove because of the extended wheel-to-hub contact. Applying an anti-seize compound on the wheel pilot of the hub will ensure easy wheel removal at a later date. Compounds such as the following may be used:

- Armite Led-Plate No. 250
- Loctite Anti-Seize No. 767
- Never-Seez
- Permabond Anti-Seize No. 82–9839.

Compounds are available for purchase locally.

IMPORTANT: Freightliner "Turbo" wheel assemblies require directional mounting, as shown in **Fig. 1**.

NOTE: Before installing a wheel and tire assembly, inspect it using the instructions in **Subject 190**. Also, follow the tire matching and mixing requirements in **Subject 050**.

1. Clean the hub and wheel mounting surfaces, and between the rims of dual wheels. Make sure the tire is inflated using the procedures in **Subject 210**.

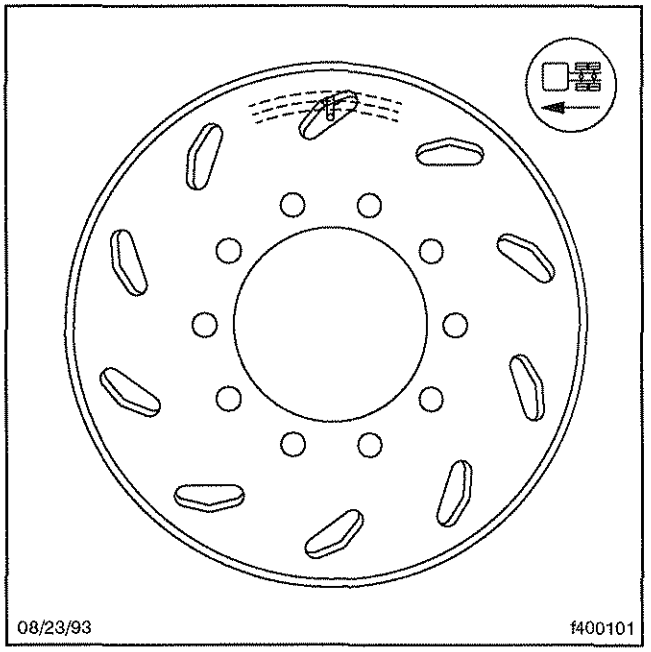


Fig. 1, Side View

10-Hole Disc Wheel With Inner and Outer Nuts; Removal and Installation

⚠ WARNING

Failure to replace damaged parts could result in the loss of a wheel or loss of vehicle control, causing personal injury or property damage. Always replace damaged parts with new parts.

IMPORTANT: If the wheel nuts cannot be tightened to minimum torque values, the studs could be turning in the hub flange, having lost their locking ability. In this situation, the wheel hub assembly is damaged and must be replaced with a new assembly. Failure to reach minimum torque values could also be caused by stripped threads on the wheel studs or wheel nuts. Again, damaged parts must be replaced with new parts.

2. If installing a rear wheel assembly, go to the next step. Install the front wheel assembly.

   2.1 Use a jack or wheel-and-tire dolly to mount the wheel assembly on the wheel studs. Be careful not to damage the threads of the wheel studs when installing the wheel assembly.

   2.2 Install a wheel nut on each wheel stud, and run them up until each nut is flush with the face or the chamfer of the wheel. Rotate the wheel a half turn to seat the parts.

   2.3 Tighten the wheel nuts 50 lbf·ft (68 N·m), following the sequence in **Fig. 2**.

   2.4 Using the same sequence, tighten the wheel nuts again, to the torque in the disc-type wheel fastener torque table in **Specifications, 400**.

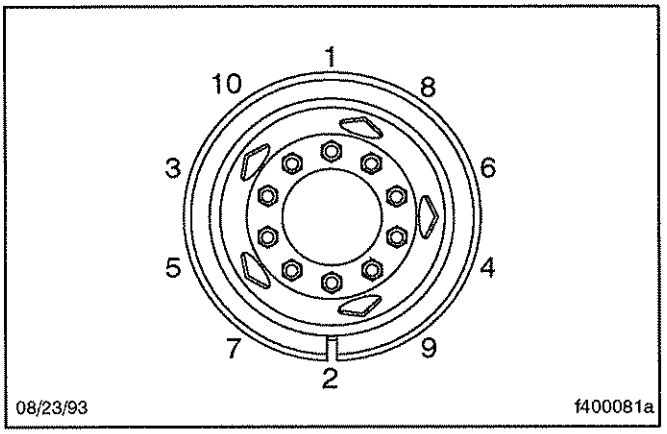


Fig. 2, 10-Stud Disc Wheel Tightening Sequence

⚠ WARNING

Failure to replace damaged parts could result in the loss of a wheel or loss of vehicle control, causing personal injury or property damage. Always replace damaged parts with new parts.

IMPORTANT: If the wheel nuts cannot be tightened to minimum torque values, the studs could be turning in the hub flange, having lost their locking ability. In this situation, the wheel hub assembly is damaged and must be replaced with a new assembly. Failure to reach minimum torque values could also be caused by stripped threads on the wheel studs or wheel nuts. Again, damaged parts must be replaced with new parts.

3. Install a rear wheel assembly:

   3.1 Use a jack or wheel-and-tire dolly to mount the inner wheel assembly on the wheel studs. Be careful not to damage the threads of the wheel studs when installing the wheel assembly.

   IMPORTANT: Mount the wheel assembly so that the balance weight(s) on the wheels are 180 degrees opposite the balance weight(s) on the brake drum **(Fig. 3)**.

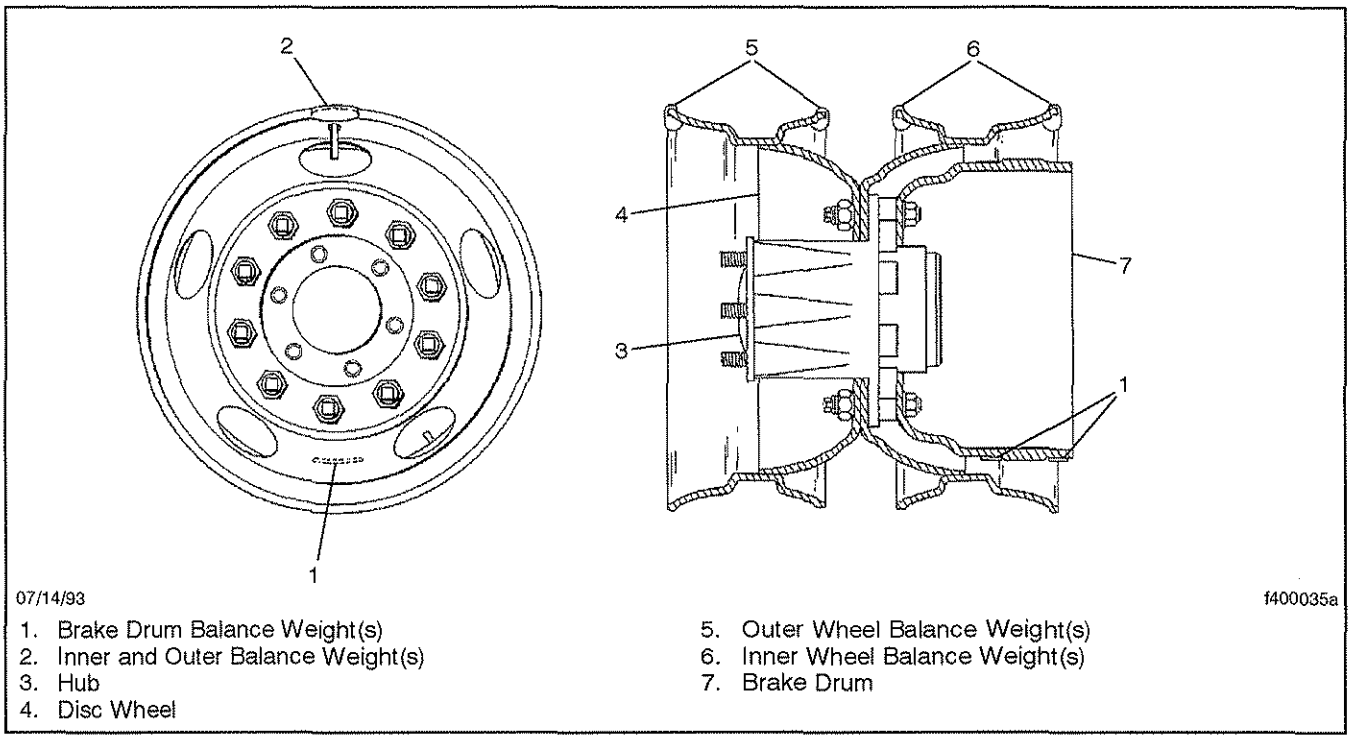
   If, on two-handhole wheels, this causes the valve stems to be in the same wheel hole, mount the outer wheel so that the outer wheel balance weight(s) are on the same side of the assembly as the brake drum balance weight(s). See**Fig. 4.**

   If, on five-handhole or aluminum wheels, the valve stems are in the same handhole, separate the valve stems by one hole. If balancing the wheels, install the wheel weights evenly and as close to 180 degrees opposite the brake drum balance weight(s) as possible. See **Fig. 5.**

   3.2 Install the inner wheel nuts on each wheel stud, and run them up until each nut is flush with the face or the chamfer of the wheel. Rotate the wheel a half turn to seat the parts.

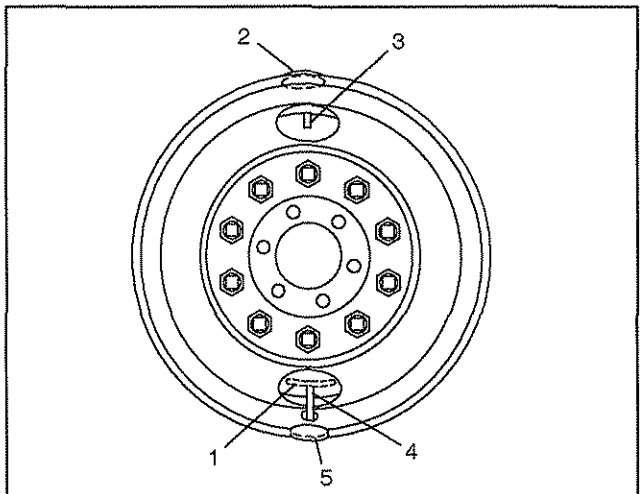
   3.3 Tighten the inner wheel nuts 50 lbf·ft (68 N·m), following the sequence in **Fig. 2**.

10-Hole Disc Wheel With Inner and Outer Nuts; Removal and Installation



1. Brake Drum Balance Weight(s)
2. Inner and Outer Balance Weight(s)
3. Hub
4. Disc Wheel
5. Outer Wheel Balance Weight(s)
6. Inner Wheel Balance Weight(s)
7. Brake Drum

Fig. 3, Recommended Location of Wheel and Brake Drum Balance Weights



1. Brake Drum Balance Weight(s)
2. Inner Wheel Balance Weight(s)
3. Inner Wheel Valve Stem
4. Outer Wheel Valve Stem
5. Outer Wheel Balance Weight(s)

Fig. 4, Alternate Location of Wheel and Brake Drum Balance Weights, Two-Handhole Wheels

3.4 Using the same sequence, tighten the inner wheel nuts again, to the torque in the disc-type wheel fastener torque table in **Specifications, 400**.

3.5 Use a jack or wheel-and-tire dolly to mount the outer dual wheel on the inner wheel nuts. Be careful not to damage the threads of the inner wheel nuts when installing the wheel assembly.

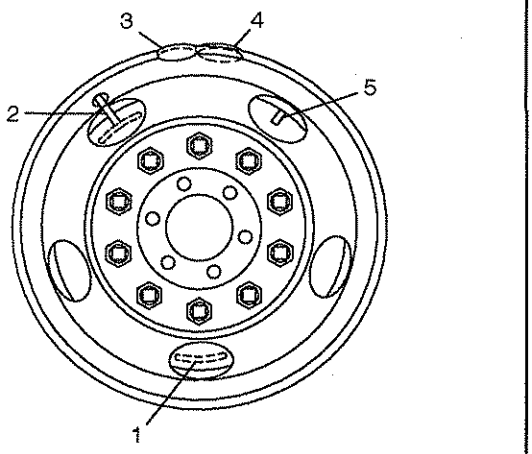
3.6 Install the outer wheel nuts following the procedures above.

4. Remove the safety stands, lower the vehicle, and remove the chocks.

⚠ CAUTION

Locknuts seat during vehicle operation. It is necessary to periodically tighten the wheel nuts to the specified torque. Not enough wheel nut torque can cause wheel shimmy, wheel damage, stud breakage, and extreme tire tread wear. Too much wheel nut torque can break studs, damage threads, and

10-Hole Disc Wheel With Inner and Outer Nuts; Removal and Installation



1. Brake Drum Balance Weight(s)
2. Outer Wheel Valve Stem
3. Outer Wheel Balance Weight(s)
4. Inner Wheel Balance Weight(s)
5. Inner Wheel Valve Stem

Fig. 5, Alternate Location of Wheel and Brake Drum Balance Weights, Five-Handhole or Aluminum Wheels

crack discs in the stud hole area. Use the specified torque values, and follow the tightening sequence in Fig. 2.

5. After operating the vehicle for 50 to 100 miles (80 to 160 km), retighten the wheel nuts to the torque in the disc-type wheel fastener torque table in **Specifications, 400**. Follow the sequence in **Fig. 2**.

NOTE: When retightening the inner wheel nuts, loosen the outer wheel nuts several turns, retighten the inner wheel nuts, then the outer wheel nuts.

Spoke Wheel, Tire and Rim Assembly; Removal and Installation

Removal

1. Chock all tires that will not be serviced, to prevent vehicle movement.
2. If removing tire and rim assemblies from a rear axle, go to the next step. Remove the tire and rim assembly from the front axle.
   - 2.1 Apply the parking brakes.
   - 2.2 Raise the front of the vehicle until the tires clear the floor. Place safety stands under the front axle.
   - 2.3 Deflate the tire being serviced by removing the valve core.
   - 2.4 Place a jack or wheel-and-tire dolly under the front tire and rim assembly being serviced. Remove the rim nuts and rim clamps, then slide the tire and rim assembly off the wheel.
3. Remove a tire and rim assembly from a rear axle.
   - 3.1 Raise the rear of the vehicle until the tires clear the floor. Place safety stands under the axle being serviced.
   - 3.2 Deflate the tire(s) being serviced by removing the valve core(s).
   - 3.3 Place a jack or wheel-and-tire dolly under the outer tire and rim assembly being serviced. Remove the rim nuts and clamps; then slide the outer tire and rim off.
   - 3.4 Remove the rim spacer. Place a jack or wheel-and-tire dolly under the inner tire and rim assembly, and slide it off.

Installation

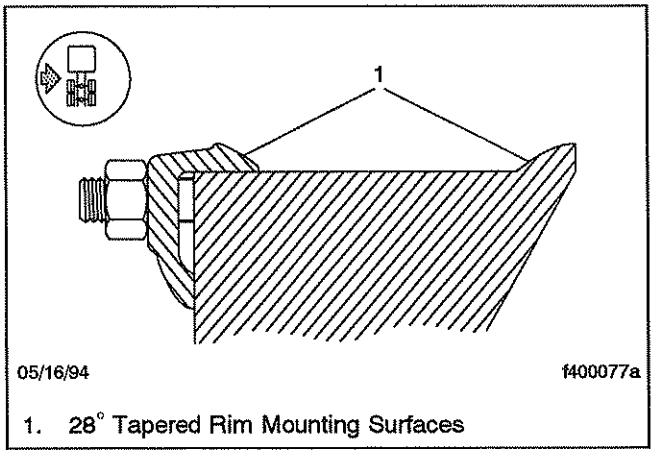
NOTE: Before installing a wheel and tire assembly, inspect it using the instructions in **Subject 190**. Also, follow the tire matching and mixing requirements in **Subject 050.**

1. Clean the wheel, rim spacer, and rim mounting surfaces. The mounting surface of the wheel is the 28-degree taper on the inboard side of each spoke. **See Fig. 1.**
2. Make sure the tire and rim assembly is inflated using the procedures in **Subject 210.**
3. If installing a rear tire and rim assembly, go to the next step. Install a front tire and rim assembly.
   - 3.1 Slide the assembly over the wheel and push it into place against the tapered mounting surface. It should fit snugly against all the tapers. Be sure that the valve stem faces out and is centered between two spokes.
   - 3.2 Install the rim clamps and nuts. Run the nuts up until the end of each wheel stud is flush with the face of its nut. Rotate the wheel a half turn to seat the parts.
   - 3.3 Tighten the rim nuts a quarter turn at a time, following the star pattern shown in **Fig. 2.** Continue until all the rim nuts are tightened to the torque in the applicable torque table in **Specifications, 400.**

CAUTION: Failure to tighten the nuts in the sequence shown, and to the correct torque, could cause misalignment of the tire and chording of the rim **(Fig. 3)**. This would result in excessive vehicle vibration and permanent damage to the rim and wheel.

WARNING: Failure to replace damaged parts could result in the loss of a wheel or loss of vehicle control, causing personal injury or property damage. Always replace damaged parts with new parts.

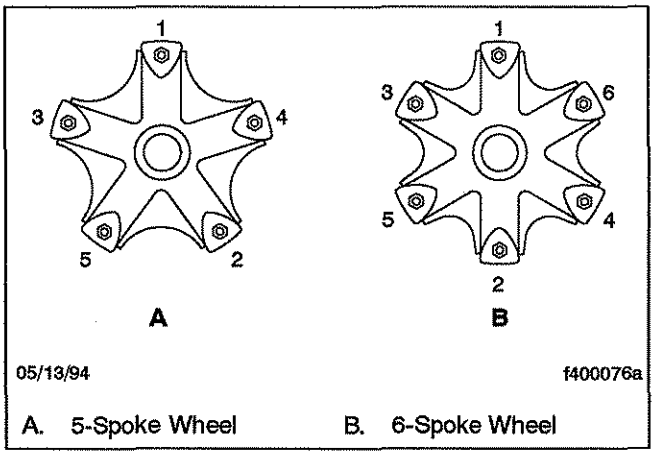
IMPORTANT: If the wheel nuts cannot be tightened to minimum torque values, the studs could be turning in the hub flange, having lost their locking ability. In this situation, the wheel hub assembly is damaged and must be replaced with a new assembly. Failure



1. 28° Tapered Rim Mounting Surfaces

Fig. 1, Spoke Wheel Tapered Mounting Surface

Spoke Wheel, Tire and Rim Assembly; Removal and Installation



A. 5-Spoke Wheel B. 6-Spoke Wheel

Fig. 2, Spoke Wheel Tightening Sequence

to reach minimum torque values could also be caused by stripped threads on the wheel studs or wheel nuts. Again, damaged parts must be replaced with new parts.

NOTE: When replacing a spoke wheel, contact the wheel manufacturer for the correct torque value for the brake drum nuts attaching the spoke wheel to the brake drum.

4. Install a rear tire and rim assembly.

   4.1 Slide the inner tire and rim over the wheel hub. Push it into position against the tapered mounting surface. Make sure the valve stem faces out and is centered between two spokes.

   4.2 Slide the rim spacer over the wheel hub.

   4.3 Slide the outer tire and rim over the wheel hub. Make sure the valve stem faces inward, and is in the same position as the inner valve stem.

   4.4 Push the whole assembly in place, so that the inner rim fits snugly against the tapers all around, the spacer is seated against the inner rim, and the outer rim is seated against the spacer.

   4.5 Install the rim clamps and nuts. Run the nuts up until the end of each stud is flush with the face of its nut. Rotate the wheel a half turn to allow the parts to seat.

   4.6 Tighten the rim nuts a quarter turn at a time, following the star pattern shown in **Fig. 2.** Continue until all the rim nuts are tightened to the torque in the applicable torque table in **Specifications, 400.**

   4.7 The clamps must not bottom out until at least 80 percent of the recommended torque is reached. If the clamps do bottom out, make sure the correct clamps and rim spacers are being used. Make sure the rim edges contact the spacer edges.

CAUTION: Failure to tighten the nuts in the sequence shown, and to the correct torque, could cause misalignment of the tire and chording of the rim **(Fig. 3).** This would result in excessive vehicle vibration and permanent damage to the rim and wheel.

WARNING: Failure to replace damaged parts could result in the loss of a wheel or loss of vehicle control, causing personal injury or property damage. Always replace damaged parts with new parts.

IMPORTANT: If the wheel nuts cannot be tightened to minimum torque values, the studs could be turning in the hub flange, having lost their locking ability. In this situation, the wheel hub assembly is damaged and must be replaced with a new assembly. Failure to reach minimum torque values could also be caused by stripped threads on the wheel studs or wheel nuts. Again, damaged parts must be replaced with new parts.

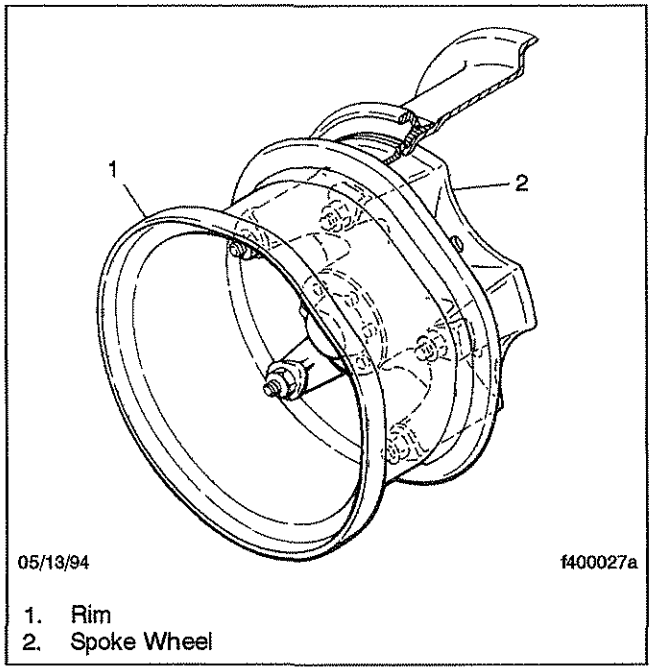
NOTE: When replacing a spoke wheel, contact the wheel manufacturer for the correct torque value for the brake drum nuts attaching the spoke wheel to the brake drum.

5. Check the wheel alignment by placing a block of wood or any other point of reference on the floor next to the tire. Rotate the tire and note any variations in the space between the tire and the block. If the variation exceeds 1/16-inch (1.5 mm) for front rims, or 1/8-inch (3 mm) for rear duals, the rim is not correctly mounted.

   To correct any misalignment, loosen the rim nuts where the largest gap occurs, and tighten the nuts on the opposite side. Recheck and correct until the variation is corrected. Make sure the rim nuts are tightened to the correct torque in the applicable torque table in **Specifications, 400.**

6. Remove the safety stands, lower the vehicle, and remove the chocks.

Spoke Wheel, Tire and Rim Assembly; Removal and Installation



1. Rim
2. Spoke Wheel

Fig. 3, Out-of-Round Rim (Rim Cording)

7. After driving the vehicle for 50 to 100 miles (80 to 160 km), retighten the rim nuts to the torque specified in the applicable torque table in **Specifications, 400.** Follow the sequence shown in **Fig. 2.**

Tire Demounting and Mounting Service Precautions

Service Precautions

WARNING: Read the following information. Failure to follow the safety precautions, before and during tire demounting and mounting, could cause tire or rim damage while servicing or in use. An incorrectly mounted tire can burst causing personal injury and equipment damage.

IMPORTANT: Don't mount or demount tires without proper training as required in Occupational Safety and Health Administration (OSHA) Rules and Regulations 1910.177, *Servicing Multi-Piece and Single Piece Rim Wheels*. Service information containing mounting and demounting instructions are available through your rim supplier. Charts detailing service procedures are available through OSHA area offices. The address and telephone number of the nearest OSHA area office can be obtained by looking in the local telephone directory under U.S. Government, Labor Department of Occupational Safety and Health Administration.

Use the information from the above sources with the following precautions before and during the demounting and mounting of tires:

- Examine all wheel and tire parts as explained in **Subject 190** and **Subject 200**. Replace damaged, rusted, or worn parts.
- Since wheels and rims are under stress, and are dangerous if improperly assembled, be sure all parts of an assembly match in size, manufacturer, and classification within a manufacturer's line. Before assembling the wheel or rim, check the catalog issued by the wheel or rim manufacturer for the correct part numbers and sizes of approved parts. Never use a part that does not bear clear, legible, and correct numbers and manufacturer's identification, even if that part appears to fit.
- Make sure that tires are stored indoors, or outdoors under cover, to prevent water collecting inside the tire.
- Use special tools, as recommended by tire suppliers, for mounting and demounting tires. These tools must be smooth, and used with care, to avoid gouging the rim.
- Loosening tire beads may be difficult, since considerable force may be needed. The use of a machine designed for loosening tire beads is recommended.
- Handle the wheels and rims on a wooden floor or rubber mat to prevent nicking or gouging the wheel or rim.
- Do not use a duck-bill hammer, or any steel hammer on wheel or rim parts. Use rubber, leather-faced, or plastic mallets to tap parts together, if necessary.
- Lubricate the tire with an approved tire-mounting lubricant. Never use antifreeze, silicones, petroleum-based lubricants, or any flammable material (ether/starting aid).
- When lubricating a tire prior to mounting, make sure excess lubricant does not run into the tire.
- Michelin Tire Corporation recommends applying lubricant to the valley of the tire, formed by the tire and rim, before using tools to break the bead.
- Michelin also recommends applying a sufficient but sparing amount of lubricant to the entire rim face when mounting a tire on a rim, to ensure correct bead seating and ease of mounting.
- Don't reinflate a tire that has been run flat or has been run at 80 per cent or less of its recommended operating pressure. Use your spare. Before removing the low tire from the vehicle, make sure it is completely deflated. Later, have the assembly taken apart and all the parts checked for damage, including the side or lockrings.
- The air pressure contained in a tire is dangerous. When servicing a tire, stay out of any potential path or route that a rim wheel component may travel during an explosive separation.

Demounting and Mounting Tubeless Tires on One-Piece Drop Center Wheels or Rims

Five Degree Full Drop Center

WARNING: Read the information in Subject 140. Failure to follow the precautions, before and during tire demounting and mounting, could cause tire or rim damage while servicing or in use. An incorrectly mounted tire can burst causing personal injury and equipment damage.

To demount or mount tubeless tires on 5 degree full drop center rims, regular or safety type, follow the same procedures used to demount or mount tubeless automobile tires.

Fifteen Degree Tapered Drop Center

WARNING: Read the information in Subject 140. Failure to follow the precautions, before and during tire demounting and mounting, could cause tire or rim damage while servicing or in use. An incorrectly mounted tire can burst causing personal injury and equipment damage.

DEMOUNTING

1. Deflate the tire being serviced by removing the valve core. Check the valve stem by running a piece of wire through the stem to make sure it is not plugged.
2. Loosen both beads from the rim by driving the flat end of the tire tool between the tire bead and the rim flange. Holding the tool upright, hammer on the neck to free the tire bead from the rim **(Fig. 1).** Repeat at 8-inch (20 cm) intervals around the flanges, until both beads are free from the rim.
3. Place the wide side of the rim down. Lubricate the tire bead and the rim. Insert the curved end of two tire tools between the bead and the rim, and just to one side of the tire valve. Step on the side of the tire, opposite from the valve, to force the first bead into the rim well **(Fig. 2).** Hold one of the tools in place with your foot and pry with the second tool, forcing the bead over the rim flange. Continue to work the first bead off of the rim.
4. When the first bead is off the rim, and the second bead is in the rim well, stand the assembly upright with the valve stem near the top. Lubricate the second bead and rim. Insert the straight end of the tool between the tire bead and the back rim flange, hooking the tool over the second flange. Lean the tire assembly toward the tool and use a rocking or bouncing action to pry the rim out of the tire. **See Fig. 3.**
5. Clean and inspect all parts. Refer to **Subject 190** and **Subject 200** for procedures.

MOUNTING

1. Place the valve stem, with a rubber washer, through the valve hole from the tire side of the

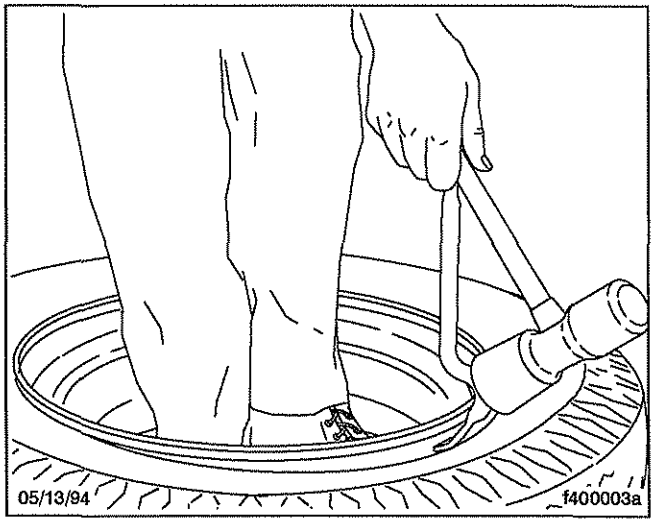


Fig. 1, Loosening the Beads

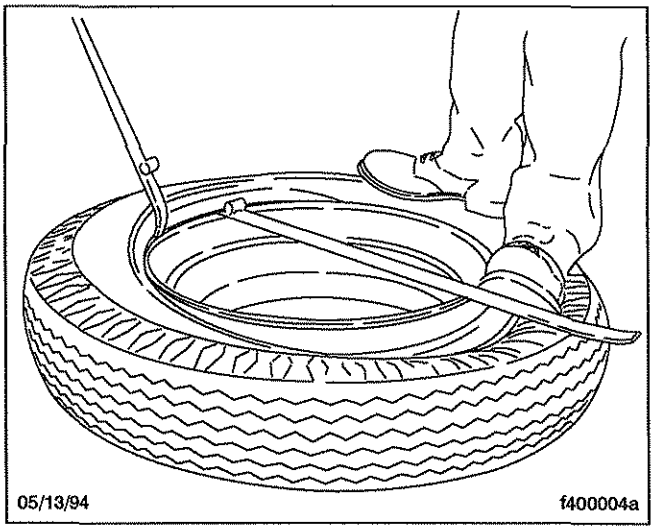


Fig. 2, Forcing Bead into the Rim Well

Demounting and Mounting Tubeless Tires on One-Piece Drop Center Wheels or Rims

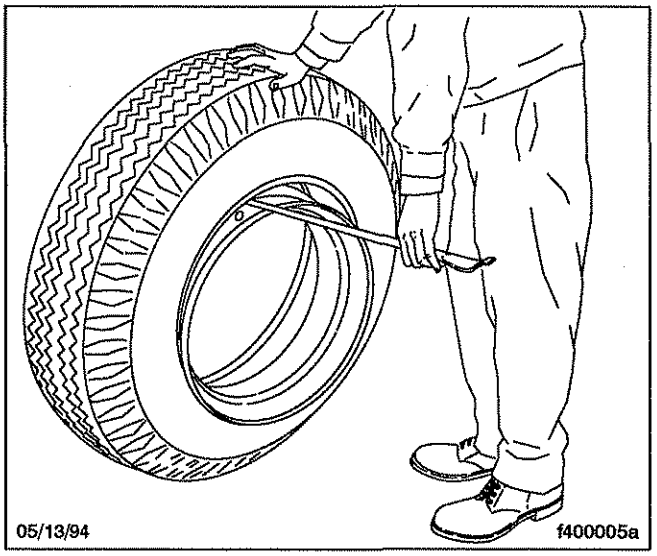


Fig. 3, Prying the Rim Out of the Tire

rim. Screw on the valve nut from the opposite side. Make sure the rubber bushing and metal collar or nut are centered and fit snugly in the valve hole **(Fig. 4).** Tighten the nut securely.

2. Place the rim on the floor with the wide side down. Using a brush or swab, lubricate both bead seats (flanges) of the rim, and both tire beads, with an approved lubricant. Apply enough lubricant to enable correct bead seating, and to make mounting easier. Don't let excess lubricant run inside the tire.

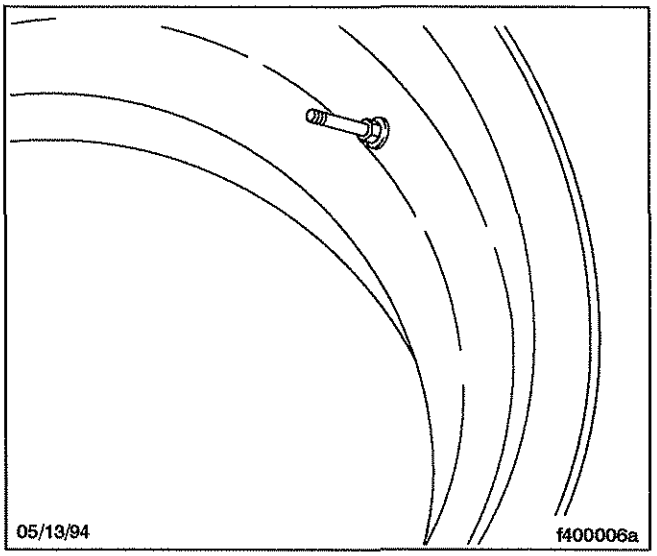


Fig. 4, Valve Stem Installation

3. Lay the tire on the rim. If there is a balance mark on the tire, line up this mark with the valve stem. Push the lower bead over the flange and into the rim well. Using the straight end of the tire tool (with the stop resting on the rim flange), take small bites to work the remaining section of the bead into the rim. **See Fig. 5.**

4. Start the upper bead over the rim flange and into the rim well by standing on the tire. If necessary, push a section of the bead into the rim well, and anchor it by attaching Vise-Grip® pliers to the rim flange (snub side toward the tire). Using the spoon end of the tire iron, with the stop toward the rim, work around the bead **(Fig. 6).** Use small bites until the bead slips over the flange and into the rim well. If necessary, insert a second tire iron and relubricate the last 8 inches (20 cm) of bead.

5. Inflate the tire. Refer to **Subject 210** for procedures.

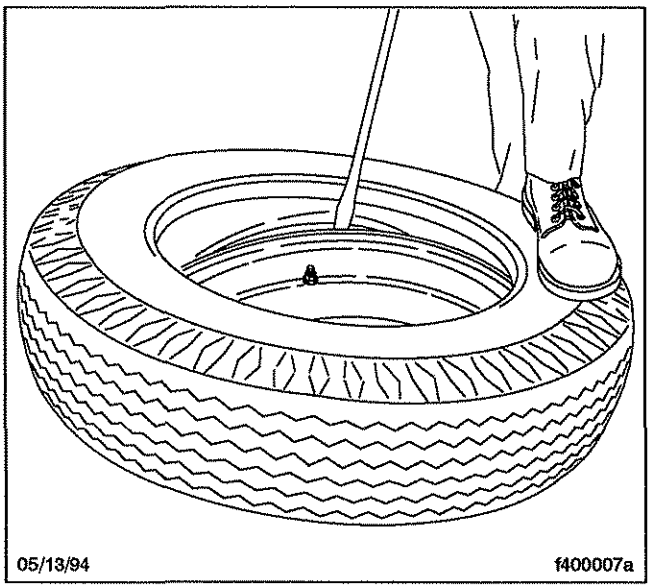


Fig. 5, Working the Lower Bead Into the Rim

Demounting and Mounting Tubeless Tires on One-Piece Drop Center Wheels or Rims

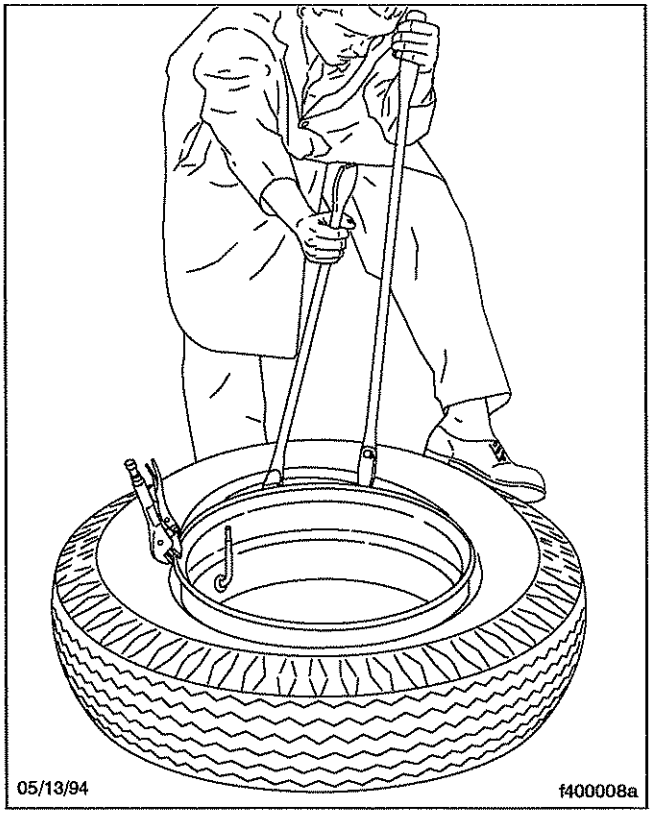


Fig. 6, Working the Upper Bead into the Rim

Demounting and Mounting Tube-Type Tires on Two-Piece Flat Base Wheels or Rims

Continuous Base, Split Side Ring

WARNING: Read the information in Subject 140. Failure to follow the precautions, before and during tire demounting and mounting, could cause tire or rim damage while servicing or in use. An incorrectly mounted tire can burst causing personal injury and equipment damage.

DEMOUNTING

1. Deflate the tire being serviced by removing the valve core. Check the valve stem by running a piece of wire through the stem to make sure it is not plugged.
2. Place the assembly on the floor, side ring up. Insert the hooked ends of the tire tools between the side ring and the sidewall of the tire. Pry the bead loose from the side ring using downward pressure on the tools **(Fig. 1).** Continue prying around the rim until the bead is loose.
3. Insert the tapered end of the tool into the prying notch on the side ring **(Fig. 2).** Pry the side ring from its groove in the rim by prying around the tire until the ring is free.

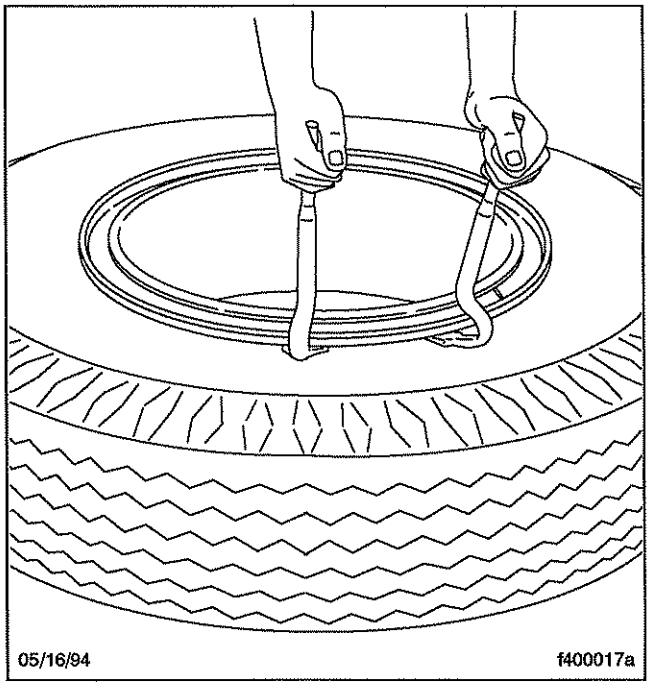


Fig. 1, Prying the Bead Loose

4. Turn the assembly over, and unseat the second tire bead from the rim. Lift the rim from the tire, and remove the tube and flap from the tire.
5. Clean and inspect all parts. Refer to **Subject 190** and **Subject 200** for procedures.

MOUNTING

1. Place the tube in the tire, then partially inflate it to round it out. Apply an approved tire lubricant to the inside and outside surfaces of both beads and to the portion of the tube that appears between the beads. Insert the flap, and lubricate the portion of the flap that faces the rim. Apply enough lubricant to enable correct bead seating, and to make mounting easier. Don't let excess lubricant run inside the tire.
2. Lay the rim flat on the floor with the valve slot up. Align the valve with the rim valve-slot. Place the tire on the rim, and insert the valve through the valve slot.
3. Place the side ring on the rim base so that the ring split is opposite the valve stem. Snap the leading end of the side ring into the rim groove **(Fig. 3).** Progressively "walk" the side ring into place. Check that the side ring is seated in the groove.
4. Inflate the tire. Refer to **Subject 210** for procedures.

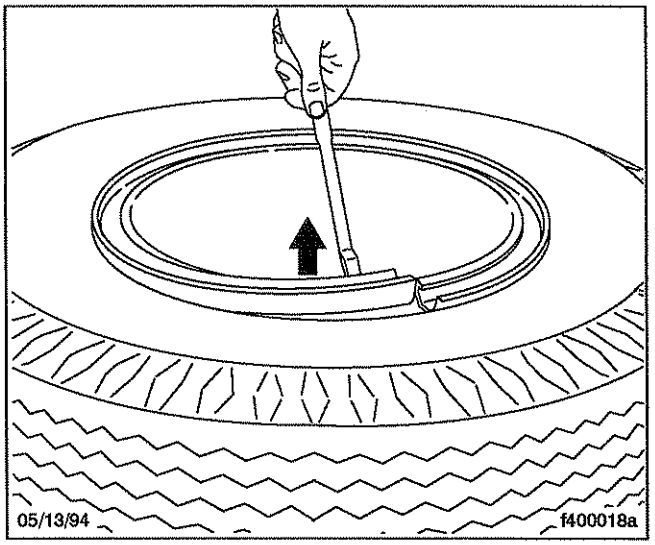


Fig. 2, Prying the Side Ring from the Groove

Demounting and Mounting Tube-Type Tires on Two-Piece Flat Base Wheels or Rims

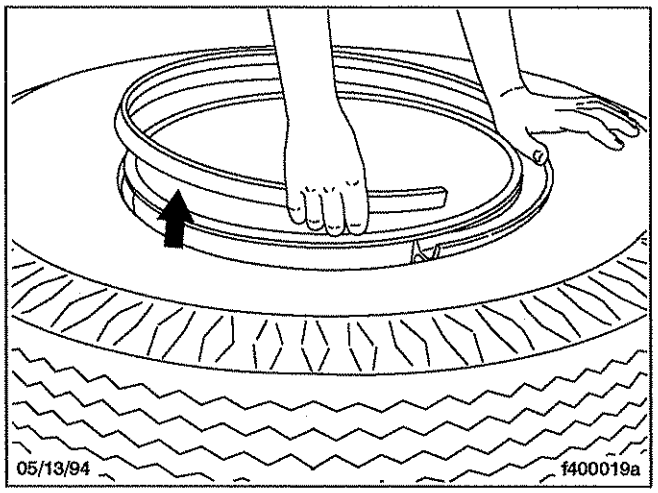


Fig. 3, Seating the Side Ring

Split Base, Continuous Side Ring

WARNING: Read the information in Subject 140. Failure to follow the precautions, before and during tire demounting and mounting, could cause tire or rim damage while servicing or in use. An incorrectly mounted tire can burst causing personal injury and equipment damage.

DEMOUNTING

1. Deflate the tire being serviced by removing the valve core. Check the valve stem by running a piece of wire through the stem to make sure it is not plugged.
2. Place the assembly on the floor, side ring up. Insert the hooked ends of the tools between the side ring and the sidewall of the tire. Pry the bead loose from the side ring using downward pressure on the tools **(Fig. 1).** Continue prying around the tire until the bead is loose.
3. Insert the tapered end of the tool into the breaking notch near the rim split, and push downward, partially offsetting the rim ends.
4. Insert the tapered end of the tool in the second rim notch, and push downward, prying the continuous side ring from the rim. **See Fig. 4.**
5. Turn the assembly over, and unseat the second tire bead from the rim. Lift the rim from the tire, and remove the tube and flap from the tire.
6. Clean and inspect all parts. Refer to **Subject 190** and **Subject 200.**

MOUNTING

1. Place the tube in the tire, then partially inflate it to round it out. Apply an approved tire lubricant to the inside and outside surfaces of both beads and to the portion of the tube that appears between the beads. Insert the flap, and lubricate the portion of the flap that faces the rim. Apply enough lubricant to enable correct bead seating, and to make mounting easier. Don't let excess lubricant run inside the tire.
2. Spread the rim base by placing a wooden block under the left side of the rim split (as shown in **Fig. 5**). Place the tire, tube, and flap, over the rim base. Lay the rim flat on the floor with the valve slot up. Align the valve with the rim's valve slot. Place the tire on the rim, and insert the valve through the valve slot.
3. Install the side ring by starting at the left side of the split and "walking" the ring into place.
4. Turn the assembly over. With the fixed flange side up, place a wooden block under the right side of the split. Tap the rim base, as shown in **Fig. 6**, until the split is correctly aligned.
5. Inflate the tire. Refer to **Subject 210** for procedures.

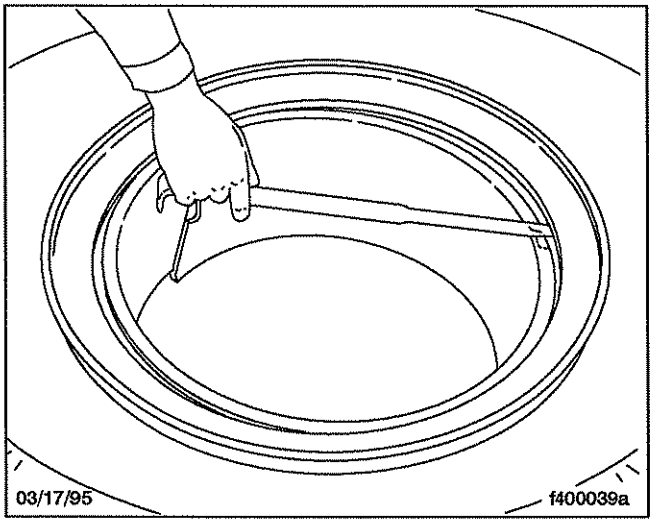


Fig. 4, Continuous Side Ring Removal

Demounting and Mounting Tube-Type Tires on Two-Piece Flat Base Wheels or Rims

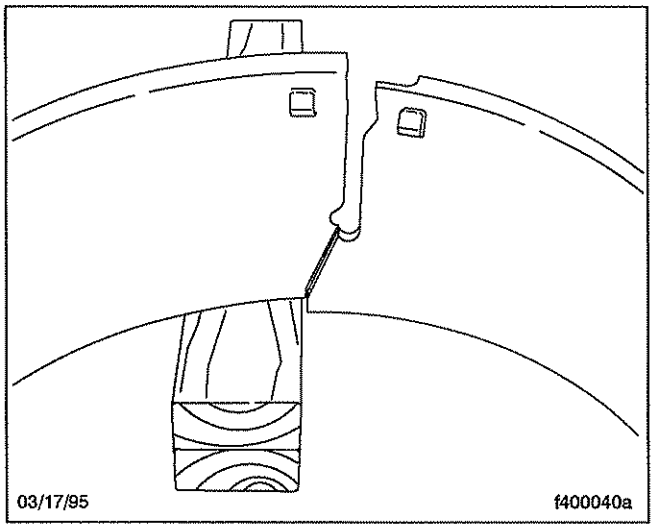


Fig. 5, Spreading the Rim Base

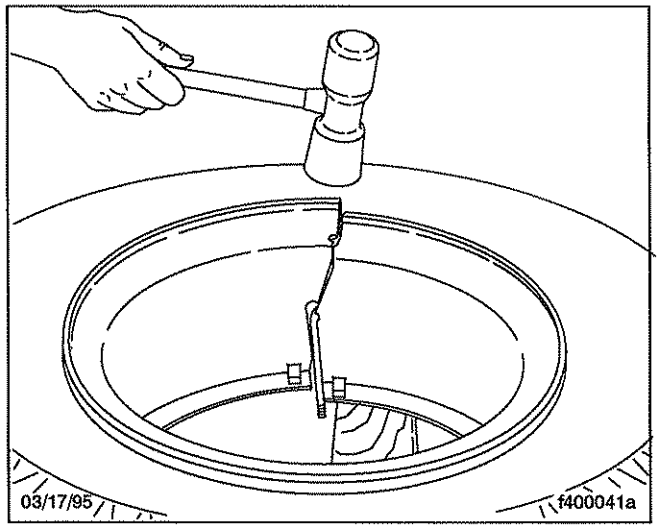


Fig. 6, Aligning the Split

Continuous Base, Continuous Side Ring

WARNING: Read the information in Subject 140. Failure to follow the precautions, before and during tire demounting and mounting, could cause tire or rim damage while servicing or in use. An incorrectly mounted tire can burst causing personal injury and equipment damage.

DEMOUNTING

1. Deflate the tire being serviced by removing the valve core. Check the valve stem by running a piece of wire through the stem to make sure it is not plugged.
2. Loosen the tire bead from the side ring by driving the curved end of a rim tool between the side ring and the bead **(Fig. 7).** Pry the bead loose from the side ring, using downward pressure on the tool. Continue prying around the tire until the bead is loose.
3. Insert the straight end of a rim tool into the notch (located between embossings) in the side ring, as shown in **Fig. 8.** Push the ring downward at the point opposite the notch. At the same time, force the tool handle downward to disengage the ring from the rim gutter. Continue prying the side ring away from the rim gutter until it is loose.
4. Turn the assembly over, and unseat the second tire bead the same way the first bead was loosened from the side ring in the step above. Stand the tire up, then remove the rim base. Remove the tube and flap from the tire.
5. Clean and inspect all parts. Refer to **Subject 190** and **Subject 200** for procedures.

MOUNTING

1. Place the tube in the tire, then partially inflate it to round it out. Apply an approved tire lubricant

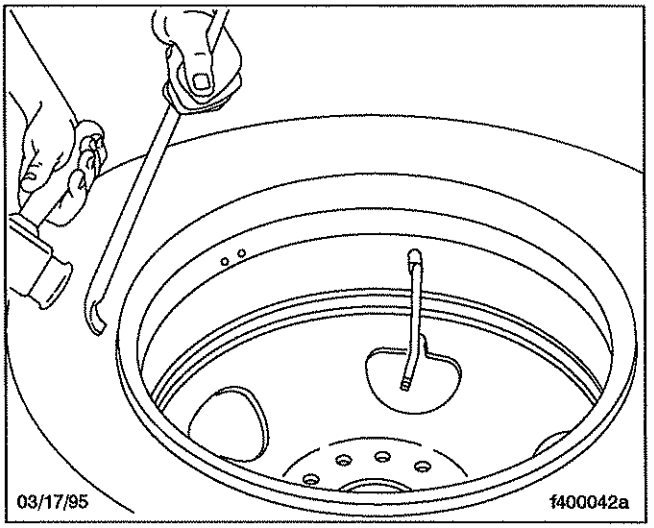


Fig. 7, Loosening the Bead

Demounting and Mounting Tube-Type Tires on Two-Piece Flat Base Wheels or Rims

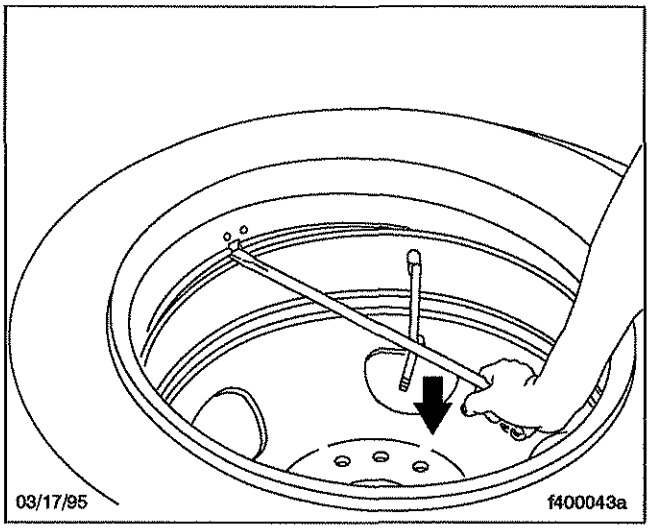


Fig. 8, Prying the Side Ring Loose

to the inside and outside surfaces of both beads and to the portion of the tube that appears between the beads. Insert the flap, and lubricate the portion of the flap that faces the rim. Apply enough lubricant to enable correct bead seating, and to make mounting easier. Don't let excess lubricant run inside the tire.

2. Place the disc portion of the wheel on the floor, with the rim gutter up. Position the tire, with the valve pointing in the desired direction, then insert the valve through the valve slot. Position the side ring by locating the operating notch between the two embossings, about 3 inches (8 cm) from the valve.

3. The two cutaway portions opposite each other in the inner diameter of the ring are placed so as to span the rim gutter. Opposite the valve, work half of the side ring into the gutter, as far as possible, using a mallet.

4. Insert the straight end of the rim tool into the notch. **See Fig. 9.** Maintaining pressure with the tool, strike the side ring downward with a mallet at the point between the tool slot and the cutaway portion, forcing the side ring over the rim gutter. Remove the tool, then strike additional blows, moving toward the other cutaway portion, until the entire toe of the side ring passes over the rim gutter. Be sure the side ring has cleared the gutter of the rim base and that the side ring can be depressed by hand.

5. Inflate the tire. Refer to **Subject 210** for procedures.

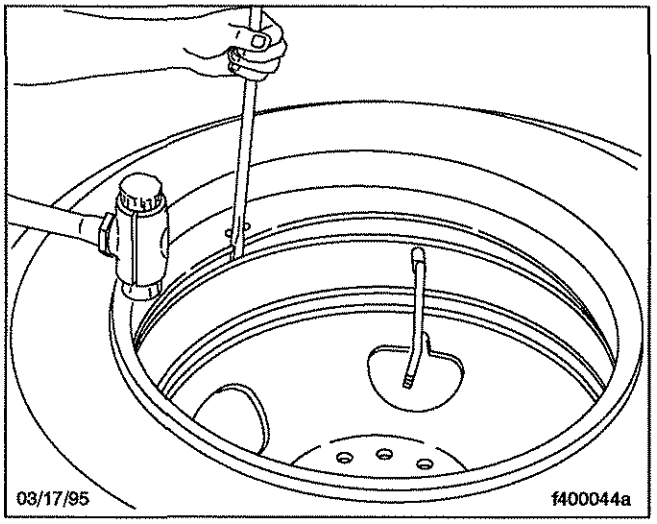


Fig. 9, Installing the Side Ring

Demounting and Mounting Tube-Type Tires on Three-Piece Flat Base Wheels or Rims

Continuous Side Ring, Split Lockring

DEMOUNTING

WARNING: Read the information in Subject 140. Failure to follow the precautions, before and during tire demounting and mounting, could cause tire or rim damage while servicing or in use. An incorrectly mounted tire can burst causing personal injury and equipment damage.

1. Deflate the tire being serviced by removing the valve core. Check the valve stem by running a piece of wire through the stem to make sure it is not plugged.
2. Place the tire on the floor, side ring up. Insert the hooked ends of the tire tools between the side ring and the sidewall of the tire. Pry the bead loose from the side ring, using downward pressure on the tools **(Fig. 1)**. Continue prying around the tire until the bead is loose.
3. With the side ring and tire bead pushed down, insert the tapered end of the tool into the notch near the split in the lockring.
4. Push downward to pry the lockring from the gutter groove of the rim base. **See Fig. 2.**
5. Using the hooked end of the tool, complete the removal of the lockring by working around the tire **(Fig. 3)**. Lift off the side ring. Turn the assembly over and unseat the second tire bead from the rim. Lift the rim from the tire and remove the tube and flap from the tire.
6. Clean and inspect all parts. Refer to **Subject 190** and **Subject 200** for procedures.

MOUNTING

1. Place the tube in the tire, then partially inflate it to round it out. Apply an approved tire lubricant to the inside and outside surfaces of both beads, and to the portion of the tube that appears between the beads. Insert the flap, and lubricate the portion of the flap that faces the rim. Apply enough lubricant to enable correct bead seating, and to make mounting easier. Don't let excess lubricant run inside the tire.
2. Lay the rim flat on the floor, with the valve slot up. Align the valve with the rim valve slot. Place the tire on the rim and insert the valve through the slot.

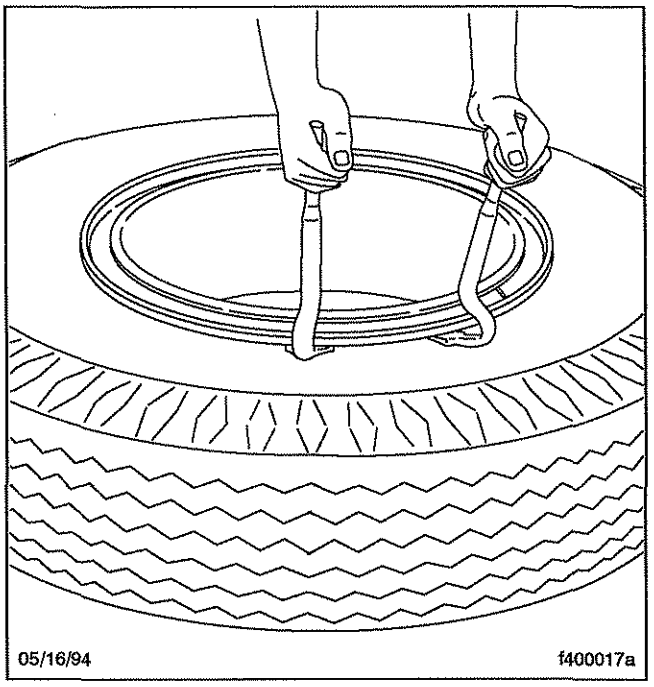


Fig. 1, Prying the Bead Loose

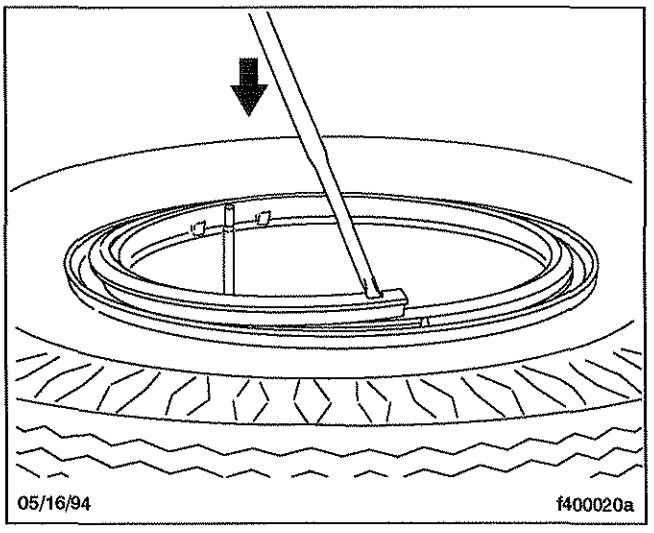


Fig. 2, Prying the Lockring from the Gutter Groove

Demounting and Mounting Tube-Type Tires on Three-Piece Flat Base Wheels or Rims

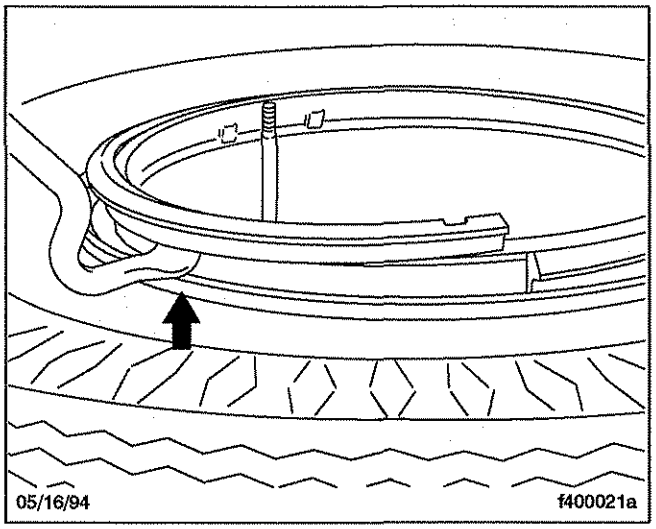


Fig. 3, Lockring Removal

3. Place the side ring on the rim base and stand on the ring to position it below the gutter grooves in the rim base.
4. Snap the leading end of the lockring into the gutter groove of the rim base, and "walk" the lockring into place **(Fig. 4).** Check that the lockring is seated in the gutter groove.
5. Inflate the tire. Refer to **Subject 210** for procedures.

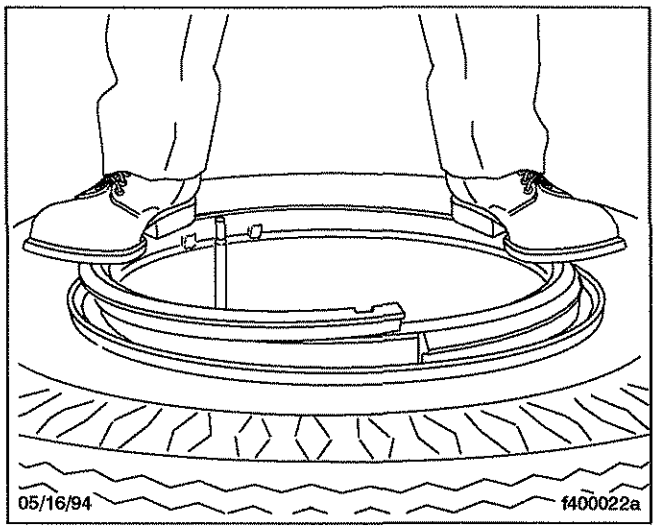


Fig. 4, Installing the Lockring

Demounting and Mounting Tube-Type Tires on Semi Drop-Center Wheels or Rims

Continuous Base, Split Side Ring

Refer to **Subject 160**, "Continuous Base, Split Side Ring," for tire demounting and mounting on a rim with a continuous base and a split side ring.

Continuous Base, Continuous Side Ring

DEMOUNTING

WARNING: Read the information in Subject 140. Failure to follow the precautions, before and during tire demounting and mounting, could cause tire or rim damage while servicing or in use. An incorrectly mounted tire can burst causing personal injury and equipment damage.

1. Deflate the tire being serviced by removing the valve core. Check the valve stem by running a piece of wire through the stem to make sure it is not plugged.
2. Place the tire and wheel on the floor with the side ring up. Loosen the first bead by driving the hooked end of the rim tool between the tire and rim flange, then press downward on the bead. Do this around the rim, using two tools, as shown in **Fig. 1.**
3. Insert the tool into the notch; then using foot pressure, force the side ring opposite the notch into the gutter **(Fig. 2).** Then, prying up and out on the side ring, carefully pry off the side ring. Don't bend the side ring.

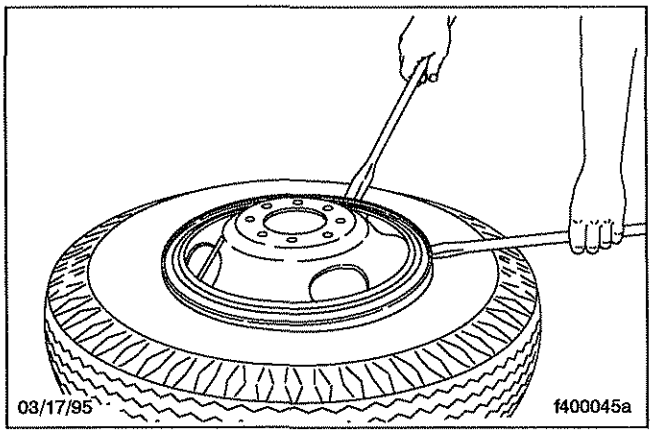


Fig. 1, Loosening the Bead

4. Force the upper tire bead into the well opposite the valve slot. With the tire tool, pry the opposite portion of the bead over the edge of the rim.
5. Turn the tire over. Using the tools, loosen the bead on the opposite bead seat. This can be done using foot pressure. Make sure one portion of the second bead is still in the rim well, then pry the opposite portion of the bead over the edge of the rim. This will free the tire from the rim **(Fig. 3).** Remove the tube and flap from the tire.
6. Clean and inspect all parts. Refer to **Subject 190** and **Subject 200** for procedures.

MOUNTING

1. Place the tube in the tire and partially inflate it to round it out. Apply an approved tire lubricant to the inside and outside surfaces of both beads

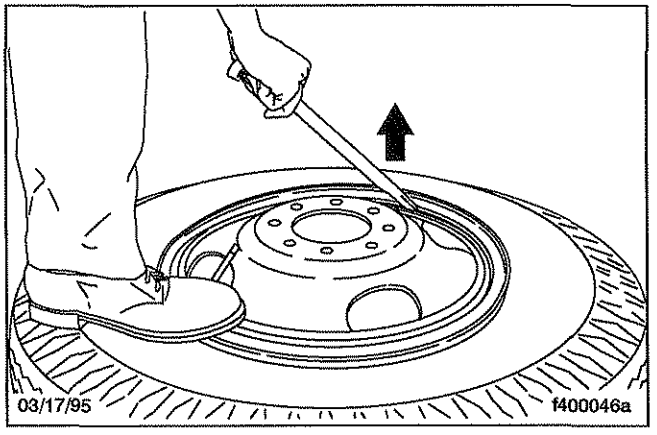


Fig. 2, Forcing the Side Ring into the Gutter

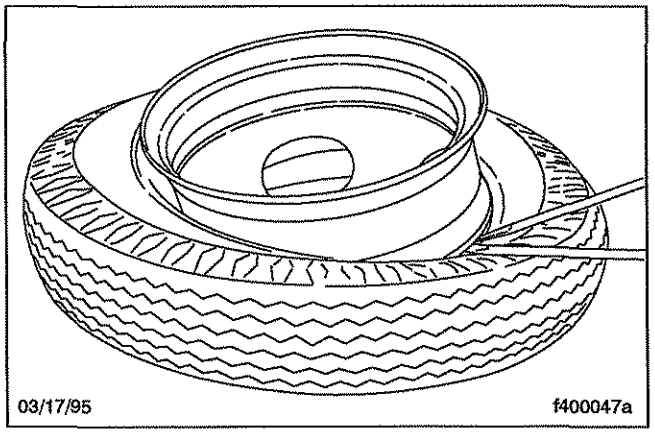


Fig. 3, Prying the Bead Over the Edge of the Rim

Demounting and Mounting Tube-Type Tires on Semi Drop-Center Wheels or Rims

and to the portion of the tube that appears between the beads. Insert the flap, and lubricate the portion of the flap that faces the rim. Apply enough lubricant to enable correct bead seating, and to make mounting easier. Don't let excess lubricant run inside the tire.

2. Place the tire on the rim so that the valve lines up with the valve hole. Insert the valve through the valve hole. Using foot pressure, work the first bead into the rim well just to the side of the valve. Pry the first bead over the rim gutter with the rim tool, moving from each side of your foot, alternately, to a point just opposite your foot **(Fig. 4).** Then pry the last section over the rim gutter.
3. To mount the second bead, start at a point opposite the valve, and using foot pressure, press the bead toe over the rim gutter and into the rim well. Mount the remainder of the bead over the rim gutter, using a thin tire tool, and following the procedure in the step above. Be careful not to pinch the tube.
4. Place half of the side ring in the rim gutter with the cutaway portions in place, as shown in **Fig. 5.** Insert the thin end of a rim tool or heavy screwdriver, then pull the side ring outward toward the centered position. Work the side ring into the gutter by striking it with a mallet.
5. Inflate the tire. Refer to **Subject 210** for procedures.

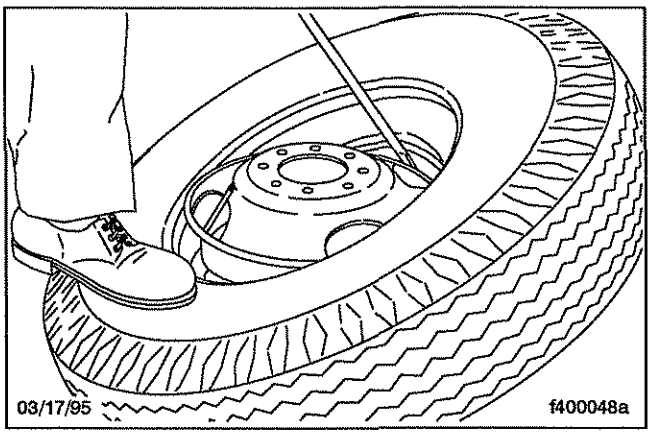


Fig. 4, Prying the Bead Over the Rim Gutter

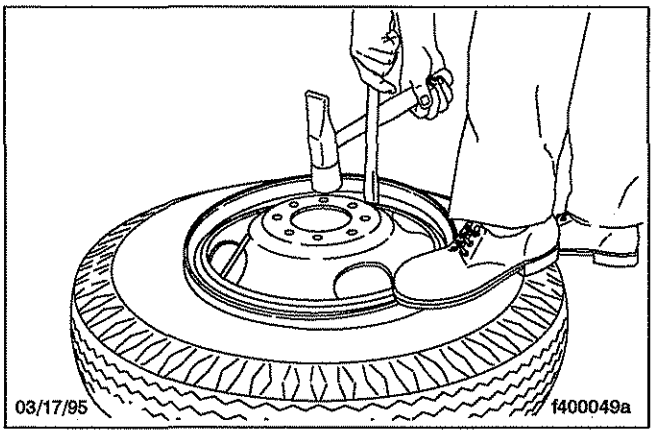


Fig. 5, Placing Half of the Side Ring in the Rim Gutter

Inspection

WARNING: Inspect the tires and wheels, and correct any problems. Failure to do so could cause tire or rim damage while servicing or while in use. An incorrectly mounted tire can burst causing equipment damage and personal injury.

Examine the wheel or rim, and all parts. Remove any grease, dirt, or rust. Using a wire brush, remove any rubber from the bead seat. Use special care when cleaning the rim gutter. Rust or other foreign matter can prevent the correct fitting of side rings. Replace corroded parts. Paint the rim to prevent corrosion.

NOTE: Don't paint Alcoa aluminum disc wheels. If the wheels are corroded, contact the manufacturer for instructions.

Sprung or broken rings **(Fig. 1),** a cracked rim, wheel **(Fig. 2),** or brake drum, damaged inner or outer wheel nuts **(Fig. 3),** or an out-of-round wheel or rim, requires the replacement of the damaged part. Replace the wheel if it has out-of-round stud holes.

NOTE: Refer to the front and rear axle sections in this manual for inspection and service procedures for the hub, wheel studs, wheel, and brake drum assemblies. When replacing the spoke wheel or the brake drum, contact the wheel manufacturer for the correct torque value for the brake drum nut that attaches the spoke wheel to the brake drum.

Inspect valve cores for cracks, bends, and air retention. Replace damaged or leaky cores.

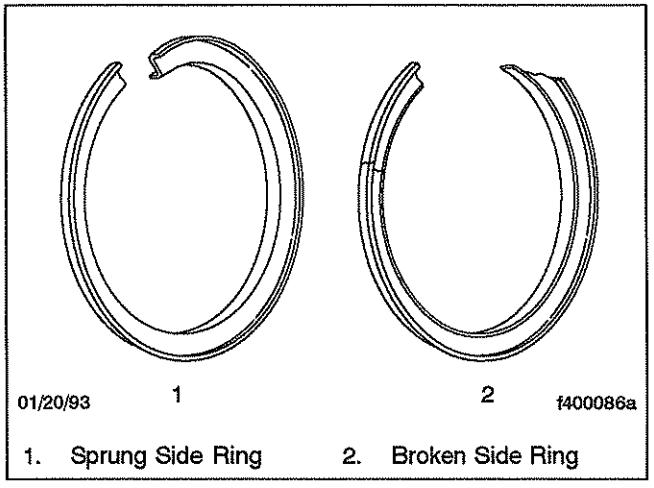


Fig. 1, Sprung and Broke Side Rings

The most critical area of a spoke wheel is the 28-degree tapered rim mounting surface **(Fig. 4).** Clean the surface and examine it for damage or excessive wear. Replace the wheel if the mounting surface is damaged or worn below the 28-degree taper.

Check the clamps, rim spacer, rim studs, and spoke-wheel nuts for damage or wear. The clamps must not be excessively worn. The end of the wedge portion must be at least 1/16-inch thick (1.5 mm). **See Fig. 5.** The rim spacer must not be bent, distorted, or crushed. Replace all damaged or broken parts.

Do not attempt to rework, weld, heat, or braze any rim or wheel parts that are cracked, broken, or damaged. Use new parts or parts that are not cracked, broken, or otherwise damaged, and that are of the same size and type.

Remove all foreign matter, such as grease and dirt, from the wheel mounting surface. Smooth any projec-

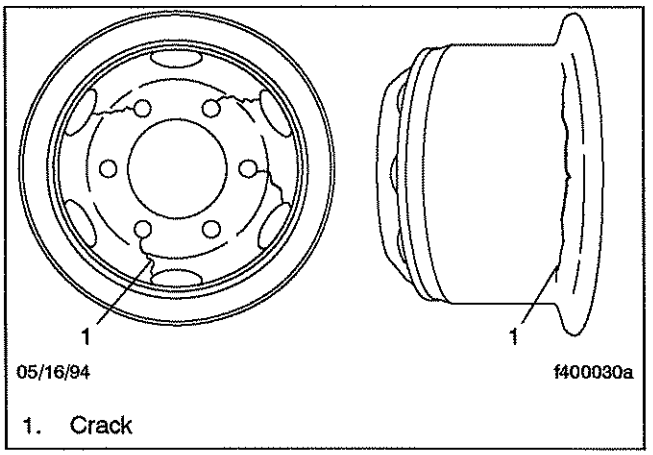


Fig. 2, Cracked Wheel and Rim

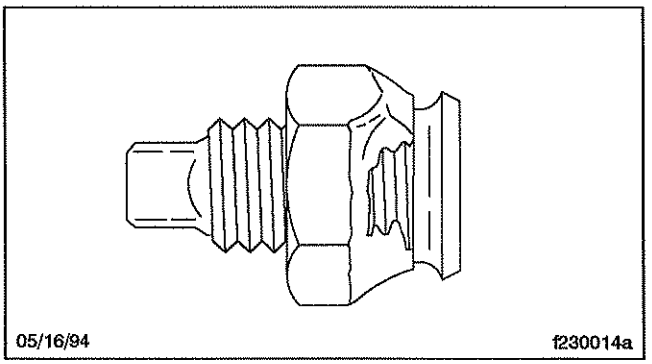
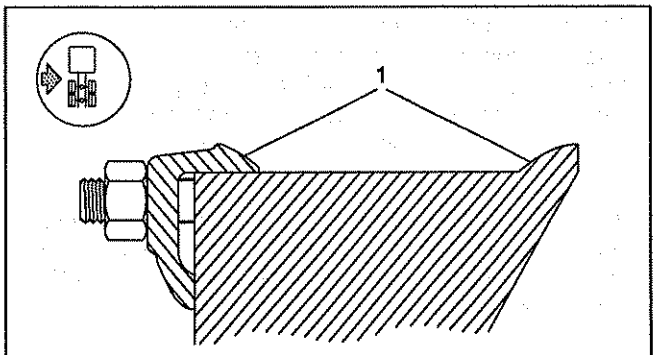


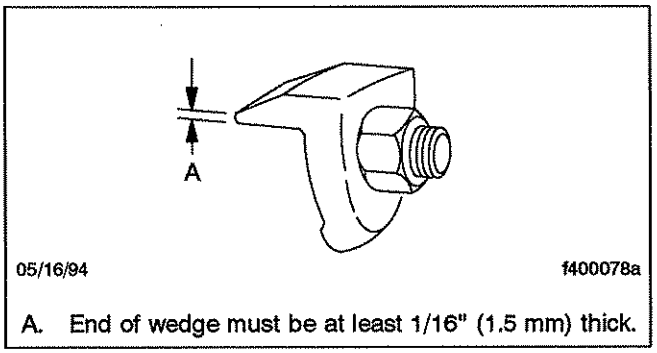
Fig. 3, Damaged Outer Wheel Nut

Wheel and Components Inspection



1. 28° Tapered Rim Mounting Surfaces

Fig. 4, Spoke Wheel Tapered Mounting Surface



A. End of wedge must be at least 1/16" (1.5 mm) thick.

Fig. 5, Rim Clamp

tions on the mounting surface to ensure even pressure when tightening the wheel nuts.

Inspection

WARNING: Inspect the tires and wheels, and correct any problems. Failure to do so could cause tire or rim damage while servicing or while in use. An incorrectly mounted tire can burst causing equipment damage and personal injury.

Inspect the inside and outside of the tire for out-of-roundness, loose cords, cuts, foreign objects, and other damage. Repair as needed. Contact the tire manufacturer for repair procedures.

Do not repair tires with the following problems:

- Cuts in the tread that are wire or breaker fiber deep.
- Tread worn to the wire or breaker fibers.
- Tread that is scalloped or otherwise worn unevenly.
- Visible, broken, deformed, or otherwise damaged bead wires.
- Deteriorated rubber.
- Rubber cracked to the wire or cord.
- Separations in the casing.
- Exposed cord (for example, due to weather checking or sidewall scuffing).

Inspect the tread for abnormal or excessive wear. Refer to **Troubleshooting, 300** for possible causes of abnormal wear. If the tires are wearing irregularly, they should be rotated. If the front axle tires become irregularly worn, they should be moved to the drive axle(s) or trailer axles. The front-end alignment should be checked. In a dual assembly, if one tire wears faster than its mate, the position of the two tires should be reversed. Refer to the vehicle maintenance manual for tire rotation procedures.

Government regulations require the removal of any tire with less than 2/32-inch (1.5 mm) tread remaining. Retread the tire (if possible), regroove it (only if marked "Regroovable" on the sidewall), or discard it.

Clean and inspect the tube and flap of tube-type tires. Discard tubes or flaps that are buckled or creased. Do not use an old tube in a new tire, and always mount a used flap in the same size tire and on the same size rim as the one from which it was removed.

Michelin Tire Corporation recommends using only new tubes, flaps, valve cores, caps, and O-rings in a new mounting.

Tire Inflation

1. Check all parts to make sure they are correctly seated prior to inflation.

NOTE: Inflate tires in a safety cage **(Fig. 1)** or an approved portable restraining device. Always use a clip-on chuck with an inline valve and gauge. Make sure the inflation hose is long enough to permit standing to the side of the tire during inflation. Never sit on or stand in front of an assembly that is being inflated.

WARNING: During initial tire inflation, there is the possibility of an explosion of the assembly. Observe the following safety rules to reduce the possibility of serious physical injury in the event of an explosion.

IMPORTANT: Inflate tires immediately after mounting, before the tire lubricant dries. Once the lubricant dries, bead positioning is not possible, even with increased inflation pressure.

Water in the tire can cause ply separation. During tire inflation, air tank reservoirs and lines must be dry. Use well-maintained air line moisture traps, and service them regularly.

2. After placing the tire in a safety cage, or an approved portable restraining device, inflate the tire to 10 psi (69 kPa). Check the parts for correct seating. If the seating is not correct, completely deflate the tire and correct the problem. Never attempt to seat rings or other parts by hammering on an inflated or partially inflated tire.

IMPORTANT: Due to the different flex characteristics of radial sidewalls, it may be necessary to use an inflation aid to help seat tubeless tire beads:

- Metal rings, which use a blast of compressed air to seat the beads.
- Rubber rings, which seal between the tire bead and rim, allowing the bead to move out and seat correctly. A well-lubricated, heavy-duty bicycle tube can be used to help seal between the tire bead and rim.

3. If there are no problems with the assembly at 10 psi (69 kPa), continue to inflate the tire to the recommended pressure. Refer to **Specifications, 400** for correct cold inflation pressures. Michelin Tire Corporation recommends an initial inflation pressure of 90 to 100 psi (620 to 690 kPa) to correctly seat the tire beads.

NOTE: The position of the beads, flap, and tube with 4 to 5 psi (28 to 35 kPa) pressure is shown in **Fig. 2.** The tube is fully rounded-out within the tire, but there isn't enough pressure to move the beads on wide-base rims. Depending on the tire size and rim condition, from 20 to 40 psi (140 to 275 kPa) pressure is needed to push the beads onto the bead seat. **See Fig. 3.**

4. After the initial inflation, completely deflate the tire by removing the valve core. This ensures correct bead seating, and prevents buckling or overstretching the tube in tube-type tires. Then inflate the tire to the recommended cold inflation pressure listed in **Specifications, 400.** Install valve caps and tighten them finger-tight.

CAUTION: Improperly inflating tube-type tires can crack or tear the edge or inside of the valve base. Once seated, the tube can stretch only in the rim area. Because resistance to stretch is greatest at the valve base, there is often enough tension to break the tube at the edge of the valve base or in the valve base.

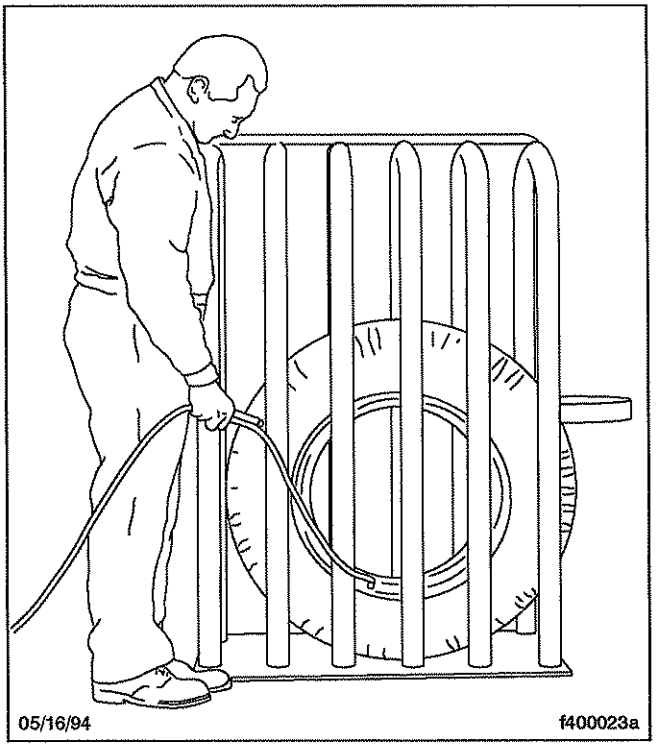
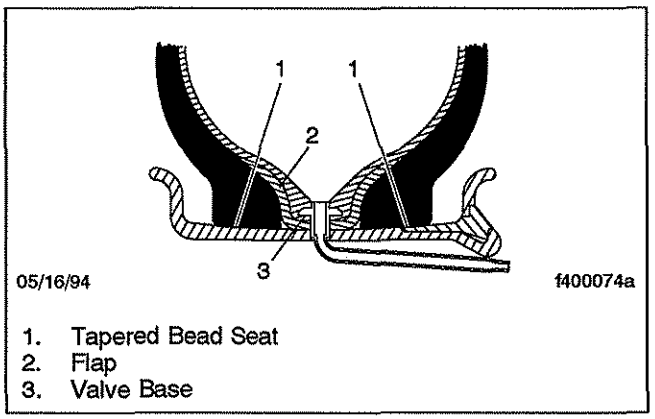


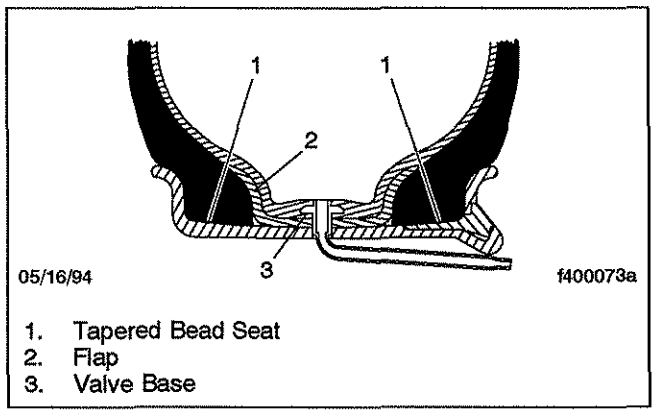
Fig. 1, Safety Cage

Tire Inflation



1. Tapered Bead Seat
2. Flap
3. Valve Base

Fig. 2, Position of Beads, Flap, and Tube at 4 to 5 psi (28 to 35 kPa)



1. Tapered Bead Seat
2. Flap
3. Valve Base

Fig. 3, Beads Pressured Onto the Bead Seat

IMPORTANT: Use tires of the same size, type, and capacity to carry the load at the recommended cold pressure. Attempting to increase the load capacity of a tire by overinflation will damage the tire assembly.

NOTE: Inflate the tires to the recommended pressure. Driving on overinflated tires will weaken the cords by reducing their ability to absorb road shocks, and will increase the danger of cuts, snags, and punctures. Overinflation will overstress and damage the rims. Driving on underinflated tires will generate excessive heat. This weakens the tire body, and reduces tire strength.

WARNING: Inflate tires to the specified pressure. Tire underinflation or overinflation will damage wheels and tires, and could result in a blowout, causing possible personal injury and property damage.

5. Check the inflation pressure 24 hours after mounting new tires.

NOTE: When testing a vehicle on a dynamometer, severe tire damage can occur. Because the manufacturers differ in their recommendations for preventing tire damage, refer to the manufacturer's instructions for testing a vehicle on a dynamometer.

Troubleshooting Chart

Problem—Abnormal Tire Wear

Possible Cause	Remedy
Tires are not inflated to the correct pressure	Operate the tires at the recommended inflation pressure and use the proper size tires, wheels, and rims for the load to be carried. Refer to **Specifications, 400.**
Inflation pressures in a dual assembly are unequal.	Inflate all tires to a uniform pressure, within 5 psi (35 kPa). Refer to **Specifications, 400** for the proper cold inflation pressures.
Dual tires are mismatched.	Examine all tires and match them according to the specifications in this section.
Vehicle is vibrating severely.	Follow the recommendations under "Vehicle Vibration" in this chart.
Brakes are grabbing.	Examine and adjust the brakes according to the instructions in the brake section in this manual.
Axles are improperly aligned.	Align the axles. Refer to the front and rear axle sections in this manual for instructions.
Wheel bearings are loose or damaged, or bushings are excessively worn.	Examine, and repair or replace according to the instructions in the front and rear axle sections in this manual.
Wear is uneven among tire sets.	Rotate the tires according to the instructions in the vehicle maintenance manual.
Driver is abusing equipment.	Caution the driver.

Problem—Vehicle Vibration

Possible Cause	Remedy
Axles are improperly aligned.	Align the axles. Refer to the front and rear axle sections in this manual for instructions.
Wheels, rims, or tires are out-of-round, bent, or distorted.	Replace damaged components.
Tires, wheels, rims, or brake drums are out-of-balance.	Determine the out of balance component and balance.
Tire beads are not properly seated.	Demount and mount the tire. Make certain adequate lubrication is used and, if necessary, use an inflation aid to help seat tubeless tire beads.
Tire and rim assembly is improperly installed on a spoke wheel.	Remove the tire and rim assembly and inspect it for out-of-round or rim chording. Replace the rim if it is damaged. Follow closely the tightening sequence and torque values listed.
Rim spacers are worn or distorted.	Replace the rim spacers.
Driveline, suspensions, or steering components are loose or worn.	Determine the location of the vibration, then repair or replace the loose or worn components.

Problem—Excessive On-the-Road Tire Failures

Possible Cause	Remedy
Tires are not inflated to the correct pressure.	Operate the tires at the recommended inflation pressure and use the proper size tires, wheels, and rims for the load to be carried. Refer to **Specifications, 400.**
Dual tires are mismatched.	Examine all tires and match them according to the specifications in this section.

Troubleshooting

Possible Cause	Remedy
Water or foreign material is inside the casing.	Clean and dry the tires and tubes prior to mounting. Make sure excess lubricant does not flow down into the tire. Store unmounted tires indoors, or under cover, to prevent moisture from collecting inside.
Tires are contaminated with oil.	Clean the tires and inspect the engine seals, transmission seals, axle-end and drive axle seals, oil filters and oil lines for leakage. Make sure the lubricant used in mounting does not contain a petroleum derivative.
Vehicle is vibrating severely.	Follow the recommendations under "Vehicle Vibration" in this chart.
Wheel or rim components are mismatched.	Check the catalog issued by the applicable wheel or rim manufacturer for the proper part numbers and sizes of approved components. Make sure that all parts of an assembly match in size, manufacturer, and classifications within a manufacturer's line. Never use a component which does not bear clear, legible, and proper numbers and manufacturer's identification, even if it appears to fit.
Parts are corroded, worn, or otherwise damaged.	Clean or replace parts as necessary.

Specifications

IMPORTANT: Tables 1 through 11 are for all tire makes except Michelin. Tables 1 through 10 list the maximum tire loads at inflation pressures for vehicles driven on paved highways at sustained speeds of 50 to 60 mph (80 to 97 km/h). Table 11 lists the variations in the load and inflation limits given in Table 1 through Table 10 needed to drive the vehicle at sustained speeds above 60 mph (97 km/h), or below 50 mph (80 km/h).

Tables 12 through 15 deal with Michelin tires only, and list the minimum cold inflation pressures for various tire sizes, types, and loads, when used in normal highway driving.

Do not reduce the pressure of a hot tire if it exceeds the specified pressure. In normal driving, tire temperature and inflation pressure increase. Increases of 10 to 15 psi (70 to 105 kPa) are common. Higher pressures may be signs of overloading, underinflation, excessive speed, improper tire size, or any combination of these factors, and must be checked when the tire is cool.

The load and cold inflation pressure must not exceed the rim or wheel manufacturer's recommendations, even though the tire may be approved for a higher load or inflation. Some rims and wheels are stamped with a maximum load and maximum cold inflation rating. Consult the rim or wheel manufacturer if they are not stamped. If the load exceeds the maximum rim or wheel capacity, the load must be adjusted or reduced.

For further data on rims and tires (other than Michelin), and for inflation and load limits not given here, see the "Tire and Rim Association Yearbook." Contact the Michelin Tire Corporation for further data on their tires.

NOTE: To obtain metric equivalents, use the following conversions:

- kg = lbs x 0.454
- kPa = psi x 6.890

Tire Load Limits, Bias Ply Tube-Type Tires, Front Axle (Maximum Speed of 60 mph [97 km/h])														
Size	Load Range	Ply Rating	Maximum Tire Loads (lbs) at Various Cold Inflation Pressures											
			55 psi	60 psi	65 psi	70 psi	75 psi	80 psi	85 psi	90 psi	95 psi	100 psi	105 psi	110 psi	115 psi
9.00-20	E	10	3560	3770	4000	4210	4410	4610	—	—	—	—	—	—	—
9.00-20	F	12	3560	3770	4000	4210	4410	4610	4790	4970	5150	—	—	—	—
9.00-20	G	14	3560	3770	4000	4210	4410	4610	4790	4970	5150	5320	5490	5670	—
10.00-20	F	12	—	4290	4530	4770	4990	5220	5430	—	—	—	—	—	—
10.00-20	G	14	—	4290	4530	4770	4990	5220	5430	5640	5840	6040	—	—	—
10.00-20	H	16	—	4290	4530	4770	4990	5220	5430	5640	5840	6040	6240	6430	6610
10.00-22	F	12	—	4560	4820	5070	5310	5550	5780	—	—	—	—	—	—
10.00-22	G	14	—	4560	4820	5070	5310	5550	5780	6000	6210	6430	—	—	—
10.00-22	H	16	—	4560	4820	5070	5310	5550	5780	6000	6210	6430	6630	6840	7030
11.00-20	F	12	—	4670	4940	5200	5450	5690	5920	—	—	—	—	—	—
11.00-20	G	14	—	4670	4940	5200	5450	5690	5920	6140	6370	6590	—	—	—
11.00-20	H	16	—	4670	4940	5200	5450	5690	5920	6140	6370	6590	6790	7010	7200
11.00-22	F	12	—	4960	5240	5520	5790	6040	6290	—	—	—	—	—	—
11.00-22	G	14	—	4960	5240	5520	5790	6040	6290	6530	6770	7000	—	—	—
11.00-22	H	16	—	4960	5240	5520	5790	6040	6290	6530	6770	7000	7220	7440	7660

Table 1, Tire Load Limits, Bias Ply Tube-Type Tires, Front Axle (Maximum Speed of 60 mph [97 km/h])

Specifications

Tire Load Limits, Bias Ply Tube-Type Tires, Rear Axle (Maximum Speed of 60 mph [97 km/h])														
Size	Load Range	Ply Rating	Maximum Tire Loads (lbs) at Various Cold Inflation Pressures											
			45 psi	50 psi	55 psi	60 psi	65 psi	70 psi	75 psi	80 psi	85 psi	90 psi	95 psi	100 psi	105 psi
9.00-20	E	10	3120	3310	3510	3690	3870	4040	—	—	—	—	—	—	—
9.00-20	F	12	3120	3310	3510	3690	3870	4040	4200	4360	4520	—	—	—	—
9.00-20	G	14	3120	3310	3510	3690	3870	4040	4200	4360	4520	4670	4820	4970	—
10.00-20	F	12	—	3760	3970	4180	4380	4580	4760	—	—	—	—	—	—
10.00-20	G	14	—	3760	3970	4180	4380	4580	4760	4950	5120	5300	—	—	—
10.00-20	H	16	—	3760	3970	4180	4380	4580	4760	4950	5120	5300	5470	5630	5800
10.00-22	F	12	—	4000	4230	4450	4660	4870	5070	—	—	—	—	—	—
10.00-22	G	14	—	4000	4230	4450	4660	4870	5070	5260	5450	5640	—	—	—
10.00-22	H	16	—	4000	4230	4450	4660	4870	5070	5260	5450	5640	5820	6000	6170
11.00-20	F	12	—	4100	4330	4560	4780	4990	5190	—	—	—	—	—	—
11.00-20	G	14	—	4100	4330	4560	4780	4990	5190	5390	5590	5780	—	—	—
11.00-20	H	16	—	4100	4330	4560	4780	4990	5190	5390	5590	5780	5960	6150	6320
11.00-22	F	12	—	4350	4600	4840	5080	5300	5520	—	—	—	—	—	—
11.00-22	G	14	—	4350	4600	4840	5080	5300	5520	5730	5940	6140	—	—	—
11.00-22	H	16	—	4350	4600	4840	5080	5300	5520	5730	5940	6140	6330	6530	6720

Table 2, Tire Load Limits, Bias Ply Tube-Type Tires, Rear Axle (Maximum Speed of 60 mph [97 km/h])

Tire Load Limits, Bias Ply Tubeless Tires, Front Axle (Maximum Speed of 60 mph [97 km/h])														
Size	Load Range	Ply Rating	Maximum Tire Loads (lbs) at Various Cold Inflation Pressures											
			55 psi	60 psi	65 psi	70 psi	75 psi	80 psi	85 psi	90 psi	95 psi	100 psi	105 psi	110 psi	115 psi
10-22.5	E	10	3560	3770	4000	4210	4410	4610	—	—	—	—	—	—	—
10-22.5	F	12	3560	3770	4000	4210	4410	4610	4790	4970	5150	—	—	—	—
10-22.5	G	14	3560	3770	4000	4210	4410	4610	4790	4970	5150	5320	5490	5670	—
11-22.5	F	12	—	4290	4530	4770	4990	5220	5430	—	—	—	—	—	—
11-22.5	G	14	—	4290	4530	4770	4990	5220	5430	5640	5840	6040	—	—	—
11-22.5	H	16	—	4290	4530	4770	4990	5220	5430	5640	5840	6040	6240	6430	6610
11-24.5	F	12	—	4560	4820	5070	5310	5550	5780	—	—	—	—	—	—
11-24.5	G	14	—	4560	4820	5070	5310	5550	5780	6000	6210	6430	—	—	—
11-24.5	H	16	—	4560	4820	5070	5310	5550	5780	6000	6210	6430	6630	6840	7030

Table 3, Tire Load Limits, Bias Ply Tubeless Tires, Front Axle (Maximum Speed of 60 mph [97 km/h])

Specifications

Tire Load Limits, Bias Ply Tubeless Tires, Rear Axle (Maximum Speed of 60 mph [97 km/h])														
Size	Load Range	Ply Rating	Maximum Tire Loads (lbs) at Various Cold Inflation Pressures											
			45 psi	50 psi	55 psi	60 psi	65 psi	70 psi	75 psi	80 psi	85 psi	90 psi	95 psi	100 psi	105 psi
10-22.5	E	10	3120	3310	3510	3690	3870	4040	—	—	—	—	—	—	—
10-22.5	F	12	3120	3310	3510	3690	3870	4040	4200	4360	4520	—	—	—	—
10-22.5	G	14	3120	3310	3510	3690	3870	4040	4200	4360	4520	4670	4820	4970	—
11-22.5	F	12	—	3760	3970	4180	4380	4580	4760	—	—	—	—	—	—
11-22.5	G	14	—	3760	3970	4180	4380	4580	4760	4950	5120	5300	—	—	—
11-22.5	H	16	—	3760	3970	4180	4380	4580	4760	4950	5120	5300	5470	5630	5800
11-24.5	F	12	—	4000	4230	4450	4660	4870	5070	—	—	—	—	—	—
11-24.5	G	14	—	4000	4230	4450	4660	4870	5070	5260	5450	5640	—	—	—
11-24.5	H	16	—	4000	4230	4450	4660	4870	5070	5260	5450	5640	5820	6000	6170

Table 4, Tire Load Limits, Bias Ply Tubeless Tires, Rear Axle (Maximum Speed of 60 mph [97 km/h])

Tire Load Limits, Bias Ply Wide Base Tires, Front Axle (Maximum Speed of 60 mph [97 km/h])														
Size	Load Range	Ply Rating	Maximum Tire Loads (lbs) at Various Cold Inflation Pressures											
			40 psi	45 psi	50 psi	55 psi	60 psi	65 psi	70 psi	75 psi	80 psi	85 psi	90 psi	95 psi	100 psi
15-19.5	D	8	4090	—	—	—	—	—	—	—	—	—	—	—	—
15-19.5	E	10	4090	4470	4830	5180	—	—	—	—	—	—	—	—	—
15-19.5	F	12	4090	4470	4830	5180	5510	5820	6130	—	—	—	—	—	—
15-19.5	G	14	4090	4470	4830	5180	5510	5820	6130	6420	6710	6980	—	—	—
15-22.5	E	10	—	—	—	5680	—	—	—	—	—	—	—	—	—
15-22.5	F	12	—	—	—	5680	6040	6390	6720	—	—	—	—	—	—
15-22.5	G	14	—	—	—	5680	6040	6390	6720	7040	7360	7660	—	—	—
15-22.5	H	16	—	—	—	5680	6040	6390	6720	7040	7360	7660	7950	8240	8520
16.5-19.5	H	16	—	—	—	6030	6410	6780	7130	7480	7810	8130	8440	—	—
16.5-22.5	H	16	—	—	—	6590	7010	7410	7790	8170	8540	8890	9230	—	—
18-19.5	G	14	—	—	—	6700	7130	7540	7930	—	—	—	—	—	—
18-19.5	H	16	—	—	—	6700	7130	7540	7930	8310	8680	9040	—	—	—
18-19.5	J	18	—	—	—	6700	7130	7540	7930	8310	8680	9040	9390	9730	10060
18-22.5	G	14	—	—	—	7310	7780	8220	8650	—	—	—	—	—	—
18-22.5	H	16	—	—	—	7310	7780	8220	8650	9070	9470	9860	—	—	—
18-22.5	J	18	—	—	—	7310	7780	8220	8650	9070	9470	9860	10240	10610	10970

Table 5, Tire Load Limits, Bias Ply Wide Base Tires, Front Axle (Maximum Speed of 60 mph [97 km/h])

Specifications

Tire Load Limits, Radial Ply Tube-Type Tires, Front Axle (Maximum Speed of 60 mph [97 km/h])														
Size	Load Range	Ply Rating	Maximum Tire Loads (lbs) at Various Cold Inflation Pressures											
			60 psi	65 psi	70 psi	75 psi	80 psi	85 psi	90 psi	95 psi	100 psi	105 psi	110 psi	115 psi	120 psi
9.00R20	E	10	3560	3770	4000	4210	4410	4610	—	—	—	—	—	—	—
9.00R20	F	12	3560	3770	4000	4210	4410	4610	4790	4970	5150	—	—	—	—
9.00R20	G	14	3560	3770	4000	4210	4410	4610	4790	4970	5150	5320	5490	5670	—
10.00R20	F	12	—	4290	4530	4770	4990	5220	5430	—	—	—	—	—	—
10.00R20	G	14	—	4290	4530	4770	4990	5220	5430	5640	5840	6040	—	—	—
10.00R20	H	16	—	4290	4530	4770	4990	5220	5430	5640	5840	6040	6240	6430	6610
10.00R22	F	12	—	4560	4820	5070	5310	5550	5780	—	—	—	—	—	—
10.00R22	G	14	—	4560	4820	5070	5310	5550	5780	6000	6210	6430	—	—	—
10.00R22	H	16	—	4560	4820	5070	5310	5550	5780	6000	6210	6430	6630	6840	7030
11.00R20	F	12	—	4670	4940	5200	5450	5690	5920	—	—	—	—	—	—
11.00R20	G	14	—	4670	4940	5200	5450	5690	5920	6140	6370	6590	—	—	—
11.00R20	H	16	—	4670	4940	5200	5450	5690	5920	6140	6370	6590	6790	7010	7200
11.00R22	F	12	—	4960	5240	5520	5790	6040	6290	—	—	—	—	—	—
11.00R22	G	14	—	4960	5240	5520	5790	6040	6290	6530	6770	7000	—	—	—
11.00R22	H	16	—	4960	5240	5520	5790	6040	6290	6530	6770	7000	7220	7440	7660

Table 6, Tire Load Limits, Radial Ply Tube-Type Tires, Front Axle (Maximum Speed of 60 mph [97 km/h])

Tire Load Limits, Radial Ply Tube-Type Tires, Rear Axle (Maximum Speed of 60 mph [97 km/h])														
Size	Load Range	Ply Rating	Maximum Tire Loads (lbs) at Various Cold Inflation Pressures											
			50 psi	55 psi	60 psi	65 psi	70 psi	75 psi	80 psi	85 psi	90 psi	95 psi	100 psi	105 psi	110 psi
9.00R20	E	10	3120	3310	3510	3690	3870	4040	—	—	—	—	—	—	—
9.00R20	F	12	3120	3310	3510	3690	3870	4040	4200	4360	4520	—	—	—	—
9.00R20	G	14	3120	3310	3510	3690	3870	4040	4200	4360	4520	4670	4820	4970	—
10.00R20	F	12	—	3760	3970	4180	4380	4580	4760	—	—	—	—	—	—
10.00R20	G	14	—	3760	3970	4180	4380	4580	4760	4950	5120	5300	—	—	—
10.00R20	H	16	—	3760	3970	4180	4380	4580	4760	4950	5120	5300	5470	5630	5800
10.00R22	F	12	—	4000	4230	4450	4660	4870	5070	—	—	—	—	—	—
10.00R22	G	14	—	4000	4230	4450	4660	4870	5070	5260	5450	5640	—	—	—
10.00R22	H	16	—	4000	4230	4450	4660	4870	5070	5260	5450	5640	5820	6000	6170
11.00R20	F	12	—	4100	4330	4560	4780	4990	5190	—	—	—	—	—	—
11.00R20	G	14	—	4100	4330	4560	4780	4990	5190	5390	5590	5780	—	—	—
11.00R20	H	16	—	4100	4330	4560	4780	4990	5190	5390	5590	5780	5960	6150	6320
11.00R22	F	12	—	4350	4600	4840	5080	5300	5520	—	—	—	—	—	—

Tire Load Limits, Radial Ply Tube-Type Tires, Rear Axle (Maximum Speed of 60 mph [97 km/h])														
Size	Load Range	Ply Rating	Maximum Tire Loads (lbs) at Various Cold Inflation Pressures											
			50 psi	55 psi	60 psi	65 psi	70 psi	75 psi	80 psi	85 psi	90 psi	95 psi	100 psi	105 psi	110 psi
11.00R22	G	14	—	4350	4600	4840	5080	5300	5520	5730	5940	6140	—	—	—
11.00R22	H	16	—	4350	4600	4840	5080	5300	5520	5730	5940	6140	6330	6530	6720

Table 7, Tire Load Limits, Radial Ply Tube-Type Tires, Rear Axle (Maximum Speed of 60 mph [97 km/h])

Tire Load Limits, Radial Ply Tubeless Tires, Front Axle (Maximum Speed of 60 mph [97 km/h])														
Size	Load Range	Ply Rating	Maximum Tire Loads (lbs) at Various Cold Inflation Pressures											
			60 psi	65 psi	70 psi	75 psi	80 psi	85 psi	90 psi	95 psi	100 psi	105 psi	110 psi	115 psi	120 psi
10R22.5	E	10	3560	3770	4000	4210	4410	4610	—	—	—	—	—	—	—
10R22.5	F	12	3560	3770	4000	4210	4410	4610	4790	4970	5150	—	—	—	—
10R22.5	G	14	3560	3770	4000	4210	4410	4610	4790	4970	5150	5320	5490	5670	—
11R22.5	F	12	—	4290	4530	4770	4990	5220	5430	—	—	—	—	—	—
11R22.5	G	14	—	4290	4530	4770	4990	5220	5430	5640	5840	6040	—	—	—
11R22.5	H	16	—	4290	4530	4770	4990	5220	5430	5640	5840	6040	6240	6430	6610
11R24.5	F	12	—	4560	4820	5070	5310	5550	5780	—	—	—	—	—	—
11R24.5	G	14	—	4560	4820	5070	5310	5550	5780	6000	6210	6430	—	—	—
11R24.5	H	16	—	4560	4820	5070	5310	5550	5780	6000	6210	6430	6630	6840	7030

Table 8, Tire Load Limits, Radial Ply Tubeless Tires, Front Axle (Maximum Speed of 60 mph [97 km/h])

Tire Load Limits, Radial Ply Tubeless Tires, Rear Axle (Maximum Speed of 60 mph [97 km/h])														
Size	Load Range	Ply Rating	Maximum Tire Loads (lbs) at Various Cold Inflation Pressures											
			50 psi	55 psi	60 psi	65 psi	70 psi	75 psi	80 psi	85 psi	90 psi	95 psi	100 psi	105 psi	110 psi
10R22.5	E	10	3120	3310	3510	3690	3870	4040	—	—	—	—	—	—	—
10R22.5	F	12	3120	3310	3510	3690	3870	4040	4200	4360	4520	—	—	—	—
10R22.5	G	14	3120	3310	3510	3690	3870	4040	4200	4360	4520	4670	4820	4970	—
11R22.5	F	12	—	3760	3970	4180	4380	4580	4760	—	—	—	—	—	—
11R22.5	G	14	—	3760	3970	4180	4380	4580	4760	4950	5120	5300	—	—	—
11R22.5	H	16	—	3760	3970	4180	4380	4580	4760	4950	5120	5300	5470	5630	5800
11R24.5	F	12	—	4000	4230	4450	4660	4870	5070	—	—	—	—	—	—
11R24.5	G	14	—	4000	4230	4450	4660	4870	5070	5260	5450	5640	—	—	—
11R24.5	H	16	—	4000	4230	4450	4660	4870	5070	5260	5450	5640	5820	6000	6170

Table 9, Tire Load Limits, Radial Ply Tubeless Tires, Rear Axle (Maximum Speed of 60 mph [97 km/h])

Specifications

Tire Load Limits, Radial Ply Wide Base Tires, Front Axle (Maximum Speed of 60 mph [97 km/h])														
Size	Load Range	Ply Rating	Maximum Tire Loads (lbs) at Various Cold Inflation Pressures											
			45 psi	50 psi	55 psi	60 psi	65 psi	70 psi	75 psi	80 psi	85 psi	90 psi	95 psi	100 psi	105 psi
15R19.5	D	8	4090	—	—	—	—	—	—	—	—	—	—	—	—
15R19.5	E	10	4090	4470	4830	5180	—	—	—	—	—	—	—	—	—
15R19.5	F	12	4090	4470	4830	5180	5510	5820	6130	—	—	—	—	—	
15R19.5	G	14	4090	4470	4830	5180	5510	5820	6130	6420	6710	6980	—	—	—
15R22.5	E	10	—	—	—	5680	—	—	—	—	—	—	—	—	—
15R22.5	F	12	—	—	—	5680	6040	6390	6720	—	—	—	—	—	—
15R22.5	G	14	—	—	—	5680	6040	6390	6720	7040	7360	7660	—	—	—
15R22.5	H	16	—	—	—	5680	6040	6390	6720	7040	7360	7660	7950	8240	8520
16.5R19.5	H	16	—	—	—	6030	6410	6780	7130	7480	7810	8130	8440	—	—
16.5R22.5	H	16	—	—	—	6590	7010	7410	7790	8170	8540	8890	9230	—	—
18R19.5	G	14	—	—	—	6700	7130	7540	7930	—	—	—	—	—	—
18R19.5	H	16	—	—	—	6700	7130	7540	7930	8310	8680	9040	—	—	—
18R19.5	J	18	—	—	—	6700	7130	7540	7930	8310	8680	9040	9390	9730	10060
18R22.5	G	14	—	—	—	7310	7780	8220	8650	—	—	—	—	—	
18R22.5	H	16	—	—	—	7310	7780	8220	8650	9070	9470	9860	—	—	—
18R22.5	J	18	—	—	—	7310	7780	8220	8650	9070	9470	9860	10240	10610	10970

Table 10, Tire Load Limits, Radial Ply Wide Base Tires, Front Axle (Maximum Speed of 60 mph [97 km/h])

Variations in Load and Inflation Limits According to Speed				
Speed Range mph (km/h)	Inflation Pressure Increase		Percent Increase/(Decrease) In Load	
	Bias Ply Tires psi (kPa)	Radial Ply Tires psi (kPa)	Regular Width Tires	Wide Base Tires
71–75 (114–120)	10 (69)*	10 (69)*	(10)	(10)
61–70 (98–112)	10 (69)*	10 (69)*	0	0
51–60 (82–96)	0	0	0	0
41–50 (66–80)	0	0	9	7
31–40 (50–64)	0	0	16	9
21–30 (34–48)	0	10 (69)*	24	12
11–20 (18–32)	0	15 (103)*	32	17

* Not to exceed the maximum rim or wheel capacity specified by the manufacturer of the rim or wheel.

Table 11, Variations in Load and Inflation Limits According to Speed

Tire Load Limits, Michelin Radial Ply Tires, Tube-Type and Tubeless, Front Axle															
Size	Load Range	Ply Rating	Maximum Tire Loads (lbs) at Various Cold Inflation Pressures												
			55 psi	60 psi	65 psi	70 psi	75 psi	80 psi	85 psi	90 psi	95 psi	100 psi	105 psi	110 psi	115 psi	120 psi
8.25R20X	E	10	2860	3090	3317	3502	3700	3912	4050	—	—	—	—	—	—	—
8.25R20X	F	12	2860	3090	3317	3502	3700	3912	4050	4307	4500	—	—	—	—	—
9.00R20X	F	12	—	—	—	—	4255	4490	4725	4963	5150	—	—	—	—	—
9.00R20X	G	14	—	—	—	—	4255	4490	4725	4963	5150	5430	5510	—	—	—
9R22.5X	E	10	2860	3090	3317	3502	3700	3912	4050	—	—	—	—	—	—	—
9R22.5X	F	12	2860	3090	3317	3502	3700	3912	4050	4307	4500	—	—	—	—	—
10.00R20X	G	14	—	—	—	—	4693	4950	5215	5470	5755	6040	—	—	—	—
10.00R20X	H	16	—	—	—	—	4693	4950	5215	5470	5755	6040	6245	6428	6610	—
10.00R22X	F	12	—	—	—	—	4960	5235	5513	5780	—	—	—	—	—	—
10.00R22X	G	14	—	—	—	—	4960	5235	5513	5780	6105	6430	—	—	—	—
10R22.5X	F	12	—	—	—	—	4255	4490	4725	4963	5150	—	—	—	—	—
10R22.5X	G	14	—	—	—	—	4255	4490	4725	4963	5150	5430	5510	—	—	—
11.00R20X	G	14	—	—	—	—	4958	5235	5513	5705	6055	6295	6590	—	—	—
11.00R20X	H	16	—	—	—	—	4958	5235	5513	5705	6055	6295	6590	6835	7200	—
11.00R22X	G	14	—	—	—	—	5265	5555	5845	6120	6435	6720	—	—	—	—
11.00R22X	H	16	—	—	—	—	5265	5555	5845	6120	6435	6720	7000	7238	7400	—
11R22.5X	G	14	—	—	—	—	4693	4950	5215	5470	5755	6040	—	—	—	—
11R22.5X	H	16	—	—	—	—	4693	4950	5215	5470	5755	6040	6245	6428	6610	—
11.00R24X	H	16	—	—	—	—	5638	5953	6268	6560	6890	7165	7500	—	—	—
11R24.5X	F	12	—	—	—	—	4960	5235	5513	5780	—	—	—	—	—	—
11R24.5X	G	14	—	—	—	—	4960	5235	5513	5780	6105	6430	—	—	—	—
12.00R20X	J	18	—	—	—	—	5198	5513	5728	6118	6448	6725	7055	7330	7605	8100
12.00R22X	H	16	—	—	—	—	—	5952	6267	6560	6890	7165	7550	—	—	—
12R22.5X	G	14	—	—	—	—	4958	5235	5513	5705	6055	6295	6590	—	—	—
12R22.5X	H	16	—	—	—	—	4958	5235	5513	5705	6055	6295	6590	6835	7200	—
12.00R24X	J	18	—	—	—	—	—	—	7028	7370	7785	8130	8543	8840	—	—
13.00R20X	J	18	—	—	—	6445	6805	7165	7557	7925	8337	8680	9055	9379	—	—
14.00R20X	J	18	—	—	—	7510	7870	8265	8660	9025	9440	9920	—	—	—	—

Table 12, Tire Load Limits, Michelin Radial Ply Tires, Tube-Type and Tubeless, Front Axle

Specifications

Tire Load Limits, Michelin Radial Ply Tires, Tube-Type and Tubeless, Rear Axle															
Size	Load Range	Ply Rating	Maximum Tire Loads (lbs) at Various Cold Inflation Pressures												
			55 psi	60 psi	65 psi	70 psi	75 psi	80 psi	85 psi	90 psi	95 psi	100 psi	105 psi	110 psi	115 psi	120 psi
8.25R20X	E	10	2610	2840	3113	3261	3473	3671	3830	—	—	—	—	—	—	—
8.25R20X	F	12	2610	2840	3113	3261	3473	3671	3830	4050	4220	—	—	—	—	—
9.00R20X	F	12	—	—	—	—	3914	4130	4349	4566	4740	—	—	—	—	—
9.00R20X	G	14	—	—	—	—	3914	4130	4349	4566	4740	4995	5080	—	—	—
9R22.5X	E	10	2610	2840	3113	3261	3473	3671	3830	—	—	—	—	—	—	—
9R22.5X	F	12	2610	2840	3113	3261	3473	3671	3830	4050	4220	—	—	—	—	—
10.00R20X	G	14	—	—	—	—	4224	4550	4693	4923	5180	5440	—	—	—	—
10.00R20X	H	16	—	—	—	—	4224	4550	4693	4923	5180	5440	5620	5880	5950	—
10.00R22X	F	12	—	—	—	—	4534	4740	4976	5200	—	—	—	—	—	—
10.00R22X	G	14	—	—	—	—	4534	4740	4976	5200	5495	5790	—	—	—	—
10R22.5X	F	12	—	—	—	—	3914	4130	4349	4566	4740	—	—	—	—	—
10R22.5X	G	14	—	—	—	—	3914	4130	4349	4566	4740	4995	5080	—	—	—
11.00R20X	G	14	—	—	—	—	4390	4635	4880	5130	5361	5575	6000	—	—	—
11.00R20X	H	16	—	—	—	—	4390	4635	4880	5130	5361	5575	6000	6055	6360	—
11.00R22X	G	14	—	—	—	—	4788	5043	5303	5544	5806	6060	—	—	—	—
11.00R22X	H	16	—	—	—	—	4788	5043	5303	5544	5806	6060	6300	6489	6650	—
11R22.5X	G	14	—	—	—	—	4224	4550	4693	4923	5180	5440	—	—	—	—
11R22.5X	H	16	—	—	—	—	4224	4550	4693	4923	5180	5440	5620	5880	5950	—
11.00R24X	H	16	—	—	—	—	5075	5346	5623	5878	6166	6408	6750	—	—	—
11R24.5X	F	12	—	—	—	—	4534	4740	4976	5200	—	—	—	—	—	—
11R24.5X	G	14	—	—	—	—	4534	4740	4976	5200	5495	5790	—	—	—	—
12.00R20X	J	18	—	—	—	—	4629	4905	5181	5435	5725	5966	6255	6500	6755	7160
12.00R22X	H	16	—	—	—	—	—	5346	5642	5912	6221	6462	6800	—	—	—
12R22.5X	G	14	—	—	—	—	4390	4635	4880	5130	5361	5575	6000	—	—	—
12R22.5X	H	16	—	—	—	—	4390	4635	4880	5130	5361	5575	6000	6055	6360	—
12.00R24X	J	18	—	—	—	—	—	—	6325	6635	7006	7316	7689	7950	—	—
13.00R20X	J	18	—	—	—	5800	6125	6448	6802	7132	7503	7812	8150	8450	—	—
14.00R20X	J	18	—	—	—	6757	7085	7440	7795	8122	8472	8900	—	—	—	—

Table 13, Tire Load Limits, Michelin Radial Ply Tires, Tube-Type and Tubeless, Rear Axle

Specifications

Tire Load Limits, Michelin Pilote X Radial Ply Tires, Tube-Type and Tubeless, Front Axle														
Size	Load Range	Ply Rating	Maximum Tire Loads (lbs) at Various Cold Inflation Pressures											
			60 psi	65 psi	70 psi	75 psi	80 psi	85 psi	90 psi	95 psi	100 psi	105 psi	110 psi	115 psi	120 psi
255/70R22.5	G	14	3173	3385	3598	3810	4023	4235	4448	4653	4805	4940	—	—	—
275/80R22.5	G	14	—	—	4560	4825	5090	5365	5625	5920	6175	—	—	—	—
275/80R24.5	G	14	—	—	4560	4825	5090	5365	5625	5920	6175	—	—	—	—
13/75R22.5	J	18	—	—	—	—	—	6043	6367	6682	6818	7308	7609	8000	—
13/80R20	J	18	—	—	—	—	5688	5995	6283	6610	6880	7210	7500	8000	—
14/80R20	J	18	—	—	—	—	—	6710	7020	7393	7700	8038	8393	8873	9040

Table 14, Tire Load Limits, Michelin Pilote X Radial Ply Tires, Tube-Type and Tubeless, Front Axle

Tire Load Limits, Michelin Pilote X Radial Ply Tires, Tube-Type and Tubeless, Rear Axle														
Size	Load Range	Ply Rating	Maximum Tire Loads (lbs) at Various Cold Inflation Pressures											
			60 psi	65 psi	70 psi	75 psi	80 psi	85 psi	90 psi	95 psi	100 psi	105 psi	110 psi	115 psi	120 psi
255/70R22.5	G	14	2943	3135	3329	3522	3713	3905	4096	4280	4420	4540	—	—	—
275/80R22.5	G	14	—	—	4113	4350	4588	4833	5070	5335	5675	—	—	—	—
275/80R24.5	G	14	—	—	4113	4350	4588	4833	5070	5335	5675	—	—	—	—
13/75R22.5	J	18	—	—	—	—	—	5417	5707	5990	6247	6552	6822	7160	—
13/80R20	J	18	—	—	—	—	5122	5512	5792	6075	6355	6625	6907	7160	—
14/80R20	J	18	—	—	—	—	—	6045	6325	6660	6937	7242	7562	7992	8140

Table 15, Tire Load Limits, Michelin Pilote X Radial Ply Tires, Tube-Type and Tubeless, Rear Axle

Disc-Type Wheel Fastener Torques			
Description	Nut Size	Wheel Manufacturer	Torque (dry threads) lbf·ft (N·m)
8-Hole Disc Wheel With Two-Piece Flange Nuts			
Front and Rear Wheel Nut	M22 x 1.5	All	450–500 (610–678)*
10-Hole Disc Wheel With Two-Piece Flange Nuts			
Front and Rear Wheel Nut	M22 x 1.5	All	450–500 (610–678)*
10-Hole Disc Wheel With Inner and Outer Nuts			
Front Wheel Nut	1-1/8–16	Alcoa	400–500 (540–678)†
		Budd	450–500 (610–678)‡
		Firestone and Motor Wheel	450–500 (610–678)
Rear Wheel Inner Nut	3/4–16	Alcoa	400–500 (540–678)†
		Budd, Firestone, and Motor Wheel	450–500 (610–678)

Specifications

Disc-Type Wheel Fastener Torques			
Description	**Nut Size**	**Wheel Manufacturer**	**Torque (dry threads) lbf·ft (N·m)**
Rear Wheel Outer Nut	1-1/8–16	Alcoa	400–500 (540–678)†
		Budd, Firestone, and Motor Wheel	450–500 (610–678)
Wheel Stud Retainer Nut	3/4–16	All	175–200 (235–270)

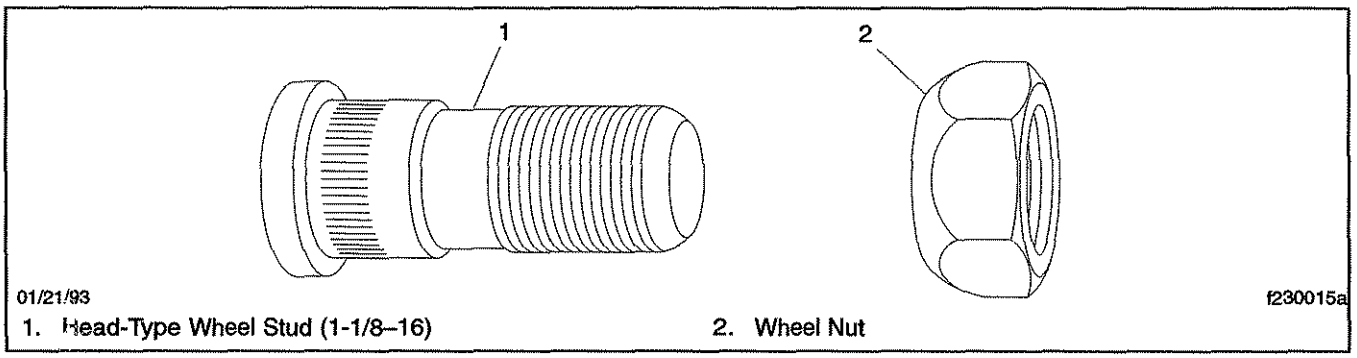
* Torque values are given for lubricated threads.
† Lubricated threads should be tightened 300 to 375 lbf·ft (405 to 510 N·m). Lubricate threads with a mixture of 25 percent colloidal graphite in cup grease or equivalent. Do not apply thread lubricant to ball seats of the nuts and wheels. Wipe it off if it is applied accidentally.
‡ On 1–1/8-16 size wheel studs with a head (**Fig. 1**), tighten the wheel nuts 650 to 750 lbf·ft (990 to 1020 N·m).

Table 16, Disc-Type Wheel Fastener Torques

Spoke-Type Wheel Mounting Torque			
Description	**Nut Size**	**Manufacturer**	**Dry Threads lbf·ft (N·m)**
Front Wheel Nut, 5 and 6 Spoke	5/8–11	Dayton and Gunite	160–175 (215–235)
		Webb	150–175 (205–235)
	3/4–10	Dayton	240–260 (325–355)
		Gunite	200–225 (270–305)*
		Webb	200–250 (270–340)
Rear Wheel Nut, 5 and 6 Spoke	5/8–11	Dayton and Gunite	160–175 (215–235)
		Webb	150–175 (205–235)
	3/4–10	Dayton	190–210 (260–285)†
		Gunite	200–225 (270–305)
		Webb	200–250 (270–340)

* On front axles with over 12,000 lb (5448 kg) capacity, tighten nuts 240 to 265 lbf·ft (325 to 360 N·m). Gunite part number W-854 nut, with a phosphate and oil coating, must be used.
† 190 to 210 lbf·ft (260 to 285 N·m) recommended when using channel spacers (**Fig. 2**). 240 to 260 lbf·ft (325 to 355 N·m) permitted when using corrugated or corrugated-channel spacers. See **Fig. 3**.

Table 17, Spoke-Type Wheel Mounting Torque



1. Head-Type Wheel Stud (1-1/8–16)
2. Wheel Nut

Fig. 1, Head-Type Wheel Stud

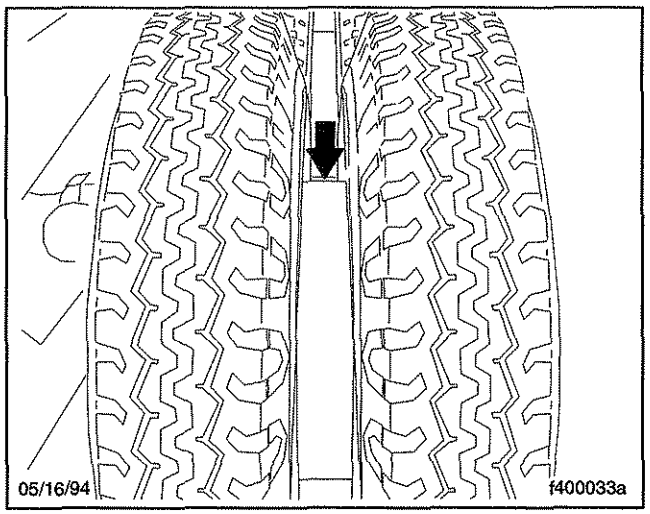


Fig. 2, Channel Spacer

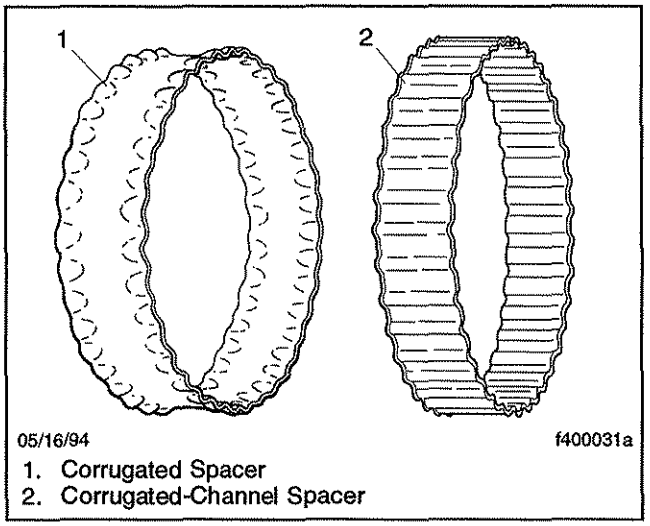


Fig. 3, Corrugated and Corrugated-Channel Spacers

Group Index, Alphabetical

Section	Section Number
Driveline Angularity and Balance	41.01
Driveline Components	41.00

Contents

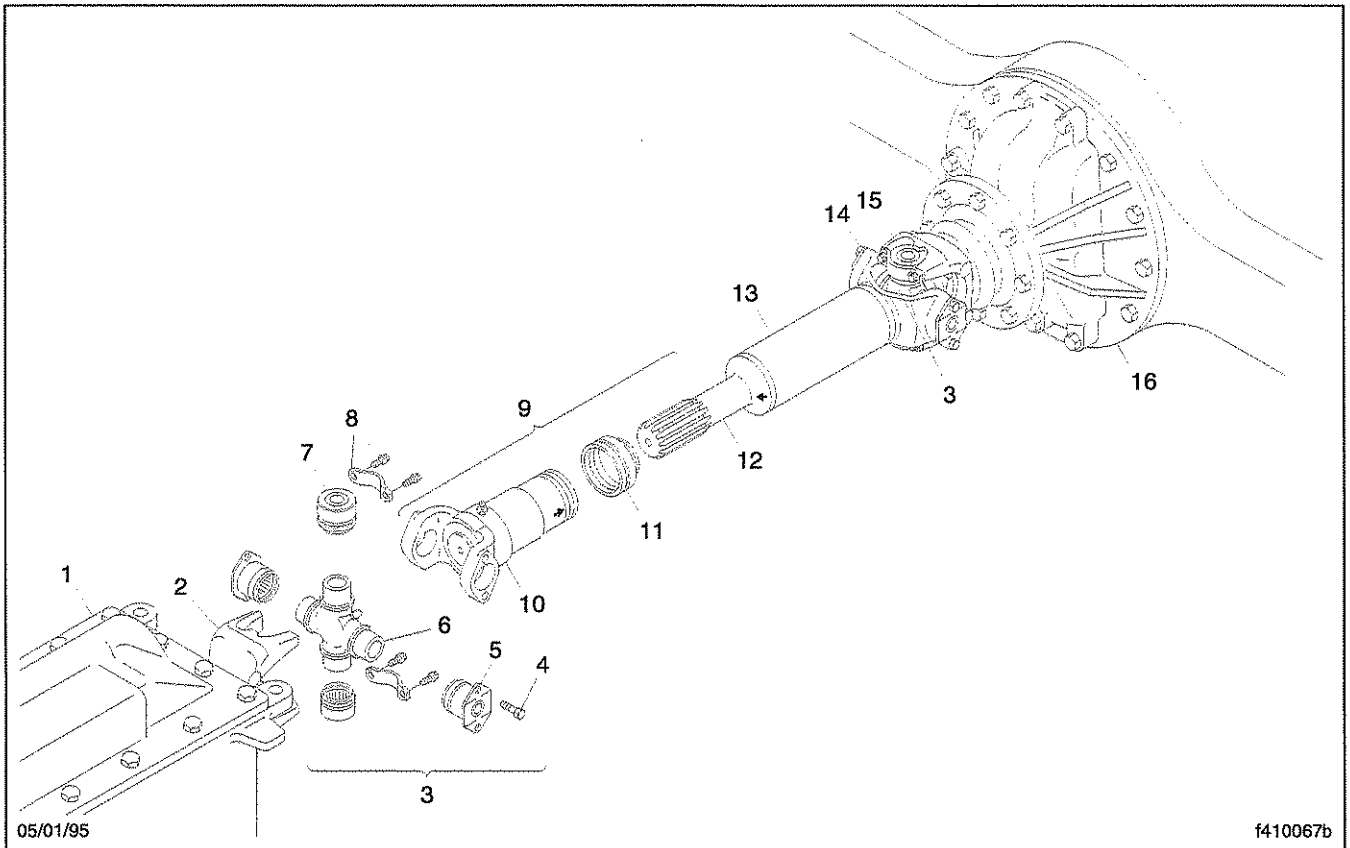
Subject	Subject Number
General Information	050
Service Operations	
U-Joint Uncoupling and Coupling With a Half-Round End-Yoke	100
U-Joint Uncoupling and Coupling With a Full-Round End-Yoke	110
Driveshaft Removal and Installation	120
Driveline Component Removal/Disassembly	130
Driveline Component Cleaning and Inspection	140
Driveline Component Replacement or Installation/Assembly	150
Troubleshooting	300
Specifications	400

General Information

The simplest driveline consists of a transmission output-shaft end-yoke, an axle input-shaft end-yoke, and a single slip-jointed driveshaft connecting the two end-yokes. See **Fig. 1.** The driveshaft is made up of a universal joint (U-joint), a sleeve-yoke, a splined stub shaft, a driveshaft tube, a tube-yoke, and a second U-joint.

DRIVELINE CONFIGURATIONS

The specific type and number of drivelines used on each vehicle depends on its number of transmissions, its number of drive axles, and its wheelbase. See **Fig. 2.** A driveline is used between each driving and driven component. A driveline connecting a main transmission (or an auxiliary transmission) to a single drive axle or forward-rear axle of a dual-drive vehicle is always referred to as a No. 2 driveline. See **Fig. 2**, examples A, B, C, D, and E. An interaxle driveline of a dual-drive vehicle is always called a No. 3 driveline. See **Fig. 2**, examples B and C. A driveline connecting



NOTE: Not all fasteners are shown.

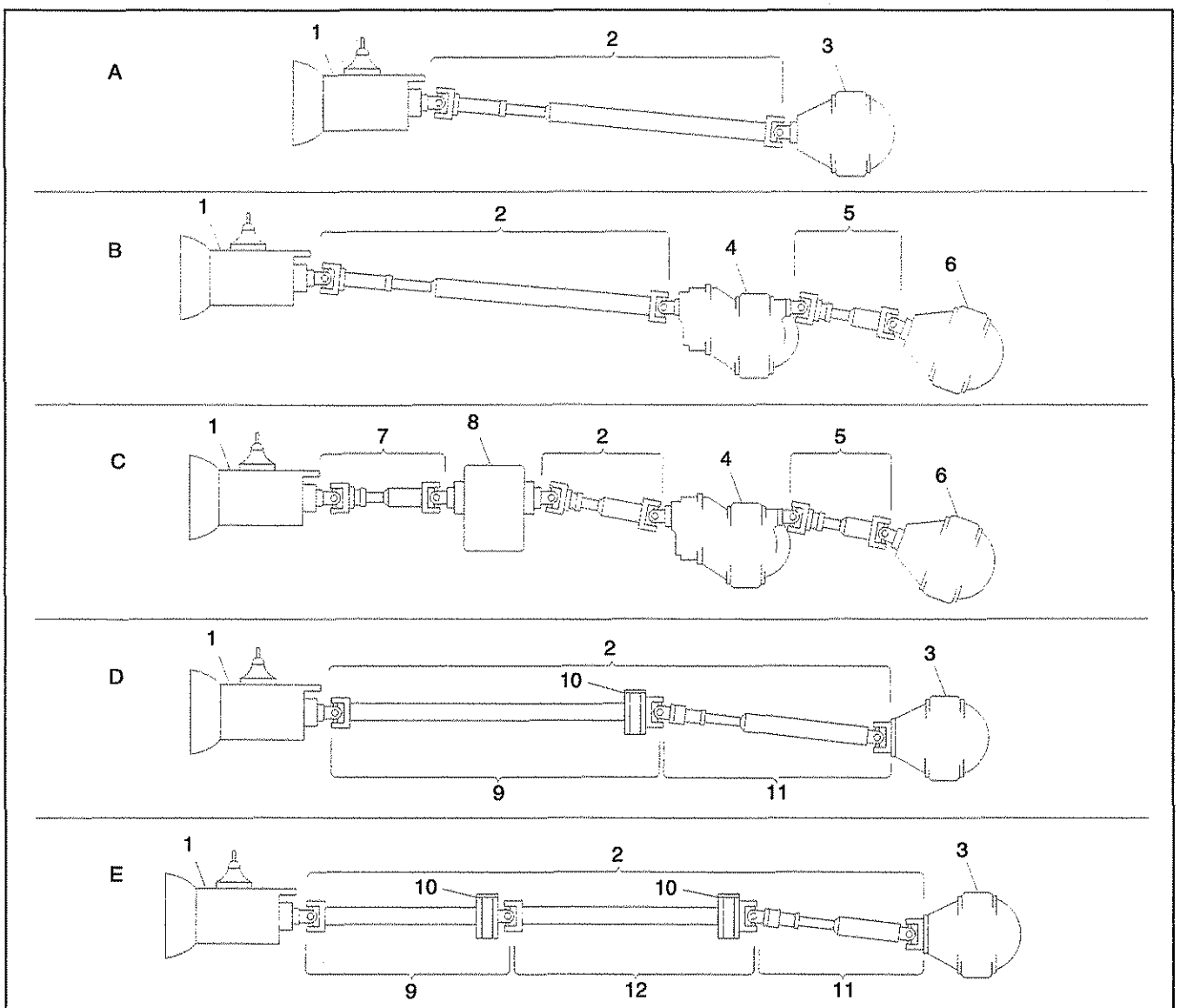
1. Transmission
2. Transmission Output-Shaft End-Yoke (half-round)
3. U-Joint Assembly
4. Bearing Plate Self-Locking Capscrew
5. Bearing Cup (for full-round yoke)
6. U-Joint Cross
7. Bearing Cup (for half-round yoke)
8. Bearing Strap and Bearing-Strap Capscrew
9. Slip-Joint Assembly
10. Sleeve-Yoke (full-round)
11. Dust Cap
12. Splined Stub Shaft
13. Driveshaft Tube
14. Tube-Yoke (full-round)
15. Axle Input-Shaft End-Yoke (half-round)
16. Rear Axle

Fig. 1, Components of a Basic Driveline

General Information

a main transmission to an auxiliary transmission is always referred to as a No. 1 driveline. See **Fig. 2**, example C.

A long driveshaft, supported only at its ends, will sag in the middle from its own weight. When turning at high rpm, it will flex, causing an out-of-balance vibration. Therefore, vehicles having a long wheelbase use a midship bearing, mounted on a frame crossmember, for additional support. See **Fig. 2**, example D. This allows the No. 2 driveline to be separated into two,



1. Main Transmission
2. No. 2 Driveline
3. Rear Axle
4. Forward-Rear Axle
5. No. 3 Driveline
6. Rearmost Axle
7. No. 1 Driveline
8. Auxiliary Transmission
9. Primary Coupling Shaft
10. Midship Bearing
11. No. 2 Driveshaft
12. Intermediate Coupling Shaft

Fig. 2, Driveline Configurations

shorter shafts (a coupling shaft and a No. 2 driveshaft), thus improving balance and stability.

Vehicles having an even longer wheelbase use two crossmember-mounted midship bearings, allowing the No. 2 driveline to be separated into three short shafts, joined by four U-joints. See **Fig. 2**, example E. The first shaft is the primary coupling shaft, the second is the intermediate coupling shaft, and the third is the No. 2 driveshaft.

SLIP-JOINTS, U-JOINTS, AND YOKES

The basic function of the driveline is to send torque from the transmission to the axle in a smooth and continuous action. Because the vehicle axles are not attached directly to the frame, but are suspended by springs, they ride in an irregular, floating motion (when going over bumps or depressions), thus changing the distance between the transmission (or coupling shaft) and the rear axle, and the distance between the rear axles. The slip-joints of the No. 2 and No. 3 driveshafts, by expanding and contracting, allow for length changes between drivetrain components. Coupling shafts do not require a slip-joint.

Motion of the rear axle(s) also causes changes to the relative angles between drivetrain components. U-joints allow transfer of torque from an output shaft (or coupling shaft) to the driveshaft, and from the driveshaft to an input shaft, even though the angles between the shafts may be constantly changing.

Each U-joint consists of a cross with a close-tolerance ground cylindrical surface (trunnion) at the end of each of the four arms. Installed on each trunnion is a bearing cup lined with bearing needles. All bearing cups are sealed to retain lubricants, and to prevent entry of foreign material. See **Fig. 3.** In operation, the four bearing cups are held stationary in a pair of yokes, while the U-joint cross pivots on its trunnions.

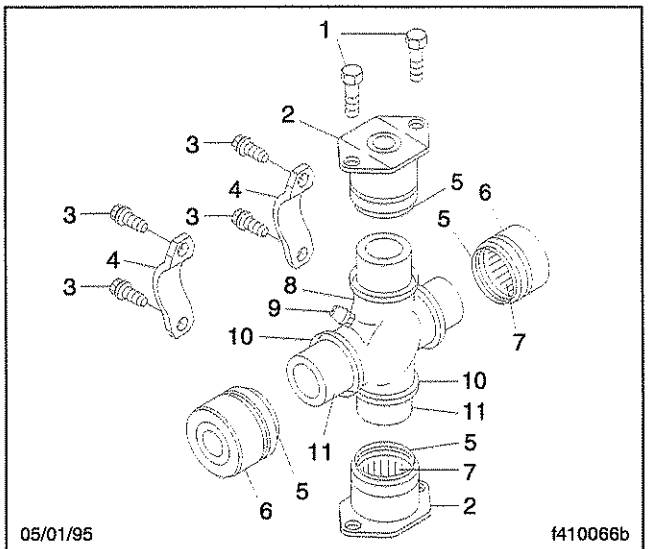
Full-round yokes are installed at the front of coupling shafts and at both ends of the No. 2 and No. 3 driveshafts. All tube-yokes (yokes that are welded into driveshaft tubes) and all sleeve-yokes (yokes that are part of the internally splined half of slip-joints) are full-round yokes. See **Fig. 4**, Refs. 4 and 9.

An end-yoke is an internally splined yoke, held on an externally splined shaft by a locknut. As standard equipment, all No. 2 driveline end-yokes are half-round, with full-round optional. And, as standard equipment, all No. 3 driveline end-yokes are full-round, with half-round optional. End-yokes are installed on the transmission output shaft, on each axle input and output shaft, and behind the midship bearing of most coupling shafts. See **Fig. 4**, Refs. 2, 7, 12, and 14.

Meritor 17T and 18T U-joints are coupled to half-round end-yokes by capscrews inserted through semicircular bearing straps that hold the bearing cups in place under tabs in the yoke cross-holes. See **Fig. 5.**

Meritor RPL Series U-joints are coupled to half-round end-yokes by capscrews inserted through the bearing cups. See **Fig. 6.**

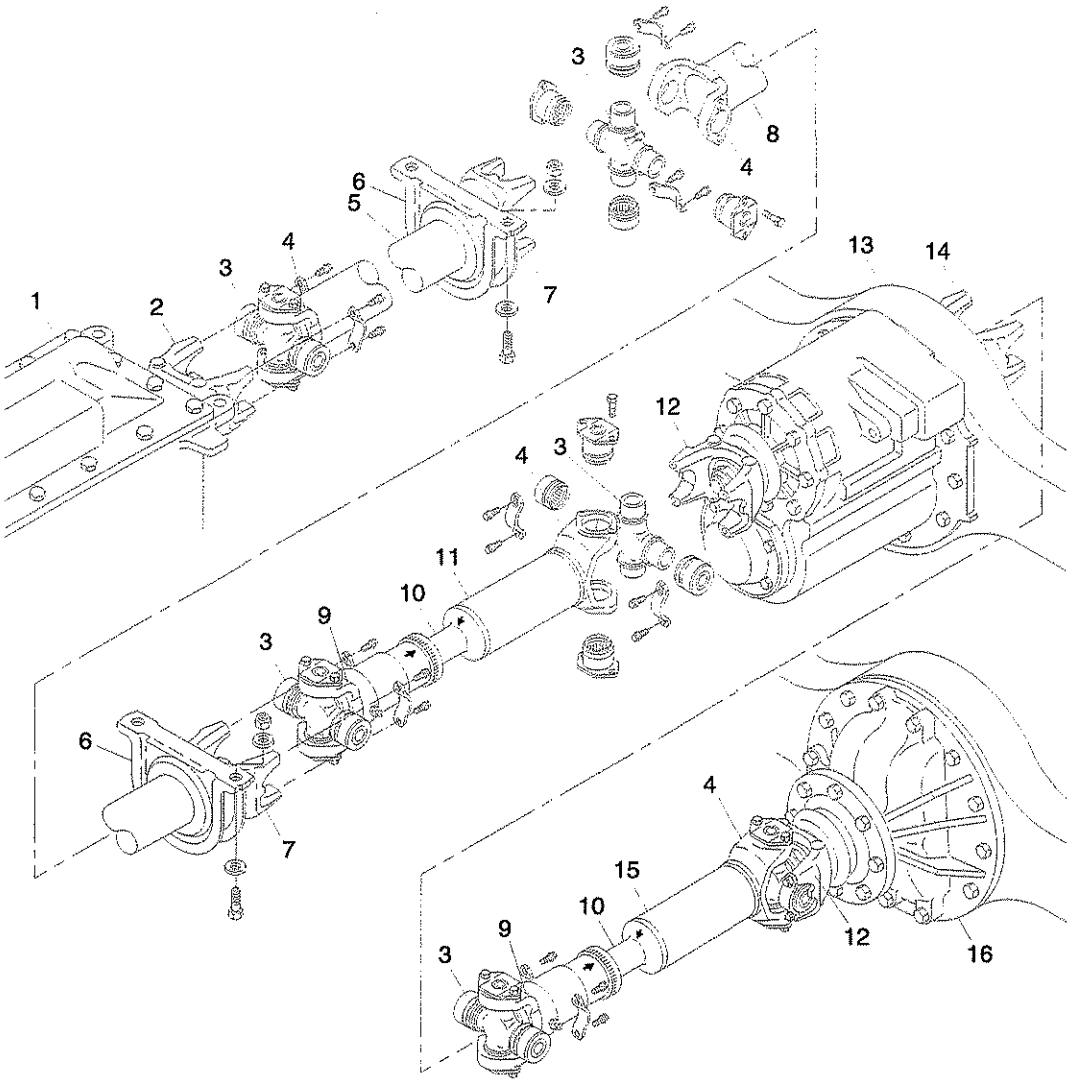
U-joints are installed in full-round tube-yokes, sleeve-yokes, and end-yokes, by inserting the cross through from the inside of both yoke cross-holes, then installing the bearing cups into the outsides of the yoke and over the ends of the trunnions. Snap rings or self-locking capscrews are installed into the yoke to secure the cups. See **Fig. 7.**



1. Bearing-Plate Capscrews
2. Bearing Cup (for full-round yoke)
3. Bearing-Strap Capscrew
4. Bearing Strap
5. Bearing-Cup Seal
6. Bearing Cup (for half-round yoke)
7. Bearing Needles
8. U-Joint Cross
9. Grease Fitting
10. U-Joint Cross Slinger
11. Trunnion

Fig. 3, Typical U-Joint

General Information



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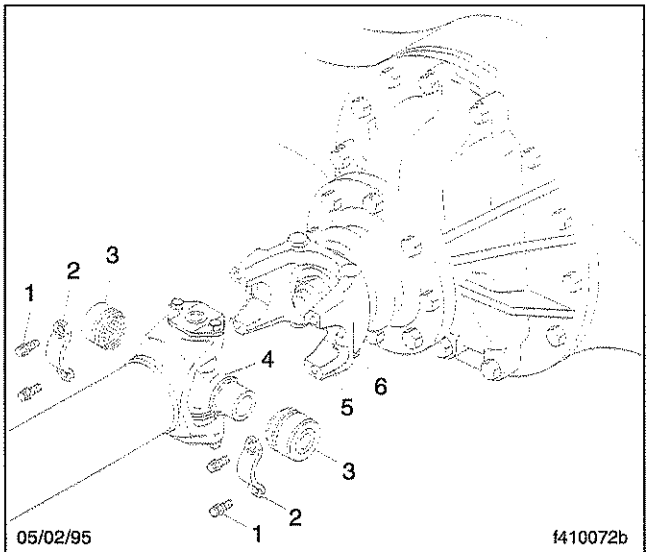
NOTE: Not all fasteners are shown.

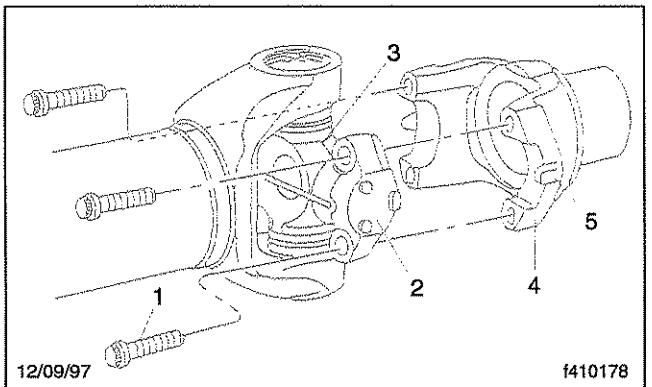
1. Transmission
2. Transmission Output-Shaft End-Yoke (half-round)
3. U-Joint Assembly
4. Full-Round Tube-Yoke
5. Primary Coupling Shaft Tube
6. Midship Bearing Assembly
7. Coupling Shaft End-Yoke (half-round)
8. Intermediate Coupling Shaft Tube
9. Sleeve-Yoke (full-round)
10. Slip-Joint Assembly
11. No. 2 Driveshaft Tube
12. Axle Input-Shaft End-Yoke (half-round)
13. Forward-Rear Axle
14. Axle Output-Shaft End-Yoke (half-round)
15. No. 3 Driveshaft Tube
16. Rearmost Axle

Fig. 4, Dual-Drive Installation With Primary and Intermediate Coupling Shafts



1. Bearing-Strap Capscrew
2. Bearing Strap
3. Bearing Cup
4. U-Joint Cross
5. Half-Round Yoke
6. Yoke Cross-Hole Tab

Fig. 5, Coupling of a U-Joint With a Half-Round End-Yoke



1. Capscrew
2. Bearing Cup
3. U-Joint Cross
4. Half-Round Yoke
5. Yoke Cross-Hole Tab

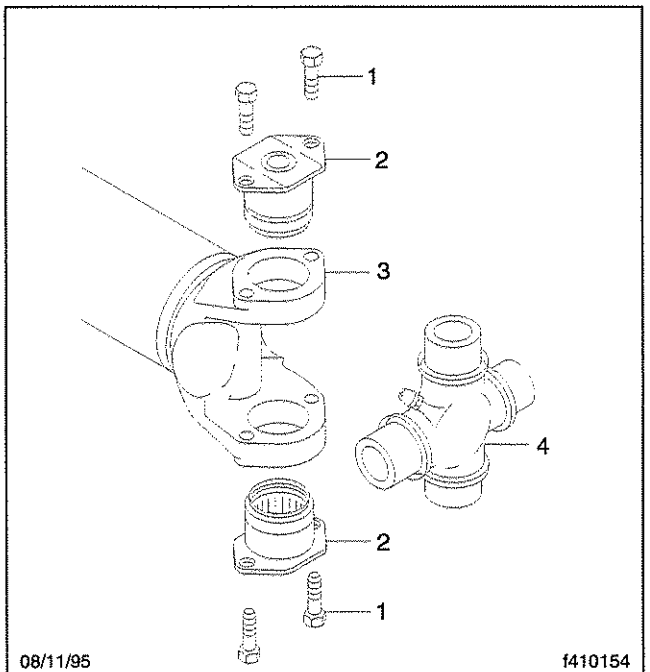
Fig. 6, Coupling of a RPL Series U-Joint

U-JOINT ANGLES, PHASING, AND DRIVELINE BALANCE

Correct U-joint working angles, U-joint phasing, and driveline balance are vital to maintaining a quiet-running drivetrain and long life of drivetrain components (including driveline components).

The U-joint working angle is the angle formed by the intersection of the driveshaft centerline and the extended centerline of the shaft of any component (or other driveshaft) to which the U-joint connects. See **Fig. 8.** Because the double oscillating motion of a U-joint that connects angled shafts causes a fluctuating speed difference between the shafts, the effect created by the U-joint at one end of the shaft must cancel the effect created by the U-joint at the other end. This is done by making U-joint working angles at both ends of the driveshaft approximately equal, with the U-joints in phase. If the yoke lugs at both ends of the shaft are lying in the same plane (a plane which bisects the shaft lengthwise) the U-joints will be in phase. See **Fig. 9.**

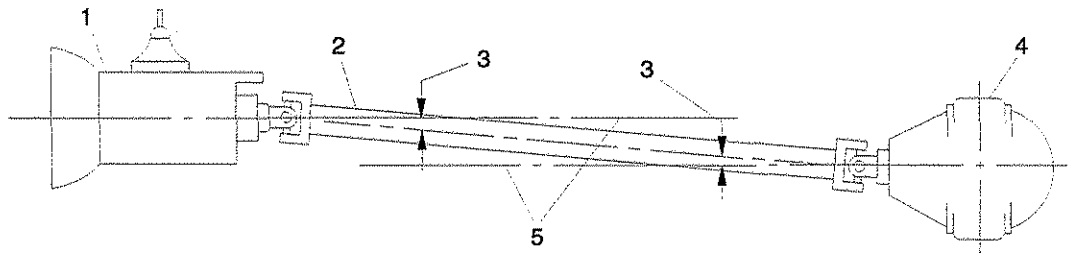
After manufacture, each driveline yoke is statically balanced. After assembly, each driveshaft and coupling shaft is checked for out-of-roundness, straightened as necessary, then dynamically balanced.



1. Bearing-Plate Self-Locking Capscrew
2. Bearing Cup (bearing-plate-type)
3. Full-Round Yoke
4. U-Joint Cross

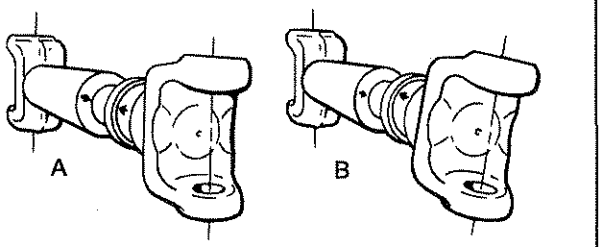
Fig. 7, Installation of a U-Joint in a Full-Round Yoke

General Information



1. Transmission
2. No. 2 Driveshaft
3. U-Joint Working Angles
4. Rear Axle
5. Extended Centerlines

Fig. 8, U-Joint Working Angles



A. In Phase B. Out of Phase

Fig. 9, U-Joint Phasing

AVOIDING DRIVELINE PROBLEMS

To ensure that U-joints turn in phase, sleeve-yokes, splined shafts, coupling shaft end-yokes, and coupling shafts, should be marked for assembly reference before disassembly. A misaligned slip-joint will seriously affect driveline balance (and U-joint phasing). Even if a slip-joint is assembled 180 degrees from its original position (which will keep the U-joints in phase), the dynamic balance of the driveshaft will be negatively affected.

A driveline can become unbalanced or greatly weakened if a driveshaft has been dented, bent, twisted, or otherwise damaged. Operating a vehicle at speeds which exceed the speed of the driveshaft's design specifications will cause an out-of-balance vibration. Any condition which allows excessive movement of a driveshaft will cause driveline imbalance: loose end-yoke nuts, loose midship bearing mounts, loose U-joint bearing cup retaining capscrews, worn U-joint trunnions and bearings, and worn slip-joint splines.

Among the most common causes of U-joint and slip-joint damage is lack of lubrication.

To keep a vehicle operating smoothly and economically, the driveline must be carefully checked and lubricated at regular intervals. For inspection and lubrication intervals and procedures, see **Group 41** of the *Century Class Trucks Maintenance Manual.*

U-Joint Uncoupling and Coupling With a Half-Round End-Yoke

U-Joint Uncoupling (See Fig. 1and Fig. 2)

NOTE: It is easier to check driveline parts, and to replace a U-joint or midship bearing assembly if the driveshaft is removed from the vehicle. If a driveshaft requires straightening or balancing, it must be removed, and installed on a lathe or a balance machine. Removal is required for replacement of slip-joint parts, a driveshaft tube, or a tube-yoke. To remove the driveshaft, see **Subject 120**.

NOTE: Many service operations do not require driveshaft removal from the vehicle: end-yoke nut tightening; drive component shaft seal or end-yoke replacement; changing U-joint phasing at the slip-yoke; and transmission or axle removal (for overhaul, repair, or replacement). To perform these operations, uncouple the U-joint at the applicable end of the appropriate driveshaft.

1. Roll the vehicle forward or backward as needed to turn the rearmost end-yoke (of the driveline that is being uncoupled) until the centerline through its cross-holes is horizontal. See **Fig. 1**, Ref. A and Ref. B.
2. Apply the parking brakes, and chock the tires.
3. If the half-round bearing cups do not already have a retaining wire installed, install a bearing-cup retaining wire. See **Fig. 1**, Ref. C. Or, install safety wire from the retaining-wire groove of one half-round bearing cup to the other.
4. Support the driveshaft with a nylon support strap.

   When uncoupling a coupling shaft, install two or three support straps, as needed. Remove the fasteners that attach the midship bearing(s) to its bracket(s). See **Fig. 1** and **Fig. 2.**
5. Remove the capscrews that secure the bearing cups or straps to the half-round yoke. Remove the bearing straps, if equipped.
6. Compress the slip-joint to remove the U-joint from the yoke.

⚠ CAUTION

Do not expose the U-joint trunnions or bearing-cup needles to dirt or grit. The smallest bits of dirt or grit can cause rapid wear and serious damage to the U-joint.

U-Joint Coupling (See Fig. 1and Fig. 2)

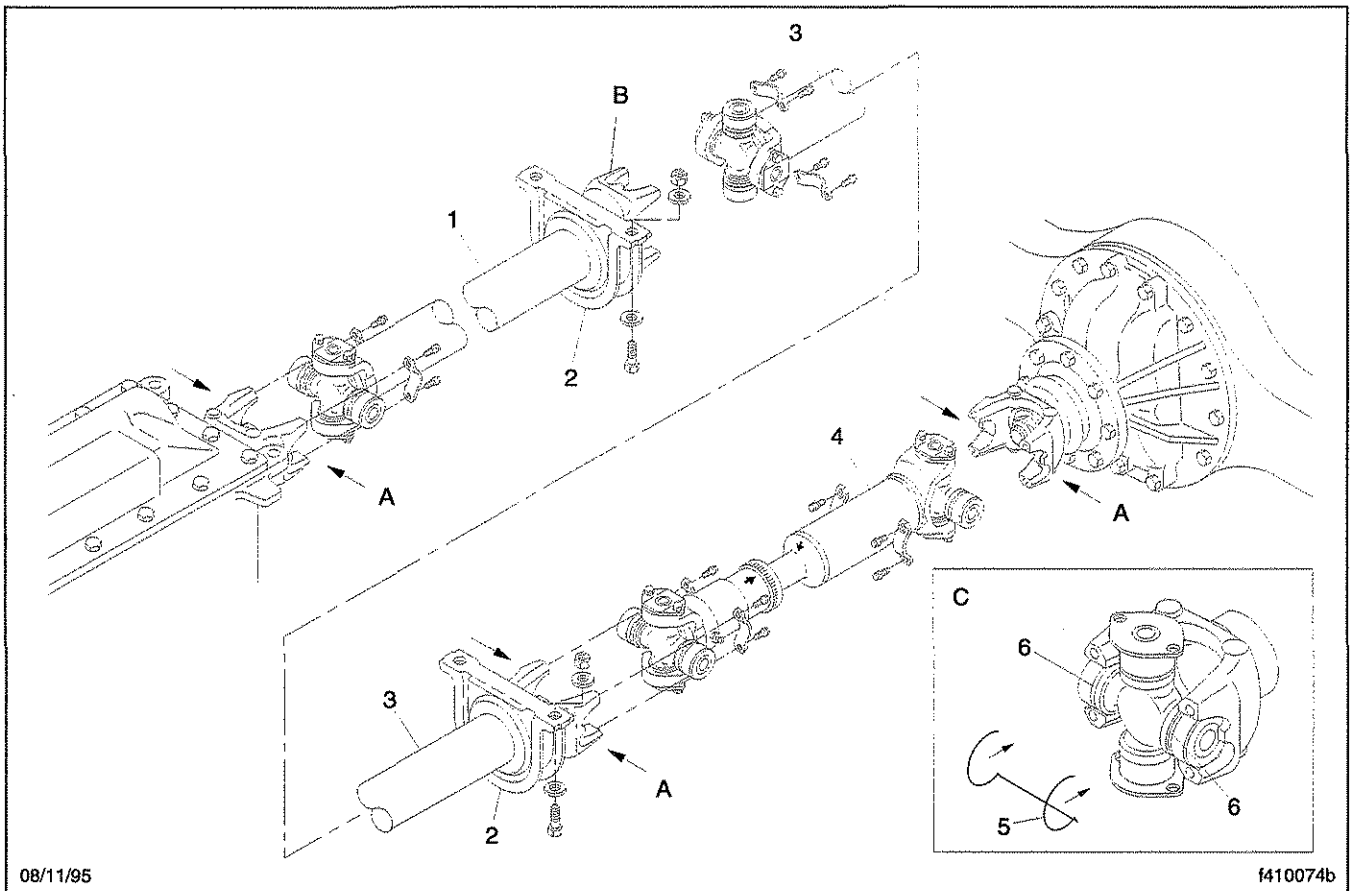
1. Check and clean the end-yoke.
   - 1.1 Check the torque on the end-yoke nut. See **Specifications, 400**.
   - 1.2 Check the end-yoke cross-holes for burrs or raised metal. Using a half-round file, remove burrs or raised metal. See **Fig. 3.**
   - 1.3 Using fine emery cloth, smooth and clean the entire surface of the yoke cross-holes and bearing straps. See **Fig. 4.**
   - 1.4 Turn the end-yoke until its cross-holes are horizontal. See **Fig. 1** and **Fig. 2**.
2. Check, clean, and lubricate the U-joint.
   - 2.1 Remove the bearing-cup retaining wire or safety wire. See **Fig. 1**, Ref. C.

⚠ CAUTION

Do not expose the U-joint trunnions or bearing-cup needles to dirt or grit. The smallest bits of dirt or grit can cause rapid wear and serious damage to the U-joint.

   - 2.2 Using fine emery cloth, smooth and clean the outside surfaces of both bearing cups. See **Fig. 5.**
   - 2.3 Check the U-joint trunnions and bearing cups for minute particles of dirt or grit. Clean if necessary. See **Subject 140**.
   - 2.4 Using NLGI grade 2 grease with EP additives, wipe a small amount of grease on the needles in the bearing cups.
   - 2.5 Using a light-weight oil, lubricate the lips of the bearing-cup seals. See **Fig. 6.**
   - 2.6 Install the bearing cups on the cross.
   - 2.7 Install a bearing-cup retaining wire. See **Fig. 1**, Ref. C. Or, install safety wire from the retaining-wire groove of one half-round bearing cup to the other.

U-Joint Uncoupling and Coupling With a Half-Round End-Yoke



NOTE: Not all fasteners are shown.

A. End-yoke cross-hole centerline is horizontal.
B. Before uncoupling/coupling the U-joint, turn the end-yoke until its cross-hole centerline is horizontal.
C. Install a half-round bearing-cup retaining wire (or safety wire) before removing the bearing straps.

1. Primary Coupling Shaft
2. Midship Bearing
3. Intermediate Coupling Shaft
4. No. 2 Driveshaft
5. Half-Round Bearing-Cup Retaining Wire
6. Retaining-Wire Groove

Fig. 1, U-Joint Uncoupling/Coupling for Drivelines With Half-Round End-Yokes, Except RPL U-Joints

3. Extend the slip-joint, while pressing the cross and bearing cups into place in the yoke cross-holes. Using a rubber or plastic mallet, gently tap the bearing cups to seat them in the yoke. See **Fig. 7.**

⚠ CAUTION

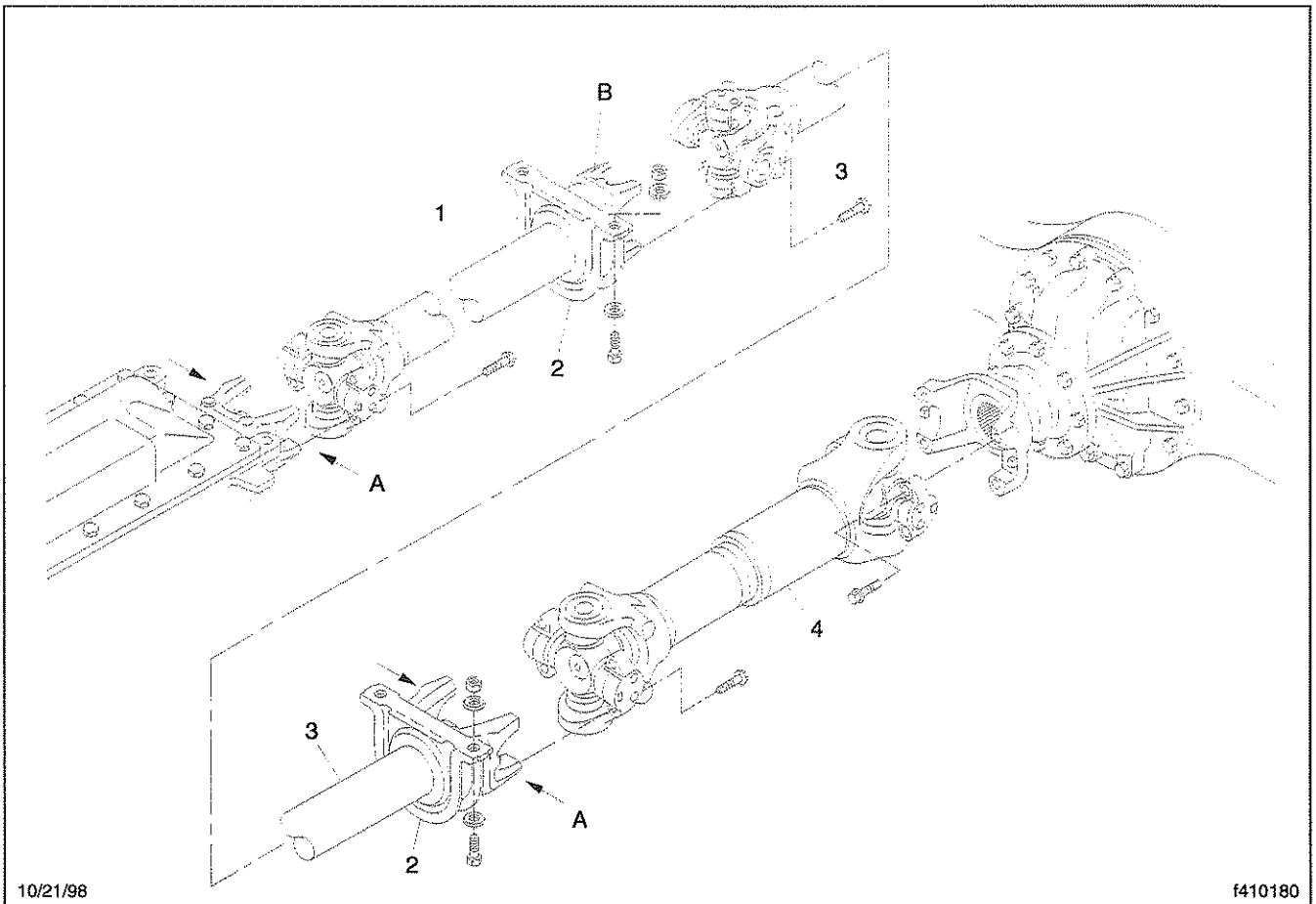
Do not use the capscrews and bearing straps (if equipped) to seat the bearing cups in the yoke. Seating the cross by tightening the bearing straps can deform the bearing straps, allowing the bearing cups to spin, which will cause rapid wear and serious damage to the U-joint.

4. Place the bearing straps (if equipped) over the cups. Install the capscrews, finger-tight.

⚠ WARNING

The self-locking capscrews must not be reused. Replace the capscrews with new ones. Also, do not undertighten or overtighten the capscrews. A loose or broken fastener at any point in the

U-Joint Uncoupling and Coupling With a Half-Round End-Yoke



NOTE: Not all fasteners are shown.

A. End-yoke cross-hole centerline is horizontal.

B. Before uncoupling/coupling the U-joint, turn the end-yoke until its cross-hole centerline is horizontal.

1. Primary Coupling Shaft
2. Midship Bearing
3. Intermediate Coupling Shaft
4. No. 2 Driveshaft

Fig. 2, U-Joint Uncoupling/Coupling for Drivelines With Half-Round End-Yokes, RPL U-Joints

driveline weakens the driveline connection, which could cause serious vehicle damage, or could result in a driveshaft separating from the vehicle. Driveline separation can cause loss of vehicle control that could result in serious personal injury or death.

Separation of the driveline can also cause damage to the driveline, driveline components, or other areas of the vehicle.

5. Alternately tighten the capscrews in increments of 20 lbf·ft (27 N·m) to the applicable torque value in **Specifications, 400**.
6. If they were removed, install the fasteners that attach each midship bearing to its bracket; tighten the flanged locknuts 91 lbf·ft (123 N·m).
7. Lubricate the U-joint, following the procedure in **Group 41** of the *Century Class Trucks Maintenance Manual*.
8. Remove the nylon support straps, then remove the chocks.

U-Joint Uncoupling and Coupling With a Half-Round End-Yoke

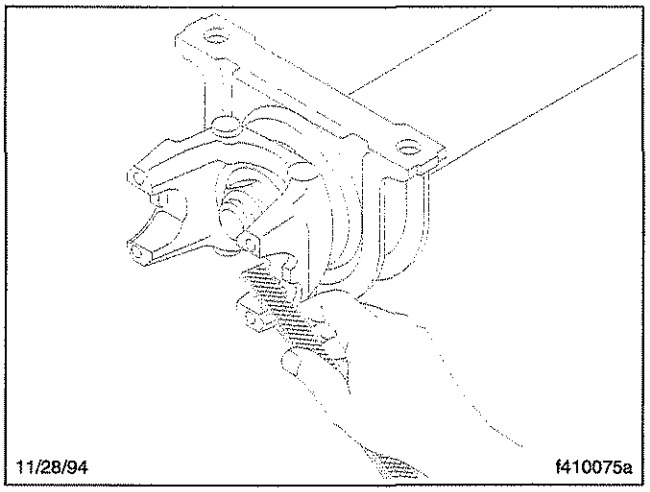
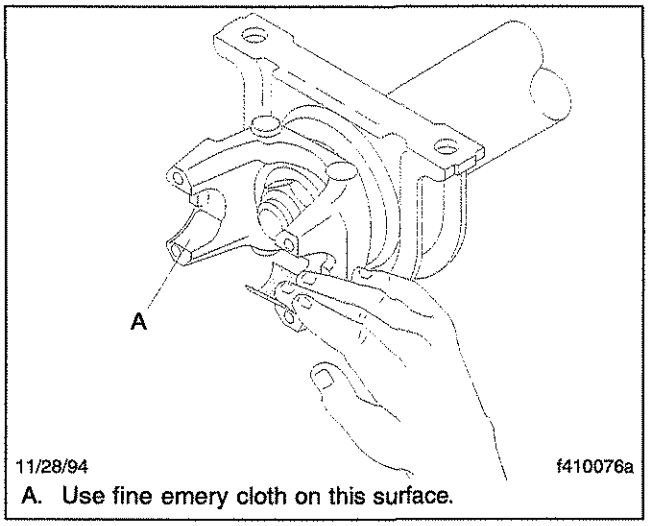
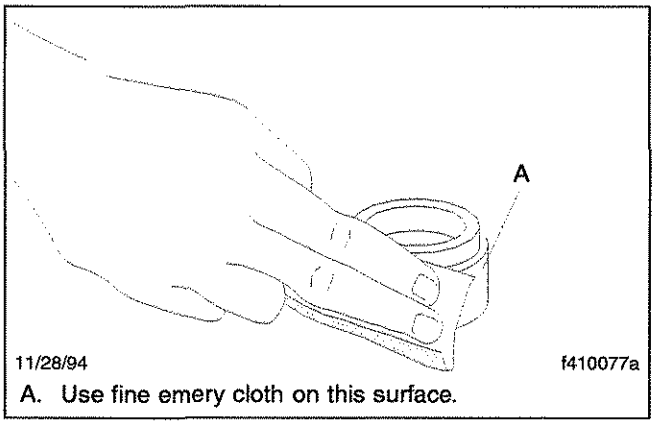


Fig. 3, Remove Burrs from a Half-Round End-Yoke Cross-Hole



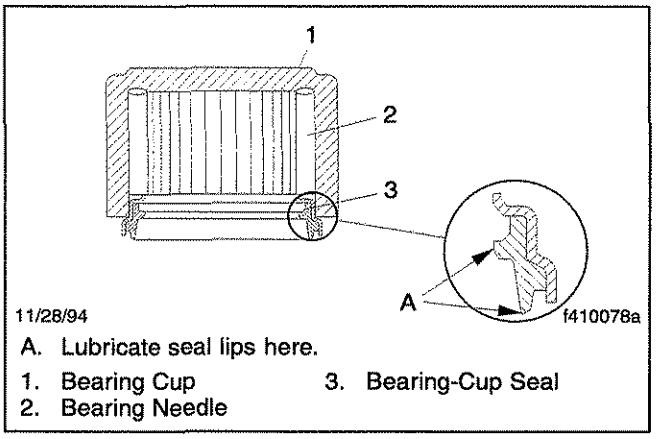
A. Use fine emery cloth on this surface.

Fig. 4, Smooth a Half-Round End-Yoke Cross-Hole



A. Use fine emery cloth on this surface.

Fig. 5, Smooth a Half-Round End-Yoke U-Joint Bearing Cup

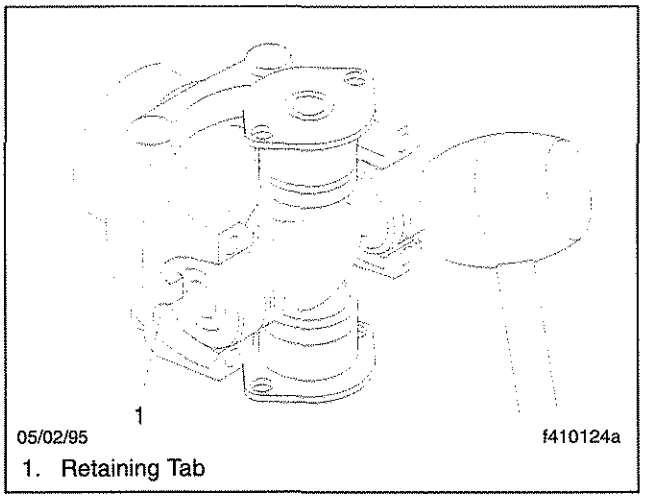


A. Lubricate seal lips here.

1. Bearing Cup
2. Bearing Needle
3. Bearing-Cup Seal

Fig. 6, Sectional View of a Half-Round End-Yoke U-Joint Bearing Cup

U-Joint Uncoupling and Coupling With a Half-Round End-Yoke



1. Retaining Tab

Fig. 7, Seat a U-Joint in a Half-Round End-Yoke

U-Joint Uncoupling and Coupling With a Full-Round End-Yoke

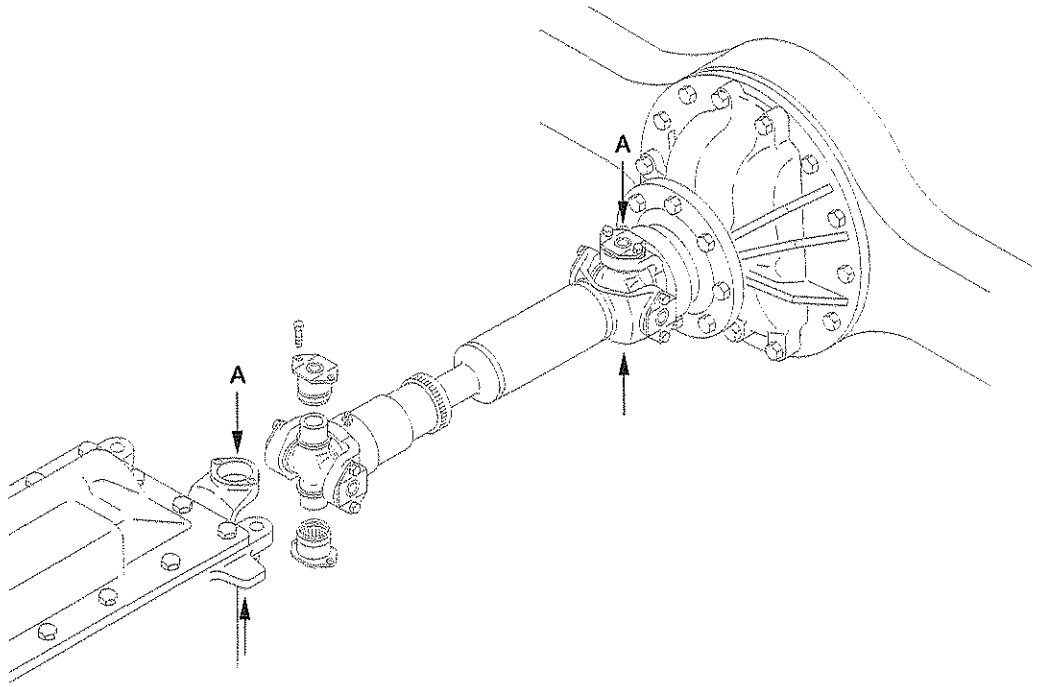
U-Joint Uncoupling (See Fig. 1)

NOTE: It is easier to check driveline parts, and to replace a U-joint or midship bearing assembly if the driveshaft is removed from the vehicle. If a driveshaft requires straightening or balancing, it must be removed, and installed on a lathe or a balance machine. Removal is required for replacement of slip-joint parts, a driveshaft tube, or a tube-yoke. To remove the driveshaft, see **Subject 120**.

NOTE: Many service operations do not require driveshaft removal from the vehicle: end-yoke nut tightening; drive component shaft seal or end-yoke replacement; changing U-joint phasing at the slip-yoke; and transmission or axle removal (for overhaul, repair, or replacement). To perform these operations, uncouple the U-joint at the applicable end of the appropriate driveshaft.

1. Roll the vehicle forward or backward as needed to turn the end-yoke (of the driveline that is being uncoupled) until the centerline through its cross-holes is vertical. See **Fig. 1**.
2. Apply the parking brakes, and chock the tires.
3. Support the driveshaft with a nylon support strap.

   When uncoupling a coupling shaft, install two or three support straps, as needed. Remove the fasteners that attach the midship bearing(s) to its bracket(s).
4. Remove and discard all four bearing-cup-plate self-locking capscrews.
5. Using one of the U-joint pullers listed in **Specifications, 400**, remove both bearing assemblies from the end-yoke cross-holes. See **Fig. 2**.
6. Compress the slip-joint and pivot the end of the U-joint cross to remove it from the yoke. Install the bearing cups on the U-joint cross, and secure them with tape.



NOTE: Not all fasteners are shown.

A. End-yoke cross-hole centerline is vertical.

Fig. 1, U-Joint Uncoupling/Coupling of a Driveline With Full-Round End-Yokes

U-Joint Uncoupling and Coupling With a Full-Round End-Yoke

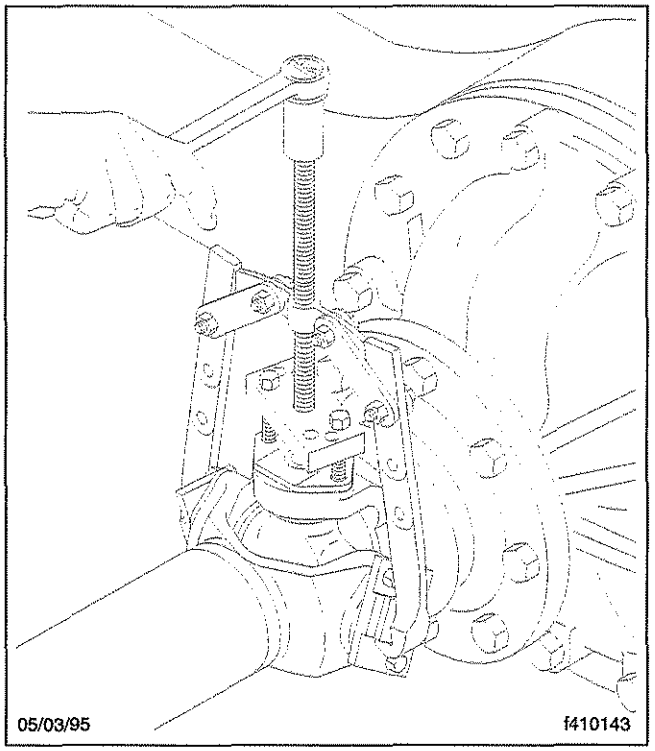


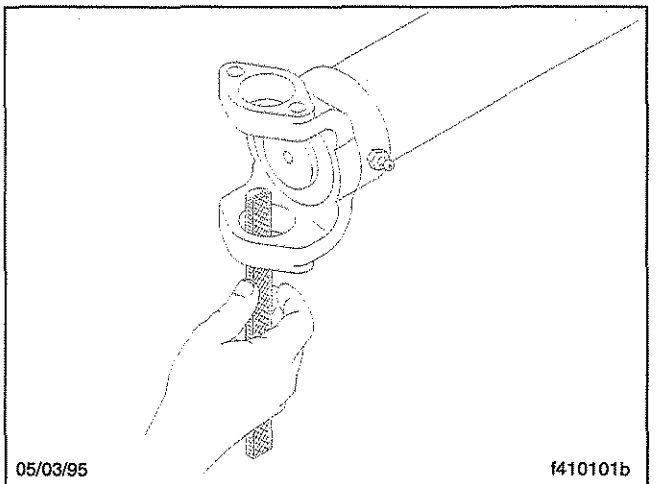
Fig. 2, Remove a Bearing Cup from a Full-Round End-Yoke

⚠ CAUTION

Do not expose the U-joint trunnions or bearing-cup needles to dirt or grit. The smallest bits of dirt or grit can cause rapid wear and serious damage to the U-joint.

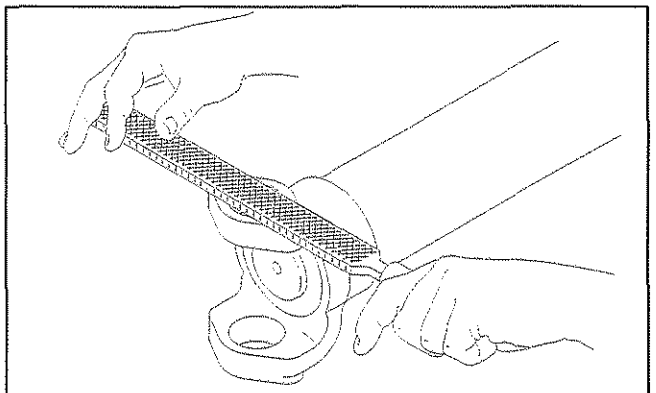
U-Joint Coupling (See Fig. 1)

1. Check and clean the end-yoke.
   - 1.1 Check the torque on the end-yoke nut. See **Specifications, 400.**
   - 1.2 Check the end-yoke cross-holes for burrs or raised metal. Using a rat-tail or half-round file, remove burrs or raised metal. See **Fig. 3.**
   - 1.3 Using a mill file, and holding it flat against the machined surface of the yoke lug, remove any burrs or raised metal. See **Fig. 4.**
   - 1.4 Using fine emery cloth, smooth and clean the entire surface of the yoke cross-holes. See **Fig. 5.**
   - 1.5 Turn the end-yoke until the centerline through its cross-holes is vertical. See **Fig. 1.**
2. Check, clean, and lubricate the U-joint.
   - 2.1 Using fine emery cloth, smooth and clean the outside surfaces of both bearing cups. See **Fig. 6.**



NOTE: Sleeve-yoke shown.

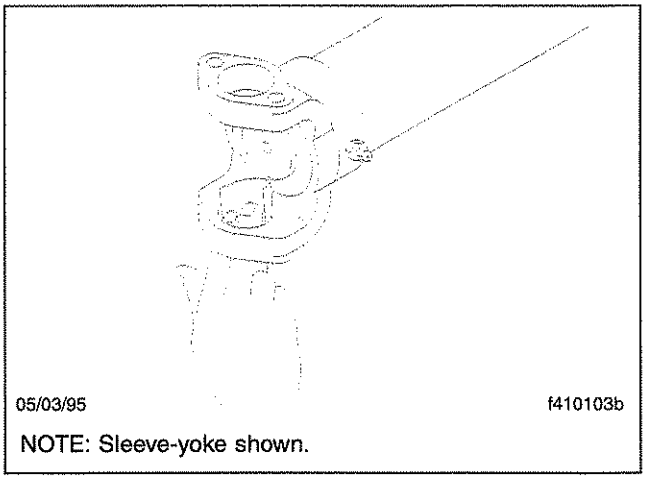
Fig. 3, Remove Burrs from a Full-Round Yoke Cross-Hole



NOTE: Sleeve-yoke shown.

Fig. 4, Remove Burrs from the Machined Surface of a Full-Round Yoke Lug

U-Joint Uncoupling and Coupling With a Full-Round End-Yoke



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NOTE: Sleeve-yoke shown.

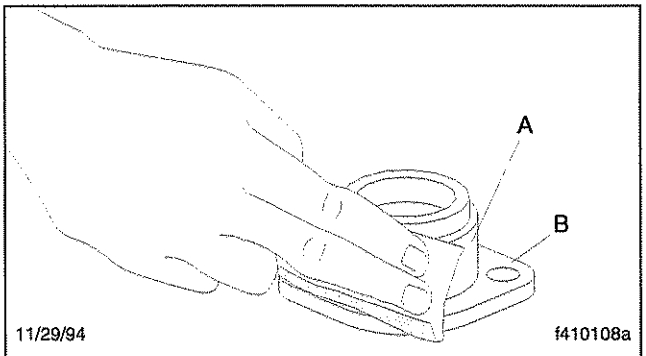
Fig. 5, Smooth a Full-Round Yoke Cross-Hole

2.2 Check the U-joint trunnions and bearing cups for minute particles of dirt or grit. Clean if necessary; see **Subject 140**.

⚠ CAUTION

Do not expose the U-joint trunnions or bearing-cup needles to dirt or grit. The smallest bits of dirt or grit can cause rapid wear and serious damage to the U-joint.

2.3 Using NLGI grade 2 grease with EP additives, wipe a small amount of grease on the needles in the bearing cups.



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A. Use fine emery cloth on this surface.

B. Use a mill file on this surface.

Fig. 6, Smoothing a Full-Round Yoke U-Joint Bearing Cup

2.4 Using a light-weight oil, lubricate the lips of the bearing-cup seals. See **Fig. 7**.

3. Couple the U-joint cross to the end-yoke.

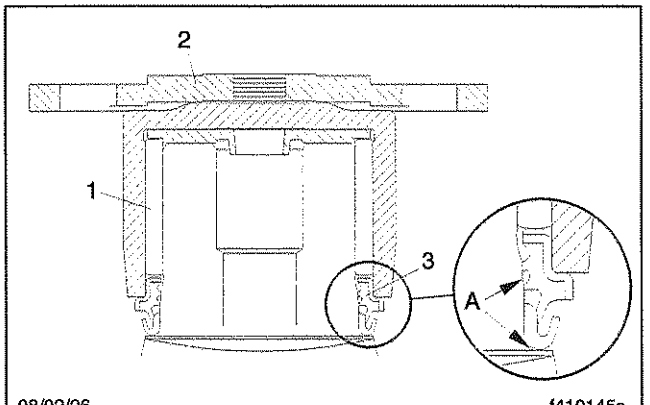
3.1 Extend the slip-joint, while pivoting the U-joint cross into place in the yoke cross-holes.

3.2 Move one end of the cross until a trunnion projects through the cross-hole, beyond the outer machined face of the yoke lug. Using a Spicer trunnion (journal) locator (see **Specifications, 400**), hold the trunnions in alignment with the cross-holes, while placing a bearing assembly over the projected trunnion, and aligning it with the cross-hole. See **Fig. 8**.

IMPORTANT: A Spicer trunnion (journal) locator should be used, to prevent damage to the U-joint trunnions and slingers.

3.3 By hand, press the bearing assembly flush with the face of the yoke. If the bearing assembly binds in the cross-hole, tap the *center* of the bearing plate with a rubber or rawhide mallet; do not tap the outer edges of the bearing plate. See **Fig. 9**.

3.4 Install *new* bearing-cup-plate self-locking capscrews (**Fig. 10**). Tighten the capscrews until all the parts are drawn



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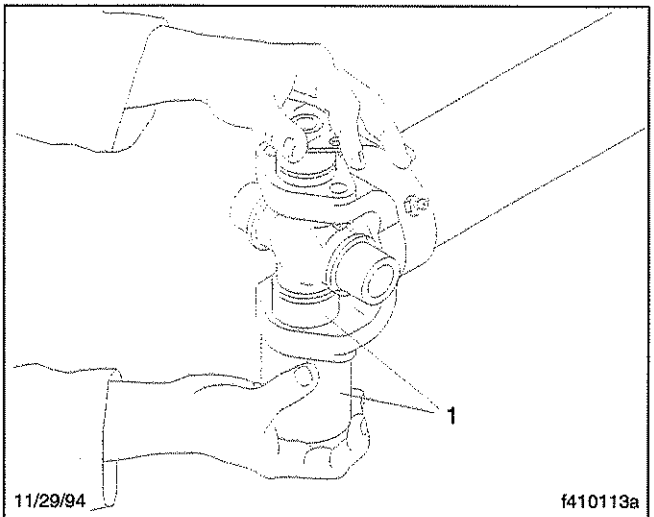
A. Lubricate seal lips here.

1. Bearing Needle
2. Bearing-Cup Plate
3. Bearing-Cup Seal

Fig. 7, Sectional View of a Full-Round Yoke U-Joint Bearing Cup

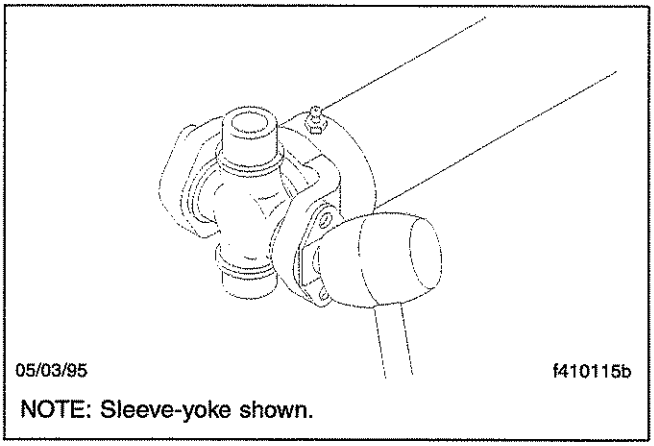
U-Joint Uncoupling and Coupling With a Full-Round End-Yoke



NOTE: Sleeve-yoke shown.

1. Trunnion Locator

Fig. 8, Use a U-Joint Trunnion Locator



NOTE: Sleeve-yoke shown.

Fig. 9, Seat a U-Joint Bearing Cup in a Full-Round Yoke

down tight, with no gaps; do not tighten the capscrews to their final torque value.

⚠ WARNING

Self-locking bearing-cup-plate capscrews must not be reused; replace the capscrews with new ones. Also, do not undertighten or overtighten any bearing-cup-plate capscrews. A loose or broken fastener at any point in the driveline weakens the driveline connection, which could cause serious vehicle damage, or could result in a driveshaft separating from the vehicle, possibly causing loss of vehicle control that could result in serious personal injury or death.

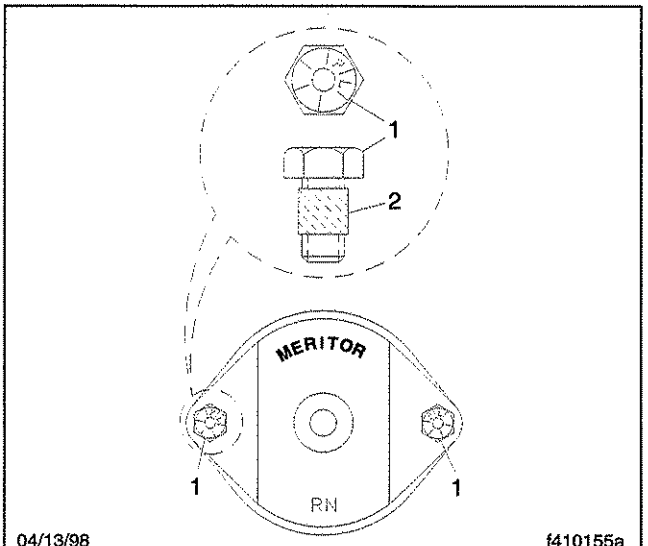
3.5 Move the cross until it projects beyond the machined surface of the opposite yoke lug. Repeat applicable substeps to install the opposite bearing.

3.6 Alternately tighten the bearing-cup-plate capscrews in increments of 5 lbf·ft (7 N·m), to the torque value in **Specifications, 400**.

4. If they were removed, install the fasteners that attach each midship bearing to its bracket; tighten the flanged locknuts 91 lbf·ft (123 N·m).

5. Lubricate the U-joint, following the procedure in **Group 41** of the *Century Class Trucks Maintenance Manual*.

6. Remove the nylon support straps, then remove the chocks.



1. Self-Locking Capscrew
2. Adhesive Band

Fig. 10, Meritor U-Joint Fasteners for Full-Round Yokes

Driveshaft Removal and Installation

NOTE: Many service operations do not require driveshaft removal from the vehicle: end-yoke nut tightening; drive component shaft seal or end-yoke replacement; changing U-joint phasing at the slip-yoke; and transmission or axle removal (for overhaul, repair, or replacement). To perform these operations, uncouple the U-joint at the applicable end of the appropriate driveshaft. See **Subject 100** for uncoupling from a *half-round* end-yoke, or see **Subject 110** for uncoupling from a *full-round* end-yoke.

NOTE: It is easier to check driveline parts, and to replace a U-joint or midship bearing assembly if the driveshaft is removed from the vehicle. If a driveshaft requires straightening or balancing, it must be removed, and installed on a lathe or balance machine. Removal is required for replacement of slip-joint parts, a driveshaft tube, or a tube-yoke.

No. 3 Driveshaft Removal (See Fig. 1 and Fig. 2)

1. Uncouple the No. 3 driveshaft from the rearmost axle. If the No. 3 driveshaft is coupled to *half-round* end-yokes, follow the uncoupling procedure in **Subject 100**. If the No. 3 driveshaft is coupled to *full-round* end-yokes, follow the uncoupling procedure in **Subject 110**.
2. Uncouple the No. 3 driveshaft from the forward-rear axle. If the No. 3 driveshaft is coupled to half-round end-yokes, follow the uncoupling procedure in **Subject 100**. If the No. 3 driveshaft is coupled to full-round end-yokes, follow the uncoupling procedure in **Subject 110**.
3. Lift the No. 3 driveshaft out of the chassis.

No. 2 Driveshaft Removal (See Fig. 3 and Fig. 4)

1. Uncouple the No. 2 driveshaft from the single or forward-rear axle. If the No. 2 driveshaft is coupled to *half-round* end-yokes, follow the uncoupling procedure in **Subject 100**. If the No. 2 driveshaft is coupled to *full-round* end-yokes, follow the uncoupling procedure in **Subject 110**.
2. Uncouple the No. 2 driveshaft from the transmission or coupling shaft. If the No. 2 driveshaft is coupled to half-round end-yokes, follow the uncoupling procedure in **Subject 100**. If the No. 2 driveshaft is coupled to full-round end-yokes, follow the uncoupling procedure in **Subject 110**.
3. Lift the No. 2 driveshaft out of the chassis.

Intermediate Coupling Shaft Removal (See Fig. 5 and Fig. 6)

1. If the No. 2 driveshaft is also being removed, remove it first.

   If the No. 2 driveshaft is not being removed, use a nylon support strap to support its forward end.
2. Uncouple the intermediate coupling shaft from the No. 2 driveshaft. If the intermediate coupling shaft has a *half-round* end-yoke, follow the uncoupling procedure in **Subject 100**. If the intermediate coupling shaft has a *full-round* end-yoke, follow the uncoupling procedure in **Subject 110**.
3. Uncouple the intermediate coupling shaft from the primary coupling shaft. See **Fig. 7** and **Fig. 8.** If the primary coupling shaft has a half-round end-yoke, follow the uncoupling procedure in **Subject 100**. If the primary coupling shaft has a full-round end-yoke, follow the uncoupling procedure in **Subject 110**.
4. Lift the intermediate coupling shaft out of the chassis.

Primary Coupling Shaft Removal (See Fig. 7 and Fig. 8)

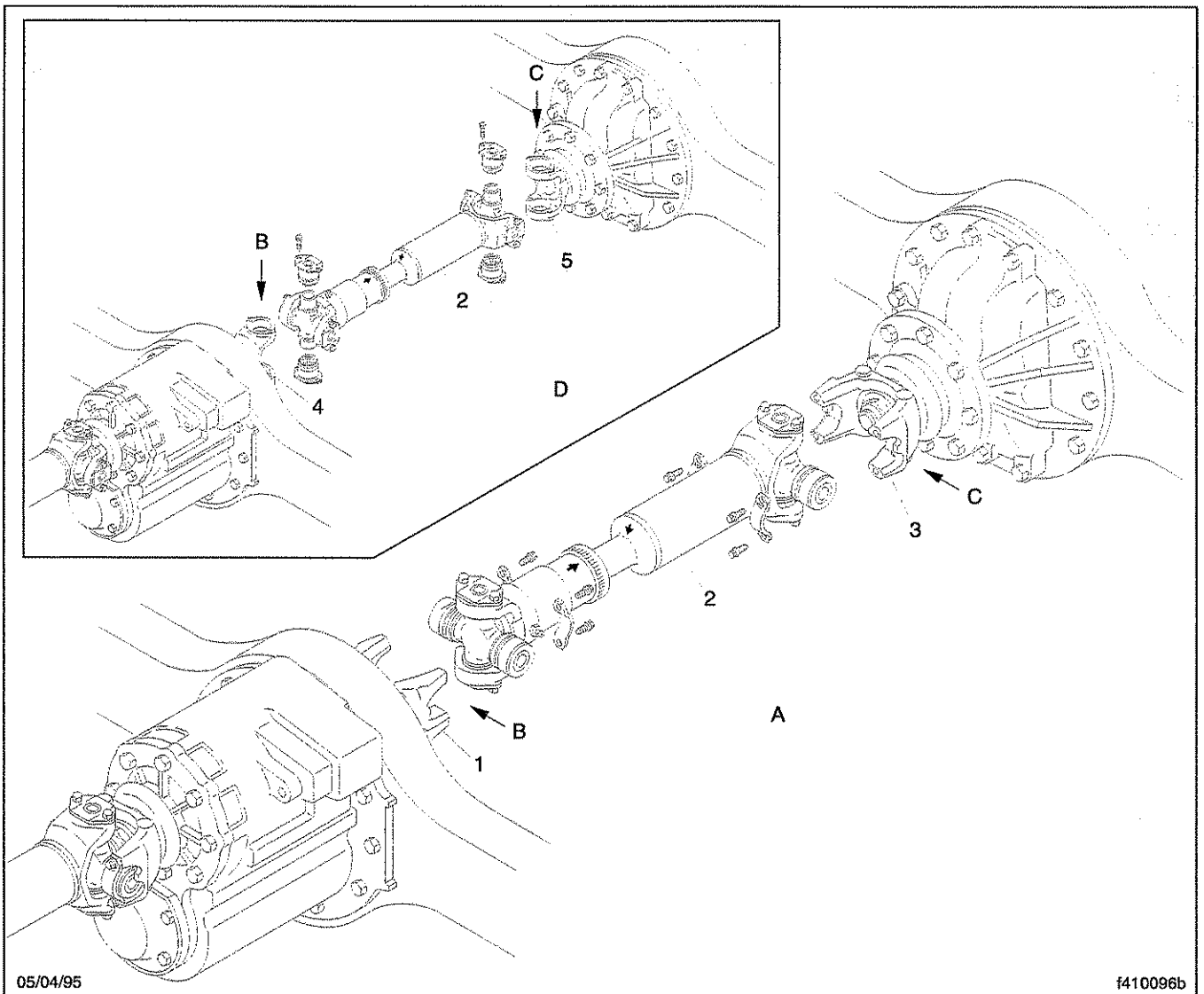
1. *For a vehicle with one coupling shaft:*

   If the No. 2 driveshaft is also being removed, remove it first.

   If the No. 2 driveshaft is not being removed, use a nylon support strap to support its forward end.

   For a vehicle with two coupling shafts:

Driveshaft Removal and Installation



NOTE: Not all fasteners are shown.

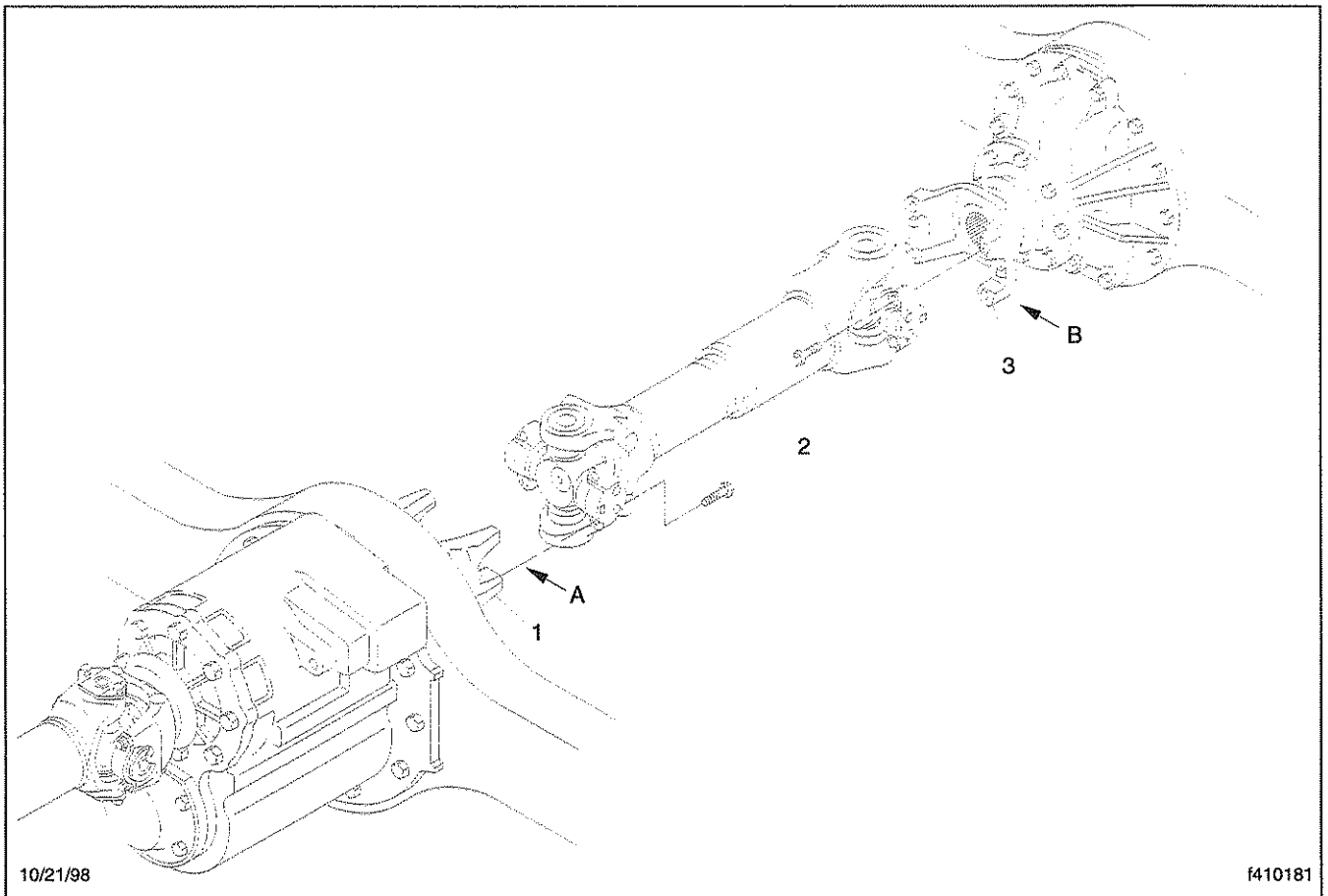
A. No. 3 Driveshaft Coupled to Half-Round End-Yokes
B. Uncouple this end last; couple this end first.
C. Uncouple this end first; couple this end last.
D. No. 3 Driveshaft Coupled to Full-Round End-Yokes
1. Forward-Rear Axle Output-Shaft Half-Round End-Yoke
2. No. 3 Driveshaft
3. Rearmost Axle Input-Shaft Half-Round End-yoke
4. Forward-Rear Axle Output-Shaft Full-Round End-Yoke
5. Rearmost Axle Input-Shaft Full-Round End-yoke

Fig. 1, Removal/Installation of a No. 3 Driveshaft Without RPL U-Joints

If the No. 2 driveshaft is also being removed, remove it first; then, remove the intermediate coupling shaft.

If the intermediate coupling shaft is also being removed (but not the No. 2 driveshaft), remove the intermediate coupling shaft first.

If only the primary coupling shaft is being removed, use nylon support straps to support the forward



NOTE: Not all fasteners are shown.

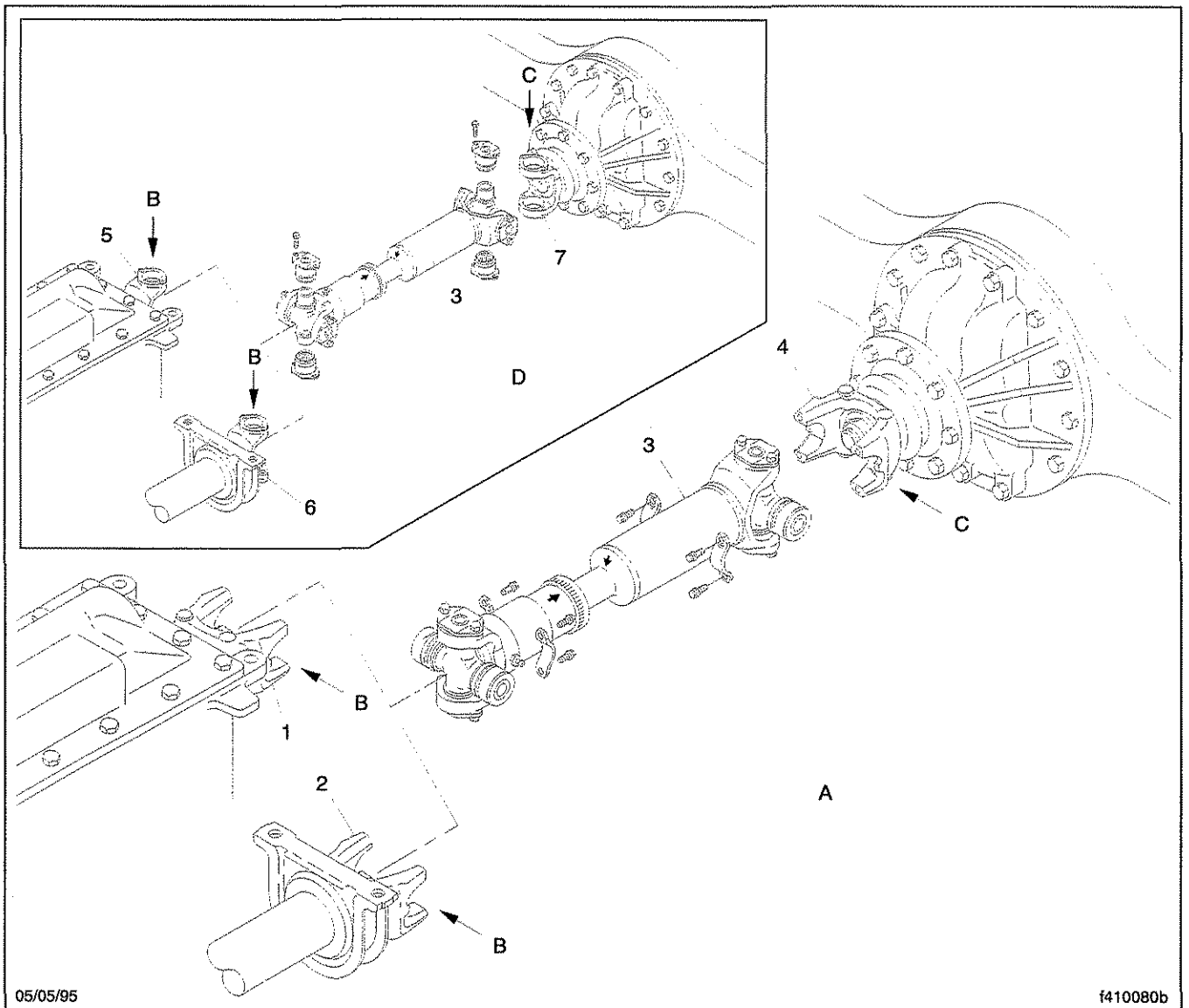
A. Uncouple this end last; couple this end first.
B. Uncouple this end first; couple this end last.
1. Forward-Rear Axle Output-Shaft Half-Round End-Yoke
2. No. 3 Driveshaft
3. Rearmost Axle Input-Shaft Half-Round End-Yoke

Fig. 2, Removal/Installation of a No. 3 Driveshaft With RPL U-Joints

end of the No. 2 driveshaft and both ends of the intermediate coupling shaft. Then, remove the fasteners that attach the intermediate coupling shaft midship bearing to its bracket. See **Fig. 7** and **Fig. 8.**

2. If not already done, uncouple the primary coupling shaft from the No. 2 driveshaft or intermediate coupling shaft. If the primary coupling shaft has a *half-round* end-yoke, follow the uncoupling procedure in **Subject 100**. If the primary coupling shaft has a *full-round* end-yoke, follow the uncoupling procedure in **Subject 110**.
3. Using two nylon support straps, support the primary coupling shaft. Then remove the fasteners that attach the primary coupling shaft midship bearing to its bracket. See **Fig. 7** and **Fig. 8.**
4. Uncouple the primary coupling shaft from the transmission. If the primary coupling shaft is coupled to a half-round end-yoke, follow the uncoupling procedure in **Subject 100**. If the primary coupling shaft is coupled to a full-round end-yoke, follow the uncoupling procedure in **Subject 110.**
5. Lift the primary coupling shaft out of the chassis.

Driveshaft Removal and Installation

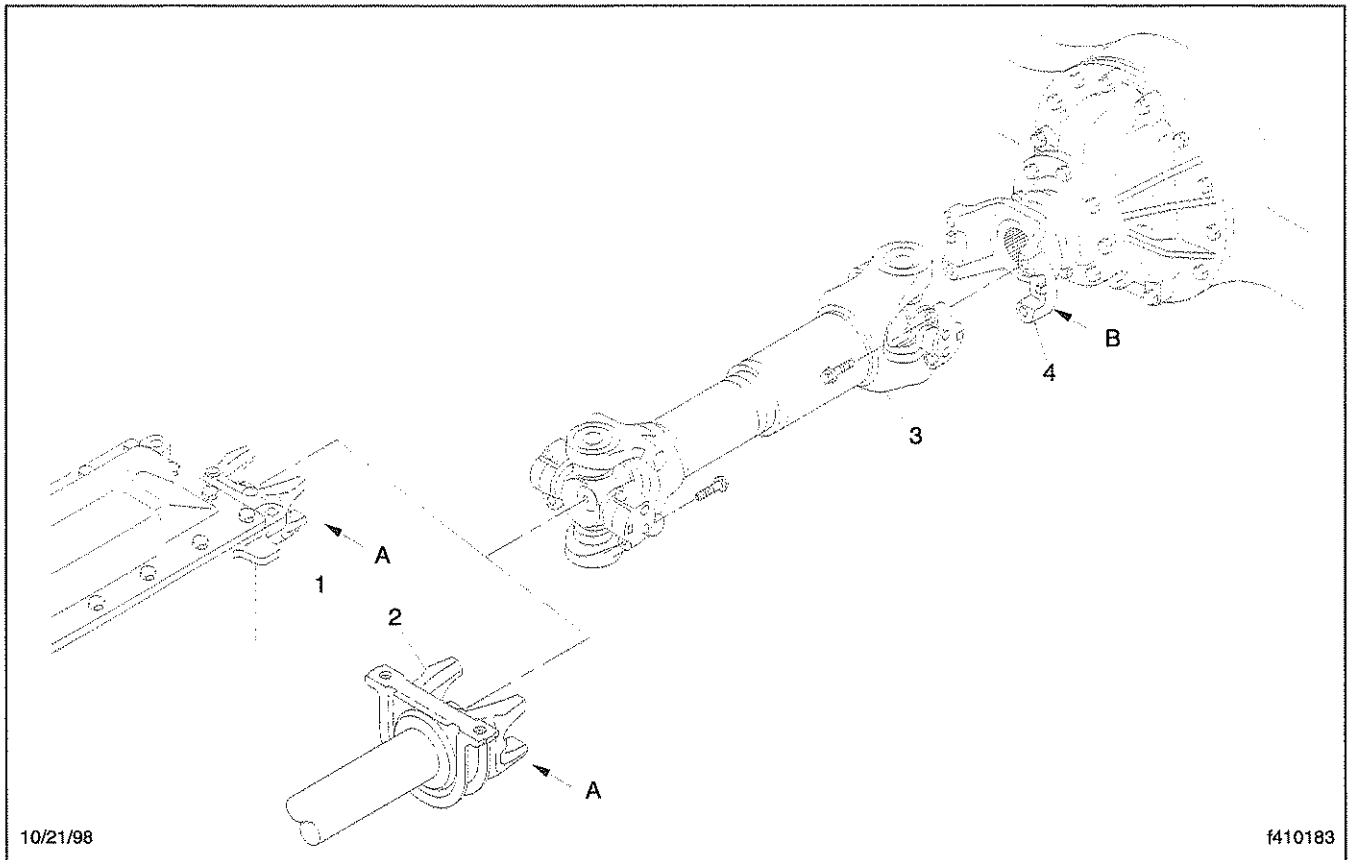


NOTE: Not all fasteners are shown.

A. No. 2 Driveshaft Coupled to Half-Round End-Yokes
B. Uncouple this end last; couple this end first.
C. Uncouple this end first; couple this end last.
D. No. 2 Driveshaft Coupled to Full-Round End-Yokes

1. Transmission Output-Shaft Half-Round End-Yoke
2. Coupling Shaft Half-Round End-Yoke
3. No. 2 Driveshaft
4. Single Axle or Forward-Rear Axle Input-Shaft Half-Round End-Yoke
5. Transmission Output-Shaft Full-Round End-Yoke
6. Coupling Shaft Full-Round End-Yoke
7. Single Axle or Forward-Rear Axle Input-Shaft Full-Round End-Yoke

Fig. 3, Removal/Installation of a No. 2 Driveshaft Without RPL U-Joints



NOTE: Not all fasteners are shown.

A. Uncouple this end last; couple this end first.
B. Uncouple this end first; couple this end last.
1. Transmission Output-Shaft Half-Round End-Yoke
2. Coupling Shaft Half-Round End-Yoke
3. No. 2 Driveshaft
4. Single Axle or Forward-Rear Axle Input-Shaft Half-Round End-Yoke

Fig. 4, Removal/Installation of a No. 2 Driveshaft With RPL U-Joints

Primary Coupling Shaft Installation

(See Fig. 7 and Fig. 8)

IMPORTANT: Before installing a coupling shaft, make sure the yokes are aligned to keep the U-joints in phase. See **Fig. 9**.

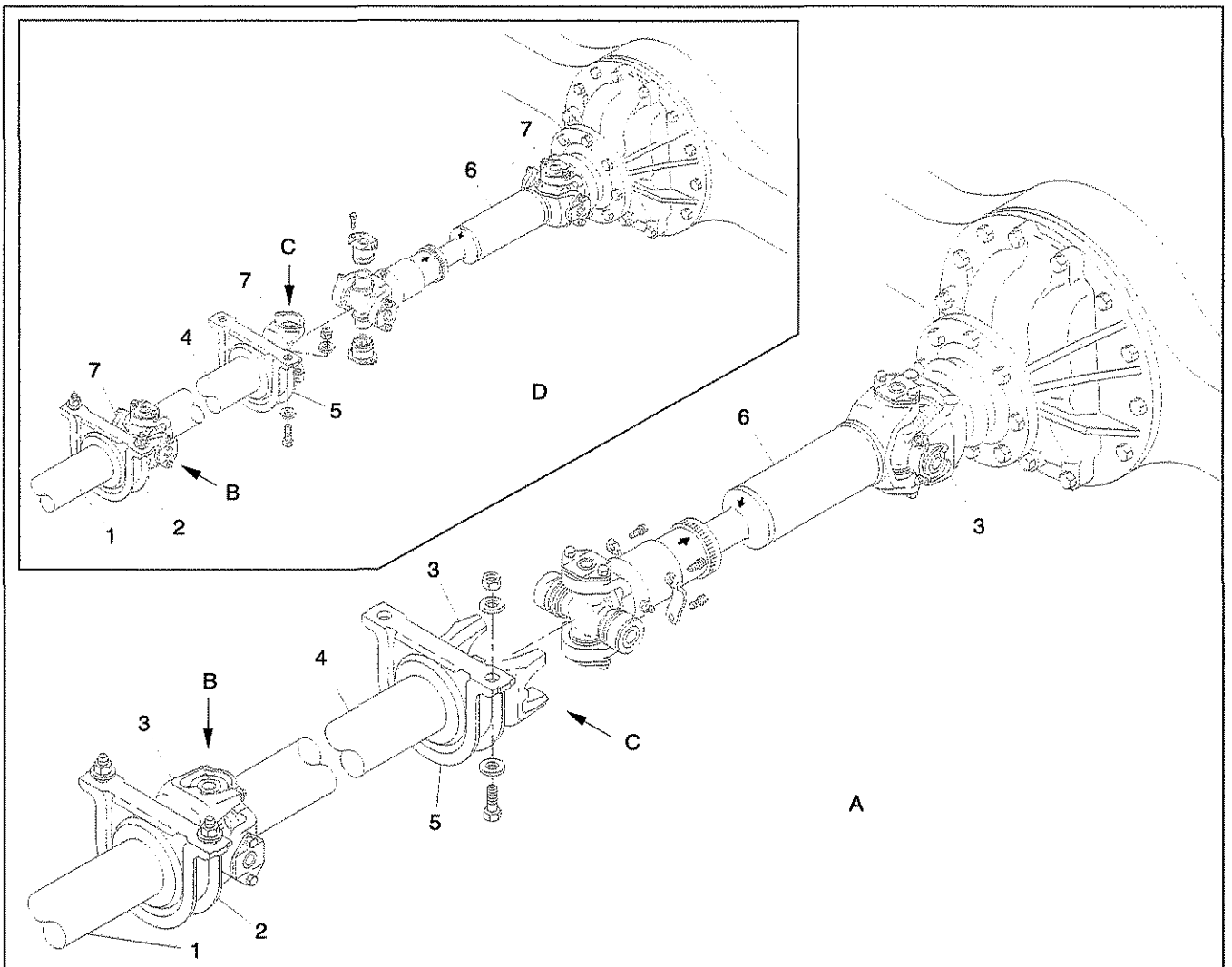
1. Place the primary coupling shaft under the vehicle and support it with nylon support straps so it can be coupled to the transmission end-yoke.
2. Couple the shaft to the transmission end-yoke. If the primary coupling shaft was coupled to a *half-round* end-yoke, follow the coupling procedure in **Subject 100**. If the primary coupling shaft was coupled to a *full-round* end-yoke, follow the coupling procedure in **Subject 110**.
3. *For a vehicle with one coupling shaft:*

   If the No. 2 driveshaft was also removed, install it, as instructed in this subject.

   If the No. 2 driveshaft was not removed, couple it to the primary coupling shaft end-yoke. If the primary coupling shaft has a half-round end-yoke, follow the coupling procedure in **Subject 100**. If the primary coupling shaft has a full-round end-yoke, follow the coupling procedure in **Subject 110**.

   For a vehicle with two coupling shafts:

Driveshaft Removal and Installation



NOTE: Not all fasteners are shown.

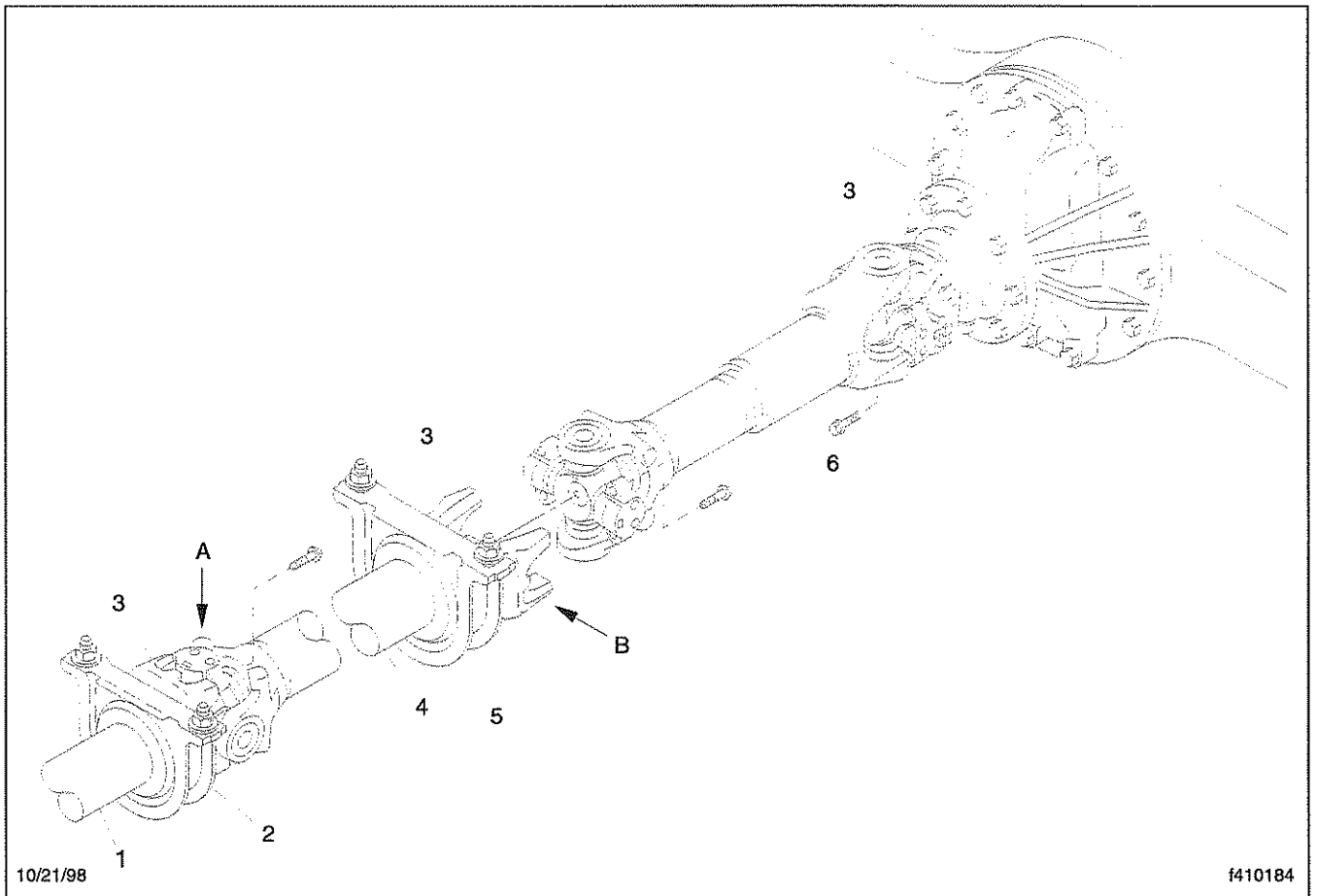
A. No. 2 Driveline With Half-Round End-Yokes
B. Uncouple this end last; couple this end first.
C. Uncouple this end first; couple this end last.
D. No. 2 Driveline With Full-Round End-Yokes

1. Primary Coupling Shaft
2. Primary Coupling Shaft Midship Bearing
3. Half-Round End-Yoke
4. Intermediate Coupling Shaft
5. Intermediate Coupling Shaft Midship Bearing
6. No. 2 Driveshaft
7. Full-Round End-Yoke

Fig. 5, Removal/Installation of an Intermediate Coupling Shaft Without RPL U-Joints

If the intermediate coupling shaft was also removed, install it, as instructed in this subject.

If only the primary coupling shaft was removed, couple the intermediate coupling shaft to the primary coupling shaft end-yoke. If the primary coupling shaft has a half-round end-yoke, follow the coupling procedure in **Subject 100**. If the primary coupling shaft has a full-round end-yoke, follow the coupling procedure in **Subject 110**.



NOTE: Not all fasteners are shown.

A. Uncouple this end last; couple this end first.
1. Primary Coupling Shaft
2. Primary Coupling Shaft Midship Bearing
3. Half-Round End-Yoke
B. Uncouple this end first; couple this end last.
4. Intermediate Coupling Shaft
5. Intermediate Coupling Shaft Midship Bearing
6. No. 2 Driveshaft

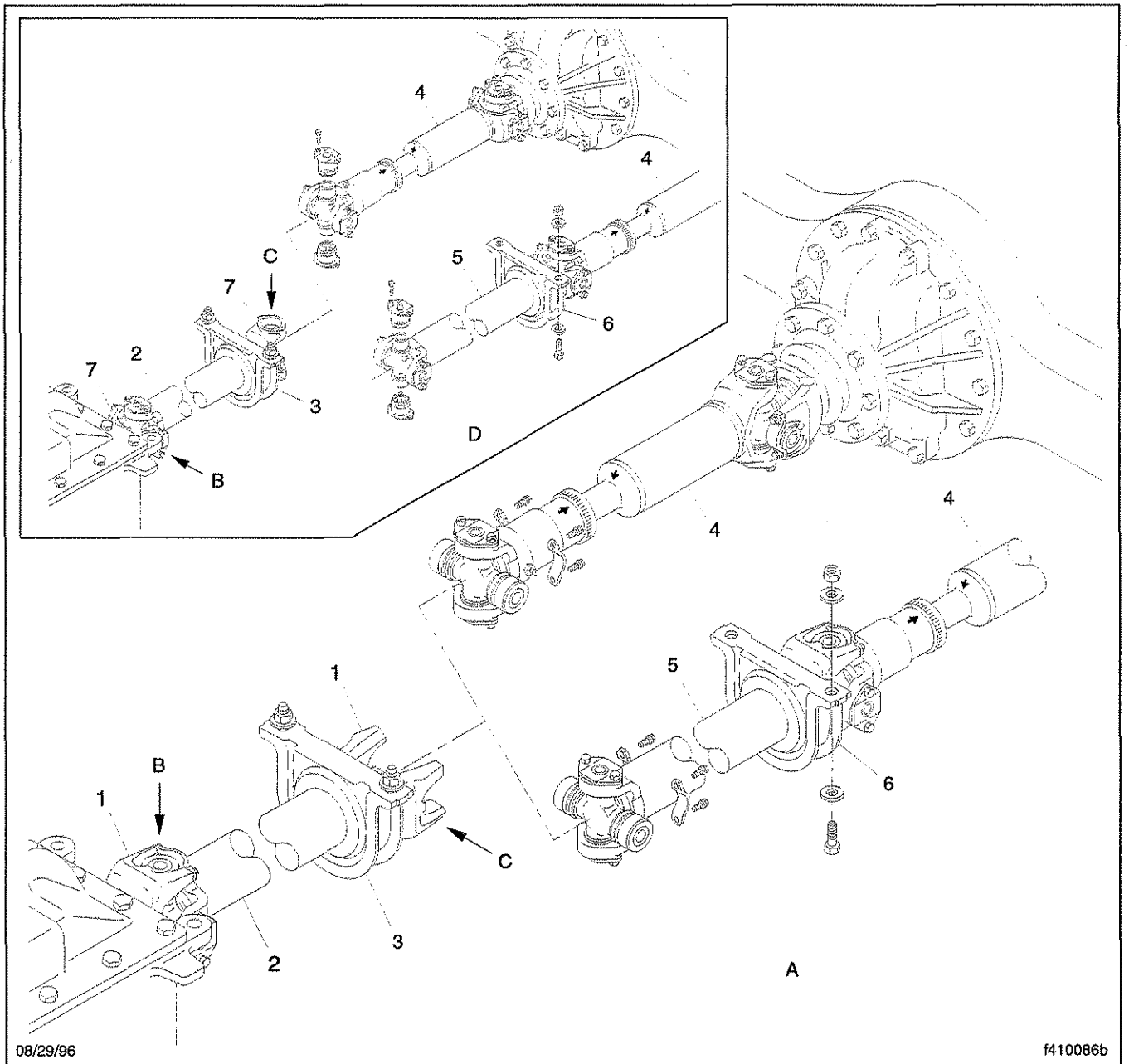
Fig. 6, Removal/Installation of an Intermediate Coupling Shaft With RPL U-Joints

Intermediate Coupling Shaft Installation (See Fig. 5 and Fig. 6)

IMPORTANT: Before installing a coupling shaft, make sure the yokes are aligned to keep the U-joints in phase. See **Fig. 9**.

1. If the primary coupling shaft was also removed, install it first, as instructed in this subject.
2. Place the intermediate coupling shaft under the vehicle and support it with nylon support straps so it can be coupled to the primary coupling shaft end-yoke.
3. Couple the intermediate coupling shaft to the primary coupling shaft end-yoke. If the intermediate coupling shaft was coupled to a *half-round* end-yoke, follow the coupling procedure in **Subject 100**. If the intermediate coupling shaft was coupled to a *full-round* end-yoke, follow the coupling procedure in **Subject 110**.
4. If the No. 2 driveshaft was also removed, install it, as instructed in this subject.

Driveshaft Removal and Installation

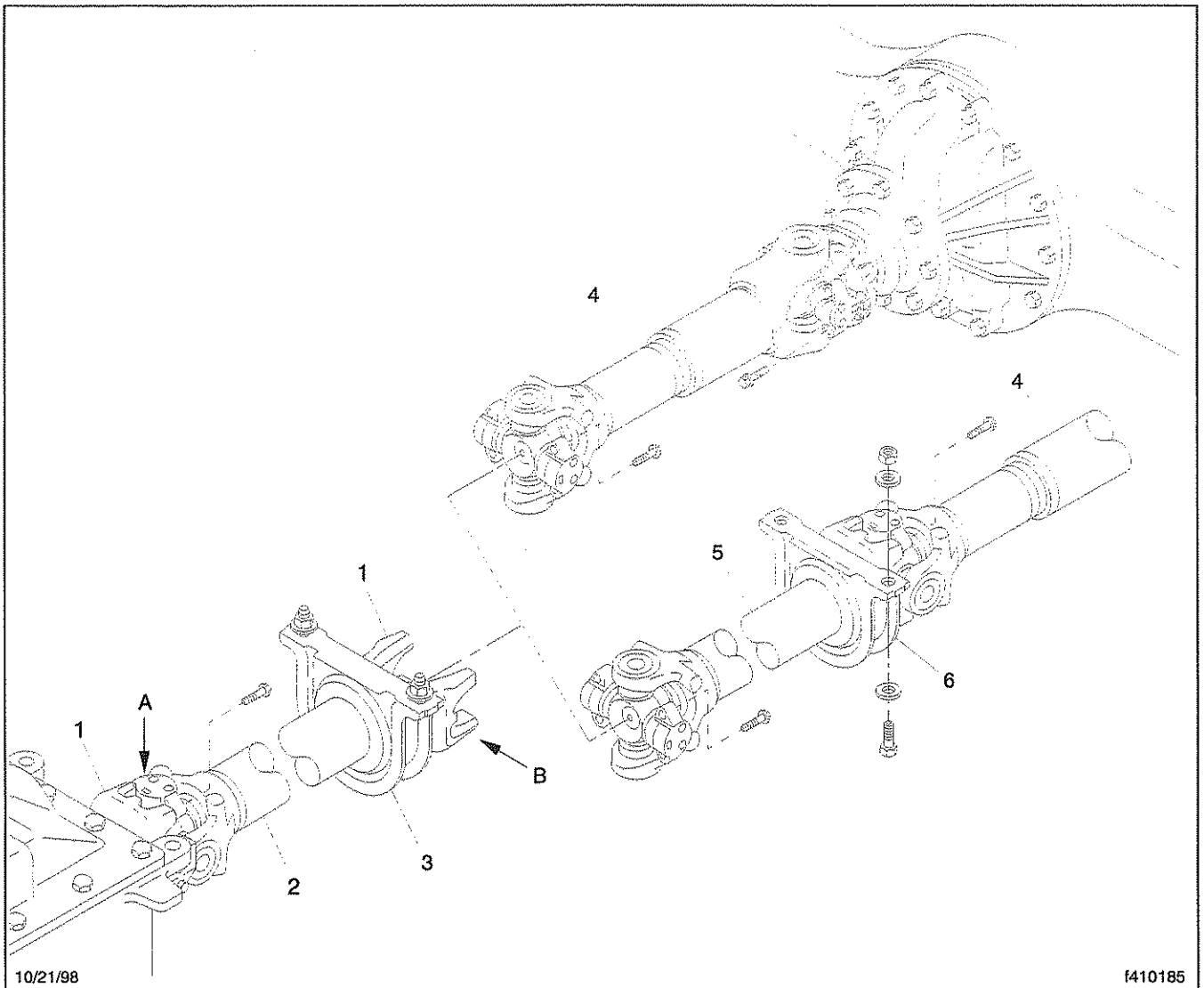


NOTE: Not all fasteners are shown.

A. No. 2 Driveline With Half-Round End-Yokes
B. Uncouple this end last; couple this end first.
C. Uncouple this end first; couple this end last.
D. No. 2 Driveline With Full-Round End-Yokes

1. Half-Round End-Yoke
2. Primary Coupling Shaft
3. Primary Coupling Shaft Midship Bearing
4. No. 2 Driveshaft
5. Intermediate Coupling Shaft
6. Intermediate Coupling Shaft Midship Bearing
7. Full-Round End-Yoke

Fig. 7, Removal/Installation of a Primary Coupling Shaft Without RPL U-Joints



NOTE: Not all fasteners are shown.

A. Uncouple this end last; couple this end first.
B. Uncouple this end first; couple this end last.
1. Half-Round End-Yoke
2. Primary Coupling Shaft
3. Primary Coupling Shaft Midship Bearing
4. No. 2 Driveshaft
5. Intermediate Coupling Shaft
6. Intermediate Coupling Shaft Midship Bearing

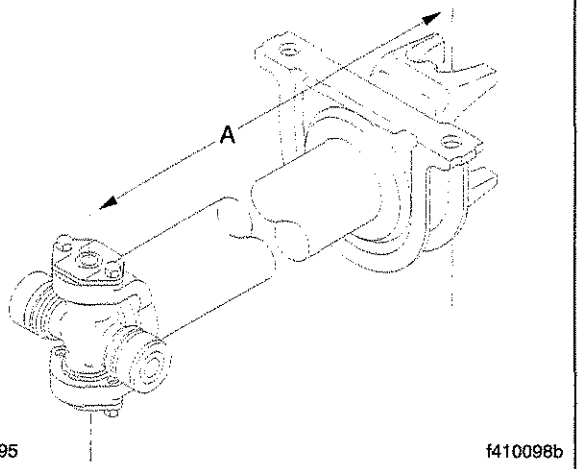
Fig. 8, Removal/Installation of a Primary Coupling Shaft With RPL U-Joints

If the No. 2 driveshaft was not removed, couple it to the intermediate coupling shaft end-yoke. If the intermediate coupling shaft has a half-round end-yoke, follow the coupling procedure in **Subject 100**. If the intermediate coupling shaft has a full-round end-yoke, follow the coupling procedure in **Subject 110**.

No. 2 Driveshaft Installation (See Fig. 3 and Fig. 4)

IMPORTANT: Before installing a No. 2 driveshaft, make sure the alignment marks on the slip-joint

Driveshaft Removal and Installation

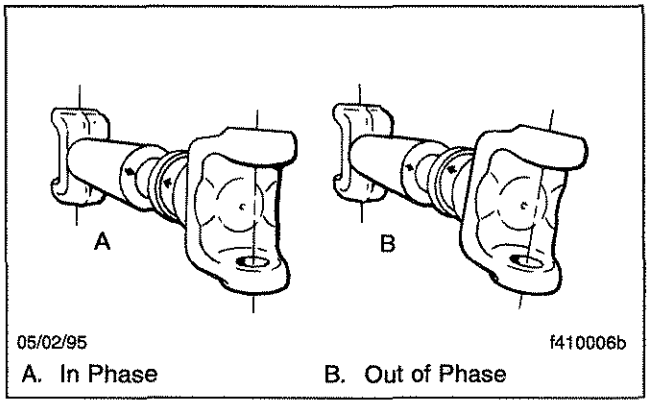


A. Cross-hole centerlines of both yokes must be in alignment.

Fig. 9, U-Joint Phasing of a Coupling Shaft

assembly are aligned, to keep the U-joints in phase; see **Fig. 10**.

1. If a primary coupling shaft was also removed, install it first, as instructed in this subject.
2. If an intermediate coupling shaft was also removed, install it before installing the No. 2 driveshaft.
3. Place the No. 2 driveshaft under the vehicle with its sleeve-yoke at the forward end, and support its rear end with a nylon support strap.
4. Couple the sleeve-yoke to the coupling shaft end-yoke or transmission output-shaft end-yoke, as applicable. If the No. 2 driveshaft was coupled to *half-round* end-yokes, follow the coupling procedure in **Subject 100**. If the No. 2 driveshaft was coupled to *full-round* end-yokes, follow the coupling procedure in **Subject 110**.
5. Couple the No. 2 driveshaft to the axle input-shaft end-yoke. If the No. 2 driveshaft was coupled to half-round end-yokes, follow the coupling procedure in **Subject 100**. If the No. 2 driveshaft was coupled to full-round end-yokes, follow the coupling procedure in **Subject 110**.



A. In Phase B. Out of Phase

Fig. 10, U-Joint Phasing

No. 3 Driveshaft Installation (See Fig. 1 and Fig. 2)

IMPORTANT: Before installing a No. 3 driveshaft, make sure the alignment marks on the slip-joint assembly are aligned, to keep the U-joints in phase; see **Fig. 10**.

1. Place the No. 3 driveshaft under the vehicle with its sleeve-yoke at the forward end, and support its rear end with a nylon support strap.
2. Couple the sleeve-yoke to the forward-rear axle output-shaft end-yoke. If the No. 3 driveshaft was coupled to *half-round* end-yokes, follow the coupling procedure in **Subject 100**. If the No. 3 driveshaft was coupled to *full-round* end-yokes, follow the coupling procedure in **Subject 110**.
3. Couple the No. 3 driveshaft to the axle input-shaft end-yoke. If the No. 3 driveshaft was coupled to half-round end-yokes, follow the coupling procedure in **Subject 100**. If the No. 3 driveshaft was coupled to full-round end-yokes, follow the coupling procedure in **Subject 110**.

U-Joint Removal

FULL-ROUND YOKES

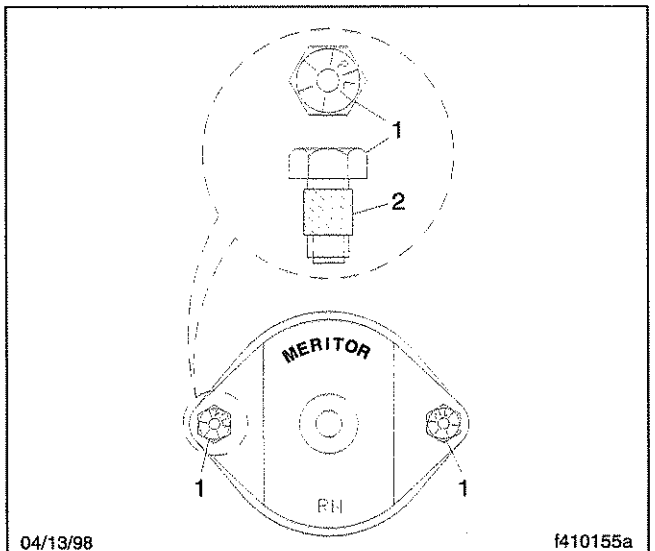
1. Remove the driveshaft from the vehicle. See **Subject 120**.
2. Place the driveshaft in V-blocks or a soft-jawed vise; do not distort the tube with excessive grip.
3. Remove and discard all four bearing-plate self-locking capscrews. See **Fig. 1**.

IMPORTANT: If the U-joint will be reinstalled, use care not to nick the cross trunnions or damage the slingers. See **Fig. 2**.

4. Using one of the U-joint pullers listed in **Specifications, 400**, remove both bearing cups from the yoke cross-holes. See **Fig. 3**. Remove the cross from the yoke.

RPL SERIES U-JOINT

1. Remove the driveshaft from the vehicle. See **Subject 120**.
2. Place the driveshaft in V-blocks or a soft-jawed vise; do not distort the tube with excessive grip.
3. Remove and discard snap rings. See **Fig. 4**.



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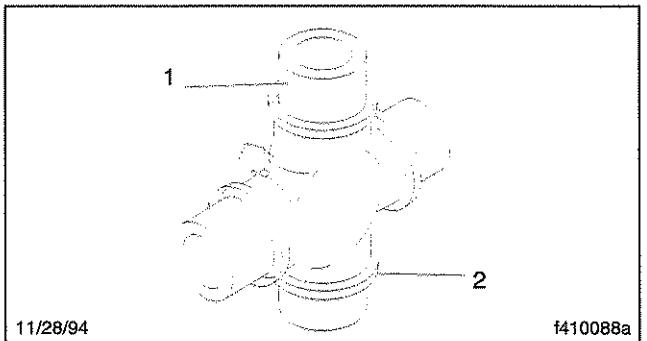
1. Self-Locking Capscrew
2. Adhesive Band

Fig. 1, Meritor U-Joint Fasteners for Full-Round Yokes

4. Cut the weld strap (**Fig. 5**) that retains the bearing cups, remove both bearing cups. See **Fig. 6**.
5. Remove both bearing cups from the yoke cross-holes. See **Fig. 7**. Remove the cross from the yoke.



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1. Trunnions 2. Slingers

Fig. 2, U-Joint Cross

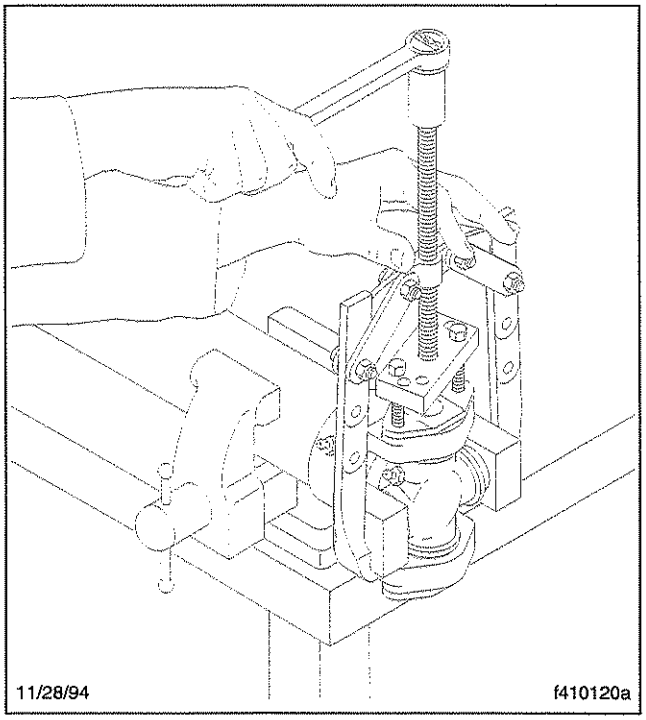

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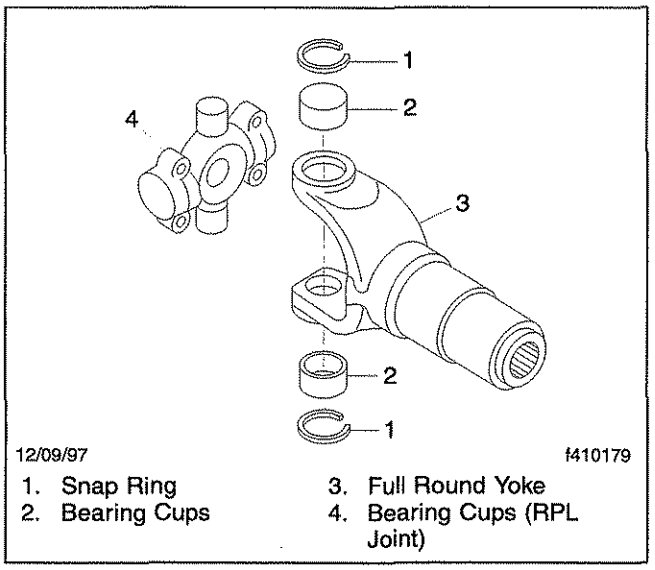
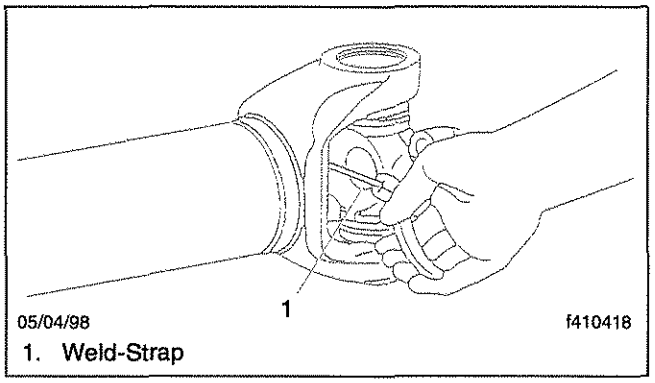
Fig. 3, Remove a Bearing Cup from a Full-Round Yoke

Driveline Component Removal/Disassembly



1. Snap Ring
2. Bearing Cups
3. Full Round Yoke
4. Bearing Cups (RPL Joint)

Fig. 4, RPL U-Joint Components



1. Weld-Strap

Fig. 5, Cut the Weld-Strap

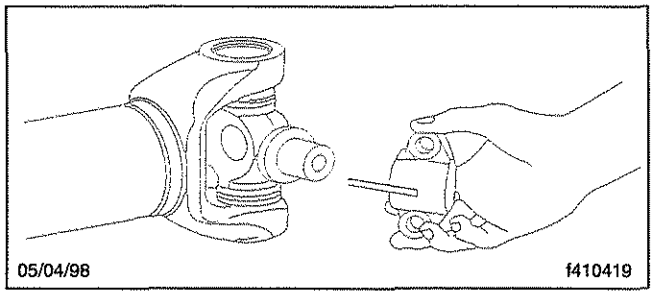


Fig. 6, Remove the Bearing Cups

Slip-Joint Disassembly

EXCEPT RPL DRIVELINES

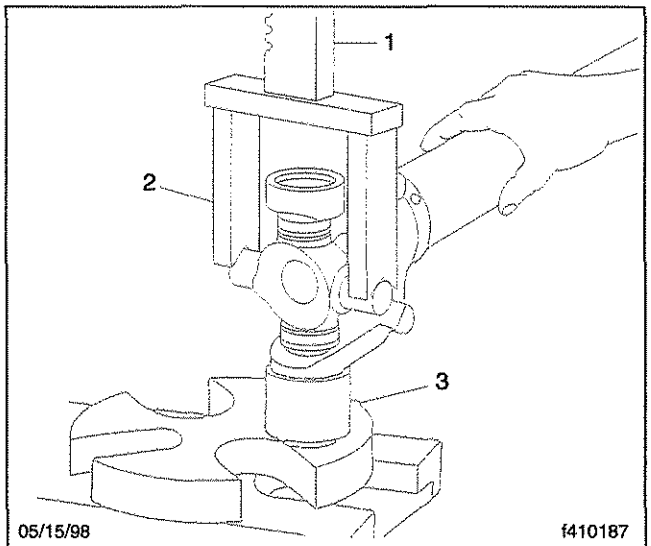
1. Check that the driveshaft yokes are aligned to hold the U-joints at either end in phase, as shown in **Fig. 8**. Using a marking stick or paint, mark the sleeve-yoke and splined shaft with alignment marks, as shown in **Fig. 9**. This will ensure proper alignment of the slip-joint components when the driveshaft is assembled.

IMPORTANT: Misaligned driveshaft yokes will cause the U-joints to be out of phase, which will cause vibration in the driveline.

2. With the driveshaft uncoupled at one end, *or* removed from the vehicle, use a strap wrench to unscrew the slip-joint dust cap from the sleeve-yoke, then pull the sleeve-yoke off of the splined shaft. Remove the dust cap, and (if so equipped) the steel washer and cork seal. See **Fig. 10**.

RPL DRIVELINES

1. Check that the driveshaft yokes are aligned to hold the U-joints at either end in phase, as shown in **Fig. 8**. Using a marking stick or paint, mark the sleeve-yoke and splined shaft with alignment marks, as shown in **Fig. 9**. This will ensure proper



1. Press
2. Bridge
3. Bearing Cup Receiver

Fig. 7, Remove Bearing Cups from an RPL U-Joint

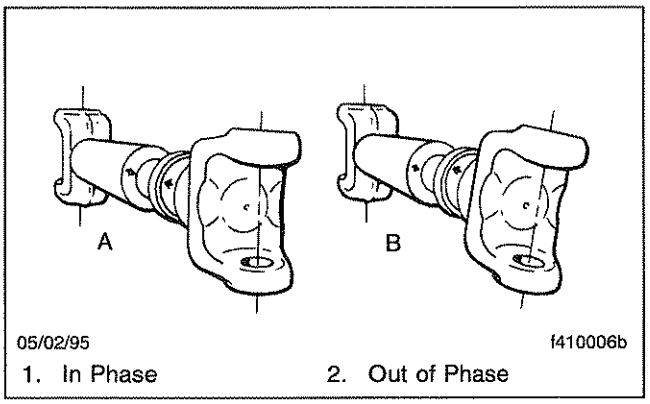


Fig. 8, U-Joint Phasing

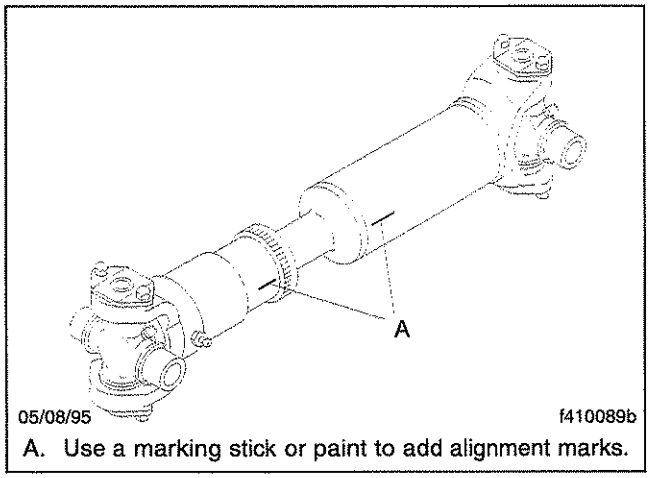


Fig. 9, Slip-Joint Alignment Marks

alignment of the slip-joint components when the driveshaft is assembled.

IMPORTANT: Misaligned driveshaft yokes will cause the U-joints to be out of phase, which will cause vibration in the driveline.

2. With the driveshaft uncoupled at one end, *or* removed from the vehicle, use a brass hammer and punch to tap the shroud off the slip seal. See **Fig. 11**.

3. Use a screwdriver to pry the seal out of the groove in the slip yoke, then pull the sleeve-yoke off of the splined shaft. Remove the shroud, and seal.

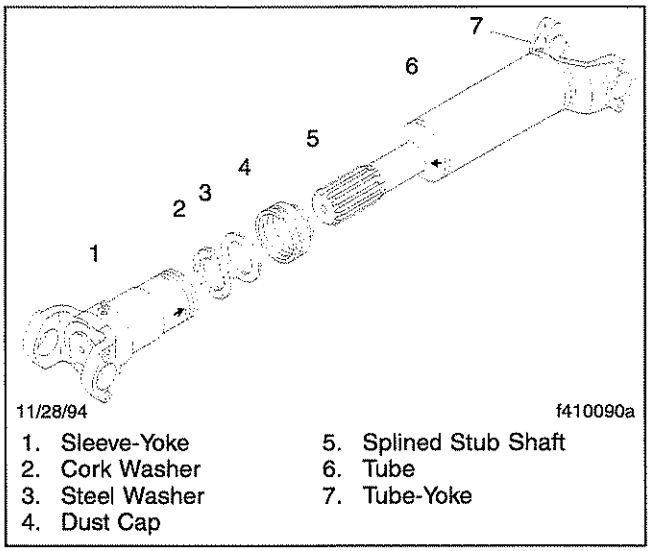


Fig. 10, Slip-Joint Components

Transmission/Axle End-Yoke Removal

IMPORTANT: Before removing a transmission output-shaft end-yoke or an axle shaft end-yoke, do the steps under "End-Yoke Cleaning and Inspection," in **Subject 140**.

1. Uncouple the driveshaft from the end-yoke (**Subject 100** for a half-round yoke or **Subject 110** for a full-round yoke), or remove the driveshaft from the vehicle (**Subject 120**).

2. Remove the end-yoke locknut. See **Fig. 12**.

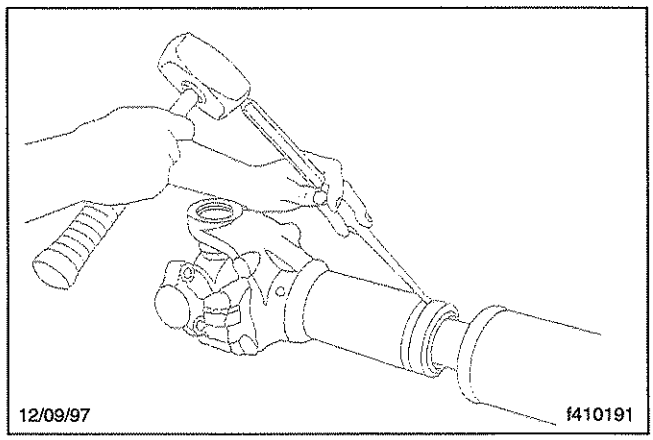


Fig. 11, Shroud Removal

Driveline Component Removal/Disassembly

3. Using a yoke puller, remove the end-yoke. See **Fig. 13** for a half-round end-yoke, or see **Fig. 14** for a full-round end-yoke.

Coupling Shaft End-Yoke and Midship Bearing Removal

1. Remove the coupling shaft from the vehicle. See **Subject 120**.
2. Clamp the coupling shaft in a soft-jawed vise; do not distort the tube with excessive grip.
3. Remove the end-yoke; see **Fig. 13** for a half-round end-yoke, or see **Fig. 14** for a full-round end-yoke. Then, remove the midship bearing and slingers. See **Fig. 15**.
   - 3.1 Use a marking stick or paint to mark the end-yoke and coupling shaft with alignment marks. See **Fig. 16**.
   - 3.2 Remove the coupling shaft end-yoke locknut.
   - 3.3 Using a yoke puller, remove the end-yoke. See **Fig. 13** for a half-round end-yoke, or see **Fig. 14** for a full-round end-yoke.
   - 3.4 Use a hammer and a brass drift to remove the midship bearing and slingers. See **Fig. 15**.

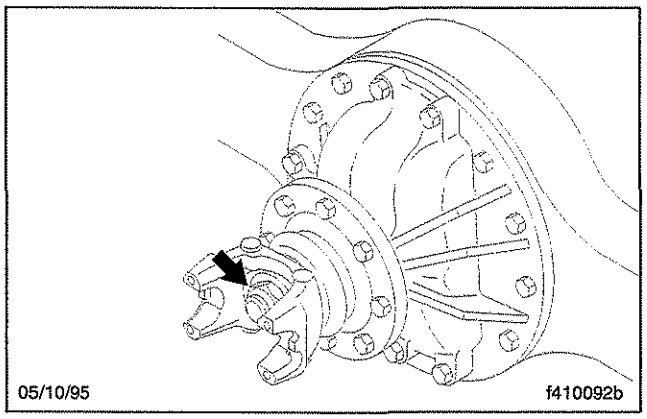
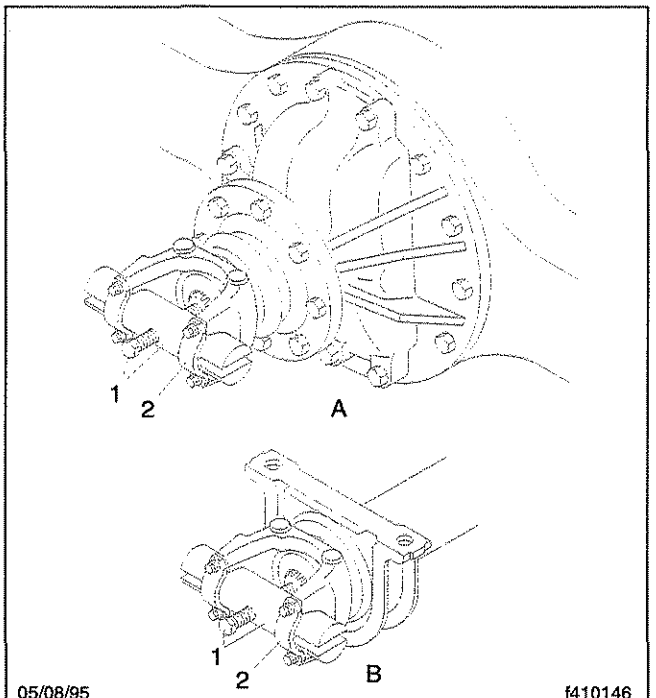
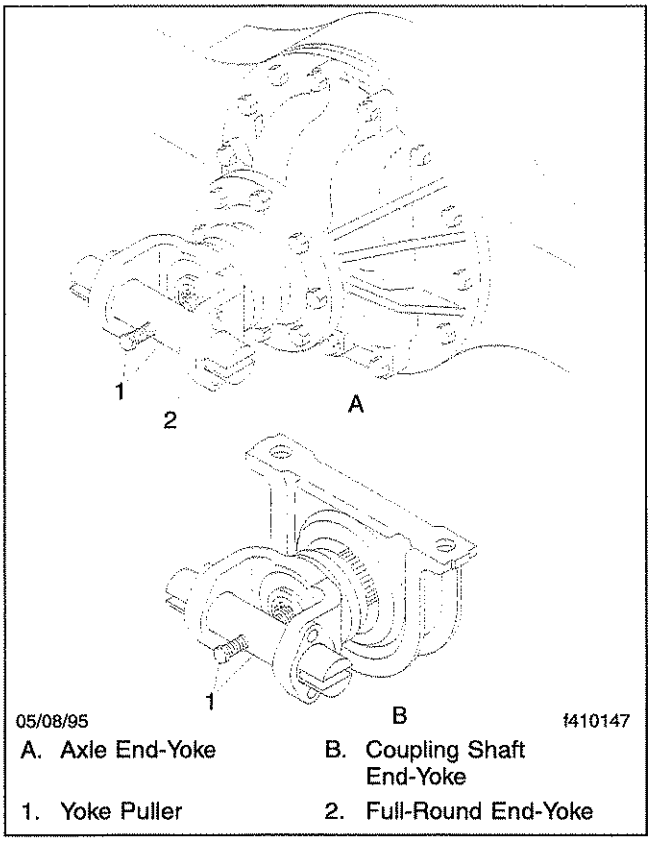


Fig. 12, Axle End-Yoke Locknut



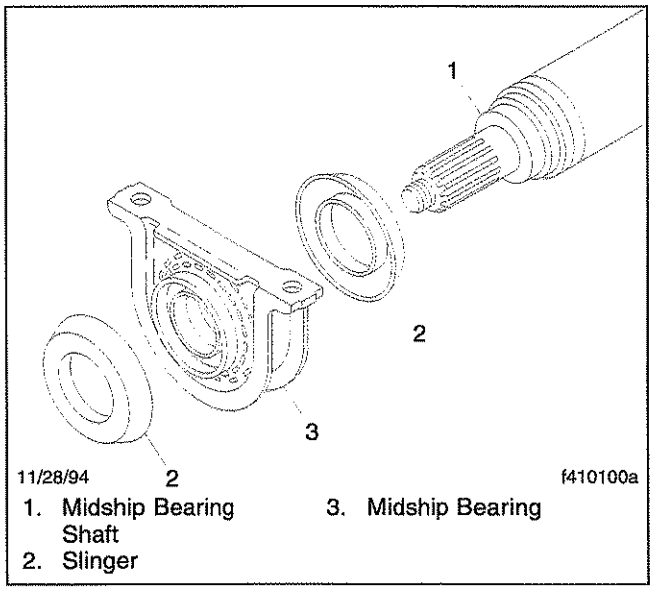
A. Axle End-Yoke
B. Coupling Shaft End-Yoke
1. Yoke Puller
2. Bearing Strap

Fig. 13, Remove a Half-Round End-Yoke



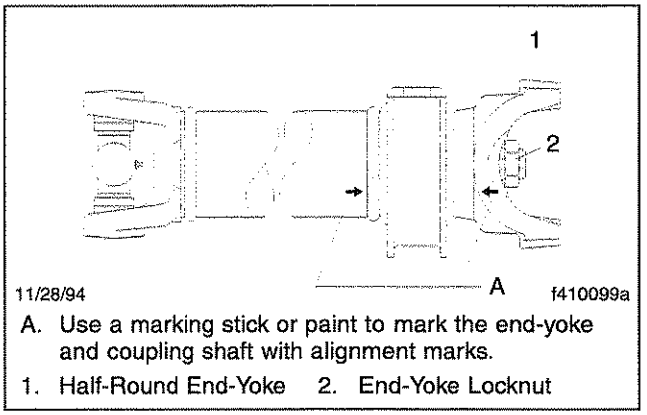
A. Axle End-Yoke
B. Coupling Shaft End-Yoke
1. Yoke Puller
2. Full-Round End-Yoke

Fig. 14, Remove a Full-Round End-Yoke



1. Midship Bearing Shaft
2. Slinger
3. Midship Bearing

Fig. 15, Midship Bearing and Slingers



A. Use a marking stick or paint to mark the end-yoke and coupling shaft with alignment marks.
1. Half-Round End-Yoke
2. End-Yoke Locknut

Fig. 16, Alignment Marks on a Coupling Shaft With an End-Yoke

Driveline Component Cleaning and Inspection

Driveshaft Tube, Slip-Joint, Sleeve-Yoke, and Tube-Yoke Cleaning and Inspection

1. With the driveshaft removed, scrape or soak away any foreign material.
2. Examine the driveshaft tube for dents, bends, twists, splitting weld-seams, and signs of missing balance weights.

   Replace the driveshaft tube if damaged; see "Driveshaft Tube, Stub Shaft (Slip-Joint), or Tube-Yoke Replacement," in **Subject 150**. If balance weights appear to be missing, have the driveshaft balanced to a maximum tolerance of one inch-ounce per ten pounds weight per end, at 3000 rpm.
3. Clean the slip-joint (male and female) splines, then check them for twisting and galling. See **Fig. 1**. Replace both the sleeve-yoke and the splined shaft if the slip-joint is damaged; see "Driveshaft Tube, Stub Shaft (Slip-Joint), or Tube-Yoke Replacement," in **Subject 150**. Remove any burrs or rough spots using fine emery cloth.
4. Check for a loose or missing sleeve-yoke plug. See **Fig. 2**. Repair or replace the plug as needed.
5. With the U-joint assemblies removed, check all driveshaft yoke cross-holes for raised metal. Using a rat-tail or half-round file, remove burrs or raised metal. See **Fig. 3**.

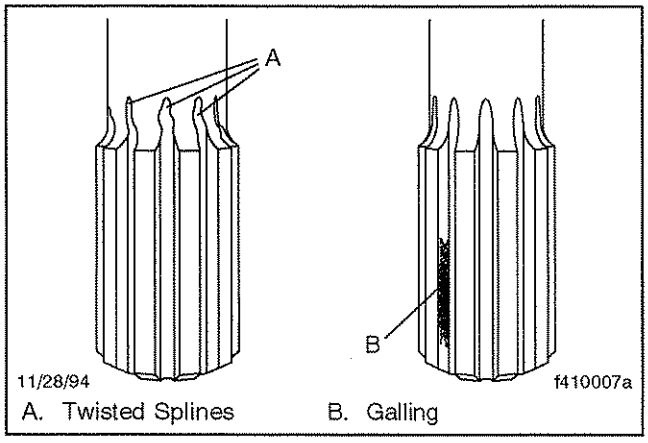


Fig. 1, Damaged Slip-Joint Splines

6. Using a mill file, and holding it flat against the machined surface of the driveshaft yoke lug, file each yoke lug, to remove any burrs or raised metal. See **Fig. 4**.
7. Using fine emery cloth, smooth and clean the entire surface of all driveshaft yoke cross-holes. See **Fig. 5**.

Midship Bearing Cleaning and Inspection

1. With the midship bearing removed from the coupling shaft, use clean rags or paper towels to wipe

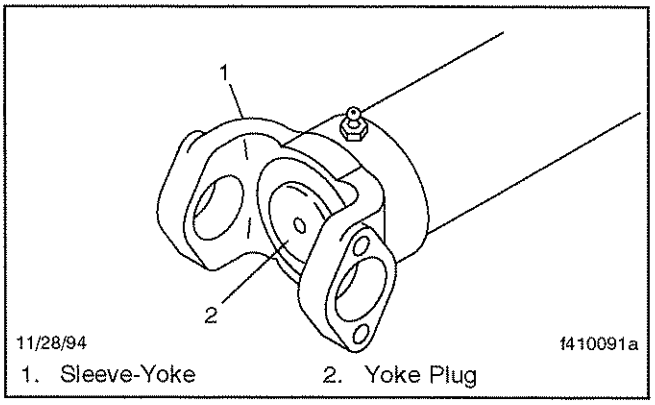


Fig. 2, Sleeve-Yoke Plug

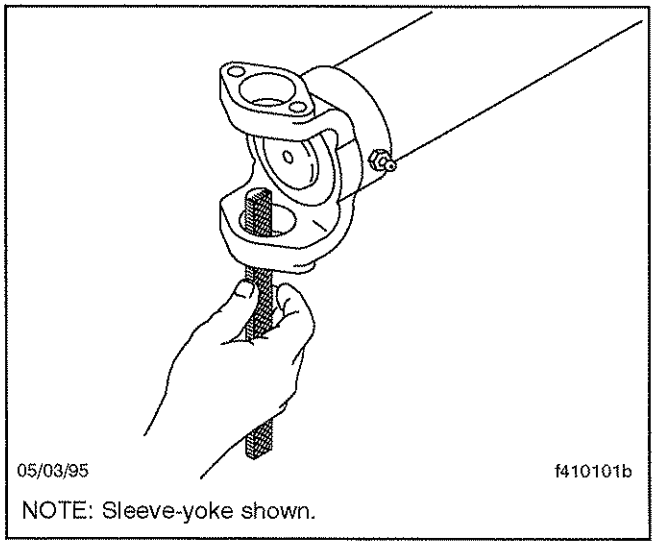


Fig. 3, Removing Burrs From a Full-Round Yoke Cross-Hole

Driveline Component Cleaning and Inspection

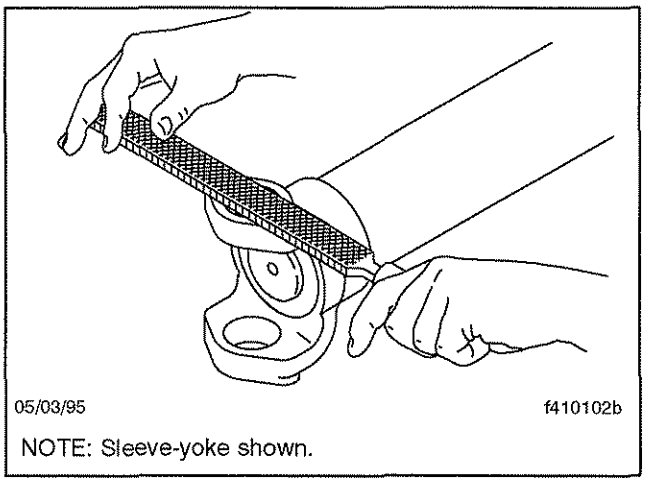


Fig. 4, Removing Burrs From the Machined Surface of a Full-Round Yoke Lug

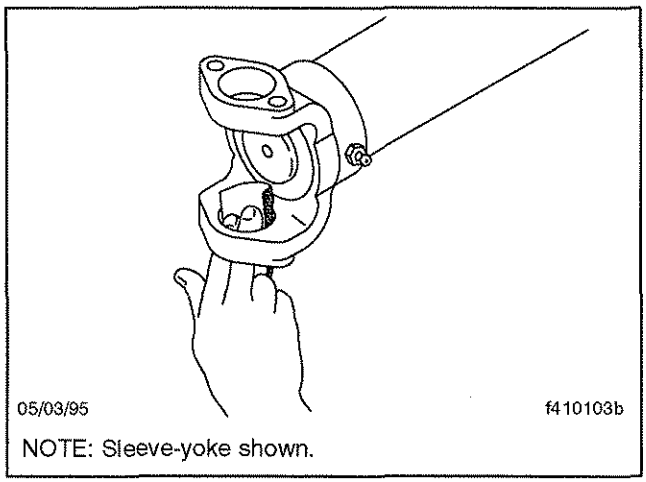


Fig. 5, Smoothing a Full-Round Yoke Cross-Hole

off the outside of the midship bearing, rubber cushion, and slingers.

IMPORTANT: Do not immerse the midship bearing in cleaning solvent. The solvent will wash out the lubricant, requiring bearing-assembly replacement.

2. Check the midship bearing for roughness or rattles by holding the outside of the bearing while manually turning the inner bearing race. Replace the bearing assembly if there are any rough spots or rattles.
3. Check the rubber cushion for deterioration or oil-soaking, and replace the midship bearing assembly if needed.

End-Yoke Cleaning and Inspection

1. With the transmission output-shaft and axle shaft end-yokes installed, check them for cracks and looseness.

   Replace cracked yokes. If the end-yoke can be moved in or out on its shaft, or can be rocked on its shaft, uncouple the driveshaft from the end-yoke. Check the drive component's shaft seal for leakage or other visible damage that may have been caused by the loose yoke. Replace the shaft seal if needed. Tighten the end-yoke nut to the torque value given in **Specifications, 400**. If the end-yoke is still loose after tightening the yoke nut, install a new yoke and yoke nut.

NOTE: If the end-yoke locknut is removed for any reason, install a new one.

2. With the U-joints uncoupled from the end-yokes, check all driveshaft and input/output shaft end-yoke cross-holes for raised metal. Using a rat-tail or half-round file, remove burrs or raised metal. See **Fig. 3** for full-round yokes, or see **Fig. 6** for half-round yokes.
3. Using a mill file, and holding it flat against the machined surface of the *full-round* end-yoke lug,

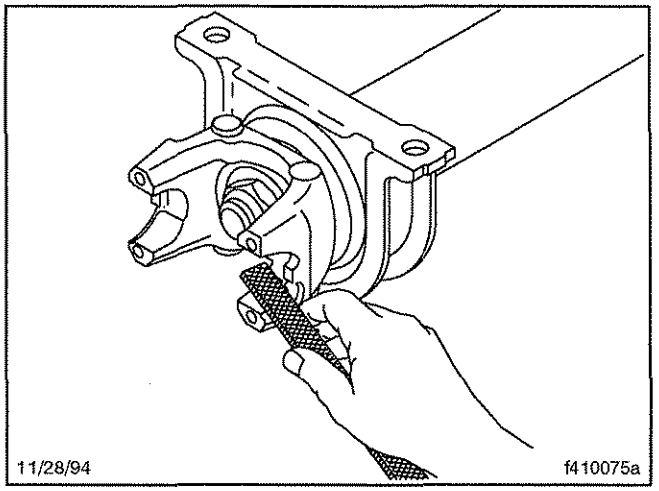


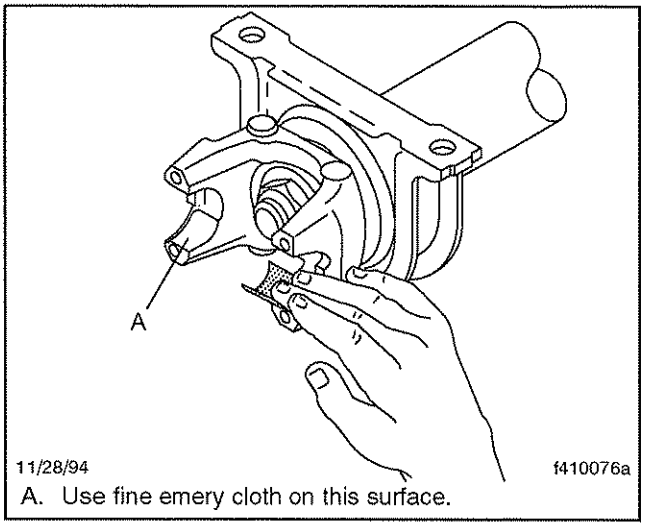
Fig. 6, Removing Burrs From a Half-Round End-Yoke Cross-Hole

file each yoke lug, to remove any burrs or raised metal. See **Fig. 4**.

4. Smooth and clean the entire surface of all end-yoke cross-holes, using fine emery cloth. See **Fig. 5** for full-round yokes, or see **Fig. 7** for half-round yokes.

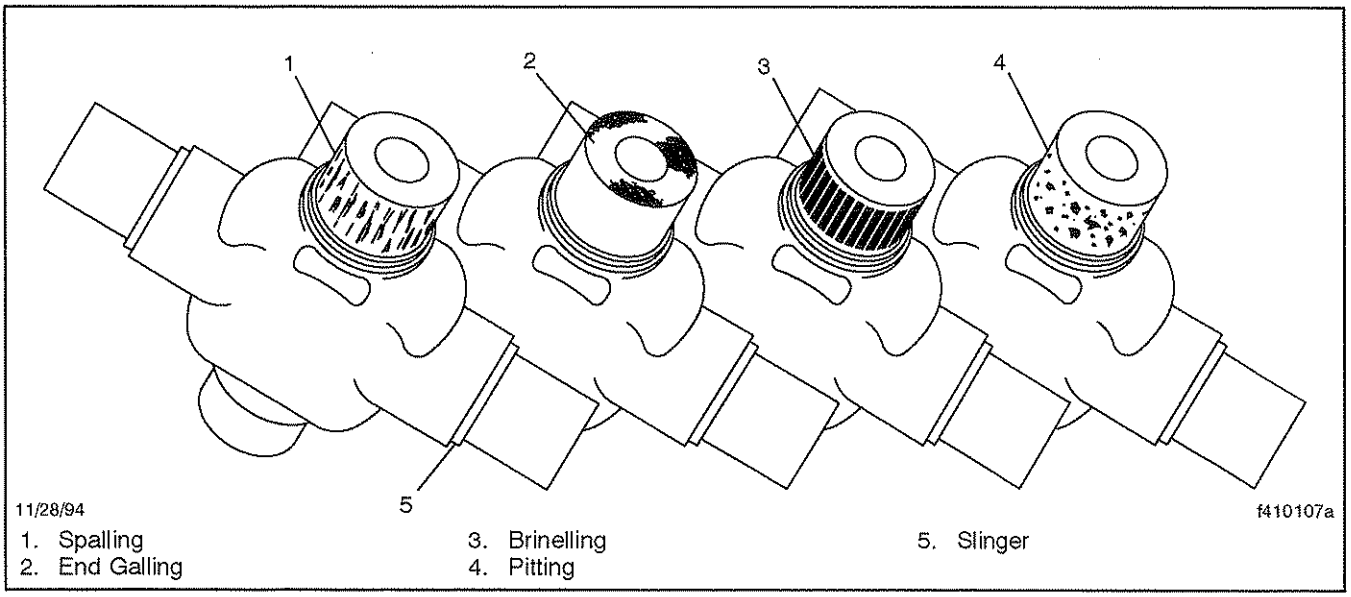
U-Joint Cleaning and Inspection

1. With the U-joints removed from the yokes, and the bearing cups removed from the crosses, inspect the U-joint cross slingers for damage, then inspect the U-joint trunnions for spalling (flaking metal), end galling (displacement of metal), brinelling (grooves caused by bearing needles), and pitting (small craters caused by corrosion). See **Fig. 8**. If damaged, replace the U-joint assembly.
2. Using a hand-type grease gun, apply multipurpose chassis grease to the fitting on each U-joint cross until all old lubricant is forced out. See **Fig. 9**. Examine the old lubricant. If it appears rusty, gritty, or burnt, replace the U-joint assembly.
3. Soak the bearing cups in a non-flammable cleaner until particles of grease and foreign matter are loosened or dissolved. Do not disassemble the bearing cups; clean the bearing needles with a short, stiff brush, then blow them dry with compressed air. Check for minute particles of dirt or grit, and clean again if necessary.
4. Check each bearing cup for missing bearing needles. Check the bearing-cup seals for nicks. See **Fig. 10** for a half-round-yoke U-joint bearing cup, or see **Fig. 11** for a full-round-yoke U-joint bearing cup. Replace the U-joint assembly if any bearing needles are missing or any seals are damaged.



A. Use fine emery cloth on this surface.

Fig. 7, Smoothing a Half-Round End-Yoke Cross-Hole



1. Spalling
2. End Galling
3. Brinelling
4. Pitting
5. Slinger

Fig. 8, Damaged U-Joint Crosses

Driveline Component Cleaning and Inspection

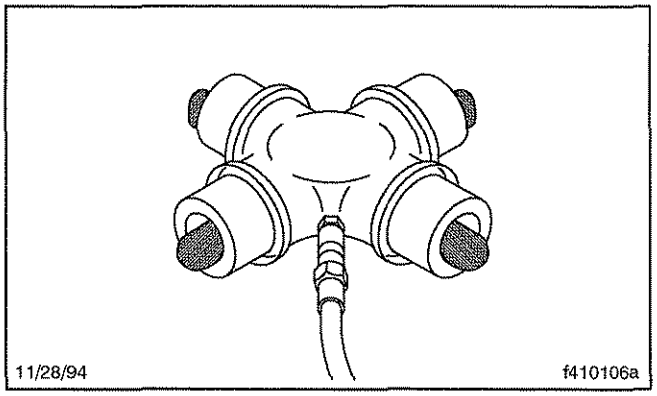
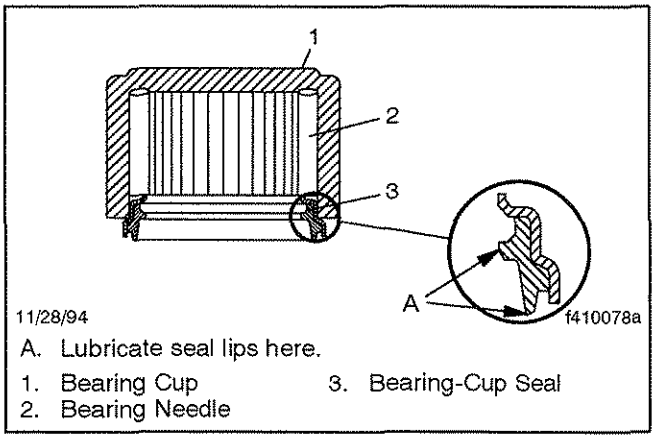


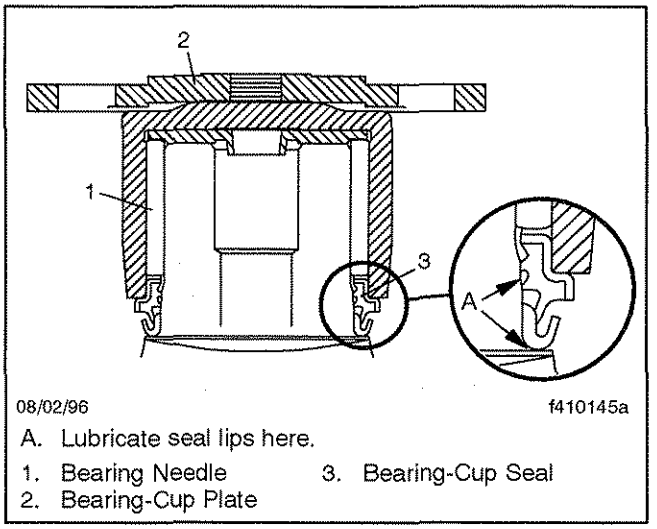
Fig. 9, Forcing Out Old Lubricant From a U-Joint Cross

5. Apply a small quantity of multipurpose chassis grease to the bearing needles in each cup, then apply a small amount of light-weight oil to the lips of the bearing-cup seals. Rotate each bearing cup on the cross to check for wear. Replace the U-joint assembly if any bearing surfaces are worn.
6. Check the underside of each bearing-cup plate for burrs or raised metal. Use a mill file to remove any burrs or raised metal. See **Fig. 12**.
7. Using fine emery cloth, smooth and clean the outside surfaces of all bearing cups. See **Fig. 12** and **Fig. 13**.



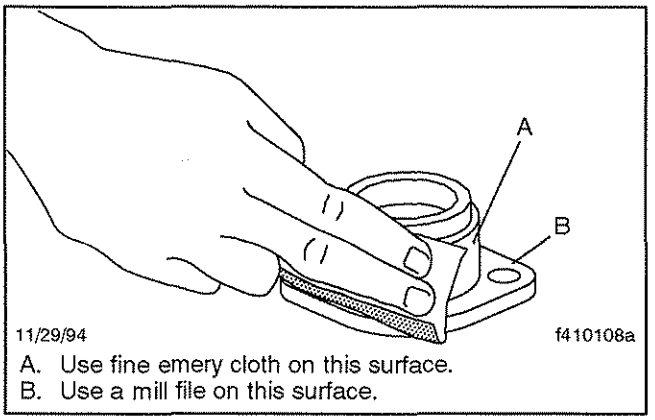
A. Lubricate seal lips here.
1. Bearing Cup
2. Bearing Needle
3. Bearing-Cup Seal

Fig. 10, Sectional View of a Half-Round End-Yoke U-Joint Bearing Cup



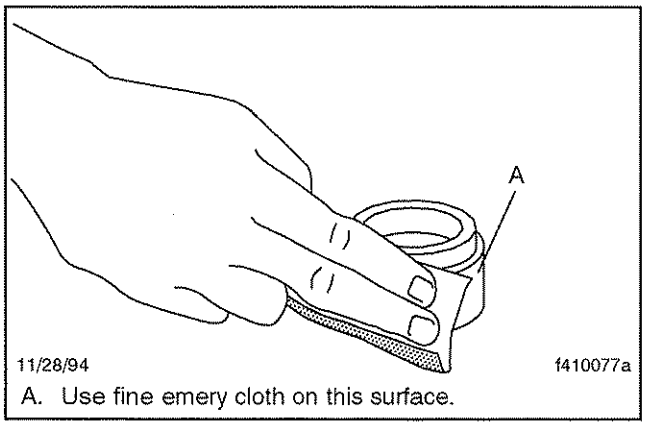
A. Lubricate seal lips here.
1. Bearing Needle
2. Bearing-Cup Plate
3. Bearing-Cup Seal

Fig. 11, Sectional View of a Full-Round Yoke U-Joint Bearing Cup



A. Use fine emery cloth on this surface.
B. Use a mill file on this surface.

Fig. 12, Smoothing a Full-Round Yoke U-Joint Bearing Cup



A. Use fine emery cloth on this surface.

Fig. 13, Smoothing a Half-Round Yoke U-Joint Bearing Cup

Driveline Component Replacement or Installation/ Assembly

Driveshaft Tube, Stub Shaft (Slip-Joint), and Tube-Yoke Replacement

IMPORTANT: Parts for different series drivelines must not be intermixed. Incorrectly assembled or worn components can affect the entire driveline, resulting in too much vibration or driveline damage.

To replace a driveshaft tube, a tube-yoke, or a stub shaft (**Fig. 1**), the driveshaft must be chucked in a lathe, so the welds can be removed. Driveshaft rebuilding should be done by a machine shop that specializes in driveline repair.

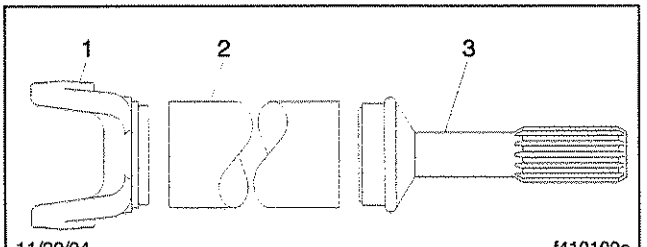
Runout limits for a new (rebuilt) driveshaft (**Fig. 2**) are:

- 0.005 inch (0.127 mm) T.I.R. (Total Indicator Reading) on the smooth portion of the stub shaft neck;
- 0.010 inch (0.254 mm) T.I.R. on the tube 3 inch (76 mm) from the front and rear welds;
- 0.015 inch (0.381 mm) T.I.R. at the center of the tube.

Balance the rebuilt driveshaft to a maximum tolerance of 1 inch-ounce per 10 pounds weight per end, at 3000 rpm.

Slip-Joint Replacement or Assembly

IMPORTANT: Parts for different series drivelines must not be intermixed. Incorrectly assembled or worn components can affect the entire driveline, resulting in too much vibration or driveline damage.

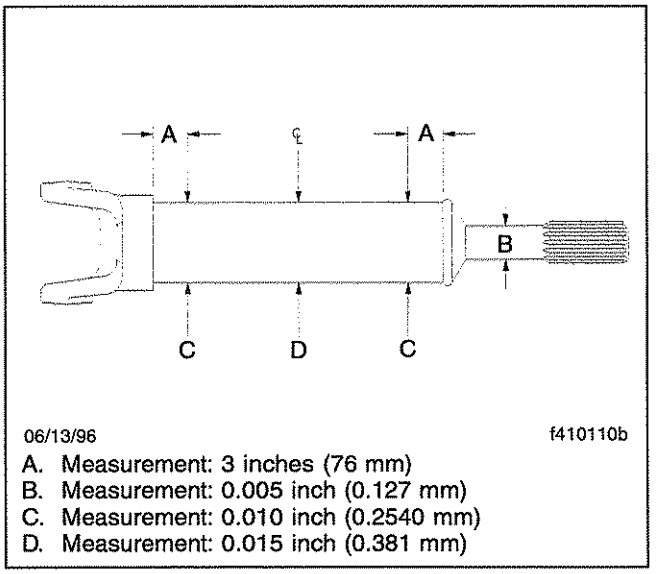


1. Tube-Yoke
2. Driveshaft Tube
3. Stub Shaft

Fig. 1, Driveshaft Tube, Stub Shaft, and Tube-Yoke

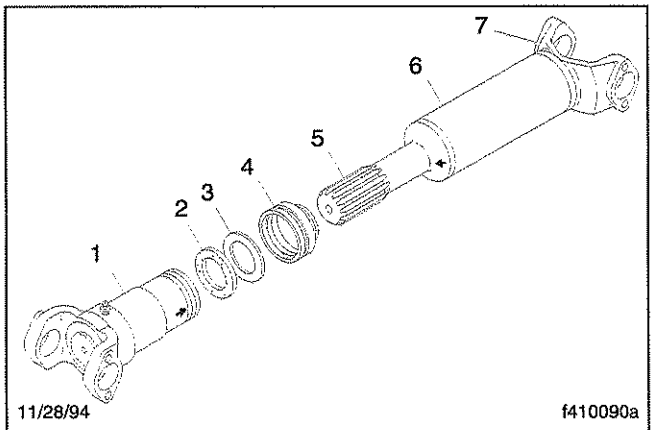
EXCEPT RPL DRIVELINES

1. Place the slip-joint dust cap, and (if so equipped) steel washer and cork seal, over the splined shaft. See **Fig. 3**.
2. Coat the splines of the shaft with multipurpose chassis grease.



A. Measurement: 3 inches (76 mm)
B. Measurement: 0.005 inch (0.127 mm)
C. Measurement: 0.010 inch (0.2540 mm)
D. Measurement: 0.015 inch (0.381 mm)

Fig. 2, Runout Specifications for a Rebuilt (or New) Driveshaft



1. Sleeve-Yoke
2. Cork Washer
3. Steel Washer
4. Dust Cap
5. Splined Stub Shaft
6. Tube
7. Tube-Yoke

Fig. 3, Slip-Joint Components

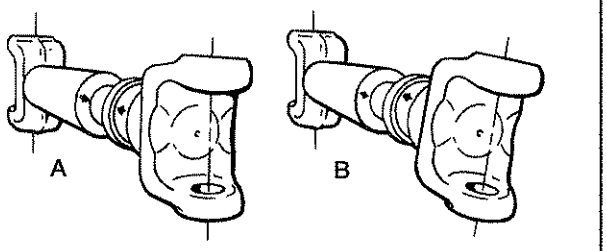
Driveline Component Replacement or Installation/ Assembly

3. Insert the splined shaft in the sleeve-yoke, so that the alignment marks are aligned, and the U-joints at each end of the driveshaft will be in phase. See **Fig. 4** and **Fig. 5**.

IMPORTANT: If no alignment marks are visible, or new slip-joint components have been installed, align the yokes, assemble the slip-joint, then have the driveline balanced to a maximum tolerance of 1 inch-ounce per 10 pounds weight per end, at 3000 rpm.

4. Install the slip-joint dust cap. Use only enough torque to seat the steel washer and cork seal (if so equipped) snug against the end of the sleeve-yoke; do not overtighten.

NOTE: The splines should slide freely, with only a slight drag from the slip-joint dust cap.



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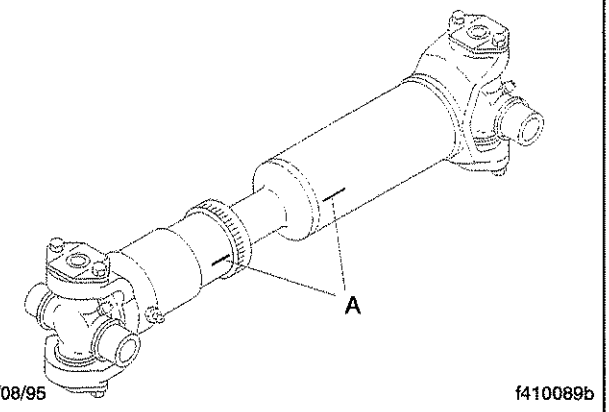
1. In Phase 2. Out of Phase

Fig. 4, U-Joint Phasing



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A. Use a marking stick or paint to add alignment marks.

Fig. 5, Slip-Joint Alignment Marks

RPL DRIVELINES

1. Remove the grease plug from the sleeve-yoke.
2. Coat the splines of the sleeve-yoke with multipurpose chassis grease.
3. Install the shroud on the splined shaft.
4. Install the seal onto the shroud.
5. Insert the splined shaft in the sleeve-yoke so that the alignment marks are aligned, and the U-joints at each end of the driveshaft will be in phase. See **Fig. 4** and **Fig. 5**.

IMPORTANT: If no alignment marks are visible, or new slip-joint components have been installed, align the yokes, assemble the slip-joint, then have the driveline balanced to a maximum tolerance of 1 inch-ounce per 10 pounds weight per end, at 3000 rpm.

6. Install the seal into the shaft groove.
7. Install the shroud. Use a brass hammer to tap the shroud over the seal.
8. Install the grease plug in the sleeve-yoke.

NOTE: The splines should slide freely, with only a slight drag from the slip-joint dust cap.

Midship Bearing and Coupling Shaft End-Yoke Replacement or Assembly

IMPORTANT: Parts for different series drivelines must not be intermixed. Incorrectly assembled or worn components can affect the entire driveline, resulting in too much vibration or driveline damage.

1. Place the coupling shaft in a soft-jawed vise; do not distort the tube with excessive grip.
2. Fill the entire cavity around the midship bearing with a waterproof grease, to shield the bearing from water and contaminants. Use enough grease to fill the cavities to the extreme edge of the slingers that surround the front and rear of the bearing. See **Fig. 6**.

NOTE: Midship bearings are permanently lubricated when manufactured; it is not necessary to pack the bearing with grease.

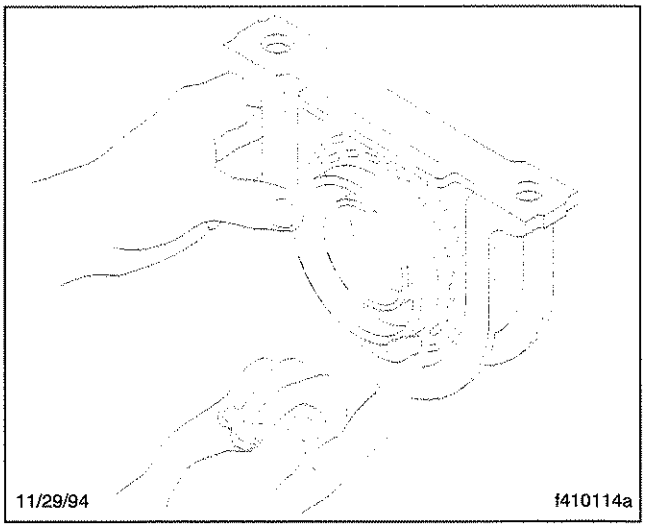


Fig. 6, Grease a Midship Bearing

3. Install one of the slingers, the midship bearing, then the other slinger on the coupling shaft. Press the bearing and slingers on by hand, as far as they will go.
4. Install the end-yoke. See **Fig. 7**.
   - 4.1 Apply Loctite® 242 to the shaft threads where the end-yoke locknut will be installed.
   - 4.2 Align the marks added to the coupling shaft and end-yoke during removal, then place the end-yoke on the shaft so the yoke bores are aligned at both ends of the shaft. See **Fig. 7**.
   - 4.3 Install the end-yoke nut, and tighten it 475 to 525 lbf·ft (645 to 710 N·m). Then back the nut off slightly, and tighten it to the same torque.

U-Joint Replacement or Installation

IMPORTANT: Parts for different series drivelines must not be intermixed. Also, components of the various makes of U-joints may not be interchangeable, and must be assembled only with compatible products. Incorrectly assembled or worn components can affect the entire driveline, resulting in too much vibration or driveline damage.

Worn bearing assemblies used with a new cross, or new bearing assemblies used with a worn cross will wear rapidly, making another replacement necessary in a short time. Always replace the cross and all four bearing assemblies at the same time.

If the slip-joint of a No. 2 or No. 3 driveshaft has been disassembled, assemble the slip-joint before installing the U-joints.

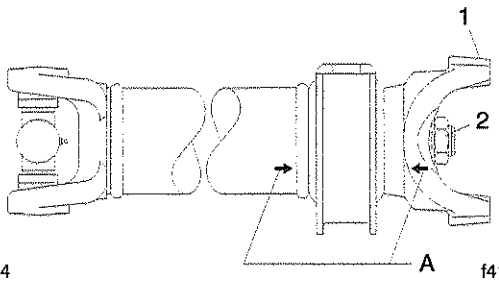
FULL ROUND YOKES

1. Place the assembled driveshaft in V-blocks or a soft-jawed vise; do not distort the tube with excessive grip.
2. For a No. 2 or No. 3 driveshaft, check that the slip-joint alignment marks are aligned, so that the U-joints at each end of the driveshaft will be in phase. See **Fig. 4** and **Fig. 5**.

   For a coupling shaft, check that the end-yoke and tube-yoke are aligned, so that the U-joints at each end of the coupling shaft will be in phase. See **Fig. 7**.

IMPORTANT: Misaligned driveshaft yokes will cause the U-joints to be out of phase, which will cause vibration in the driveline.

3. Inspect and lubricate the U-joint; see **Subject 140**.
4. Install the U-joint cross and bearing assemblies in the yoke.
   - 4.1 Position the U-joint cross in the driveshaft yoke so one grease fitting points toward the driveshaft, and aligns with the grease fitting on the sleeve-yoke (if so equipped). See **Fig. 8**.



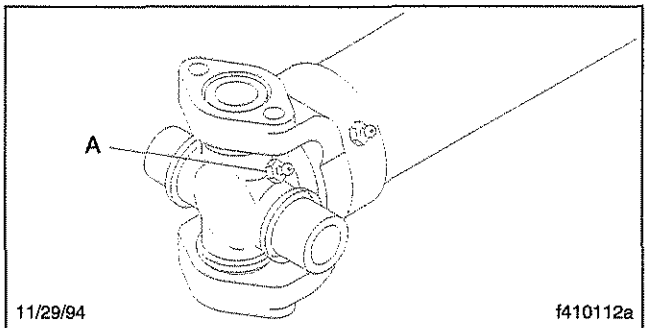
A. Use a marking stick or paint to mark the end-yoke and coupling shaft with alignment marks.
1. Half-Round End-Yoke 2. End-Yoke Locknut

Fig. 7, Alignment Marks on a Coupling Shaft With an End-Yoke

Driveline Component Replacement or Installation/ Assembly

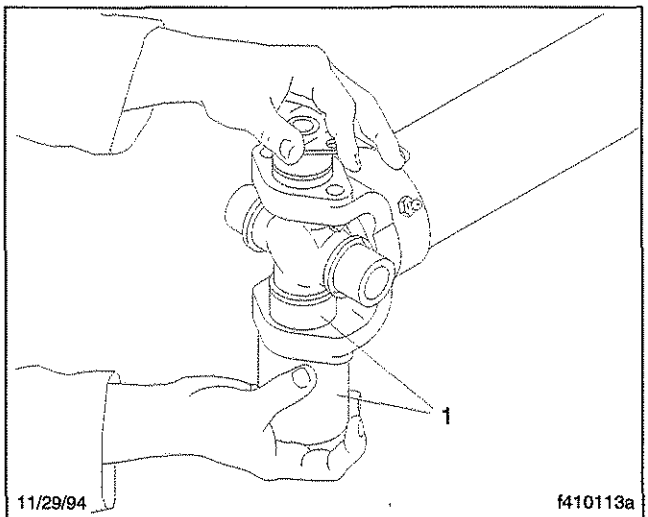
4.2 Move one end of the cross until a trunnion projects through the cross-hole, beyond the outer machined face of the yoke lug. Using a Spicer trunnion (journal) locator (see **Specifications, 400**), hold the trunnions in alignment with the cross-holes, while placing a bearing cup (plate-type) over the projected trunnion, and aligning it with the cross-hole. See **Fig. 9**.

IMPORTANT: A Spicer trunnion (journal) locator should be used to prevent damage to the U-joint trunnions and slingers.



A. Install the cross with grease fitting pointing toward the driveshaft, and aligned with the sleeve-yoke grease fitting.

Fig. 8, U-Joint Grease Fitting Positioning



NOTE: Sleeve-yoke shown.

1. Trunnion Locator

Fig. 9, Use a U-Joint Trunnion Locator

4.3 By hand, press the bearing-cup-plate flush with the face of the yoke. If the bearing cup binds in the cross-hole, tap the *center* of the bearing-cup plate with a leather or rubber mallet; do not tap the outer edges of the plate. See **Fig. 10**.

4.4 Install *new* bearing-cup-plate self-locking capscrews. See **Fig. 11**. Tighten the capscrews until all the parts are drawn down tight, with no gaps; do not tighten the capscrews to their final torque value.

⚠ WARNING

Self-locking bearing-cup-plate capscrews must not be reused; replace the capscrews with new ones. Also, do not undertighten or overtighten any bearing-cup-plate capscrews. A loose or broken fastener at any point in the driveline weakens the driveline connection, which could cause serious vehicle damage, or could result in a driveshaft separating from the vehicle, possibly causing loss of vehicle control that could result in serious personal injury or death.

4.5 Move the cross until it projects beyond the machined surface of the opposite yoke lug. Using the above procedure, install the opposite bearing assembly and its fasteners.

4.6 Slightly back off all four capscrews, then alternately tighten them in increments of 5 lbf·ft (7 N·m), to the applicable torque value in **Specifications, 400**.

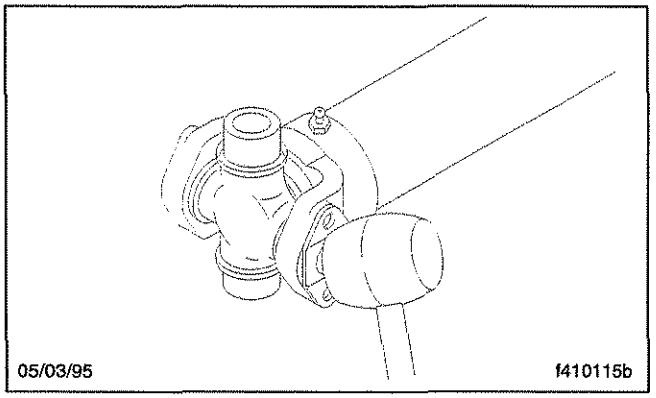
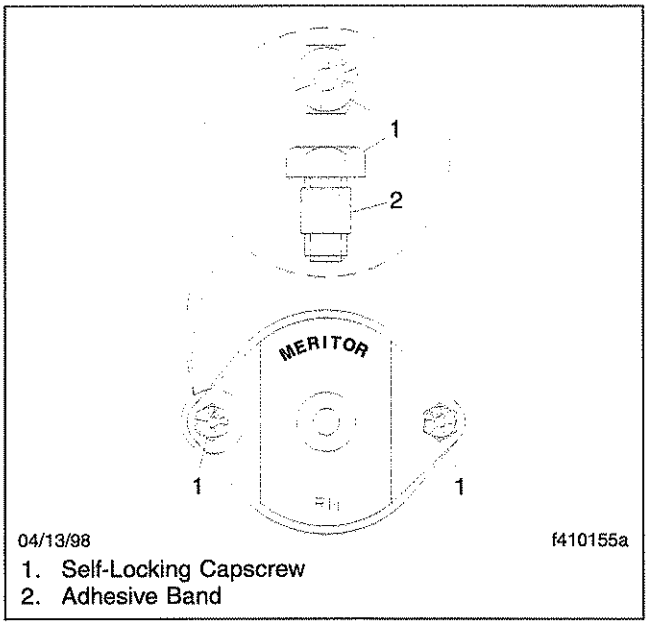


Fig. 10, Seat a U-Joint Bearing Cup In a Full-Round Yoke

Driveline Component Replacement or Installation/ Assembly



1. Self-Locking Capscrew
2. Adhesive Band

Fig. 11, Meritor U-Joint Fasteners for Full-Round Yokes

NOTE: The U-joint should flex, and be free of excessive bind. A slight drag is the most desirable condition for new U-joints. Excessive looseness is not desirable, and may result in an unbalanced driveshaft.

RPL SERIES U-JOINT

1. Place the assembled driveshaft in V-blocks or a soft-jawed vise; do not distort the tube with excessive grip.
2. For a No. 2 or No. 3 driveshaft, check that the slip-joint alignment marks are aligned, so that the U-joints at each end of the driveshaft will be in phase. See **Fig. 4** and **Fig. 5**.

   For a coupling shaft, check that the end-yoke and tube-yoke are aligned, so that the U-joints at each end of the coupling shaft will be in phase. See **Fig. 7**.

IMPORTANT: Misaligned driveshaft yokes will cause the U-joints to be out of phase, which will cause vibration in the driveline.

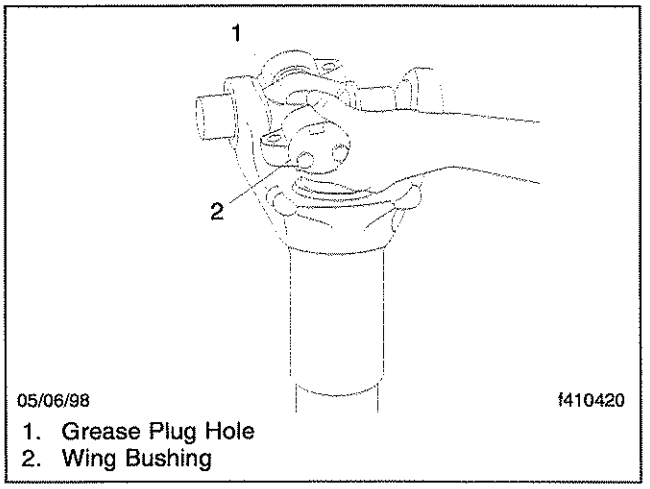
3. Inspect the U-joint. See **Subject 140**.
4. Install the U-joint cross and bearing assemblies in the yoke.

4.1 Position the U-joint cross in the driveshaft yoke so the grease plug hole is facing outboard. See **Fig. 12**.

4.2 Move one end of the cross until a trunnion projects through the cross-hole, beyond the outer machined face of the yoke lug. Place a bearing cup over the projected trunnion, and align it with the cross-hole.

4.3 Press the bearing cup into the yoke slightly past the snap ring groove. See **Fig. 13**. Check that the bearing cup is aligned with the universal joint trunnion.

4.4 Install the snap ring into the snap ring groove. See **Fig. 14**.



1. Grease Plug Hole
2. Wing Bushing

Fig. 12, Fit the U-Joint

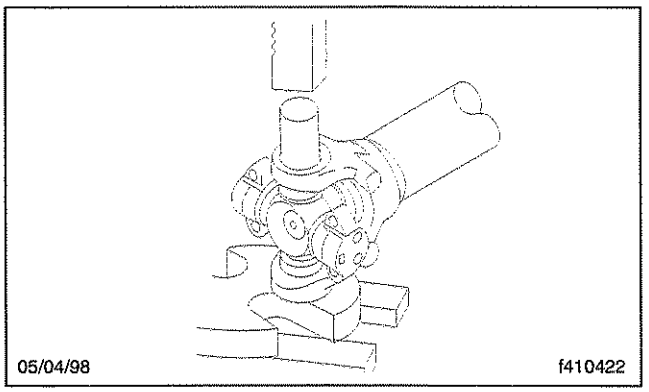


Fig. 13, Install Bearing Cups, RPL Series U-Joint

Driveline Component Replacement or Installation/ Assembly

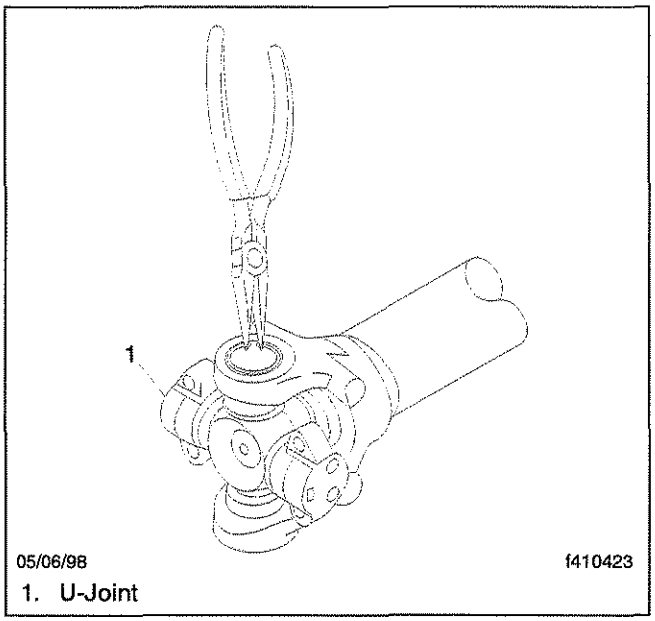
4.5 Use a snap ring installation gauge to check that the snap ring is fully seated in the snap ring groove. See **Fig. 15**.

4.6 Move the cross until it projects beyond the machined surface of the opposite yoke lug. Using the above procedure, install the opposite bearing cup assembly.

4.7 Install the grease plug. Tighten the grease plug until the hex head breaks off. See **Fig. 16**.

NOTE: The U-joint should flex, and be free of excessive bind. A slight drag is the most desirable condition for new U-joints. Excessive looseness is not desirable, and may result in an unbalanced driveshaft.

4.8 If the universal joint does not move freely, strike the yoke ear with a brass or copper hammer. See **Fig. 17**.



1. U-Joint

Fig. 14, Install the Snap Rings

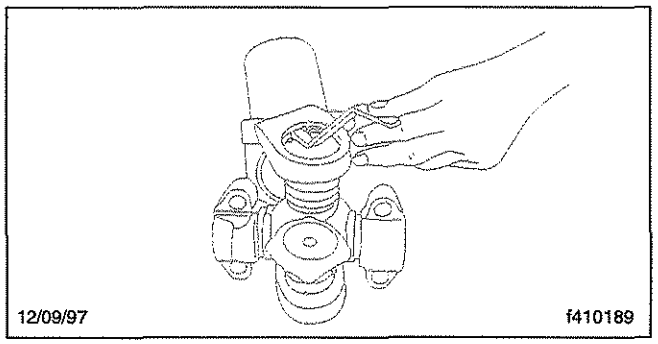


Fig. 15, Check Snap Ring Installation

Transmission/Axle End-Yoke Replacement or Installation

IMPORTANT: Parts for different series drivelines must not be intermixed. Incorrectly assembled or worn components can affect the entire driveline, resulting in too much vibration or driveline damage.

1. Apply Loctite® 242 to the input- or output-shaft threads where the end-yoke locknut will be installed. See **Fig. 18**.
2. By hand, install the end-yoke on the input or output shaft as far as it will go.

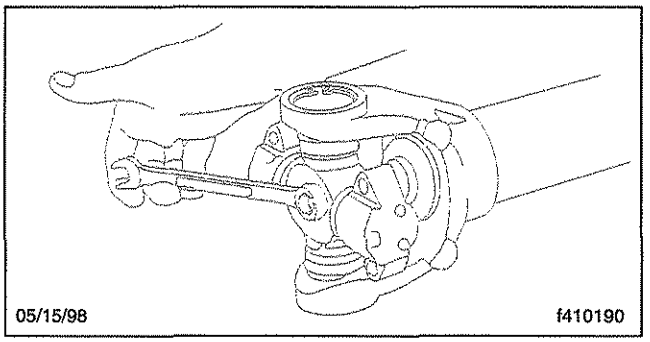
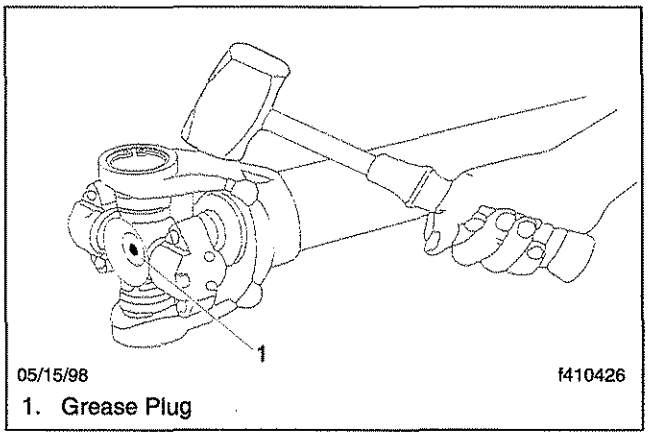


Fig. 16, Grease Plug Installation



1. Grease Plug

Fig. 17, Strike the Yoke Ear

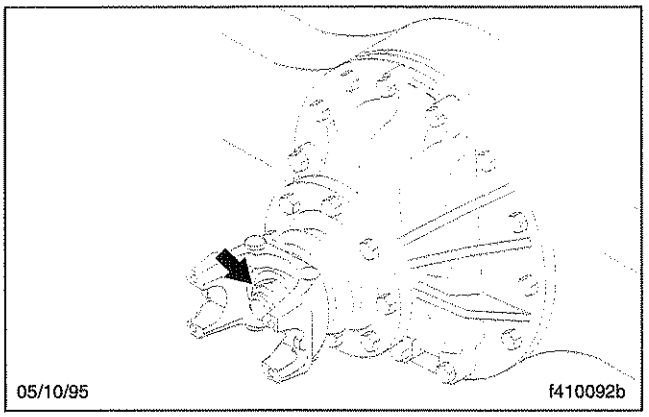


Fig. 18, Axle End-Yoke Locknut

3. Install a new end-yoke locknut, and tighten it to the applicable torque value in **Specifications, 400**.

Troubleshooting

Noise or vibration associated with the driveline can be caused by non-driveline parts. To find the cause of noise or vibration, first road test the loaded vehicle. Drive in all gears and at all speed ranges for which the vehicle was designed, including those at which problems are reported.

NOTE: Operating a vehicle at speeds that exceed its drivetrain design specifications may cause an out-of-balance vibration.

The following is a troubleshooting elimination process; checks should be made in the order listed. At each step where a problem is found, correct the problem before proceeding to the next step, then test drive the vehicle to see if other problems still exist. If no other problems exist, the elimination process may be ended at that step.

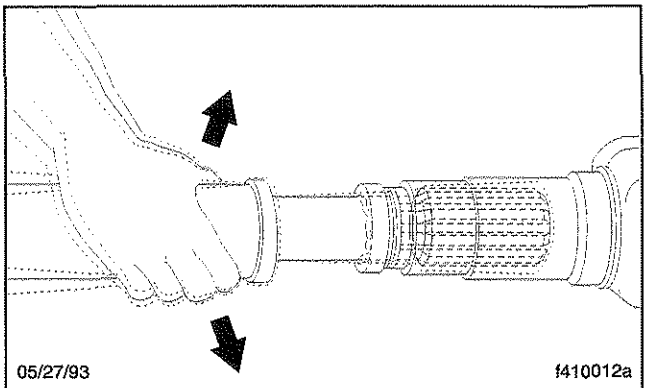
1. Check all tires for uneven wear and for out-of-roundness. Check for mismatched tires. Look for wheels and rims that are out of alignment. For instructions, see **Group 40**.
2. Check the rear suspension for loose or broken U-bolts; broken, shifted, or mismatched rear springs; or broken spring seats. If so equipped, check the air suspension for incorrect air spring height. Look for anything that could cause angular misalignment of the rear axle pinion(s). For instructions, see **Group 32**.
3. Check the frame rails and crossmembers for bends, twists, or breaks; for frame-alignment-checking and crossmember-replacement instructions, see **Group 31**.
4. Check the engine and transmission mounts; see **Group 01** (Engine) and **Group 26** (transmission). Check the coupling shaft's midship bearing mounts. Replace mountings that are deteriorated or oil-soaked; tighten loose mounting bolts. Oil-soaked or deteriorated mountings, or loose mounting bolts, can cause driveline angular misalignment.
5. Check for loose U-joint bearing-cup-plate and bearing-strap capscrews. Tighten any loose fastener to the applicable torque value in **Specifications, 400**.

⚠ CAUTION

Do not overtighten the bearing-cup-plate or bearing-strap capscrews. A loose or broken fastener at any point in the driveline weakens the driveline connection, which could result in serious vehicle damage.

6. Check all U-joint assemblies, slip-joint splines, and midship bearings for wear.
   - 6.1 Try to move each driveshaft up and down, and from side to side. If movement is greater than 0.006 in (0.15 mm) of a U-joint cross in its bearings, replace the U-joint assembly.
   - 6.2 If the midship bearing rattles or is loose on its shaft, replace it.
   - 6.3 Try to bend the sleeve-yoke and splined shaft up and down, and from side to side. See **Fig. 1**. If looseness is greater than 0.007 in (0.18 mm), replace the sleeve-yoke and splined shaft.

     If driveline components must be replaced, see **Subject 150**.
7. Check each driveshaft for an indication of missing balance weights. If any weights appear to be missing, have the driveshaft balanced to a maximum tolerance of 1 inch-ounce per 10 pounds weight per end, at 3000 rpm.
8. Check each driveshaft for dents, bends, twists, or other damage.



Try to bend the sleeve-yoke and splined shaft up and down, and from side to side.

Fig. 1, Check for Slip-Joint Spline Wear

Troubleshooting

If damaged, jack up the rear axle, support it on jackstands, place the transmission in neutral, and turn the driveshaft by hand to check runout.

The driveshaft must be straight within 0.015 inch (0.38 mm) on the slip-joint seal surface of the splined shaft, 0.020 inch (0.51 mm) on the tube 3 inch (76 mm) from the front and the rear welds, and 0.025 inch (0.635 mm) at the center of the tube. See **Fig. 2**.

If the driveshaft is not straight within specifications, replace the tube. See **Subject 150** for runout specifications for a *new* (or rebuilt) driveshaft.

9. Check each driveline for proper U-joint phasing. See **Fig. 3**.

   9.1 On No. 2 and No. 3 driveshafts, if the U-joints are out of phase, check the slip-joint for alignment marks. If necessary, disassemble the slip-joint, and align the marks.

NOTE: To disassemble the slip-joint, uncouple the U-joint at one end of the driveshaft, unscrew the slip-joint seal from the sleeve-yoke, then pull the sleeve-yoke and splined shaft apart. Reverse the procedure to assemble the slip-joint.

   9.2 If no alignment marks are present, disassemble the slip-joint, and reassemble it with the U-joints in one of the two in-phase positions (180 degrees apart).

   Test drive the vehicle, then assemble the slip-joint in the other in-phase position. Test drive the vehicle again.

   Determine which in-phase position provides vibration-free operation. Assemble the slip-joint in the correct in-phase position, and mark the slip-joint with alignment marks.

   9.3 If the U-joints are out of phase on a coupling shaft, uncouple the U-joint from the coupling shaft end-yoke, then remove the end-yoke nut. Remove the end-yoke, using a yoke puller. See **Fig. 4** for a half-round end-yoke, or see **Fig. 5** for a full-round end-yoke. Align the end-yoke, then install it by hand. Install the end-yoke nut, and tighten it 475 to 525 lbf·ft (645 to 710 N·m). Slightly back off the nut, and again tighten it to the same torque. Couple the coupling shaft to the driveshaft U-joint.

10. Check the torque on all of the end-yoke nuts in the drivetrain; see the applicable torque values in **Specifications, 400**.

    If any yoke nut was not at its specified torque, check the yoke for wear by trying to move it up and down, and back and forth. If the yoke can be rocked on its shaft, or moved in or out on its shaft, replace the yoke and yoke nut. See **Subject 150**.

    If the yoke is not worn, tighten the yoke nut to its torque value.

11. *On single-drive vehicles:*

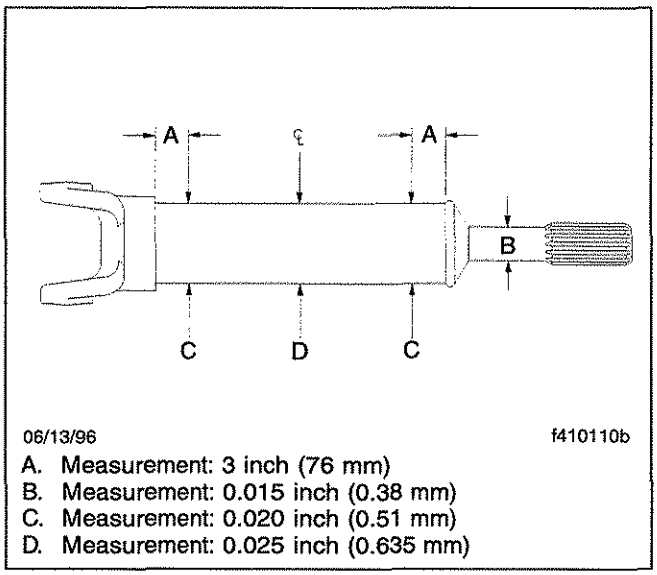


Fig. 2, Runout Specifications for a Used Driveshaft

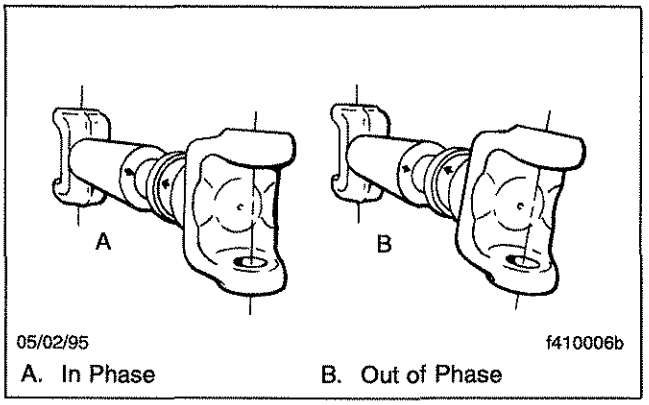
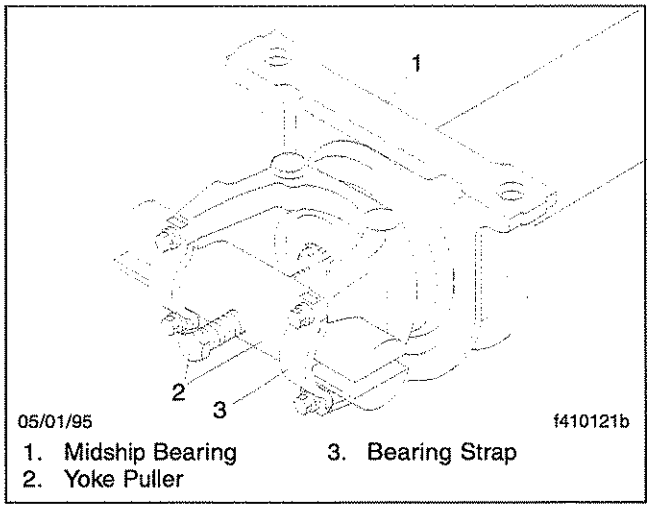
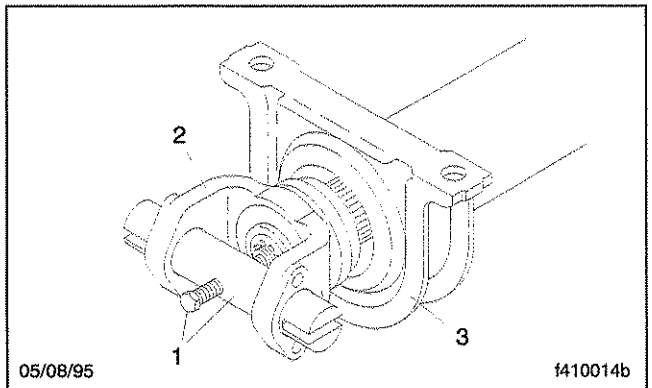


Fig. 3, U-Joint Phasing



1. Midship Bearing
2. Yoke Puller
3. Bearing Strap

Fig. 4, Remove a Half-Round End-Yoke from a Coupling Shaft



1. Yoke Puller
2. Full-Round Yoke
3. Midship Bearing

Fig. 5, Remove a Full-Round End-Yoke from a Coupling Shaft

Have the No. 2 driveshaft balanced to a maximum tolerance of 1 inch-ounce per 10 pounds weight per end, at 3000 rpm.

On dual-drive vehicles:

11.1 Remove the No. 3 driveline; then, with the interaxle differential locked, test drive the vehicle.

11.2 If vibration still exists, install the No. 3 driveline, then have the No. 2 driveshaft balanced to a maximum tolerance of 1 inch-ounce per 10 pounds weight per end, at 3000 rpm.

If *no* vibration exists, check that both rear axle gear ratios are matched. If the gear ratios do not match, replace one of the gear sets with a gear set having the correct ratio, then install the No. 3 driveline.

11.3 Have the No. 3 driveshaft balanced to a maximum tolerance of 1 inch-ounce per 10 pounds weight per end, at 3000 rpm.

11.4 Have the No. 2 driveshaft balanced to a maximum tolerance of 1 inch-ounce per 10 pounds weight per end, at 3000 rpm.

12. If so equipped, balance the coupling shaft(s) to a maximum tolerance of 1 inch-ounce per 10 pounds weight per end, at 3000 rpm.

Specifications

Fastener Torques				
Description			**Size**	**Torque: lbf·ft (N·m)**
End-Yoke Nut				
Transmission Output Shaft	Fuller	RT 8609	1-1/2–18	400–450 (542–610)
		T/X 14607 RT 8608 /7608LL RTO 11909MLL /14909MLL /11908LL RTX 16709 /15710 /16710 RT/X 11609 /11709 /12609 /12709 /13609 /13709 / 14609 /14709 /11710 /12710 /13710 /14710 RTO/X 11708LL /14708LL RT/O/X 14715 /15715 RTLO 12610 /13610 /14610 /15610 /16610 /12713 / 14713 /16713 /14718 /16718 /18718	2–16	450–500 (610–678)
	Meritor	RM/O/X 9–115 /–125 /–135 /–145 /–155 RM/X 10–115 /–125 /–135 /–145 /–155 /–165 RMO 13–145	2–16	450–500 (610–678)
	Allison	HD Series	2–16	600–800 (813–1085)
Single Axle Input Shaft	Eaton	23105S/D, 23080S/D	1-3/4–12	840–1020 (1139–1383)
	Meritor	RS–21–160 /–23–160 /–23–161 /–23–185 /–25–160	M45 x 1.5	996–1232 (1350–1670)
Forward-Rear Axle Input Shaft	Eaton	DT 402/P, DS/DD 404/P, DT/DP 451P	1-5/8–18	780–960 (1058–1302)
		DP/DS/DT 461P	1-7/8–12	840–1020 (1139–1383)
	Meritor	RT–40–145 /–44–145	M39 x 1.5	922–1132 (1250–1535)
		RT–46–160	M45 x 1.5	996–1232 (1350–1670)
Forward-Rear Axle Output Shaft	Eaton	DT 402/P, DS/DD 404/P, DT/DP 451P	1-1/4–12	480–600 (651–813)
		DP/DS/DT 461P	1-3/4–12	840–1020 (1139–1383)
	Meritor	RT–40–145 /–44–145 /–46–160	M39 x 1.5	922–1132 (1250–1535)
Rearmost Axle Input Shaft	Eaton	DT 402/P, DS/DD 404/P, DT/DP 451P	1-1/2–18	560–700 (759–949)
		DP/DS/DT 461P	1-3/4–12	840–1020 (1139–1383)
	Meritor	RT–40–145 /–44–145	M39 x 1.5	922–1132 (1250–1535)
		RT–46–160	M45 x 1.5	996–1232 (1350–1670)
Midship Bearing (Coupling Shaft)			1-1/4–18	475–525 (645–710)
U-Joint Capscrew				
Bearing Plate (for full-round yoke)			3/8–24	43 (49)
Bearing Strap (for half-round yoke)			1/2–20	125 (169)
RPL U-joints			1/2–20	125 (169)
Midship Bearing Locknut				

Specifications

Fastener Torques		
Description	**Size**	**Torque: lbf.ft (N.m)**
Bracket to Crossmember	1/2–13	91 (123)
Bearing Mount to Bracket	1/2–13	91 (123)

Table 1, Fastener Torques

Special Tools

JOURNAL LOCATOR (FOR INSTALLING U-JOINTS IN FULL-ROUND YOKES)

To order, contact your Dana Corporation Spicer Service Representative.

U-JOINT REMOVAL TOOL KIT (FOR REMOVING U-JOINTS FROM FULL-ROUND YOKES)

To order Owatonna Tool Kit No. 7057, contact:

Owatonna Tool Company
Owatonna, Minnesota 55060

END-YOKE PULLER (FOR REMOVING END-YOKES FROM TRANSMISSION OUTPUT SHAFTS, COUPLING SHAFTS, AND REAR-AXLE INPUT AND OUTPUT SHAFTS)

To order End-Yoke Puller J 7804–01, contact:

Kent-Moore Tool Division
29784 Little Mack
Roseville, MI 48066–2298
Telephone: 1–800–328–6657 Telex: 244040 KMTR
UR FAX: (313) 774–9870

To order Yoke and Flange Remover SP–450, contact:

G & W Tool Company
907 South Dewey
Wagoner, OK 74467

Driveline Angularity and Balance 41.01

Contents

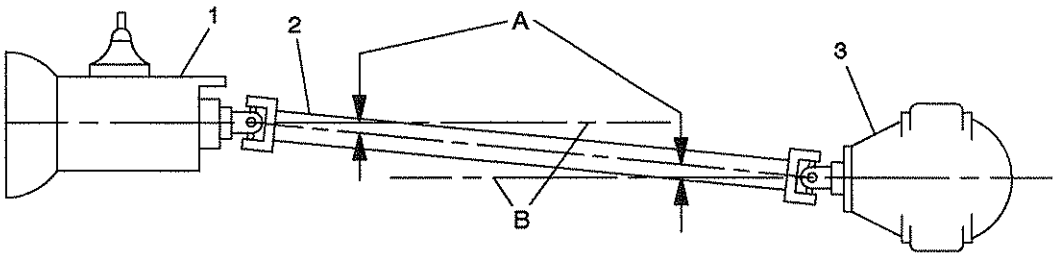
Subject	Subject Number
General Information	050
Service Operations	
Engine and Pinion Angle Measurement	100
Driveline Angle Checking	110
Specifications	400

Driveline Angularity

The most important consideration of driveline angularity is the U-joint working angle. A U-joint working angle is the angle formed by the intersection of the driveshaft centerline and the extended centerline of the shaft of any component to which the U-joint connects. **See Fig. 1.** Because the action of a U-joint causes a fluctuating speed difference between the shafts it connects, the effect created by the U-joint at the input-shaft end-yoke must cancel the effect created by the U-joint at the output-shaft end-yoke. This is done by making the U-joint working angles at both ends of the driveshaft approximately equal, with the U-joints in phase.

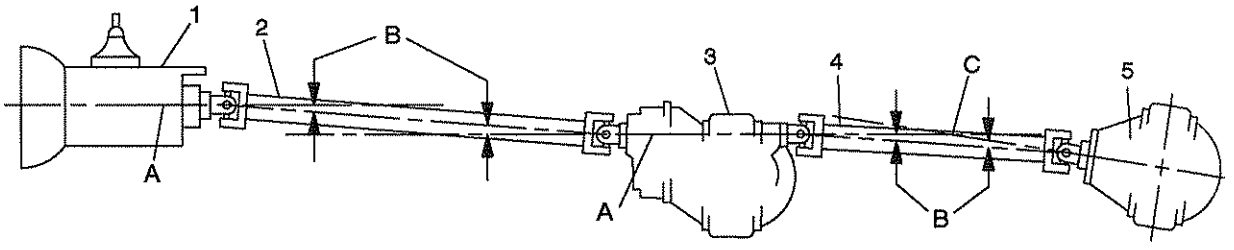
The U-joint working angles may be made approximately equal by either of two basic arrangements: a parallel arrangement (**Fig. 1**), or an intersecting arrangement (**Fig. 2**).

Driveline angularity may be adversely affected if rear suspension U-bolts are loose or broken; rear springs are broken, shifted, or mismatched; spring seats are broken; frame rails are bent, twisted, or broken; or



A. Equal U-Joint Working Angles
B. Parallel Centerlines
1. Transmission
2. No. 2 Driveshaft
3. Rear Axle

Fig. 1, Parallel Arrangement for Single-Drive Vehicles



A. Parallel Centerlines
B. Equal U-Joint Working Angles
C. Intersecting Centerlines
1. Transmission
2. No. 2 Driveshaft
3. Forward-Rear Axle
4. No. 3 Driveshaft
5. Rearmost Axle

Fig. 2, Intersecting Planing Arrangements for Dual-Drive Vehicles

transmission or engine mounts are loose or deteriorated.

U-Joint Phasing

The fluctuating speed difference, caused by the action of a U-joint connecting angled shafts, can be cancelled only if the U-joint at the other end of the driveshaft is in phase with that U-joint (and the U-joint working angles are approximately equal). If the yoke lugs at both ends of the driveshaft are lying in the same plane (a plane which bisects the shaft lengthwise) the U-joints will be in phase. **See Fig. 3.**

To ensure that the U-joints turn in phase, the sleeve-yoke and splined shaft of driveshaft slip-joints, and the coupling shaft and midship bearing end-yoke, should be marked for assembly reference before disassembly.

Driveline Balance

After manufacture, each driveline yoke is statically balanced. After assembly of the slip-joint, each driveshaft is checked for out-of-roundness, and straightened as necessary; then each shaft is dynamically balanced.

If the driveshaft slip-joint is disassembled for any reason, the sleeve-yoke and splined shaft should be marked for assembly alignment. Misaligned slip-joints will seriously affect the U-joint phasing and balance of the driveline. Even if the slip-joint is assembled 180 degrees from its original position (which will keep the U-joints in phase), the dynamic balance of the driveshaft will be negatively affected.

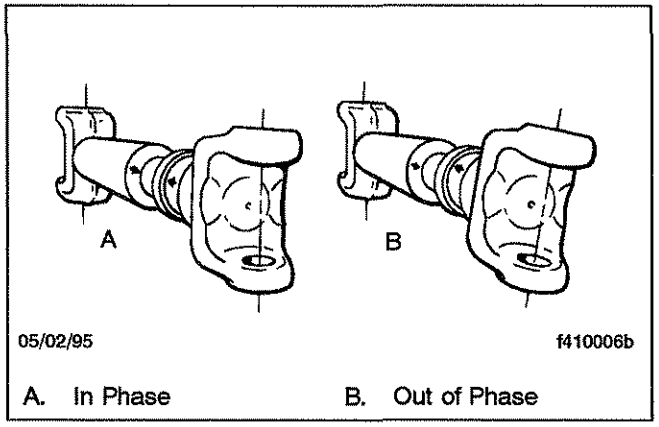


Fig. 3, Driveline U-Joint Phasing

A driveline can become unbalanced or greatly weakened if a driveshaft has been dented, bent, twisted, or otherwise damaged. Operating a vehicle at speeds which exceed the speed of the driveshaft's design specifications will cause an out-of-balance vibration. Loose end-yoke nuts, loose midship bearing or auxiliary transmission mounts, loose bearing retainer capscrews, worn U-joint trunnions or bearings, and worn slip-joint splines can lead to excessive movement of the driveshaft and cause driveline imbalance.

Midship Bearings

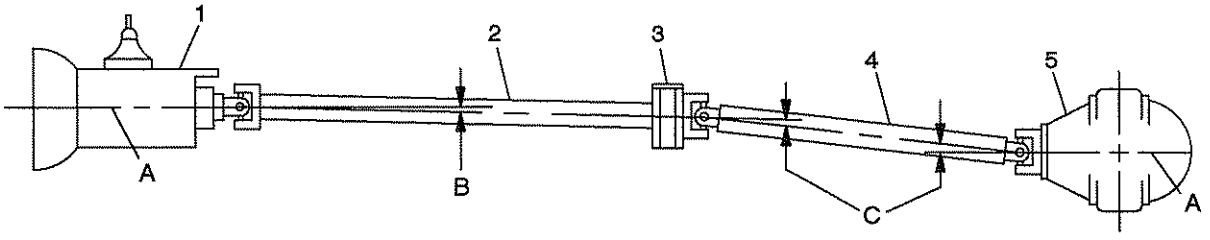
A long driveshaft, supported only at its ends, will sag in the middle from its own weight. When turning at high rpm, it will flex, causing an out-of-balance vibration. Therefore, most vehicles having a long wheelbase use a midship bearing, mounted on a crossmember in the frame, for additional driveline support. **See Fig. 4.** This allows the driveshaft to be separated into two shorter shafts, thus improving balance and stability.

Angularity Standards and Drivetrain Configuration

The U-joints require a minimum working angle of 1/2 degree to ensure needle-roller movement in the U-joint bearings. Without this movement, brinelling of the trunnion bearing-contact surfaces would occur. Suspension movement causes driveshaft angles to change (and therefore, needle-roller movement) in both of the U-joints attached to driveshafts that connect to the axles. However, no angle change occurs in the U-joints attached to a driveshaft which connects the main transmission to a midship bearing or auxiliary transmission. Their working angles must be established during installation.

When a midship bearing is included in the drivetrain, it is installed so that the centerline of the coupling shaft is in horizontal (side-to-side) alignment within 1/2 degree, and within 1/2 to 1 degree of vertical alignment, with the centerline of the main transmission output shaft. **See Fig. 4.**

When an auxiliary transmission is included in the drivetrain, it is installed so that the centerline of the inter-transmission (no. 1) driveline is in exact horizontal (side-to-side) alignment (within 1/2 degree), and down 1/2 to 1 degree from vertical alignment, with the centerline of the main transmission output shaft.



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A. Parallel Centerlines
B. 1/2 to 1 Degree
C. Working Angles Unequal by 1/2 to 1 Degree

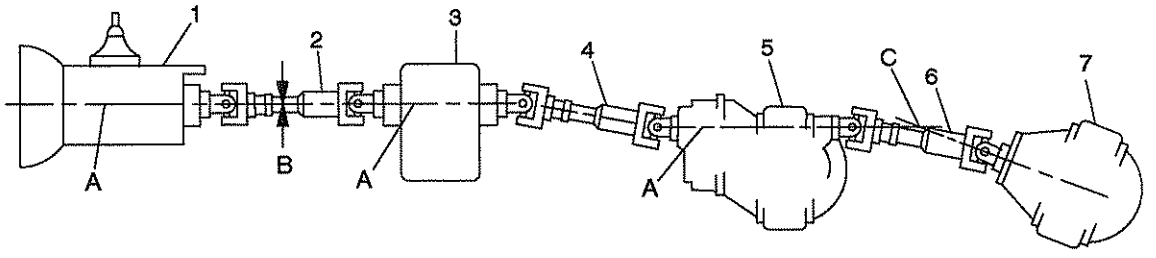
1. Main Transmission
2. Coupling Shaft
3. Midship Bearing
4. No. 2 Driveshaft
5. Rear Axle

Fig. 4, Midship Bearing in a Single-Drive Vehicle

Further, the auxiliary transmission thru-shaft centerline must be parallel (horizontally and vertically) to the centerline of the main transmission output shaft, in order to achieve equal working angles. **See Fig. 5.**

Every U-joint has a maximum working angle, determined by the design and size of its cross assembly and yokes. Exceeding the maximum working angle can cause rapid U-joint wear, or in severe cases, destruction of the U-joint. For smooth operation and long drivetrain component life, the U-joint working angles must be kept small and approximately equal for each shaft.

The U-joint working angles may be made approximately equal by either of two basic arrangements: a parallel arrangement (**Fig. 1**) or an intersecting arrangement (**Fig. 2**). The parallel arrangement consists of installing the drivetrain components so that all of the input, output, and thru-shaft centerlines are



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A. Parallel Centerlines
B. 1/2 to 1 Degree
C. Intersecting Centerlines

1. Main Transmission
2. No. 1 Driveline
3. Auxiliary Transmission
4. No. 2 Driveshaft
5. Forward-Rear Axle
6. No. 3 Driveshaft
7. Rearmost Axle

Fig. 5, Auxiliary Transmission in a Dual-Drive Vehicle

approximately parallel. The intersecting arrangement (used only for some interaxle drivelines) consists of installing the drive components so that the rearmost axle pinion shaft's extended centerline intersects the forward-rear axle thru-shaft's extended centerline approximately midway between the U-joints, when all of the other shafts (including the forward-rear axle thru-shaft) are approximately parallel.

All single-drive vehicles, and the forward-rear axles of dual-drive vehicles, use the parallel arrangement. Rearmost axles of dual-drive vehicles may use the parallel arrangement or the intersecting arrangement, depending on the drivetrain configuration.

The specific drivetrain configuration of each Freightliner vehicle consists of its wheelbase, number and type of axles, axle spacing, type of suspension, and number of transmissions. The specific drivetrain configuration determines the driveline arrangement and required installation angles of all the vehicle's drivetrain components.

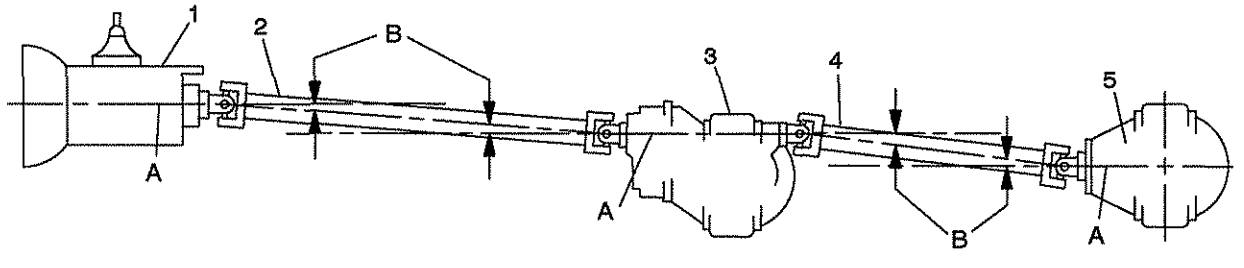
The simplest drivetrain configuration consists of a single short driveline connecting a main transmission to a single-drive axle, in a parallel arrangement. This driveshaft is always referred to as the no. 2 driveshaft. The parallel arrangement always used on single-drive vehicles is **shown in Fig. 1**.

On dual-drive vehicles that have both axle input shafts of approximately the same height, a parallel arrangement is used. The driveshaft connecting the main (or auxiliary) transmission to the forward-rear axle is always referred to as the no. 2 driveshaft; and the interaxle driveshaft is always referred to as the no. 3 driveshaft. **See Fig. 6**, which shows a parallel arrangement when used on dual-drive vehicles.

Most dual-drive vehicles have a high thru-shaft on the forward-rear axle, and a low pinion on the rearmost axle. When the vehicle is on level ground, the interaxle (no. 3) driveshaft may create very sharp U-joint working angles with the input and output shafts when they are parallel. In normal driving, the U-joints could momentarily exceed their maximum working angle, and driveline or drivetrain damage could result. By using an intersecting arrangement at the no. 3 driveshaft, smaller U-joint working angles are created, promoting longer U-joint life and reduced driveline vibration. An intersecting arrangement used on dual-drive vehicles is **shown in Fig. 2.**

However, some axle spacings, axle models, and suspension designs allow additional axle movement or axle windup that requires additional clearances between the driveshaft and the frame or suspension components, or that creates other conditions that make the intersecting arrangement of the no. 3 driveshaft unsatisfactory. For those drivetrain configurations, it is necessary to use a modified parallel or modified-intersecting arrangement for the no. 3 driveshaft.

On drivetrain configurations that require a modified parallel arrangement, the rearmost-axle pinion shaft centerline is placed at an angle that is 2 degrees higher above horizontal than are the other input and output shafts. **See Fig. 7.**



A. Parallel Centerlines
B. Equal U-Joint Working Angles

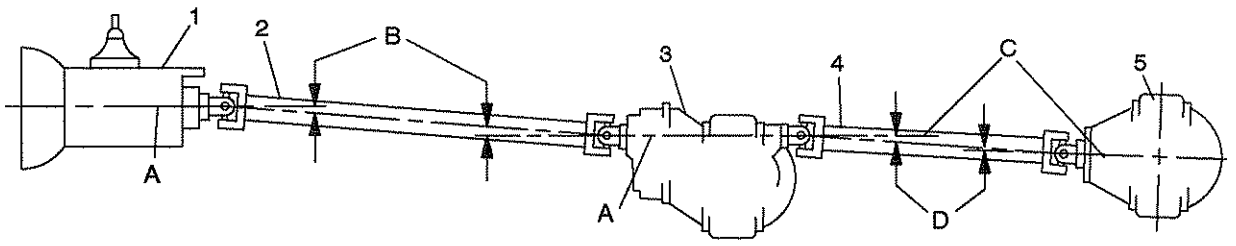
1. Transmission
2. No. 2 Driveshaft
3. Forward-Rear Axle
4. No. 3 Driveshaft
5. Rearmost Axle

Fig. 6, Parallel Arrangement for Dual-Drive Vehicles

On drivetrain configurations that require a modified-intersecting arrangement, the "proper" intersecting angle is determined, then the rearmost-axle pinion shaft centerline is placed at an angle that is 2 degrees closer to horizontal than the "proper" intersecting angle. **See Fig. 8.**

The axle pinion angles for all suspensions are factory-set for correct driveline angularity. On Freightliner spring suspensions, tapered axle planing shims at the springs maintain the correct axle pinion angle. On Hendrickson suspensions, spacers at the torque rods are used to maintain the correct axle pinion angles.

In the field, whenever axle or suspension components are changed, the axle pinion angles may also change. If this occurs, contact your district service manager for the correct axle pinion angle adjustment procedure.



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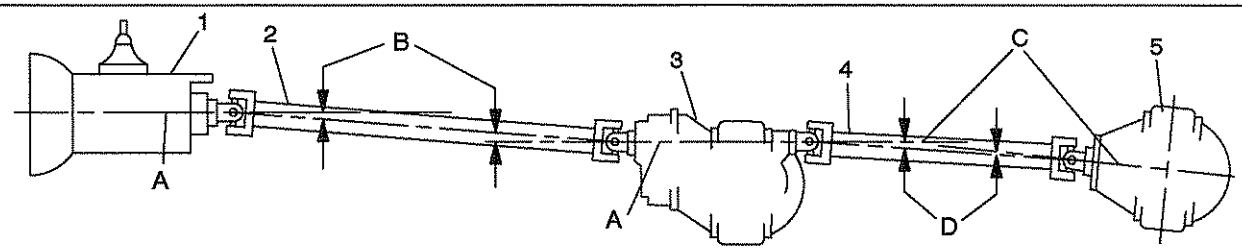
A. Parallel Centerlines
B. Equal U-Joint Working Angles
C. Modified-Parallel Centerlines
D. U-Joint Working Angles Not Equal by 2 Degrees

1. Transmission
2. No. 2 Driveshaft
3. Forward-Rear Axle
4. No. 3 Driveshaft
5. Rearmost Axle

Fig. 7, Modified-Parallel Arrangement for Dual-Drive Vehicles



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A. Parallel Centerlines
B. Equal U-Joint Working Angles
C. Modified-Intersecting Centerlines
D. U-Joint Working Angles Not Equal by 2 Degrees

1. Transmission
2. No. 2 Driveshaft
3. Forward-Rear Axle
4. No. 3 Driveshaft
5. Rearmost Axle

Fig. 8, Modified-Intersecting Arrangement for Dual-Drive Vehicles

Engine and Pinion Angle Measurement

Before checking the pinion angles or engine angle, check that the engine and transmission mounts are tight and in good condition. Loose or deteriorated mounts will cause inaccurate readings.

Using a digital angle meter, spirit level protractor **(see Fig. 1)**, or the head of a machinists's protractor, measure the engine angle, driveshaft angles, and pinion angles. Read all angles to the nearest one-tenth of a degree (6 minutes).

After adjustment of any driveline angle, check the angle again.

To measure the engine angle (transmission output-shaft angle) or axle pinion angles, do the following:

1. Inflate the vehicle tires to their normal operating pressure.
2. Park the unloaded vehicle on a level surface. Do not try to level the vehicle frame by jacking the front or rear axles. If the frame cannot be leveled from front to rear, determine and record the off-level inclination of the frame, and add or subtract that value from the measured values.
3. Chock the tires and place the transmission in neutral. Release the parking brakes.
4. The transmission output-shaft, coupling-shaft, and axle input- and output-yoke angles can be measured at either the top or bottom lug of the end-yoke being checked. For a full-round end-yoke, remove the bearing cup from the yoke lug. See **Section 41.00** for full-round end-yoke bearing cup removal.
5. Turn the end-yoke until the machined surface of the yoke lug is horizontal. **See Fig. 2.**

NOTE: To turn the driveshaft, raise one side of the rear (single-drive) or rearmost (dual-drive) axle until the tires are off the ground. Place a safety stand under the axle. With the transmission in neutral, and the interaxle differential (if equipped) unlocked, turn the tire to move the driveshaft.

6. Adjust the protractor scale to read 0 degrees. Position the protractor alongside the U-joint trunnion, on the machined surface of the end-yoke, and at a 90-degree angle to the frame centerline. **See Fig. 2.** Then turn the end-yoke until the bubble in the level vial is exactly between the two marks on the vial. Remove the jack stand and lower the rear axle to the ground.
7. Without changing the position of the end-yoke, turn the protractor until it is parallel to the frame centerline. **See Fig. 3.** Adjust the calibrated scale so the bubble is exactly between the two marks on the level vial. Record the calibrated scale reading opposite the "0" mark. Correct this value for any previously recorded off-level inclination.
8. For a full-round end-yoke, install the bearing cup. See **Section 41.00** for full-round end-yoke bearing cup installation.

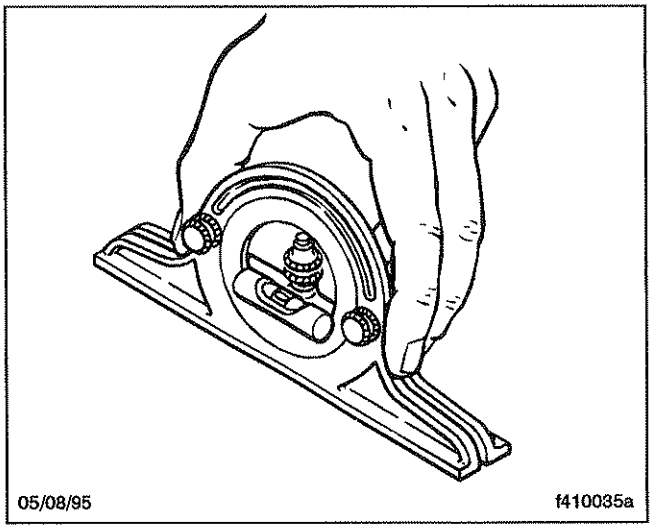
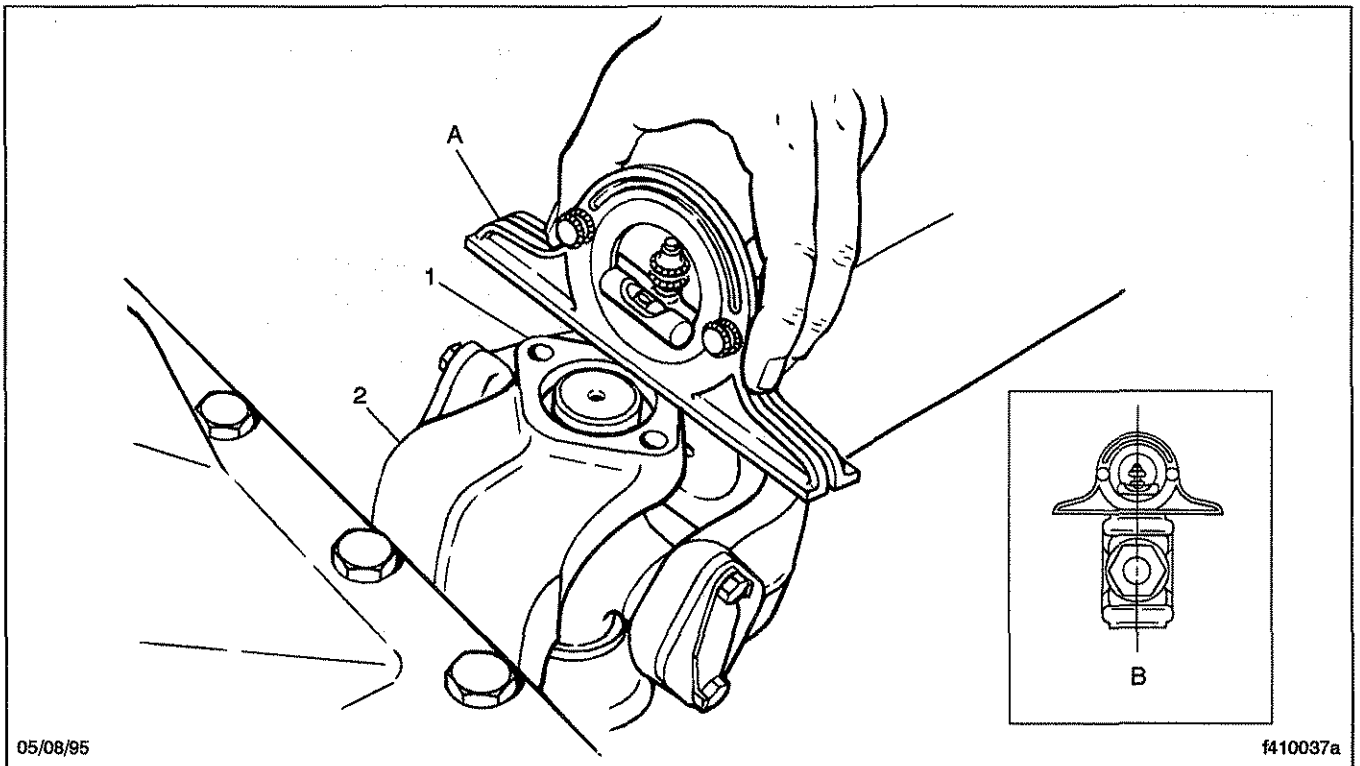


Fig. 1, Spirit Level Protractor

Engine and Pinion Angle Measurement

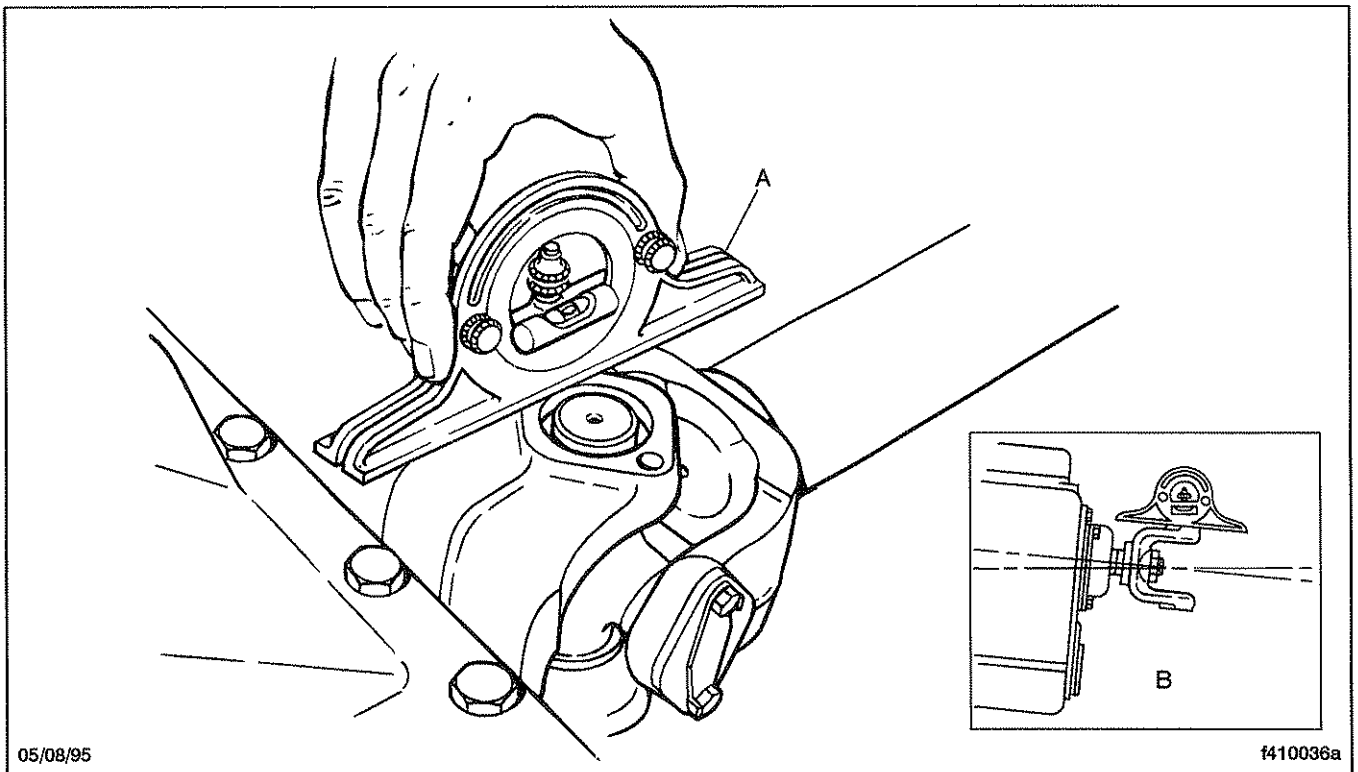


NOTE: Full-round end-yoke is shown.

A. Protractor held at right angle to vehicle frame centerline.
B. End view of end-yoke.

1. Machined Surface of Yoke Lug
2. End-Yoke

Fig. 2, Horizontal Positioning of Yoke Lug Machined Surface



NOTE: Full-round end-yoke is shown.

A. Protractor held parallel to vehicle frame centerline.
B. Side view of end-yoke.

Fig. 3, Measuring Pinion Angles

Driveline Angle Checking

If a vehicle is equipped with a Freightliner spring suspension, the axle pinion angles are factory-set using alignment shims at the rear springs. These shims have notches on the thick end of the shim. Count the number of notches in the thick end of each shim to make sure that the correct shim is used. Also, make sure the thick end of the shim is positioned correctly. See the applicable table in **Specifications, 400** for shim identification and use. If the axle pinion angles on these suspensions are incorrect, contact your district service manager for the adjustment procedure.

If a vehicle is equipped with a Hendrickson suspension, spacers at the torque rods are used to maintain the correct axle pinion angles. If the measured axle pinion angles on these suspensions are not the same as the angles listed in the applicable table in **Specifications, 400**, contact your district service manager for the adjustment procedure.

NOTE: In any of the following steps, if an off-level inclination was added to or subtracted from the engine angle, the same figure must be added to or subtracted from the coupling shaft or axle pinion reading before comparing the angles.

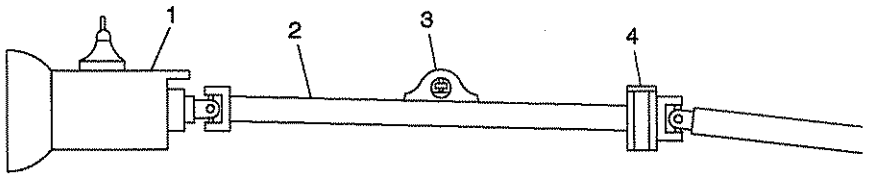
1. Check the engine angle at the transmission output-shaft end-yoke. The engine angle must be 3 degrees ±1/2 degree. For instructions, see **Subject 100.**
2. If the driveline includes a midship bearing, place a protractor on top of the coupling shaft. Align the protractor with the shaft centerline. **See Fig. 1.** Read the scale to the nearest one-tenth of a degree (6 minutes). The centerline of the coupling shaft must be 1/2 degree out of vertical alignment with the transmission output shaft. **See Fig. 2.** Compare this reading with the measured engine angle.

   If needed, adjust the midship bearing mounting to meet the above specification. Contact your district service manager for midship bearing mount adjusting procedures.
3. On single-drive installations, measure the rear axle pinion angle at the back of the no. 2 driveline; for instructions, see **Subject 100.**

   The measured rear axle pinion angle must be equal ±1 degree to the measured engine angle. If the rear axle pinion angle does not meet the above specification, contact your district service manager.
4. On dual-drive installations, measure the forward-rear-axle pinion angle (at the rear of the no. 2 driveline); for instructions, see **Subject 100.**

   The measured forward-rear-axle pinion angle must be equal ±1 degree to the measured engine angle. If the forward-rear-axle pinion angle does not meet the above specification, contact your district service manager.

   Measure the rearmost-axle pinion angle (at the rear of the no. 3 driveline); for instructions, see **Subject 100.**



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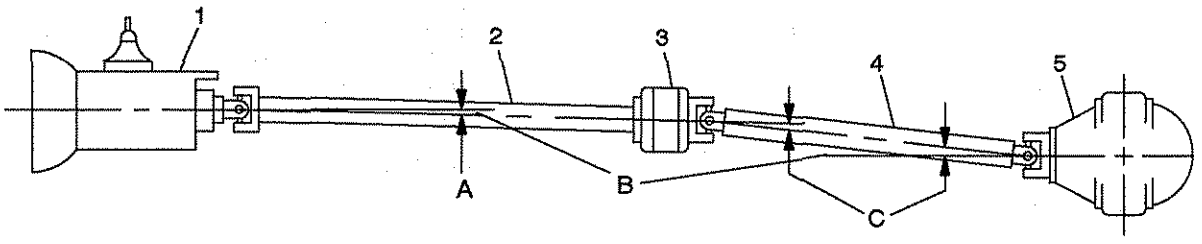
1. Transmission
2. Coupling Shaft
3. Protractor
4. Midship Bearing

Fig. 1, Coupling Shaft Angularity

Driveline Angle Checking



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A. 1/2-Degree Minimum
B. Parallel Centerlines
C. Working Angles Unequal by 1/2 to 1 Degree

1. Transmission
2. Coupling Shaft
3. Midship Bearing
4. No. 2 Driveshaft
5. Rear Axle

Fig. 2, Midship Bearing in a Single-Drive Vehicle

Compare the measured angle with that shown in the applicable table in **Specifications, 400**. The measured rearmost-axle pinion angle must be equal ±1 degree to the angle shown in the table. If the measured angle is incorrect, contact your district service manager.

Planing Angle Specifications

Engine Angle (for All Single-Drive-Axle Suspensions): Adjust to 5 degrees ±1/2 degree.

Engine Angle (for All Dual-Drive-Axle Suspensions): Adjust to 3-1/2 degrees ±1/2 degree.

Single-Drive-Axle Suspensions (All): Adjust rear axle pinion angle to 3 degrees ±1 degree.

Dual-Drive-Axle—Freightliner AirLiner Suspensions With Rockwell RT–40/–44/–46 Axles: Adjust axle pinion angles to the values in **Table 1**, ±1 degree.

Dual-Drive-Axle—Freightliner AirLiner Suspensions With Eaton D–402 Axles: Adjust axle pinion angles to the values in **Table 2**, ±1 degree.

Dual-Drive-Axle—Freightliner AirLiner Suspensions With Eaton D–404 Axles: Adjust axle pinion angles to the values in **Table 3**, ±1 degree.

Dual-Drive-Axle—Freightliner Spring Suspensions (with Rockwell RT–40/–44/–46 Axles, or Eaton D–402/–404 Axles): Adjust axle pinion angles to the values in **Table 4**, ±1 degree. **See Table 5** for shim notch decoding.

Dual-Drive-Axle—Hendrickson Suspensions With 52-Inch Axle Spacing: Adjust axle pinion angles to the values in **Table 6**, ±1 degree.

Dual-Drive-Axle—Hendrickson Suspensions With 54-Inch Axle Spacing: Adjust axle pinion angles to the values in **Table 7**, ±1 degree.

Dual-Drive-Axle—Hendrickson Suspensions With 56-Inch Axle Spacing: Adjust axle pinion angles to the values in **Table 8**, ±1 degree.

Dual-Drive-Axle—Hendrickson Suspensions With 60-Inch Axle Spacing: Adjust axle pinion angles to the values in **Table 9**, ±1 degree.

Dual-Drive-Axle—Hendrickson Suspensions With 72.5-Inch Axle Spacing: Adjust axle pinion angles to the values in **Table 10**, ±1 degree.

Freightliner AirLiner Suspensions With Rockwell RT–40/–44/–46 Axles

Axle Seat Angle (degrees)		Measured Suspension Height* (Inches)	Rear Suspension Load (pounds)									
			Unladen		30,000		34,000		36,000		40,000	
			Axle Pinion Angle (degrees)									
Fwd	Rear		Fwd	Rear	Fwd	Rear	Fwd	Rear	Fwd	Rear	Fwd	Rear
3.0	5.5	2.375 (min)	2.1	10.6	3.0	11.5	3.2	11.7	3.3	11.8	3.5	12.0
		2.5	2.4	10.9	3.3	11.8	3.5	12.0	3.6	12.1	3.7	12.2
		2.625	2.7	11.2	3.6	12.1	3.8	12.3	3.8	12.3	4.0	12.5
		2.75	2.9	11.4	3.9	12.4	4.0	12.5	4.1	12.6	4.3	12.8
		2.87 (max)	3.2	11.7	4.2	12.7	4.3	12.8	4.4	12.9	4.6	13.1

* Measure suspension height at the forward drive-axle stop on the driver's side; **see Section 32.04** for complete instructions.

Table 1, Freightliner AirLiner Suspensions With Rockwell RT–40/–44/–46 Axles

Specifications

Freightliner AirLiner Suspensions With Eaton D–402 Axles												
Axle Seat Angle (degrees)		Measured Suspension Height* (Inches)	Rear Suspension Load (pounds)									
			Unladen		30,000		34,000		36,000		40,000	
			Axle Pinion Angle (degrees)									
Fwd	Rear		Fwd	Rear	Fwd	Rear	Fwd	Rear	Fwd	Rear	Fwd	Rear
3.0	3.0	2.375 (min)	2.1	8.1	3.0	9.0	3.2	9.2	3.3	9.3	3.5	9.5
		2.5	2.4	8.4	3.3	9.3	3.5	9.5	3.6	9.6	3.7	9.7
		2.625	2.7	8.7	3.6	9.6	3.8	9.8	3.8	9.8	4.0	10.0
		2.75	2.9	8.9	3.9	9.9	4.0	10.0	4.1	10.1	4.3	10.3
		2.87 (max)	3.2	9.2	4.2	10.2	4.3	10.3	4.4	10.4	4.6	10.6

* Measure suspension height at the forward drive-axle stop on the driver's side; **see Section 32.04** for complete instructions.

Table 2, Freightliner AirLiner Suspensions With Eaton D–402 Axles

Freightliner AirLiner Suspensions With Eaton D–404 Axles												
Axle Seat Angle (degrees)		Measured Suspension Height* (Inches)	Rear Suspension Load (pounds)									
			Unladen		30,000		34,000		36,000		40,000	
			Axle Pinion Angle (degrees)									
Fwd	Rear		Fwd	Rear	Fwd	Rear	Fwd	Rear	Fwd	Rear	Fwd	Rear
3.0	4.5	2.375 (min)	2.1	9.6	3.0	10.5	3.2	10.7	3.3	10.8	3.5	11.0
		2.5	2.4	9.9	3.3	10.8	3.5	11.0	3.6	11.1	3.7	11.2
		2.625	2.7	10.2	3.6	11.1	3.8	11.3	3.8	11.3	4.0	11.5
		2.75	2.9	10.4	3.9	11.4	4.0	11.5	4.1	11.6	4.3	11.8
		2.87 (max)	3.2	10.7	4.2	11.7	4.3	11.8	4.4	11.9	4.6	12.1

* Measure suspension height at the forward drive-axle stop on the driver's side; **see Section 32.04** for complete instructions.

Table 3, Freightliner AirLiner Suspensions With Eaton D–404 Axles

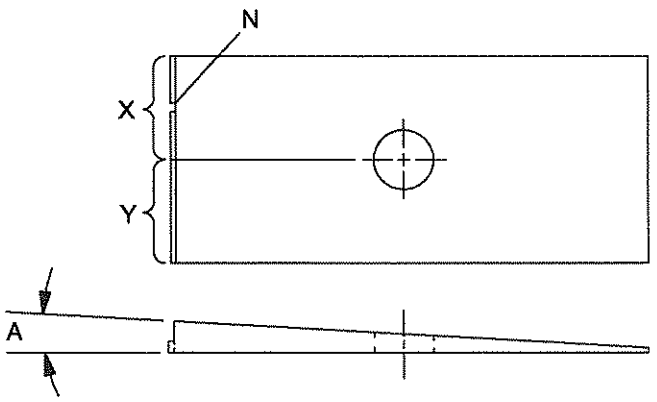
Freightliner Spring Suspensions (with Rockwell RT–40/–44/–46 Axles, or Eaton D–402/–404 Axles)										
Axle Model	Forward-Rear Axle					Rearmost Axle				
	Pinion Angle (degrees)	Spring Seat Spacer	Shim Angle (degrees)	Orientation of Shim's Thick End	Number of Shim Notches*	Pinion Angle (degrees)	Spring Seat Spacer	Shim Angle (degrees)	Orientation of Shim's Thick End	Number of Shim Notches†
Rockwell Axles (all axle spacings; laden and unladen)										
RT–40/–44/–46	3.0	Yes	None	—	—	11.0	None	1.0	Aft	2
Eaton Axles (all axle spacings; laden and unladen)										

Specifications

Freightliner Spring Suspensions (with Rockwell RT–40/–44/–46 Axles, or Eaton D–402/–404 Axles)										
Axle Model	Forward-Rear Axle					Rearmost Axle				
	Pinion Angle (degrees)	Spring Seat Spacer	Shim Angle (degrees)	Orientation of Shim's Thick End	Number of Shim Notches*	Pinion Angle (degrees)	Spring Seat Spacer	Shim Angle (degrees)	Orientation of Shim's Thick End	Number of Shim Notches†
D–402	3.0	None	None	—	—	10.0	None	None	—	—
D–404	3.0	Yes	None	—	—	10.5	None	0.5	Aft	1

* **See Table 5** for shim notch decoding.
† **See Table 5** for shim notch decoding.

Table 4, Freightliner Spring Suspensions (with Rockwell RT–40/–44/–46 Axles, or Eaton D–402/–404 Axles)



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Shim Angle *A* (degrees)	Notches (N) at *X*	Notches (N) at *Y*
0.5	One (total at x plus y)	
1.0	Two	none
1.5	Three	none
2.0	Four (total at x plus y)	
2.5	Five (total at x plus y)	
3.0	Six (total at x plus y)	
3.5	Zero	Zero
4.0	One	One
4.5	Two	One

Table 5, Shim Notch Decoding

Specifications

Hendrickson Suspensions With 52-Inch Axle Spacing										
Axle Model	Suspension Model	Saddle Height (inches)	Planing Angle (degrees)				Suspension Control Rod			
			Unladen		Laden		Forward Axle		Rear Axle	
			Front	Rear	Front	Rear	Rod Length (inches)	Spacer Thickness (inches)	Rod Length (inches)	Spacer Thickness (inches)
D402(P), D451P	RS–400, –460	12.88	3.2	9.3	3.0	9.5	22.5	—	25	0.125
D402(P), D451P	RS–400, –460	14	3.3	9.2	3.0	9.5	22.5	—	25	0.125
D402(P), D451P	RT2–400	7.19	4.2	10.3	3.0	9.5	22.5	0.125	25	—
D402(P), D451P	RT2–460	6	4.4	10.4	3.0	9.5	22.5	0.125	25	—
D402(P), D451P	RT2–460	7.19	2.8	8.5	3.0	9.5	22.5	—	25.25	0.125
D402(P), D451P	RTE2–400	7.19	4.6	10.6	3.0	9.5	22	0.125	25.5	0.125
D402(P), D451P	RTE2–460	7.19	4.8	10.6	3.0	9.5	22.25	0.125	25.25	—
D404(P)	RS–400, –460	12.88	3.2	10.1	3.0	10.3	22.5	—	25.25	0.125
D404(P)	RS–400, –460	14	3.3	10.0	3.0	10.3	22.5	—	25.25	—
D404(P)	RT2–400	7.19	4.2	11.1	3.0	10.3	22.5	0.125	25.25	—
D404(P)	RT2–460	6	4.4	11.2	3.0	10.3	22.5	0.125	25.25	—
D404(P)	RT2–460	7.19	2.8	9.3	3.0	10.3	22.5	—	25.5	0.125
D404(P)	RTE2–400	7.19	4.6	11.4	3.0	10.3	22	0.125	25.75	0.125
D404(P)	RTE2–460	7.19	4.8	11.4	3.0	10.3	22.25	0.125	25.5	—
D461P	RS–400, –460	12.88	3.1	10.8	3.0	10.9	22.5	0.125	25.5	0.125
D461P	RS–400, –460	14	3.2	10.6	3.0	10.9	22.5	—	25.5	—
D461P	RT2–400	7.19	4.1	11.7	3.0	10.9	22.25	—	25.5	—
D461P	RT2–460	6	4.3	11.8	3.0	10.9	22.5	0.125	25.5	—
D461P	RT2–460	7.19	2.8	10.0	3.0	10.9	22.5	0.125	25.75	0.125
D461P	RTE2–400	7.19	4.5	12.1	3.0	10.9	22	0.125	26	0.125
D461P	RTE2–460	7.19	4.7	12.0	3.0	10.9	22.25	0.125	25.75	—
RT40/44–145(P)	RS–400, –460	12.88	3.2	11.6	3.0	11.8	22.5	—	25.75	0.125
RT40/44–145(P)	RS–400, –460	14	3.3	11.5	3.0	11.8	22.5	—	25.75	—
RT40/44–145(P)	RT2–400	7.19	4.2	12.6	3.0	11.8	22.25	—	25.75	—
RT40/44–145(P)	RT2–460	6	4.4	12.6	3.0	11.8	22.5	0.125	25.75	—
RT40/44–145(P)	RT2–460	7.19	2.8	10.8	3.0	11.8	22.5	—	26	0.125
RT40/44–145(P)	RTE2–400	7.19	4.6	12.9	3.0	11.8	22	0.125	26.25	0.125
RT40/44–145(P)	RTE2–460	7.19	4.8	12.9	3.0	11.8	22.25	—	26	—
RT46–160(P)	RS–400, –460	12.88	3.1	11.3	3.0	11.4	22.5	0.125	25.75	0.125
RT46–160(P)	RS–400, –460	14	3.2	11.1	3.0	11.4	22.5	—	25.75	0.125
RT46–160(P)	RT2–400	7.19	4.1	12.2	3.0	11.4	22.25	—	25.75	—

Hendrickson Suspensions With 52-Inch Axle Spacing										
Axle Model	Suspension Model	Saddle Height (inches)	Planing Angle (degrees)				Suspension Control Rod			
			Unladen		Laden		Forward Axle		Rear Axle	
			Front	Rear	Front	Rear	Rod Length (inches)	Spacer Thickness (inches)	Rod Length (inches)	Spacer Thickness (inches)
RT46–160(P)	RT2–460	6	4.3	12.3	3.0	11.4	22.5	0.125	25.75	—
RT46–160(P)	RT2–460	7.19	2.8	10.5	3.0	11.4	22.5	0.125	25.75	—
RT46–160(P)	RTE2–400	7.19	4.5	12.6	3.0	11.4	22	0.125	26.25	0.125
RT46–160(P)	RTE2–460	7.19	4.7	12.5	3.0	11.4	22.25	0.125	26	—

Table 6, Hendrickson Suspensions With 52-Inch Axle Spacing

Hendrickson Suspensions With 54-Inch Axle Spacing										
Axle Model	Suspension Model	Saddle Height (inches)	Planing Angle (degrees)				Suspension Control Rod			
			Unladen		Laden		Forward Axle		Rear Axle	
			Front	Rear	Front	Rear	Rod Length (inches)	Spacer Thickness (inches)	Rod Length (inches)	Spacer Thickness (inches)
D402(P), D451P	RS–400, –460	14	3.3	8.6	3.0	8.9	23.5	—	25.75	—
D402(P), D451P	RS–400, –460	12.88	3.2	8.7	3.0	8.9	23.5	—	25.75	0.125
D402(P), D451P	RT2–400	7.19	4.2	9.7	3.0	8.9	23.5	0.125	25.75	—
D402(P), D451P	RT2–460	6	4.4	9.8	3.0	8.9	23.5	0.125	25.75	—
D402(P), D451P	RTE2–400	7.19	4.6	10.0	3.0	8.9	23	0.125	26.25	0.125
D402(P), D451P	RTE2–460	7.19	4.8	10.0	3.0	8.9	23.25	0.125	26	—
D404(P)	RS–400, –460	14	3.3	9.4	3.0	9.7	23.5	—	26	—
D404(P)	RS–400, –460	12.88	3.1	9.5	3.0	9.7	23.5	—	26	0.125
D404(P)	RT2–400	7.19	4.2	10.5	3.0	9.7	23.25	—	26	—
D404(P)	RT2–460	6	4.4	10.6	3.0	9.7	23.5	0.125	26	—
D404(P)	RTE2–400	7.19	4.6	10.8	3.0	9.7	23	0.125	26.5	—
D404(P)	RTE2–460	7.19	4.8	10.8	3.0	9.7	23.25	0.125	26.25	—
D461P	RS–400, –460	14	3.2	10.0	3.0	10.2	23.5	—	26.25	—
D461P	RS–400, –460	12.88	3.1	10.1	3.0	10.2	23.5	0.125	26.25	0.125
D461P	RT2–400	7.19	4.1	11.1	3.0	10.2	23.25	—	26.25	—
D461P	RT2–460	6	4.3	11.1	3.0	10.2	23.5	0.125	26.25	—
D461P	RTE2–400	7.19	4.5	11.4	3.0	10.2	23	0.125	26.75	0.125
D461P	RTE2–460	7.19	4.7	11.3	3.0	10.2	23.25	0.125	26.5	—
RT40/44–145(P)	RS–400, –460	14	3.3	10.8	3.0	11.1	23.5	—	26.5	—

Specifications

Hendrickson Suspensions With 54-Inch Axle Spacing										
Axle Model	Suspension Model	Saddle Height (inches)	Planing Angle (degrees)				Suspension Control Rod			
			Unladen		Laden		Forward Axle		Rear Axle	
			Front	Rear	Front	Rear	Rod Length (inches)	Spacer Thickness (inches)	Rod Length (inches)	Spacer Thickness (inches)
RT40/44–145(P)	RS–400, –460	12.88	3.1	10.9	3.0	11.1	23.5	—	26.5	0.125
RT40/44–145(P)	RT2–400	7.19	4.2	11.9	3.0	11.1	23.25	—	26.5	—
RT40/44–145(P)	RT2–460	6	4.4	12.0	3.0	11.1	23.5	0.125	26.5	—
RT40/44–145(P)	RTE2–400	7.19	4.6	12.2	3.0	11.1	23	—	27	—
RT40/44–145(P)	RTE2–460	7.19	4.8	12.2	3.0	11.1	23.25	0.125	26.75	—
RT46–160(P)	RS–400	14	3.2	10.6	3.0	10.8	23.5	—	26.5	0.125
RT46–160(P)	RS–460	14	3.2	10.6	3.0	10.8	23.5	—	26.5	—
RT46–160(P)	RS–400, –460	12.88	3.1	10.7	3.0	10.8	23.5	0.125	26.5	0.125
RT46–160(P)	RT2–400	7.19	4.1	11.7	3.0	10.8	23.25	—	26.5	—
RT46–160(P)	RT2–460	6	4.3	11.7	3.0	10.8	23.25	—	26.5	—
RT46–160(P)	RTE2–400	7.19	4.5	12.0	3.0	10.8	23	0.125	27	0.125
RT46–160(P)	RTE2–460	7.19	4.7	11.9	3.0	10.8	23.25	0.125	26.75	—

Table 7, Hendrickson Suspensions With 54-Inch Axle Spacing

Hendrickson Suspensions With 56-Inch Axle Spacing										
Axle Model	Suspension Model	Saddle Height (inches)	Planing Angle (degrees)				Suspension Control Rod			
			Unladen		Laden		Forward Axle		Rear Axle	
			Front	Rear	Front	Rear	Rod Length (inches)	Spacer Thickness (inches)	Rod Length (inches)	Spacer Thickness (inches)
D402(P), D451P	RTE2–460	7.19	4.8	9.6	3.0	8.5	24.25	0.125	27	0.125
D404(P)	RTE2–460	7.19	4.8	10.3	3.0	9.2	24.25	0.125	27.25	0.125
D461P	RTE2–460	7.19	4.7	10.9	3.0	9.8	24.25	0.125	27.5	0.125
RT40/44–145(P)	RTE2–460	7.19	4.4	11.7	3.0	10.6	24.25	0.125	27.75	0.125
RT46–160(P)	RTE2–460	7.19	4.7	11.4	3.0	10.3	24.25	0.125	27.5	—

Table 8, Hendrickson Suspensions With 56-Inch Axle Spacing

Group Index, Alphabetical

Section	Section Number
Air Brake Plumbing, Cab and Chassis	42.23
Air Brake Proportioning System, Bendix BP–R1 Valve	42.11
Air Brake System Troubleshooting	42.10
Air Dryer, Bendix AD–9	42.02
Air Dryer, Meritor WABCO System Saver 1200	42.25
Air Lines and Fittings	42.13
Air Reservoir	42.09
Air Reservoir Automatic Drain Valve, Bendix DV–2	42.16
Automatic Slack Adjuster, Gunite®	42.20
Automatic Slack Adjusters, Haldex (SAB)	42.12
Automatic Slack Adjuster, Meritor	42.05
Bendix® Antilock Braking System (ABS)	42.29
Control Module, Bendix MV–3	42.01
Double Check Valve, Bendix	42.21
Dryer Reservoir Module (DRM), Bendix	42.27
Dual Brake Valve, Bendix E–6	42.03
Eaton® Antilock Braking System (ABS)	42.28
Eaton Brakes	42.14
Meritor CamLaster Brakes	42.30
Meritor Cam-Master® Q Plus and P Series Brakes	42.04
Meritor WABCO® Antilock Braking System (ABS)	42.08
Midland Service Brake Chamber	42.07
Parking Brake Hand Valve, Bendix PP–DC	42.00
Quick Release Valve, Bendix QR–1	42.18
Quick Release Valve, Bendix QR–1C	42.22
Relay Valve, Bendix R–12 and R–14	42.19
Tandem Brake Chambers, Anchorlok®	42.17
Tandem Brake Chambers, MGM® "TR" Series	42.06
Tractor Protection Valve, Bendix TP–3DC	42.24
Trailer Brake Control Valve, Midland	42.15

Parking Brake Dash Valve, Bendix PP–DC 42.00

Contents

Subject	Subject Number
General Description and Principles of Operation	050
Service Operations	
Safety Precautions	100
Parking Brake Dash Valve Tests	110
Parking Brake Dash Valve Removal and Installation	120
Parking Brake Dash Valve Disassembly and Assembly	130

General Description

The Bendix PP–DC parking brake air valve is installed on trucks with air brakes, and is used to control the rear axle parking brakes. It is a push-pull type of valve, and is mounted on the right side of the dash.

Principles of Operation

When the valve knob is pulled out, air is exhausted from the parking brake chambers, releasing the springs, and applying the parking brakes. When the knob is pushed in, air flows into the parking brake chambers from one of the reservoirs, and compresses the springs, releasing the parking brakes.

The PP–DC has a double check valve feature. If the pressure drops 20 to 30 psi (138 to 207 kPa) in either air system (primary or secondary), the valve will automatically use air pressure from the system with the higher pressure for the parking brakes. This prevents the parking brakes from applying automatically unless pressure is lost from both systems.

Safety Precautions

When working on or around air brake systems and components, observe the following precautions:

1. Chock the tires and stop the engine before working under a vehicle. Keep hands away from brake chamber push rods and slack adjusters; they may apply as air system pressure drops.
2. Never connect or disconnect a hose or line containing compressed air. It may whip as air escapes. Never remove a component or pipe plug unless you are certain all system pressure has been released.
3. Never exceed recommended air pressure and always wear safety glasses when working with compressed air. Never look into air jets or direct them at anyone.
4. Never attempt to disassemble a component until you have read and understood recommended procedures. Some components contain powerful springs and injury can result if not properly disassembled. Use only proper tools and observe all precautions pertaining to use of those tools.

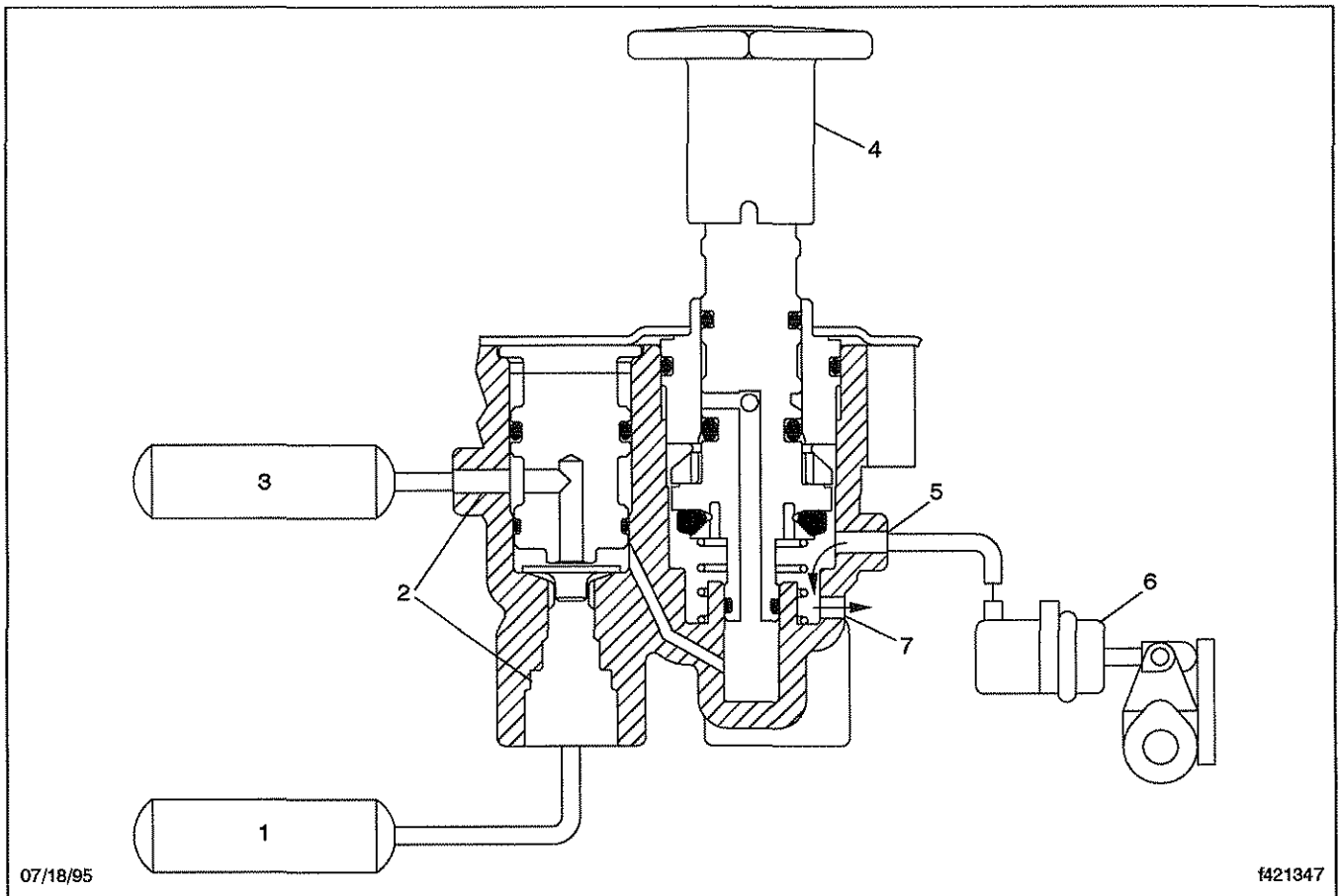
IMPORTANT: To do the following tests, connect two separate 120 psi (827 kPa) air sources to the PP–DC supply ports. **See Fig. 1.** Tee an accurate test gauge into the supply lines, and provide for a means to control supply line pressure. Connect a small volume air source with a gauge to the delivery port.

Operating Test

1. Chock the tires.
2. Start the engine and build up the air pressure to the normal operating level.
3. With the valve knob pulled out, supply either supply port with 120 psi (827 kPa) of pressure. Push the valve knob in. Air pressure should rise in the delivery line and equal supply line pressure.

   Pull the valve knob out. Delivery pressure should exhaust to zero.
4. Build air pressure to each supply souce to 120 psi (827 kPa). Decrease supply pressure at the secondary service reservoir supply port at a rate of 10 psi (69 kPa) per second.

   Primary supply pressure and delivery pressure should not drop below 100 psi (689 kPa). Repeat



1. Primary Service Reservoir
2. Supply Port
3. Secondary Service Reservoir
4. Valve Knob
5. Delivery Port
6. Brake Chamber
7. Exhaust Port

Fig. 1, Parking Brake Dash Valve (sectional valve)

Parking Brake Dash Valve Tests

this step for decreasing primary service reservoir pressure.

5. Build air pressure to each supply souce to 120 psi (827 kPa). Then, decrease both supply pressures to below 20 to 30 psi (138 to 207 kPa). The valve knob should automatically pop out when the pressure is within that range.
6. If the valve does not work as described, repair the valve or replace it following instructions under **Subject 130.**

Leak Testing

1. Chock the tires.
2. Supply the valve with 120 psi (827 kPa) from the primary reservoir supply port.
3. With the valve knob pulled out, coat the exhaust port and the plunger stem with a soapy solution. Leakage at the either fitting should not exceed a 1-inch (2.5-cm) bubble every five seconds.There should be no leakage from the secondary reservoir supply port.
4. Supply the valve with 120 psi (827 kPa) from the secondary reservoir supply port. There should be no leakage from the primary reservoir supply port.
5. With the valve knob pushed in, coat the exhaust port and the plunger stem with a soapy solution. Leakage at the fittings should not exceed a 1-inch (2.5-cm) bubble every three seconds. If it does, replace or repair the valve, following instructions under **Subject 130.**

Parking Brake Dash Valve Removal and Installation

Removal (See Fig. 1)

WARNING: Review the precautions under Safety Precautions, 100 before doing any work on the parking brake valve. Failure to do so could result in personal injury.

1. Park the vehicle on a level surface, apply the parking brakes, chock the tires, and drain the air tanks.
2. Remove the trim plate assembly from the radio and heater/air conditioner control panel.
3. Remove the screw from the right-hand trim cap. Remove the trim cap from the dash.
4. Remove the four screws that attach the auxiliary instrument panel in the dash. Pull the panel out to access the valve mounting screws.
5. Turn the valve knob counterclockwise and remove it from the valve stem.
6. Mark the air lines for later reference, then disconnect them from the valve assembly.

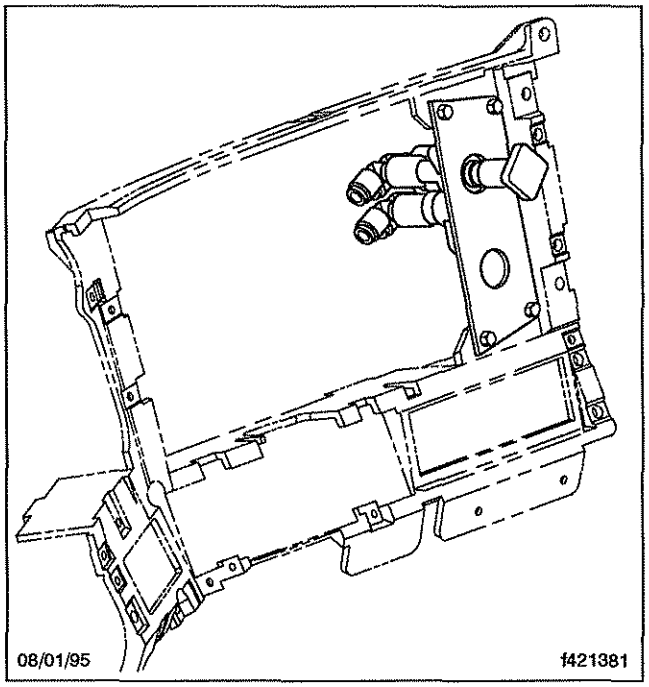


Fig. 1, Parking Brake Hand Valve Mounting (components have been removed from the auxiliary instrument panel for clarity)

NOTE: The primary supply line is green; the secondary supply line is red; the exhaust line is black and 1/2 inch (13 mm) in diameter; the delivery line is black and 3/8 inch (9.6 mm) in diameter.

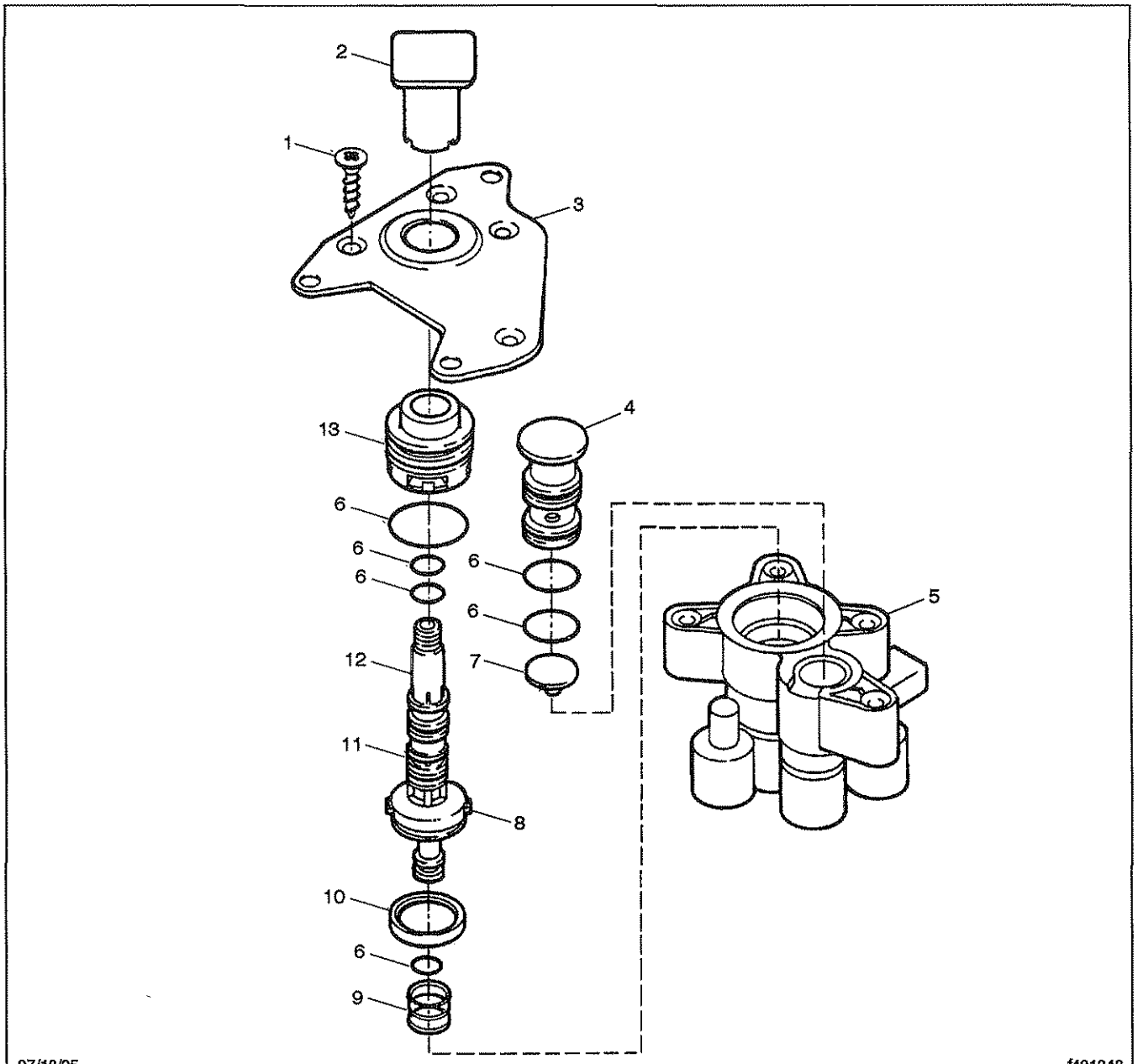
7. Remove the four screws that attach the valve and the to the auxiliary instrument panel. Remove the valve.

Installation

1. Position the valve assembly in the auxiliary instrument panel. Install the four mounting screws.
2. Connect the air lines to the applicable fittings.
   - 2.1 Tighten the fitting hand tight.
   - 2.2 Using a wrench, tighten the fitting until the connection feels firm.
   - 2.3 Tighten the fitting an additional one-sixth turn.
3. Screw the valve knob onto the valve stem.
4. Leak test the fittings, following the instructions under **Subject 110.**
5. Install the auxiliary instrument panel, right-hand trim cap, and the radio and heater/air conditioner trim plate assembly.

Parking Brake Dash Valve Disassembly and Assembly

Disassembly (See Fig. 1)



1. Screw
2. Valve Knob
3. Cover
4. Check Valve Seat
5. Valve Body
6. O-Ring
7. Check Valve
8. Index Tab
9. Plunger Spring
10. Exhaust Seal
11. Plunger
12. Plunger Stem
13. Guide Spool

Fig. 1, Exploded View

Parking Brake Dash Valve Disassembly and Assembly

1. Remove the valve assembly from the dash, following the instructions under **Subject 120.**
2. Put the valve assembly in a soft-jawed or padded vise.
3. Remove the screws that attach the cover to the body. Remove the cover.
4. Pull the plunger stem and remove the plunger and guide spool from the body.
5. Remove and discard the plunger spring.
6. Using a screwdriver (if needed), carefully remove the check valve seat from the body. Use care to not damage either the check valve seat or the valve body.
7. Remove and discard the check valve seat O-rings.
8. Turn the body upside down and gently tap it on a flat surface to remove the check valve. Discard the check valve.
9. Remove the guide spool from the plunger. Remove and discard the O-ring.
10. Remove and discard the O-rings from the plunger. Also, remove and discard the exhaust seal.

Assembly (See Fig. 1)

1. Clean and dry all the parts.
2. Check all the parts. Replace a part if any wear or damage is found.
3. Lightly grease all the parts—including the new parts from the maintenance kit—with Dow Corning 55 silicone pneumatic grease or equivalent.
4. Position the check valve in its seat in the body with the flat surface of the valve facing up. If needed, reach into the body to make sure that the valve is seated evenly in the bore.
5. Install the O-rings on the check valve seat and install the assembly into the body. Make sure that the check valve seat is even with the valve body surface.
6. Install the plunger spring into the body. Make sure that the spring is upright and seated properly in the body bore.

NOTE: The plunger spring should surround the protrusion or "lip" at the bottom of the body bore.

7. Install the O-rings onto the plunger, then install the plunger into the body.

   For ease of installation, line up the plunger's index tabs with the spaces in the body bore.
8. Install the O-ring on the guide spool. Install the spool over the plunger and into the body. Firmly press the guide spool into position.
9. Install the screws that attach the cover to the body. Tighten the screws 35 lbf·in (400 N·cm).
10. Install the valve in the dash, then leak test it. Follow the instructions under **Subject 120** for installation and **Subject 110** for leak testing.

Contents

Subject	Subject Number
General Description and Principles of Operation	050
Service Operations	
Control Module Operating Tests	100
Control Module Removal and Installation	110
Control Module Disassembly, Cleaning and Inspection, and Assembly	120

General Description

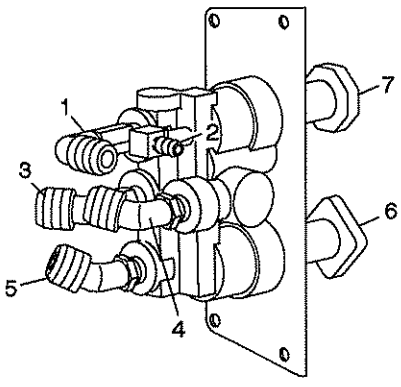
The dash-mounted MV–3 control module is a two-button, push-pull control valve housed in a single body, which includes a dual circuit supply valve and a check valve.

The valve body, plungers, and spools are made out of a nonmetallic, noncorrosive material. All air connections are at the back of the valve with the exception of the optional auxiliary port, which is located in the side of the valve. **See Fig. 1.**

The MV–3 module has several uses: tractor protection control; trailer service air supply; system park; trailer park only; trailer charge with tractor spring brakes applied (tractor park only); and supply reservoir selection.

The MV–3 includes a spring-loaded, dual-circuit supply valve, which selects the primary air reservoir as the air source for both control valves, unless the pressure in the primary air reservoir falls more than 30 psi (207 kPa) below that of the secondary air reservoir. Then, the dual-circuit supply valve will shuttle and establish the secondary air reservoir as the air source.

NOTE: The primary air reservoir supplies the rear tractor axle; the secondary air reservoir supplies the front axle.



1. Delivery–Trailer Port
2. Exhaust Port
3. Secondary Reservoir Supply Port
4. Primary Reservoir Supply Port
5. Delivery–Tractor Port
6. Parking Brake Control Valve Knob
7. Trailer Air Supply Knob

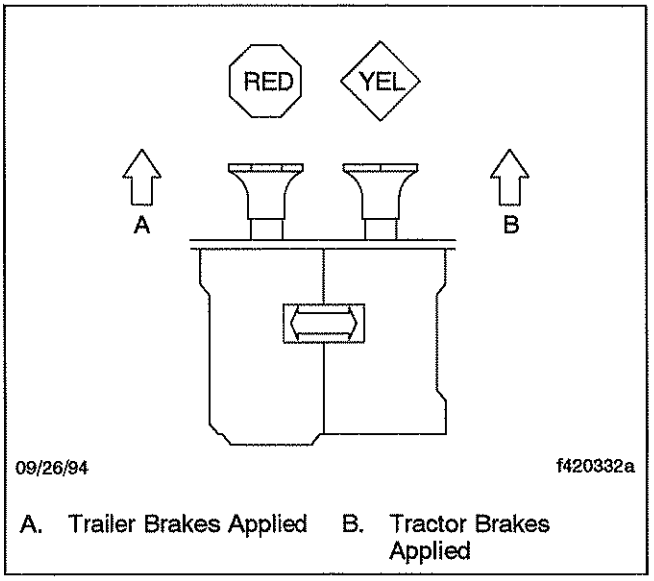
Fig. 1, MV–3 Parking Brake Valve

The trailer air supply valve (**Fig. 2**), actuated by a red knob, delivers air to the trailer supply line. The parking brake valve, actuated by a yellow knob (**Fig. 2**), controls the spring parking brakes on the tractor, and when exhausted, simultaneously causes the trailer supply valve to trip and exhaust, thus applying both the tractor and the trailer parking brakes as required by federal regulations. The trailer parking brakes may be independently released by pushing only the trailer air supply valve (red) knob in.

Principles of Operation

INITIAL CHARGE

With both the primary and the secondary systems completely discharged (the primary and secondary ports are still fully pressured), both knobs are out. **See Fig. 2.** When system pressure reaches 65 psi (448 kPa), the red knob (trailer air supply) may be pushed in, and should stay in, charging the trailer system and releasing the trailer parking brakes. **See Fig. 3.** The yellow knob (parking brake) may now be pushed in, which will supply air to the tractor parking brakes, releasing them.



A. Trailer Brakes Applied B. Tractor Brakes Applied

Fig. 2, Trailer and Tractor Delivery Air Discharged (control knobs out)

General Description and Principles of Operation

NORMAL OPERATION POSITION

When both knobs are pushed in, air is supplied to the trailer and the tractor parking brakes; all parking brakes are released. **See Fig. 4.** This is the normal operating mode.

ACTUATION OF TRAILER PARK OR EMERGENCY BRAKES

To actuate the trailer parking brakes only, the red knob is pulled out, exhausting the trailer supply line. The trailer parking brakes are now applied, either by emergency air or parking brakes, depending on the type of trailer system. This mode would be used to uncouple from the trailer, and during bobtail operation. **See Fig. 5.**

SYSTEM PARK

With both knobs in, the parking brakes on both the tractor and the trailer may be actuated by pulling the yellow (parking brake) knob out. This exhausts the air from the tractor parking brakes and simultaneously causes the red (trailer air supply) knob to pop out, applying the trailer parking brakes (this complies with federal regulations that one control must apply all the parking brakes on the vehicle). **See Fig. 2.**

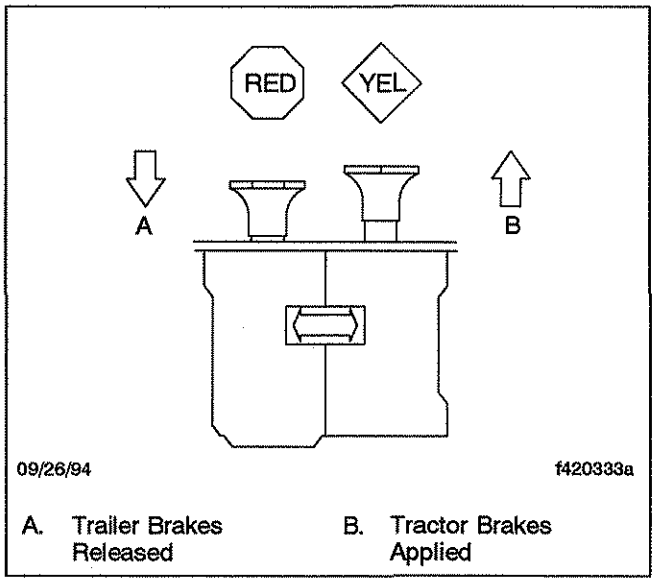


Fig. 3, Trailer Parking Brakes Released (red control knob pushed in)

TRAILER CHARGE

If both valves are out, parking the combination vehicle, and it is desired to recharge the trailer (leaving only the tractor parking brakes applied), the red knob may be pushed in, repressurizing the trailer supply line. This mode might also be used to park a combination

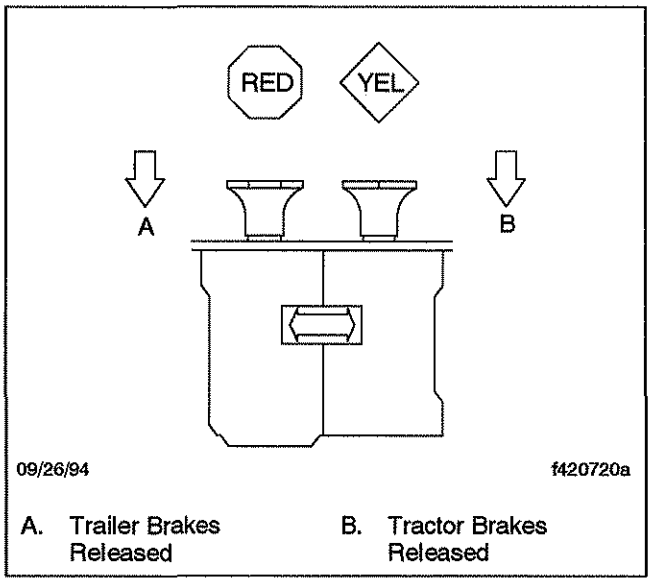


Fig. 4, Trailer and Tractor Brakes Released (both control knobs pushed in)

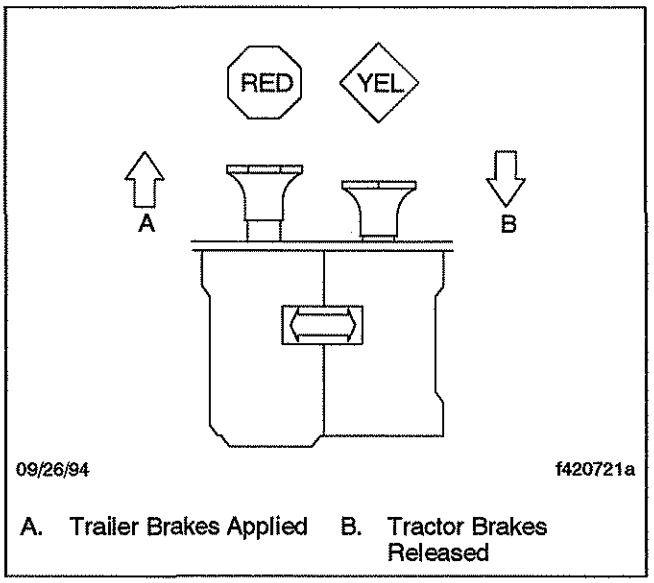


Fig. 5, Trailer Parking Brakes Applied (red control knob pulled out)

vehicle with air actuated emergency brakes on the trailer to provide demonstrated parking capability with the tractor spring brakes only. **See Fig. 3.**

AUTOMATIC APPLICATION

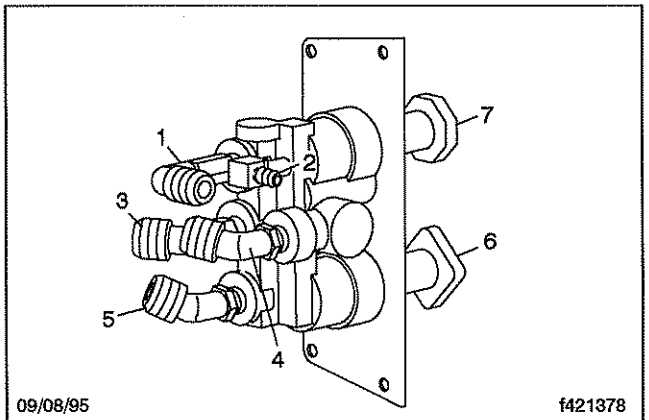
If air pressure drops to 35 to 45 psi (241 to 310 kPa) in both the primary and the secondary systems, the red knob (trailer air supply valve) will automatically pop out, applying the emergency or parking brakes on the trailer. If the red knob is held in manually and the pressure decreases to 25 to 35 psi (172 to 241 kPa), a tripper piston within the MV–3 valve will move upward, exhausting the trailer supply, and applying the trailer parking brakes. If air pressure drops in both the primary and the secondary systems, the yellow (parking brake) knob will pop out at about 20 to 30 psi (138 to 207 kPa), applying the tractor parking brakes.

A warning buzzer and light are activated when pressure in either the primary or the secondary system drops below 64 to 76 psi (441 to 524 kPa).

Tests

With the air brake system charged to 120 psi (827 kPa), check for leaks, using the following instructions. Repair or replace components as needed.

1. Apply a soap solution and check for leakage between the body and cover plate. No leakage is permitted.
2. Push in the red knob. The knob must stay in. Leakage at the exhaust port **(Fig. 1)** must not exceed a 1-inch (25-mm) bubble in 5 seconds.
3. Slowly reduce pressure in both service reservoirs. The red knob must pop out at 35 to 45 psi (241 to 310 kPa) and maintain the supply pressure. Leakage at the exhaust port must not exceed a 1-inch (25-mm) bubble in 5 seconds.
4. Hold the red knob in and continue to reduce pressure in all service reservoirs. Air must start to escape from the exhaust port when the trailer line pressure reaches 20 to 35 psi (138 to 241 kPa).
5. Release the red knob and rebuild the supply pressure to 120 psi (827 kPa). Push in the yellow knob; the yellow knob must remain in. Leakage at the exhaust port should not exceed a 1-inch (25-mm) bubble in 5 seconds.



1. Delivery–Trailer Port
2. Exhaust Port
3. Secondary Reservoir Supply Port
4. Primary Reservoir Supply Port
5. Delivery–Tractor Port
6. Parking Brake Control Valve Knob
7. Trailer Air Supply Knob

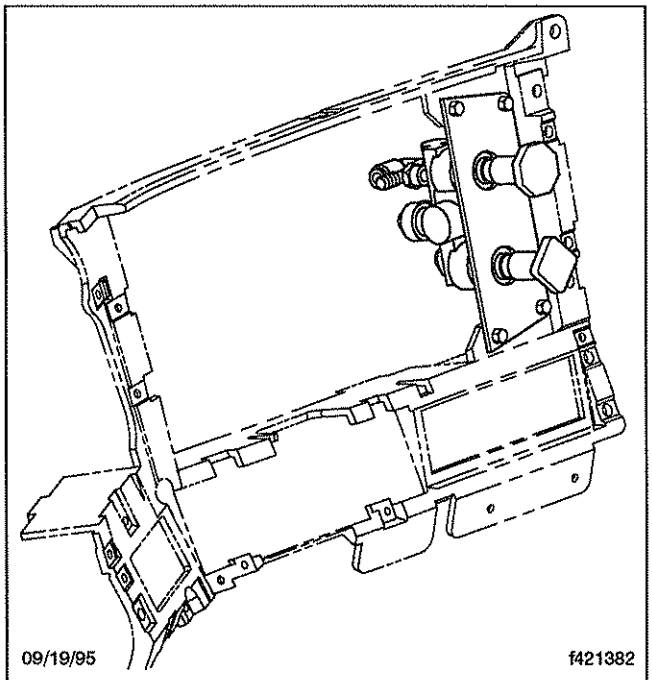
Fig. 1, MV–3 Parking Brake Valve

6. Pull the red knob out. Slowly reduce pressure in all service reservoirs. The yellow knob must pop out at 20 to 30 psi (138 to 207 kPa) and maintain supply pressure. Leakage at the exhaust port should not exceed a 1-inch (25-mm) bubble in 5 seconds.
7. Charge the system to 120 psi (827 kPa), and push both knobs in. Pull the red knob out. The yellow knob must remain in. Push the red knob in and pull the yellow knob out. The red knob must pop out at once.
8. Install a gauge to monitor tractor spring brake delivery pressure. Build 120 psi (827 kPa) pressure in the primary and secondary air reservoirs. Push in the yellow knob. Delivery pressure should equal the pressure in the primary air reservoir. Reduce the pressure in the primary air reservoir. Delivery pressure and the primary air reservoir pressure should descend together to 90 to 105 psi (621 to 724 kPa), at which point the dual-circuit supply valve shuttle should switch to the secondary air reservoir; delivery pressure should increase to the secondary air reservoir pressure. After the primary air reservoir pressure is reduced to zero, there should not be audible leakage at the primary air reservoir opening. Stop the leak that was created in the primary air reservoir.
9. Leaving the yellow knob in, recharge the secondary air reservoir to 120 psi (827 kPa). The delivery pressure should also read 120 psi (827 kPa). Recharge the primary air reservoir to 100 psi (689 kPa). Slowly vent the secondary air reservoir. As the secondary air reservoir pressure and the delivery line pressure descend, pressure should stabilize at about 100 psi (689 kPa).
10. Close all leakage points and charge both reservoirs to 120 psi (827 kPa). Position the red knob out and the yellow knob in. Develop a leak in the spring brake delivery line **(Fig. 1)** and hold the yellow knob in. The primary air reservoir pressure will go to zero; and the secondary air reservoir pressure will drop to 20 to 30 psi (138 to 207 kPa). The dual-circuit supply valve shuttle should cycle several times during the leak-down period.

Removal (See Fig. 1)

WARNING: Wear eye protection when draining the air system or loosening an air line because dirt or sludge could fly out at high speeds. Don't direct the airstreams at anyone. Don't disconnect pressurized hoses, since they may whip as air escapes. Failure to take all necessary precautions could result in personal injury.

1. Park the vehicle on a level surface, apply the parking brakes, chock the tires, and drain the air tanks .
2. Remove the trim plate assembly from the radio and heater/air conditioner control panel.
3. Remove the screw from the right-hand trim cap. Remove the trim cap from the dash.
4. Unscrew the red and yellow knobs from the stems of the spools on the MV–3 valve by turning them in a counterclockwise direction. Mark these knobs in relation to the valve for later reference.



NOTE: Components have been removed from the auxiliary instrument panel for clarity.

Fig. 1, MV–3 Control Valve Mounting

5. Remove the four screws that attach the auxiliary instrument panel in the dash. Pull the panel out to access the control module mounting screws.
6. Remove and save the four mounting screws and washers from the four corners of the cover plate.
7. With the valve and cover plate assembly pulled out slightly from the dash panel, remove the air lines from the back of the valve.
8. Pull the valve out of the dash.

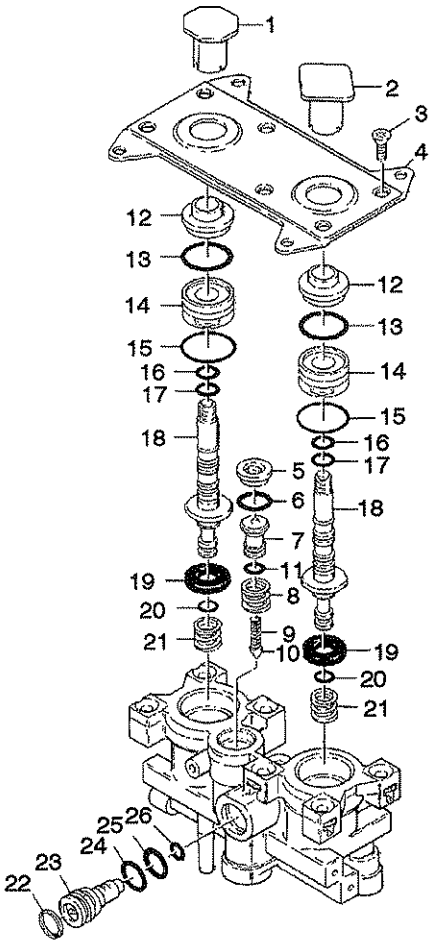
Installation

1. Connect the air lines to the proper ports. The color of the air lines should match the colored collar at the valve fitting.
2. Align the valve in the dash and install the four screws and washers into the corners of the cover plate.
3. Attach the red and yellow knobs onto the threaded stems of the spools, making sure that they are oriented correctly as noted during removal.
4. Leak test the fittings, following the instructions under **Subject 100.**
5. Install the auxiliary instrument panel, right-hand trim cap, and the radio and heater/air conditioner trim plate assembly.
6. Remove the chocks.

Control Module Disassembly, Cleaning and Inspection, and Assembly

Disassembly (See Fig. 1)

1. Remove the six screws from the cover plate and carefully remove the cover plate from the valve.
2. Remove the cap and O-ring from the bore of the tripper valve. Remove the tripper piston, large spring, small spring, and check valve. These parts will all fall out of the cavity of the MV–3 by tilting the body forward. Remove the O-ring from its groove on the piston.
3. Remove the two main spools from the body of the MV–3 valve by grasping the stem and pulling



10/05/94 f420470a

1. Red Knob
2. Yellow Knob
3. Screw
4. Cover Plate
5. Cap
6. O-Ring
7. Tripper Piston
8. Spring, Large Diameter
9. Spring, Small Diameter
10. Check Valve
11. O-Ring
12. Guide Cap
13. O-Ring
14. Guide Spool
15. O-Ring
16. O-Ring
17. O-Ring
18. Plunger
19. Exhuast Seal, Beveled
20. O-Ring
21. Spring
22. Retaining Ring
23. Cap and Dual Circuit Valve Assembly
24. O-Ring
25. O-Ring
26. O-Ring

Fig. 1, MV–3 Valve, Exploded View

Control Module Disassembly, Cleaning and Inspection, and Assembly

firmly. Remove the spring from the bottom of each spool cavity.

4. Pull the guide cap and guide spool over the threaded end of one of the plungers. Remove the O-ring from the guide cap and the O-ring from the guide spool. Remove the other O-rings and the exhaust seal from the plunger.
5. Repeat the previous step on the remaining spool assembly.
6. Remove the retaining ring from the cavity of the MV–3 body that contains the dual circuit supply valve.
7. Using a pair of needle nose pliers, grasp the bar in the center of the cap and dual circuit supply valve and remove the dual circuit valve assembly. Remove the three O-rings from the valve or from the cavity of the body, if some have remained there. Other than the three external O-rings, don't disassemble the piston assembly further.

NOTE: If during the removal of this assembly from the body the cap dislodges from the rest of the valve, the remaining parts can be removed using bent wire. The spring, piston and O-ring that are internal to the dual circuit valve assembly are nonserviceable.

Cleaning and Inspection

The nonmetallic components making up most of the parts of the MV–3 *should not be immersed in any solvent type cleaner.* Old lubricant should be wiped out with a clean dry cloth.

If any visible damage to the body or the spools is found, replace the complete unit.

Assembly

DUAL CIRCUIT SUPPLY VALVE

1. Lubricate all O-rings, bores, and sliding surfaces with silicone lubricant Bendix 291126, Dow Corning 55-M, or equivalent.
2. Install O-rings onto the cap and dual circuit supply valve. Then install the assembly—small diameter first—into its cavity in the body.
3. Install the retaining ring (Ref. 22) making sure it is fully seated in its groove.

SPOOLS

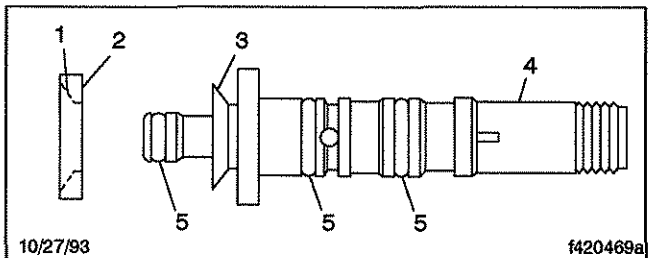
1. Install the O-rings and the exhaust seal onto the stem of the plunger.

CAUTION: The exhaust seal (Ref. 19) must be installed so that its beveled surface mates with the beveled surface of the plunger. **See Fig. 2.**

2. Install the O-ring onto the guide spool and the O-ring onto the guide cap. Place the guide cap on top of the guide spool, and install the entire assembly over the threaded end of the plunger; press down firmly until it snaps into place.
3. Install the spring over the boss in the bottom of the spool cavity in the body of the MV–3 valve. Place the spool assembly into the body, keeping the spool square to the body. Press and turn the stem until the spool is fully seated in its cavity. Note the assembly is keyed and can be installed one way only.
4. Repeat the previous steps for the opposite spool.

SHUTTLE AND CHECK VALVE

1. Install the O-ring into its groove on the tripper piston; then install the O-ring onto the cap.
2. Install the large spring on the piston and the small spring on the boss of the check valve.
3. Install the spring and check valve into their cavity in the body of the MV–3 valve (tapered end of the valve to enter cavity first). Make sure the spring is centered in the bore.



1. Inside Bevel
2. Exhaust Seal
3. Mating Exhaust Seal Bevel
4. Plunger
5. O-Rings

Fig. 2, Plunger Assembly

4. Install the piston assembly into the cavity, making sure the spring mates with the bore of the piston.
5. Install the cap with O-ring.
6. Attach the cover plate to the valve body using the six screws. Torque them 25 lbf·in (280 N·cm).
7. Check the operation of the valve using the instructions in **Subject 100.**

Contents

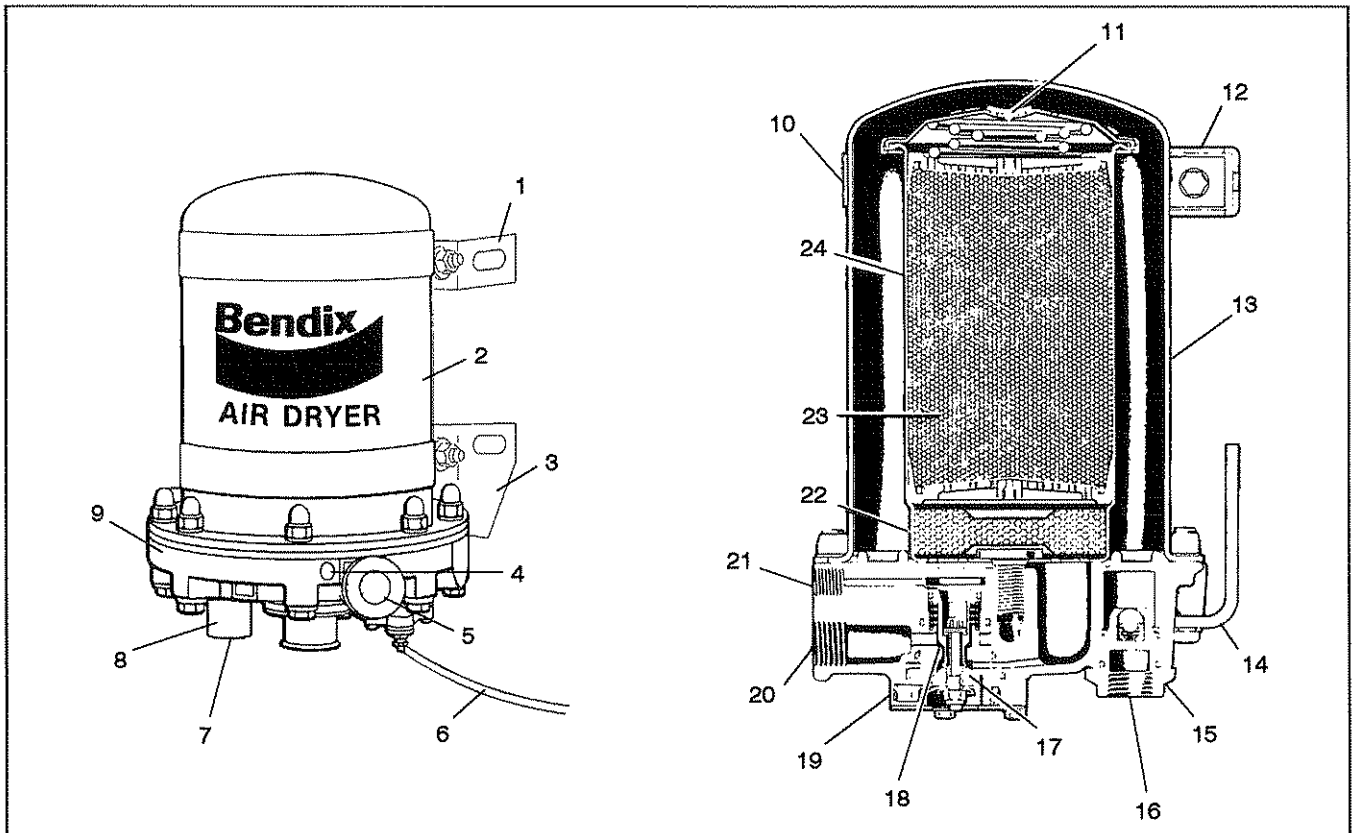
Subject	Subject Number
General Description and Principles of Operation	050
Safety Precautions	100
Service Operations	
Air Dryer Removal and Installation	110
Air Dryer Disassembly, Cleaning and Inspection, and Assembly	120
Air Dryer Thermostat Testing	130
Troubleshooting	300

General Description

The function of the Bendix AD–9 air dryer **(Fig. 1)** is to collect and remove air system contaminants in solid, liquid, and vapor form before they enter the brake system.

The AD–9 air dryer consists of the desiccant cartridge and a die-cast aluminum end cover secured to a cylindrical steel outer shell with eight capscrews and nuts. The end cover contains a check valve assembly, a safety valve, three threaded air connections and the purge valve housing assembly. The removable purge valve housing assembly features a purge valve mechanism and a turbocharger cutoff that are designed to prevent loss of engine turbo boost pressure during the purge cycle of the air dryer.

To ease servicing, the desiccant cartridge and discharge check valve assembly are screw-in types. The purge valve housing assembly, which includes the heater and thermostat assembly, and the discharge check valve assembly, can be serviced without removing the air dryer from the vehicle. The screw-in desiccant cartridge requires removal of the air dryer assembly from the vehicle.



1. Upper Bracket
2. Outer Shell
3. Lower Bracket
4. Control Port
5. Supply Port
6. Wiring Harness
7. Delivery Port
8. Check Valve Assembly
9. End Cover
10. Upper Bracket Strap
11. Check Valve
12. Upper Bracket
13. Housing
14. Lower Bracket
15. Check Valve Assembly
16. Delivery Port
17. Purge Valve
18. Turbo Cutoff Piston
19. Purge Valve Housing Assembly
20. Supply Port
21. Control Port
22. Oil Separator
23. Desiccant Bed
24. Desiccant Cartridge

Fig. 1, Bendix AD–9 Air Dryer and Cutaway View

General Description and Principles of Operation

The AD–9 has three female pipe thread air connections; each is identified as follows **(see Table 1):**

Port I.D.	Function/Connection
4-CON	Control Port (purge valve control and turbo cutoff)
11-SUP	Supply Port (air in)
2-DEL	Delivery Port (air out)

Table 1

There are four versions of the AD–9 air dryer:

- Standard **(see Fig. 2):**

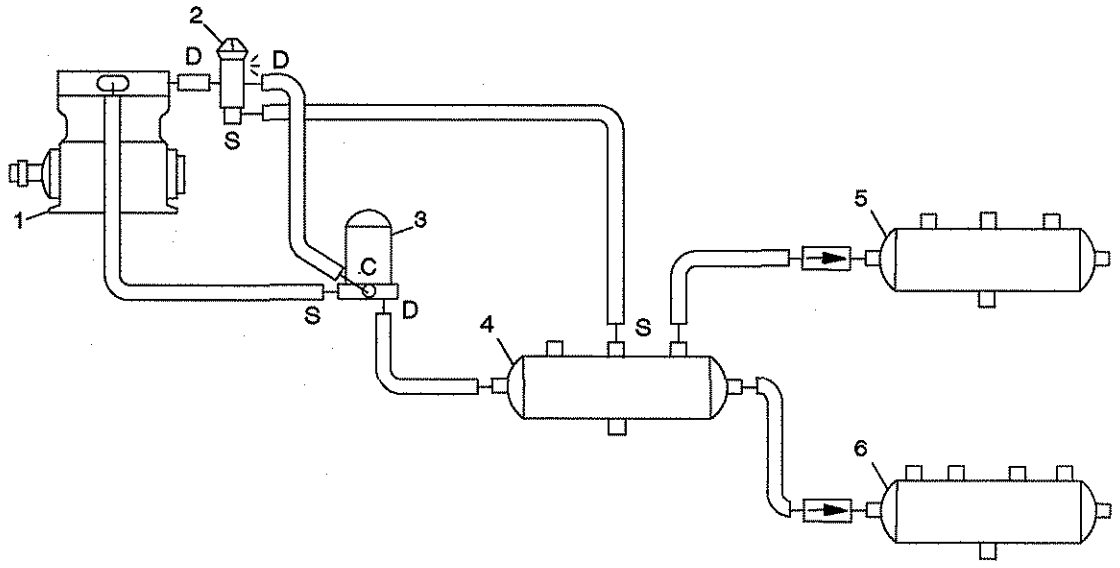
  The standard air dryer uses a metal seat turbo cutoff valve. The function of the metal seat is to prevent turbocharger boost pressure loss through the air dryer during the purge (compressor unloaded) mode. Some low level turbo air leakage can occur in the unloaded mode.

- Discharge Line Unloader Style **(see Fig. 3):**

  The discharge line unloader style air dryer is usually used on brake systems that have compressors equipped with a discharge unloader valve, but no integral unloading mechanisms. This air dryer is designed to bypass the turbo cutoff mechanism on the dryer, allowing air from the compressor to be vented out the bottom of the air dryer when the brake system is in a non-charging mode. An air governor is used on this system and replaces the discharge line unloader valve normally installed in the compressor's discharge line. This type of air dryer can be identified by the "U" stamped on the side of the purge valve housing.

- Soft Seat Air Dryer **(see Fig. 4):**

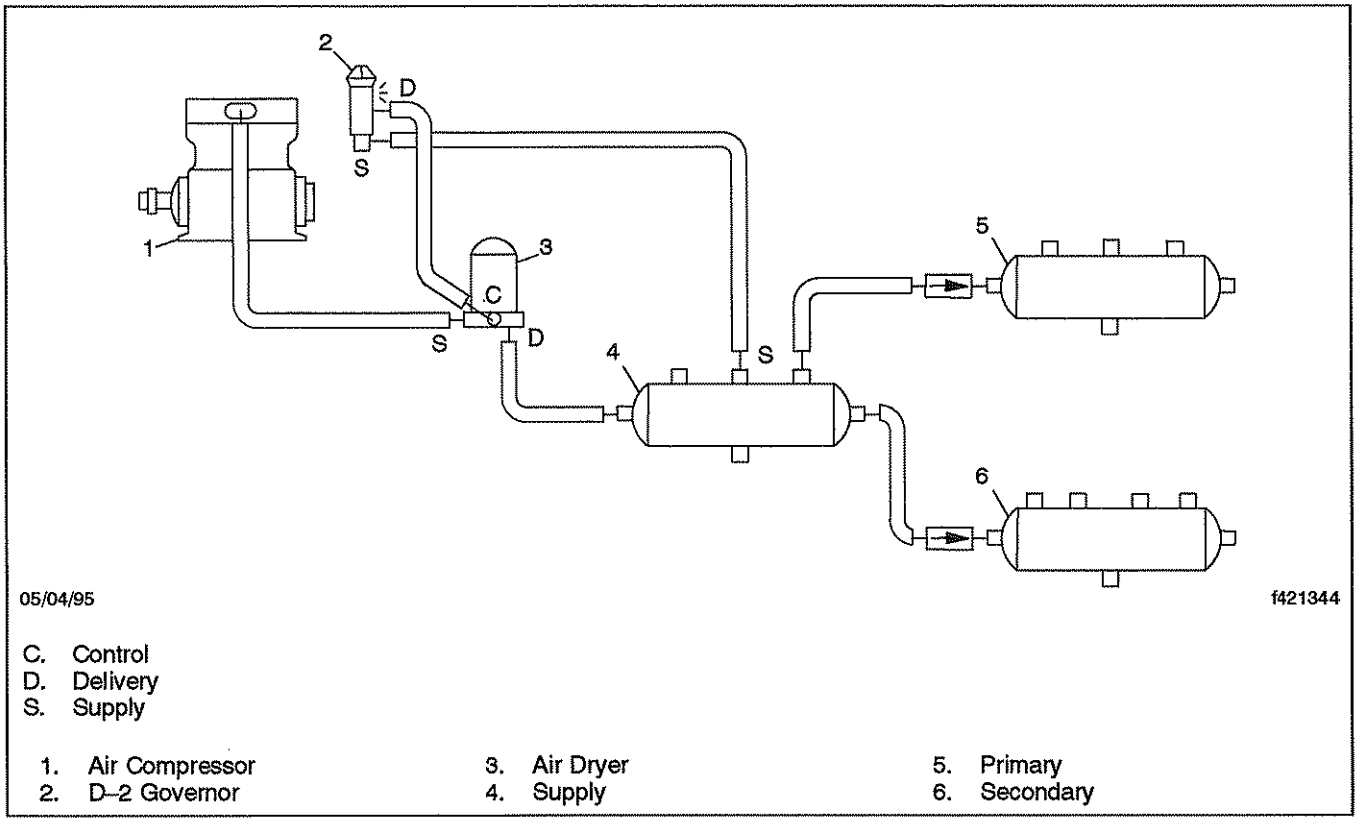
  The soft seat style air dryer is usually used on vehicles equipped with Holset "E" and "QE" type air compressors. This air dryer eliminates the need for the Holset ECON valve (which is plumbed in the compressor discharge line).



C. Control
D. Delivery
S. Supply

1. Air Compressor
2. D–2 Governor
3. Air Dryer
4. Supply
5. Primary
6. Secondary

Fig. 2, Standard Air Dryer Plumbing Diagram



C. Control
D. Delivery
S. Supply

1. Air Compressor
2. D–2 Governor
3. Air Dryer
4. Supply
5. Primary
6. Secondary

Fig. 3, Discharge Line Unloader Style Air Dryer Plumbing Diagram

However, external plumbing of the make-up line and make-up line check valve is still required.

- Drop-In Air Dryer **(see Fig. 5):**

  The drop-in style air dryer *can only be used* on vehicles equipped with Holset "E" and "QE" type air compressors. This air dryer eliminates any external plumbing requirements (such as the ECON valve, make-up line, and make-up line check valve). All of these components are an integral part of the air dryer.

Principles of Operation

The AD–9 air dryer alternates between two operational modes or cycles during operation: the charge cycle and the purge cycle.

CHARGE CYCLE **(See Fig. 6)**

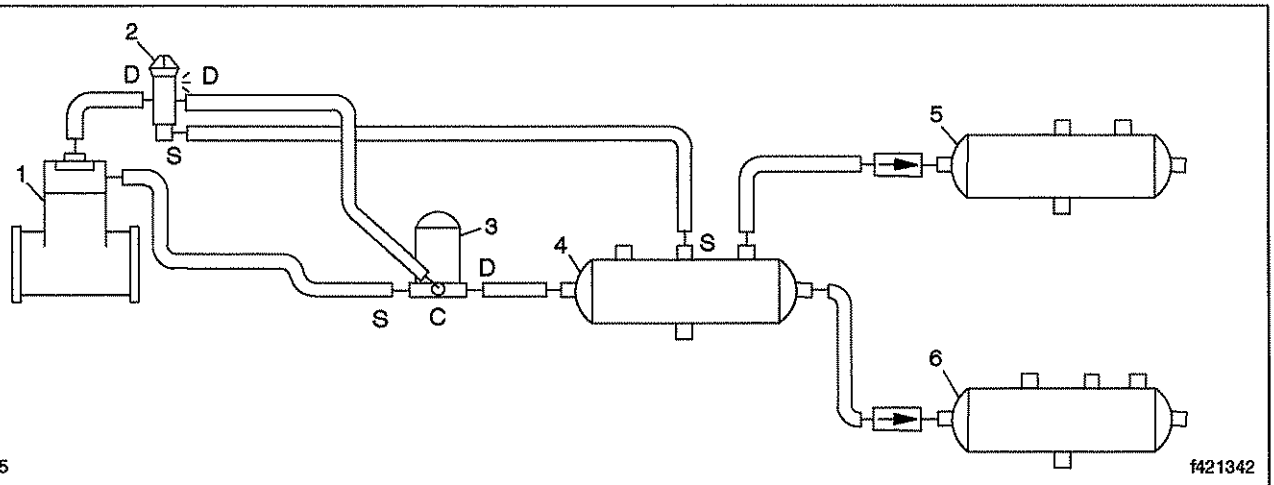
When the compressor is loaded (compressing air), pressurized air, along with oil, oil vapor, water, and water vapor flow through the compressor discharge line to the supply port of the air dryer end cover. As air travels through the end-cover assembly, its direction of flow changes several times, reducing the temperature, causing contaminants to condense and drop to the bottom or sump of the air dryer end cover.

After exiting the end cover, air flows into the desiccant cartridge. Once in the cartridge, air first flows through an oil separator, which removes water, oil, oil vapor, and solid contaminants.

Air exits the oil separator and enters the desiccant drying bed. Air flowing through the column of desiccant becomes progressively drier as water vapor sticks to the desiccant material in a process known as adsorption. The desiccant cartridge, using the adsorption process typically removes 95 percent of the water vapor from the pressurized air.

Most of the dry air exits the desiccant cartridge through its integral single check valve to fill the purge volume between the desiccant cartridge and outer shell. Some

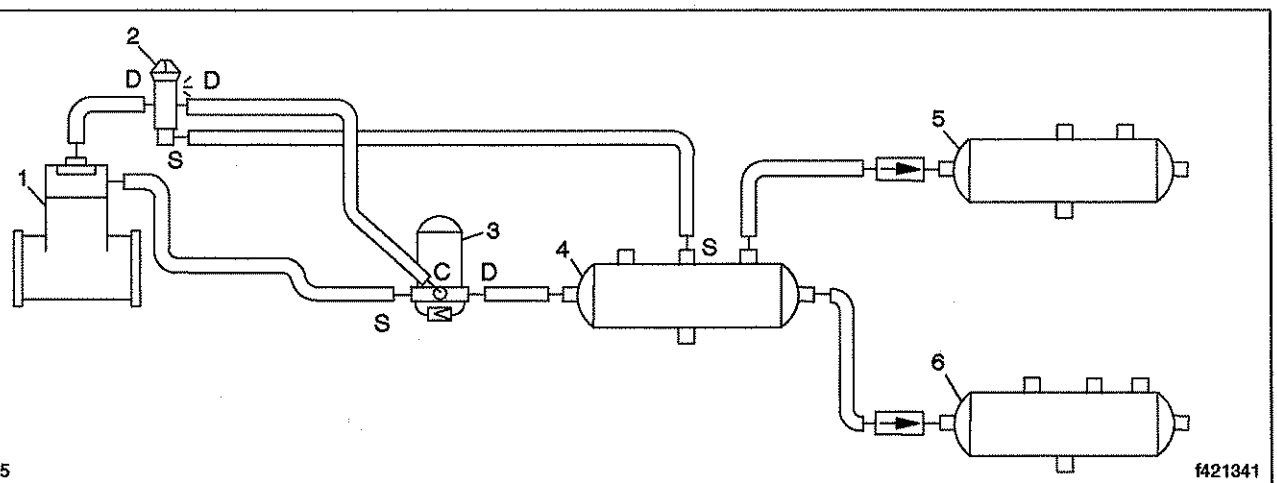
General Description and Principles of Operation



C. Control
D. Delivery
S. Supply

1. Holset E or QE Air Compressor
2. D–2 Governor
3. Air Dryer
4. Supply
5. Primary
6. Secondary

Fig. 4, Soft Seat Air Dryer Plumbing Diagram

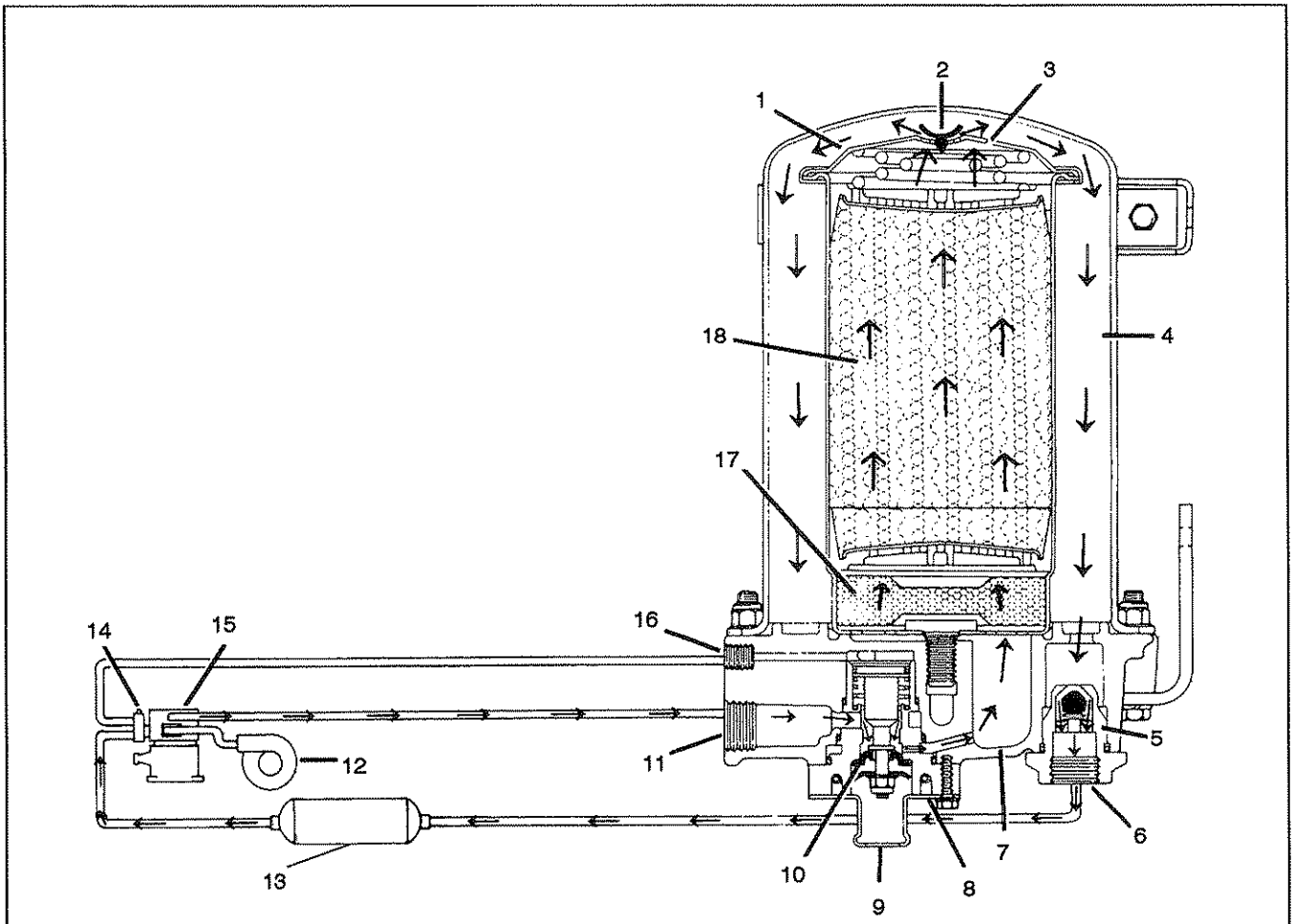


C. Control
D. Delivery
S. Supply

1. Holset E or QE Air Compressor
2. D–2 Governor
3. Air Dryer
4. Supply
5. Primary
6. Secondary

Fig. 5, Drop-in Style Air Dryer Plumbing Diagram

air also exits the desiccant cartridge through the purge orifice adjacent to the check valve.



1. Desiccant Cartridge
2. Check Valve
3. Orifice
4. Purge Volume
5. Check Valve Assembly
6. Delivery Port
7. Sump
8. Heater Element
9. Exhaust
10. Purge Valve
11. Supply Port
12. Engine Turbocharger
13. Reservoir
14. Governor
15. Compressor
16. Control Port
17. Oil Separator
18. Desiccant Bed

Fig. 6, AD–9 Charge Cycle

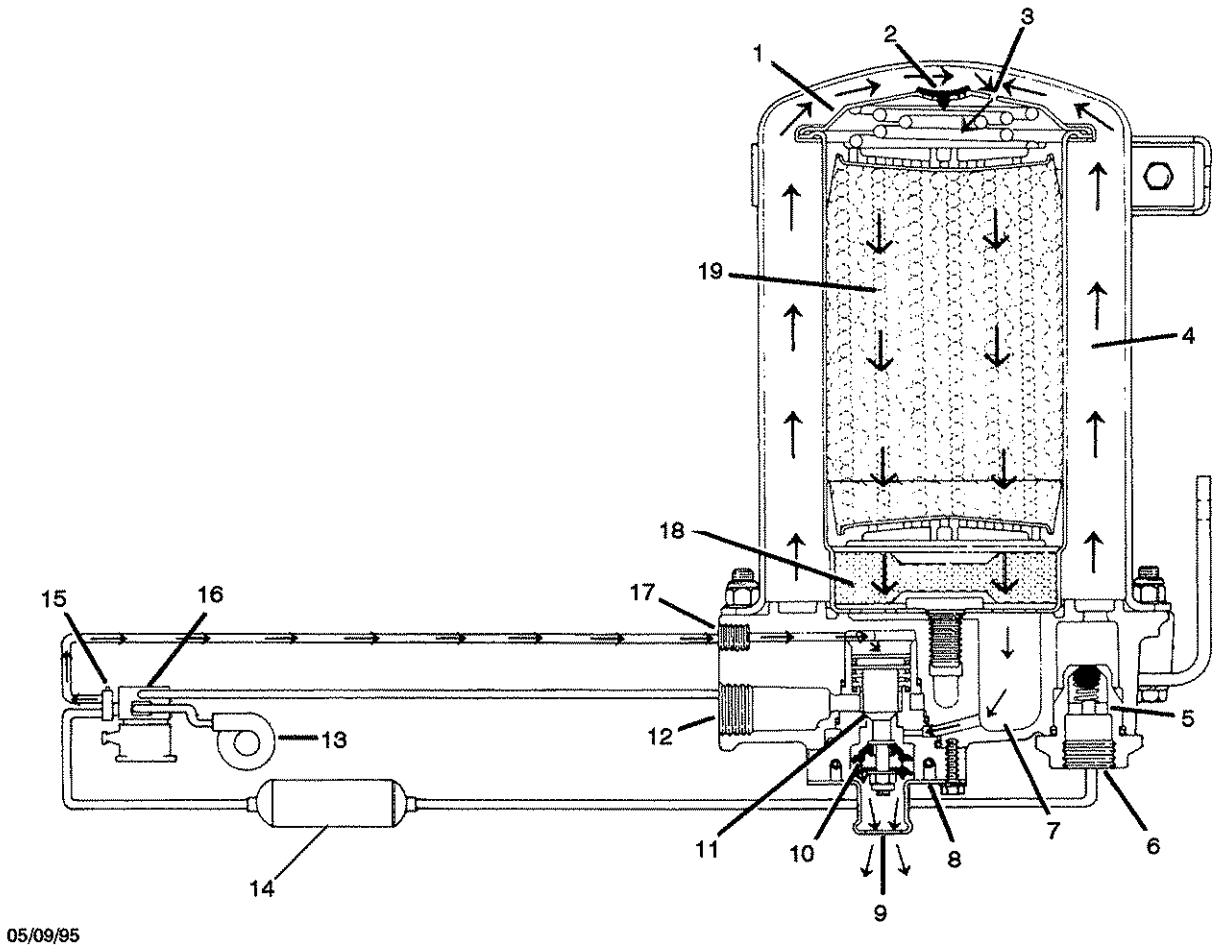
Dry air flows out of the purge volume through the single check valve assembly and out the delivery port to the first (supply) reservoir of the air system.

The air dryer remains in the charge cycle until air brake system pressure builds to the governor cutout setting.

PURGE CYCLE (See Fig. 7)

When the brake system pressure reaches the governor cutout setting, the compressor unloads (air compression stopped), and the purge cycle of the air dryer begins. When the governor unloads the compressor, it pressurizes the unloader mechanism and line connect-

General Description and Principles of Operation



1. Desiccant Cartridge
2. Check Valve
3. Orifice
4. Purge Volume
5. Check Valve Assembly
6. Delivery Port
7. Sump
8. Heater Element
9. Exhaust
10. Purge Valve
11. Turbocharger Cutoff Piston
12. Supply Port
13. Engine Turbocharger
14. Reservoir
15. Governor
16. Compressor
17. Control Port
18. Oil Separator
19. Desiccant Bed

Fig. 7, AD–9 Purge Cycle

ing the governor unloader port to the AD–9 end cover control port. The purge piston moves in response to air pressure causing the purge valve to open to atmosphere and partially close off the supply of air from the compressor. This is further discussed under "Turbo Cutoff Feature."

Contaminants in the end cover sump are expelled immediately when the purge valve opens. Also, air that was flowing through the desiccant cartridge changes direction and begins to flow toward the open purge valve. Oil and solid contaminants collected by the

oil separator are removed by air flowing from the desiccant drying bed to the open purge valve.

The initial purge and desiccant cartridge decompression last only a few seconds and are signaled by an audible burst of air at the AD–9 exhaust. The actual reactivation of the desiccant drying bed begins as dry air flows from the purge volume through the desiccant cartridge purge orifice and into the desiccant drying bed. Pressurized air from the purge volume expands after passing through the purge orifice; its pressure is lowered and its volume increased. Dry air flowing through the drying bed reactivates the desiccant material by removing the water vapor sticking to it. Generally, it takes 15 to 30 seconds for the entire purge volume of a standard AD–9 to flow through the desiccant drying bed.

The end cover single check valve assembly prevents compressed air in the brake system from returning to the air dryer during the purge cycle. After the 30 second purge cycle is complete, the air dryer is ready for the next charge cycle to begin.

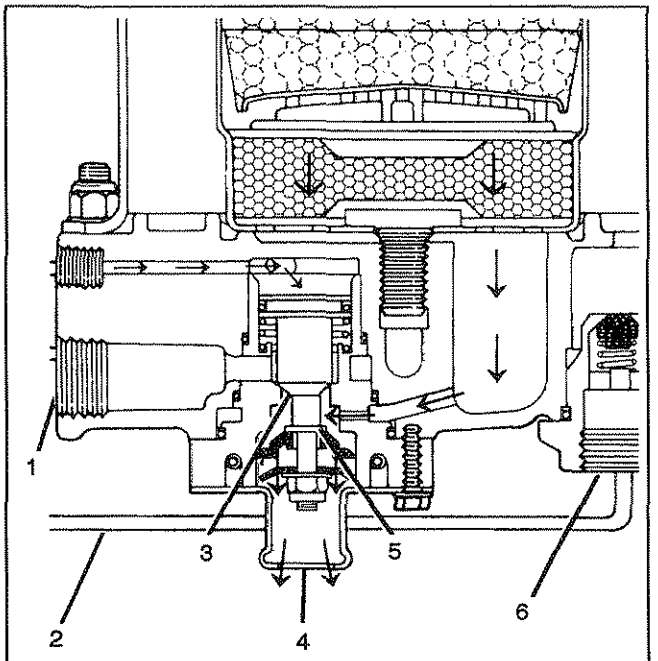
The purge valve will remain open after the purge cycle is complete, and will not close until air brake system pressure is reduced and the governor signals the compressor to charge.

NOTE: The air dryer should be periodically checked for operation and tested for leaks. Refer to the brake section in the vehicle maintenance manual for intervals and procedures.

TURBOCHARGER CUTOFF FEATURE **(See Fig. 8)**

Primarily, the turbo cutoff valve prevents loss of engine turbocharger air pressure through the AD–9 in systems where the compressor intake is connected to the engine turbocharger. The turbo cutoff valve also reduces the puffing of air out the open exhaust when a naturally aspirated, single cylinder compressor equipped with an inlet check valve is in use.

At the beginning of the purge cycle, the downward travel of the purge piston is stopped when the turbo cutoff valve (tapered portion of the purge piston) contacts its mating metal seat in the purge valve housing. With the turbo cutoff valve seated (closed position), air in the discharge line and AD–9 supply port is restricted from entering the air dryer. While the turbo cutoff *effectively* prevents loss of turbocharger boost pressure to the engine, some seepage of air may be detected under certain conditions of compressor, engine, and turbocharger operation. Even so, there will be low pressure trapped in the discharge line.



1. Supply Port
2. Discharge Line
3. Turbocharger Cutoff Piston
4. Exhaust
5. Purge Valve
6. Check Valve Assembly

Fig. 8, AD–9 Turbo Cutoff

Safety Precautions

When working on or around air brake systems and components, observe the following precautions:

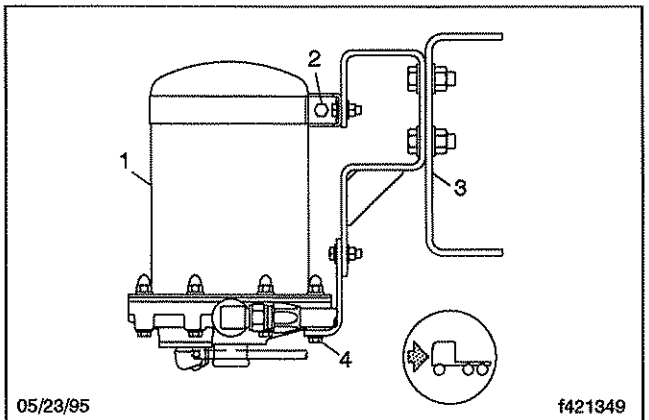
1. Chock the tires and stop the engine before working under a vehicle. Depleting air system pressure may cause the vehicle to roll. Keep hands away from brake chamber push rods and slack adjusters, which may apply as air pressure drops.
2. Never connect or disconnect a hose or line containing compressed air. It may whip as air escapes. Never remove a component or pipe plug unless you are certain all system pressure has been released.
3. Never exceed recommended air pressure, and always wear safety glasses when working with compressed air. Never look into air jets or direct them at anyone.
4. Don't disassemble a component until you have read and understood the service procedures. Some components contain powerful springs, and injury can result if not properly disassembled. Use the correct tools, and observe all precautions pertaining to use of those tools.
5. Replacement hardware, tubing, hose, fittings, etc. should be the equivalent size, type, length, and strength of the original equipment.

   Make sure that when replacing tubing or hose, all of the original supports, clamps, or suspending devices are installed or replaced.
6. Replace devices with stripped threads or damaged parts. Repairs requiring machining should not be attempted.

Removal (See Fig. 1)

WARNING: Before working on or around air brake systems and components, read the safety precautions in Subject 100. Failure to do so could result in personal injury.

1. Park the vehicle on a level surface and chock the tires.
2. Completely drain all of the reservoirs.
3. Remove the air dryer.
   - 3.1 Mark and disconnect the three air lines from the end cover, and note the position of end cover ports relative to the vehicle.
   - 3.2 Unplug the vehicle wiring harness from the heater and thermostat assembly connector on the exhaust cover.
   - 3.3 Loosen the capscrew securing the upper bracket strap.
   - 3.4 Remove, save, and mark the two end cover capscrews, locknuts, and four special washers that retain the lower mounting bracket to the end cover. Also mark the two holes of the end cover (these receive the two longest capscrews.)
   - 3.5 Remove the air dryer from its mounting brackets.



1. Air Dryer
2. Upper Bracket Strap Capscrew
3. Right Frame Rail
4. End Cover Fastener

Fig. 1, Air Dryer Mounting

Installation (See Fig. 1)

WARNING: Before working on or around air brake systems and components, read the safety precautions in Subject 100. Failure to do so could result in personal injury.

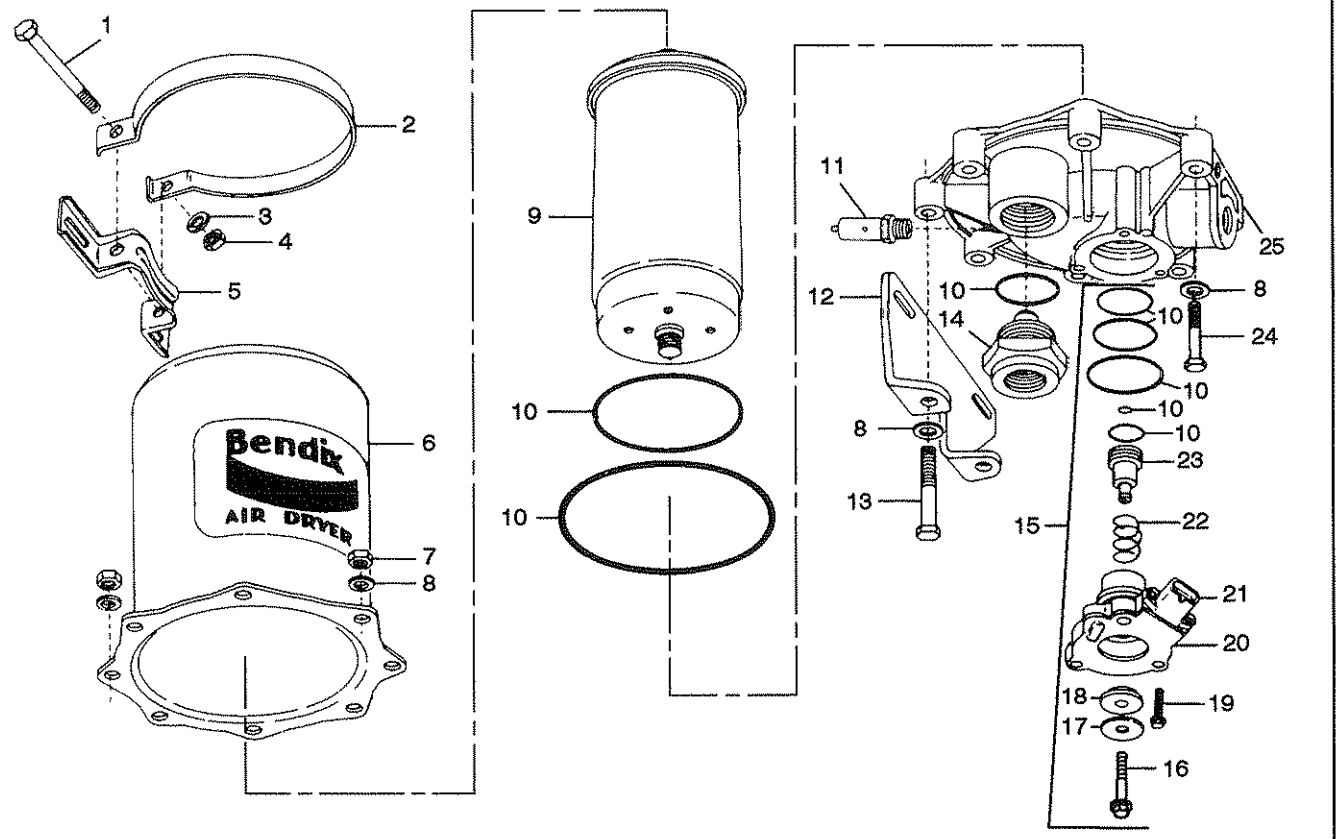
1. Install the assembled air dryer on the vehicle.
   - 1.1 Position the air dryer up into the upper mounting bracket and strap. Align the two unused holes in the end cover with the bottom mounting bracket so that the bottom bracket supports the air dryer. The end cover should rest on the bracket.
   - 1.2 Using the two longest capscrews, four special washers, and two locknuts, secure the air dryer to the lower bracket. Tighten the two remaining capscrews 270 to 385 lbf·in (3060 to 4340 N·cm).
   - 1.3 Tighten the capscrew and nut on the upper mounting bracket strap 80 to 120 lbf·in (900 to 1360 N·cm).
   - 1.4 As marked earlier in "Removal," connect the three air lines to the ports on the end cover.
   - 1.5 Connect the vehicle wiring harness to the air dryer heater and thermostat assembly connector by plugging it into the air dryer connector until its lock tab snaps in place.
2. Test the air dryer following instructions in the brake section in the vehicle maintenance manual.

Air Dryer Disassembly, Cleaning and Inspection, and Assembly

As a convenience when rebuilding the air dryer, several replacement parts and maintenance kits are available that do not require full disassembly. Use the instructions provided with these parts or kits.

Disassembly (See Fig. 1)

WARNING: Before working on or around air brake systems and components, read the safety precautions in Subject 100. Failure to do so could result in personal injury.



1. 5/16-Inch x 4-1/2 Inch Upper Bracket Capscrew
2. Upper Bracket Strap
3. 5/16-Inch Lockwasher
4. 5/16-Inch Locknut
5. Upper Mounting Bracket
6. Housing
7. Locknut
8. 3/8-Inch Special Washer
9. Desiccant Cartridge
10. O-Ring
11. Safety Valve
12. Lower Mounting Bracket
13. 3/8-Inch Capscrew (Long)
14. Check Valve Assembly
15. Purge Valve Assembly
16. Purge Valve Bolt
17. Exhaust Diaphragm
18. Purge Valve
19. 1/4-Inch Tapping Screw
20. Purge Valve Housing
21. Heater and Thermostat Assembly
22. Return Spring
23. Purge Piston
24. 3/8-Inch Capscrew
25. End Cover

Fig. 1, AD–9 Exploded View

Air Dryer Disassembly, Cleaning and Inspection, and Assembly

CAUTION: While servicing the air dryer, don't use a clamping device (vise, C-clamp, etc.) to hold any die cast aluminum part, as damage may result. To hold the end cover, install a pipe nipple in the supply port, and clamp the nipple in a vise.

1. Remove the air dryer from the vehicle. Refer to **Subject 110.**
2. Remove the check valve assembly and O-ring. Remove the O-ring from the check valve assembly.
3. Remove the purge valve housing assembly.
   - 3.1 Remove the three self-tapping screws that secure the purge valve housing assembly to the end cover assembly.
   - 3.2 Pull the purge valve housing assembly out of the end cover assembly.
   - 3.3 Remove and discard the three O-rings from the exterior of the purge valve housing assembly.

   NOTE: These O-rings may lodge in and have to be removed from the end cover bores.
4. Remove the heater and thermostat assembly.
   - 4.1 Remove and discard the two screws that attach the heater and thermostat assembly to the purge valve housing.
   - 4.2 Gently rotate the electrical connector to the left until the thermostat clears the purge valve housing. Then, slide the heater element out, to the right and up. Discard the assembly.
5. Disassemble the purge valve housing assembly.
   - 5.1 If a flat non-extended exhaust cover is used, leave it intact while servicing the purge valve housing assembly.

     If an extended type exhaust cover is used for the attachment of an exhaust hose, *carefully* separate the exhaust cover from the purge valve housing. *Use a thin flat blade to pry the exhaust cover off, taking care not to damage the potting material (RTV sealant) under the cover.*
   - 5.2 Remove the bolt from the bottom of the purge valve housing assembly. Remove the diaphragm and the purge valve from the purge valve housing.
   - 5.3 Remove the purge piston, the return spring and two O-rings (one on the outside and the other in the inside of the purge piston).
6. Remove the remaining six capscrews (Ref. 24), locknuts (Ref. 7), and twelve special washers (Ref. 8) that secure the end cover to the housing (Ref. 6). Separate the end cover and desiccant cartridge (Ref. 9) from the housing (Ref. 6).
7. Remove the end-cover-to-outer-housing O-ring.
8. Don't remove the safety valve (Ref. 11) from the end cover unless it is known to be inoperative. If replacement is needed, apply thread sealant or Teflon® tape on the threads of the replacement valve and tighten 120 to 400 lbf·in (1360 to 4520 N·m). Make sure the drain hole (slot) is facing down.
9. Place a strap or chain wrench around the desiccant cartridge (Ref. 9) so that it is about 2 to 3 inches (5 to 8 cm) away from the end cover. Rotate the cartridge counterclockwise until it completely separates from the end cover.

NOTE: Torque of up to 50 lbf·ft (68 N·m) may be needed to do this disassembly.

10. Remove the desiccant cartridge O-ring from the end cover.

Cleaning and Inspection

WARNING: Before working on or around air brake systems and components, read the safety precautions in Subject 100. Failure to do so could result in personal injury.

1. Wash all metal parts thoroughly, using a quality commercial solvent, such as mineral spirits.
2. Check for severe corrosion, pitting, and cracks on the inside and outside of all metal parts that will be reused. Superficial corrosion and pitting on the outside of the upper and lower body halves is acceptable.
3. Inspect the bores of both the end cover and the purge-valve housing for deep scuffing or gouges.

4. Make sure that all purge-valve housing and end cover passages are open and free of blockages.
5. Inspect the pipe threads in the end cover. Make sure they are clean and free of thread sealant.
6. Inspect the purge-valve housing bore and seats for excessive wear and scuffing.
7. Inspect the purge valve piston seat for excessive wear.
8. Inspect all air line fittings for corrosion. Clean all old thread sealant from the pipe threads.
9. Replace all removed O-rings with new ones that are provided in the kits.

   Replace parts that show any of the conditions described in the previous steps.

Assembly (See Fig. 1)

WARNING: Before working on or around air brake systems and components, read the safety precautions in Subject 100. Failure to do so could result in personal injury.

1. Before assembly, coat all O-rings, O-ring grooves, and bores with a generous amount of barium-base lubricant. **See Fig. 1** during assembly unless otherwise advised.

IMPORTANT: When installing the heater and thermostat assembly, make sure that the seal ring under the electrical connector is not twisted.

2. Install the heater and thermostat assembly.
   - 2.1 Insert the heater element into the slot in the purge valve housing until the connector contacts the housing.
   - 2.2 Gently push the connector and the thermostat to the left until the thermostat clears the cavity in the housing. Then, turn the connector to the right while pushing the thermostat all the way down into the cavity.

     Make sure that the connector is seated evenly against the housing.
   - 2.3 Install the two mounting screws. Tighten the screws 10 to 20 lbf·in (113 to 226 N·cm).
3. Assemble the purge-valve housing.
   - 3.1 Install the O-ring on the purge piston. Place the return spring in the purge-valve housing. Place the O-ring in the bore of the purge piston. Insert the purge piston into the spring. Push the piston into the purge-valve housing until it bottoms.
   - 3.2 While holding the purge piston in, install the following parts: the purge valve with its rubber side first, followed by the diaphragm and the bolt. Torque the purge valve bolt 60 to 80 lbf·in (680 to 900 N·cm).
   - 3.3 Install the three O-rings in their correct locations on the purge-valve housing.
   - 3.4 If an extended type exhaust cover was removed, install it on the purge-valve housing assembly, making sure the "bubble" portion is positioned over the thermostat.
   - 3.5 Install the assembled purge-valve housing in the end cover; make sure you orient both parts so that the connector is about 10 degrees clockwise from the supply port. Also, make sure the purge-valve housing is fully seated against the end cover.
   - 3.6 Secure the purge-valve housing to the end cover using the three self-tapping screws. Start all three screws by hand, then torque them 85 to 125 lbf·in (960 to 1400 N·cm).
4. Install an O-ring on the check-valve assembly, then install the assembly in the end cover using a socket. Tighten it 200 to 250 lbf·in (2260 to 2820 N·cm).
5. Install the desiccant cartridge in the end cover.
   - 5.1 Install the smaller desiccant cartridge O-ring in its groove in the end cover. Using a light coat of barium grease, lubricate the bottom of the desiccant cartridge in the area that will contact the O-ring and end cover.
   - 5.2 Screw the desiccant cartridge into the end cover until the cartridge contacts the

Air Dryer Disassembly, Cleaning and Inspection, and Assembly

O-ring. Using a strap or chain wrench positioned 2 to 3 inches (5 to 8 cm) from the bottom of the cartridge, turn the desiccant cartridge clockwise 180 to 225 degrees beyond the position where initial contact was made with the O-ring. Torque should not exceed 50 lbf·ft (68 N·m).

6. Install the housing over the desiccant cartridge.

   6.1 Install the large O-ring on the shoulder in the end cover. Place the housing over the desiccant cartridge and align the holes.

   6.2 Install the six capscrews, locknuts, and the twelve special washers, making sure they are positioned as referenced earlier. The two longer capscrews will be used to secure the air dryer to its mounting bracket.

   6.3 Tighten the six capscrews and nuts in a star pattern (depending on lower bracket location) 270 to 385 lbf·in (3060 to 4340 N·cm). **See Fig. 2.**

NOTE: The two remaining bolt holes in the end cover and two 3/8-inch capscrews must be the ones marked during removal to ensure correct orientation of the ports and adequate length of the capscrews.

7. Connect the electrical connector to the heater and thermostat assembly.

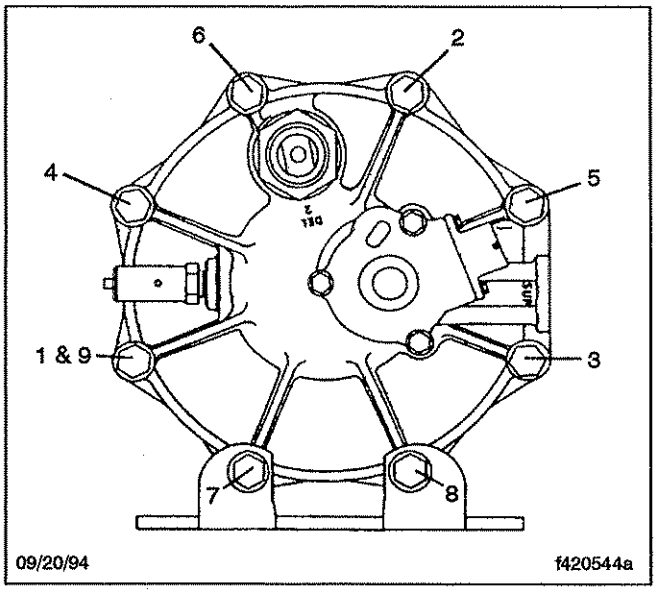


Fig. 2, End Cover to Housing Torque Pattern

8. Test the air dryer for proper operation. For instructions, refer to **Subject 130.**

Testing

During cold-weather operation, check the operation of the end cover heater and thermostat assembly.

1. With the ignition on, check for voltage to the heater and thermostat assembly. Unplug the electrical connector at the air dryer, and place the test leads on each of the pins of the male connector. If there is no voltage, look for a blown fuse, broken wires, or corrosion in the vehicle wiring harness. Check that a good ground path exists.

2. Check the thermostat and heater operation. Turn off the ignition switch and cool the end cover assembly to below 40°F (4°C). Using an ohmmeter, check the resistance between the electrical pins in the female connector. The resistance should be 1.5 to 3.0 ohms for the 12-volt heater assembly, and 6.8 to 9.0 ohms for the 24-volt heater assembly.

NOTE: Some early models of the AD–9 will have resistance readings of 1.0 to 2.5 ohms for the 12-volt heater assembly, and 4.8 to 7.2 ohms for the 24-volt heater assembly. If the resistance is higher than this, replace the purge-valve housing assembly, which includes the heater and thermostat assembly.

3. Warm the end cover assembly to over 90°F (32°C) and again check the resistance. It should exceed 1000 ohms. If it does, the thermostat and heater assembly is operating properly. If it doesn't, replace the purge-valve housing assembly, which includes the heater and thermostat assembly.

Problem—Air Dryer Is Constantly Cycling or Purging

Possible Cause	Remedy
Excessive system leakage.	Test for excessive leakage. Eliminate leaks, as needed. Allowable leakage is as follows: • Single Vehicle—1 psi/min (7 kPa/min) per service reservoir • Tractor/Trailer—3 psi/min (21 kPa/min) per service reservoir
There is excessive leakage in the fittings, hoses, and tubing connected to the compressor, air dryer, and wet tank.	Using a soap solution, test for leakage at the fittings, drain valve, and safety valve in the wet tank. Repair or replace as needed.
Check valve assembly in the air dryer end cover is not working.	Remove the check valve assembly from the end cover. Apply compressed air to the delivery side of the valve. Apply a soap solution at opposite end, and check for leakage. Permissible leakage is a 1-inch (2.5-cm) bubble in 5 seconds. If there is excessive leakage, replace the check valve assembly.
Governor is inoperative.	Test the governor for proper cut-in or cut-out pressures and excessive leakage in both positions.
Leaking purge-valve housing assembly or O-rings in the air dryer end cover.	With the supply port open to atmosphere, apply 120 psi (830 kPa) at the control port. Apply a soap solution to the supply port and exhaust port (purge valve seat area). Permissible leakage is a 1-inch (2.5-cm) bubble in 5 seconds. Repair or replace as needed.
Compressor unloader mechanism is leaking excessively.	Remove the air strainer or fitting from the compressor inlet cavity. With the compressor unloaded, check for unloader piston leakage. Slight leakage is allowed.
Holset "E" type compressor.	Test the air dryer system. For instructions, refer to Bendix Product Bulletin PRO-08-19 entitled "Troubleshooting the Holset "E" Compressor System with Bendix Air Dryer."
Lack of air at the governor RES port (rapid cycling of the governor).	Test the governor for proper pressure at the RES port. Pressure should not drop below cut-in pressure when the compressor begins the unloaded cycle. If the pressure does drop, check for kinks or restrictions in the line connected to the RES port. The line connected to the RES port on the governor must be the same diameter, or larger than the lines connected to the UNL ports on the governor.

Problem—Water in the Vehicle Reservoirs

Possible Cause	Remedy
Desiccant cartridge assembly contains excessive contaminants.	Replace the desiccant cartridge.
Discharge line is of improper length or material.	Discharge line must consist of at least 6 ft. (1.8m) of wire braid Teflon hose, copper tubing, or a combination of both between the discharge port of the compressor and the air dryer supply port. Discharge line lengths and inside diameter requirements are dependent on the vehicle application. Contact your local Bendix representative for further information.
Air system was charged from an outside air source that did not pass through an air dryer.	If the system must have an outside air fill provision, the outside air should pass through an air dryer. This practice should be minimized.
Air dryer is not purging.	Refer to "Problem—Air Dryer Does Not Purge or Exhaust Air."
Purge (air exhaust) is insufficient due to excessive system leakage.	Refer to "Problem—Air Dryer Is Constantly Cycling or Purging."

Troubleshooting

Possible Cause	Remedy
Air bypasses the desiccant cartridge assembly.	Replace the desiccant cartridge/end cover O-ring. Make sure the desiccant cartridge assembly is properly installed.
Purge (air exhaust) time is significantly less than the minimum allowable.	Replace the desiccant cartridge/end cover O-ring. Make sure the desiccant cartridge assembly is properly installed. Replace the desiccant cartridge assembly.
Excessive air usage—air dryer not compatible with vehicle air system.	Install an accessory bypass system. Consult your Bendix representative for additional information.

Problem—Safety Valve on Air Dryer Is Popping Off or Exhausting Air

Possible Cause	Remedy
Desiccant cartridge is plugged or saturated.	Check the compressor for excessive oil passing, or incorrect installation. Repair or replace as needed.
The check valve in the air dryer end cover is inoperative.	Test to determine if air is passing through the check valve. Repair or replace as needed.
There is a problem in the fittings, hose, or tubing between the air dryer and the wet tank.	See if air is reaching the first reservoir. Inspect for kinked tubing or hose. Check for undrilled or restricted hose or tubing fittings.
Safety valve setting is lower than the maximum system pressure.	Reduce the system pressure, or install a safety valve with a higher pressure setting.

Problem—Constant Exhaust of Air at the Air Dryer Purge Valve Exhaust; Unable to Build System Pressure

Possible Cause	Remedy
Air dryer purge valve is leaking excessively.	With the compressor loaded, apply a soap solution on the purge valve exhaust to test for excessive leakage. Repair the purge valve as needed.
The governor is inoperative.	Check the governor for proper cut-in and cut-out pressures, and excessive leakage in both positions. Repair or replace as needed.
Purge control line is connected to the reservoir or exhaust port of the governor.	Connect the purge control line to the unloader port of the governor.
Purge valve is frozen open due to an inoperative heater or thermostat, bad wiring, or a blown fuse.	Test the heater and thermostat, following instructions in this manual.
Inlet and outlet air connections are reversed—unable to build system pressure.	Reconnect the lines properly.
Discharge line is kinked or blocked.	See if air passes through the discharge line. Check for kinks, bends, or excessive carbon deposits.
There are excessive bends in the discharge line. Water is collecting and freezing.	Discharge line should be constantly sloping from the compressor to the air dryer with as few bends as possible.
System is leaking excessively.	Test for excessive leakage. Eliminate leaks, as needed. Allowable leakage is as follows: • Single Vehicle—1 psi/min (7 kPa/min) per service reservoir • Tractor/Trailer—3 psi/min (21 kPa/min) per service reservoir
Purge valve stays open; supply air leaks to control side.	Replace the purge valve assembly O-rings.

Problem—Air Dryer Does Not Purge or Exhaust Air

Possible Cause	Remedy
Purge control line is broken, kinked, frozen, plugged, or disconnected.	See if air flows through the purge control line when the compressor is unloaded. The purge control line must be connected to the unloader port of the governor.
Air dryer purge valve isn't working.	See if air reaches the purge valve. If it does, repair the purge valve.
The governor is inoperative.	Check the governor for proper cut-in and cut-out pressures, and excessive leakage in both positions. Repair or replace as needed.
Inlet and outlet air connections are reversed—unable to build system pressure.	Reconnect the lines properly.
Discharge line is kinked or blocked.	See if air passes through the discharge line. Check for kinks, bends, or excessive carbon deposits.
There are excessive bends in the discharge line. Water is collecting and freezing.	Discharge line should be constantly sloping from the compressor to the air dryer with as few bends as possible.

Problem—Desiccant Is Being Expelled from the Air Dryer Purge Valve Exhaust (May Look Like Whitish Liquid, Paste, or Small Beads); or, Unsatisfactory Desiccant Life

Possible Cause	Remedy
This problem usually occurs with one or more of the previous problems.	Refer to the appropriate corrections listed previously.
Air dryer is not securely mounted; there is excessive vibration.	Vibration should be held to a minimum. Tighten the mounting fasteners.
Cloth-covered perforated plate in the air dryer desiccant cartridge is damaged, or the cartridge was rebuilt incorrectly.	Replace the plate or cartridge as needed. High operating temperatures may cause deterioration of filter cloth. Check the installation.
Compressor is passing excessive oil.	Check for proper compressor installation; if symptoms persist, replace the compressor.
Heater and thermostat, wiring, or a fuse is at fault, and isn't allowing the air dryer to purge during cold weather.	Test the heater and thermostat, following instructions in this manual.
Desiccant cartridge not attached properly to the end cover.	Check the torque and tighten if necessary. Refer to **Subject 120** for instructions.

Problem—Pinging Noise Is Excessive During Compressor Loaded Cycle

Possible Cause	Remedy
Pinging noise is due to a single cylinder compressor with high pulse cycles.	A slight pinging sound may be heard during system build-up when a single cylinder compressor is used. If this sound is deemed objectionable, it can be reduced substantially by increasing the discharge line volume. This is done by adding a 90 in^3 (1475 cm^3) reservoir between the compressor and the air dryer.

Troubleshooting

Problem—Constant Air Seepage at the Purge Valve (Non-Charging Mode)

Possible Cause	Remedy
Air compressor inlet is pressurized by the engine turbocharger.	Some pressure leakage past the metal seat of the turbocharger cutoff feature of the AD-9 air dryer is normal, and may be heard. This slight loss of air will not affect the engine or turbocharger performance.
Check valve assembly in the air dryer end cover is not working.	Remove the check valve assembly from the end cover. Apply compressed air to the delivery side of the valve. Apply a soap solution at opposite end, and check for leakage. Permissible leakage is a 1-inch (2.5-cm) bubble in 5 seconds. If there is excessive leakage, replace the check valve assembly.

Problem—Air Dryer Purge Piston Cycles Rapidly in the Unloaded Mode

Possible Cause	Remedy
Compressor does not "unload."	Check the governor installation: there is no air line from the governor to the compressor, or the line is restricted. Repair or replace as needed.

Dual Brake Valve, Bendix E–6

42.03

Contents

Subject	Subject Number
General Description and Principles of Operation	050
Service Operations	
Bendix E–6 Brake Valve Operating and Leakage Checks	100
Bendix E–6 Brake Valve Removal and Installation	110
Bendix E–6 Brake Valve Disassembly, Cleaning and Inspecting, and Assembly	120

General Description and Principles of Operation (See Fig. 1)

The dual circuit brake valve (foot valve) controls the air supply and delivery of the dual circuit brake system. The brake valve is mounted on the firewall.

APPLYING

The primary circuit of the brake valve is controlled by the brake pedal and a plunger. When the brake pedal is depressed, the plunger applies pressure on the spring seat, rubber spring, and the primary (upper) piston. The downward movement of the primary piston closes the upper exhaust valve, and then opens the upper inlet valve, allowing high-pressure air from port 11 to flow to low-pressure port 21.

The secondary circuit is pneumatically operated by the pressure from the primary circuit. Primary circuit pressure on top of the relay piston first closes the lower exhaust valve, and then opens the lower inlet valve, allowing high-pressure from port 12 to flow to low-pressure port 22.

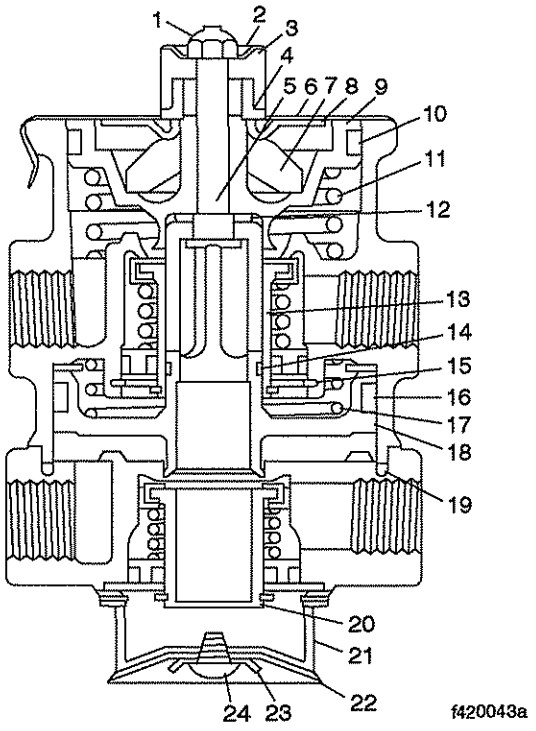
HOLDING

As air pressure builds in the primary circuit, the pressure under the primary piston will match the pressure of the rubber spring. This allows the piston to move up enough to close the upper inlet valve, and prevent the flow of air from the primary air tank into the brake valve. The exhaust port remains closed.

RELEASING

When the pedal is released, the push rod releases pressure from the spring seat, rubber spring, and the primary (upper) piston. Air pressure builds to push the piston up, opening the upper exhaust valve and allowing air from the primary circuit to escape through the exhaust port.

In the secondary circuit, the release of primary air pressure allows air under the relay piston, pushing the piston up and opening the lower exhaust valve. All remaining air pressure is vented through the exhaust port.



1. Locknut
2. Spring Seat
3. Stem Spring
4. Spring Seat Nut
5. Primary Piston Stem
6. Primary Piston Retainer
7. Rubber Spring
8. Spring Seat
9. Primary Piston
10. Primary Piston O-Ring
11. Primary Piston Return Spring
12. Small Washer
13. Upper Inlet and Exhaust Valve Assembly
14. Small O-Ring
15. Retaining Ring
16. Large O-Ring
17. Relay Piston Spring (if equipped)
18. Relay Piston
19. Rubber Seal Ring
20. Lower Inlet and Exhaust Valve Assembly
21. Exhaust Cover
22. Exhaust Diaphragm
23. Washer
24. Phillips Head Screw

Fig. 1, Bendix E-6 Dual Circuit Foot Valve (sectional view)

Bendix E–6 Brake Valve Operating and Leakage Checks

Operating Checks

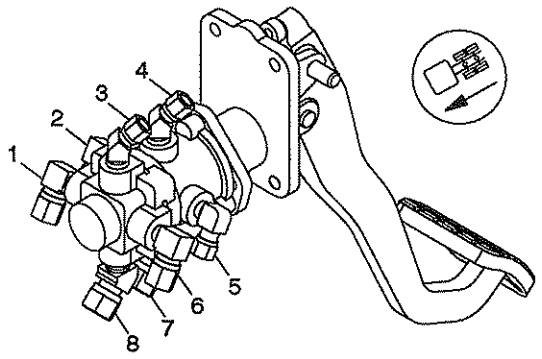
IMPORTANT: If there is a change in the way a vehicle brakes, or if low pressure warnings occur, check the operation of the brakes' air system. Although the brake system may continue to work, do not operate the vehicle until the braking circuits, including the pneumatic and mechanical devices, have been repaired and are operating normally. Always check the brake system for proper operation after doing brake work, and before returning the vehicle to service.

Check for the proper brake valve operation as follows:

1. Apply the parking brakes, and chock the tires.
2. Connect test gauges to the primary and secondary delivery ports on the brake valve. **See Fig. 1.**

NOTE: When checking the delivery pressure of the primary and secondary circuits, use test gauges that are accurate.

3. Start the engine and build air pressure to 120 psi (827 kPa).



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1. Supply Circuit to Front Brake Valve
2. Primary Delivery Circuit to Tractor Protection Valve
3. Secondary Supply Circuit to Dash Valve
4. Primary Supply Circuit to Dash Valve
5. Delivery Circuit to Rear Brake Valve
6. Secondary Delivery Circuit to Tractor Protection Valve (if not equipped with a hand valve)
7. Primary Supply Circuit to Primary Supply Reservoir
8. Secondary Supply Circuit to Secondary Supply Reservoir

Fig. 1, Brake Valve Plumbing Circuits

4. Depress the pedal to several different positions; check the pressure on the test gauges to ensure that it varies equally and proportionately with the movement of the brake pedal.
5. Fully depress the brake pedal, then release it. After a full application is released, the reading on the test gauges should promptly fall to zero.

NOTE: Pressure in the primary delivery circuit will be about 2 psi (14 kPa) greater than pressure in the secondary delivery circuit (if both supply reservoirs are at the same pressure). This is normal for this valve.

6. Go to "Leakage Check."

Leakage Check

1. Make and hold a pressure application of 80 psi (552 kPa).
2. Check the air line fittings for leaks: tighten or replace fittings as needed.
3. Coat the exhaust port and body of the valve with a soap solution, and check for leakage. The leakage permitted is a one-inch bubble in 3 seconds.

   If the brake valve does not function as described above, or if leakage is excessive, replace it with a new or remanufactured unit.

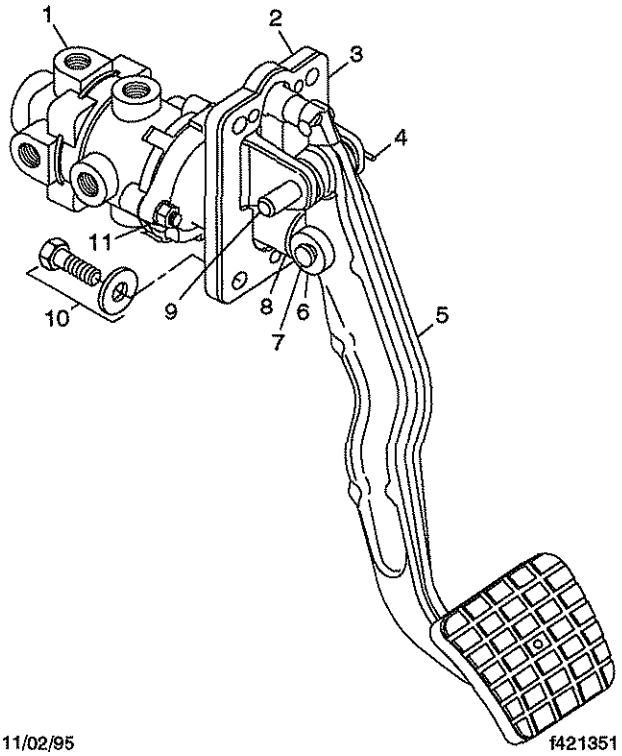
   Repeat the leakage test before placing the brake valve in service.
4. Remove the chocks from the tires.

Bendix E–6 Brake Valve Removal and Installation

Removal (See Fig. 1)

1. Chock the tires, then tilt the hood. For instructions, refer to the vehicle driver's manual.

WARNING: When draining the air system, don't look into the air jets or direct them toward another person, because dirt or sludge particles may be in the airstream. Don't disconnect pressurized hoses because they may whip as air escapes from the line. Failure to take all necessary precautions during service operations of the air brake system can result in personal injury.



1. Brake Valve
2. Mounting Plate Adaptor
3. Gasket
4. Roll Pin
5. Brake Pedal Assembly
6. Roller
7. Roller Pivot Pin
8. Plunger
9. Shaft Pivot Pin
10. 5/16–18 Capscrew and Flatwasher
11. 5/16–18 Locknut and Washer

Fig. 1, Brake Valve Mounting

2. Drain all of the air reservoirs.
3. Mark the brake valve air supply and delivery lines for assembly reference. Disconnect the air lines from the brake valve, and plug them to keep out contaminants.
4. Remove the brake valve.
   - 4.1 Remove the 5/16-18 capscrews and flatwashers that attach the brake valve and mounting adaptor to the front cab mount plate.
   - 4.2 Remove the the 5/16-18 locknuts and washers that attach the brake valve to the mounting adaptor.
   - 4.3 Remove the plunger from the mounting adaptor. Wipe off the old grease from the plunger and adaptor.
5. Note the locations and positions of the double check valves (if equipped), then remove them from the brake valve. Clean off the dirt and old sealant from the threads of the valves and elbows.

Installation (See Fig. 1)

WARNING: When applying sealant, make sure that excess sealant doesn't get inside either the male or the female fittings. Loose foreign material inside the air plumbing may clog a valve, causing a loss of brake control, which could result in personal injury.

1. If equipped with a hand brake valve, apply a small quantity of Loctite® Pipe Sealant (with Teflon® 59241), or an equivalent sealant, to the male threads of each of the double check valves and the elbows.

   Install the double check valves and elbows in the ports of the brake valve. Tighten each valve finger-tight, then tighten them one additional turn with a wrench. As needed, further tighten them until they are properly positioned.

2. Lubricate the sliding surface of the brake plunger with barium grease, part number BW 246671 or

Bendix E–6 Brake Valve Removal and Installation

Pennzoil Adhezoplex EP 2. Install the plunger in the mounting adaptor.

3. Using the 5/16–18 locknuts and washers, attach the mounting adaptor to the brake valve. Tighten the capscrews 10–13 lbf·ft (14–18 N·m).
4. Install the brake valve and mounting adaptor on the outside of the front cab mount plate. Install the adaptor mounting capscrews and flatwashers. Tighten the capscrews 10–13 lbf·ft (14–18 N·m).
5. Connect the air lines, as previously marked. Tighten the nuts finger-tight. Using a wrench, further tighten the nuts until there is resistance, then tighten one-sixth additional turn.
6. Check and secure the air lines and electrical wires so they can't interfere with the movement of the brake pedal.
7. Return the hood to the operating position. For instructions, refer to the vehicle driver's manual.
8. Perform the operating and leakage checks. For instructions, refer to **Subject 100.**
9. Remove the chocks from the tires.
10. Test drive the vehicle in a safe area at low speed. Make several brake applications to be sure the vehicle comes to a safe stop.

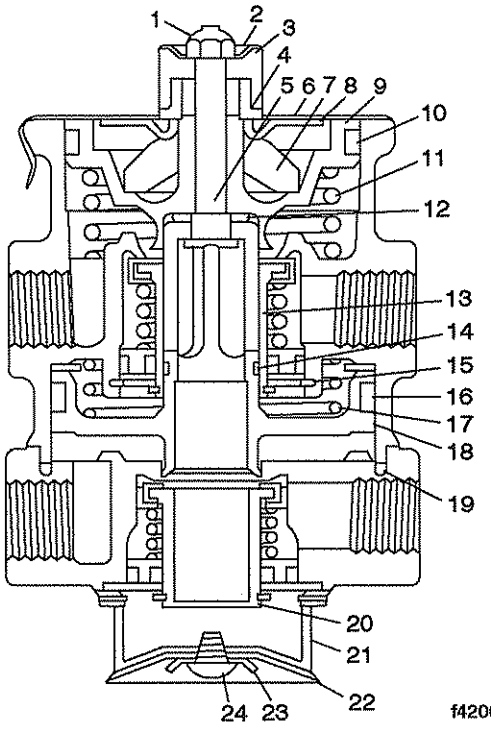
Bendix E–6 Brake Valve Disassembly, Cleaning and Inspecting, and Assembly

Disassembly (See Fig. 1)

1. Remove the valve from the vehicle. For instructions, refer to **Subject 110.**
2. Remove the screw (Ref. 24) that attaches the exhaust diaphragm (Ref. 22) and washer (Ref. 23) to the exhaust cover (Ref. 21).
3. Remove the four screws that attach the exhaust cover to the lower valve body.
4. Remove the lower inlet and exhaust valve assembly (Ref. 20).
5. Remove the four hexhead capscrews and washers that attach the lower and upper valve bodies. Separate the valve bodies.
6. Remove the rubber seal ring (Ref. 19) from the lower valve body.
7. Apply thumb pressure to the primary piston, then lift out and up on the three lock tabs of the primary piston retainer (Ref. 6).

WARNING: The locknut and spring seat are used to restrain the primary piston return spring, stem spring, and the relay piston spring. The combined force of these springs is about 50 pounds (220 N). When removing these springs, use care to prevent them from flying out and possibly causing personal injury. Manually or mechanically hold down these springs when removing the locknut.

8. Using a 3/8-inch wrench, hold the locknut (Ref. 1) on the threaded end of the primary piston stem (Ref. 5). Insert a screwdriver in the exhaust passage through the center of the valve, and engage the slotted head of the stem.
9. Using the screwdriver to keep the stem from turning, remove the locknut, spring seat (Ref. 2), and the stem spring (Ref. 3).
10. Being careful to avoid damaging the valve seats, remove the relay piston (Ref. 18), relay piston spring (Ref. 17), and the primary piston and primary piston return spring (Refs. 9 and 11).
11. Remove the small washer (Ref. 12) from the cavity in the lower side of the primary piston.
12. Turn the spring seat nut (Ref. 4) counterclockwise, and separate the spring seat nut, spring seat (Ref. 8), and the rubber spring (Ref. 7). Remove the primary piston O-ring (Ref. 10).



1. Locknut
2. Spring Seat
3. Stem Spring
4. Spring Seat Nut
5. Primary Piston Stem
6. Primary Piston Retainer
7. Rubber Spring
8. Spring Seat
9. Primary Piston
10. Primary Piston O-Ring
11. Primary Piston Return Spring
12. Small Washer
13. Upper Inlet and Exhaust Valve Assembly
14. Small O-Ring
15. Retaining Ring
16. Large O-Ring
17. Relay Piston Spring (if equipped)
18. Relay Piston
19. Rubber Seal Ring
20. Lower Inlet and Exhaust Valve Assembly
21. Exhaust Cover
22. Exhaust Diaphragm
23. Washer
24. Phillips Head Screw

Fig. 1, Bendix E-6 Dual Circuit Foot Valve (sectional view)

Bendix E–6 Brake Valve Disassembly, Cleaning and Inspecting, and Assembly

13. Remove the small and large O-rings (Refs. 14 and 16) from the relay piston (Ref. 18).
14. Remove the retaining ring (Ref. 15). Remove the upper inlet and exhaust valve assembly (Ref. 13).

Cleaning and Inspecting

Wash all metal parts in mineral spirits and dry them thoroughly with compressed air. Inspect the valve seat surfaces of the pistons and the valve housings for conditions that could cause leakage. Inspect air line fittings for corrosion, and replace corroded fittings.

Assembly (See Fig. 1)

NOTE: Keep the work area, tools, and brake valve parts clean during assembly.

1. Using Dow Corning 55-M pneumatic grease, or equivalent, lightly grease all the new O-rings, O-ring grooves, piston bores, and all sliding surfaces.
2. Place the upper inlet and exhaust assembly (Ref. 13) in the upper body, and secure the assembly with the retaining ring (Ref. 15). Make sure that the retaining ring is seated in its groove.
3. Install the large and small O-rings (Refs. 16 and 14) on the relay piston (Ref. 18).
4. Install the primary piston O-ring (Ref. 10) in the piston O-ring groove.
5. Install the rubber spring (Ref. 7), concave side down, in the primary piston (Ref. 9). Place the spring seat (Ref. 8), flat side up, over the rubber spring.
6. Install the spring seat nut (Ref. 4) and turn the nut clockwise until the top surface of the spring seat is even with the top surface of the piston. Set this assembly aside.
7. Place the relay piston spring (Ref. 17), if equipped, in the concave portion of the relay piston. Install the relay piston through the upper inlet and exhaust assembly (Ref. 13), and into the underside of the upper valve body.
8. Place a screwdriver (blade up) in a vise. Place the primary piston stem (Ref. 5) in the relay piston. Position the upper valve body over the screwdriver blade, with the blade engaged in the slotted head of the piston stem.
9. Place the small washer (Ref. 12) over the stem.
10. Install the primary piston return spring (Ref. 11) in the upper valve body piston bore.
11. Install the primary piston and rubber spring assembly (assembled previously) over the stem, and into the upper valve body piston bore.

WARNING: The locknut and spring seat are used to restrain the primary piston return spring, stem spring, and the relay piston spring. The combined force of these springs is about 50 pounds (222 N). When installing these springs, use care to prevent them from flying out and possibly causing personal injury. Manually or mechanically hold down these springs when installing the locknut.

12. Push down and hold the primary and relay pistons in the upper valve body.
13. Place the stem spring (Ref. 3) over the spring seat nut (Ref. 4). Place the spring seat over the stem.
14. Install the locknut (Ref. 1) on the stem. Tighten the locknut 20 to 30 lbf·in (220 to 340 N·cm).
15. Install the primary piston retainer (Ref. 6) over the piston. Make sure that all three lock tabs have engaged the outer lip of the valve body.
16. Install the rubber seal ring (Ref. 19) in the lower valve body.
17. Attach the lower and upper valve bodies. Install the four hexhead capscrews and washers. Tighten the capscrews 11 lbf·ft (15 N·m).
18. Install the lower inlet and exhaust valve assembly (Ref. 20).
19. Install the four screws that attach the exhaust cover to the lower valve body.
20. Install the screw that attaches the exhaust diaphragm and washer to the exhaust cover.
21. Install the brake valve. For instructions, refer to **Subject 110.**

Contents

Subject	Subject Number
General Information	050
Service Operations	
Safety Precautions	100
Brake Shoe Removal and Installation	110
Brake Shoe and Lining Inspection	120
Brake Adjustment	130
Brake Shoe Lining Replacement	140
Brake Components Disassembly and Inspection, Cleaning, and Assembly	150
Troubleshooting	300
Specifications	400

General Description

Meritor Cam-Master® brakes are air actuated, cam operated, foundation brakes. The main components in each brake assembly (wheel end) consists of:

- a camshaft-and-chamber bracket;
- a "S" head camshaft;
- a brake spider;
- two brake shoe and lining assemblies;
- a return spring;
- and, two anchor pins.

The "S" head camshaft is bushing mounted inside the camshaft-and-chamber bracket; and it transfers braking force from the slack adjuster to the brake shoe assemblies. Each brake shoe is mounted to the brake spider through an anchor pin; and it is controlled (moved) by either the outward braking force of the "S" head camshaft or the inward restoring force of the return spring. The brake spider is fastened to the axle flange and the camshaft-and-chamber bracket is mounted to the brake spider.

The steer axles are available with "Q" Plus brakes. See **Fig. 1**. Either 16-1/2 inch (419 mm) by 5 inch (127 mm) or 16-1/2 inch (419 mm) by 6 inch (152 mm) fabricated double web brake shoes are used with the "Q" Plus brakes.

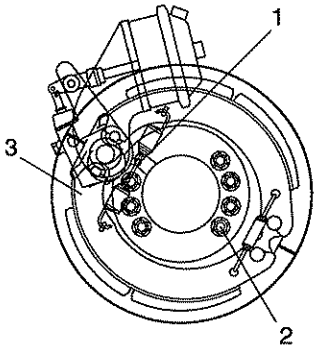
The "Q" Plus brake shoes are designed with open anchor pin ends. Two retainer springs couple the brake shoes (anchor pin ends) to the anchor pins. Then, the anchor pins are coupled to the brake spider. This design makes "quick change" brake service possible.

Meritor steer axles have seven holes for attaching the spider to the axle flange. There is an eighth hole in the axle flange, which holds an ABS wheel speed sensor bushing, on both left and right sides of the steer axle. See **Fig. 2**. The seven holes used for attachment of the spider to the axle flange are 0.656 inch in diameter. The eighth hole is oversized at 0.687 inch in diameter. Depending on what side the axle flange is viewed from, the eighth hole is either in the 10 o'clock or 2 o'clock position.

The rear axles are available with either "Q" Plus or "P" Series brakes. See **Fig. 3**. 16-1/2 inch (419 mm) by 7 inch (171 mm) heavy-duty fabricated double web brake shoes are used with the "Q" Plus brakes and 16-1/2 (419 mm) inch by 7 inch (171 mm) cast double web brake shoes are used with the "P" Series brakes.

Unlike the "Q" Plus brake shoes, the "P" Series brake shoes are designed with closed anchor pin ends. The anchor pins couple the brake shoes (the anchor pin ends) to the brake spider.

"Q" Plus LX500 and MX500 brakes are extended maintenance brakes. These brakes can be identified by an identification tag affixed to the brake shoe.



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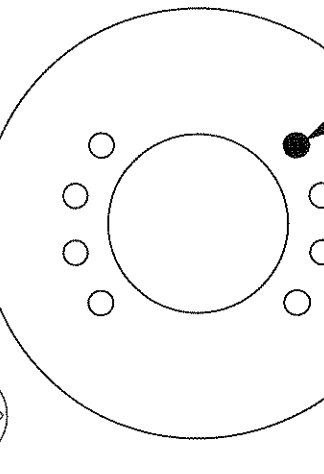
1. ABS Sensor Bushing
2. Brake Spider Fastener
3. Brake Shoe Assembly

Fig. 1, Front Axle "Q" Plus Brake



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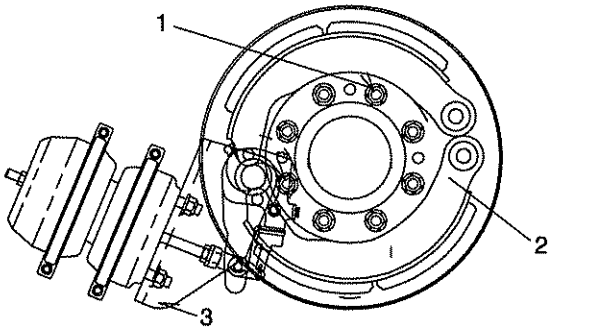
A. Open (10 o'clock or 2 o'clock)

Fig. 2, Open Hole Location

General Information



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1. Brake Spider Fastener
2. Brake Shoe Assembly
3. Camshaft-and-Chamber Bracket

Fig. 3, Rear Axle "P" Series Brake

An additional identification tag is affixed to the brake camshaft-and-chamber bracket (on top of the plugged grease hole).

Principles of Operation

When the brake pedal is depressed, compressed air enters the brake chamber, causing the diaphragm to move a push rod assembly.

The push rod, which is connected to a slack adjuster, turns the slack adjuster and brake camshaft. As the camshaft turns, the S-type cam head, which is between the brake shoe rollers, forces the brake shoes against the brake drum, and braking occurs.

When the brakes are released and air is exhausted from the brake chamber, the actuator return spring (within the brake chamber) and the brake shoe return spring, return the camshaft, brake shoes, slack adjuster, and the push rod to their released positions.

⚠ WARNING

Breathing brake lining dust (asbestos or non-asbestos) could cause lung cancer or lung disease. OSHA has set maximum levels of exposure and requires workers to wear an air purifying respirator approved by MSHA or NIOSH. Wear a respirator at all times when servicing the brakes, starting with the removal of the wheels and continuing through assembly.

Safety Precautions

Because some brake linings contain asbestos, you should know the potential hazards of asbestos and the precautions to be taken. Exposure to airborne asbestos brake lining dust can cause serious and possibly fatal diseases such as asbestosis (a chronic lung disease) and cancer. Because medical experts believe that long-term exposure to some *non-asbestos* fibers could also be a health hazard, the following precautions should also be observed if servicing non-asbestos brake linings.

Areas where brake work is done, should be separate from other operations if possible. The entrance to the areas should have a sign displayed indicating the health hazard as required by OHSA regulations.

During brake servicing, an air purifying respirator with high-efficiency filters must be worn. The respirator and filter must be approved by MSHA or NIOSH, and worn during all procedures.

OSHA recommends that enclosed cylinders equipped with vacuums and high-efficiency (HEPA) filters be used during brake repairs. Under this system, the entire brake assembly is placed within the cylinder and the mechanic works on the brake through sleeves attached to the cylinder. Compressed air is blown into the cylinder to clean the assembly, and the dirty air is then removed from the cylinder by the vacuum.

If such an enclosed system isn't available, the brake assembly must be cleaned in the open air. During disassembly, carefully place all parts on the floor to minimize creating airborne dust. Using an industrial vacuum cleaner with a HEPA filter system, remove dust from the brake drums, brake backing plates, and brake parts. After vacuuming, any remaining dust should be removed using a rag soaked in water and wrung until nearly dry. Don't use compressed air or dry brushing to clean the brake assembly.

If grinding or other machining of the brake linings is necessary, other precautions must be taken because exposure to asbestos dust is highest during such operations. In addition, to the use of an approved respirator, there must be local exhaust ventilation such that worker exposures are kept as low as possible.

Work areas should be cleaned by industrial vacuums with HEPA filters or by wet wiping. Compressed air or dry sweeping should never be used for cleaning. Asbestos-containing waste, such as dirty rags, should be sealed, labeled and disposed of as required by EPA and OSHA regulations. Respirators should be used when emptying vacuum cleaners and handling asbestos waste products.

Workers should wash before eating, drinking, or smoking, should shower after work, and should not wear work clothes home. Work clothes should be vacuumed after use and then laundered, without shaking, to prevent the release of asbestos fibers into the air.

⚠ WARNING

Before starting the procedure below, read the safety precaution information in Subject 100. Failure to be aware of the dangers of brake lining dust exposure could result in serious and permanent health damage.

IMPORTANT: When replacing the brake linings, use a dial indicator to measure the cam-to-bushing radial free play (the up-and-down and side-to-side free play of the camshaft) and the camshaft axial end play (the in-and-out end play of the camshaft).

Replace the bushings if the cam-to-bushing radial free play exceeds:

- for all Cam-Master brakes except "Q" Plus (LX500 and MX500), 0.030 inch (0.8 mm) of movement;
- for "Q" Plus (LX500 and MX500), 0.020 inch (0.5 mm) of movement.

Remove the snap ring from the end of the slack adjuster and add shims between the slack adjuster and the snap ring if the axial end play exceeds:

- for all Cam-Master brakes except "Q" Plus (LX500 and MX500), 0.060 inch (1.5 mm) of movement;
- for "Q" Plus (LX500 and MX500), 0.005 to 0.030 inch (0.13 to 0.80 mm) of movement.

For more instructions, see **Subject 150**.

"P" Series Brake Shoe Removal and Installation

REMOVAL

1. Park the vehicle on a level surface, apply the parking brakes, and chock the tires.
2. Raise the front or rear axle, then place safety stands under the frame or axle. Be sure the stands will support the weight of the vehicle.

⚠ WARNING

When work is being done on a spring chamber, carefully follow the service instructions of the chamber manufacturer. The sudden release of a compressed spring can cause serious personal injury.

3. If the brakes have spring chambers, carefully cage and lock the springs so that the springs cannot actuate during disassembly.

⚠ CAUTION

For a Meritor automatic slack adjuster, before turning the manual adjusting nut in the clockwise direction to back off the slack adjuster, disengage the pull-pawl by raising it up about 1/32 inch (0.8 mm). Failure to do so could damage the pull-pawl teeth. The brake clearance will not automatically adjust if the pull-pawl is damaged. For more instructions, see Subject 130.

NOTE: For a Haldex or a Gunite automatic slack adjuster, there is an internal clutch that resists the manual adjusting nut from being turned in the counterclockwise direction (de-adjust direction). When turning the manual adjusting nut in the counterclockwise direction to back off the slack adjuster, a torque of approximately 30 lbf·ft (41 N·m) will need to be applied to overcome the resistance of the internal clutch.

4. For each wheel end, back off the automatic slack adjuster by turning its manual adjusting nut until the brake shoes retract and the drum will clear the linings.
5. Remove the wheels and brake drums. For instructions, see **Group 33** or **Group 35** in this manual.
6. Remove the brake shoes.

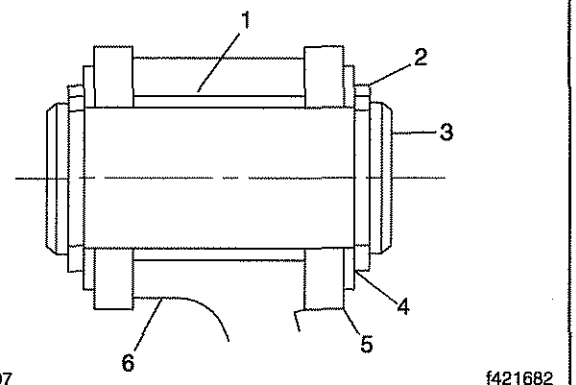
   6.1 Remove the anchor pin snap rings and washers from the anchor pins. See **Fig. 1**.

⚠ WARNING

Wear eye protection when using a drift. Do not hit steel parts with a steel hammer. To do so could cause steel pieces to break off and cause serious eye injury.

   6.2 Remove the top anchor pin with a brass drift. See **Fig. 2**.

Brake Shoe Removal and Installation



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1. Bushing
2. Snap Ring
3. Anchor Pin
4. Washer
5. Brake Shoe
6. Brake Spider

Fig. 1, Anchor Pin Assembly

6.3 Rotate the top brake shoe to release the tension on the return spring. Then, remove the brake shoe. See **Fig. 3**.

⚠ WARNING

Wear eye protection when using a drift. Do not hit steel parts with a steel hammer. To do so could cause steel pieces to break off and cause serious eye injury.

6.4 Remove the bottom anchor pin with a brass drift. See **Fig. 4**. Then, remove the bottom brake shoe.

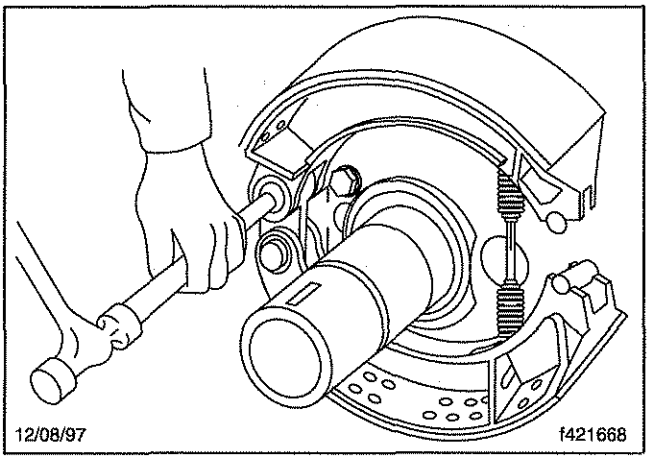

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Fig. 2, Remove/Install the Anchor Pin

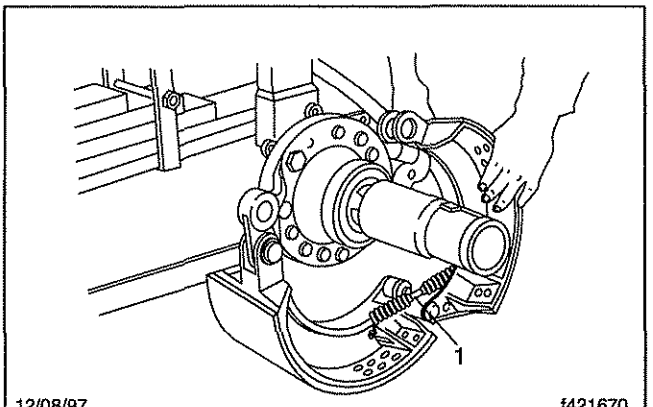
6.5 If necessary, remove the cam rollers from the brake shoes. See **Fig. 5**.

7. Inspect the brake shoes and linings for wear or damage. For instructions, see **Subject 120**.

8. Inspect the anchor pin bushings for wear. The inner surface must be smooth. Inspect the brake spider. For inspection instructions, see **Subject 150**.

⚠ WARNING

Wear eye protection when using a drift. Do not hit steel parts with a steel hammer. To do so could cause steel pieces to break off and cause serious eye injury.



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1. Brake Return Spring

Fig. 3, Remove/Install the Top Brake Shoe

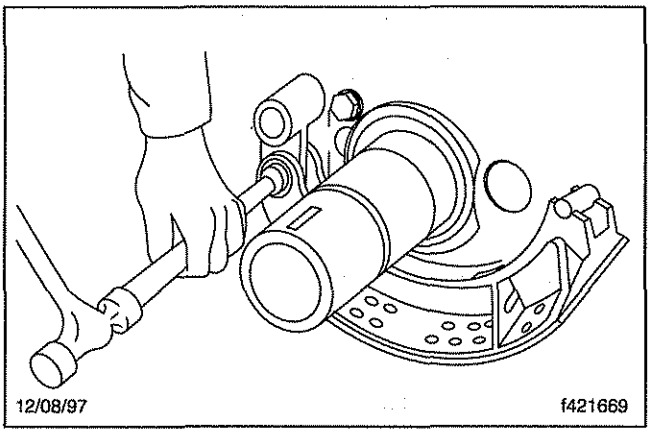

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Fig. 4, Remove/Install Lower Brake Shoe

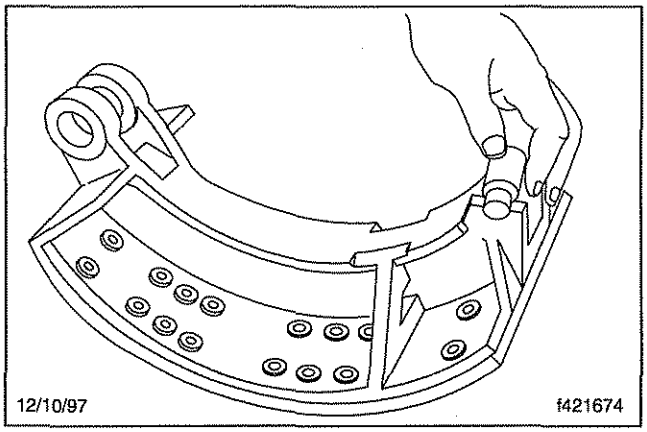


Fig. 5, Remove the Cam Rollers

9. If necessary and with an appropriate brass drift, remove the worn anchor pin bushings from the brake spider.

IMPORTANT: If the linings are being replaced, disassemble and inspect the camshaft-and-chamber bracket. For instructions, see **Subject 150**.

INSTALLATION

⚠ WARNING

Wear eye protection when using a drift. Do not hit steel parts with a steel hammer. To do so could cause steel pieces to break off and cause serious eye injury.

1. If necessary and with an appropriate brass drift, install new anchor pin bushings. Align the holes in the bushings with the holes in the brake spider.
2. Install the brake shoes.

   NOTE: When lubricating the cam rollers, do not get grease on the part of the roller that touches the cam head.

   2.1 With an NLGI grade 1 or 2 multi-purpose chassis or temperature resistant grease (Meritor [formerly Rockwell] O-616A, O-617-A, O-617B, O-645, or O-692), lubricate the cam rollers where they touch the brake shoes. Then, attach the cam rollers to the brake shoes.

   2.2 With an NLGI grade 1 or 2 multi-purpose chassis or temperature resistant grease (Meritor O-616A, O-617-A, O-617B, O-645, or O-692), lubricate the anchor pins where they touch the brake shoes.

   2.3 Put the lower brake shoe in position on the brake spider.

⚠ WARNING

Wear eye protection when using a drift. Do not hit steel parts with a steel hammer. To do so could cause steel pieces to break off and cause serious eye injury.

   2.4 Using a brass drift, install the lower brake shoe anchor pin. If necessary, align the flat or groove on the anchor pin with the holes in the brake spider and bushing. See **Fig. 4**.

   2.5 Install the washer and snap ring on the lower brake shoe anchor pin. See **Fig. 1**.

   2.6 Install a new brake shoe return spring on the brake shoes. Then, move the upper brake shoe in position over the brake spider. See **Fig. 3**.

   2.7 Using a brass drift, install the upper brake shoe anchor pin. If necessary, align the flat or groove on the anchor pin with the holes in the brake spider and bushing. See **Fig. 2**.

   2.8 Install the washer and snap ring on the lower brake shoe anchor pin. See **Fig. 1**.

3. Install the brake drums and wheels. For instructions, see **Group 33** or **Group 35** in this manual.
4. Adjust the brakes at the slack adjusters. For instructions, see **Subject 130**.
5. Remove the safety stands, lower the vehicle, and remove the chocks from the tires.

⚠ WARNING

When work is being done on a spring chamber, carefully follow the service instructions of the chamber manufacturer. The sudden release of a compressed spring can cause serious personal injury.

Brake Shoe Removal and Installation

6. If the brake has spring chambers, carefully release the springs.

⚠ DANGER

Don't operate the vehicle until the brakes have been adjusted and checked for proper operation. To do so could result in inadequate or no braking ability, which could cause personal injury or death, and property damage.

7. Before you put the vehicle in service, in a safe area, check for proper brake operation.

   7.1 Apply and release the brakes several times to check for air leaks and proper operation of the slack adjusters.

   7.2 Do several low speed stops to ensure proper parts replacement and full vehicle control.

   7.3 Make ten 40 to 20 mph (60 to 30 km/h) snubs to seat the linings.

   7.4 Make ten stops from 20 mph (30 km/h) at 50 percent air pressure.

   7.5 Make a full-pressure stop from 20 mph (30 km/h).

   7.6 Immediately after doing the above stops, check the drum temperatures. Any drums that are significantly cooler than others show lack of braking effort on those wheels.

"Q" Plus Brake Shoe Removal and Installation

REMOVAL

1. Park the vehicle on a level surface, apply the parking brakes, and chock the tires.
2. Raise the front or rear axle, then place safety stands under the frame or axle. Be sure the stands will support the weight of the vehicle.

⚠ WARNING

When work is being done on the spring chamber, carefully follow the service instructions of the chamber manufacturer. The sudden release of a compressed spring can cause serious personal injury.

3. If the brake has spring chambers, carefully cage and lock the springs so that the springs cannot actuate during disassembly.

⚠ CAUTION

For a Meritor automatic slack adjuster, before turning the manual adjusting nut in the clockwise direction to back off the slack adjuster, disengage the pull-pawl by raising it up about 1/32 inch (0.8 mm). Failure to do so could damage the pull-pawl teeth. The brake clearance will not automatically adjust if the pull-pawl is damaged. For more instructions, see Subject 130.

NOTE: For a Haldex or a Gunite automatic slack adjuster, there is an internal clutch that resists the manual adjusting nut from being turned in the counterclockwise direction (de-adjust direction). When turning the manual adjusting nut in the counterclockwise direction to back off the slack adjuster, a torque of approximately 30 lbf·ft (41 N·m) will need to be applied to overcome the resistance of the internal clutch.

4. For each wheel end, back off the automatic slack adjuster by turning its manual adjusting nut until the brake shoes retract and the drum will clear the linings.
5. Remove the wheels and brake drums. For instructions, see **Group 33** or **Group 35** in this manual.
6. Remove the brake shoes.

   6.1 Push down on the bottom brake shoe, then pull on the roller retaining clip to remove the bottom cam roller. See **Fig. 6**.

   6.2 Lift the top brake shoe and pull on the roller retaining clip to remove the top cam roller.

   6.3 Lift the bottom shoe to release tension on the brake return spring. Remove the spring. See **Fig. 7**.

   6.4 Rotate the bottom shoe to release tension on the two retaining springs. Remove the springs and brake shoes. See **Fig. 8**.

7. Inspect the brake shoes and linings for wear or damage. For instructions, see **Subject 120.**

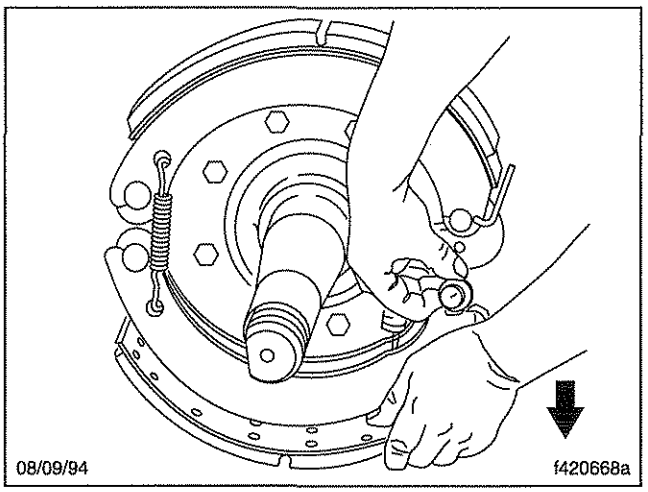


Fig. 6, Remove the Bottom Cam Roller

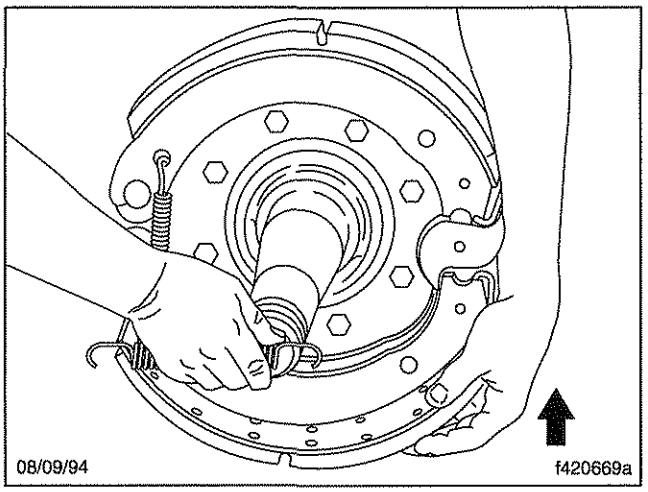


Fig. 7, Remove the Spring

IMPORTANT: If the linings are being replaced, disassemble and inspect the camshaft-and-chamber bracket. For instructions, see **Subject 150**.

INSTALLATION

IMPORTANT: For best brake performance, don't mix "Q" Plus brakes with other brakes.

1. Install the brake shoes.

   NOTE: When lubricating the cam rollers, do not get grease on the part of the roller that touches the cam head.

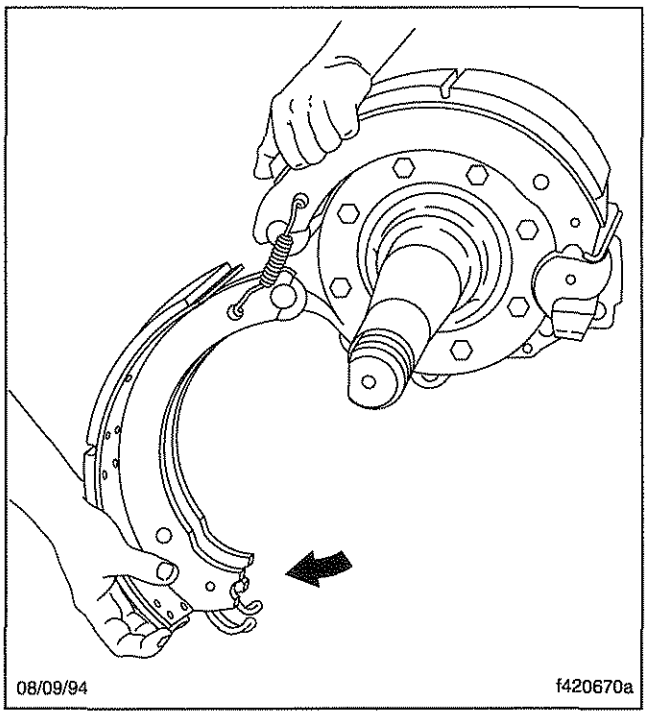


Fig. 8, Remove the Brake Shoes

1.1 With an NLGI grade 1 or 2 multi-purpose chassis or temperature resistant grease (Meritor [formerly Rockwell] O-616A, O-617-A, O-617B, O-645, or O-692), Lubricate the cam rollers where they touch the brake shoes.

1.2 With an NLGI grade 1 or 2 multi-purpose chassis or temperature resistant grease (Meritor O-617-A, O-617B, O-645, or O-692), lubricate the anchor pins where they touch the brake shoes.

1.3 Place the upper brake shoe in position on the top anchor pin. Hold the lower brake shoe on the bottom anchor pin and attach two new brake shoe retaining springs. See **Fig. 9**.

1.4 Turn the lower brake shoe forward and install a new brake shoe return spring. Install the open end of the spring hooks toward the camshaft. See **Fig. 10**.

1.5 Pull each brake shoe away from the cam to allow enough space to install the cam rollers and retainers. Squeeze the ears of

Brake Shoe Removal and Installation

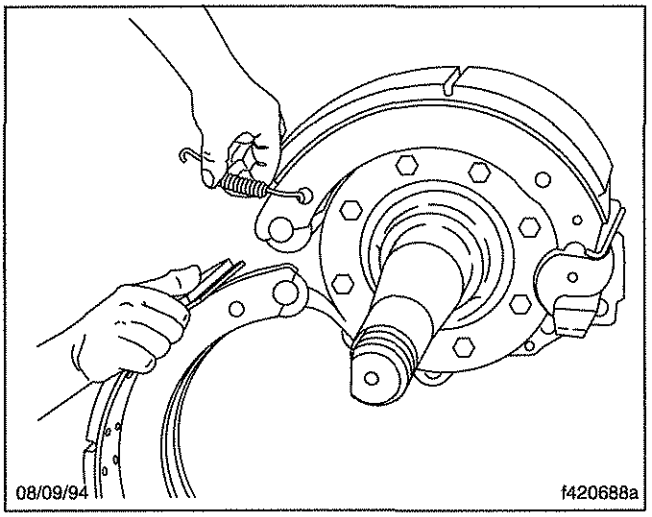


Fig. 9, Attach the Retaining Springs

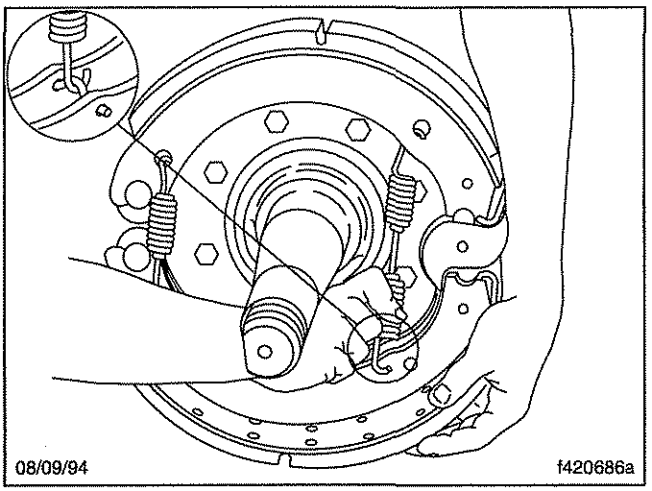


Fig. 10, Attach the Return Spring

the retainer together to permit the retainer to fit between the brake shoe webs. See **Fig. 11**.

1.6 Push the retainer into the brake shoe until the ears lock in the holes in the shoe webs. See **Fig. 12**.

2. Install the wheels and brake drums. For instructions, see **Group 33** or **Group 35** in this manual.
3. Adjust the brakes at the slack adjusters. For instructions, see **Subject 130**.
4. Remove the safety stands, lower the vehicle, and remove the chocks from the tires.

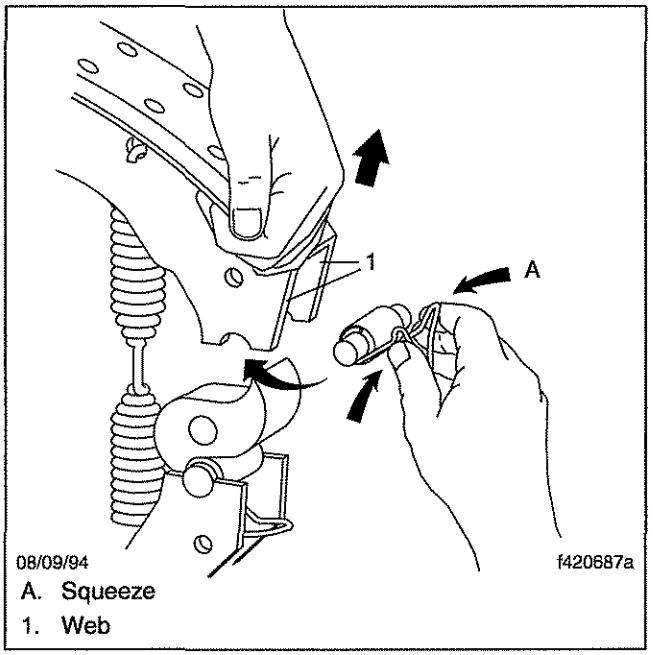


Fig. 11, Squeeze the Retainer

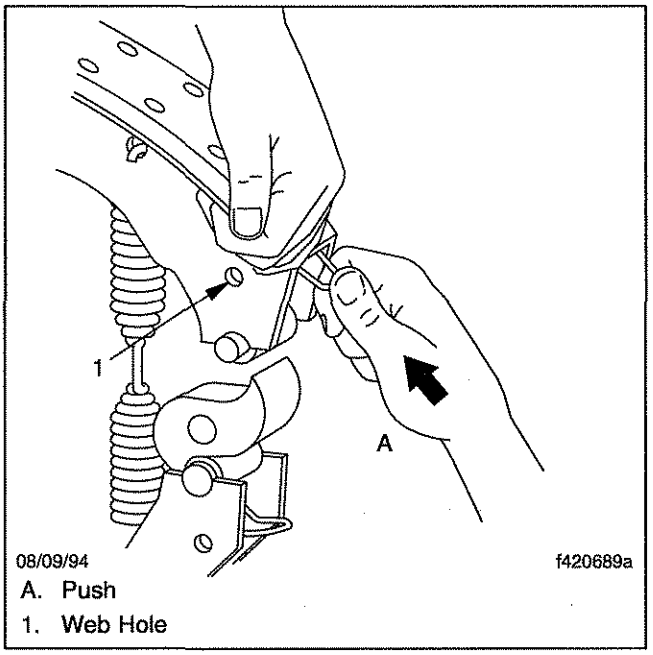


Fig. 12, Push the Retainer

⚠ WARNING

When work is being done on a spring chamber, carefully follow the service instructions of the chamber manufacturer. The sudden release of a compressed spring can cause serious personal injury.

5. If the brakes have spring chambers, carefully release the springs.

⚠ DANGER

Don't operate the vehicle until the brakes have been adjusted and checked for proper operation. To do so could result in inadequate or no braking ability, which could cause personal injury or death, and property damage.

6. Before you put the vehicle in service, in a safe area, check for proper brake operation.

   6.1 Apply and release the brakes several times to check for air leaks and proper operation of the slack adjusters.

   6.2 Do several low speed stops to ensure proper parts replacement and full vehicle control.

   6.3 Make ten 40 to 20 mph (60 to 30 km/h) snubs to seat the linings.

   6.4 Make ten stops from 20 mph (30 km/h) at 50 percent air pressure.

   6.5 Make a full-pressure stop from 20 mph (30 km/h).

   6.6 Immediately after doing the above stops, check the drum temperatures. Any drums that are significantly cooler than others shows a lack of braking effort on those wheels.

⚠ WARNING

Before starting the procedure below, read the safety precaution information in Subject 100. Failure to be aware of the dangers of brake lining dust exposure could result in serious and permanent health damage.

Inspection

1. Remove the brake shoes using the instructions in **Subject 110**.
2. Check the linings.

   2.1 If the linings are grease-or oil-soaked, cracked, or worn to less than 1/4-inch (6.4 mm) thickness at any point, replace them.

⚠ CAUTION

Do not let the brake linings wear to the point were the rivets or bolts touch the drums. Damage to the drums will occur if the linings are allowed to wear to the point.

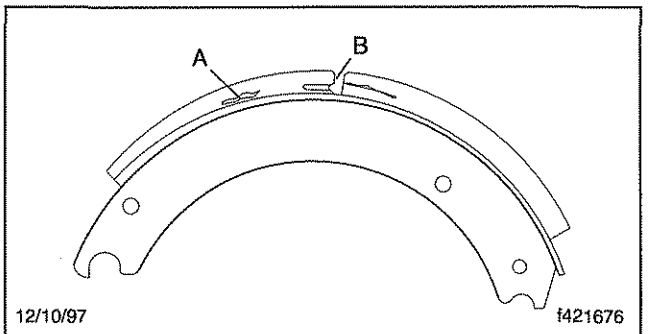
2.2 Replace the linings if the lining surface is closer than 1/32 inch (0.8 mm) to any rivet head.

If bolts are installed, the linings should not be allowed to wear to the point where rivets or bolts may contact the brake drums.

2.3 The lining is considered worn-out and the vehicle should not be driven if:

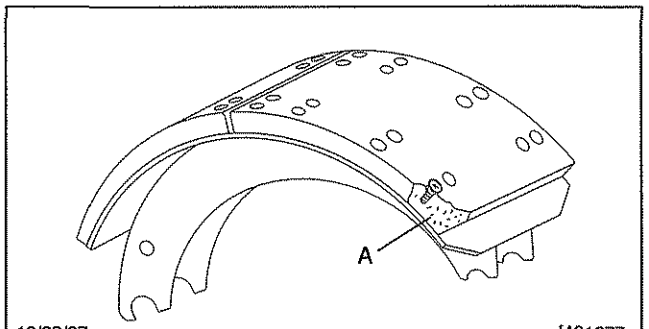
- Cracks on the lining surface exceed 1/16 inch (1.6 mm);
- The lining edge shows cracks or voids over 1/16 inch (1.6 mm) in width and 1-1/2 inches (38 mm) in length. See **Fig. 1**;
- Portions of the lining are missing exposing a rivet when viewed from the edge. See **Fig. 2**;
- Cracks extend across the lining face and through the lining edge, or the lining is loose on the shoe. See **Fig. 3**.

2.4 The vehicle is still operational but the linings should be replaced as soon as possible if:



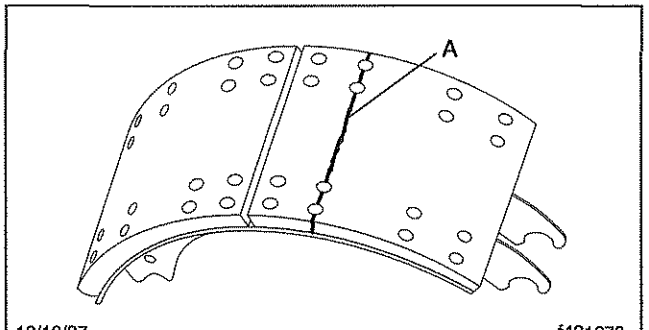
A. Cracks exceeding 1-1/2 inches (38 mm) in length.
B. Cracks or voids exceeding 1/16 inch (1.6 mm) in width.

Fig. 1, Cracks and Voids



A. Exposed fastening device.

Fig. 2, Portions of Brake Lining Missing



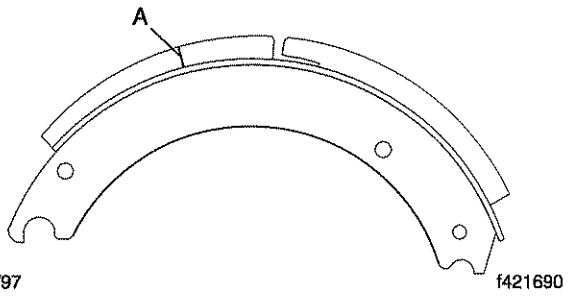
A. Cracks extending through the lining edge.

Fig. 3, Cracks in the Brake Lining

Brake Shoe and Lining Inspection

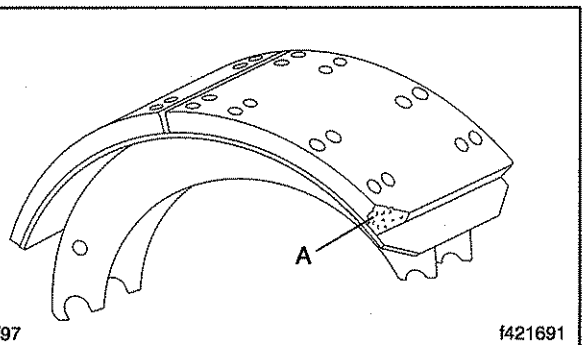
- Horizontal or vertical cracks in the lining edge exhibit no loss of material and do not exceed 1/16 inch (1.6 mm) in width or 1-1/2 inches (38 mm) in length. See **Fig. 4**;
- Corner portions of the lining are missing with no fastener exposed. See **Fig. 5**;
- Surface cracks extend from hole to hole or if there is scoring and contamination from road debris. See **Fig. 6**.

3. Check the brake shoes for bent or cracked webs or tables, rust, broken welds, expanded or out-of-round rivet or bolt holes, and correct alignment. Replace the shoes if any of these conditions exist.



A. Cracks not exceeding 1-1/2 inches (38 mm) in length or 1/16 inch (1.6 mm) in width.

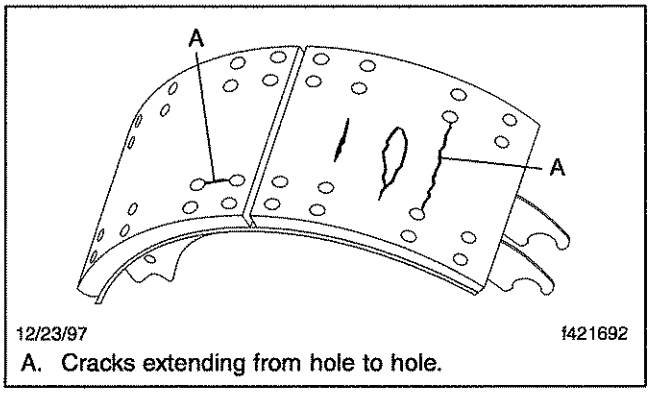
Fig. 4, Cracks and Voids



A. Corner segment missing with no fastener exposed.

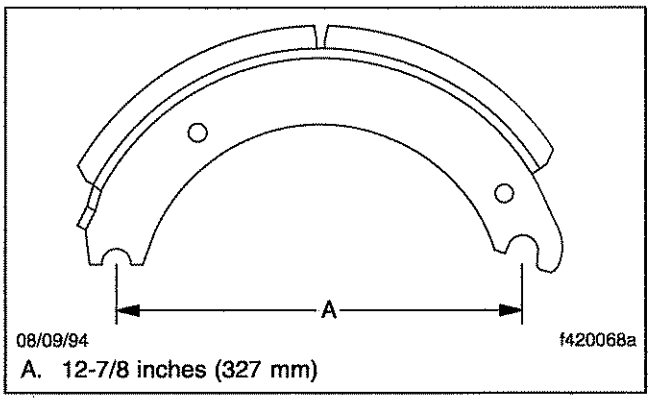
Fig. 5, Portions of the Brake Lining Missing

4. Check the brake shoes for visible wear (looseness) at the anchor pin holes and the camshaft roller recesses. Replace the shoe if needed.
5. Check the diameter of the anchor pin holes. The anchor pin holes must not exceed 1.009 inch (25.6 mm). Check the distance from the center of the anchor pin hole to the center of the cam roller hole (the shoe span). The shoe span must not exceed 12-7/8 inches (327 mm). Replace the shoe if needed. See **Fig. 7**.



A. Cracks extending from hole to hole.

Fig. 6, Crack in the Brake Lining



A. 12-7/8 inches (327 mm)

Fig. 7, Measuring the Shoe Span

Adjustment

ROCKWELL AUTOMATIC SLACK ADJUSTER

1. Check the free-stroke.

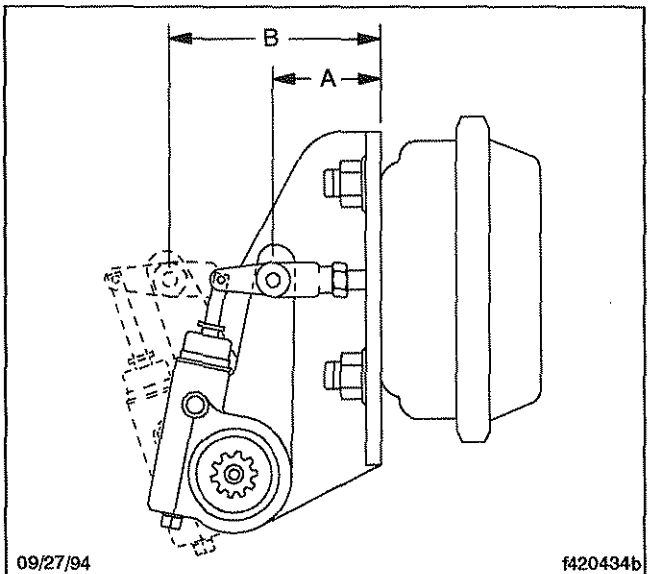
   1.1 With the brakes fully released, measure the distance from the bottom of the brake chamber to the center of the large clevis pin. **See Fig. 1**, Ref. A.

   1.2 Use a pry bar to move the slack adjuster and apply the brakes. Again, measure the distance from the bottom of the brake chamber to the center of the large clevis pin. **See Fig. 1**, Ref. B.

   1.3 The difference between the two measurements is the initial free-stroke, and sets the clearance between the linings and the drum.

   1.4 The free-stroke must be 5/8 to 3/4 inch (16 to 19 mm);

   If the free-stroke is correct, go to the next step.



NOTE: Subtract measurement A from B.

A. Measurement with the brakes released.
B. Measurement with the brakes applied.

Fig. 1, Measuring Initial Free-Stroke

   1.5 If the free-stroke is incorrect, remove the pressure relief capscrew (**Fig. 2**, Ref. 16), spring (Ref. 18), and pawl assembly (Ref. 19) from the slack adjuster housing. If equipped with a pull-pawl assembly **(Fig. 3),** carefully insert a screwdriver and raise the relief cap about 1/8 inch (3.2 mm).

CAUTION: Before turning the adjusting nut, remove the pressure relief capscrew, spring, and pawl assembly. If equipped with a pull-pawl assembly, raise the relief cap about 1/8 inch (3.2 mm). Failure to do so could strip the teeth on the pawl.

   1.6 Turn the adjusting nut 1/8 turn, as shown in **Fig. 4.** Measure the stroke again, and adjust until it is correct.

2. Check for correct brake chamber stroke.

   2.1 With the brakes fully released, measure the distance from the bottom of the brake chamber to the center of the large clevis pin. **See Fig. 1**, Ref. A.

   2.2 Build air pressure to 100 psi (689 kPa). Shut down the engine. Fully apply the brakes, then measure the distance from the bottom of the brake chamber to the center of the large clevis pin. **See Fig. 1**, Ref. B. The difference between the measurements is the brake chamber stroke.

   2.3 The brake chamber stroke must be less than the measurements shown in **Table 1.** If the brake chamber stroke is incorrect, remove the pressure relief capscrew (**Fig. 2**, Ref. 16), spring (Ref. 18), and pawl assembly (Ref. 19) from the slack adjuster housing. If equipped with a pull-pawl assembly **(Fig. 3),** carefully insert a screwdriver and raise the relief cap about 1/8 inch (3.2 mm).

CAUTION: Before turning the adjusting nut, remove the pressure relief capscrew, spring, and pawl assembly. If equipped with a pull-pawl assembly, raise the relief cap about 1/8 inch (3.2 mm). Failure to do so could strip the teeth on the pawl.

Brake Adjustment

2.4 Turn the adjusting nut 1/8 turn, as shown in **Fig. 4.** Measure the stroke again, and adjust until correct.

If necessary, replace the slack adjuster. For instructions, refer to the applicable slack adjuster section in this group.

CAUTION: Don't make the adjusted chamber stroke too short. The free-stroke must not be less than 5/8 to 3/4 inch (16 to 19 mm). If the chamber stroke is too short, the linings can drag and damage the brake.

If the stroke varies or remains greater than the specified range, check the brake components. For instructions, refer to **Subject 140.**

2.5 If removed, install the pawl assembly, spring, and the pressure relief capscrew. Tighten the capscrew 15 to 20 lbf·ft (20 to 27 N·m). Or, remove the screwdriver from the pull-pawl assembly (if equipped).

Brake Adjustment

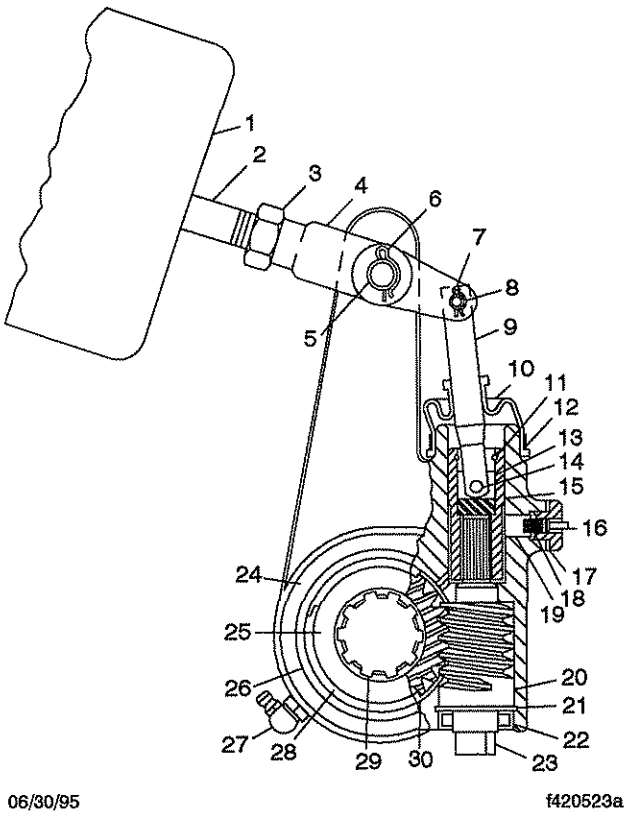
2.4 Turn the adjusting nut 1/8 turn, as shown in **Fig. 4.** Measure the stroke again, and adjust until correct.

If necessary, replace the slack adjuster. For instructions, refer to the applicable slack adjuster section in this group.

CAUTION: Don't make the adjusted chamber stroke too short. The free-stroke must not be less than 5/8 to 3/4 inch (16 to 19 mm). If the chamber stroke is too short, the linings can drag and damage the brake.

If the stroke varies or remains greater than the specified range, check the brake components. For instructions, refer to **Subject 140.**

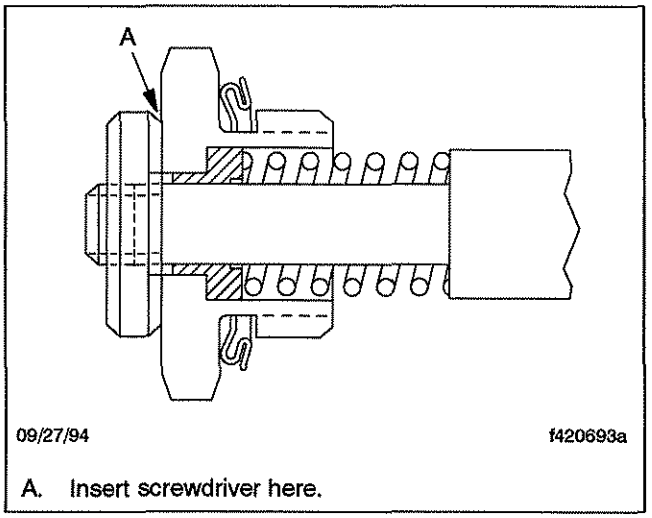
2.5 If removed, install the pawl assembly, spring, and the pressure relief capscrew. Tighten the capscrew 15 to 20 lbf·ft (20 to 27 N·m). Or, remove the screwdriver from the pull-pawl assembly (if equipped).



1. Brake Air Chamber
2. Brake Chamber Push Rod
3. Clevis Jam Nut
4. Clevis
5. Clevis Pin (large)
6. Cotter Pin (large)
7. Cotter Pin (small)
8. Clevis Pin (small)
9. Actuator Rod
10. Boot
11. Piston Retaining Ring
12. Boot Retaining Clamp
13. Actuator Piston
14. Roller (Pin)
15. Actuator (Adjusting Screw)
16. Pressure Relief Capscrew (shown 90 degrees out of position)
17. Gasket
18. Pawl Spring
19. Pawl Assembly
20. Worm
21. Worm Retaining Snap Ring
22. Worm Seal
23. Manual (Worm) Adjusting Nut End
24. Slack Adjuster
25. Gear
26. Gear Thrustwasher
27. Grease Fitting
28. Gear Retaining Ring
29. Camshaft Splines
30. Gear-to-Body Seal

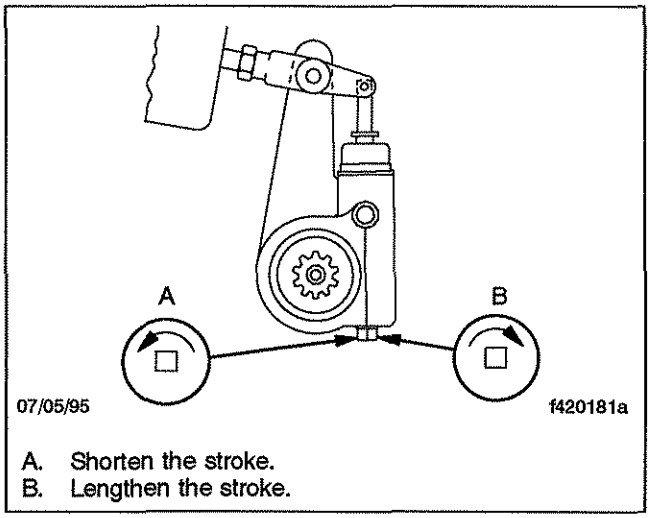
Fig. 2, Rockwell Automatic Slack Adjuster

Brake Adjustment



A. Insert screwdriver here.

Fig. 3, Pull-Pawl Assembly (sectional view)



A. Shorten the stroke.
B. Lengthen the stroke.

Fig. 4, Turn the Adjusting Nut

Chamber Size	Stroke Inch (mm)
9, 12	Less than 1-3/8 (35)
16, 20, 24	Less than 1-3/4 (44)
24*, 30	Less than 2 (51)
36	Less than 2-1/4 (57)

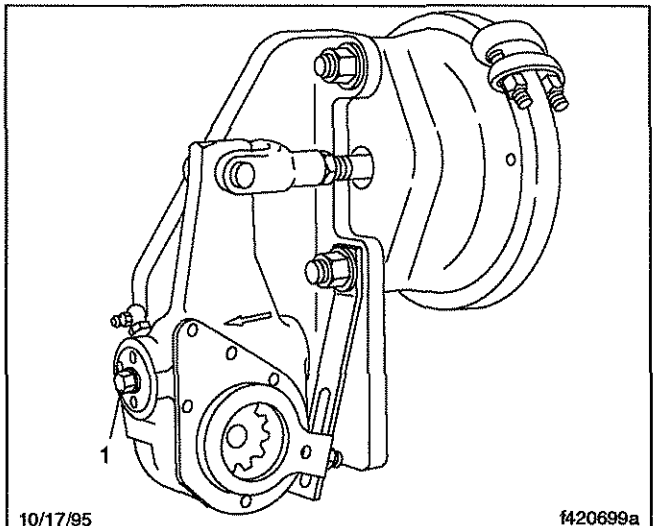
* Long Stroke

Table 1, Maximum Adjusted Brake Chamber Stroke

HALDEX AUTOMATIC SLACK ADJUSTER

1. Turn the adjusting hexnut clockwise until the brake lining meets the brake drum, then back off counterclockwise 3/4 turn. **See Fig. 5.** There will be a ratcheting sound.
2. Measure the distance from the bottom of the air chamber to the far side of the clevis-pin hole (**Fig. 6**, Ref. A). Record the exact distance as measurement A. Apply and hold an 80 psi (551 kPa) brake application. Measure the distance from the bottom of the brake chamber to the far side of the clevis-pin hole (**Fig. 6**, Ref. B). Record the exact distance as measurement B. Subtract measurement A from measurement B to determine the applied stroke. Compare this value to the value in **Table 2.**

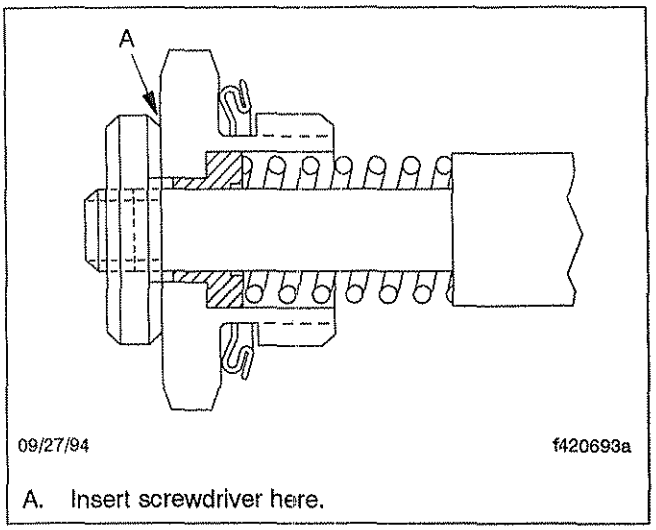
   If the stroke varies or remains greater than the specified range, check the brake components. For instructions, refer to **Subject 140.** If necessary, replace the slack adjuster. For instructions, refer to the applicable slack adjuster section in this manual.



1. Adjusting Hexnut

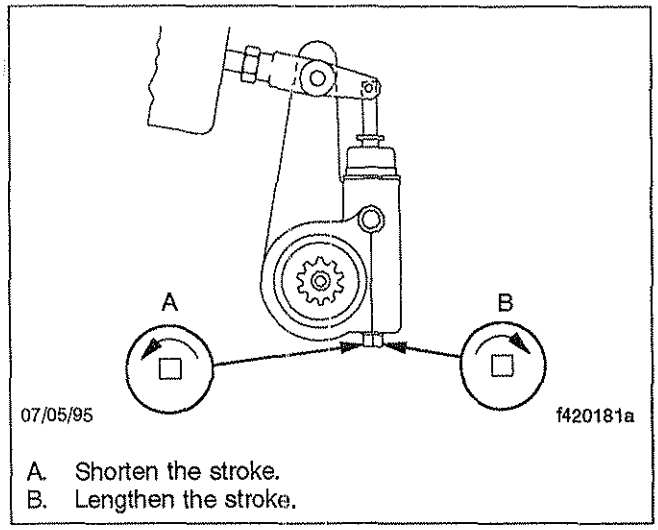
Fig. 5, Turn the Adjusting Hexnut

Brake Adjustment



A. Insert screwdriver here.

Fig. 3, Pull-Pawl Assembly (sectional view)



A. Shorten the stroke.
B. Lengthen the stroke.

Fig. 4, Turn the Adjusting Nut

Chamber Size	Stroke inch (mm)
9, 12	Less than 1-3/8 (35)
16, 20, 24	Less than 1-3/4 (44)
24*, 30	Less than 2 (51)
36	Less than 2-1/4 (57)

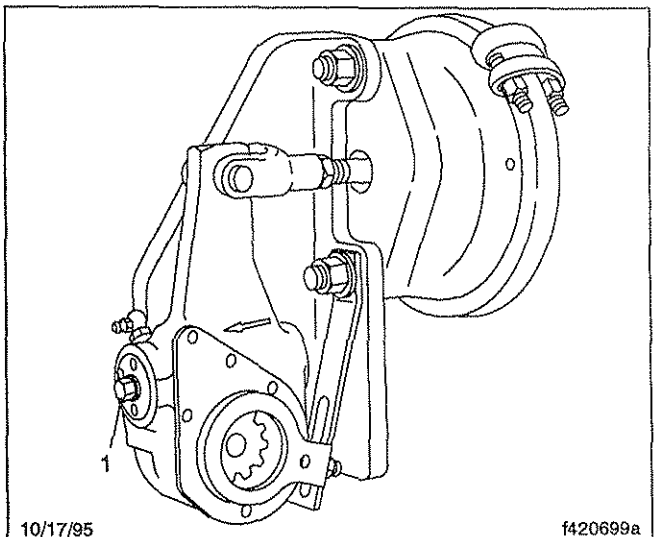
* Long Stroke

Table 1, Maximum Adjusted Brake Chamber Stroke

HALDEX AUTOMATIC SLACK ADJUSTER

1. Turn the adjusting hexnut clockwise until the brake lining meets the brake drum, then back off counterclockwise 3/4 turn. **See Fig. 5.** There will be a ratcheting sound.
2. Measure the distance from the bottom of the air chamber to the far side of the clevis-pin hole (**Fig. 6**, Ref. A). Record the exact distance as measurement A. Apply and hold an 80 psi (551 kPa) brake application. Measure the distance from the bottom of the brake chamber to the far side of the clevis-pin hole (**Fig. 6**, Ref. B). Record the exact distance as measurement B. Subtract measurement A from measurement B to determine the applied stroke. Compare this value to the value in **Table 2.**

   If the stroke varies or remains greater than the specified range, check the brake components. For instructions, refer to **Subject 140.** If necessary, replace the slack adjuster. For instructions, refer to the applicable slack adjuster section in this manual.



1. Adjusting Hexnut

Fig. 5, Turn the Adjusting Hexnut

Chamber Size	Stroke inch (mm)
16	3/4 to 1-3/4 (19 to 44)
20	1 to 1-/34 (25 to 44)
24	1 to 1-7/8 (25 to 48)
30	1-1/2 to 2 (38 to 51)

Table 2, Maximum Adjusted Brake Chamber Strokes With Haldex Automatic Slack Adjusters

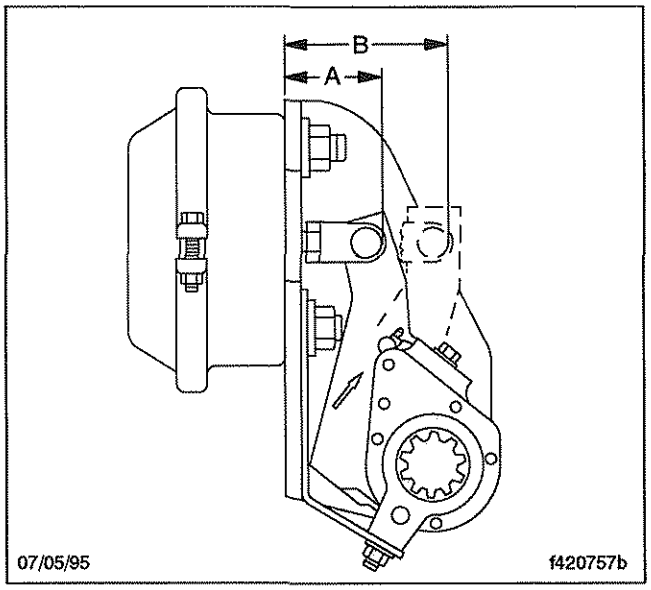


Fig. 6, Brake Stroke Check, Haldex (SAB) Automatic Slack Adjuster

Pre-Adjustment Checks and General Adjustment Information

Before adjusting the brakes, check and adjust the following:

- Adjust the wheel bearings. For instructions, see **Group 33** or **Group 35** in this manual.
- Check the slack adjuster and the brake chamber for loose fasteners and tighten as necessary. For torque specifications, see **Specifications 400**. For slack adjuster installation instructions, see the appropriate section in this group.

Brakes with automatic slack adjusters should never have to be manually adjusted while in service. The only time automatic slack adjusters should be manually adjusted is during installation or after the brakes have been relined.

For cam brakes, there are two brake chamber stroke measurement specifications, applied chamber stroke and free-stroke.

The procedure for adjusting the brake chamber stroke (at the slack adjuster's manual adjusting nut) may vary between each slack adjuster manufacturer. But, there are three basic procedures in completing a manual brake chamber stroke adjustment. They consist of:

A. Adjusting the approximate brake chamber stroke from the manual adjusting nut of the slack adjuster.

B. Measuring and readjusting the free-stroke.

C. Measuring and readjusting the applied chamber stroke.

The force used to move the slack adjuster from its released position to its applied position (where the brake linings contact the brake drum) distinguishes the free-stroke from the applied chamber stroke. The free-stroke is measured using a lever to move the slack adjuster (from the released to the applied positions). The applied chamber stroke is measured using an 80 to 90 psi (550 to 620 kPa) brake application to move the slack adjuster (from the released to applied positions). The stroke (free or applied chamber) is the distance that the large clevis pin moves when the brakes are applied.

With the engine off, 100 psi (689 kPa) of air tank pressure will apply the required (80 to 90 psi [550 to 620 kPa]) brake application for measuring the applied chamber stroke. The applied chamber stroke measurement can be used for diagnostic purposes. If the applied chamber stroke is too long or too short, this may indicate excessive wear in the cam, cam bushings, return springs, or air chamber. The applied chamber stroke should always be readjusted (minimized) to within the specified limit; but it should not be reduced to the point where the free stroke is too short and the brakes drag. To check for brake drag, spin the wheel end, tap the rim lightly with a hammer, and listen for a drag noise (a sharp ringing sound).

IMPORTANT: The U.S. Department of Transportation (DOT), Federal Highway Administration has issued the applied chamber stroke specifications for cam brakes. When the applied chamber stroke is checked and readjusted, it must not be greater than the DOT specification. See **Table 1**.

Stroke Limits		
Chamber Type (Size)	**Maximum Allowable (Applied) Stroke, inch (mm)***	**Desired Free-Stroke, inch (mm)**
16	1-3/4 (44)	5/8 to 3/4 (15.9 to 19.1)
16 (long stroke)†	2 (51)	5/8 to 3/4 (15.9 to 19.1)
20	1-3/4 (44)	5/8 to 3/4 (15.9 to 19.1)
20 (long stroke)†	2 (51)	5/8 to 3/4 (15.9 to 19.1)
24	1-3/4 (44)	5/8 to 3/4 (15.9 to 19.1)
24 (long stroke)†	2 (51)	5/8 to 3/4 (15.9 to 19.1)
30	2 (51)	5/8 to 3/4 (15.9 to 19.1)

Brake Adjustment

Stroke Limits		
Chamber Type (Size)	**Maximum Allowable (Applied) Stroke, inch (mm)***	**Desired Free-Stroke, inch (mm)**
30 (long stroke)†	2-1/2 (64)	5/8 to 3/4 (15.9 to 19.1)
36	2-1/4 (57)	5/8 to 3/4 (15.9 to 19.1)

* These specifications are relative to a brake application with 80-90 psi (550-620 kPa) air pressure in the brake chambers.
† Long stroke design is indicated by a tag, or embossing, on the brake chamber.

Table 1, Stroke Limits

Adjustment

MERITOR AUTOMATIC SLACK ADJUSTER

1. See the pre-adjustment checks and general adjustment information in this subject before adjusting the brakes.
2. Park the vehicle on a level surface, apply the parking brakes, and chock the tires.
3. Raise the front or rear axle. Then, place safety stands under the frame or axle. Be sure the stands will support the weight of the vehicle.
4. Fully release the brakes (the air chamber push rod must be fully retracted).
5. Check the condition of the boot on the slack adjuster. It should be held in the proper position with a retaining clip. If the boot is torn or cracked, see **Section 42.17** for slack adjuster disassembly and inspection procedures.

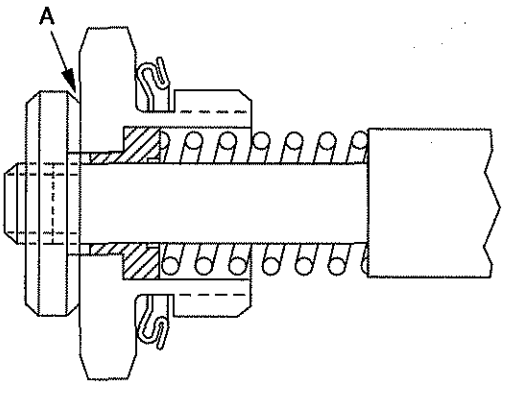
⚠ CAUTION

Before turning the manual adjusting nut of the slack adjuster, disengage the pull-pawl by raising it up about 1/32 inch (0.8 mm). Failure to do so could damage the pull-pawl teeth. A damaged pull-pawl will not allow the slack adjuster to automatically adjust the brake clearance.

6. With a screwdriver, pry the pull-pawl up at least 1/32 inch (0.8 mm). This will disengage the pull-pawl teeth from the actuator of the slack adjuster. See **Fig. 1**. Wedge the screwdriver in place. The pull-pawl will need to be disengaged until the brake adjustment is complete.

NOTE: When the screwdriver is removed, the pull-pawl will re-engage automatically.

7. Adjust the approximate brake chamber stroke from the manual adjusting nut on the slack adjuster (**Fig. 2**).
   - 7.1 Turn the adjusting nut counterclockwise until the brake linings touch the brake drum.
   - 7.2 Then, turn the adjusting nut one-half turn in the clockwise direction.
8. Measure and readjust the free-stroke.
   - 8.1 Measure the distance from the bottom of the brake chamber to the center of the large clevis pin. See **Fig. 3**, Ref. A. Record this measurement as dimension A.
   - 8.2 Using a lever, move the slack adjuster until the brake linings contact the brake drum. Then, measure the distance from the



A. Insert screwdriver here.

Fig. 1, Disengage the Pull-Pawl

Brake Adjustment

Stroke Limits		
Chamber Type (Size)	**Maximum Allowable (Applied) Stroke, inch (mm)***	**Desired Free-Stroke, inch (mm)**
30 (long stroke)†	2-1/2 (64)	5/8 to 3/4 (15.9 to 19.1)
36	2-1/4 (57)	5/8 to 3/4 (15.9 to 19.1)

* These specifications are relative to a brake application with 80-90 psi (550-620 kPa) air pressure in the brake chambers.
† Long stroke design is indicated by a tag, or embossing, on the brake chamber.

Table 1, Stroke Limits

Adjustment

MERITOR AUTOMATIC SLACK ADJUSTER

1. See the pre-adjustment checks and general adjustment information in this subject before adjusting the brakes.
2. Park the vehicle on a level surface, apply the parking brakes, and chock the tires.
3. Raise the front or rear axle. Then, place safety stands under the frame or axle. Be sure the stands will support the weight of the vehicle.
4. Fully release the brakes (the air chamber push rod must be fully retracted).
5. Check the condition of the boot on the slack adjuster. It should be held in the proper position with a retaining clip. If the boot is torn or cracked, see **Section 42.17** for slack adjuster disassembly and inspection procedures.

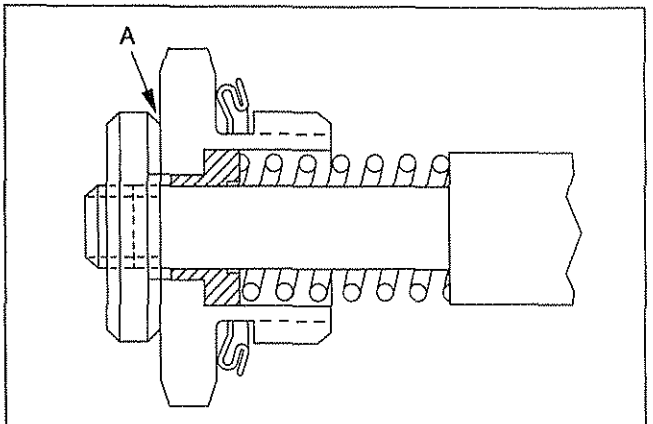
⚠ CAUTION

Before turning the manual adjusting nut of the slack adjuster, disengage the pull-pawl by raising it up about 1/32 inch (0.8 mm). Failure to do so could damage the pull-pawl teeth. A damaged pull-pawl will not allow the slack adjuster to automatically adjust the brake clearance.

6. With a screwdriver, pry the pull-pawl up at least 1/32 inch (0.8 mm). This will disengage the pull-pawl teeth from the actuator of the slack adjuster. See **Fig. 1**. Wedge the screwdriver in place. The pull-pawl will need to be disengaged until the brake adjustment is complete.

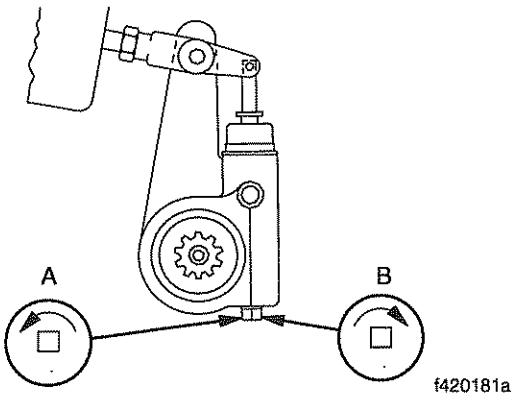
NOTE: When the screwdriver is removed, the pull-pawl will re-engage automatically.

7. Adjust the approximate brake chamber stroke from the manual adjusting nut on the slack adjuster **(Fig. 2)**.
   - 7.1 Turn the adjusting nut counterclockwise until the brake linings touch the brake drum.
   - 7.2 Then, turn the adjusting nut one-half turn in the clockwise direction.
8. Measure and readjust the free-stroke.
   - 8.1 Measure the distance from the bottom of the brake chamber to the center of the large clevis pin. See **Fig. 3**, Ref. A. Record this measurement as dimension A.
   - 8.2 Using a lever, move the slack adjuster until the brake linings contact the brake drum. Then, measure the distance from the



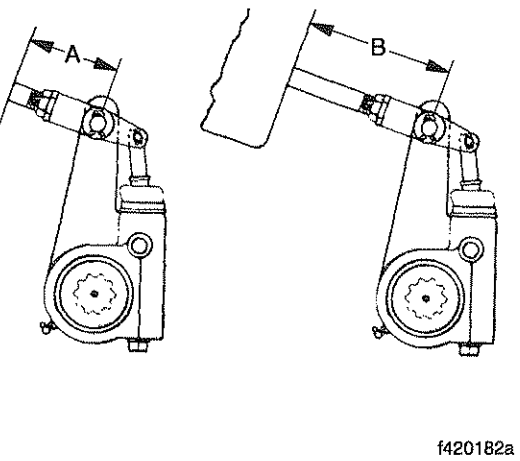
A. Insert screwdriver here.

Fig. 1, Disengage the Pull-Pawl



A. Shorten stroke.
B. Lengthen stroke.

Fig. 2, Turn the Adjusting Nut



NOTE: For either free-stroke or applied chamber stroke, subtract measurement A from B.

A. Measurement with the brakes released.
B. Measurement with the brakes applied, by manual lever (free-stroke) or by pressurized brake application (applied chamber stroke).

Fig. 3, Measuring the Stroke

bottom of the brake chamber to the center of the large clevis pin. See **Fig. 3**, Ref. B. Record this measurement as dimension B.

8.3 Subtract dimension A from dimension B. The difference between these dimensions is the free-stroke.

The free-stroke should be within the range specified in **Table 1**.

8.4 If the free-stroke is not within the range specified in **Table 1**, turn the adjusting nut one-eighth turn, as shown in **Fig. 2**. Then, measure the free-stroke again, and readjust until it is correct.

9. Measure and readjust the applied chamber stroke.

9.1 Build air pressure to 100 psi (689 kPa). Shut down the engine.

9.2 Fully apply the brakes. Then, measure the distance from the bottom of the brake chamber to the center of the large clevis pin. See **Fig. 3**, Ref. B. Record this measurement as dimension C.

9.3 Subtract dimension A (measured in the previous step [**Fig. 3**, Ref. A]) from dimension C. The difference between these dimensions is the applied chamber stroke.

9.4 The applied chamber stroke must be less than the measurements specified in **Table 1**.

⚠ CAUTION

The readjusted applied chamber stroke should be as short as possible (allowable), but not so short that the free-stroke is too short and the linings drag. If the linings drag, the brakes could be damaged.

9.5 If the applied chamber stroke is incorrect, turn the adjusting nut one-eight turn, as shown in **Fig. 2**. Measure the applied chamber stroke again, and readjust until correct.

9.6 If the slack adjuster is not maintaining the correct applied chamber stroke, check the condition of the foundation brakes (see **Subject 150**). If necessary, replace the slack adjuster. For instructions, see **Section 42.17** in this group.

10. Remove the screwdriver from the pull-pawl assembly. This will engage the pull-pawl to the actuator.

11. Lower the vehicle, remove the safety stands, and remove the chocks from the tires.

Brake Adjustment

⚠ DANGER

Don't operate the vehicle until the brakes have been checked for proper operation. To do so could result in inadequate or no braking ability, which could cause personal injury or death, and property damage.

12. Check for proper brake operation. For instructions, see **Subject 110**.

HALDEX AUTOMATIC SLACK ADJUSTER

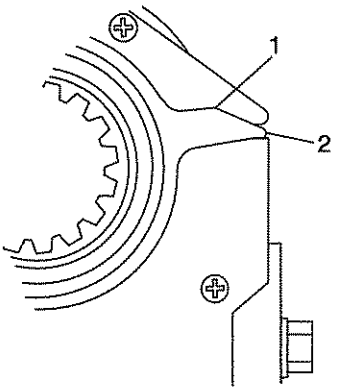
1. See the pre-adjustment checks and general adjustment information in this subject before adjusting the brakes.
2. Park the vehicle on a level surface, apply the parking brakes, and chock the tires.
3. Raise the front or rear axle. Then, place safety stands under the frame or axle. Be sure the stands will support the weight of the vehicle.
4. Fully release the brakes (the air chamber push rod must be fully retracted).

⚠ CAUTION

If the slack adjuster is equipped with an installation indicator, the indicator must be in the slotted area as shown in Fig. 4. If the installation indicator is not within the slotted area, the control arm is installed in the wrong position. This may result in tight brakes and excessive lining wear and possible brake damage.

5. If the slack adjuster is equipped with an installation indicator, check that the installation indicator is within the slotted area. See **Fig. 4**. If the installation indicator is not within the slotted area, the control arm is not properly installed. For slack adjuster installation instructions, see **Section 42.16** in this group.
6. Check the de-adjustment torque (the internal clutch slippage) of the slack adjuster.
   - 6.1 Place a torque wrench on the 7/16-inch adjusting hexnut. See **Fig. 5**.
   - 6.2 While turning the torque wrench in a counterclockwise direction, measure how much torque is required to overcome the resistance of the internal clutch. A normal ratcheting sound will occur while the adjusting hexnut is backed off in the counterclockwise direction. The minimum allowable de-adjustment torque is 13 lbf·ft (17.6 N·m).

   If the clutch slips with a torque less than 13 lbf·ft (17.6 N·m), the slack adjuster must be replaced. For instructions see **Section 42.16** in this manual.



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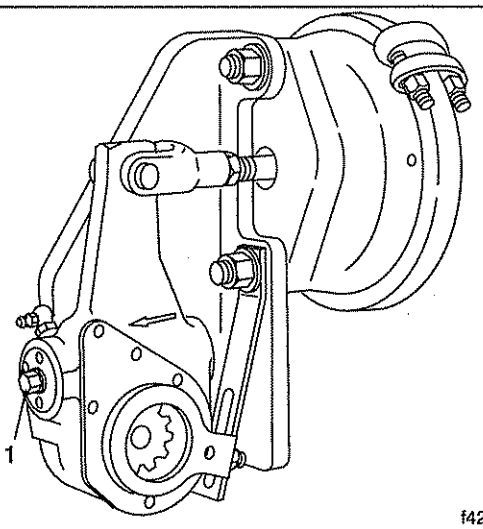
1. Indicator Arrow
2. Slot

Fig. 4, Installation Indicator



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1. Adjusting Hexnut

Fig. 5, Adjusting Hexnut

Brake Adjustment

⚠ DANGER

Don't operate the vehicle until the brakes have been checked for proper operation. To do so could result in inadequate or no braking ability, which could cause personal injury or death, and property damage.

12. Check for proper brake operation. For instructions, see **Subject 110**.

HALDEX AUTOMATIC SLACK ADJUSTER

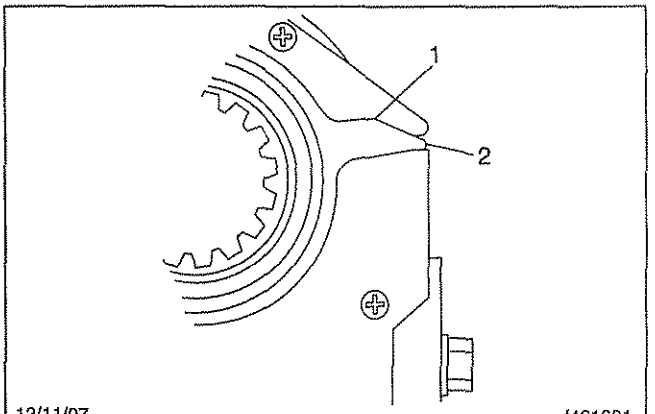
1. See the pre-adjustment checks and general adjustment information in this subject before adjusting the brakes.
2. Park the vehicle on a level surface, apply the parking brakes, and chock the tires.
3. Raise the front or rear axle. Then, place safety stands under the frame or axle. Be sure the stands will support the weight of the vehicle.
4. Fully release the brakes (the air chamber push rod must be fully retracted).

⚠ CAUTION

If the slack adjuster is equipped with an installation indicator, the indicator must be in the slotted area as shown in Fig. 4. If the installation indicator is not within the slotted area, the control arm is installed in the wrong position. This may result in tight brakes and excessive lining wear and possible brake damage.

5. If the slack adjuster is equipped with an installation indicator, check that the installation indicator is within the slotted area. See **Fig. 4**. If the installation indicator is not within the slotted area, the control arm is not properly installed. For slack adjuster installation instructions, see **Section 42.16** in this group.
6. Check the de-adjustrnent torque (the internal clutch slippage) of the slack adjuster.
   - 6.1 Place a torque wrench on the 7/16-inch adjusting hexnut. See **Fig. 5**.
   - 6.2 While turning the torque wrench in a counterclockwise direction, measure how much torque is required to overcome the resistance of the internal clutch. A normal ratcheting sound will occur while the adjusting hexnut is backed off in the counterclockwise direction. The minimum allowable de-adjustment torque is 13 lbf·ft (17.6 N·m).

   If the clutch slips with a torque less than 13 lbf·ft (17.6 N·m), the slack adjuster must be replaced. For instructions see **Section 42.16** in this manual.



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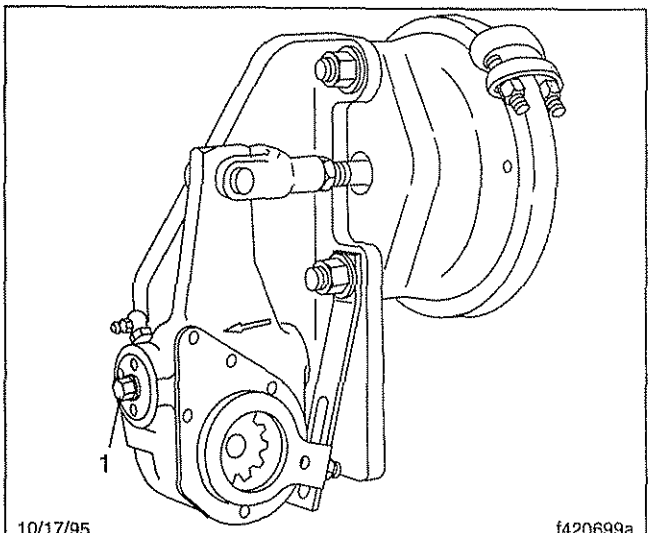
1. Indicator Arrow
2. Slot

Fig. 4, Installation Indicator



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1. Adjusting Hexnut

Fig. 5, Adjusting Hexnut

7. Adjust the approximate brake chamber stroke from the manual adjusting nut on the slack adjuster.

   7.1 Turn the adjusting hexnut clockwise until the brake linings contact the brake drum.

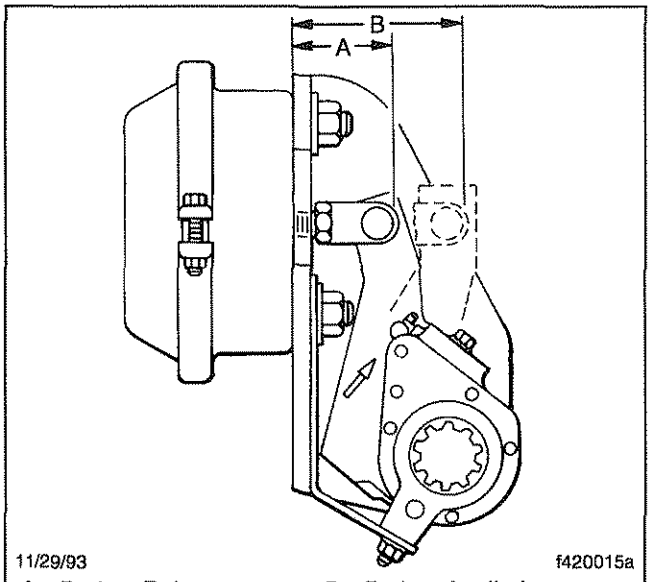
   7.2 Then, turn the adjusting hexnut one-half turn in the opposite direction. A normal ratcheting sound will occur when the adjusting hexnut is backed off in the counterclockwise direction.

8. Measure and readjust the free-stroke.

   8.1 Measure the distance from the face of the brake chamber to the far side of the clevis pin. See **Fig. 6**, Ref. A. Record this measurement as dimension A.

   8.2 Using a lever, move the slack adjuster until the brake linings contact the brake drum. Then, measure the distance from the face of the brake chamber to the far side of the clevis pin. See **Fig. 6**, Ref. B. Record this measurement as dimension B.

   8.3 Subtract dimension A from dimension B. The difference between these dimensions is the free-stroke. The free-stroke should be within the range specified in **Table 1**.



A. Brakes Releases B. Brakes Applied

Fig. 6, Measure the Stroke

   8.4 If the free-stroke is not within the range specified in **Table 1**, turn the adjusting nut in the direction required. Then, measure the free-stroke again, and readjust until it is correct.

9. Measure and readjust the applied chamber stroke.

   9.1 Build air pressure to 100 psi (689 kPa). Shut down the engine.

   9.2 Fully apply the brakes. Then, measure the distance from the face of the brake chamber to the far side of the clevis pin hole. See **Fig. 6**, Ref. B. Record this measurement as dimension C.

   9.3 Subtract dimension A (measured in the previous step [**Fig. 6**, Ref. A]) from dimension C. The difference between these dimensions is the applied chamber stroke. The applied chamber stroke must be less than the measurements shown in **Table 1**.

   9.4 If the applied chamber stroke is not correct, turn the adjusting nut in the direction required. Then, measure the applied chamber stroke again, and readjust until it is correct.

   9.5 If the slack adjuster is not maintaining the correct applied chamber stroke, check the condition of the foundation brakes (see **Subject 150**). If necessary, replace the slack adjuster. For instructions, see **Section 42.16** in this group.

10. Lower the vehicle, remove the safety stands, and remove the chocks from the tires.

⚠ DANGER

Don't operate the vehicle until the brakes have been checked for proper operation. To do so could result in inadequate or no braking ability, which could cause personal injury or death, and property damage.

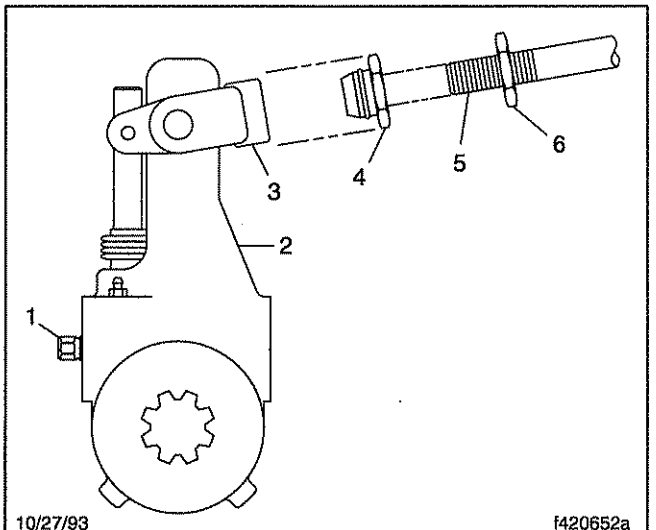
11. Check for proper brake operation. For instructions, see **Subject 110**.

Brake Adjustment

GUNITE AUTOMATIC SLACK ADJUSTER

1. See the pre-adjustment checks and general adjustment information in this subject before adjusting the brakes.
2. Park the vehicle on a level surface, apply the parking brakes, and chock the tires.
3. Raise the front or rear axle. Then, place safety stands under the frame or axle. Be sure the stands will support the weight of the vehicle.
4. Fully release the brakes (the air chamber push rod must be fully retracted).
5. Check the de-adjustment torque (the internal clutch slippage) of the slack adjuster.
   - 5.1 Place a torque wrench on the adjusting hexnut. See **Fig. 7**.
   - 5.2 While turning the torque wrench in a counterclockwise direction, measure how much torque is required to overcome the resistance of the internal clutch. A normal ratcheting sound will occur while the adjusting hexnut is backed off in the counterclockwise direction. The de-adjustment torque must not be less than 15 lbf·ft (20 N·m).

     If the clutch slips with a torque less than 15 lbf·ft (20 N·m), the slack adjuster must be replaced. For instructions see **Section 42.15** in this manual.
6. Adjust the approximate brake chamber stroke from the manual adjusting nut on the slack adjuster.
   - 6.1 Turn the adjusting hexnut clockwise until the brake linings contact the brake drum.
   - 6.2 Turn the adjusting hexnut counterclockwise one-half turn. There should be about 30 lbf·ft (41 N·m) resistance, and a ratcheting sound will occur.
7. Measure and readjust the free-stroke.
   - 7.1 Measure the distance from the bottom of the brake chamber to the center of the large clevis pin. See **Fig. 8**, Ref. A. Record this measurement as dimension A.
   - 7.2 Using a lever, move the slack adjuster until the brake linings contact the brake drum. Then, measure the distance from the bottom of the brake chamber to the center of the large clevis pin. See **Fig. 8**, Ref. B. Record this measurement as dimension B.
   - 7.3 Subtract dimension A from dimension B. The difference between these dimensions is the free-stroke. The free-stroke should be within the range specified in **Table 1**.
   - 7.4 If the free-stroke is not within the range specified in **Table 1**, turn the adjusting nut in the direction required. Then, measure the free-stroke again, and readjust until it is correct.
8. Measure the applied chamber stroke.
   - 8.1 Build air pressure to 100 psi (689 kPa). Shut down the engine.
   - 8.2 Fully apply the brakes. Then, measure the distance from the bottom of the brake chamber to the center of the large clevis pin. See **Fig. 8**, Ref. B. Record this measurement as dimension C.
   - 8.3 Subtract dimension A (measured in the previous step [**Fig. 8**, Ref. A]) from dimension C. The difference between these dimensions is the applied chamber stroke. The



1. Adjusting Hexnut
2. Slack Adjuster
3. Clevis
4. Quick-Connect
5. Push Rod
6. Jam Nut

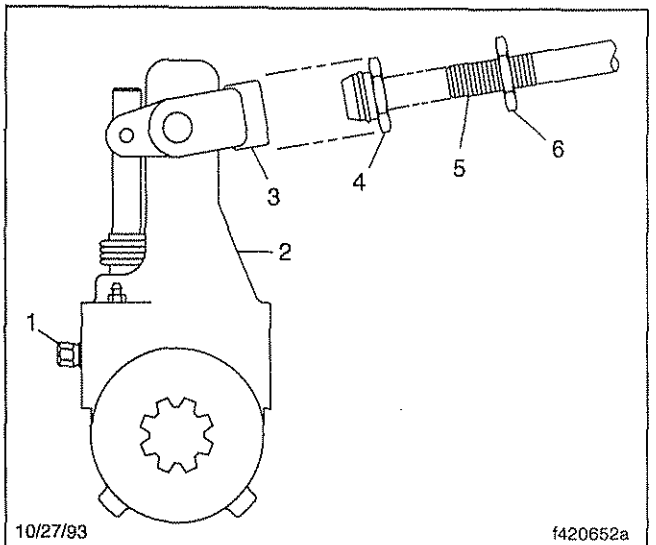
Fig. 7, Gunite Slack Adjuster

Brake Adjustment

GUNITE AUTOMATIC SLACK ADJUSTER

1. See the pre-adjustment checks and general adjustment information in this subject before adjusting the brakes.
2. Park the vehicle on a level surface, apply the parking brakes, and chock the tires.
3. Raise the front or rear axle. Then, place safety stands under the frame or axle. Be sure the stands will support the weight of the vehicle.
4. Fully release the brakes (the air chamber push rod must be fully retracted).
5. Check the de-adjustment torque (the internal clutch slippage) of the slack adjuster.
   - 5.1 Place a torque wrench on the adjusting hexnut. See **Fig. 7**.
   - 5.2 While turning the torque wrench in a counterclockwise direction, measure how much torque is required to overcome the resistance of the internal clutch. A normal ratcheting sound will occur while the adjusting hexnut is backed off in the counterclockwise direction. The de-adjustment torque must not be less than 15 lbf·ft (20 N·m).

     If the clutch slips with a torque less than 15 lbf·ft (20 N·m), the slack adjuster must be replaced. For instructions see **Section 42.15** in this manual.
6. Adjust the approximate brake chamber stroke from the manual adjusting nut on the slack adjuster.
   - 6.1 Turn the adjusting hexnut clockwise until the brake linings contact the brake drum.
   - 6.2 Turn the adjusting hexnut counterclockwise one-half turn. There should be about 30 lbf·ft (41 N·m) resistance, and a ratcheting sound will occur.
7. Measure and readjust the free-stroke.
   - 7.1 Measure the distance from the bottom of the brake chamber to the center of the large clevis pin. See **Fig. 8**, Ref. A. Record this measurement as dimension A.
   - 7.2 Using a lever, move the slack adjuster until the brake linings contact the brake drum. Then, measure the distance from the bottom of the brake chamber to the center of the large clevis pin. See **Fig. 8**, Ref. B. Record this measurement as dimension B.
   - 7.3 Subtract dimension A from dimension B. The difference between these dimensions is the free-stroke. The free-stroke should be within the range specified in **Table 1**.
   - 7.4 If the free-stroke is not within the range specified in **Table 1**, turn the adjusting nut in the direction required. Then, measure the free-stroke again, and readjust until it is correct.
8. Measure the applied chamber stroke.
   - 8.1 Build air pressure to 100 psi (689 kPa). Shut down the engine.
   - 8.2 Fully apply the brakes. Then, measure the distance from the bottom of the brake chamber to the center of the large clevis pin. See **Fig. 8**, Ref. B. Record this measurement as dimension C.
   - 8.3 Subtract dimension A (measured in the previous step [**Fig. 8**, Ref. A]) from dimension C. The difference between these dimensions is the applied chamber stroke. The



1. Adjusting Hexnut
2. Slack Adjuster
3. Clevis
4. Quick-Connect
5. Push Rod
6. Jam Nut

Fig. 7, Gunite Slack Adjuster

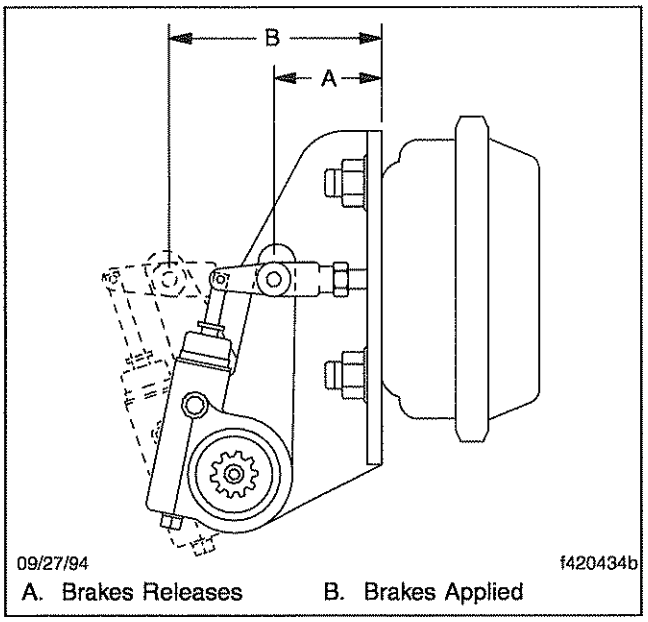


Fig. 8, Measure the Stroke

applied chamber stroke must be less than the measurements shown in **Table 1**.

8.4 If the applied chamber stroke is not correct, turn the adjusting nut in the direction required. Then, measure the free-stroke again, and readjust until it is correct.

8.5 If the slack adjuster is not maintaining the correct applied chamber stroke, check the condition of the foundation brakes (see **Subject 150**). If necessary, replace the slack adjuster. For instructions, see **Section 42.15** in this group.

9. Lower the vehicle, remove the safety stands, and remove the chocks from the tires.

⚠ DANGER

Don't operate the vehicle until the brakes have been checked for proper operation. To do so could result in inadequate or no braking ability, which could cause personal injury or death, and property damage.

10. Check for proper brake operation. For instructions, see **Subject 110**.

⚠ WARNING

Before starting the procedure below, read the safety precaution information in Subject 100. Failure to be aware of the dangers of brake lining dust exposure could result in serious and permanent health damage.

Replacement

IMPORTANT: Vehicle brake systems require the correct lining material to perform as originally designed. The type of lining material that is specified for the vehicle is based on several technical considerations and DOT braking performance regulations. To ensure fewer relines and greater compatibility with the vehicles brake system, insist on the same quality OEM friction lining material.

Always reline both wheels of a single axle and all wheels of a tandem axle at the same time. Always install the same linings and drums on both wheels of a single axle and all four wheels of a tandem axle. It is not necessary that both axles (front and rear) have the same linings and drum.

Combination linings with different friction ratings for the primary and secondary shoes are sometimes used. When combination friction lining sets are used, the lining blocks must be installed in the correct locations on the brake shoes.

NOTE: Always follow the instructions supplied with the replacement combination lining sets for correct installation. The primary linings must be installed on the primary shoe. The first shoe past the cam in the direction of the wheel rotation is the primary shoe. The primary shoe can be either at the top or the bottom position, depending on the location of the cam. If the cam is behind the axle, then the top shoe is the primary shoe. If the cam is in front of the axle, then the bottom shoe is the primary shoe. See **Fig. 1** and **Fig. 2**.

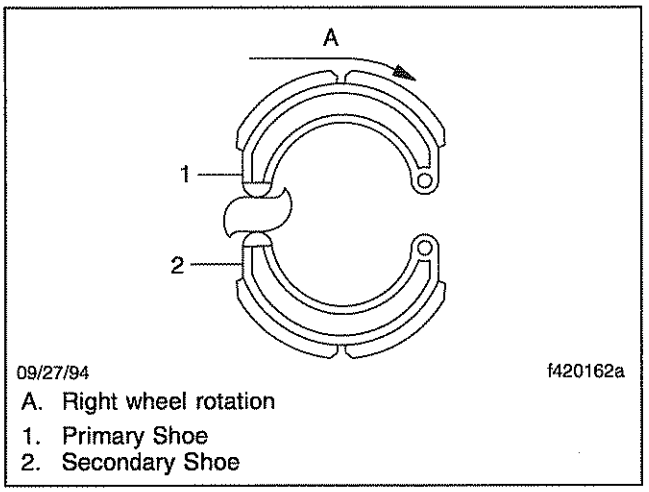
1. Remove the brake shoes. See **Subject 110** for instructions.

IMPORTANT: When replacing the brake linings, use a dial indicator to measure the cam-to-bushing radial free play (the up-and-down and side-to-side free play of the camshaft) and the camshaft axial end play (the in-and-out end play of the camshaft).

Replace the bushings if the cam-to-bushing radial free play exceeds:

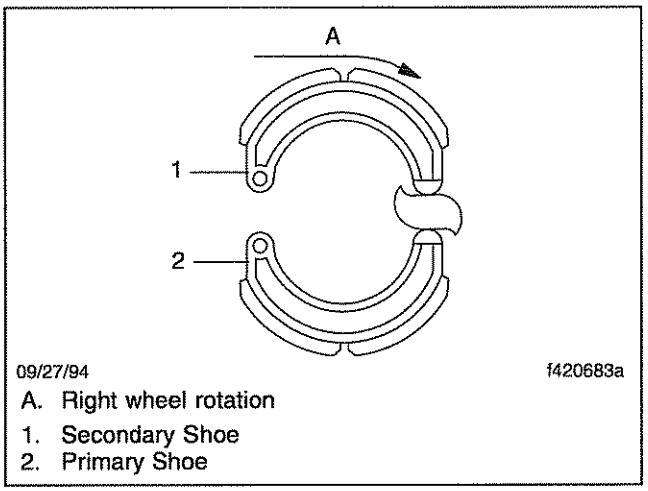
- for all Cam-Master brakes except "Q" Plus (LX500 and MX500), 0.030 inch (0.8 mm) of movement;
- for "Q" Plus (LX500 and MX500), 0.020 inch (0.5 mm) of movement.

Remove the snap ring from the end of the slack adjuster and add shims between the slack adjuster and the snap ring if the axial end play exceeds:



A. Right wheel rotation
1. Primary Shoe
2. Secondary Shoe

Fig. 1, Camshaft Behind the Axle



A. Right wheel rotation
1. Secondary Shoe
2. Primary Shoe

Fig. 2, Camshaft Ahead of the Axle

Brake Shoe Lining Replacement

- for all Cam-Master brakes except "Q" Plus (LX500 and MX500), 0.060 inch (1.5 mm) of movement;
- for "Q" Plus (LX500 and MX500), 0.005 to 0.030 inch (0.13 to 0.80 mm) of movement.

For more instructions, see **Subject 150**.

2. Disassemble the lining blocks from the brake shoes.

   2.1 If the lining blocks are bolted, proceed to the next substep. Otherwise, if the lining blocks are riveted, using a suitable riveting mandrel, push out the old rivets.

⚠ CAUTION

Drilling out rivets or cutting off rivet heads with a chisel can cause the rivet hole to become out-of-round. This could damage the brake shoe.

   2.2 If the lining blocks are bolted, remove the bolts, lockwashers, and nuts.

   2.3 Separate the lining blocks from the brake shoes.

3. Check the brake shoes for rust, expanded rivet or bolt holes, broken welds and correct alignment. Replace the shoe if any of these conditions exist.

4. If necessary, clean the brake shoe with solvent and wire brush the shoe table. Then, paint the brake shoe with rust inhibitive paint.

5. Assemble the lining blocks to the brake shoes.

   IMPORTANT: Use rivets that have the correct material, shank diameter, length, head size, and shape. Use tubular rivets that are 1/4-inch diameter by 9/16-inch long, SAE no. 10, made of plated steel or brass.

   5.1 If the lining blocks are bolted, proceed to the next substep. Otherwise, if the lining blocks are riveted, align the brake shoe rivet holes with the corresponding lining block holes. Using a C-clamp, clamp the lining block to the brake shoe.

   Insert the correct size rivets into all the holes and threads. Then, temporarily hold the rivets in place with masking tape.

   Fasten the rivets (from the lining block to the brake shoe) in the sequence shown in **Fig. 3**.

   5.2 If the lining blocks are bolted, align the brake shoe bolt holes with the corresponding lining block holes. Using a C-clamp, clamp the lining block to the brake shoe.

   Insert the correct size bolts, and new lockwashers into all the holes and threads. Loosely install the nuts.

   Tighten the nuts (in the sequence shown in **Fig. 3**):

   - 18 to 23 lbf·ft (24 to 31 N·m) for 3/8-inch brass bolts;
   - 80 to 100 lbf·in (900 to 1120 N·cm) for 1/4-inch brass bolts.

6. Check the lining installation by trying to insert a 0.010 inch (0.25 mm) feeler gauge between the linings and the shoe table along the edges. See **Fig. 4**, Ref. A. It should not be possible to insert the feeler gauge anywhere along the edge, except beyond the last row of rivets at each end. See **Fig. 5**, Ref. A. A larger clearance (up to 0.025 inch [0.64 mm]) may exist at the ends.

7. Circle grind the brake lining to obtain the correct lining-to-drum contact. With the cam in the full-release position, the new brake linings must be ground 0.070 inch (1.8 mm) less than the drum diameter. The cam must be adjusted and the lining

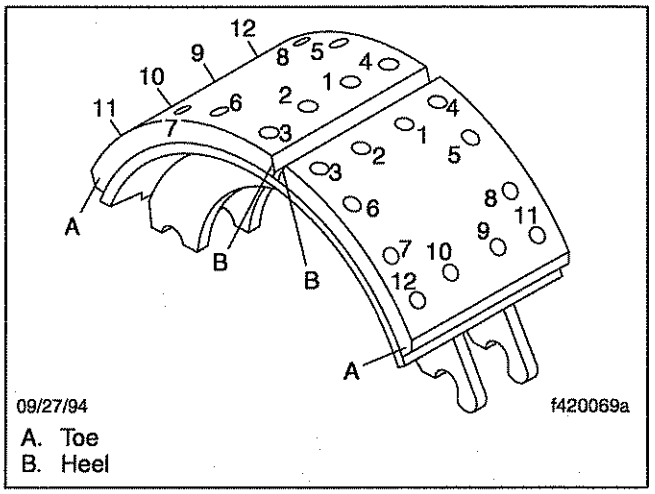


Fig. 3, Fastening Sequence

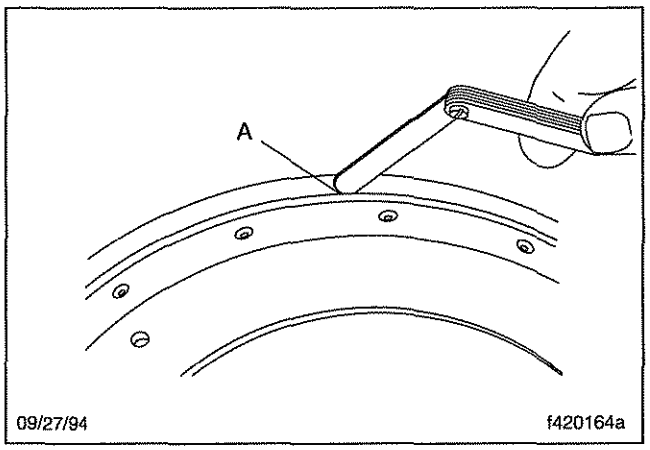


Fig. 4, Check Clearance Along Edge

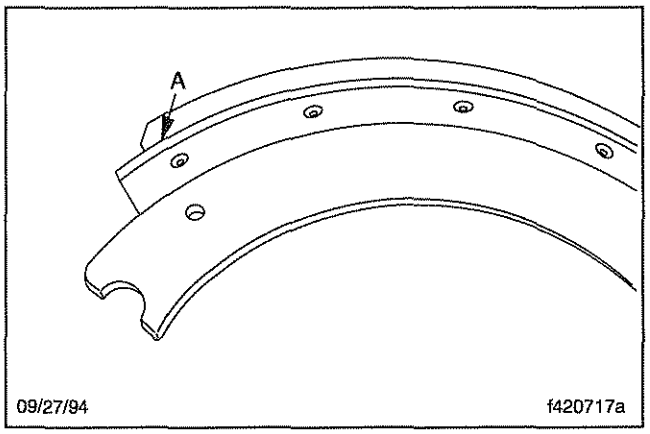


Fig. 5, Check Clearance at Ends

ground until there is an 80 percent lining-to-drum contact, which must be continuous and in the center of the lining.

8. Install the brake shoes, see **Subject 110** for instructions.

Brake Components Disassembly and Inspection, Cleaning, and Assembly

Disassembly and Inspection (See Fig. 1, Fig. 2, Fig. 3, or Fig. 4)

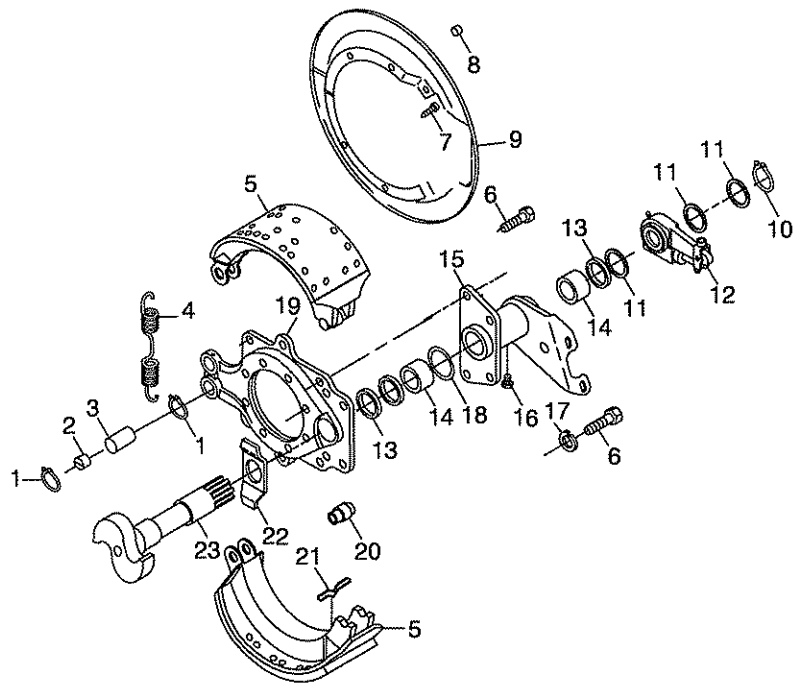
⚠ WARNING

Before starting the procedure below, read the safety precaution information in Subject 100. Failure to be aware of the dangers of brake lining dust exposure could result in serious and permanent health damage.

1. Remove the brake shoes, see **Subject 110** for instructions.

NOTE: Meritor recommends that the brake drum not be turned or rebored (resurfaced). Turning or reboring drums can decrease the strength and heat capacity of the drum.

2. Inspect the brake drum (**Fig. 5**).
   - 2.1 Check the drum for cracks, severe heat-checking, heat spotting, scoring, pitting, distortion, and out-of-round.
   - 2.2 With, a drum caliper or other measuring device, measure the inside diameter of the drum in several locations. Replace the drum if it exceeds the maximum diameter stamped on it. Replace cracked drums. Some drums that are glazed, grooved, or out-of-round can be repaired. For detailed

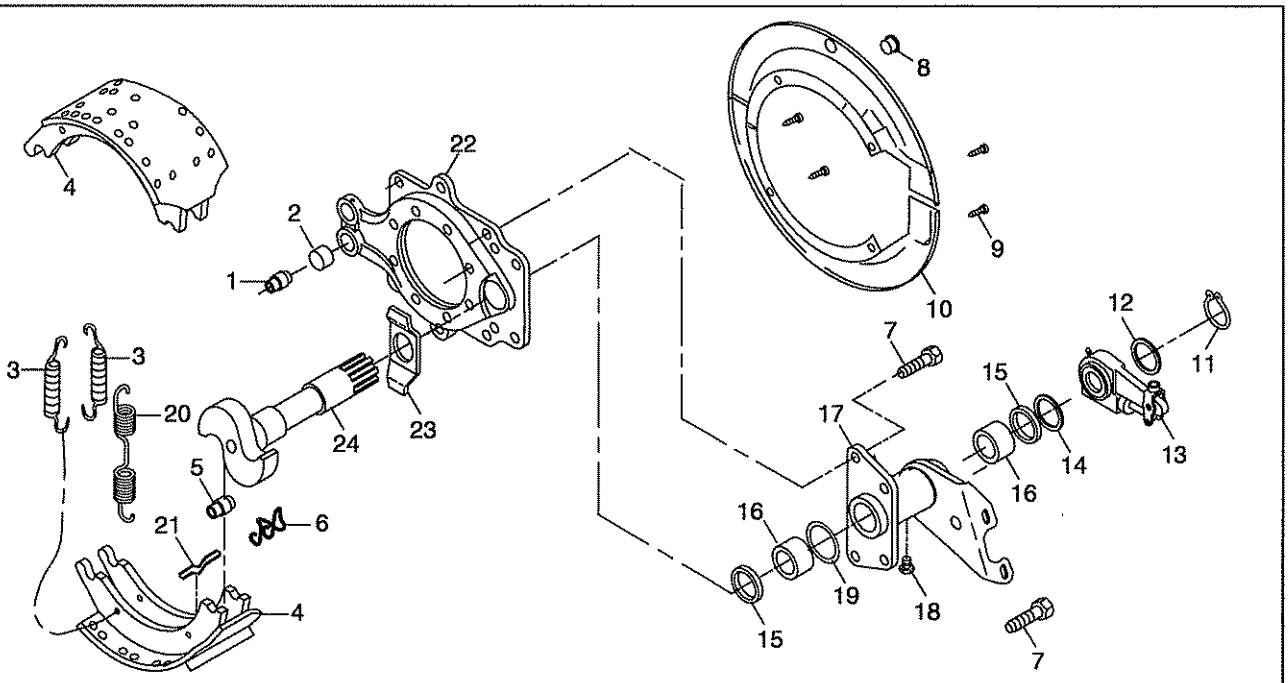


12/11/97 f421683

1. Anchor Pin Snap Ring
2. Anchor Pin Bushing
3. Brake Shoe Anchor Pin
4. Brake Shoe Return Spring
5. Brake Shoe and Lining Assembly
6. Camshaft Bracket Capscrew
7. Dust Shield Capscrew
8. Plug
9. Dust Shield
10. Camshaft Snap Ring
11. Spacing Washer
12. Automatic Slack Adjuster
13. Camshaft Grease Seal
14. Camshaft Bushing
15. Camshaft-and-Chamber Bracket
16. Grease Fitting
17. Bracket Capscrew Washer
18. Camshaft Bracket Seal
19. Brake Spider
20. Brake Shoe Roller
21. Return Spring Pin
22. Camhead Washer
23. "S" Head Camshaft

Fig. 1, P Series Brake, Exploded View

Brake Components Disassembly and Inspection, Cleaning, and Assembly



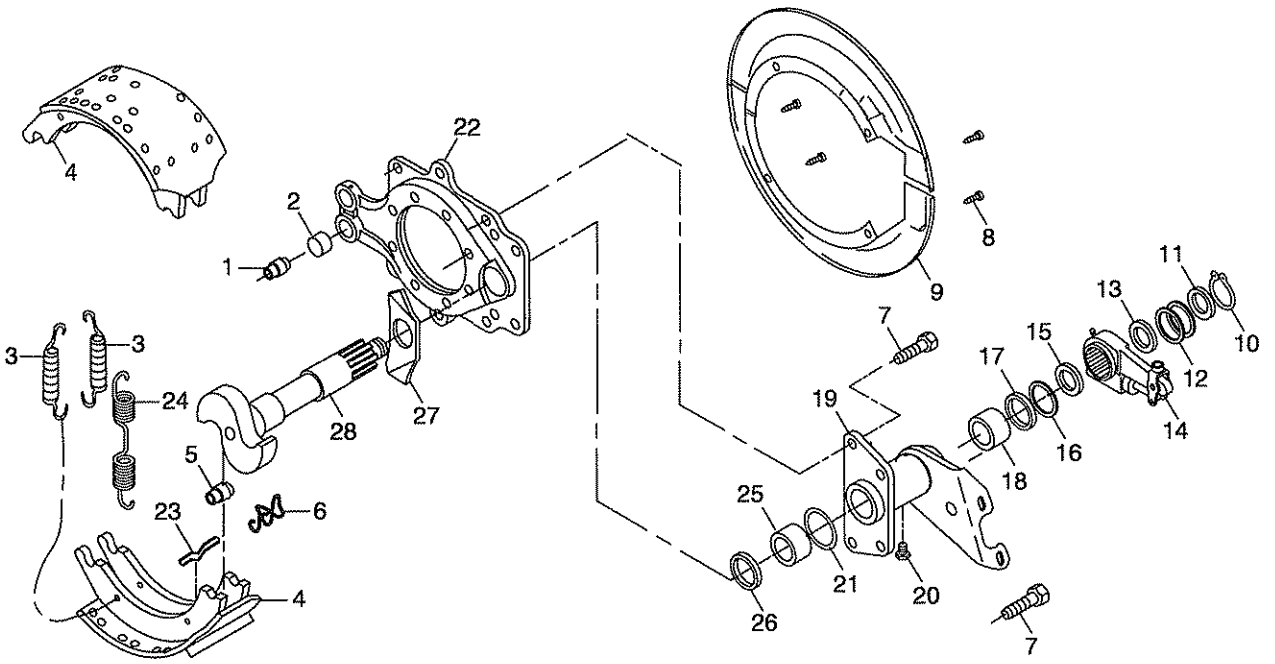
1. Brake Shoe Anchor Pin	9. Dust Shield Capscrew	17. Camshaft-and-Chamber Bracket
2. Anchor Pin Bushings	10. Dust Shield	18. Grease Fitting
3. Shoe Retaining Spring	11. Camshaft Snap Ring	19. Chamber Bracket Seal
4. Brake Shoe and Lining Assembly	12. Spacing Washer	20. Brake Shoe Return Spring
5. Brake Shoe Roller	13. Automatic Slack Adjuster	21. Brake Shoe Return Spring Pin
6. Brake Shoe Roller Retainer	14. Thick Camshaft Washer	22. Brake Spider
7. Chamber Bracket Capscrew	15. Camshaft Grease Seal	23. Camhead Washer
8. Plug	16. Camshaft Bushing	24. "S" Head Camshaft

Fig. 2, Q Plus Brake (without LX500 & MX500 id. tag), Exploded View

instructions, see **Group 33** or **Group 35** in this manual.

3. Remove the push rod clevis pin and disconnect the slack adjuster from the push rod clevis. See **Fig. 6**.
4. Check the camshaft radial free play (**Fig. 7**).
   - 4.1 Using a dial indicator, measure the up-and-down and side-to-side free play of the camshaft.
   - 4.2 For all Cam-Master brakes except the "Q" Plus (LX500 and MX500) brakes, replace the camshaft bushings if there is more than 0.030 inch (0.8 mm) of free play. For "Q" Plus (LX500 and MX500) brakes, replace the camshaft bushings if there is more than 0.020 inch (0.5 mm) of free play.
5. Remove the slack adjuster.
   - 5.1 From the slack adjuster side of the camshaft-and-chamber bracket, remove any snap rings, washers, spacers, and the orange slack adjuster seal ("Q" Plus LX500 and MX500 only) from the camshaft.
   - 5.2 Remove the slack adjuster from the camshaft.
6. Inspect the slack adjuster for damage or binding.
   - 6.1 Check the slack adjuster clevis for cracks or bushing wear. Check the splines for chipped teeth and deformation. Replace as needed.

Brake Components Disassembly and Inspection, Cleaning, and Assembly



NOTE: 16-1/2 inch Q Plus (with LX500 and MX500 identification tags, and a cast brake spider) brake shown.

1. Brake Shoe Anchor Pin
2. Anchor Pin Bushing
3. Brake Shoe Retaining Spring
4. Brake Shoe and Lining Assembly
5. Brake Shoe Roller
6. Brake Shoe Roller Retainer
7. Chamber Bracket Capscrew
8. Dust Shield Capscrew
9. Dust Shield
10. Camshaft Snap Ring
11. Spacing Washer
12. Thin Spacing Washer
13. Orange Seal, Automatic Slack Adjuster
14. Automatic Slack Adjuster
15. Seal, Automatic Slack Adjuster
16. Thick Camshaft Washer
17. Camshaft Seal
18. Camshaft Bushing, 1.50" I.D.
19. Camshaft-and-Chamber Bracket
20. Pipe Plug
21. Chamber Bracket Seal
22. Brake Spider, Cast
23. Brake Shoe Return Spring Pin
24. Brake Shoe Return Spring
25. Camshaft Bushing, 1.625" I.D.
26. Orange Camshaft Seal
27. Camhead Washer
28. "S" Head Camshaft

Fig. 3, Q Plus LX500 & MX500 Brake (with cast spider), Exploded View

⚠ CAUTION

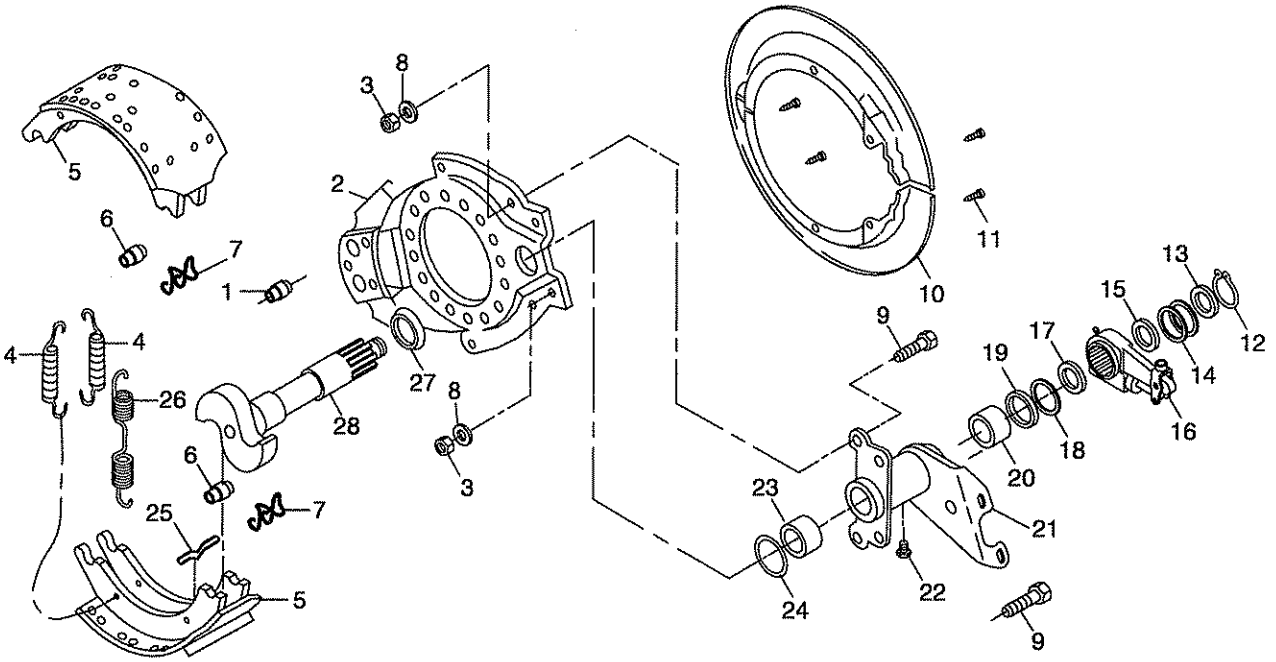
For a Meritor automatic slack adjuster, before turning the manual adjusting nut, disengage the pull-pawl by raising it up about 1/32 inch (0.8 mm). Failure to do so could damage the pull-pawl teeth. A damaged pull-pawl will not allow the slack adjuster to automatically adjust the brake clearance.

NOTE: For a Haldex or a Gunite automatic slack adjuster, there is an internal clutch that resists the manual adjusting nut from being turned in the counterclockwise direction (de-adjust direction). When checking these slack adjusters for binding, only rotate the manual adjusting nut in the clockwise direction.

6.2 Using a wrench, turn the manual adjusting nut so that the worm gear rotates a full 360 degrees. If there is binding, or if excessive force is need to turn the slack adjuster, replace it. For instructions, see the appropriate slack adjuster section in this group.

IMPORTANT: If any slack adjuster problem is found, repair or replace the unit, depending on the manufacturer's recommendations.

Brake Components Disassembly and Inspection, Cleaning, and Assembly

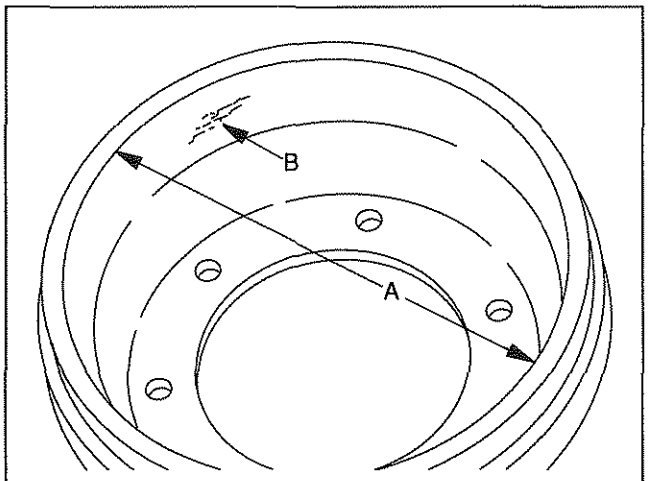


NOTE: 16-1/2 inch drive axle Q Plus (with LX500 and MX500 identification tags, and a stamped brake spider) brake shown.

1. Brake Shoe Anchor Pin
2. Brake Spider, Stamped
3. Nut (4), Grade 8
4. Brake Shoe Retaining Spring
5. Brake Shoe and Lining Assembly
6. Brake Shoe Roller
7. Brake Shoe Retainer
8. Washers (4), Hard
9. Capscrew, Grade 8
10. Dust Shield
11. Dust Shield Capscrew
12. Camshaft Snap Ring
13. Spacing Washer
14. Thin Spacing Washer
15. Orange Seal, Automatic Slack Adjuster
16. Automatic Slack Adjuster
17. Seal, Automatic Slack Adjuster
18. Thick Camshaft Washer
19. Camshaft Seal
20. Camshaft Bushing, 1.50" I.D.
21. Camshaft-and-Chamber Bracket
22. Pipe Plug
23. Camshaft Bushing, 1.625" I.D.
24. Orange Camshaft Seal
25. Brake Shoe Return Spring Pin
26. Brake Shoe Return Spring
27. Camhead Washer
28. "S" Head Camshaft

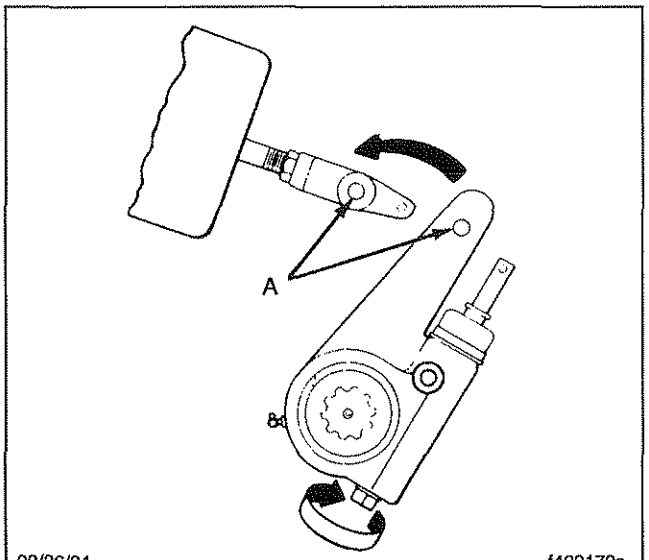
Fig. 4, Q Plus LX500 & MX500 Brake (with stamped spider), Exploded View

7. Remove the camshaft by grasping its head and pulling the camshaft outboard from the brake spider and camshaft-and-chamber bracket. See **Fig. 8**. Then, remove the thrust washer from the camshaft.
8. Check the camshaft spline end for cracks, corrosion, or worn or deformed splines. Replace the camshaft if damaged.
9. Check the camshaft bearing journals for wear or corrosion. Replace the camshaft if it is worn or if roughness is felt in the journal area.
10. Inspect the camshaft head for brinelling, cracking, or flat spots. Replace the camshaft if a ridge can be felt between the worn area and the cam head surface.
11. From the brake spider and slack adjuster ends of the camshaft-and-chamber bracket, remove and



A. Check for diameter and for out-of-round.
B. Check for cracks, heat checks, glazing, and grooves.

Fig. 5, Check the Drum



A. Push Rod Clevis Hole

Fig. 6, Disconnect Push Rod Clevis

inspect the camshaft grease seals. If a grease seal lip is nicked, cut or distorted, replace it.

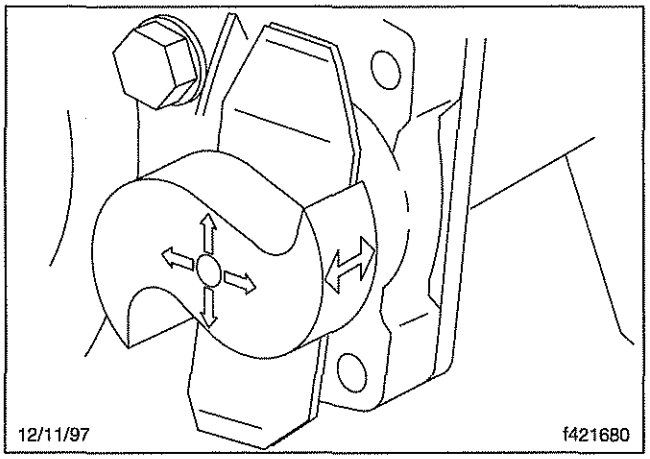


Fig. 7, Check Free Play

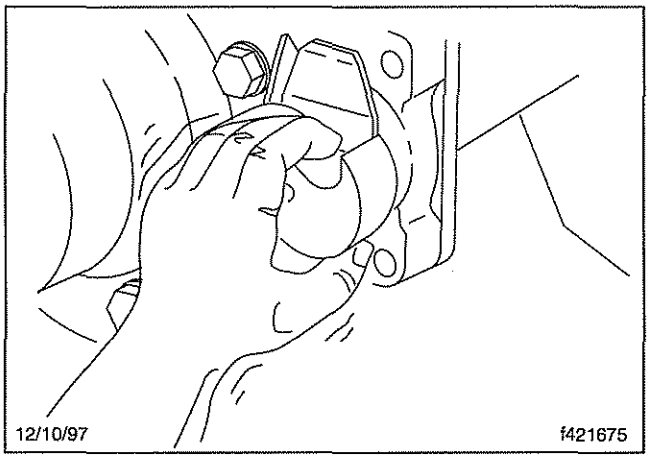


Fig. 8, Remove the Camshaft

⚠ WARNING

When removing bushings with a driver, wear eye protection. Do not hit steel parts with a steel hammer. To do so could cause steel pieces to break off, which could cause serious eye injury.

12. Using the correct size driver, remove the camshaft bushings from the camshaft-and-chamber bracket.
13. Check the camshaft bushings for wear. The inner surface must be smooth; if rough or abrasive, replace the bushings.
14. Remove the brake chamber stud nuts and lockwashers that attach the brake chamber to the camshaft-and-chamber bracket.

Brake Components Disassembly and Inspection, Cleaning, and Assembly

Check the chamber for a cracked housing, bent push rod, loose clamp ring, loose air fitting, air leaks, or clogged vent holes. Repair or replace brake chamber parts as needed.

15. Remove and inspect the camshaft-and-chamber bracket. Remove and discard its gasket.

    Check the bracket for a bent, broken or cracked arm, and cracked welds. Replace the bracket if any of these conditions exist.

16. Remove the brake spider-to-axle attaching nuts, hardened washers, and bolts. Remove the brake spider from the axle flange.

17. If equipped, remove the four capscrews that attach the dust shield to the brake spider; remove the dust shield.

NOTE: For "P" Series brakes, the anchor pins have already been removed (in the brake removal).

18. Inspect the brake spider and parts for damage; replace as needed.

    18.1 Check the bolt holes, cam area, and anchor pin area for cracks and check for expanded anchor pin holes. Replace if damaged.

    18.2 Check the anchor pins. If worn or loose, replace them.

    18.3 Check the anchor pin bushings for wear. The inner surfaces must be smooth. If any surface is rough or abrasive, replace the part.

Cleaning

⚠ WARNING

Before starting the procedure below, read the safety precaution information in Subject 100. Failure to be aware of the dangers of brake lining dust exposure could result in serious and permanent health damage.

⚠ CAUTION

Do not clean ground or polished metal parts in a hot solution tank or with water, steam, or alkaline solutions. These solutions will cause parts to corrode.

For corrosion protection, do not apply brake grease or corrosion-preventive materials to the brake linings or the brake drum.

After removing the brake parts being serviced, do the following:

1. Clean the camshaft journals with an emery cloth.
2. Wire brush all parts exposed to mud, road dirt, and salt, including the exterior of the drum, brake spider, camshaft-and-chamber bracket, and dust shields (if equipped). If relining the shoes, thoroughly wire-brush the shoe tables, and paint them with a rust inhibitive coating.

⚠ CAUTION

A thick layer of oxidation and dirt on the outside of a brake drum acts as an insulator and may hinder normal heat dissipation. Make sure oxidation and dirt are removed by wire brushing, or damage to brake components could occur.

3. Using an industrial vacuum cleaner with a HEPA filter system, remove excessive dust accumulation from the brake parts.
4. Wipe the interior of the drums with a damp rag to remove lining dust.
5. Prepare the brake parts for assembly.

    5.1 Thoroughly, clean all the brake parts.

    For ground or polished metal parts, use a cleaning solvent to clean the parts and surfaces that are ground or polished.

    For rough metal parts, use a cleaning solvent, or a weak alkaline solution in a hot solution tank, to clean the parts. If a hot solution tank is used, leave the rough parts in the hot solution tank until they are completely cleaned and heated. Remove the rough parts from the hot solution tank and wash them with water until the alkaline solution is removed.

    5.2 Thoroughly dry all the brake parts with either compressed air or a clean soft cloth (or paper) rag.

⚠ WARNING

All worn or damaged brake parts must be replaced. If the brakes are assembled with worn or damaged brake parts, the brakes may not perform to their capacity and a brake failure may occur, which could cause personal injury and property damage.

5.3 Thoroughly inspect all the brake parts for wear or damage. It is very important that all the parts be carefully inspected before they are assembled. Repair or replace and worn or damaged parts.

5.4 To protect the parts from corrosion, apply a thin layer of brake grease to the parts which have been cleaned, dried, inspected, and will be assembled.

If the parts will be stored, apply a special material that prevents corrosion and rust on all surfaces. The parts should be stored in special paper (or other material) that prevents corrosion and rust.

Assembly (See Fig. 1, Fig. 2, Fig. 3, or Fig. 4)

⚠ WARNING

Before starting the procedure below, read the safety precaution information in Subject 100. Failure to be aware of the dangers of brake lining dust exposure could result in serious and permanent health damage.

1. Install the dust shield, if equipped.

   Position the dust shield against the brake spider, and install the capscrews. Tighten the capscrews:

   - 5/16–18 Grade 5; 15 to 20 lbf·ft (20 to 27 N·m)
   - 3/8–16 Grade 5; 25 to 35 lbf·ft (34 to 47 N·m)
   - 3/8–16 Grade 8; 35 to 50 lbf·ft (47 to 68 N·m)

2. Install the brake spider.

   Place the brake spider on the axle flange. Using a hardened washer under the bolt head and the nut, install the mounting fasteners. Tighten the bolts (**Fig. 9**) in a cross pattern:

   - 7/16–20; 60 to 75 lbf·ft (81 to 102 N·m)
   - 1/2–20; 85 to 115 lbf·ft (115 to 156 N·m)
   - 9/16–18; 135 to 165 lbf·ft (176 to 224 N·m)
   - 5/8–18; 180 to 230 lbf·ft (244 to 312 N·m)

3. Install the camshaft-and-chamber bracket and the brake chamber.

   3.1 Place the camshaft-and-chamber bracket and gasket against the brake spider, and install the lockwashers and capscrews. Tighten the capscrews:

   - Without hexnuts, 1/2–13 Grade 5; 65 to 85 lbf·ft (88 to 116 N·m)
   - Without hexnuts, 1/2–13 Grade 8; 70 to 100 lbf·ft (95 to 136 N·m)
   - With locknuts, 5/8–18; 130 to 165 lbf·ft (176 to 224 N·m)
   - With plain hexnuts, 5/8–18; 150 to 190 lbf·ft (203 to 258 N·m)

   3.2 Place the brake chamber on the mounting flange (camshaft-and-chamber bracket) with the chamber mounting studs through the flange holes. Install the hardened flatwashers, lockwashers, and stud nuts. Tighten the brake chamber fasteners to the torque values listed in **Specifications 400**.

   NOTE: If replacing a brake chamber, make sure that the new chamber is the same size and make as the brake chamber on the other side of the axle.

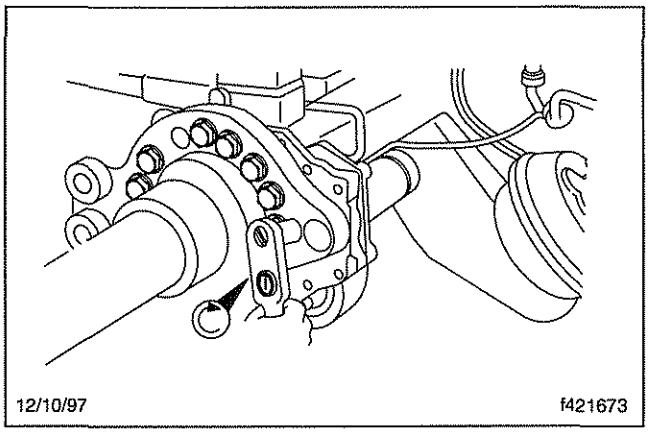


Fig. 9, Tighten the Brake Spider Bolts

Brake Components Disassembly and Inspection, Cleaning, and Assembly

IMPORTANT: The grease seals are installed in both the brake spider and slack adjuster ends of the camshaft-and-chamber bracket, the grease seals must be installed with their lips toward the slack adjuster end of the camshaft-and-chamber bracket tube.

NOTE: To avoid shorter lining life, Meritor recommends replacing the springs, rollers, anchor pins, and camshaft bushings when the linings are replaced. For brakes with the "Q" Plus LX500 and MX500 identification tags, if replacing the linings before the recommended service interval (3 years or 500,000 miles [800 000 km]), the camshaft bushings and the seals do not have to be replaced.

4. Using a seal driver, install the camshaft seals and the new camshaft bushings into the brake spider and slack adjuster ends of the camshaft-and-chamber bracket (**Fig. 10**). Install the seals with their lips toward the slack adjuster (**Fig. 11**).
5. Install the camshaft (**Fig. 12**).
   - 5.1 Put the camhead thrust washer on the camshaft with the bent flaps toward the brake spider.
   - 5.2 Apply a thin film of grease on the inside of the camshaft bushings and journals. For the recommended grease specification, see **Specifications 400**. Don't grease the camshaft head area.
   - 5.3 Apply a thin film of rust preventive grease on the camshaft splines. For the recommended grease specification, see **Specifications 400**.
   - 5.4 Carefully slip the camshaft into the brake spider and the camshaft-and-chamber bracket tube. The camshaft should turn freely by hand.
6. Install the slack adjuster.
   - 6.1 Slide the spacing washer on the camshaft. Install the slack adjuster seal with the lip facing the brake spider ("Q" Plus LX500 and MX500 only).

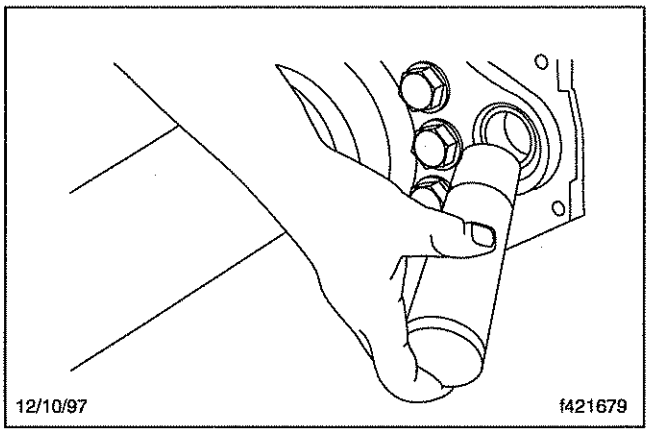
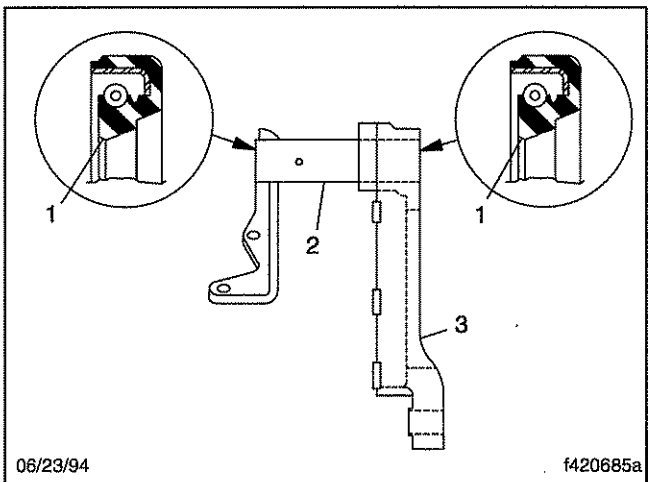


Fig. 10, Install the Seals and Bushings



NOTE: The seal is facing towards the slack adjuster.

1. Seal Lip
2. Camshaft-and-Chamber Bracket
3. Brake Spider

Fig. 11, Positioning the Seals

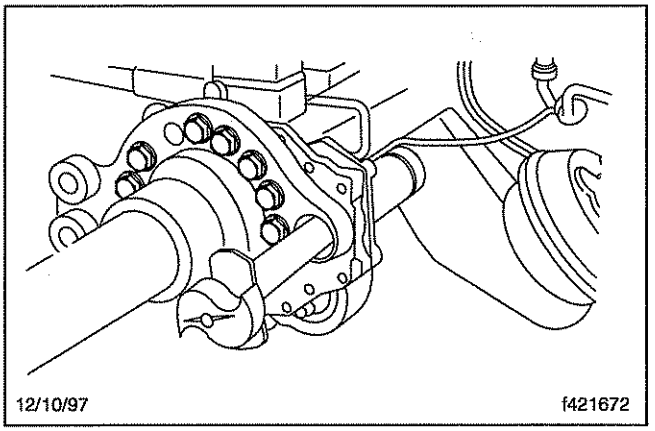


Fig. 12, Install the Camshaft

6.2 Slide the slack adjuster on the camshaft, with the adjuster nut on the side opposite of the brake chamber.

6.3 Install the orange slack adjuster seal with the lip facing the snap ring ("Q" Plus LX500 and MX500 only), the outer washers, and snap ring.

6.4 Use a dial indicator to measure the in-and-out (axial) end-play of the camshaft. For all Cam-Master brakes, except the "Q" Plus brakes with a LX500 and MX500 identification tag, there should be no more than 0.060 inch (1.5 mm) movement. For the "Q" Plus brakes with a LX500 and MX500 identification tag, the axial end play should be within 0.005 to 0.030 inch (0.13 to 0.80 mm). See **Fig. 7**. If necessary, add the appropriate number of spacing shims to achieve the correct axial end play.

6.5 Apply anti-seize compound to the two clevis pins.

⚠ CAUTION

For Meritor automatic slack adjusters, before turning the manual adjusting nut, disengage the pull-pawl by raising it up about 1/32 inch (0.8 mm). Failure to do so could damage the pull-pawl teeth. A damaged pull-pawl will not allow the slack adjuster to automatically adjust the brake clearance.

6.6 Using a wrench, turn the manual adjusting nut to align the large hole in the slack adjuster housing with the large hole in the clevis (**Fig. 13**). Then, insert both the clevis pins and cotter pins.

7. For the "Q" Plus brakes with the LX500 and MX500 identification tag, proceed to the next step. Otherwise, pressure lube the camshaft-and-chamber bracket bushings.

7.1 Pump multipurpose chassis grease (NLGI grade 1 or 2) into the camshaft-and-chamber bracket until it appears at the slack adjuster end of the bracket. For recommended grease specification, see **Specifications 400**.

NOTE: The use of meter-type fittings, having a maximum 40 psi (276 kPa) pressure relief at shutoff, is recommended.

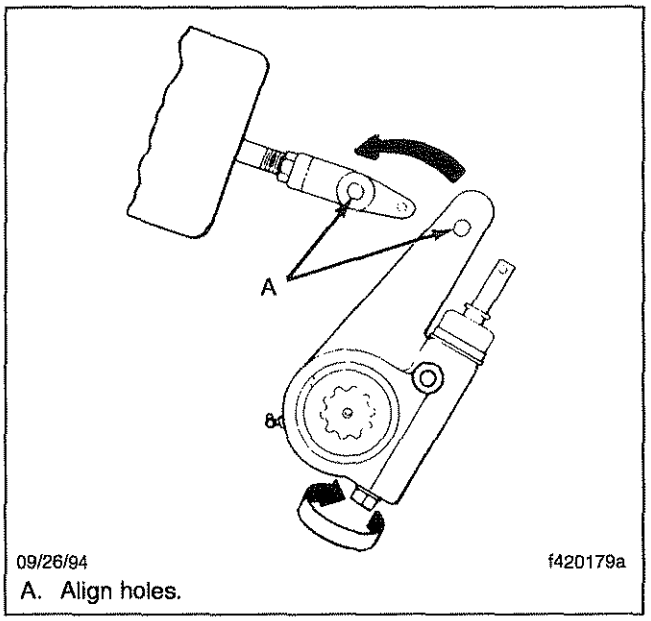
7.2 Use care that no grease enters the drum cavity. If grease leaks out under the cam head, the camshaft grease seal is worn or damaged, or is installed backwards.

For the "Q" Plus LX500 and MX500 brakes, if the brake linings are being replaced before the service interval (every 3 years or 500,000 miles [800 000 km], whichever comes first), then the camshaft-and-chamber bracket and the slack adjuster do not need lubrication.

8. For all Cam-Master brakes, except the "Q" Plus LX500 and MX500, proceed to the next step. Otherwise, when changing the brake linings for the Q" Plus LX500 and MX500 brakes at the service interval (which is performed every 3 years or 500,000 miles [800 000 km], whichever comes first). Lubricate the camshaft-and-chamber bracket and the automatic slack adjuster.

8.1 Remove the identification tag from the camshaft-and-chamber bracket housing.

8.2 Remove the grease plugs from both the camshaft-and-chamber bracket and the automatic slack adjuster.



A. Align holes.

Fig. 13, Attach the Slack Adjuster to the Clevis

Brake Components Disassembly and Inspection, Cleaning, and Assembly

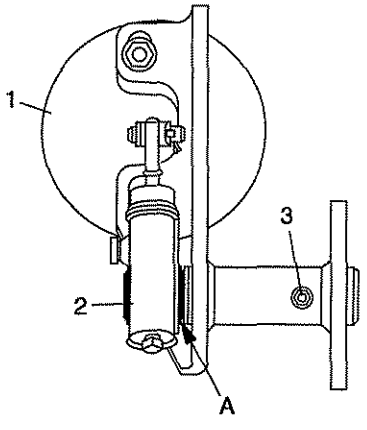
8.3 Install grease fittings.

⚠ WARNING

When lubricating the camshaft-and-chamber bracket, if grease leaks out under the cam head, the camshaft grease seal is worn or damaged. See disassembly and inspection for grease seal replacement instructions. If the seal is not replaced, the brake linings could be contaminated by grease and the vehicles stopping distance could be reduced, which could result in personal injury or property damage.

8.4 Using Meritor approved NLGI grade 2 synthetic polyurea grease (EVO-LUBE TEK-615), lubricate the brake assembly through the grease fitting in the bracket (**Fig. 14**, Ref. 3) until new grease flows from the inboard seal.

8.5 Using Meritor approved NLGI grade 2 synthetic polyurea grease (EVO-LUBE TEK-615), lubricate the slack adjuster through the grease fitting (**Fig. 15**, Ref. 7) until new grease flows out of the pull-pawl or camshaft seal.



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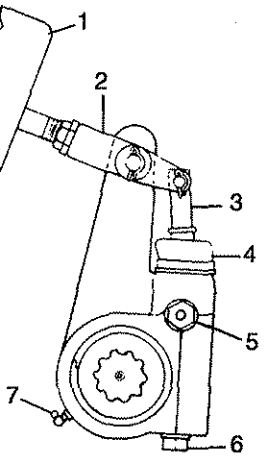
A. Grease Exit
1. Brake Chamber
2. Slack Adjuster
3. Grease Fitting (or lube plug)

Fig. 14, Camshaft-and-Chamber Bracket Lubrication

8.6 Replace the grease fittings with new grease plugs and cover the bracket plug with a new identification tag.

9. Install the brake shoes. For instructions, refer to **Subject 110**.



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1. Brake Chamber
2. Clevis
3. Actuator Rod
4. Boot
5. Pressure-Relief Capscrew, Gasket, Pawl Spring, and Pawl
6. Manual Adjusting Nut
7. Grease Fitting (or lube plug)

Fig. 15, Slack Adjuster Lubrication

Troubleshooting Tables

Problem—No Adjustment or Adjusted Stroke is Too Long

Problem—No Adjustment or Adjusted Stroke is Too Long	
Possible Cause	**Remedy**
The wrong slack adjuster is installed.	Replace the slack adjuster with the correct one.
The clevis is not installed correctly.	Check the slack adjuster installation. For instructions, see the appropriate slack adjuster section in this group.
There is excessive wear between the clevis and collar.	Check the gap between the clevis and the collar. The maximum allowable gap is 0.060 inch (1.5 mm). Replace the threaded clevis as necessary.
The jam nut at the clevis is loose.	Tighten the jam nut to specifications.
The large clevis pin bushing in the slack adjuster arm is worn.	Measure the inside diameter of the large clevis pin bushing. The inside diameter must not be larger than 0.53 inch (13.46 mm). Replace the bushing as necessary.
The return spring in the air chamber is weak or broken.	Check the air spring force. At the first movement of the push rod, the spring force must be at least 32 lbf (142.3 N). Replace the return spring or air chamber as necessary.
The spring brake is not fully retracting.	Repair or replace the spring brake.
The pull-pawl or the actuator is worn (the teeth are stripped).	Replace the pull-pawl or the actuator in the slack adjuster.
The slack adjuster has internal damage.	Inspect the slack adjuster. Repair or replace the slack adjuster as necessary. For instructions, see the appropriate slack adjuster section in this group.
There is excessive play between the slack adjuster gear and the splines of the camshaft.	Replace the camshaft and/or the slack adjuster as necessary.
Foundation brake components are worn.	Replace the components.

Problem—Linings Dragging or Adjusted Stroke is Too Short

Problem—Linings Dragging or Adjusted Stroke is Too Short	
Possible Cause	**Remedy**
The incorrect brake linings are installed	Install the correct Meritor approved brake linings.
The wrong slack adjuster is installed.	Replace the slack adjuster with the correct one.
The clevis is not installed correctly.	Check the slack adjuster installation. For instructions, see the appropriate slack adjuster section in this group.
The jam nut at the clevis is loose.	Tighten the jam nut to specifications.
The spring brake is not fully retracting.	Repair or replace the spring brake.
The manual (free-stroke) adjustment is incorrect.	Adjust the free-stroke and applied chamber stroke. For instructions, see **Subject 130**.
Poor contact between the linings and the drum, or the drum is out-of-round.	Repair or replace the drum or the linings.
There is a brake temperature imbalance.	Correct the brake balance.

Brake Torque Specifications				
Description	**Grade**	**Size**	**Torque, lbf.in (N.cm)**	**Torque, lbf.ft (N.m)**
Brake Shoe Lining Nuts	5	3/8"	—	18–23 (24–31)
Brake Shoe Lining Nuts	5	1/4"	80–100 (900–1120)	—
Dust Shield Capscrews	—	5/16–18	—	12–20 (16–27)
Dust Shield Capscrews	8	3/8–16	—	30–50 (41–68)
Dust Shield Capscrews	5	3/8–16	—	25–35 (34–47)
Camshaft-and-Chamber Bracket Capscrews	5	1/2–13	—	65–100 (88–136)
Camshaft-and-Chamber Bracket Capscrews	8	1/2–13	—	90–120 (122–163)
Camshaft and Chamber With Locknuts	—	5/8–18	—	130–165 (176–224)
Camshaft and Chamber With Plain Nuts	—	5/8–18	—	150–190 (203–258)
Spider Capscrews	—	7/16–20	—	60–75 (81–102)
Spider Capscrews	—	1/2–20	—	85–115 (115–156)
Spider Capscrews	—	9/16–18	—	130–165 (176–224)
Spider Capscrews	—	5/8–18	—	180–230 (244–312)

Table 1, Brake Torque Specifications

Brake Chamber Torque Specifications			
Chamber Type (Size)	**Midland Brake Chamber, lbf.ft (N.m)**	**MGM Brake Chamber, lbf.ft (N.m)**	**Anchorlok Brake Chamber, lbf.ft (N.m)**
16	35 to 50 (48 to 68)	35 to 40 (48 to 54)	Not Available
20	70 to 100 (95 to 136)	100 to 115 (136 to 156)	With hexnut, 110 to 115 (149 to 203) With locknut, 85 to 95 (115 to 129)
24	70 to 100 (95 to 136)	100 to 115 (136 to 156)	With hexnut, 110 to 115 (149 to 203) With locknut, 85 to 95 (115 to 129)
30	70 to 100 (95 to 136)	100 to 115 (136 to 156)	With hexnut, 110 to 115 (149 to 203) With locknut, 85 to 95 (115 to 129)

Specifications

Brake Chamber Torque Specifications			
Chamber Type (Size)	**Midland Brake Chamber, lbf·ft (N·m)**	**MGM Brake Chamber, lbf·ft (N·m)**	**Anchorlok Brake Chamber, lbf·ft (N·m)**
36	70 to 100 (95 to 136)	100 to 115 (136 to 156)	With hexnut, 110 to 115 (149 to 203) With locknut, 85 to 95 (115 to 129)
Spring Chamber	70 to 100 (95 to 136)	100 to 115 (136 to 156)	With hexnut, 110 to 115 (149 to 203) With locknut, 85 to 95 (115 to 129)

Table 2, Brake Chamber Torque Specifications

Meritor Grease Specification			
Specification Number	**NLGI Grade**	**Grease Type**	**Outside Temperature, °F (°C)**
O–616–A	1	Clay-Base	Down to –40 (–40)
O–617–A or O–617–B	1 and 2	Lithium 12-Hydroxy Stearate or Lithium Complex	See Manufacturer's Specification
O–645	2	Synthetic Oil, Clay-Base	Down to –65 (–54)
O–692	1 and 2	Lithium-Base	Down to –40 (–40)
O–637	1 and 2	Calcium-Base	See Manufacturer's Specification
O–641	—	Anti-Seize	See Manufacturer's Specification
O–695	2	Synthetic Polyurea	–40 (–40)

Table 3, Meritor Grease Specification

Component Lubrication						
Meritor Grease Specification Number						
Brake Type	**Clevis Pins**	**Camshaft Splines**	**Anchor Pins**	**Brake Shoe Rollers**	**Camshaft Bushings**	**Slack Adjuster**
All Cam-Master Brakes, Except "Q" Plus LX500 and MX500 Brakes	O–616–A, O–645, O–692, O–637, or O–641	O–616–A, O–617–A, O–617–B, O–645, O–692, O–637, or O–641	O–616–A, O–617–A, O–617–B, O–645, O–692	O–616–A, O–617–A, O–617–B, O–645, O–692	O–616–A, O–617–A, O–617–B, O–645, O–692	O–616A, O–645, O–692
"Q" Plus LX500 and MX500 Brakes Only	O–695	O–695	O–617–A, O–617–B, O–645, O–692	O–617–A, O–617–B	O–616–A, O–617–A, O–617–B, O–645, O–692	O–695

Table 4, Component Lubrication

Automatic Slack Adjuster, Rockwell 42.05

Contents

Subject	Subject Number
General Imformation	050
Service Operations	
Slack Adjuster Removal and Installation	100
Slack Adjuster Disassembly, Cleaning and Inspection, and Assembly	110
Specifications	400

General Description

The Meritor automatic slack adjuster has two main functions:

- As a lever, it converts the straight-line force of the brake chamber push rod to torque on the brake camshaft. Rotation of the camshaft forces the brake shoes against the brake drum.
- As an automatic adjuster, it automatically maintains brake chamber push rod stroke, which controls lining-to-drum clearance during operation.

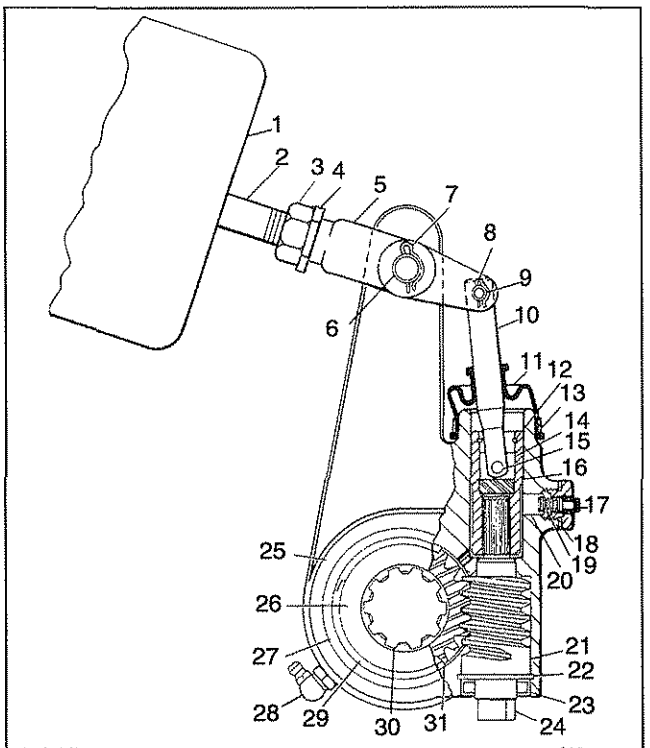
With an automatic slack adjuster, brakes adjust automatically when needed. As long as the push-rod stroke doesn't exceed the desired length, no adjustment takes place. Adjustment is made on the return stroke, as air is released and the forces in the gearset are low. The force to make an adjustment comes directly from the brake shoe return spring and the brake chamber return spring.

Principles of Operation (See Fig. 1)

The externally splined end of the worm (Ref. 21) fits the internal splines on the actuator (Ref. 16). Angled serrations on the spring-held pawl (Ref. 20) correspond with serrations on the actuator exterior. The serrations are formed to allow free upward movement of the actuator, and to lock in on the actuator serrations on a downward movement. As the brake is applied, the brake chamber push rod, connected to the end of the clevis, moves outward, forcing the slack adjuster arm to turn on the brake camshaft centerline. The actuator rod (Ref. 10) is connected to the clevis at one end, and to a small piston at the other end.

As the slack adjuster arm moves, the actuator rod is moved upward and outward, pulling the piston (Ref. 14) upward.

When lining wear becomes excessive, the brake chamber push-rod stroke goes beyond the desired length. The piston then makes contact with the retaining ring (Ref. 12) and pulls up the actuator. As the actuator moves upward and reaches a preset distance, it slides over one serration on the pawl. When the push rod moves back toward the brake chamber, the actuator is forced downward. Because the serrations in the pawl and actuator are now locked in, the actuator, following the curve of its serrations as it moves downward, turns slightly. This action causes the worm to turn, advancing the gear (Ref. 26) and the camshaft to automatically adjust the brake.



1. Brake Air Chamber
2. Brake Chamber Push Rod
3. Clevis Jam Nut
4. Quick-Connect Collar (if equipped)
5. Clevis
6. Clevis Pin (large)
7. Cotter Pin (large)
8. Cotter Pin (small)
9. Clevis Pin (small)
10. Actuator Rod
11. Boot
12. Piston Retaining Ring
13. Boot Retaining Clamp
14. Actuator Piston
15. Roller (Pin)
16. Actuator (Adjusting Screw)
17. Pressure Relief Capscrew (shown 90 degrees out of position)
18. Gasket
19. Pawl Spring
20. Pawl Assembly
21. Worm
22. Worm Retaining Snap Ring
23. Worm Seal
24. Manual (Worm) Adjusting Nut End
25. Slack Adjuster
26. Gear
27. Gear Thrustwasher
28. Grease Fitting (if equipped)
29. Gear Retaining Ring
30. Camshaft Splines
31. Gear-to-Body Seal

Fig. 1, Meritor Slack Adjuster

Slack Adjuster Removal and Installation

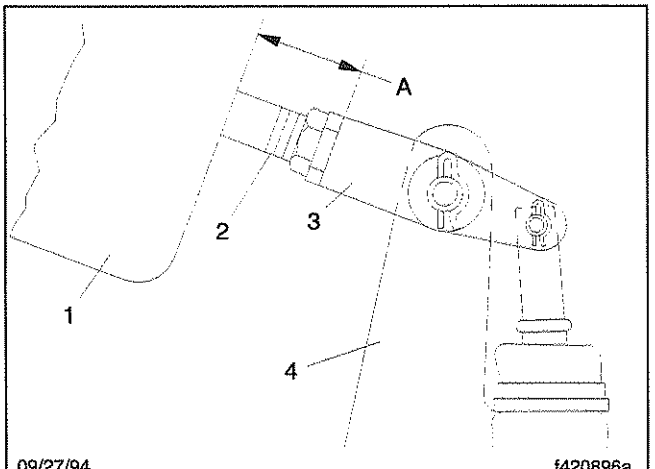
Removal

1. Park the vehicle on a level surface, and chock the tires. If the rear slack adjusters will be removed, release the parking brakes, then cage the power spring of the parking brake chamber.

⚠ WARNING

Manually cage each parking brake chamber power spring in the release (no application) position before continuing. Loss of brake chamber air pressure will cause sudden application of the parking brakes, which could result in personal injury.

2. Mark or measure the position of the clevis on the brake chamber push rod. See **Fig. 1**.
3. Remove the cotter pins from the clevis pins. Remove the clevis pins.
4. Remove the pressure relief capscrew, spring, and pawl assembly from the slack adjuster housing. See **Fig. 2**. If equipped with a pull-pawl assembly (**Fig. 3**), carefully insert a screwdriver and raise the relief cap about 1/8 inch (3.2 mm).



A. Mark or measure this distance.
1. Brake Chamber
2. Brake Chamber Push Rod
3. Clevis
4. Slack Adjuster

Fig. 1, Mark or Measure the Position of the Clevis

⚠ CAUTION

Before turning the adjusting nut, remove the pressure relief capscrew, spring, and pawl assembly. If equipped with a pull-pawl assembly, raise the relief cap about 1/8 inch (3.2 mm). Failure to do so could strip the teeth on the pawl.

5. Using a wrench, turn the manual adjusting nut, and move the slack adjuster away from the clevis. See **Fig. 4**.
6. Remove the snap ring and washers that attach the slack adjuster to the brake camshaft and save them for later installation.
7. Remove the slack adjuster from the camshaft.
8. Note the location and number of any remaining spacing washers on the camshaft, and then remove them. Save them for later installation.
9. If replacing the clevis, loosen the clevis jam nut. Remove the clevis and jam nut from the brake chamber push rod.

Installation

1. Inspect parts, and then prepare the slack adjuster for installation.

   1.1 Check the brake camshaft splines for wear or corrosion.

   1.2 Coat the camshaft splines and the splines of the slack adjuster gear with Meritor lubricant 0–637, Southwest SA 8249496, or an equivalent.

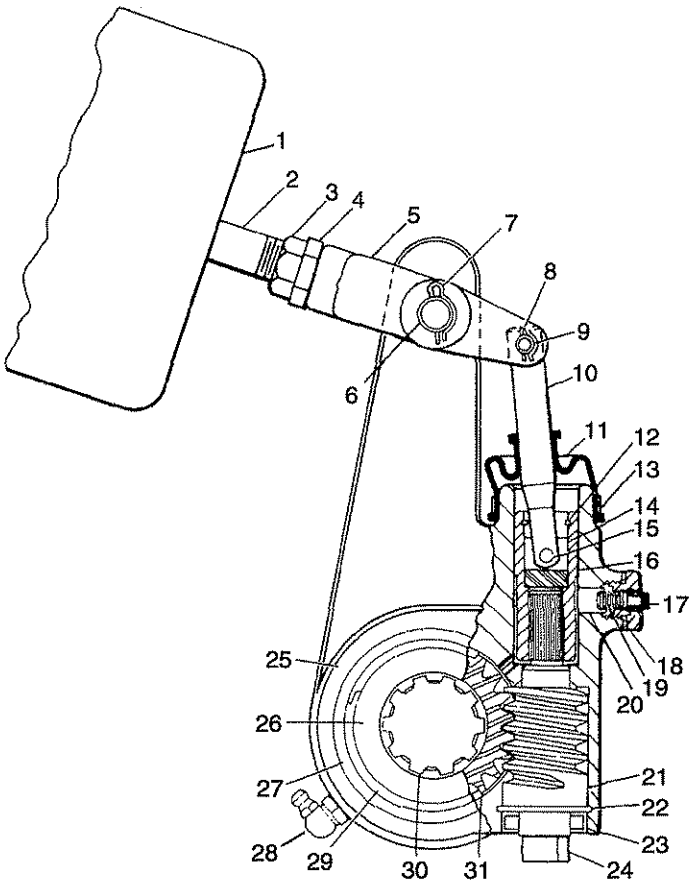
   IMPORTANT: These lubricants provide corrosion protection. Do not mix these lubricants with other types.

   1.3 Apply the service brake and parking brake several times. Make sure the return spring retracts the push rod quickly and completely. Replace the return spring or brake chamber if needed.

2. If previously removed, install the clevis and jam nut.

   Check that the clevis is in the same position on the brake chamber push rod as marked or measured

Slack Adjuster Removal and Installation



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1. Brake Air Chamber
2. Brake Chamber Push Rod
3. Clevis Jam Nut
4. Quick-Connect Collar (if equipped)
5. Clevis
6. Clevis Pin (large)
7. Cotter Pin (large)
8. Cotter Pin (small)
9. Clevis Pin (small)
10. Actuator Rod
11. Boot
12. Piston Retaining Ring
13. Boot Retaining Clamp
14. Actuator Piston
15. Roller (Pin)
16. Actuator (Adjusting Screw)
17. Pressure Relief Capscrew (shown 90 degrees out of position)
18. Gasket
19. Pawl Spring
20. Pawl Assembly
21. Worm
22. Worm Retaining Snap Ring
23. Worm Seal
24. Manual (Worm) Adjusting Nut End
25. Slack Adjuster
26. Gear
27. Gear Thrustwasher
28. Grease Fitting (if equipped)
29. Gear Retaining Ring
30. Camshaft Splines
31. Gear-to-Body Seal

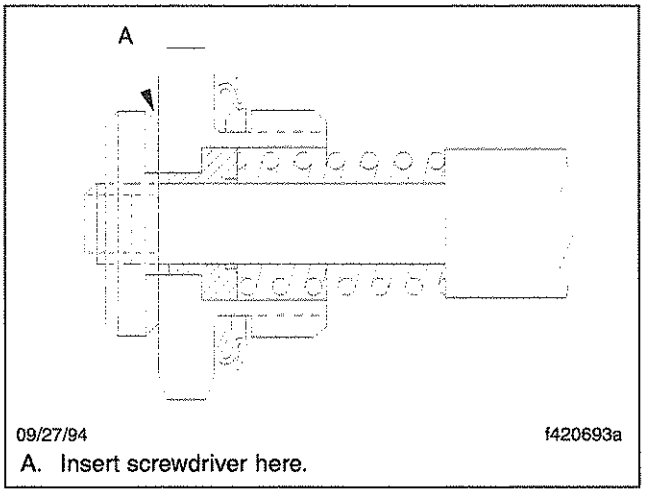
Fig. 2, Meritor Automatic Slack Adjuster

during removal. Do not tighten the jam nut against the clevis.

NOTE: Use a clevis with a 1/2–20 UNF thread if equipped with type 9, 12, or 16 brake chambers. Use a clevis with a 5/8–18 UNF thread size if equipped with type 20, 24, 30, or 36 brake chambers.

3. Install the slack adjuster.

   3.1 If installing a new slack adjuster, use an installation template (**Fig. 5**) and measure the new slack adjuster to make sure it is the same length as the slack adjuster that was removed. Refer to the appropriate table in **Specifications 400** for the length of slack



A. Insert screwdriver here.

Fig. 3, Pull-Pawl Assembly (sectional view)

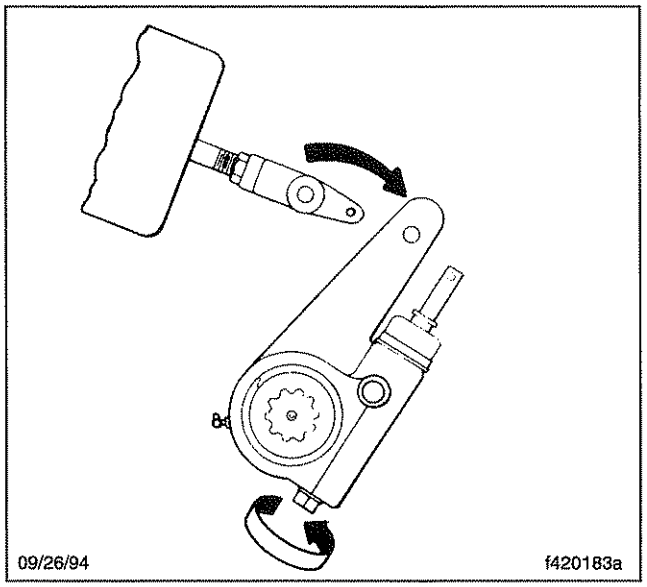


Fig. 4, Turn the Manual Adjusting Nut

adjusters that should be used with various sizes of brake chambers.

NOTE: Depending on the type of brakes used on a tractor or trailer, several types of installation templates are used. They can be made using the measurements provided in **Fig. 6**. Or, they can be ordered from:

Attn: Literature Distribution Meritor International 2135 W. Maple Road Troy, Michigan 48084

3.2 Position the slack adjuster on the camshaft.

3.3 Install the spacing washers and the snap ring that attach the slack adjuster to the camshaft. Add enough washers to limit the camshaft end play to 0.060 inch (1.5 mm). Check the end play using the instructions in the brake chamber section in this manual.

3.4 If installing a new slack adjuster, remove the pressure relief capscrew, spring, and pawl assembly from the slack adjuster housing. If equipped with a pull-pawl assembly (**Fig. 3**), carefully insert a screwdriver and raise the relief cap about 1/8 inch (3.2 mm).

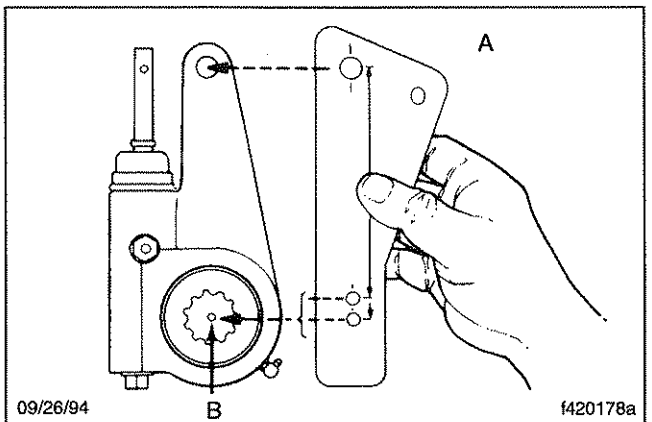
⚠ CAUTION

Before turning the adjusting nut, remove the pressure relief capscrew, spring, and pawl assembly. If equipped with a pull-pawl assembly, raise the relief cap about 1/8 inch (3.2 mm). Failure to do so could strip the teeth on the pawl.

3.5 Using a wrench, turn the manual adjusting nut to align the hole in the slack adjuster housing with the large hole in the clevis. See **Fig. 7**.

3.6 With the brakes fully released, place the applicable installation template over the clevis and camshaft end. See **Fig. 8**.

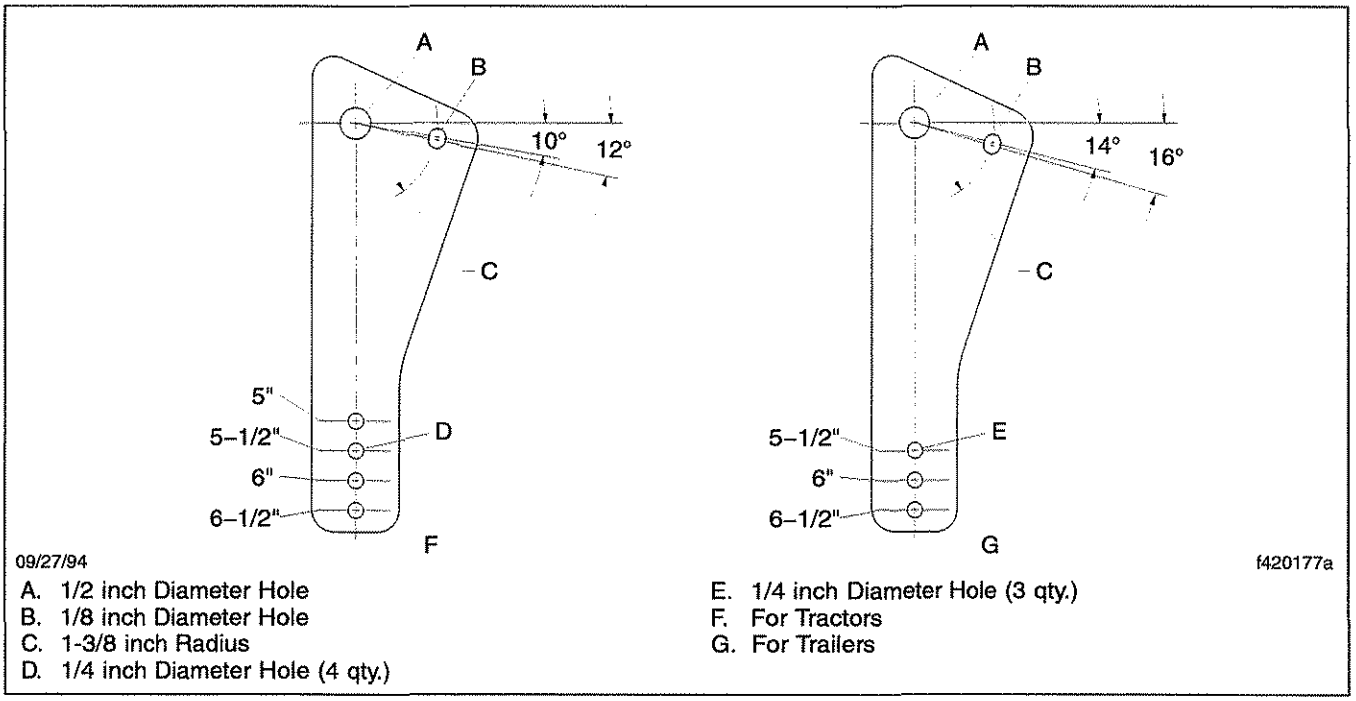
3.7 Temporarily insert the large clevis pin through the large holes in the template and the clevis.



A. Measure slack adjuster arm length.
B. Camshaft Center

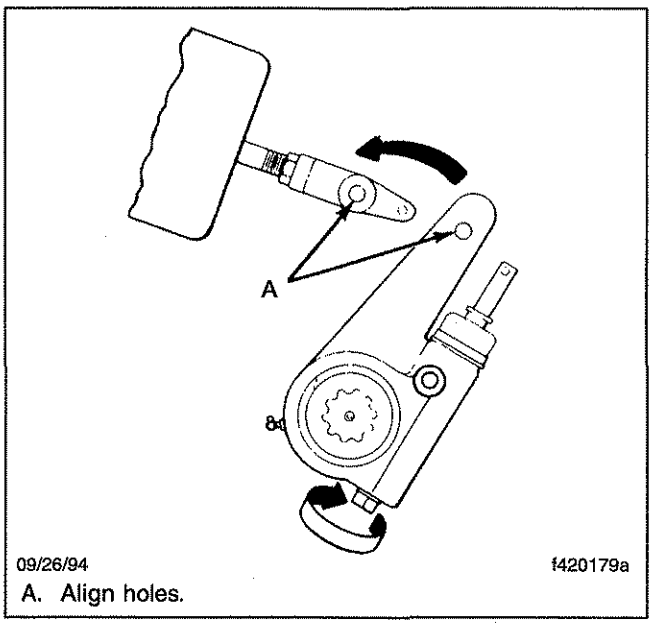
Fig. 5, Use an Installation Template

Slack Adjuster Removal and Installation



A. 1/2 inch Diameter Hole
B. 1/8 inch Diameter Hole
C. 1-3/8 inch Radius
D. 1/4 inch Diameter Hole (4 qty.)
E. 1/4 inch Diameter Hole (3 qty.)
F. For Tractors
G. For Trailers

Fig. 6, Dimensions for Installation Templates



A. Align holes.

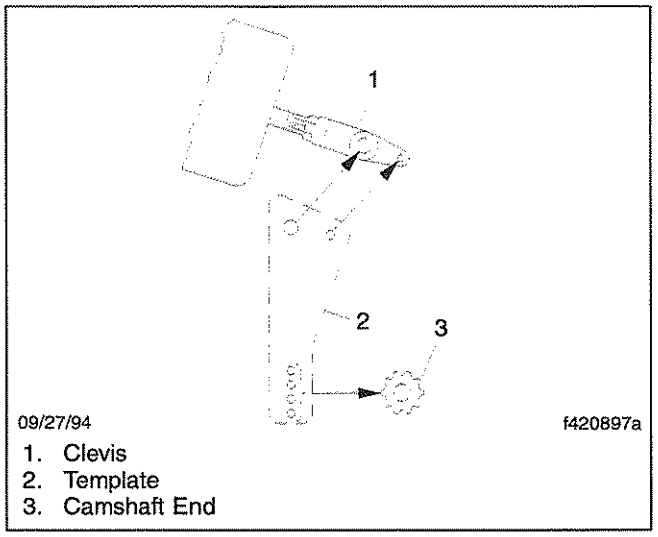
Fig. 7, Align the Large Holes in the Clevis and the Slack Adjuster

3.8 Select the hole in the template that matches the length of the slack adjuster. Hold the template in place on the center of the camshaft with a pencil.

3.9 Look through the small hole in the template and see if the small hole in the clevis is completely visible. If the hole in the clevis is not completely visible, adjust the position of the clevis on the push rod until the small clevis hole is completely visible. Temporarily place the small clevis pin through the template and clevis to make sure the alignment is correct. Remove both pins and the template. Insert both clevis pins with the pin head on the inboard side of the slack adjuster. Be sure the small clevis pin is inserted through the hole in the actuator rod. Install and lock new cotter pins to secure the clevis pins.

IMPORTANT: Make sure that there is at least 1/2 inch (13 mm) of thread engagement between the clevis and the push rod. Also, check that the push rod doesn't extend through the clevis more than 1/8 inch (3.2 mm). See **Fig. 9**. If needed, either cut the push rod, install a new push rod, or install a new brake chamber.

Slack Adjuster Removal and Installation

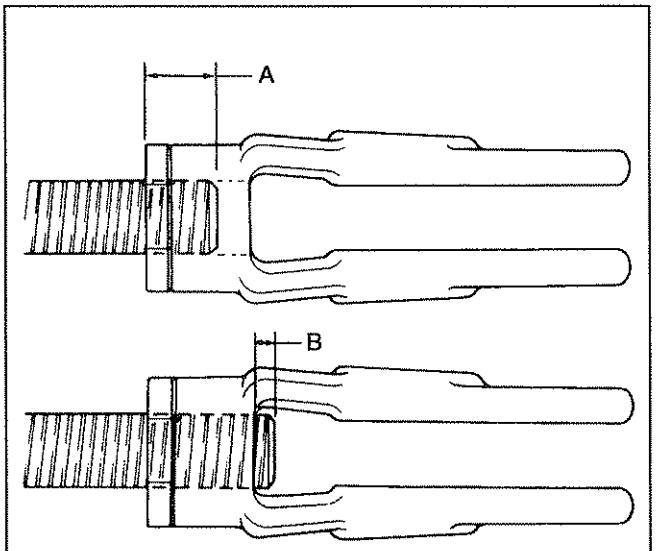


1. Clevis
2. Template
3. Camshaft End

Fig. 8, Place Template over the Clevis and Camshaft End

3.10 For 1/2–20 UNF threads, tighten the clevis jam nut 20 to 30 lbf·ft (27 to 41 N·m). For 5/8–18 UNF threads, tighten the jam nut 25 to 50 lbf·ft (34 to 68 N·m).

4. Set the free-stroke.



A. Minimum 1/2" (13 mm)
B. Maximum 1/8" (3.2 mm)

Fig. 9, Check Push Rod Engagement

4.1 Turn the manual adjusting nut counterclockwise until the brake linings contact the brake drum.

4.2 Set the approximate clearance between the linings and the drum: turn the adjusting nut clockwise one-half turn.

4.3 With the brakes fully released, measure the distance from the bottom of the brake chamber to the center of the large clevis pin. See **Fig. 10**, Ref. B.

4.4 Use a pry bar to move the slack adjuster, and apply the brakes. Again, measure the distance from the bottom of the brake chamber to the center of the large clevis pin. See **Fig. 10**, Ref. A.

The difference between the two measurements is the initial free-stroke, and sets the clearance between the linings and the drum.

The free stroke must be:

Drum brakes—5/8 to 3/4 inch (16 to 19 mm).

If the free stroke is incorrect, turn the adjusting nut one-eighth turn, as shown in **Fig. 11**. Measure the stroke again, and adjust until it is correct.

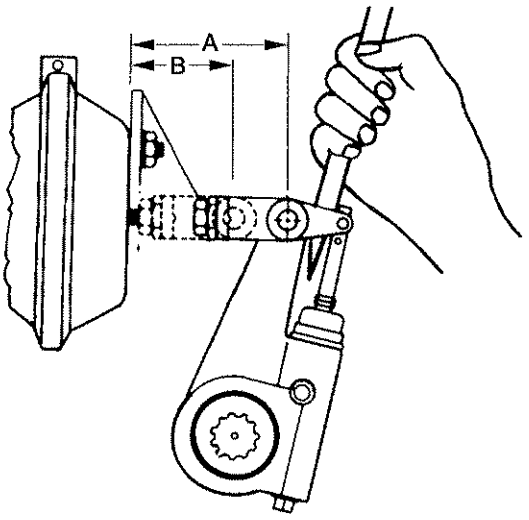
5. Measure the brake chamber stroke, and adjust as needed.

5.1 With the brakes fully released, measure the distance from the bottom of the brake chamber to the center of the large clevis pin. See **Fig. 12**, Ref. A.

5.2 Build air pressure to 100 psi (689 kPa). Shut down the engine. Fully apply the brakes, then measure the distance from the bottom of the brake chamber to the center of the large clevis pin. See **Fig. 12**, Ref. B. The difference between the measurements is the brake chamber stroke.

5.3 The brake chamber stroke must be less than the measurements shown in the appropriate table in **Specifications 400**. If needed, turn the adjusting nut to adjust the brake chamber stroke.

Slack Adjuster Removal and Installation



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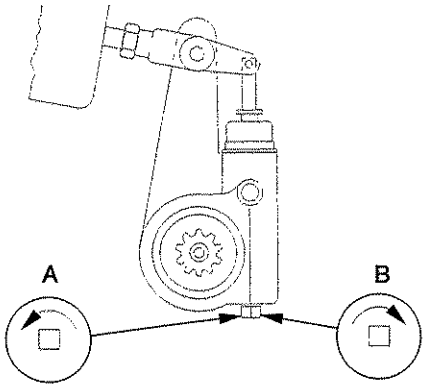
NOTE: For a drum brake, A minus B must equal 5/8" to 3/4" (16 to 19 mm).

Fig. 10, Measuring Free-Stroke

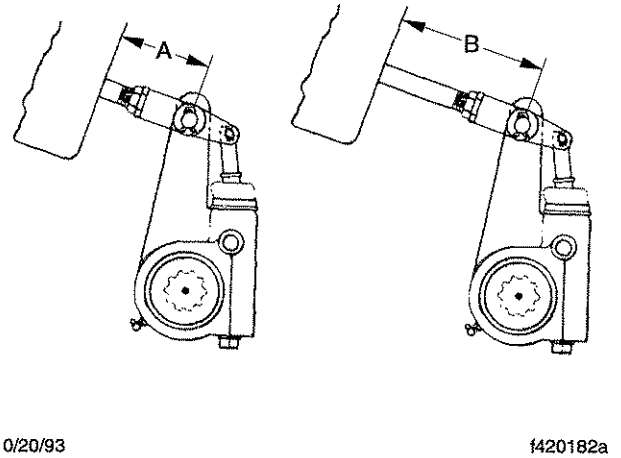


07/05/95 f420181a

A. Shorten stroke. B. Lengthen stroke.

Fig. 11, Turn the Adjusting Nut

If the stroke varies or remains greater than the specified range, check the brake components, including the camshafts, camshaft bushings, anchor pins, rollers, chamber brackets, clevis, and clevis pins. For instructions, refer to the applicable brake section in this group.



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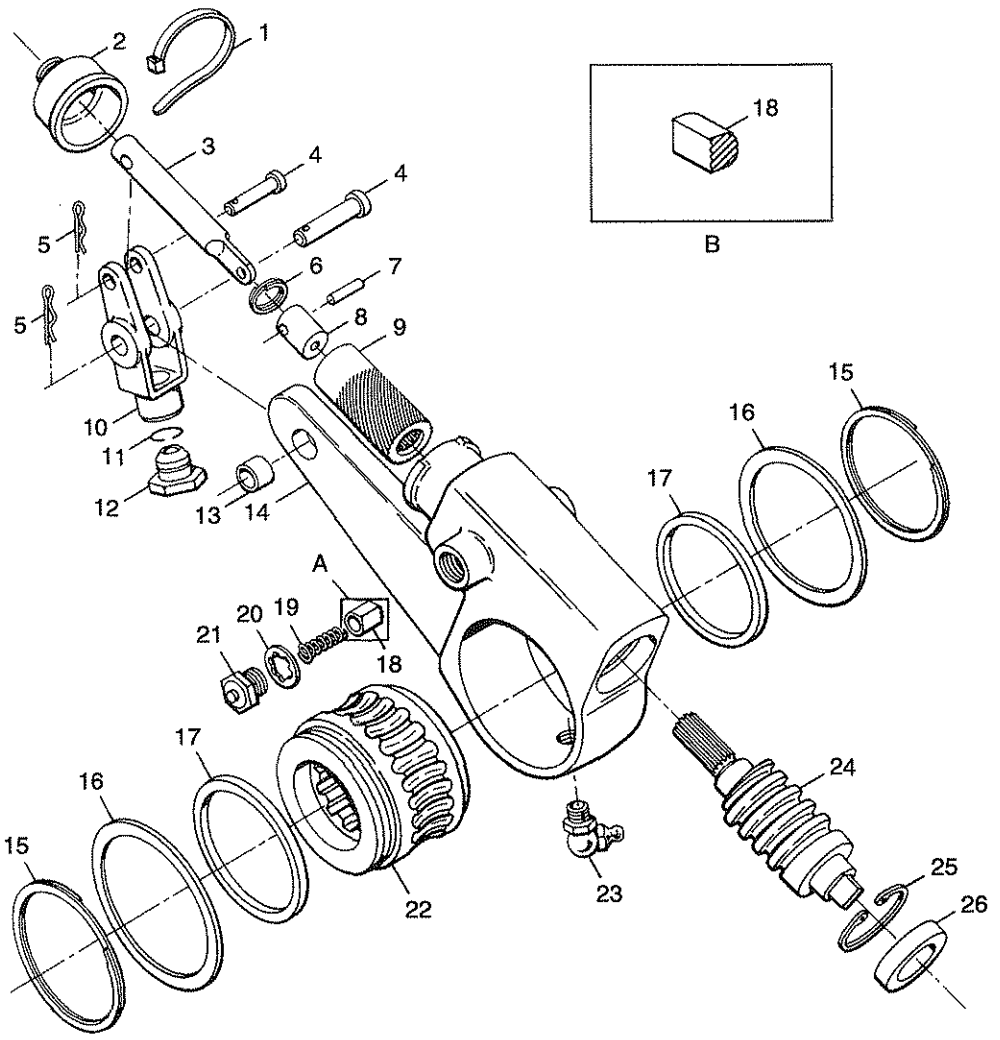
NOTE: Measure distance *A* with the brakes released; measure distance *B* with the brakes applied.

Fig. 12, Measuring Adjusted Brake Chamber Stroke

6. Install the pawl assembly, spring, and the pressure relief capscrew. Tighten the capscrew 15 to 20 lbf·ft (20 to 27 N·m). Or, remove the screwdriver from the pull-pawl assembly (if equipped).
7. If equipped with a grease fitting, lube the slack adjuster through the grease fitting until the lubricant is forced out through the pressure relief fitting (or pawl slot), or through the gear splines around the inboard snap ring.
8. If a rear axle slack adjuster was installed, manually uncage the parking brake. For instructions, refer to the applicable brake chamber section in this group.
9. Remove the chocks from the tires.

Slack Adjuster Disassembly, Cleaning and Inspection, and Assembly

Disassembly (See Fig. 1)



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A. See Detail B.

B. End view showing serrations.

1. Boot Retaining Clamp
2. Boot
3. Actuator Rod
4. Clevis Pin
5. Cotter Pin
6. Piston Retaining Ring
7. Roller (Pin)
8. Actuator Piston
9. Actuator
10. Clevis
11. Clevis Retaining Ring (if equipped)
12. Quick-Connect Collar (if equipped)
13. Large Clevis Pin Bushing
14. Slack Adjuster Housing
15. Gear Retaining Ring
16. Gear Thrustwasher
17. Gear-to-Body Seal
18. Adjusting Pawl
19. Pawl Spring
20. Gasket
21. Pressure Relief Capscrew
22. Gear
23. Grease Fitting (if equipped)
24. Worm
25. Worm Retaining Snap Ring
26. Worm Grease Seal

Fig. 1, Slack Adjuster (exploded view)

Slack Adjuster Disassembly, Cleaning and Inspection, and Assembly

IMPORTANT: The extended lube slack adjuster cannot be disassembled. If an extended lube slack adjuster is not working properly, it must be replaced.

1. Remove the slack adjuster. For instructions, see **Subject 100**.
2. Cut the boot retaining clamp, and remove the clamp from the rubber boot.
3. Remove the boot and the actuator (adjusting sleeve) from the housing. See **Fig. 2**. You may need to first work the boot off of the housing before removing the actuator.
4. Using a small screwdriver, press down the piston retaining ring and force it out of the groove (**Fig. 3**). Using pliers, unwind the ring and pull it out.
5. Pull the actuator rod, piston, and pin from the actuator bore.
6. Using a small hammer and brass drift punch, remove the pin from the rod and piston. See **Fig. 4**.
7. Using a small screwdriver, pry the grease seal from around the worm. See **Fig. 5**.
8. Using snap ring pliers, remove the retaining ring from the worm. See **Fig. 6**.
9. Using a wrench, turn the manual adjusting nut, and wind the worm out of the bore.
10. On one side of the housing, insert a small screwdriver into the notch at the end of the retaining ring. Remove the end of the retaining ring from the groove.

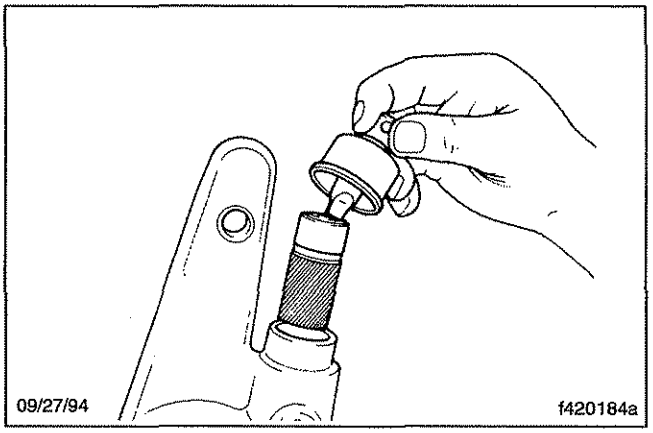


Fig. 2, Removal of the Actuator

Unwind the ring by hand and pull it out of the groove. See **Fig. 7**. Remove the thrustwasher.

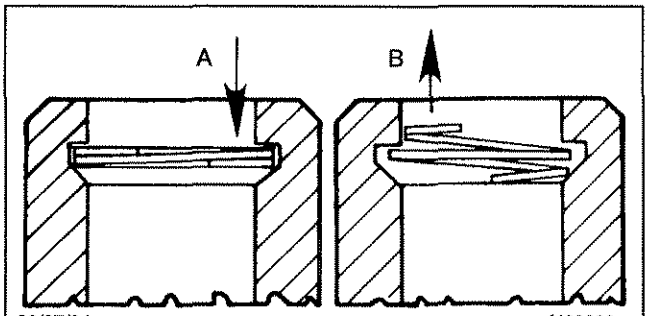
11. Push the gear far enough out of the housing to remove one gear seal.

    Push the gear far enough out of the opposite side of the housing to remove the other gear seal. Remove the gear from the housing.

Cleaning and Inspection

⚠ CAUTION

Don't clean ground or polished parts in a hot solution tank or with water-and-alkaline solutions,



A. Push the ring down.
B. Pull the ring out.

Fig. 3, Removal of the Internal Piston Retaining Ring

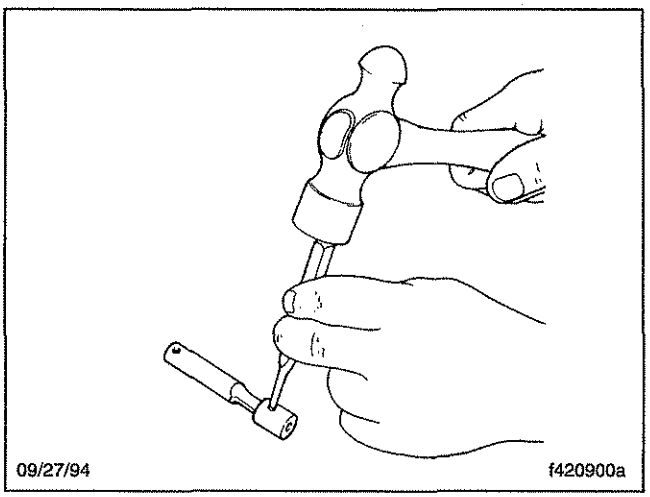


Fig. 4, Remove the Pin from the Rod and Piston

Slack Adjuster Disassembly, Cleaning and Inspection, and Assembly

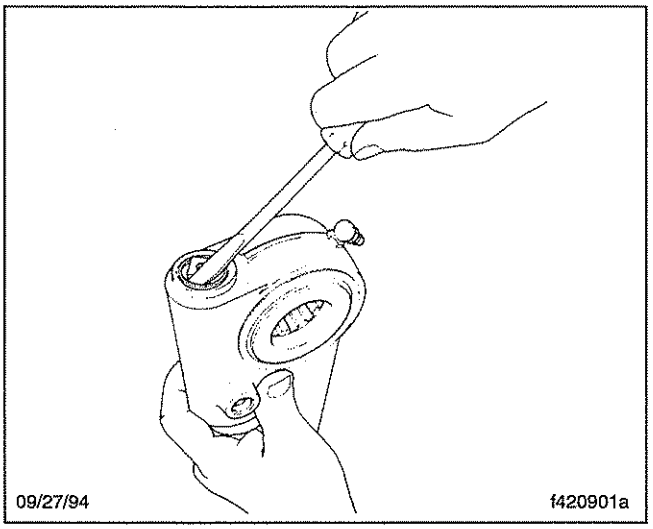


Fig. 5, Pry out the Grease Seal

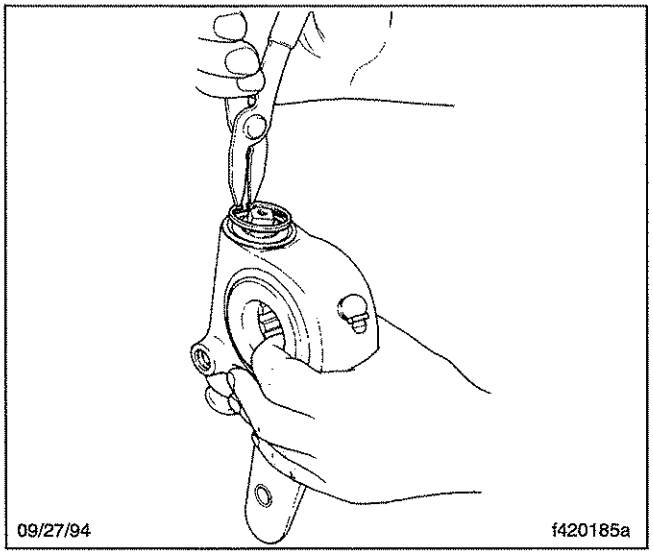


Fig. 6, Remove the Worm Retaining Ring

such as sodium hydroxide, orthosilicates, or phosphates. Also, don't use solvent-type cleaners on any nonmetallic parts. Doing so could damage the parts.

1. Clean the slack adjuster parts.
   - 1.1 Clean all parts having ground and polished surfaces (such as the worm, worm gear, and inner bores of the slack housing) with solvent-type cleaners, such as emulsion cleaners, carbon tetrachloride, or petroleum solvents (excluding gasoline).
   - 1.2 Dry all parts immediately after cleaning. Use soft, clean, lint-free absorbent paper towels, or wiping rags free of abrasive material such as lapping compound, metal filings, or contaminated oil.
2. Inspect all parts for wear or damage.
   - 2.1 Inspect all parts for wear or stress. Replace as needed.
   - 2.2 Inspect the seals, and discard if they show any signs of damage.
   - 2.3 Check the condition and fit of the large clevis pin bushing in the arm of the slack adjuster. Don't remove the bushing unless it is worn or egg-shaped.
3. If storing parts for any length of time, treat them with a good rust preventative, and wrap them in special paper or other material designed to prevent corrosion.

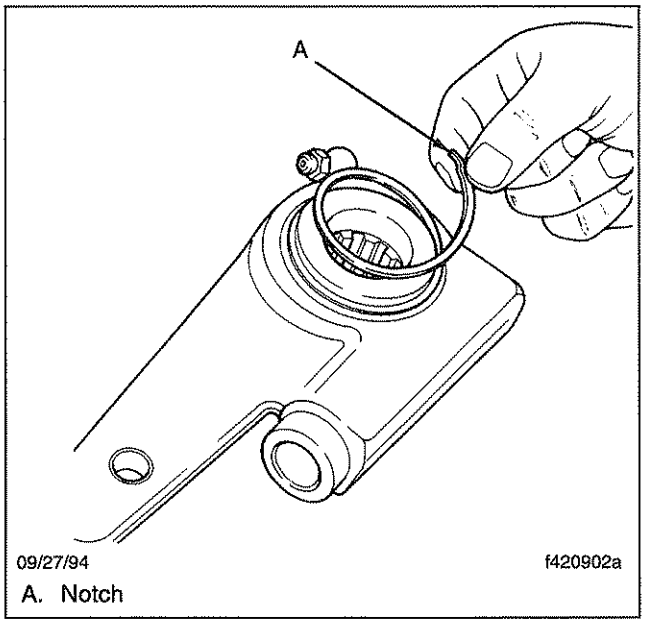


Fig. 7, Remove the Gear Retaining Ring

Slack Adjuster Disassembly, Cleaning and Inspection, and Assembly

Assembly (See Fig. 1)

1. Coat all parts and the gear bore with a grease recommended in the appropriate table in **Specifications 400**.
2. Install the gear into the housing.
   - 2.1 Place the gear, without the gear seals, into the housing. Keep one seal groove outside the housing.

     Make sure the gear goes straight into the bore. If needed, use a small rawhide mallet to tap the gear into place.
   - 2.2 Install a seal into the groove. See **Fig. 8**.

⚠ CAUTION

Do not push the side of the gear that has the seal installed through the housing. Damage to the seal will occur when it passes the sharp edges of the intersecting worm bore.

   - 2.3 Push the gear far enough out the opposite side of the housing so you can see the other seal groove.
   - 2.4 Install the seal in the groove, and push the gear into the housing.

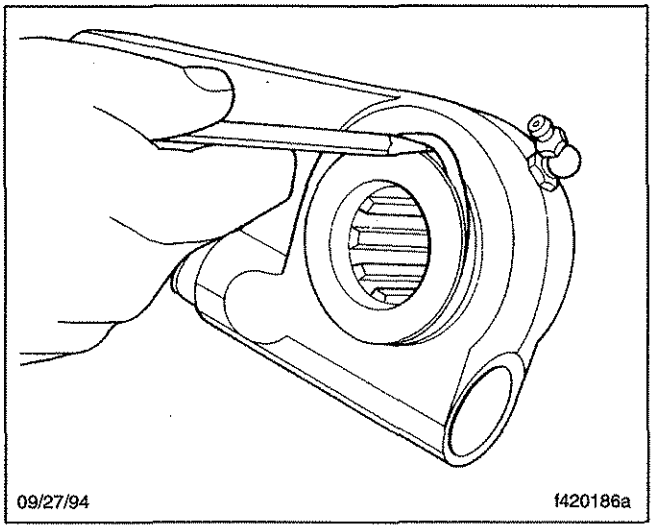


Fig. 8, Install a Seal

   - 2.5 On one side of the gear, position a thrust-washer around the gear and against the housing. Spread out the retaining ring coil. Put one end of the coil into the groove in the outer diameter of the gear. Work around the gear and press the coil into the groove.
   - 2.6 Repeat this step for the other side of the gear.
3. Install the worm into the housing.
   - 3.1 Place the worm into the bore, then turn the adjusting nut to wind the worm to the bottom of the bore.
   - 3.2 Install the retaining snap ring.
   - 3.3 Place the grease seal over the worm bore, with the lips facing outward and the metal retainer facing toward the inside of the bore. See **Fig. 9**. Using a hammer and a 1-3/16 inch seal driver, install the seal.

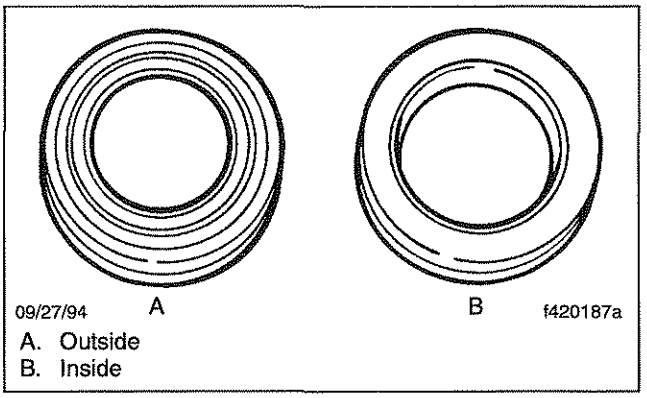
⚠ CAUTION

Failure to install the grease seal properly could allow contaminants to enter the housing and damage the parts.

4. Assemble the actuator, rod, and piston.
   - 4.1 Using a small hammer and brass drift punch, install the pin that connects the piston and actuator rod.
   - 4.2 Insert the actuator rod and piston into the actuator (adjusting sleeve).
   - 4.3 Slide the piston retaining ring over the rod. Spread out the coils of the ring. Using a small screwdriver, press one end of the ring into the groove. See **Fig. 10**. Press on the ring and work it around the groove until it is completely seated in the groove.

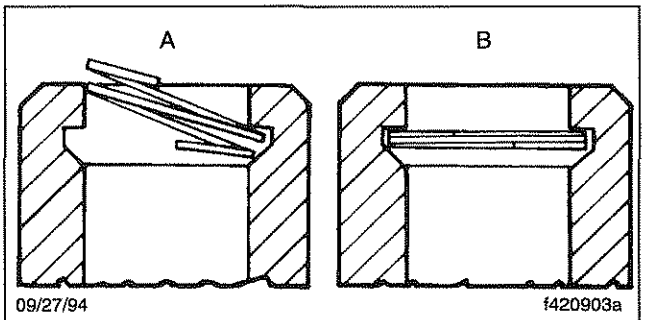
     See if the ring is seated correctly. You will not be able to pull the piston out of the actuator if the ring is seated correctly.
5. Slide the actuator assembly along the splines of the worm and into the slack housing.
6. Lubricate the actuator rod with grease, then slip the boot over the rod. Attach the boot to the

Slack Adjuster Disassembly, Cleaning and Inspection, and Assembly



A. Outside
B. Inside

Fig. 9, Grease Seal Placement



A. Start bottom coil.
B. Tuck ring into groove.

Fig. 10, Installation of the Internal Piston Retaining Ring

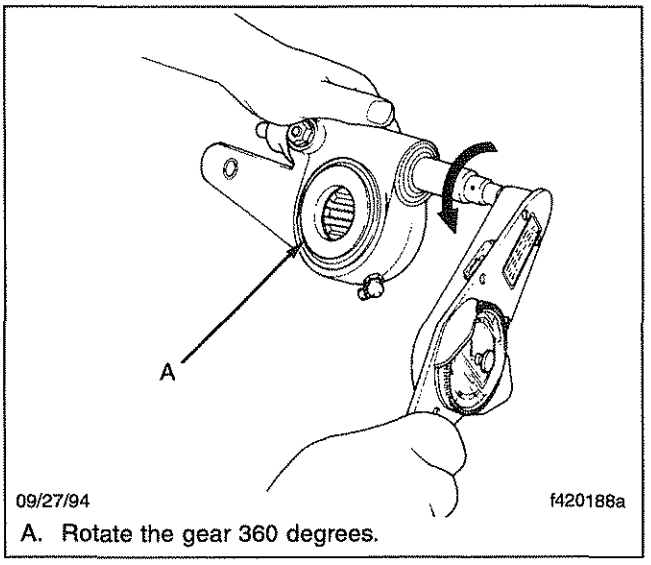
housing with a silastic coating and a new retaining clamp.

Make sure that the top of the boot fits on the round part of the rod, not the tapered part.

Seal the top part of the boot with a silastic coating.

7. If previously removed, install a new bushing into the large clevis pin hole in the arm of the slack adjuster.
8. Lubricate the slack adjuster through the grease fitting (if equipped) until the lubricant is forced out through the pressure relief fitting (or pawl slot), or through the gear splines around the inboard snap ring.
9. Attach a lbf·in/N·cm torque wrench to the adjusting nut. Watch the torque scale while turning the gear 360 degrees. See **Fig. 11**. If the torque remains 25 lbf·in (280 N·cm) or less, the slack adjuster is working correctly.

   If the torque is more than 25 lbf·in (280 N·cm), the slack adjuster is not working correctly. Disassemble the slack, and check for correct assembly and alignment of parts.
10. Install the slack adjuster. For instructions, see **Subject 100**.



A. Rotate the gear 360 degrees.

Fig. 11, Slack Adjuster Torque Check

Slack Adjuster Arm Length: inches (mm)	Chamber Size
5 (127)	9, 12, 16, 20, 24, 30
5-1/2 (140)	9, 12, 16, 20, 24, 30, 36
6 (152)	24, 30, 36
6-1/2 (165)	30, 36

Table 1, Slack Adjuster Arm Lengths

Lubricant Type	Temperature
Meritor 0–616–A Texaco Thermotex EP No. 1 Shell Darina No. 1 Texaco Hytherm EP No. 1 Aralub 3837 Tribolube 12, Grade 1 Meritor 0–692 Amoco Super Permalube No. 2 Citco Premium Lithium EP No. 2 Exxon Ronex MP No. 2 Kendall L–427 Super Blu No. 2 Mobilith AW No. 1 Sohio Factran EP No. 2	Above –40°F (–40°C)
Meritor 0–645 Mobil 28	Below –40°F (–40°C)

Table 2, Lubricant Specifications

Chamber Size	Maximum Chamber Stroke	
	Standard Stroke Chambers	Long Stroke Chambers
9	Less than 1-3/8 inches (35 mm)	—
12	Less than 1-3/8 inches (35 mm)	—
16	Less than 1-3/4 inches (44 mm)	Less than 2 inches (51 mm)
20	Less than 1-3/4 inches (44 mm)	Less than 2 inches (51 mm)
24	Less than 1-3/4 inches (44 mm)	Less than 2 inches (51 mm): *2-1/2 inch rated stroke* Less than 2-1/4 inches (63 mm): *3-inch rated stroke*
30	Less than 2 inches (51 mm)	Less than 2-1/2 inches (57 mm)
36	Less than 2-1/4 inches (57 mm)	—

Table 3, Maximum Adjusted Brake Chamber Strokes

Tandem Brake Chambers, MGM® "TR" Series 42.06

Contents

Subject	Subject Number
General Information and Principles of Operation	050
Service Operations	
Power Spring Manual Compression and Reset	100
Service Brake Diaphragm Replacement	110
Parking Brake Diaphragm Replacement	115
Combination Service and Parking Brake Chamber Removal and Installation	120
Specifications	400

DANGER: Don't attempt to remove the factory-sealed clamp ring (see Fig. 1) for any purpose at any time. The parking/emergency brake section is not intended to be serviced. Serious injury or death may result from the sudden release of the power spring.

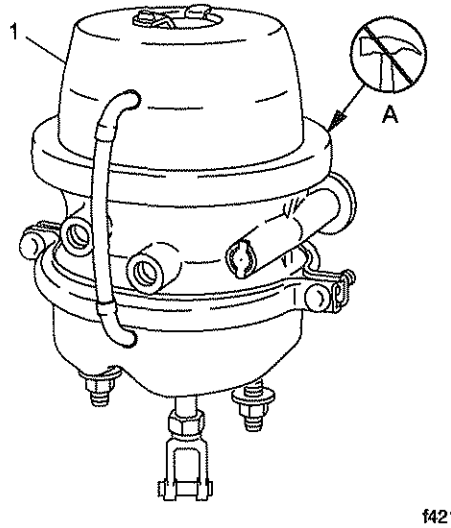
IMPORTANT: On MGM "TR" Series chambers, the parking/emergency brake section is factory sealed (no clamp ring) and is a *non-serviceable* unit.

General Information

MGM "TR" Series tandem cam brake chamber consists of a service brake section and a parking/emergency spring brake section. **See Fig. 2.** The service brake section is the smaller section near the clevis assembly.

In the service brake section, the flange case and non-pressure chamber contain a service return spring, piston rod assembly, and service brake diaphragm.

In the parking/emergency brake section, the flange case and the head contain a return spring, a push rod assembly, a parking (spring) brake diaphragm, a piston, a power spring, and a detachable release bolt.



A. Do not remove the factory-sealed clamp ring.

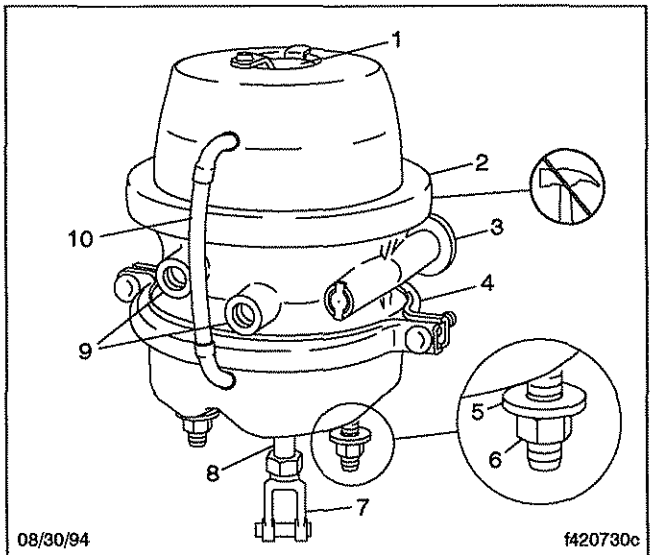
1. Model TR-T (TR Series) Brake Chamber

Fig. 1, Brake Chamber

All MGM brake chambers are mounted to the frame using prevailing torque locknuts and hardened flatwashers.

MGM "TR" Series chambers may be equipped with an external breather tube that protects the parking brake chamber from contaminants. These chambers are called Model "TR-T" chambers. **See Fig. 2.**

Periodic maintenance of the brake chambers is required. Also, whenever the service brake chamber is disassembled (*do not attempt to disassemble the parking brake chamber*), the parts should be inspected for damage. For maintenance schedules and procedures, and for inspection of brake chamber parts, refer to the vehicle maintenance manual.



Do not remove the factory-sealed clamp ring.

1. End Cover Cap
2. Factory Sealed Parking Brake Clamp Ring
3. Release Bolt Storage Pocket
4. Service Brake Clamp Ring
5. Hardened Flatwasher
6. Prevailing Torque Locknut
7. Clevis Assembly
8. Piston Rod
9. Air Inlet Ports
10. External Breather Tube

Fig. 2, Model TR-T (TR Series) Brake Chamber

General Information and Principles of Operation

Principles of Operation

SERVICE BRAKES

As the brake pedal is depressed, compressed air enters the service brake chamber through a port. Air pressure acts upon a diaphragm, which forces the piston rod toward the non-pressure chamber, applying a straight-line force to the slack adjuster, which converts it to a rotational force. This in turn rotates the camshaft and applies the brakes.

Then, when the brake pedal is released, air is exhausted from the service brake chamber, and the return spring allows the diaphragm, piston rod, and slack adjuster to return to their normal positions, releasing the brakes.

PARKING/EMERGENCY BRAKES

During parking brake release, compressed air enters the parking brake chamber and acts upon the diaphragm and piston, fully compressing the power spring. When the power spring is compressed, the parking brakes are released; the service brakes can then be operated at the brake pedal.

During parking brake application, air is exhausted from the parking brake chamber. The power spring releases, forcing the piston and parking brake diaphragm toward the flange case. The resulting motion on the push rod forces the service brake diaphragm and piston rod outward, applying the brakes.

Power Spring Manual Compression and Reset

DANGER: Don't attempt to remove the factory-sealed clamp ring (see Fig. 1), for any purpose at any time. The parking/emergency brake section is not intended to be serviced. Serious injury or death may result from the sudden release of the power spring.

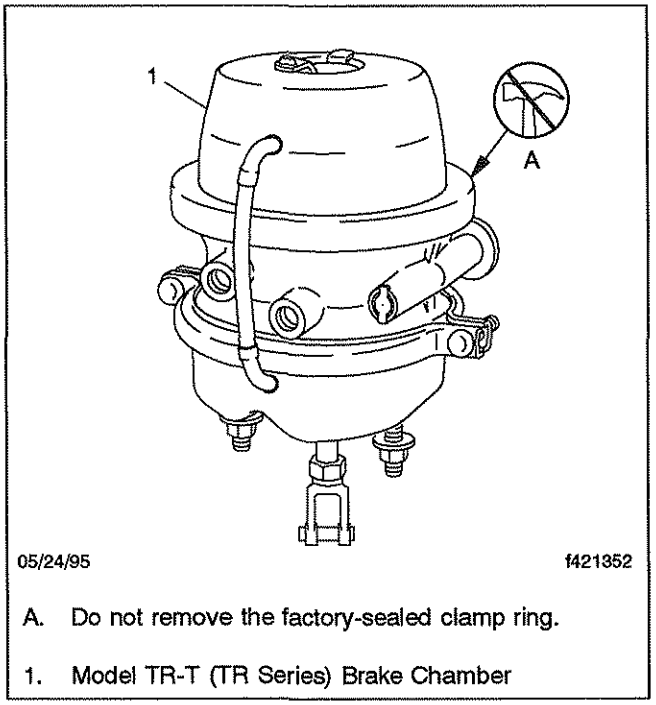
Manual Compression (Parking Brake Release)

1. Chock the tires.
2. Remove the end cover cap from the center-hole in the head of the chamber. **See Fig. 2.**

DANGER: Do not attempt to cage the power spring if the parking brake chamber is damaged severely enough to lose its structural integrity. If the power spring were to break loose, it could result in death, severe personal injury, or property damage.

A DAMAGED PARKING BRAKE CHAMBER IS EXTREMELY DANGEROUS! Only qualified service personnel should attempt to remove and disarm a damaged chamber. Using a torch, burn off the piston rod in the space between the clevis and the base of the service chamber.

Remove the chamber carefully from its bracket, and disarm it inside a suitable container. For disarming procedures, consult the MGM service manual.



A. Do not remove the factory-sealed clamp ring.

1. Model TR-T (TR Series) Brake Chamber

Fig. 1, Brake Chamber

3. Manually release the parking brake (cage the power spring).

   3.1 Using a hand wrench (*don't use an impact wrench*), unscrew the release nut, and remove the nut, flatwasher, and release bolt from the storage pocket on the side of the chamber. **See Fig. 3.**

   IMPORTANT: If these parts are not stored on the chamber, they must be otherwise obtained or purchased; the parking brake cannot be manually released without them.

   3.2 Apply at least 90 psi (620 kPa) air pressure to the parking brake inlet port (set parking brake in the "release" position).

   3.3 Insert the release bolt into the center-hole in the chamber head **(see Fig. 4).** Insert the bolt until it bottoms out into the hole in the piston inside the chamber.

   IMPORTANT: If you are not absolutely sure that the formed end of the bolt has engaged the piston correctly, repeat this step. Repeat it until you are absolutely sure.

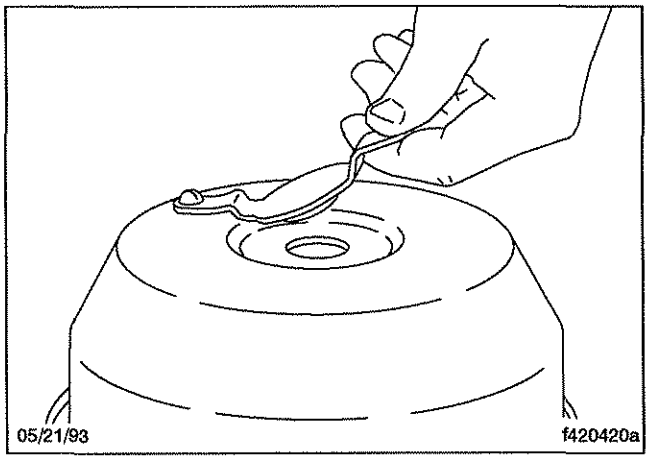


Fig. 2, Remove the End-Cover Cap

Power Spring Manual Compression and Reset

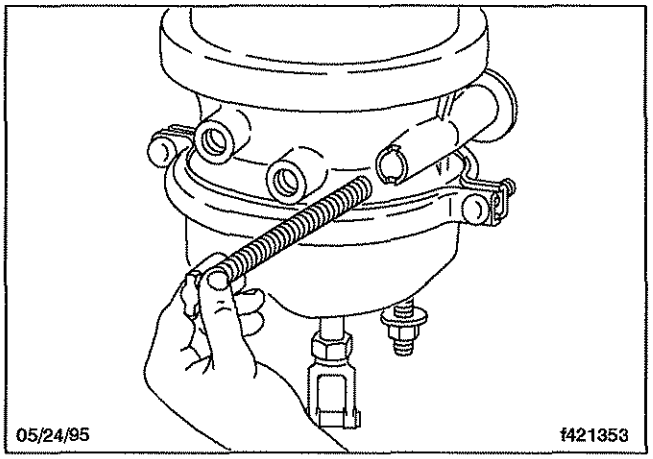


Fig. 3, Remove the Release Bolt

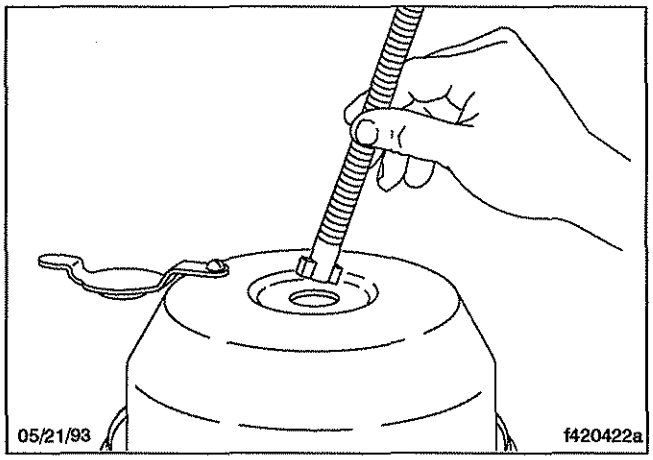


Fig. 4, Insert the Release Bolt

3.4 Turn the release bolt one-quarter turn clockwise, and pull the bolt out to lock its formed end into the piston.

IMPORTANT: If the bolt doesn't lock into the piston in less than 1/2-inch (13-mm) outward movement, repeat these steps until you are sure it does lock.

3.5 Then, holding the bolt locked into the piston, install the flatwasher and release nut on the end of the release bolt, and turn down the nut against the flatwasher until it is finger-tight. **See Fig. 5.**

CAUTION: Don't exceed 50 lbf·ft (68 N·m) torque on the release nut; and don't use an impact wrench on this nut. Too much torque could distort the head of the chamber and prevent manual release of the parking brake.

3.6 Using a hand wrench (*don't use an impact wrench*), turn the release nut clockwise until the bolt extends 3 inches (76 mm) above the nut. **See Fig. 6.**

IMPORTANT: Don't exceed the 3-inch (76-mm) length.

4. Once the power spring has been caged, exhaust the compressed air from the parking brake.

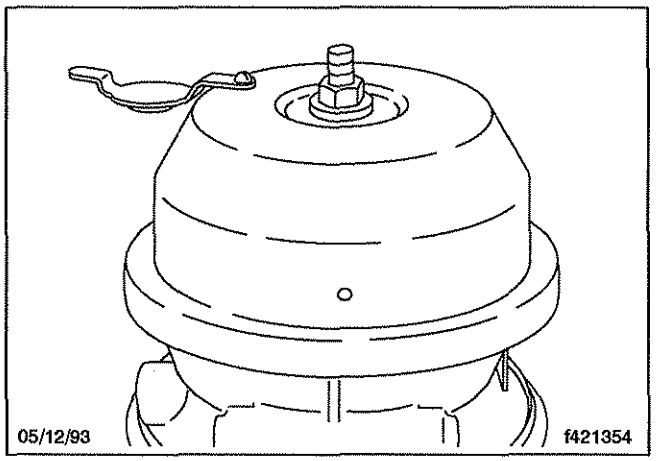
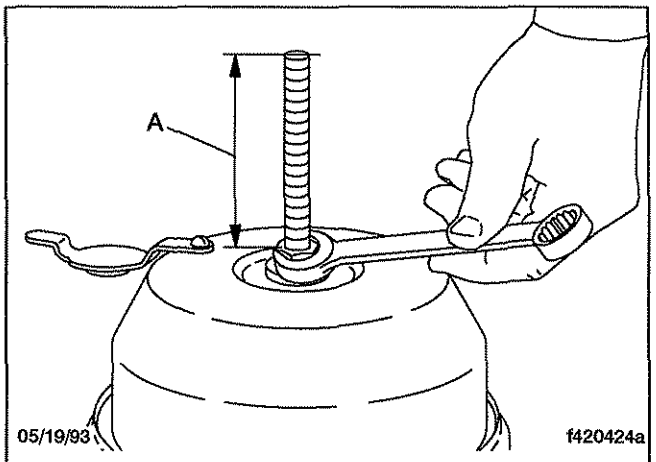


Fig. 5, Flatwasher and Release Nut Installed



Don't exceed the 3-inch (76-mm) length.

A. Measure this distance.

Fig. 6, Turn the Release Nut

Manual Reset (Parking Brake Reset)

1. Uncage the power spring.

   1.1 Apply at least 90 psi (620 kPa) air pressure to the parking brake inlet port (set parking brake in the "release" position).

   CAUTION: Don't exceed 50 lbf·ft (68 N·m) torque on the release nut; and don't use an impact wrench on this nut. Too much torque could distort the head of the chamber and prevent manual release of the parking brake.

   1.2 With air applied to the parking brake section (the parking brake control valve is in the "release" position), use a hand wrench to turn the release nut *counterclockwise* until the bolt bottoms out in the unit.

   1.3 Remove the nut and flatwasher.

   1.4 Push the release bolt into the piston and turn the release bolt one-quarter turn counterclockwise to unlock its formed end from the piston. Remove the release bolt from the center-hole of the chamber.

2. Using a hand wrench (*don't use an impact wrench*), install the release bolt, flatwasher, and release nut in the storage pocket. MGM recommends 10 lbf·ft (14 N·m) torque on the nut against the flatwasher **(see Fig. 7).**

3. Snap the end cover cap in place over the center-hole in the chamber head. **See Fig. 8.**

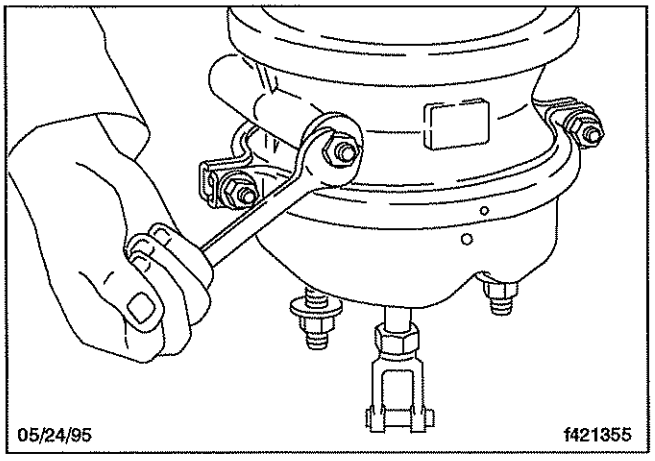


Fig. 7, Tighten the Release Nut

CAUTION: If the external breather tube or end cover cap is missing or incorrectly installed, road dirt and debris can adversely affect the operation of the brake chamber. Once inside the chamber, dirt and debris cause the internal parts to deteriorate and shorten their lives. Operating the unit without the external breather tube or end cover cap in place voids the MGM warranty.

4. Check the plastic end cover cap periodically, and replace it with a new one at once if damaged or missing. For intervals, refer to the vehicle maintenance manual.

5. Remove the chocks from the tires.

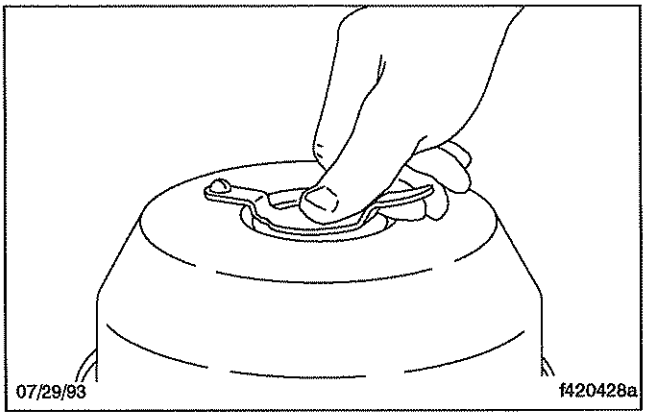


Fig. 8, Snap the End Cover Cap in Place

DANGER: Don't attempt to remove the factory-sealed clamp ring (see Fig. 1) for any purpose at any time. The parking/emergency brake section is not intended to be serviced. Serious injury or death may result from the sudden release of the power spring.

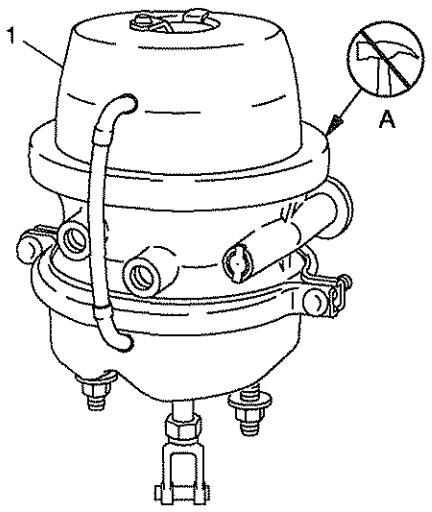
Removal

1. To make removal and installation of the parking brake section easier (without removing the service brake chamber), lock off the service chamber piston rod.

   1.1 Apply the service brakes by actuating the driver's foot brake treadle valve.

   1.2 With the brakes applied, clamp a pair of locking-jaw pliers on the piston rod to lock the rod in place when the air pressure is released **(see Fig. 2).**

WARNING: Before caging (compressing) the power spring, chock the vehicle tires and read the warnings and instructions in this section (see Subject 100). When the power spring is caged, the vehicle may be without brakes, allowing it to roll out of control, possibly resulting in personal injury or property damage.



A. Do not remove the factory-sealed clamp ring.

1. Model TR-T (TR Series) Brake Chamber

Fig. 1, Brake Chamber

2. Manually release the parking brake (cage the power spring). For instructions, refer to **Subject 100.**

3. Mark the air lines for later reference. Then carefully disconnect them from the brake chamber.

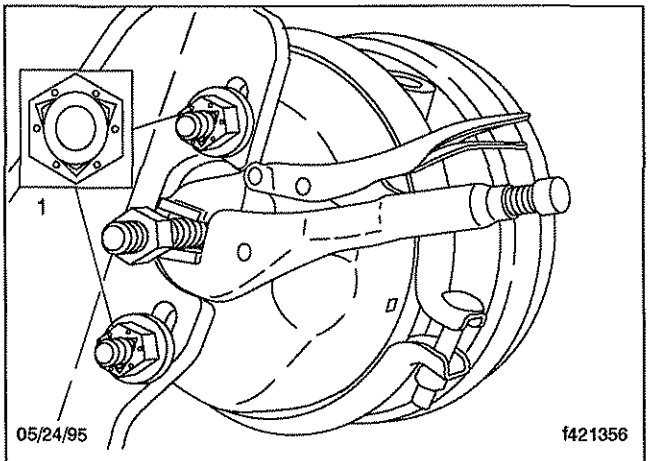
   On chambers equipped with an external breather tube, disconnect the tube and elbow from the service brake chamber.

DANGER: Don't attempt to remove the factory-sealed clamp ring (see Fig. 1) for any purpose at any time. The parking/emergency brake section is not intended to be serviced. Serious injury or death may result from the sudden release of the power spring.

4. Remove the parking brake section from the service brake section.

   4.1 Using a hand wrench (*don't use an impact wrench*), remove the clamp nuts on the *service* clamp ring (*do not disassemble the parking brake section*).

   4.2 While holding the parking brake section securely in place, remove the service clamp ring. Then remove the parking brake section from the service brake non-pressure chamber **(see Fig. 3).**



1. Prevailing Torque Locknut

Fig. 2, Lock the Piston Rod in Place

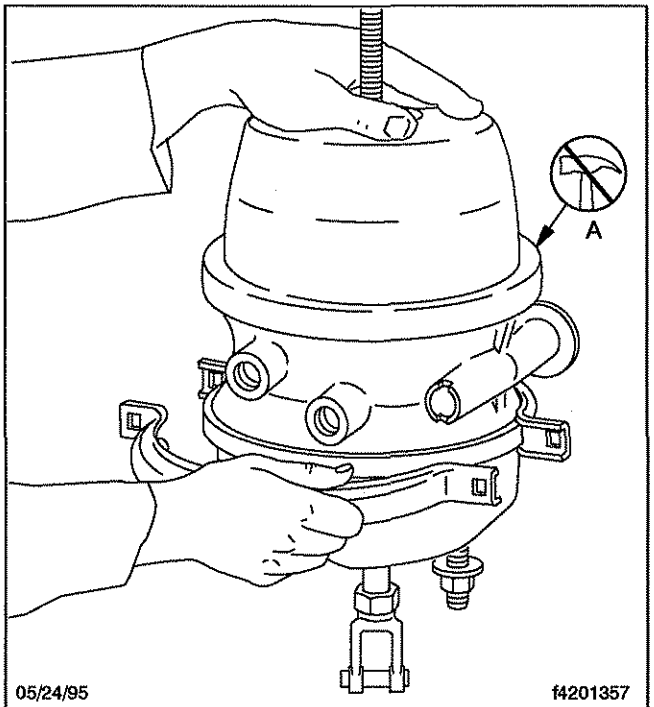
Service Brake Diaphragm Replacement

5. Remove the service brake diaphragm from the bottom of the parking brake section.

Installation

IMPORTANT: At this time, take the opportunity to inspect the parking/emergency brake section, and replace it if it shows signs of damage, corrosion, or rust. Follow the detailed inspection instructions in the vehicle maintenance manual.

1. Inspect all parts in the service (non-pressure) chamber. Replace any damaged or worn parts with genuine MGM-engineered replacement parts.
2. Place the new service brake diaphragm in the bottom recess of the parking brake section **(see Fig. 4).**
3. Install the (new, if needed) parking/emergency brake section.



A. Do not remove the factory-sealed clamp ring.

Fig. 3, Remove the Service Clamp Ring

3.1 If installing a new parking brake section, be sure it is the same size and make as the old one.

3.2 Check that the release bolt is fully extended outward. For instructions, refer to **Subject 100.**

3.3 Install the parking brake section on the service chamber so that all mating parts are aligned straight and the air lines are positioned to mate with the vehicle air supply lines.

4. Install the service brake clamp ring.

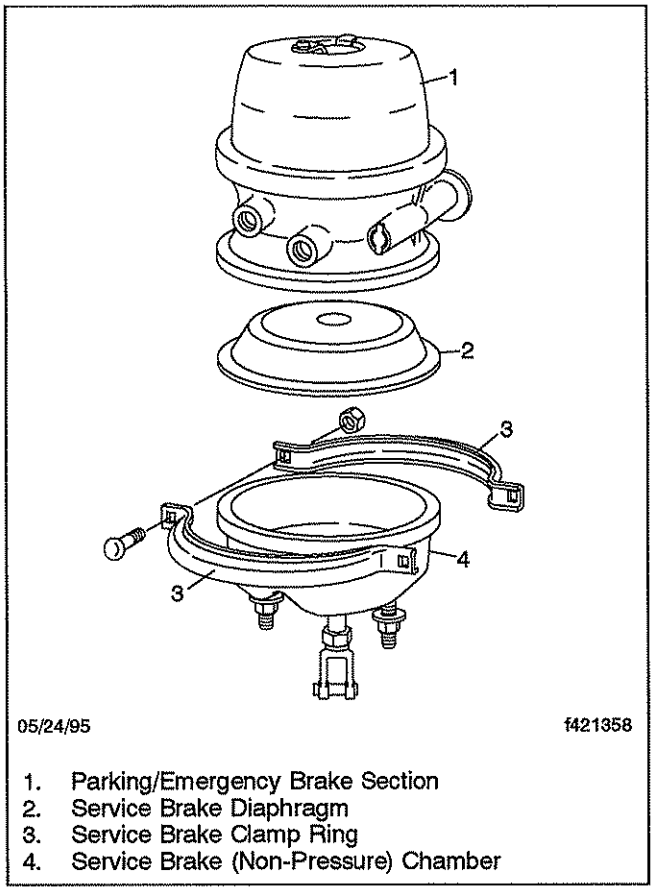
4.1 With the service brake clamp ring in place, install the clamp bolts and nuts.

4.2 Using a hand wrench (*don't use an impact wrench*), alternately tighten each clamp nut in increments of 60 to 120 lbf·in (680 to 1360 N·cm) while constantly rechecking the alignment of mating parts.

If realignment is needed, loosen the nuts again, and repeat this substep.

4.3 Firmly tap around the circumference of the service clamp ring with a rubber mallet to ensure full seating of the clamp. Tighten the nuts to a final torque of 25 to 30 lbf·ft (34 to 41 N·m).

5. Make sure the air hose fittings are free of grease, dirt, and other debris. Then, apply Loctite® 242 sealant, or an equivalent, to the fittings, and install, as referenced earlier. Using a hand wrench (*don't use an impact wrench*), tighten the fittings 25 lbf·ft (34 N·m).
6. Using the vehicle system air, charge the parking brake with full line pressure—at least 100 psi (690 kPa). Using only soapy water (*never any type of oil,* which could deteriorate rubber parts), check for air leaks at the air lines and fittings. If bubbles or leaks appear, tighten the fittings slightly, but not over 25 lbf·ft (34 N·m).
7. With the parking brake still charged with full line pressure, apply and hold the foot brake treadle valve down to charge the service brake chamber. Remove the locking-jaw pliers from the service piston rod so that the piston returns to a normal position in the chamber.



1. Parking/Emergency Brake Section
2. Service Brake Diaphragm
3. Service Brake Clamp Ring
4. Service Brake (Non-Pressure) Chamber

Fig. 4, Brake Chamber Parts

DANGER: Don't attempt to remove the factory-sealed clamp ring (see Fig. 1) for any purpose at any time. The parking/emergency brake section is not intended to be serviced. Serious injury or death may result from the sudden release of the power spring.

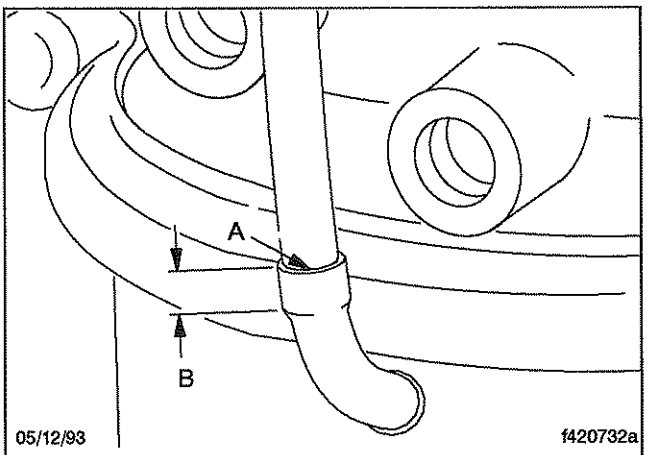
8. Test for air leaks around the circumference of the *service* brake clamp ring. If bubbles or leaks appear, firmly tap the circumference of the clamp ring with a rubber mallet, and retighten the clamp nuts until leaks cease (*do not touch the parking brake section*). MGM recommends 25 to 30 lbf·ft (34 to 41 N·m) torque on the clamp hexnuts.

9. On chambers equipped with an external breather tube, make sure that the open end of the tube is free of grease, dirt, and other debris. Then, apply a high-quality rubber cement to the tube and insert it into the elbow at least 1/2 inch (13 mm). **See Fig. 5.** Insert the tube into the service brake chamber.

10. With air pressure now exhausted from the service brake chamber, but held on the parking brake, reset the parking brakes by uncaging the power spring, and snap the end cover cap in place. For instructions, refer to **Subject 100.**

11. Adjust the brakes at the slack adjuster.

IMPORTANT: After replacing any brake chamber components, check the piston rod stroke and actuating alignment to ensure correct installation and foundation brake adjustment. No foundation brake adjustments, parking brake or service brake, can be made at the chamber and all "stroke" adjustments must be made at the slack adjuster. For instructions, refer to the applicable slack adjuster section in this group.



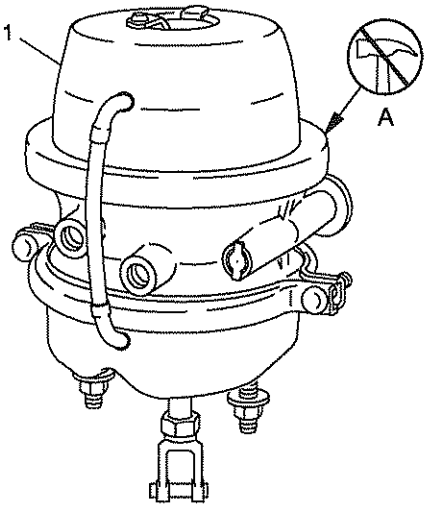
A. Apply adhesive here.
B. Check for 1/2" (13 mm) minimum engagement.

Fig. 5, Install the External Breather Tube

Replacement

DANGER: Don't attempt to remove the factory-sealed clamp ring (see Fig. 1) for any purpose at any time. The parking/emergency brake section is not intended to be serviced. Serious injury or death may result from the sudden release of the power spring.

IMPORTANT: The parking/emergency brake section can be replaced as a unit. For instructions, refer to **Subject 110.**



A. Do not remove the factory-sealed clamp ring.

1. Model TR-T (TR Series) Brake Chamber

Fig. 1, Brake Chamber

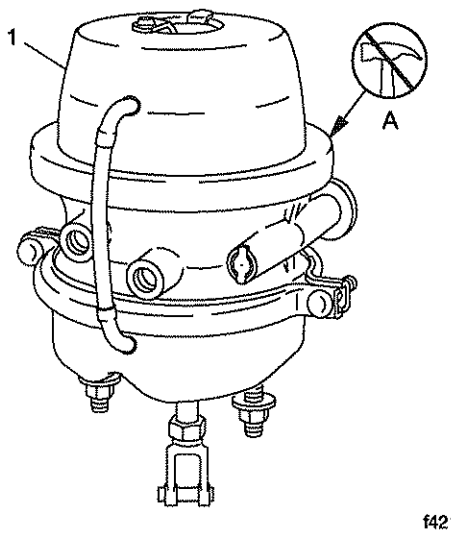
Combination Service and Parking Brake Chamber Removal and Installation

DANGER: Don't attempt to remove the factory-sealed parking brake clamp ring (see Fig. 1) for any purpose at any time. The parking/emergency brake section is not intended to be serviced. Serious injury or death may result from the sudden release of the power spring.

Removal (See Fig. 2)

WARNING: Before caging (compressing) the power spring, chock the vehicle tires and read the warnings and instructions in this section (see Subject 100). When the power spring is caged, the vehicle may be without brakes, allowing it to roll out of control, possibly resulting in personal injury or property damage.

1. Manually release the parking brake (cage the power spring). For instructions, refer to **Subject 100.**
2. Mark the air lines for later reference. Then carefully disconnect them from the brake chambers.
3. Remove the brake chamber from the vehicle.



A. Do not remove the factory-sealed clamp ring.

1. Model TR-T (TR Series) Brake Chamber

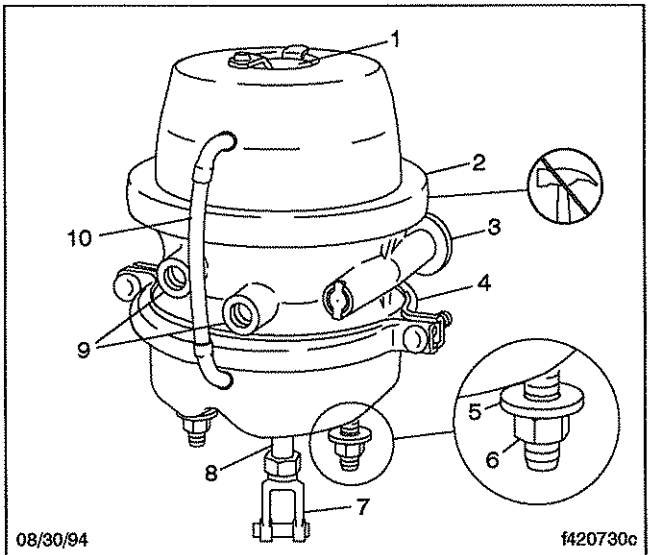
Fig. 1

3.1 Remove the cotter pin(s) from the clevis pin(s), then remove the clevis pin(s) from the clevis. Disconnect the clevis from the slack adjuster.

NOTE: Gunite and Rockwell automatic slack adjusters have two clevis pins, one large and one small, each locked by a cotter pin.

3.2 Make sure the parking brake has been released manually (the power spring has been caged). For instructions, refer to **Subject 100.** Also, make sure that the service brake piston is fully retracted (in the brakes "OFF" position). Then, record both of the following dimensions in either mm or inches, measuring outward from the base of the service brake chamber **(see Fig. 3):**

X dimension: to end of threaded piston rod



Do not remove the factory-sealed clamp ring.

1. End Cover Cap
2. Factory Sealed Parking Brake Clamp Ring
3. Release Bolt Storage Pocket
4. Service Brake Clamp Ring
5. Hardened Flatwasher
6. Prevailing Torque Locknut
7. Clevis Assembly
8. Piston Rod
9. Air Inlet Ports
10. External Breather Tube

Fig. 2, Model TR-T (TR Series) Brake Chamber

Combination Service and Parking Brake Chamber Removal and Installation

Y dimension: to centerline of (large) clevis pin

IMPORTANT: If new chambers are to be attached to manual slack adjusters, the Y dimension is the most critical measurement. When installing the new assembly, its service piston rod must be cut **(see Fig. 4)** to exactly duplicate this "rod-plus-clevis" length *after* the clevis assembly is installed on the piston rod.

If new chambers are to be attached to automatic slack adjusters, the X dimension is the most critical measurement. When installing the new assembly, its service piston rod must be cut **(see Fig. 4)** to exactly duplicate the "rod only" length *before* the clevis assembly is installed on the piston rod.

3.3 From each mounting stud, remove any installed nuts and washers. Then, cautiously remove the brake chamber from the mounting bracket.

Installation (See Fig. 2)

1. If installing a new brake chamber unit, do the following steps:

   1.1 First, make sure the power spring is caged (release bolt fully extended outward). If not, go to **Subject 100** and do the applicable steps.

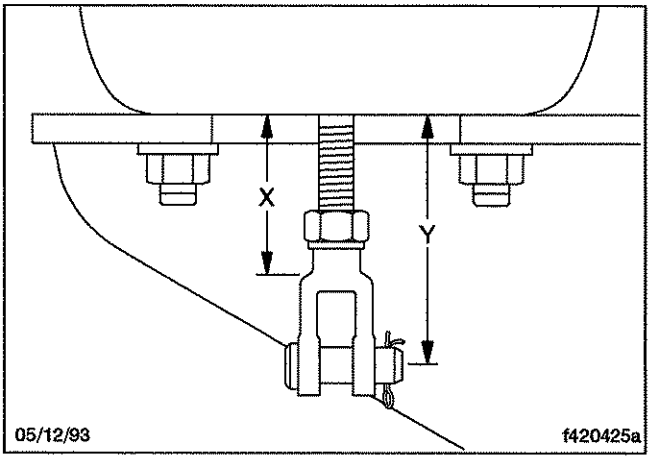


Fig. 3, Measure X and Y

   1.2 Make sure that the piston rod is the same length as the rod on the old unit (measure the rods when *both* chambers are caged).

   1.3 Be sure the new chamber is the same size and make as the brake chamber installed on the other side of the axle.

   1.4 Remove the prevailing torque locknut and hardened flatwasher from each of the mounting studs on the chamber.

2. Clean the face of the mounting bracket, and install the chamber on the bracket, paying close attention to positioning the chamber air inlet ports for correct alignment to the vehicle air lines.

WARNING: Tighten the mounting nuts with a hand wrench, not an impact wrench. An impact wrench could damage the mounting fasteners, reducing the force of the brakes. This could result in personal injury or property damage.

3. Install one hardened flatwasher and prevailing torque locknut on each mounting stud. Using a hand wrench (*don't use an impact wrench*), tighten the nuts 100 to 115 lbf·ft (136 to 156 N·m). Make sure the flatwasher is installed between the locknut and the mounting bracket.

   On chambers equipped with an external breather tube, make sure that the tube is installed in the side of the chamber that faces away from the road surface. An improperly installed breather tube voids the MGM warranty.

4. Check mating and alignment with the vehicle air lines.

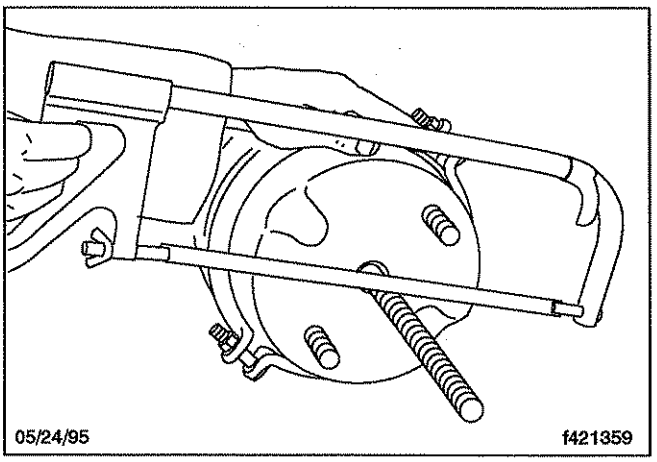


Fig. 4, Cut the Service Piston Rod

DANGER: Don't attempt to remove the factory-sealed parking brake clamp ring (see Fig. 1) for any purpose at any time. The parking/emergency brake section is not intended to be serviced. Serious injury or death may result from the sudden release of the power spring.

4.1 Using a hand wrench (*don't use an impact wrench*), loosen the clamp nuts on the *service* clamp ring (*do not disassemble the parking brake section*).

4.2 Reposition the air inlet ports, as needed, to mate with vehicle air supply lines.

Alternately tighten each clamp nut in increments of 60 to 120 lbf·in (680 to 1360 N·cm) while constantly rechecking the alignment of mating parts.

If realignment is needed, loosen the nuts again, and repeat this substep.

4.3 Firmly tap around the circumference of the service clamp ring with a rubber mallet to ensure full seating of the clamp. Tighten the nuts to a final torque of 25 to 30 lbf·ft (34 to 41 N·m).

5. Install the slack adjuster. Refer to the applicable slack adjuster section in this group for installation instructions.

6. Inspect the piston rod to be sure it is working free, not binding, and is square with the chamber bottom within ±3° in any direction from zero to full stroke. If there is misalignment, make corrections by loosening the locknuts and repositioning the chamber on the mounting bracket, or by shimming the slack adjuster to the right or left on the camshaft.

7. Make sure the air hose fittings are free of grease, dirt, and other debris. Then, apply Loctite® 242 sealant, or an equivalent, to the fittings, and install, as referenced earlier. Using a hand wrench (*don't use an impact wrench*), tighten the fittings 25 lbf·ft (34 N·m).

8. Using the vehicle system air, charge the parking brake with full line pressure, at least 100 psi (690 kPa). Using only soapy water (*never any type of oil,* which could deteriorate rubber parts), check for air leaks at the air lines and fittings. If bubbles or leaks appear, tighten the fittings slightly, but not over 25 lbf·ft (34 N·m).

DANGER: Don't attempt to remove the factory-sealed parking brake clamp ring (see Fig. 1) for any purpose at any time. The parking/emergency brake section is not intended to be serviced. Serious injury or death may result from the sudden release of the power spring.

IMPORTANT: If the service brake clamp ring was loosened to reposition the air inlet ports, apply air to the parking brake, and then apply and hold the foot brake treadle valve down to charge the service brake chamber. Now test for air leaks around the circumference of the *service* brake clamp ring. If bubbles or leaks appear, firmly tap the circumference of the clamp ring with a rubber mallet, and retighten the clamp nuts until leaks cease (*do not touch the parking brake section*). MGM recommends 25 to 30 lbf·ft (34 to 41 N·m) torque on the clamp hexnuts.

9. With air pressure now exhausted from the service brake chamber, but held on the parking brake, reset the parking brakes by uncaging the power spring, and snap the end cover cap in place. For instructions, refer to **Subject 100.**

10. Adjust the brakes at the slack adjuster. For instructions, refer to the applicable slack adjuster section in this group.

IMPORTANT: After replacing any brake chamber, check the piston rod stroke and actuating alignment to ensure correct installation and foundation brake adjustment. No foundation brake adjustments, parking brake or service brake, can be made at the chamber and all "stroke" adjustments must be made at the slack adjuster. For instructions, refer to the applicable slack adjuster section in this group.

Description	Torque lbf·ft (N·m)
Spring Brake Release Bolt Nut (in storage pocket)	10 (14)
Service Brake Clamp Ring Nut	25–30 (34–41)
Brake Chamber Mounting Stud Nut	100–115 (136–156)
Air Hose Fitting-to-Chamber	25 (34)

Table 1, Torque Values

Contents

Subject	Subject Number
General Description and Principles of Operation	050
Service Operations	
Brake Chamber Operating and Leakage Tests	100
Brake Chamber Diaphragm Replacement	110
Brake Chamber Removal and Installation	120
Brake Chamber Disassembly, Inspection and Cleaning, and Assembly	130
Specifications	400

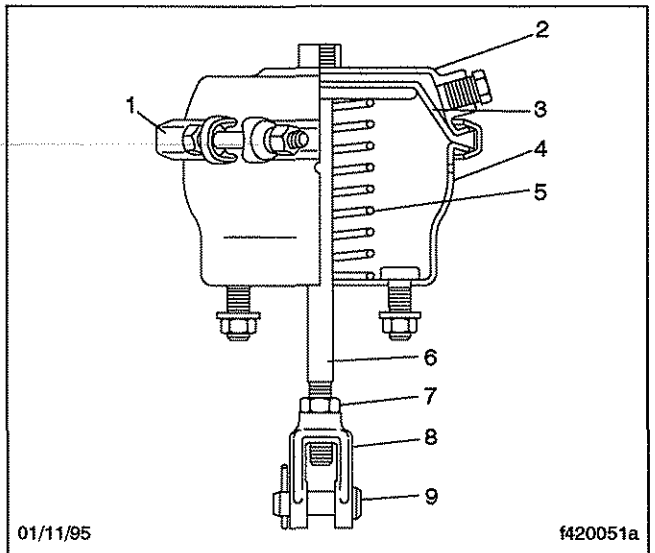
General Description

Brake chambers convert the energy of compressed air into the mechanical force and motion needed to apply the brakes. Two chambers operate the brakes, one on each side of the axle.

Each brake chamber consists of two dished metal sections: the cover assembly and the body assembly, which are separated by a nylon-neoprene diaphragm. A metal two-segment clamp ring holds the assemblies together. **See Fig. 1.**

In front of the diaphragm are the body, piston rod assembly, and a piston rod spring. The threaded piston rod assembly extends through the bottom of the body and connects to the clevis. **See Fig. 1.**

Different sized brake chambers are identified by numbers, which specify the effective area of the diaphragm. For example, a type 16 brake chamber has 16 square inches of effective area.



1. Clamp Ring
2. Cover Assembly
3. Diaphragm
4. Body Assembly
5. Piston Rod Spring
6. Piston Rod Assembly
7. Piston Rod Nut
8. Clevis
9. Clevis Pin

Fig. 1, Sectional View

Principles of Operation

The greater the air pressure admitted to the brake chamber, the greater the force applied by the piston rod. Piston rod force is determined by multiplying the delivered air pressure by the effective diaphragm area. For example, if 60 psi (415 kPa) is admitted to a type 16 brake chamber, the force on the end of the piston rod is about 960 lb (436 kg).

When the brake pedal is depressed, air pressure from the brake valve passes through the port in the brake chamber cover to move the diaphragm and piston rod assembly forward. This compresses the spring, and applies a straight-line force to the slack adjuster, which converts it to a rotational force. This in turn rotates the camshaft and applies the brakes.

When the brake pedal is released, compressed air behind the diaphragm exhausts through the quick release valve. The spring then allows the piston rod assembly and diaphragm to return to their previous positions.

NOTE: For both of these tests, the air system must be pressurized to at least 80 psi (550 kPa).

Operating Test

1. Chock the tires.
2. Apply the brakes. Check that each piston rod moves out promptly, without binding.
3. Release the brakes. Check that each piston rod returns to the released position promptly, without binding.
4. Check the brake chamber stroke. It should be as short as possible without causing the brakes to drag. If needed, adjust the travel of the piston rod at the slack adjuster. For instructions, refer to the foundation brake section in this manual.

Leakage Test

1. Apply the brakes and hold them on full line pressure of at least 80 psi (550 kPa).
2. Using a soap solution, coat the clamp ring. Leakage is excessive if it produces a 1-inch (25-mm) bubble within five seconds.

CAUTION: Don't overtighten the clamp ring. This can distort the flange sealing surface, or the clamp ring itself.

3. If the leakage is excessive, tighten the clamp ring flange nuts evenly until the leakage is reduced. For acceptable torque ranges, refer to **Specifications, 400.**
4. Using a soap solution, coat the area around the piston-rod hole. No leakage is permitted. If there is leakage, replace the diaphragm. For instructions, refer to **Subject 110.**

Brake Chamber Diaphragm Replacement

NOTE: This procedure is for service of a leaking brake chamber *diaphragm only*. If there are any other problems, refer to the applicable subjects elsewhere in this section.

Replacement

1. Chock the tires.

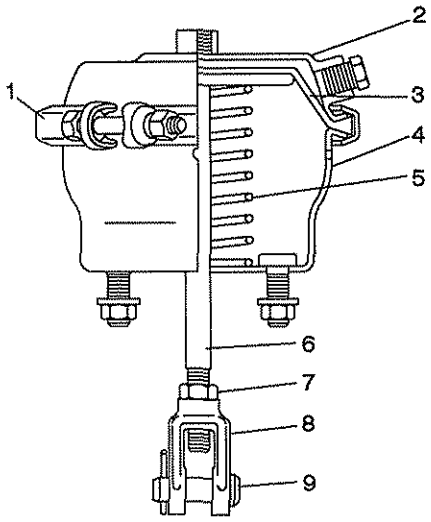
WARNING: Wear safety goggles when draining the air system or loosening an air line because dirt or sludge could fly out at high speeds. Don't direct the airstreams at anyone. Don't disconnect pressurized hoses, since they may whip as air escapes. Failure to take all necessary precautions could result in personal injury.

Follow the manufacturer's recommendations when working on any air device so as to avoid injury or damage from parts which, when released, are subject to mechanical (spring) or compressed-air propulsion.

2. Drain the air reservoirs and lines.
3. Back off the slack adjuster; for instructions, refer to the applicable slack adjuster section in this manual. Pull out the piston rod. **See Fig. 1.** Clamp the rod at the chamber body to protect it from damage.
4. Before disassembly, mark a reference line along the chamber to allow the parts to be reassembled later in their old positions. **See Fig. 2.**
5. Replace the diaphragm.
   - 5.1 Remove one clamp ring bolt and flange nut completely and loosen the other bolt and flange nut enough to remove the clamp ring.
   - 5.2 Remove the cover assembly, and replace the diaphragm.

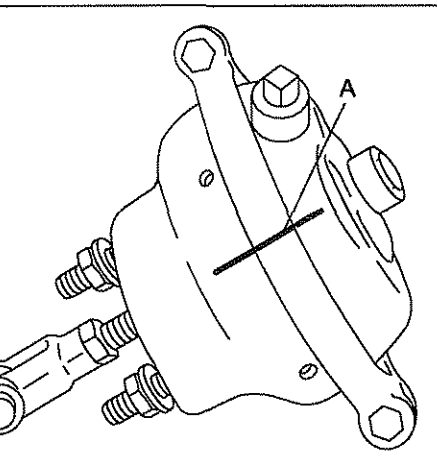
   CAUTION: Don't overtighten the clamp ring. This can distort the flange sealing surface, or the clamp ring itself.

   - 5.3 Position the cover assembly and clamp ring (aligning the reference marks), and install the clamp ring bolt and flange nut. Tighten the flange nuts evenly to eliminate leakage. For acceptable torque ranges, refer to **Specifications, 400.**
6. Release the clamp on the piston rod.
7. Do both of the tests **in Subject 100.**



1. Clamp Ring
2. Cover Assembly
3. Diaphragm
4. Body Assembly
5. Piston Rod Spring
6. Piston Rod Assembly
7. Piston Rod Nut
8. Clevis
9. Clevis Pin

Fig. 1, Sectional View



A. Reference Line

Fig. 2, Mark a Reference Line

Brake Chamber Diaphragm Replacement

8. Adjust the brakes at the slack adjuster. For instructions, refer to the applicable foundation brake section in this manual.
9. Remove the chocks from the tires.

Brake Chamber Removal and Installation

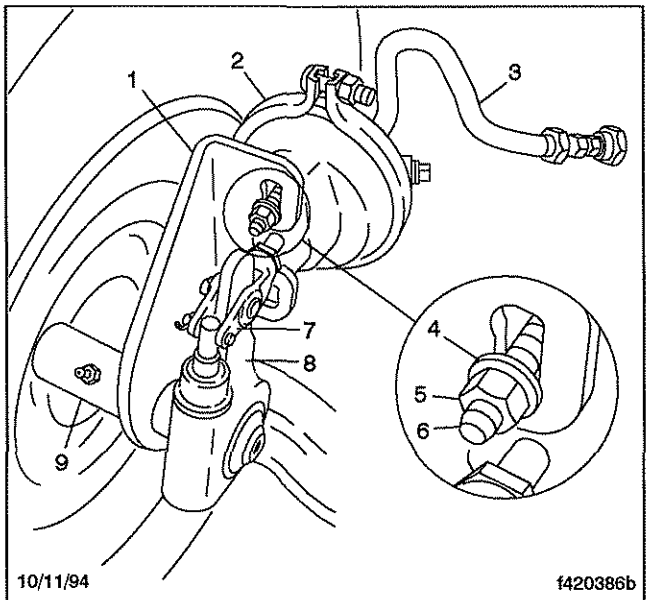
Removal (See Fig. 1)

1. Chock the tires.

WARNING: Wear safety goggles when draining the air system or loosening an air line because dirt or sludge could fly out at high speeds. Don't direct the airstreams at other people. Don't disconnect pressurized hoses, since they may whip as air escapes. Failure to take all necessary precautions could result in severe personal injury.

Follow the manufacturer's recommendations when working on any air device so as to avoid injury or damage from parts which, when released, are subject to mechanical (spring) or compressed-air propulsion.

2. Drain the air reservoirs and lines.
3. Carefully disconnect the air line from the brake chamber.



1. Chamber Mounting Bracket
2. Brake Chamber
3. Air Line
4. Hardened Flatwasher
5. Prevailing Torque Locknut
6. Chamber Mounting Stud
7. Clevis Assembly
8. Slack Adjuster (Automatic Type)
9. Camshaft Tube

Fig. 1, Brake Chamber Mounting

4. Remove the brake chamber.

4.1 Remove the cotter pin(s) from the clevis pin(s).

NOTE: Automatic slack adjusters have two clevis pins, one large and one small, each locked by a cotter pin.

4.2 Remove the clevis pin(s) from the slack adjuster.

4.3 From each mounting stud, remove any installed nuts and washers. Remove the brake chamber from the vehicle.

Installation (See Fig. 1)

1. Before installing a new chamber, be sure the new chamber is the same size and make as the brake chamber on the other side of the axle.
2. Install the brake chamber.

2.1 Attach the brake chamber to the mounting bracket using a hardened flatwasher and prevailing torque locknut. Install the flatwasher between the locknut and the mounting bracket.

2.2 Tighten the locknuts. **See Table 1** for the correct torque value.

Description	Chamber Size (in²)	Torque lbf·ft (N·m)
Brake Chamber Mounting-Stud Locknuts	12	30 (41)
	16 (7/16-inch Stud)	40 (54)
	16 (1/2-inch Stud)	75 (102)
	20	100 (136)
	24	100 (136)

Table 1, Mounting-Stud Locknut Torque Values

2.3 Connect the clevis pins to the slack adjuster.

2.4 Install and lock new cotter pin(s) to secure the clevis pin(s).

Brake Chamber Removal and Installation

NOTE: Automatic slack adjusters have two clevis pins, one large and one small, each locked by a cotter pin.

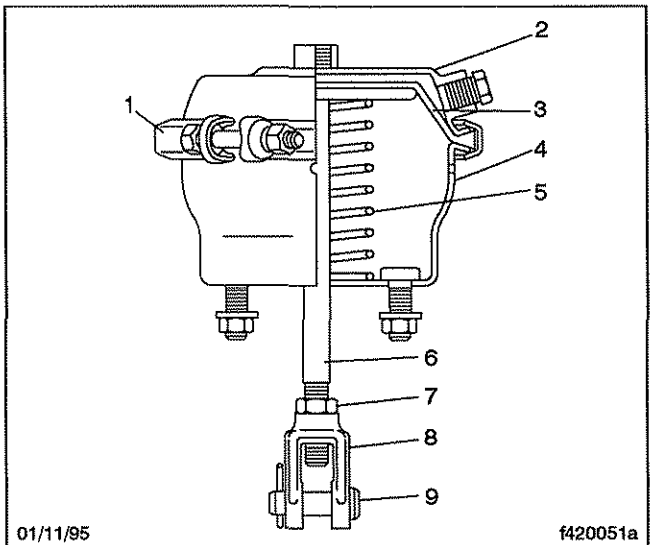
3. Adjust the brakes at the slack adjuster. For instructions, refer to the applicable foundation brake section in this manual.
4. Connect the air line to the brake chamber.
   - 4.1 Check that the hoses are properly supported and, if needed, clamped to provide good clearance.
   - 4.2 Before connecting the air line, make sure the fittings are clean and free of debris.
   - 4.3 Connect the air line as follows: tighten the nut finger-tight. Using a wrench, further tighten the nut until there is resistance, then tighten one-sixth turn more.
5. Do both of the tests **In Subject 100.**
6. Remove the chocks from the tires.

Brake Chamber Disassembly, Inspection and Cleaning, and Assembly

Disassembly (See Fig. 1)

NOTE: If the brake chamber is to be disassembled without removing the body assembly from the vehicle, first back off the slack adjuster. For instructions, refer to the applicable slack adjuster section in this manual.

1. Before disassembly, mark a reference line along the chamber to allow the parts to be reassembled later in their old positions. **See Fig. 2.**
2. Pull out the piston rod. Clamp the rod at the chamber body to protect it from damage.
3. Disassemble the brake chamber.
   - 3.1 Remove one clamp ring bolt and flange nut completely and loosen the other bolt and flange nut enough to remove the clamp ring.
   - 3.2 Remove the cover assembly and the diaphragm.
   - 3.3 Remove the clevis locknut and clevis from the piston rod, and release the clamp on the piston rod, being careful to contain the piston rod assembly and body until the return spring is relaxed.
   - 3.4 Remove the piston rod assembly and spring.

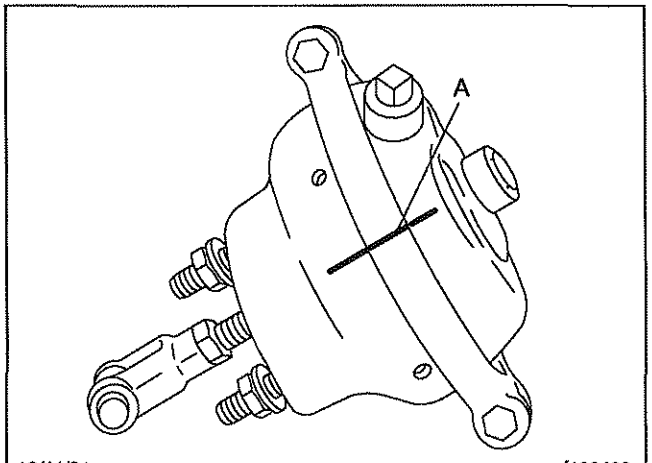


1. Cover Assembly
2. Diaphragm
3. Body Assembly
4. Piston Rod Spring
5. Clamp Ring
6. Piston Rod Assembly
7. Piston Rod Nut
8. Clevis
9. Clevis Pin

Fig. 1, Sectional View

Inspection and Cleaning

1. Clean all metal parts with cleaning solvent.
2. Inspect all parts for wear or damage; replace as needed.
   - 2.1 Check the cover and the body for dents. If any are too deep to be pounded out, replace as needed.
   - 2.2 Check the diaphragm for wear or deterioration and replace it if necessary. Midland recommends replacement of the diaphragm whenever the service brake chamber is opened for inspection.
   - 2.3 Inspect all other parts not considered serviceable. Replace if necessary.



A. Reference Line

Fig. 2, Mark a Reference Line

Brake Chamber Disassembly, Inspection and Cleaning, and Assembly

Assembly (See Fig. 1)

1. Stand the piston rod assembly upright on a flat surface (if the chamber was removed from the vehicle).
2. Assemble the brake chamber.
   - 2.1 Place the return spring on the piston rod.
   - 2.2 Place the body on the piston rod assembly, and press the body down, working against the tension of the spring, until the body bottoms out on the flat surface. Clamp the rod at the body, making sure to protect the rod from damage. Insert the piston rod assembly through the body and clamp the rod (if the body wasn't removed from the vehicle).
   - 2.3 Place the diaphragm in the body.

   CAUTION: Don't overtighten the clamp ring. This can distort the flange sealing surface, or the clamp ring itself.

   - 2.4 Position the cover assembly and clamp ring (aligning the reference marks), and install the clamp ring bolt and flange nut. Tighten the flange nuts evenly to eliminate leakage. For acceptable torque ranges, refer to **Specifications, 400.**
3. Install the clevis locknut and clevis, and release the clamp on the piston rod.
4. If the brake chamber was removed from the vehicle, install it. For instructions, refer to **Subject 120.**
5. Do both of the tests found **in Subject 100.**

Description	Chamber Size (in²)	Torque lbf·ft (N·m)
Brake Chamber Mounting-Stud Locknuts	12	30 (41)
	16 (7/16-inch Stud)	40 (54)
	16 (1/2-inch Stud)	75 (102)
	20	100 (136)
	24	100 (136)

Table 1, Mounting-Stud Locknut Torque Values

Description	Chamber Size (in²)	Torque lbf·in (N·cm)
Clamp Ring Flange Nuts	12	200 to 250 (2260 to 2820)
	16	200 to 250 (2260 to 2820)
	20	110 to 225 (1240 to 2540)
	24	150 to 225 (1700 to 2540)

Table 2, Clamp Ring Torque Values

Description	Chamber Size (in²)	Torque N·m (lbf·ft)
Piston Rod Nuts	12	27–41 (20–30)
	16 (7/16-inch Stud)	27–41 (20–30)
	16 (1/2-inch Stud)	27–41 (20–30)
	20	45–122 (33–90)
	24	45–122 (33–90)

Table 3, Piston Rod Nut Torque Values

Rockwell WABCO® Antilock Braking System (ABS) 42.08

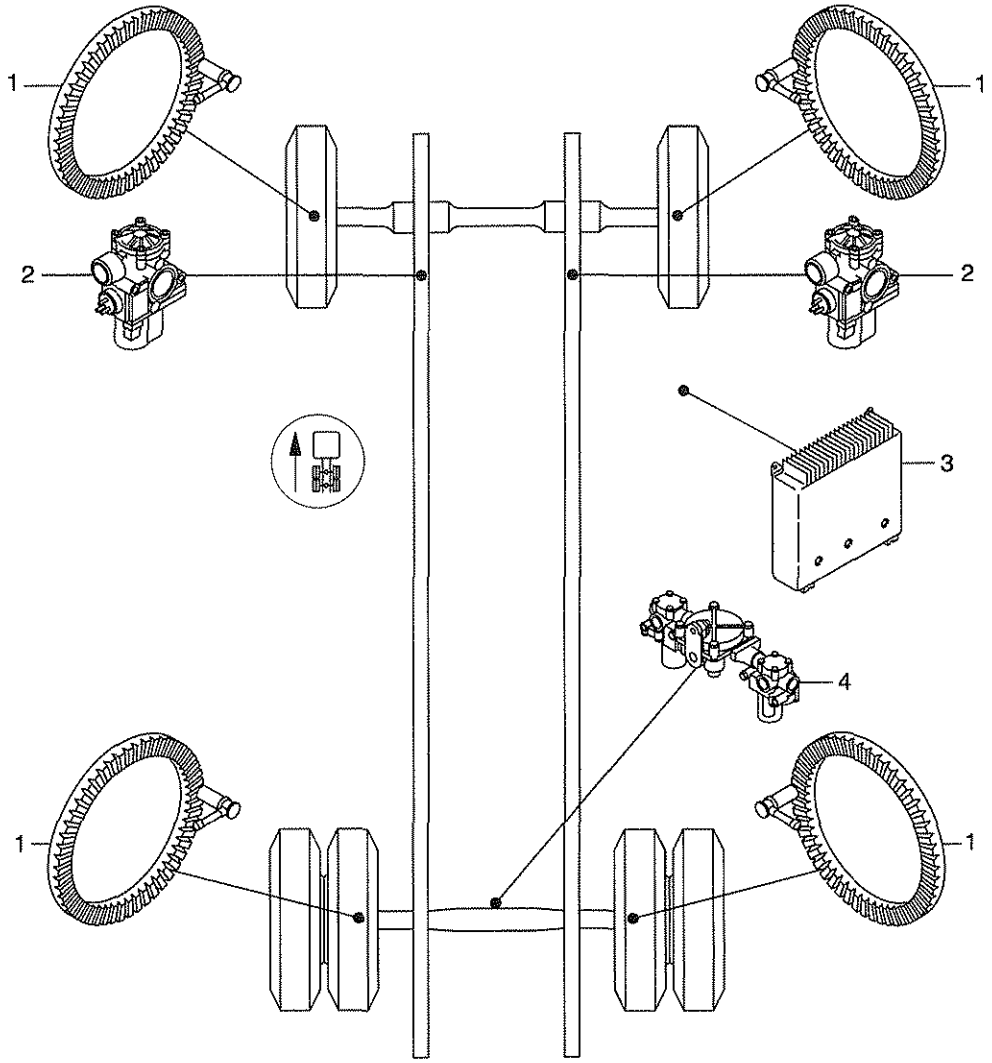
Contents

Subject	Subject Number
General Description and Principles of Operation	050
Service Operations	
Wheel Speed Sensor Replacement	100
Control Valve Replacement	110
Wheel Speed Sensor Adjustment, Rear Axle	120
Combination Solenoid Control Valve Disassembly and Assembly	130
ABS Tone Ring Installation on Service Hubs	140
Troubleshooting Using the Instrument Panel Blink Codes	300
Specifications	400

General Description (See Fig. 1)

The Meritor WABCO Antilock Braking System (ABS) is an electronic wheel speed monitoring and control system that works with the standard air brake system. ABS passively monitors vehicle wheel speed at all times, and controls wheel speed during emergency stops. If equipped with Automatic Traction Control, wheel spin is controlled during reduced-traction starts. In normal braking applications, the standard air brake system is in effect.

ABS includes signal-generating tone wheels and sensors located in the wheel hubs of each sensed wheel.



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1. Tone Wheel and Sensor
2. Solenoid Control Valve
3. Electronic Control Unit
4. Combination Solenoid Control Valve

Fig. 1, Location of ABS Components, Four-Channel System

General Description and Principles of Operation

The sensors transmit vehicle wheel speed information to an electronic control unit. According to programmed specifications, the control unit signals the appropriate solenoid control valve to increase, reduce, or maintain air pressure supply in the brake chamber. This prevents front and rear wheel lockup, and enhances steering control during emergency braking situations. If equipped with Automatic Traction Control, an additional solenoid valve is installed. During reduced-traction starts, the system automatically applies the brakes on the wheel that is spinning, left or right side, to transfer power to the opposite-side wheel. If both the left and right wheels spin, then engine power is automatically reduced.

Principles of Operation

The ABS electronic control unit (**Fig. 2**) is a digital microcomputer that serves as the information processing and command center for the antilock braking system. The control unit receives and processes vehicle wheel speed information from the sensors. During emergency brake applications, the control unit regulates the braking force applied to each wheel by sending control signals to the solenoid control valves (**Fig. 3**).

ABS MAJOR COMPONENTS

Wheel Speed Sensor

The wheel speed sensors use pulse feedback from tone wheels located in the front and rear axle wheel hubs. When the vehicle is moving, the teeth of the tone wheel cause interruptions in a magnetic field created by the sensor. The interruptions create electrical pulses that are sent by the sensor to the electronic control unit.

Electronic Control Unit (ECU)

The electronic control unit (ECU), located in a panel just behind the driver's seat, contains microcomputers to monitor the front and rear control channels. The ECU receives speed sensor pulses and interprets these signals to calculate wheel speed and a vehicle reference speed. If the calculations indicate wheel slip or lockup, the appropriate control circuit signals the solenoid control valve(s) to increase or decrease braking pressure.

⚠ CAUTION

Before performing any electric welding on a vehicle, disconnect the battery power and ground cables and the electrical harness connectors at the bottom of the ABS electronic control unit (ECU). See Fig. 2. Electric currents produced during elec-

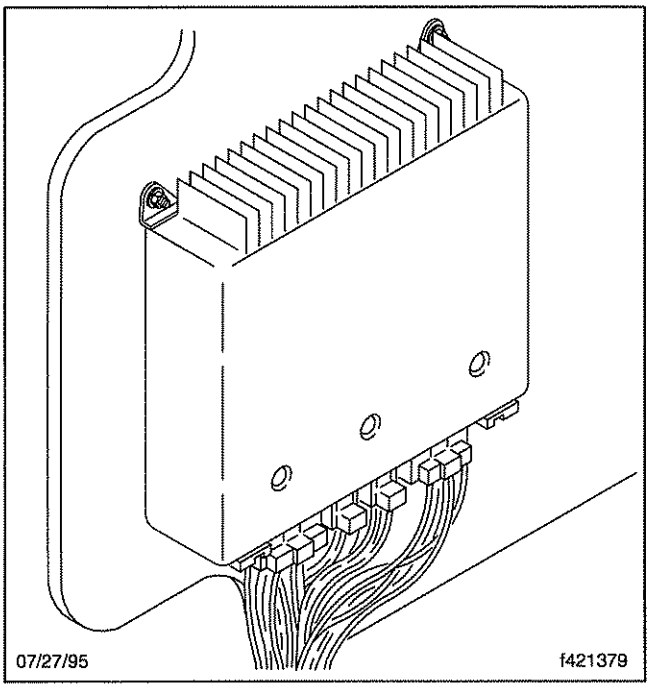


Fig. 2, Electronic Control Unit

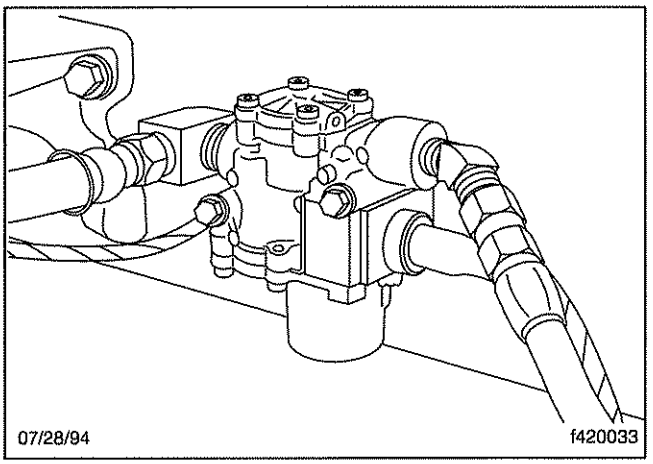


Fig. 3, Solenoid Control Valve, Front Axle Mounting shown

tric welding can damage various electronic components on the vehicle.

The ECU contains another microcomputer that provides a safety circuit to constantly monitor the wheel sensors, traction control valve (if equipped), solenoid control valves, and the electrical circuitry. After the ignition switch is turned on, the tractor warning light (TRAC ABS) and the wheel spin (WHL SPIN) indicator light come on for about three seconds. See **Fig. 4**. After about three seconds, the lights go out only if all of the tractor's ABS components are working.

A wheel spin (WHL SPIN) indicator light comes on if one of the drive wheels spins during acceleration. See **Fig. 4**. See the vehicle driver's manual for operating instructions.

IMPORTANT: If the TRAC ABS warning light and the WHL SPIN indicator light do not work as described above, repair the ABS/ATC system. See **Troubleshooting 300** for fault diagnosis.

If the vehicle is equipped with an electronic engine, an automatic traction control (ATC) system may be installed. On these vehicles, the ATC system automatically reduces wheel spin during reduced-traction starts.

An "ATC Function" switch (if equipped), allows the driver to select from two levels of drive axle traction-control assistance:

- NORMAL/SPIN—which reduces drive axle wheel spin on icy, wet, or sand covered roads.
- ATC—which allows a higher threshold of drive axle wheel spin to help burn through a thin layer of ice, or to help throw off accumulated mud or snow.

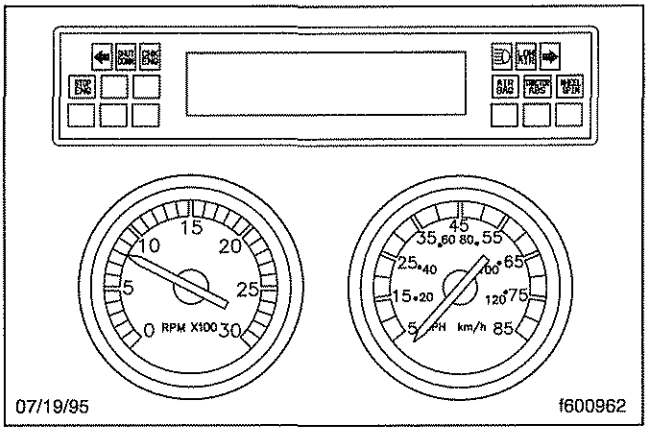


Fig. 4, ABS Dash Lights

The ATC mode is indicated by a flashing WHL SPIN light. To engage this mode, the ATC function switch (this is a momentary switch) must be pressed once the vehicle is started. The ECU indicates the activation by a constant flashing of the WHL SPIN lamp. This mode is disengaged by again pressing the ATC function switch. See the vehicle driver's manual for complete operating instructions.

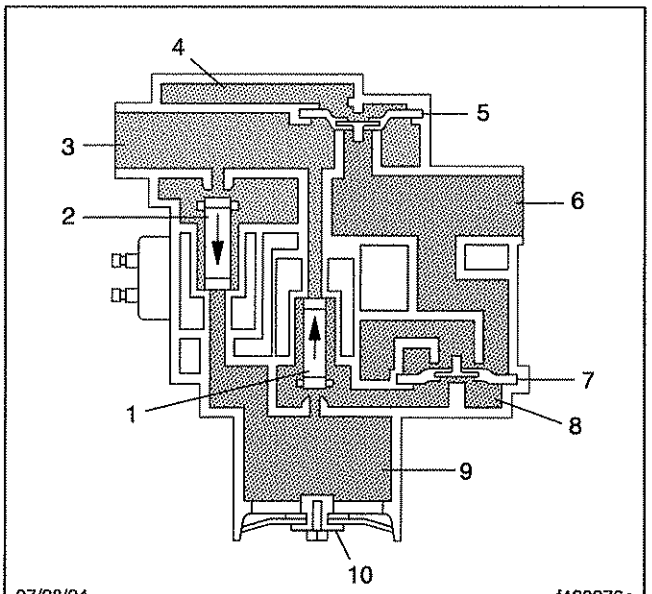
If, during vehicle operation, the safety circuit senses a failure in any part of the ABS system (a sensor, solenoid control valve, wiring connection, short circuit, etc.), the tractor warning light (TRAC ABS) comes on, and the control circuit where the failure occurred is switched to normal braking action. The remaining control circuit will retain the ABS effect. Even if the ABS system is completely inoperative, normal braking is maintained. An exception would be if a solenoid control valve (or combination solenoid control valve) is damaged and inoperative. As these components are an integral part of the air brake system, normal braking may be impaired or inoperative.

Solenoid Control Valve

The solenoid control valves for the front axle brakes are attached on each side of the vehicle (inboard of the forward fuel tank brackets). The combination solenoid control valves (which include a relay valve) for the rear axle brakes are attached to the either the center or forward suspension crossmember near the brake chambers. Depending on the signal received from the electronic control unit, the control valve prevents wheel lockup by reducing, maintaining, or increasing brake chamber air pressure. During normal braking applications, compressed air flows freely to the brake chamber through the control valve.

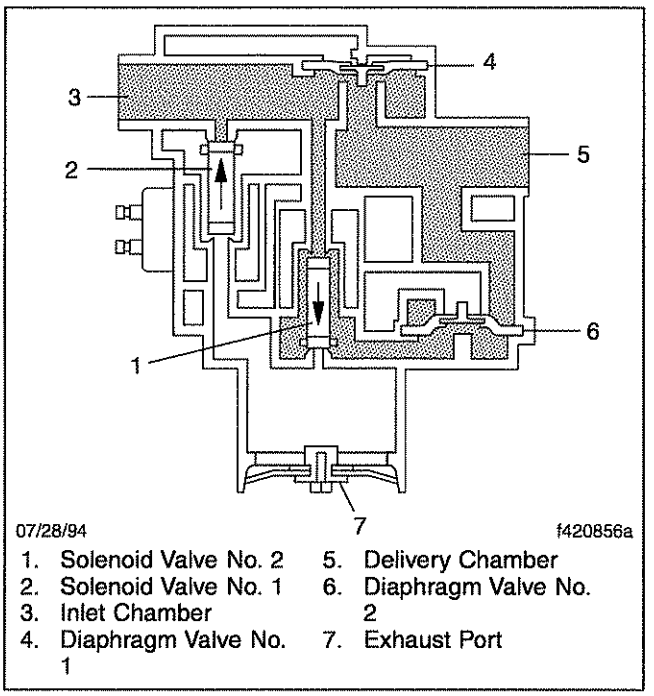
If the electronic control unit signals indicate wheel lockup, air pressure is reduced in the brake chamber. Solenoid valve 1 opens allowing compressed air to enter the inlet chamber and pilot chamber 1. See **Fig. 5**.

At the same time, solenoid valve 1 closes off the exhaust chamber preventing the escape of air from the inlet chamber to atmosphere. Compressed air in the inlet chamber is forced into pilot chamber 1, closing diaphragm valve 1; this prevents air passage



1. Solenoid Valve No. 2
2. Solenoid Valve No. 1
3. Inlet Chamber
4. Pilot Chamber No. 1
5. Diaphragm Valve No. 1
6. Delivery Chamber
7. Diaphragm Valve No. 2
8. Pilot Chamber No. 2
9. Exhaust Chamber
10. Exhaust Port

Fig. 5, Wheel Lockup Cycle



1. Solenoid Valve No. 2
2. Solenoid Valve No. 1
3. Inlet Chamber
4. Diaphragm Valve No. 1
5. Delivery Chamber
6. Diaphragm Valve No. 2
7. Exhaust Port

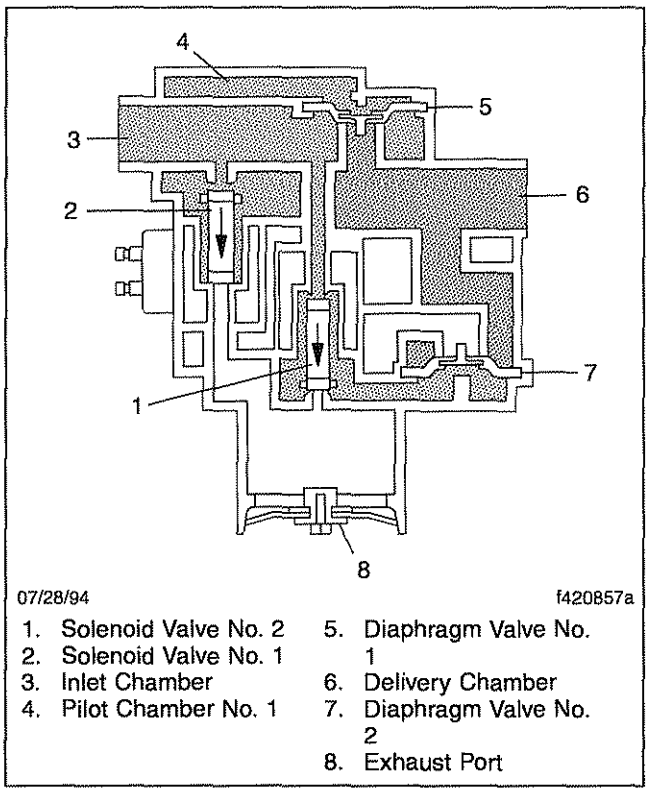
Fig. 6, Pressure Increase Cycle

to the delivery chamber. Solenoid valve 2 also opens allowing air to vent from pilot chamber 2 through the exhaust port. Complete venting of all air in the delivery chamber occurs as diaphragm valve 2 opens.

As wheel speed increases, the control valve alternately increases, then maintains brake pressure until the proper wheel speed is obtained, or until wheel lockup occurs and the control cycle starts again.

During the pressure increase cycle (**Fig. 6**), both solenoid valves are closed. Compressed air entering through the inlet chamber forces diaphragm valve 1 open, allowing air to pass through the delivery chamber into the brake chamber. At the same time, pressure within the control valve keeps diaphragm valve 2 closed, preventing air from escaping through the exhaust port.

If maintaining brake air pressure (**Fig. 7**), solenoid valve 1 opens and compressed air passes from the inlet chamber into pilot chamber 1. Both of the diaphragm valves are forced closed, sealing the delivery chamber and maintaining brake air pressure.



1. Solenoid Valve No. 2
2. Solenoid Valve No. 1
3. Inlet Chamber
4. Pilot Chamber No. 1
5. Diaphragm Valve No. 1
6. Delivery Chamber
7. Diaphragm Valve No. 2
8. Exhaust Port

Fig. 7, Maintaining Brake Air Pressure Cycle

Wheel Speed Sensor Replacement

NOTE: Wire repairs may require the use of special tools for certain connectors and terminals. Refer to **Group 54** (wiring) in this manual for information on special terminals and connectors, and on ordering tools for them.

FRONT AXLE

1. Chock the rear tires to prevent vehicle movement. Apply the parking brakes.
2. Twist and pull the sensor, to remove it from the steering knuckle **(Fig. 1).**
3. Remove the sensor cable from the steering knuckle top cap.
4. Disconnect the sensor cable from the chassis harness.
5. Remove the clamping bushing from the steering knuckle.
6. Connect the sensor cable to the chassis harness.
7. Attach the sensor cable to the steering knuckle top cap.

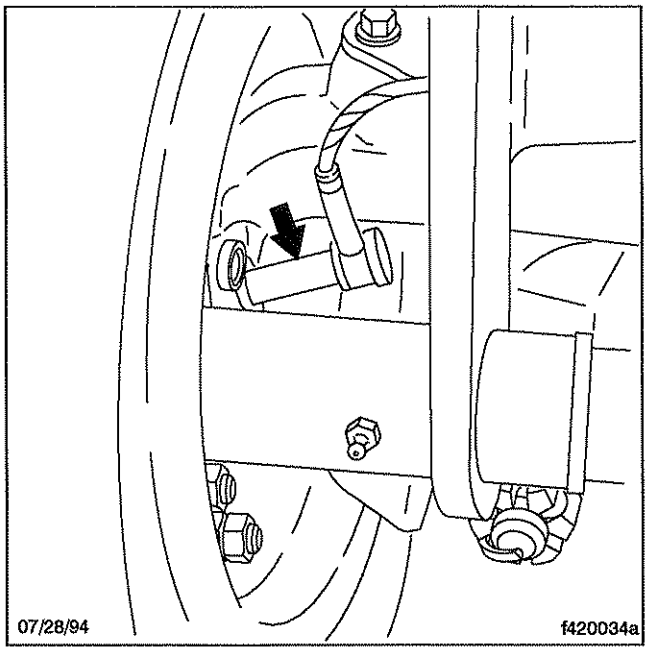


Fig. 1, Remove the Wheel Speed Sensor

8. Press the clamping bushing into the brake spider hole until it stops.
9. Coat the sensor with Mobil HP, Valvoline EP 633, Penzoil 707L, or an equivalent. Press the sensor into the clamping bushing until it is stopped by the tone wheel.
10. Remove the chocks from the rear tires.

REAR AXLE

1. Chock the front tires to prevent vehicle movement. Apply the parking brakes.
2. Raise the rear of the vehicle until the tires clear the ground. Place safety stands under the axle.
3. Back off the slack adjuster to release the rear axle brake shoes.
4. Remove the wheel and tire assembly from the rear axle. For instructions, refer to **Group 40** in this manual.
5. Remove the brake drum. For instructions, refer to **Group 35** in this manual.
6. Twist and pull the sensor, to remove it from the mounting block in the axle housing.
7. Remove the clamping bushing.
8. Remove the capscrew that attaches the sensor cable and the hose clamp to the axle tube.
9. Disconnect the sensor cable from the chassis harness.
10. Connect the sensor cable to the chassis harness.
11. Attach the hose clamp and sensor cable to the axle tube located between the backing plate and the spring plate.
12. Press the clamping bushing into the mounting block until it stops.
13. Coat the sensor with Mobil HP, Valvoline EP633, Penzoil 707L, or an equivalent. Using your hand, push the sensor into the clamping bushing until it is stopped by the tone wheel.
14. Install the brake drum on the wheel hub. For instructions, refer to **Group 35** in this manual.
15. Adjust the rear axle brakes. For instructions, refer to the applicable brake section in this manual.

Wheel Speed Sensor Replacement

16. Install the wheel and tire assembly, and tighten the wheel nuts. Use the tightening sequence and torque values listed in **Group 40** in this manual.
17. Remove the safety stands, lower the vehicle, and remove the chocks from the front tires.

Replacement (See Fig. 1 or Fig. 2)

NOTE: Wire repairs may require the use of special tools for certain connectors and terminals. See **Group 54** in this manual for information on special terminals and connectors, and on ordering tools for them.

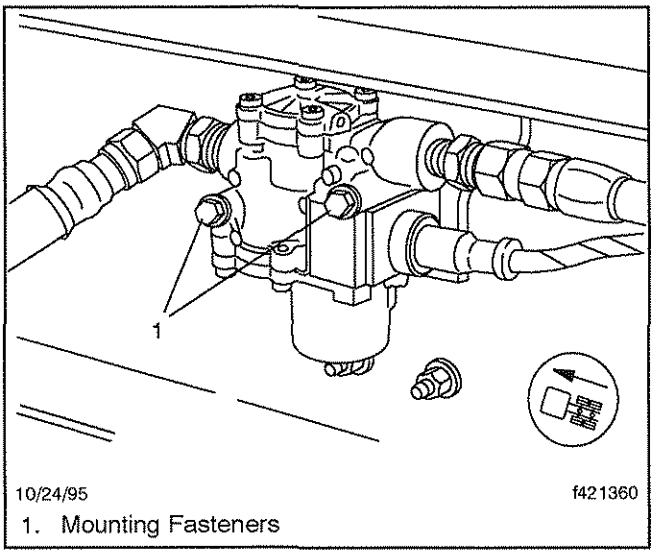


Fig. 1, Solenoid Control Valve Mounting (inside right-hand rail mounting shown)

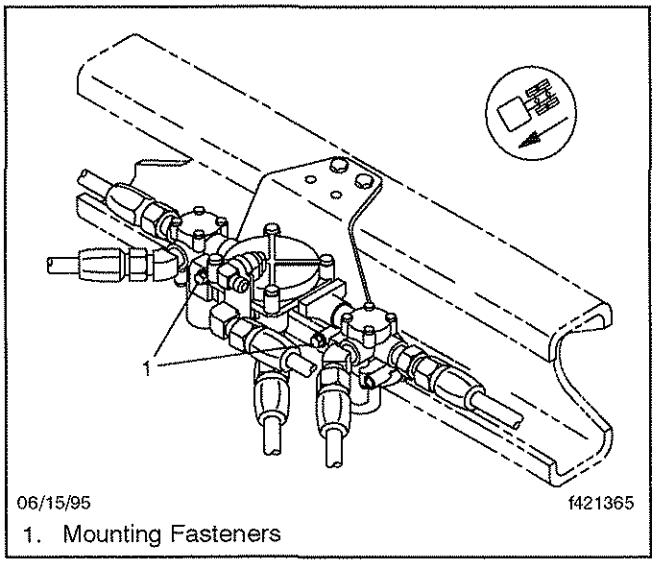


Fig. 2, Combination Solenoid Control Valve Mounting (rear axle mounting shown)

1. Chock the front and rear tires.
2. Release the pressure from the air reservoirs.
3. Disconnect the wiring from the solenoid control valve, or combination solenoid control valve(s).
4. Mark the air lines for ease of installation. Disconnect the air lines.
5. Remove the two mounting capscrews, washers, and nuts.
6. Remove the solenoid control valve.

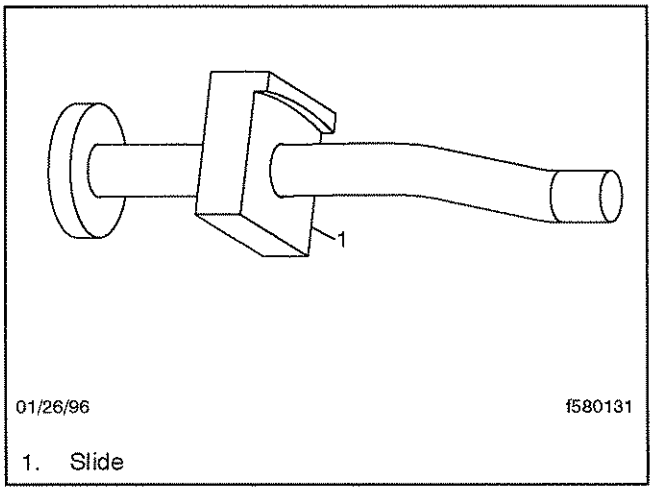
NOTE: The combination solenoid control valve can be disassembled if replacement of the relay valve, automatic traction control valve, or one of the solenoid control valves is needed. For disassembly and assembly instructions, see **Subject 130**.

7. Install the solenoid valve using the above instructions in reverse order. Tighten the mounting nuts 18 lbf·ft (24 N·m).

Adjustment

NOTE: The following adjustment procedure requires the use of special tool T11–17556–000. Use of this tool, available through the PDCs, eliminates the time-consuming task of removing the wheel and tire assembly, and the brake drum. **See Fig. 1.**

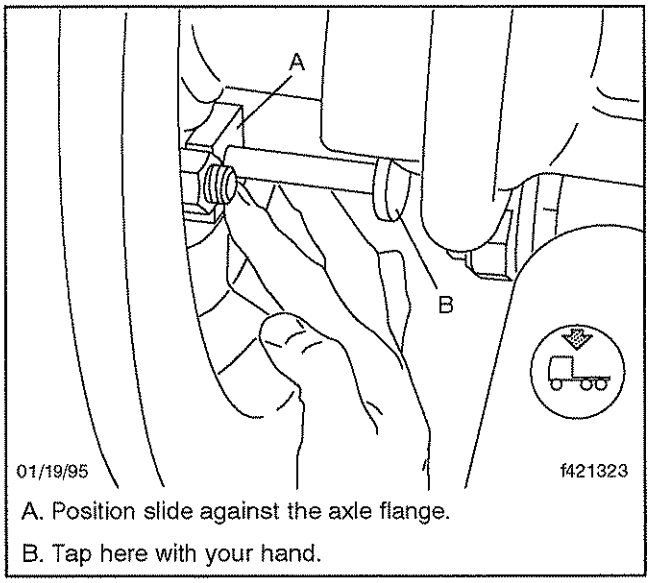
1. Park the vehicle on level ground, set the parking brake, and shut down the engine.
2. Chock the front tires.
3. Find the sensor access hole in the rear axle flange.
   - 3.1 View the brake drum and axle from the rear. The ABS sensor wiring harness should be visible passing through a hole in the 12 o'clock position.
   - 3.2 Find the S cam at either the 3 o'clock or 9 o'clock position.
   - 3.3 Just opposite the S cam is the sensor access hole, approximately 3/4 inch (19 mm) diameter.
4. Insert the service tool T11–17556–000 into this hole.
5. Position the slide of the tool on the axle flange to align the tool. **See Fig. 2.**
6. Tap the tool lightly with the palm of your hand. This will ensure the sensor is touching the tone wheel.



1. Slide

Fig. 1, ABS Sensor Adjustment Tool

7. Remove the tool from the wheel and repeat the procedure on the other rear axle speed sensor.
8. Remove the chocks from the tires.



A. Position slide against the axle flange.

B. Tap here with your hand.

Fig. 2, Position the Tool

Combination Solenoid Control Valve Disassembly and Assembly

Disassembly (See Fig. 1)

1. Use a 6 mm allen-head wrench to loosen and remove the allen-head bolts.
2. Carefully separate the ABS control valve(s) from the relay valve.
3. Remove and discard the old O-rings.

Assembly (See Fig. 1)

1. Lubricate the replacement O-rings with the grease provided.
2. Plug any unused ports on the replacement valve(s).
3. Attach the ABS control valve(s) to the relay valve. Tighten the allen-head bolts 13 to 15 lbf·ft (18 to 20 N·m).

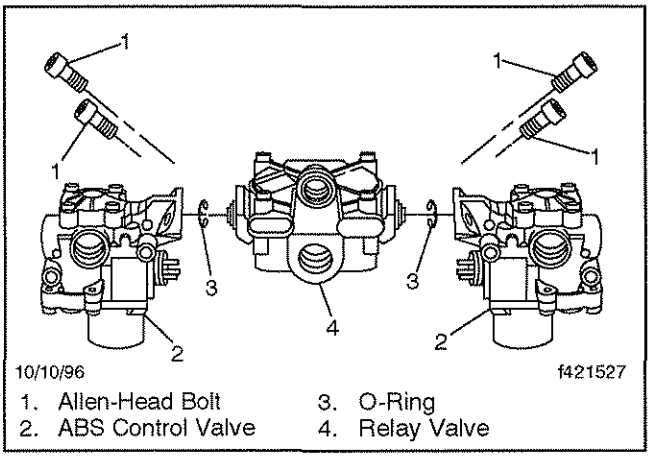


Fig. 1, Combination Solenoid Control Valve

ABS Tone Ring Installation on Service Hubs

Installation

IMPORTANT: Some ABS service hubs do not have a tone ring installed on the hub. The tone ring must be ordered separately and installed on the hub before installation of the hub onto the axle. Tone rings are made of a special material and require a specific installation procedure for proper installation.

⚠ WARNING

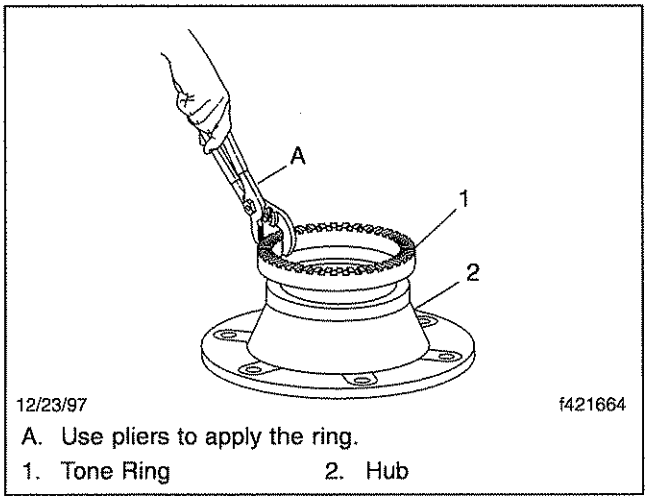
When installing an ABS system, special ABS hubs must be ordered. Machining of older hubs to accommodate the installation of tone rings can cause problems due to insufficient hub bore wall thickness. Machining an older hub with insufficient hub bore wall thickness could result in cracking, causing bearing damage and wheel loss. This could cause an accident resulting in personal injury and property damage.

1. Submerge the tone ring in boiling water or place it in an oven at 250°F (121°C) for approximately 15 minutes.

⚠ CAUTION

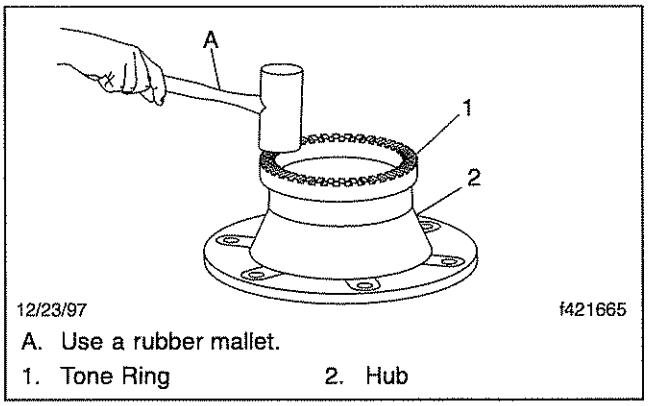
Do not attempt to heat the tone ring with a torch as this can damage the ring.

2. Using pliers, remove the tone ring from the boiling water or oven and center it on the machined area of the hub bore. See **Fig. 1**.
3. While the tone ring is still hot, make sure that it is properly centered on the machined surface. Using a rubber mallet, tap the tone ring until it bottoms out around the machined surface on the hub. See **Fig. 2**.
4. Install the hub on the axle. Position a dial indicator with a magnetic base so the dial indicator is against the tone ring teeth. See **Fig. 3**.
5. Rotate the hub and check the ring for runout. The runout should be less than 0.005 inch (0.13 mm). See **Fig. 4**.
6. Install the wheel. For instructions, see **Group 40** of this manual.



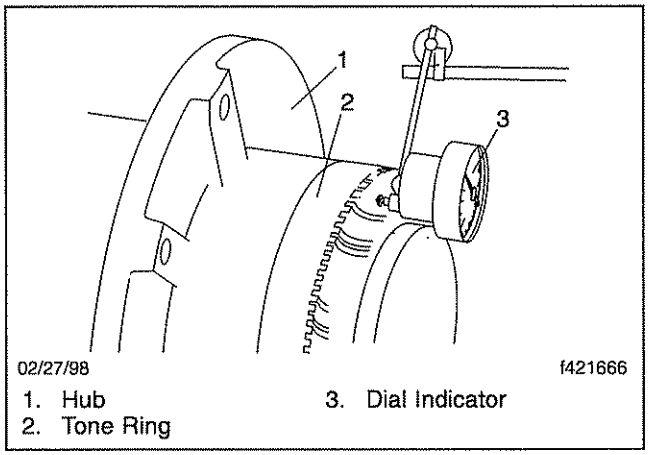
A. Use pliers to apply the ring.
1. Tone Ring 2. Hub

Fig. 1, Install the Ring on the Hub



A. Use a rubber mallet.
1. Tone Ring 2. Hub

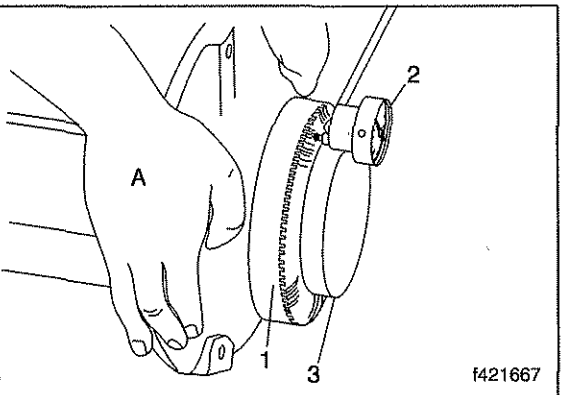
Fig. 2, Tap the Tone Ring



1. Hub
2. Tone Ring
3. Dial Indicator

Fig. 3, Position the Dial Indicator

ABS Tone Ring Installation on Service Hubs



A. Rotate the hub.

1. Tone Ring
2. Dial Indicator
3. Axle

Fig. 4, Check Tone Ring Runout

Troubleshooting

This subject includes the following troubleshooting methods:

- Troubleshooting using the instrument panel blink codes
- Troubleshooting using the instrument control unit (ICU) fault codes

USING THE INSTRUMENTATION PANEL BLINK CODES

This system has built-in diagnostics to ensure that all components are operating properly. Under normal conditions, the tractor warning light (TRAC ABS) and wheel spin light (WHL SPIN) come on when the ignition is turned on. After about three seconds these lights should go out if all of the tractor's ABS/ATC components are working. If either light stays on, or comes back on later, a problem within the ABS/ATC system has occurred. The vehicle can continue to be driven, but the ABS system could be partially or completely inoperative. To check the type of fault code recorded, stop the vehicle and turn off the engine. Then, turn on the ignition switch, but don't start the engine. If the light is still on, there is an "active" system fault that must be repaired to ensure proper system operation. If the light is not on, a "historical or intermittent" fault (indicating a loose connector or broken wire) has been recorded in the ECU memory.

NOTE: If troubleshooting the system with the Pro-Link 9000, use the instruction booklet that is supplied with the data cartridge.

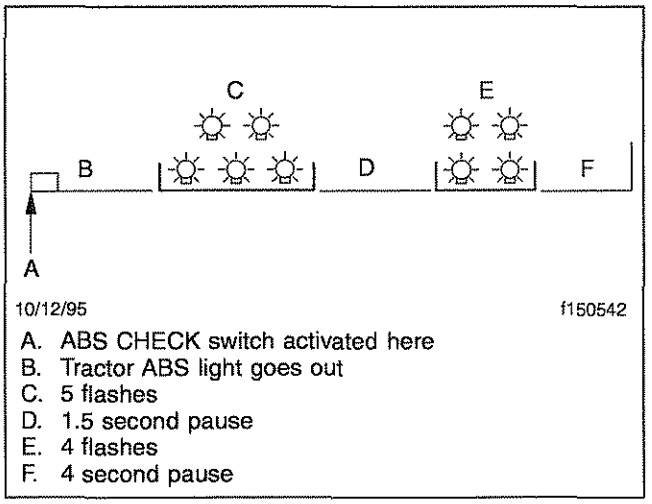
Use the ABS CHECK switch (which is located on the ECU in a panel just behind the driver's seat) and the TRAC ABS light to display system faults. With the ignition switch on, depress (for about one second) and release the switch. The TRAC ABS light should go out. After a one and one-half second pause, the TRAC ABS light will blink the first digit of the two-digit fault code. The number of blinks displaying the first digit will be a number between one and eight. After another one and one-half second pause, the second digit will be displayed. The number of blinks displaying the second digit will be a number between one and six. After a four second pause, the diagnostic code cycle continues to repeat the "active" fault code until it is repaired. If "historical" fault codes exist, the code cycle will display all recorded faults.

For example (**Fig. 1**), after the ABS CHECK switch has been depressed and released, fault code 54 is shown by five flashes, a pause of one and one-half seconds, followed by four flashes. After a four second pause, the same fault code will continue to repeat, always ending with a four second pause.

NOTE: When there are no fault codes in the ECU memory, blink code 1-1 is displayed.

Once a fault code has been identified, use a volt/ohmmeter to check the electrical harness at the ECU's pin connectors (there is a 6-pin, 9-pin, 15-pin, and 18-pin connector at the ECU, which is located in a panel just behind the driver's seat). Connect the ohmmeter leads to the applicable pins on each connector. See **Fig. 2**, and **Table 1**, for a description of the circuit wire numbers and their location within the pin connectors.

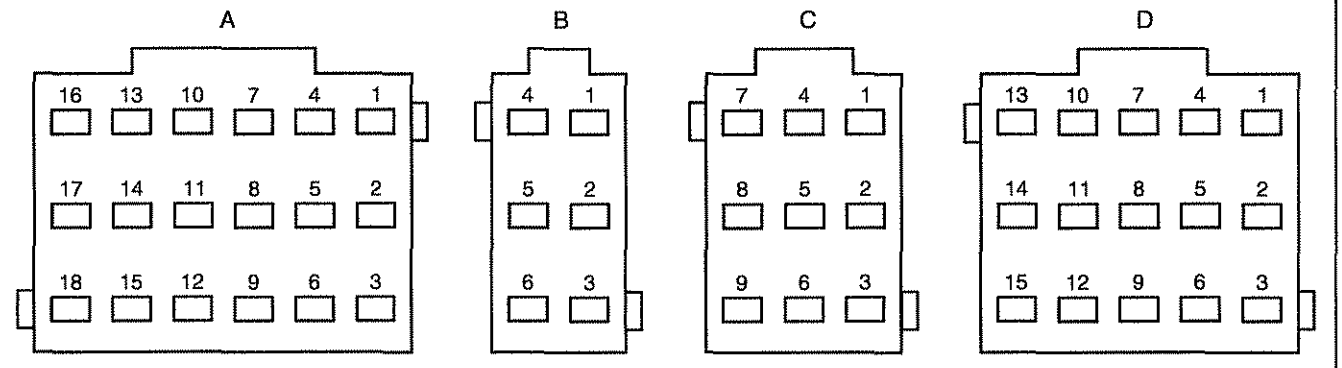
IMPORTANT: The ignition switch must be off when connecting or disconnecting the ECU.



A. ABS CHECK switch activated here
B. Tractor ABS light goes out
C. 5 flashes
D. 1.5 second pause
E. 4 flashes
F. 4 second pause

Fig. 1, Fault Code 54 shown

Troubleshooting



A. 18-Pin Connector
B. 6-Pin Connector
C. 9-Pin Connector
D. 15-Pin Connector

Fig. 2, ECU Pin Connectors

Circuit Wire Numbers and Descriptions			
Pin Connector	**Pin Number**	**Freightliner Wire Number**	**WABCO Circuit Description**
6-Pin	1	378LF0	Left Front Solenoid Control Valve, Out
	2	378LF1	Left Front Solenoid Control Valve, In
	3	378LF–	Left Front Solenoid Control Valve, Ground
	4	377LF+	Left Front Sensor, High
	5	377LF–	Left Front Sensor, Low
9-Pin	4	377RF+	Right Front Sensor, High
	5	377RF–	Right Front Sensor, Low
	7	378RF0	Right Front Solenoid Control Valve, Out
	8	378RF1	Right Front Solenoid Control Valve, In
	9	378RF–	Right Front Solenoid Control Valve, Ground

Circuit Wire Numbers and Descriptions			
Pin Connector	**Pin Number**	**Freightliner Wire Number**	**WABCO Circuit Description**
15-Pin	1	378LR0	Left Rear Solenoid Control Valve, Out
	2	378LR1	Left Rear Solenoid Control Valve, In
	3	378LR–	Left Rear Solenoid Control Valve, Ground
	4	378T–	ATC Valve Return
	5	377LR+	Left Rear Sensor, High
	6	377LR–	Left Rear Sensor, Low
	7	378T+	ATC Valve Supply
	8	377RR+	Right Rear Sensor, High
	9	377RR–	Right Rear Sensor, Low
	10	378RR0	Right Rear Solenoid Valve, Out
	11	378RR1	Right Rear Solenoid Valve, In
	12	378RR–	Right Rear Solenoid Valve, Ground
18-Pin	1	1922–	J1922 Data Link Negative to ECU
	3	1922+	J1922 Data Link Positive to ECU
	6	376T	ATC Switch (Mud/Snow) Signal
	7	376C	ECU Ignition Supply
	8	376B	ECU #2 Positive 12 Volt Supply
	9	376A	ECU #1 Positive 12 Volt Supply
	10	GND3	ECU Control Ground
	11	GND2	ECU #2 Ground
	12	GND1	ECU #1 Ground
	13	1587–	J1587 Data Link Negative to ECU
	14	1587+	J1587 Data Link Positive to ECU
	16	376S	Wheel Spin Light Signal
	17	376R	Retarder Interrupt Signal
	18	376L	Tractor ABS Indictator Light Signal

Table 1, Circuit Wire Numbers and Descriptions

If the TRAC ABS or WHL SPIN lights do not operate correctly after the ignition is turned on (the lights don't come on at all or they don't go out after about three seconds), check all related circuit breakers in the electrical panel behind the driver's seat, and replace if necessary. Check the wiring to the ABS CHECK switch and the warning lamps. Refer to **Table 2**, and repair or replace the wiring as needed. Make sure that a charged 12-volt battery is available (the ABS system needs at least 11 volts to work).

Troubleshooting

ABS CHECK Switch and Warning Lamps Wiring Checks				
Wiring Tested	**Test These Pins**	**Volt/Ohmmeter Reading**	**Possible Cause**	**Remedy**
Tractor Warning (TRAC ABS) Light	On the 18-pin connector, pins 7 and 18	2 to 50 ohms (depends on bulb wattage)	Wiring to the light is shorted or open; or the bulb needs replacing.	Repair the wiring, or replace the bulb.
Wheel Spin Light	On the 18-pin connector, pins 7 and 16	2 to 50 ohms (depends on bulb wattage)	Wiring to the light is shorted or open; or the bulb needs replacing.	Repair the wiring, or replace the bulb.
ABS CHECK Switch	On the 18-pin connector, pins 10 and 18 (also, turn on the ABS CHECK switch).	0 to 2 ohms	Wiring to the switch is shorted or open; or the switch needs replacing.	Repair the wiring, or replace the switch.

Table 2, ABS CHECK Switch and Warning Lamps Wiring Checks

Refer to the applicable table in this section for fault codes, pins to be tested, and the correct volt/ohmmeter readings. Repair or replace the components and/or wiring if the readings are not correct.

NOTE: Wire repairs may require the use of special tools for certain connectors and terminals.

Refer to **Group 54** in this manual for information on special terminals and connectors, and ordering tools for them.

Refer to the wiring diagram in **Specifications, 400** when troubleshooting the ABS system. The key switch must be turned on (engine off) to activate the blink codes.

If a fault still can't be repaired, or erased from ECU memory, contact your Rockwell District Service Manager, or call Rockwell WABCO at 1-800-535-5560.

NOTE: An "active" fault code cannot be erased from ECU memory. "Historical" faults can be erased from ECU memory without being repaired. However, make sure that all "historical" fault codes are recorded because they should be repaired as soon as possible.

Historical fault codes can be erased all at once from the ECU memory. Erase historical fault codes by depressing the ABS CHECK switch for at least three seconds (but less than six seconds). After releasing the switch, the TRAC ABS light will go out in one-half second, then there will be a four second pause. After the pause, the TRAC ABS light will flash eight times (only if there are no active fault codes–if there are, you will only see the two system flashes), followed by another four second pause. Then, the TRAC ABS light will flash two times, another four second pause will follow and the same cycle of two flashes and four-second pauses will continue until the ignition switch is turned off, then back on.

IMPORTANT: Before performing any vehicle testing on a dynomometer, disable the automatic traction control (if equipped) as follows: Depress the ABS CHECK switch for at least three seconds (but less than six seconds). After releasing the switch, the TRAC ABS light will go out in one-half second, a four second pause will occur, then the TRAC ABS light will flash two times, a four second pause will follow, and the same cycle of two flashes and four-second pauses will continue until the engine is turned off, then back on. The WHL SPIN light will also be on (indicating that ATC is enabled) during this process. Make sure that all "historical" fault codes are recorded because they will be erased when performing this procedure.

USING THE INSTRUMENTATION CONTROL UNIT (ICU) FAULT CODES

The first six digits of the ICU fault code indicate the system component or area you need to troubleshooting. To find the component or area that corresponds to a fault code, see **Table 3**. After that, refer to the appropriate table for the troubleshooting procedure.

If the First Six Digits of the Fault Code Are:	Troubleshoot this Component or Area:	See Table:
136001	Left Front Wheel Sensor	See **Table 4.**
136002	Right Front Wheel Sensor	See **Table 5.**
136003	Left Rear Wheel Sensor	See **Table 6.**
136004	Right Rear Wheel Sensor	See **Table 7.**
136005	Left Third Wheel Sensor*	See **Table 8.**
136006	Right Third Wheel Sensor*	See **Table 9.**
136007	Left Front Solenoid Control Valve	See **Table 10.**
136008	Right Front Solenoid Control Valve	See **Table 11.**
136009	Left Rear Solenoid Control Valve	See **Table 12.**
136010	Right Rear Solenoid Control Valve	See **Table 13.**
136011	Left Third Solenoid Control Valve†	See **Table 14.**
136012	Right Third Solenoid Control Valve	See **Table 15.**
136013	Retarder	See **Table 16.**
136014	Ground (diagonal 1)	See **Table 17.**
136015	Ground (diagonal 2)	See **Table 18.**
136018	ATC Valve	See **Table 19.**
136023	Warning Light	See **Table 20.**
136248	SAE-J1939 Datalink	See **Table 21.**
136249	SAE-J1922 Datalink	See **Table 22.**
136251	Voltage	See **Table 23.**
136253	Configuration	See **Table 24.**
136254	Miscellaneous	See **Table 25.**

* The left or right third wheel sensor is located at the wheel end of the rearmost axle on a 6S/4M or 6S/6M configuration.
† The left or right third solenoid control valve is located on the chassis near the rearmost axle on a 6S/6M configuration.

Table 3, ICU Fault Codes and Corresponding System Components/Areas

Left Front Wheel Sensor Troubleshooting					
ICU Fault Code			Problem	Diagnostic Procedure	Blink Code
MID	SID	FMI			
136	001	01	Excessive air gap	Adjust the sensor. Verify the adjustment by measuring the voltage across pins 4 and 5 of the 6-pin connector. A good measurement should be above 0.2 volts AC when the tire is rotated at 30 rpm. Check for loose wheel bearings and/or excessive hub runout.	3–2
136	001	02	Incorrect tire	Check for correct tire size. Check for correct number of teeth on the tone wheel.	5–2
136	001	03	Shorted to power	Measure the potential across pin 4 and ground and pin 5 and ground. If the measurement indicates a potential, the sensor is shorted to power.	4–2

Troubleshooting

Left Front Wheel Sensor Troubleshooting					
ICU Fault Code			Problem	Diagnostic Procedure	Blink Code
MID	SID	FMI			
136	001	04	Shorted to ground	Check the continuity between pin 4 and ground and pin 5 and ground. If continuity exists in either pin, the sensor is shorted to ground.	4–2
136	001	05	Open circuit	Check the continuity between pins 4 and 5 of the 6-pin connector. A good resistance measurement will be between 700 and 3000 ohms.	4–2
136	001	06	Short circuit	Check the continuity between pins 4 and 5 of the 6-pin connector. A good resistance measurement will be between 700 and 3000 ohms.	4–2
136	001	07	Damaged tone wheel	Check the tone wheel for damage such as missing teeth.	6–2
136	001	08	Wheel slip	Adjust the sensor. Verify the adjustment by measuring the voltage across pins 4 and 5 of the 6-pin connector. A good measurement should be above 0.2 volts AC when the tire is rotated at 30 rpm.	3–2
136	001	09	Wires mismatched	Check for a mis-match fault of another sensor and correct the problem in the wiring harness.	5–2
136	001	10	Intermittent signal loss	Adjust the sensor. Verify the adjustment by measuring the voltage across pins 4 and 5 of the 6-pin connector. A good measurement should be above 0.2 volts AC when the tire is rotated at 30 rpm.	3–2
136	001	11	Erratic signal	Check the sensor wiring and connectors for intermittent contact. Check the tone wheel for damage. Verify the signal by measuring the voltage across pins 4 and 5 of the 6-pin connector. A good measurement should be above 0.2 volts AC when the tire is rotated at 30 rpm.	5–2
136	001	12	Frequency incorrect	Check the sensor wiring and connectors for intermittent contact. Check the ECU for an improper fault.	5–2

Table 4, Left Front Wheel Sensor Troubleshooting

Right Front Wheel Sensor Troubleshooting					
ICU Fault Code			Problem	Diagnostic Procedure	Blink Code
MID	SID	FMI			
136	002	01	Excessive air gap	Adjust the sensor. Verify the adjustment by measuring the voltage across pins 4 and 5 of the 9-pin connector. A good measurement should be above 0.2 volts AC when the tire is rotated at 30 rpm. Check for loose wheel bearings and/or excessive hub runout.	3–1
136	002	02	Incorrect tire	Check for correct tire size. Check for correct number of teeth on the tone wheel.	5–1
136	002	03	Shorted to power	Measure the potential across pin 4 and ground, and pin 5 and ground. If the measurement indicates a potential, the sensor is shorted to power.	4–1

Right Front Wheel Sensor Troubleshooting					
ICU Fault Code			Problem	Diagnostic Procedure	Blink Code
MID	SID	FMI			
136	002	04	Shorted to ground	Check the continuity between pin 4 and ground, and pin 5 and ground. If continuity exists in either pin, the sensor is shorted to ground.	4–1
136	002	05	Open circuit	Check the continuity between pins 4 and 5 of the 9-pin connector. A good resistance measurement will be between 700 and 3000 ohms.	4–1
136	002	06	Short circuit	Check the continuity between pins 4 and 5 of the 9-pin connector. A good resistance measurement will be between 700 and 3000 ohms.	4–1
136	002	07	Damaged tone wheel	Check the tone wheel for damage such as missing teeth.	6–1
136	002	08	Wheel slip	Adjust the sensor. Verify the adjustment by measuring the voltage across pins 4 and 5 of the 9-pin connector. A good measurement should be above 0.2 volts AC when the tire is rotated at 30 rpm.	3–1
136	002	09	Wires mismatched	Check for a mis-match fault of another sensor and correct the problem in the wiring harness.	5–1
136	002	10	Intermittent signal loss	Adjust the sensor. Verify the adjustment by measuring the voltage across pins 4 and 5 of the 9-pin connector. A good measurement should be above 0.2 volts AC when the tire is rotated at 30 rpm.	3–1
136	002	11	Erratic signal	Check the sensor wiring and connectors for intermittent contact. Check the tone wheel for damage. Verify the signal by measuring the voltage across pins 4 and 5 of the 9-pin connector. A good measurement should be above 0.2 volts AC when the tire is rotated at 30 rpm.	5–1
136	002	12	Frequency incorrect	Check the sensor wiring and connectors for intermittent contact. Check the ECU for an improper fault.	5–1

Table 5, Right Front Wheel Sensor Troubleshooting

Left Rear Wheel Sensor Troubleshooting					
ICU Fault Code			Problem	Diagnostic Procedure	Blink Code
MID	SID	FMI			
136	003	01	Excessive air gap	Adjust the sensor. Verify the adjustment by measuring the voltage across pins 4 and 5 of the 15-pin connector. A good measurement should be above 0.2 volts AC when the tire is rotated at 30 rpm. Check for loose wheel bearings and/or excessive hub runout.	3–4
136	003	02	Incorrect tire	Check for correct tire size. Check for correct number of teeth on the tone wheel.	5–4
136	003	03	Shorted to power	Measure the potential across pin 4 and ground, and pin 5 and ground. If the measurement indicates a potential, the sensor is shorted to power.	4–4

Troubleshooting

Left Rear Wheel Sensor Troubleshooting					
ICU Fault Code			Problem	Diagnostic Procedure	Blink Code
MID	SID	FMI			
136	003	04	Shorted to ground	Check the continuity between pin 4 and ground, and pin 5 and ground. If continuity exists in either pin, the sensor is shorted to ground.	4–4
136	003	05	Open circuit	Check the continuity between pins 4 and 5 of the 15-pin connector. A good resistance measurement will be between 700 and 3000 ohms.	4–4
136	003	06	Short circuit	Check the continuity between pins 4 and 5 of the 15-pin connector. A good resistance measurement will be between 700 and 3000 ohms.	4–4
136	003	07	Damaged tone wheel	Check the tone wheel for damage such as missing teeth.	6–4
136	003	08	Wheel slip	Adjust the sensor. Verify the adjustment by measuring the voltage across pins 4 and 5 of the 15-pin connector. A good measurement should be above 0.2 volts AC when the tire is rotated at 30 rpm.	3–4
136	003	09	Wires mismatched	Check for a mis-match fault of another sensor and correct the problem in the wiring harness.	5–4
136	003	10	Intermittent signal loss	Adjust the sensor. Verify the adjustment by measuring the voltage across pins 4 and 5 of the 15-pin connector. A good measurement should be above 0.2 volts AC when the tire is rotated at 30 rpm.	3–4
136	003	11	Erratic signal	Check the sensor wiring and connectors for intermittent contact. Check the tone wheel for damage. Verify the signal by measuring the voltage across pins 4 and 5 of the 15-pin connector. A good measurement should be above 0.2 volts AC when the tire is rotated at 30 rpm.	5–4
136	003	12	Frequency incorrect	Check the sensor wiring and connectors for intermittent contact. Check the ECU for an improper fault.	5–4

Table 6, Left Rear Wheel Sensor Troubleshooting

Right Rear Wheel Sensor Troubleshooting					
ICU Fault Code			Problem	Diagnostic Procedure	Blink Code
MID	SID	FMI			
136	004	01	Excessive air gap	Adjust the sensor. Verify the adjustment by measuring the voltage across pins 8 and 9 of the 15-pin connector. A good measurement should be above 0.2 volts AC when the tire is rotated at 30 rpm. Check for loose wheel bearings and/or excessive hub runout.	3–3
136	004	02	Incorrect tire	Check for correct tire size. Check for correct number of teeth on the tone wheel.	5–3
136	004	03	Shorted to power	Measure the potential across pin 8 and ground, and pin 9 and ground. If the measurement indicates a potential, the sensor is shorted to power.	4–3

Right Rear Wheel Sensor Troubleshooting					
ICU Fault Code			Problem	Diagnostic Procedure	Blink Code
MID	SID	FMI			
136	004	04	Shorted to ground	Check the continuity between pin 8 and ground, and pin 9 and ground. If continuity exists in either pin, the sensor is shorted to ground.	4–3
136	004	05	Open circuit	Check the continuity between pins 8 and 9 of the 15-pin connector. A good resistance measurement will be between 700 and 3000 ohms.	4–3
136	004	06	Short circuit	Check the continuity between pins 8 and 9 of the 15-pin connector. A good resistance measurement will be between 700 and 3000 ohms.	4–3
136	004	07	Damaged tone wheel	Check the tone wheel for damage such as missing teeth.	6–3
136	004	08	Wheel slip	Adjust the sensor. Verify the adjustment by measuring the voltage across pins 8 and 9 of the 15-pin connector. A good measurement should be above 0.2 volts AC when the tire is rotated at 30 rpm.	3–3
136	004	09	Wires mismatched	Check for a mis-match fault of another sensor and correct the problem in the wiring harness.	5–3
136	004	10	Intermittent signal loss	Adjust the sensor. Verify the adjustment by measuring the voltage across pins 8 and 9 of the 15-pin connector. A good measurement should be above 0.2 volts AC when the tire is rotated at 30 rpm.	3–3
136	004	11	Erratic signal	Check the sensor wiring and connectors for intermittent contact. Check the tone wheel for damage. Verify the signal by measuring the voltage across pins 8 and 9 of the 15-pin connector. A good measurement should be above 0.2 volts AC when the tire is rotated at 30 rpm.	5–3
136	004	12	Frequency incorrect	Check the sensor wiring and connectors for intermittent contact. Check the ECU for an improper fault.	5–3

Table 7, Right Rear Wheel Sensor Troubleshooting

Left Tag Wheel Sensor Troubleshooting					
ICU Fault Code			Problem	Diagnostic Procedure	Blink Code
MID	SID	FMI			
136	005	01	Excessive air gap	Adjust the sensor. Verify the adjustment by measuring the voltage across pins 5 and 6 of the 12-pin connector. A good measurement should be above 0.2 volts AC when the tire is rotated at 30 rpm. Check for loose wheel bearings and/or excessive hub runout.	3–6
136	005	02	Incorrect tire	Check for correct tire size. Check for correct number of teeth on the tone wheel.	5–6
136	005	03	Shorted to power	Measure the potential across pin 5 and ground, and pin 6 and ground. If the measurement indicates a potential, the sensor is shorted to power.	4–6

Troubleshooting

Left Tag Wheel Sensor Troubleshooting					
ICU Fault Code			Problem	Diagnostic Procedure	Blink Code
MID	SID	FMI			
136	005	04	Shorted to ground	Check the continuity between pin 5 and ground, and pin 6 and ground. If continuity exists in either pin, the sensor is shorted to ground.	4–6
136	005	05	Open circuit	Check the continuity between pins 5 and 6 of the 12-pin connector. A good resistance measurement will be between 700 and 3000 ohms.	4–6
136	005	06	Short circuit	Check the continuity between pins 5 and 6 of the 12-pin connector. A good resistance measurement will be between 700 and 3000 ohms.	4–6
136	005	07	Damaged tone wheel	Check the tone wheel for damage such as missing teeth.	6–6
136	005	08	Wheel slip	Adjust the sensor. Verify the adjustment by measuring the voltage across pins 5 and 6 of the 12-pin connector. A good measurement should be above 0.2 volts AC when the tire is rotated at 30 rpm.	3–6
136	005	09	Wires mismatched	Check for a mis-match fault of another sensor and correct the problem in the wiring harness.	5–6
136	005	10	Intermittent signal loss	Adjust the sensor. Verify the adjustment by measuring the voltage across pins 5 and 6 of the 12-pin connector. A good measurement should be above 0.2 volts AC when the tire is rotated at 30 rpm.	3–6
136	005	11	Erratic signal	Check the sensor wiring and connectors for intermittent contact. Check the tone wheel for damage. Verify the signal by measuring the voltage across pins 5 and 6 of the 12-pin connector. A good measurement should be above 0.2 volts AC when the tire is rotated at 30 rpm.	5–6
136	005	12	Frequency incorrect	Check the sensor wiring and connectors for intermittent contact. Check the ECU for an improper fault.	5–6

Table 8, Left Tag Wheel Sensor Troubleshooting

Right Tag Wheel Sensor Troubleshooting					
ICU Fault Code			Problem	Diagnostic Procedure	Blink Code
MID	SID	FMI			
136	006	01	Excessive air gap	Adjust the sensor. Verify the adjustment by measuring the voltage across pins 8 and 9 of the 12-pin connector. A good measurement should be above 0.2 volts AC when the tire is rotated at 30 rpm. Check for loose wheel bearings and/or excessive hub runout.	3–5
136	006	02	Incorrect tire	Check for correct tire size. Check for correct number of teeth on the tone wheel.	5–5
136	006	03	Shorted to power	Measure the potential across pin 8 and ground, and pin 9 and ground. If the measurement indicates a potential, the sensor is shorted to power.	4–5

Right Tag Wheel Sensor Troubleshooting					
ICU Fault Code			Problem	Diagnostic Procedure	Blink Code
MID	SID	FMI			
136	006	04	Shorted to ground	Check the continuity between pin 8 and ground, and pin 9 and ground. If continuity exists in either pin, the sensor is shorted to ground.	4–5
136	006	05	Open circuit	Check the continuity between pins 8 and 9 of the 12-pin connector. A good resistance measurement will be between 700 and 3000 ohms.	4–5
136	006	06	Short circuit	Check the continuity between pins 8 and 9 of the 12-pin connector. A good resistance measurement will be between 700 and 3000 ohms.	4–5
136	006	07	Damaged tone wheel	Check the tone wheel for damage such as missing teeth.	6–5
136	006	08	Wheel slip	Adjust the sensor. Verify the adjustment by measuring the voltage across pins 8 and 9 of the 12-pin connector. A good measurement should be above 0.2 volts AC when the tire is rotated at 30 rpm.	3–5
136	006	09	Wires mismatched	Check for a mis-match fault of another sensor and correct the problem in the wiring harness.	5–5
136	006	10	Intermittent signal loss	Adjust the sensor. Verify the adjustment by measuring the voltage across pins 8 and 9 of the 12-pin connector. A good measurement should be above 0.2 volts AC when the tire is rotated at 30 rpm.	3–5
136	006	11	Erratic signal	Check the sensor wiring and connectors for intermittent contact. Check the tone wheel for damage. Verify the signal by measuring the voltage across pins 8 and 9 of the 12-pin connector. A good measurement should be above 0.2 volts AC when the tire is rotated at 30 rpm.	5–5
136	006	12	Frequency incorrect	Check the sensor wiring and connectors for intermittent contact. Check the ECU for an improper fault.	5–5

Table 9, Right Tag Wheel Sensor Troubleshooting

Left Front Solenoid Control Valve Troubleshooting					
ICU Fault Code			Problem	Diagnostic Procedure	Blink Code
MID	SID	FMI			
136	007	01	Open circuit in the inlet and/or outlet solenoid circuits	Check the solenoid control valve wiring. Check for damaged wiring in the inlet, outlet and ground circuits. Check the resistance between pin 1 of the 6-pin connector and pin 3, and between pin 2 and pin 3. A good measurement should be between 4 and 8 ohms.	2–2
136	007	03	Shorted to power	Check the solenoid control valve wiring. Check for damaged wiring in the inlet, outlet and ground circuits. Measure the potential across pin 1 of the 6-pin connector and pin 3, and between pin 2 and pin 3. If the measurement indicates a potential, the valve is shorted to power.	2–2

Troubleshooting

Left Front Solenoid Control Valve Troubleshooting					
ICU Fault Code			Problem	Diagnostic Procedure	Blink Code
MID	SID	FMI			
136	007	05	Open circuit	Check the solenoid control valve wiring. Check for damaged wiring in the inlet, outlet and ground circuits. Check the resistance between pin 1 of the 6-pin connector and pin 3, and between pin 2 and pin 3. A good measurement should be between 4 and 8 ohms.	2–2
136	007	06	Shorted to ground	Check continuity between pin 1 of the 6-pin connector and ground, and pin 2 and ground. If continuity exists in either pin, the valve is shorted to ground.	2–2

Table 10, Left Front Solenoid Control Valve Troubleshooting

Right Front Solenoid Control Valve Troubleshooting					
ICU Fault Code			Problem	Diagnostic Procedure	Blink Code
MID	SID	FMI			
136	008	01	Open circuit in the inlet and/or outlet solenoid circuits	Check the solenoid control valve wiring. Check for damaged wiring in the inlet, outlet and ground circuits. Check the resistance between pin 7 of the 9-pin connector and pin 9, and between pin 8 and pin 9. A good measurement should be between 4 and 8 ohms.	2–1
136	008	03	Shorted to power	Check the solenoid control valve wiring. Check for damaged wiring in the inlet, outlet and ground circuits. Measure the potential across pin 7 of the 9-pin connector and pin 9, and between pin 8 and pin 9. If the measurement indicates a potential, the valve is shorted to power.	2–1
136	008	05	Open circuit	Check the solenoid control valve wiring. Check for damaged wiring in the inlet, outlet and ground circuits. Check the resistance between pin 7 of the 9-pin connector and pin 9, and between pin 8 and pin 9. A good measurement should be between 4 and 8 ohms.	2–1
136	008	06	Shorted to ground	Check continuity between pin 7 of the 9-pin connector and ground, and pin 8 and ground. If continuity exists in either pin, the valve is shorted to ground.	2–1

Table 11, Right Front Solenoid Control Valve Troubleshooting

Left Rear Solenoid Control Valve Troubleshooting					
ICU Fault Code			Problem	Diagnostic Procedure	Blink Code
MID	SID	FMI			
136	009	01	Open circuit in the inlet and/or outlet solenoid circuits	Check the solenoid control valve wiring. Check for damaged wiring in the inlet, outlet and ground circuits. Check the resistance between pin 1 of the 15-pin connector and pin 3, and between pin 2 and pin 3. A good measurement should be between 4 and 8 ohms.	2–4
136	009	03	Shorted to power	Check the solenoid control valve wiring. Check for damaged wiring in the inlet, outlet and ground circuits. Measure the potential across pin 1 of the 15-pin connector and pin 3, and between pin 2 and pin 3. If the measurement indicates a potential, the valve is shorted to power.	2–4
136	009	05	Open circuit	Check the solenoid control valve wiring. Check for damaged wiring in the inlet, outlet and ground circuits. Check the resistance between pin 1 of the 15-pin connector and pin 3, and between pin 2 and pin 3. A good measurement should be between 4 and 8 ohms.	2–4
136	009	06	Shorted to ground	Check continuity between pin 1 of the 15-pin connector and ground, and pin 2 and ground. If continuity exists in either pin, the valve is shorted to ground.	2–4

Table 12, Left Rear Solenoid Control Valve Troubleshooting

Right Rear Solenoid Control Valve Troubleshooting					
ICU Fault Code			Problem	Diagnostic Procedure	Blink Code
MID	SID	FMI			
136	010	01	Open circuit in the inlet and/or outlet solenoid circuits	Check the solenoid control valve wiring. Check for damaged wiring in the inlet, outlet and ground circuits. Check the resistance between pin 10 of the 15-pin connector and pin 12, and between pin 11 and pin 12. A good measurement should be between 4 and 8 ohms.	2–3
136	010	03	Shorted to power	Check the solenoid control valve wiring. Check for damaged wiring in the inlet, outlet and ground circuits. Measure the potential across pin 10 of the 15-pin connector and pin 12, and between pin 11 and pin 12. If the measurement indicates a potential, the valve is shorted to power.	2–3
136	010	05	Open circuit	Check the solenoid control valve wiring. Check for damaged wiring in the inlet, outlet and ground circuits. Check the resistance between pin 10 of the 15-pin connector and pin 12, and between pin 11 and pin 12. A good measurement should be between 4 and 8 ohms.	2–3
136	010	06	Shorted to ground	Check continuity between pin 10 of the 15-pin connector and ground, and pin 11 and ground. If continuity exists in either pin, the valve is shorted to ground.	2–3

Table 13, Right Rear Solenoid Control Valve Troubleshooting

Troubleshooting

Left Third Solenoid Control Valve Troubleshooting					
ICU Fault Code			Problem	Diagnostic Procedure	Blink Code
MID	SID	FMI			
136	011	01	Open circuit in the inlet and/or outlet solenoid circuits	Check the solenoid control valve wiring. Check for damaged wiring in the inlet, outlet and ground circuits. Check the resistance between pin 1 of the 12-pin connector and pin 3, and between pin 2 and pin 3. A good measurement should be between 4 and 8 ohms.	2–6
136	011	03	Shorted to power	Check the solenoid control valve wiring. Check for damaged wiring in the inlet, outlet and ground circuits. Measure the potential across pin 1 of the 12-pin connector and pin 3, and between pin 2 and pin 3. If the measurement indicates a potential, the valve is shorted to power.	2–6
136	011	05	Open circuit	Check the solenoid control valve wiring. Check for damaged wiring in the inlet, outlet and ground circuits. Check the resistance between pin 1 of the 12-pin connector and pin 3, and between pin 2 and pin 3. A good measurement should be between 4 and 8 ohms.	2–6
136	011	06	Shorted to ground	Check continuity between pin 1 of the 12-pin connector and ground, and pin 2 and ground. If continuity exists in either pin, the valve is shorted to ground.	2–6

Table 14, Left Third Solenoid Control Valve Troubleshooting

Right Third Solenoid Control Valve Troubleshooting					
ICU Fault Code			Problem	Diagnostic Procedure	Blink Code
MID	SID	FMI			
136	012	01	Open circuit in the inlet and/or outlet solenoid circuits	Check the solenoid control valve wiring. Check for damaged wiring in the inlet, outlet and ground circuits. Check the resistance between pin 10 of the 12-pin connector and pin 12, and between pin 11 and pin 12. A good measurement should be between 4 and 8 ohms.	2–5
136	012	03	Shorted to power	Check the solenoid control valve wiring. Check for damaged wiring in the inlet, outlet and ground circuits. Measure the potential across pin 10 of the 12-pin connector and pin 12, and between pin 11 and pin 12. If the measurement indicates a potential, the valve is shorted to power.	2–5
136	012	05	Open circuit	Check the solenoid control valve wiring. Check for damaged wiring in the inlet, outlet and ground circuits. Check the resistance between pin 10 of the 12-pin connector and pin 12, and between pin 11 and pin 12. A good measurement should be between 4 and 8 ohms.	2–5
136	012	06	Shorted to ground	Check continuity between pin 10 of the 12-pin connector and ground, and pin 11 and ground. If continuity exists in either pin, the valve is shorted to ground.	2–5

Table 15, Right Third Solenoid Control Valve Troubleshooting

Retarder Troubleshooting					
ICU Fault Code			Problem	Diagnostic Procedure	Blink Code
MID	SID	FMI			
136	013	03	Shorted to power	Measure the potential between pin 17 on the 18-pin connector and ground. If the measurement indicates a potential, the relay circuit is shorted to power.	7–3
136	013	05	Open circuit	Check continuity of the retarder relay circuit 376R. Replace the wire if continuity does not exist.	7–3
136	013	06	Shorted to ground	Check continuity between pin 17 on the 18-pin connector and ground. If continuity exists, the retarder relay circuit is shorted to ground.	7–3

Table 16, Retarder Troubleshooting

Ground (diagonal 1) Troubleshooting					
ICU Fault Code			Problem	Diagnostic Procedure	Blink Code
MID	SID	FMI			
136	014	03	Ground, diagonal 2, shorted to power	Measure potential between pin 9 on the 9-pin connector and ground, pin 3 on the 15-pin connector and ground, and pin 3 on the 12-pin connector (if applicable) and ground. If measurements indicate a potential, a solenoid control valve ground is shorted to power.	8–5
136	014	04	Voltage, diagonal 2, low voltage/open circuit	Check the 10A circuit breaker. Check pin 9 in the 18-pin connector for proper contact. Check continuity of the circuit. If continuity does not exist, replace the wire.	8–1
136	014	05	Ground, diagonal 2, open circuit	Check continuity between pins 11 and 12 in the 18-pin connector. If continuity does not exist, replace the wire to pin 12.	8–5
136	014	06	Ground, diagonal 2, short to low	Check continuity between pins 7 and 8 in the 9-pin connector and ground, pins 1 and 2 in the 15-pin connector and ground, and pins 1 and 2 in the 12-pin connector and ground. If continuity exists, a solenoid control valve circuit is shorted to ground.	8–5

Table 17, Ground (diagonal 1) Troubleshooting

Ground (diagonal 2) Troubleshooting					
ICU Fault Code			Problem	Diagnostic Procedure	Blink Code
MID	SID	FMI			
136	015	03	Ground, diagonal 1, shorted to power	Measure potential between pin 3 on the 6-pin connector and ground, pin 12 on the 15-pin connector and ground, and pin 12 on the 12-pin connector (if applicable) and ground. If measurements indicate a potential, a solenoid control valve ground is shorted to power.	8–5
136	015	04	Voltage, diagonal 1, low voltage/open circuit	Check the 10A circuit breaker. Check pin 8 in the 18-pin connector for proper contact. Check continuity of the circuit. If continuity does not exist, replace the wire.	8–1

Troubleshooting

Ground (diagonal 2) Troubleshooting					
ICU Fault Code			Problem	Diagnostic Procedure	Blink Code
MID	SID	FMI			
136	015	05	Ground, diagonal 1, open circuit	Check continuity between pins 11 and 12 in the 18-pin connector. If continuity does not exist, replace the wire to pin 11.	8–5
136	015	06	Ground, diagonal 1, short to low	Check continuity between pins 1 and 2 in the 6-pin connector and ground, pins 10 and 11 in the 15-pin connector and ground, and pins 10 and 11 in the 12-pin connector and ground. If continuity exists, a solenoid control valve circuit is shorted to ground.	8–5

Table 18, Ground (diagonal 2) Troubleshooting

ATC Valve Troubleshooting					
ICU Fault Code			Problem	Diagnostic Procedure	Blink Code
MID	SID	FMI			
136	018	03	ATC valve, shorted to power	Measure the potential between pin 3 in the 15-pin connector and ground, and pin 7 in the 15-pin connector and ground. If measurements indicate a potential, the ATC valve is shorted to power.	7–2
136	018	05	ATC valve, open circuit	Check continuity between pins 4 and 7 in the 15-pin connector. If continuity does not exist replace the wiring. A good measurement will read between 8 and 14 ohms.	7–2
136	018	06	ATC valve, shorted to ground	Check continuity between pins 14 in the 15-pin connector and ground, and pin 7 in the 15-pin connector and ground. If continuity exists, replace the ATC valve wiring.	7–2

Table 19, ATC Valve Troubleshooting

Warning Light Troubleshooting					
ICU Fault Code			Problem	Diagnostic Procedure	Blink Code
MID	SID	FMI			
136	023	05	Warning Light	Check the bulb and continuity of the warning light circuit. Was the blink code switch activated longer than 16 seconds? If so, cycle the ignition off and on to verify the fault.	7–4

Table 20, Warning Light Troubleshooting

SAE-J1939 Datalink Troubleshooting					
ICU Fault Code			Problem	Diagnostic Procedure	Blink Code
MID	SID	FMI			
136	231	02	J1939 plausibility error	Check the speedometer calibration. Check for tire size mismatch.	7–1
136	231	05	J1939 open circuit	Check J1939 datalink connections. Check for continuity of datalink wires.	7–1
136	231	06	J1939 shorted to ground	Check the continuity between pin 1 and ground, and pin 3 and ground. If continuity exists, the J1939 datalink is shorted to ground.	7–1
136	231	09	J1939 time-out	Check other J1939 ECUs for incorrect communication.	7–1
136	231	12	J1939, internal error	Cycle the ignition off and on. If the fault detection repeats, replace the ABS electronic control unit.	8–3

Table 21, SAE-J1939 Datalink Troubleshooting

J1922 Datalink Troubleshooting					
ICU Fault Code			Problem	Diagnostic Procedure	Blink Code
MID	SID	FMI			
136	249	05	The J1922 datalink has an open circuit	Check the J1922 datalink connections. Check continuity of the datalink wires.	7–1
136	249	06	The J1922 datalink is shorted to ground	Check continuity between pin 1 and ground, and pin 3 and ground. If continuity exists, the J1922 datalink is shorted to ground.	7–1
136	249	10	The J1922 bus is not free	Check other J1922 ECUs for incorrect communication.	7–1

Table 22, J1922 Datalink Troubleshooting

Overvoltage Troubleshooting					
ICU Fault Code			Problem	Diagnostic Procedure	Blink Code
MID	SID	FMI			
136	251	03	Overvoltage, diagonal 1 or 2	Check the alternator output and the battery potential. Supply voltage is greater than 14 volts for more than 5 seconds.	8–2

Table 23, Overvoltage Troubleshooting

Troubleshooting

Configuration Troubleshooting					
ICU Fault Code			Problem	Diagnostic Procedure	Blink Code
MID	SID	FMI			
136	253	01	ATC configuration	Check the wires responsible for parameter setting.	7–5
136	253	02	EEPROM, wheel parameter incorrect	Cycle the ignition off and on. If the fault detection repeats, replace the ABS electronic control unit.	8–4
136	253	12	EEPROM, checksum	Check the parameter setting. Diagnostic device disconnected during active diagnosis. Cycle the ignition off and on. If the fault detection repeats, replace the ABS electronic control unit.	8–4

Table 24, Configuration Troubleshooting

Miscellaneous ABS Troubleshooting					
ICU Fault Code			Problem	Diagnostic Procedure	Blink Code
MID	SID	FMI			
136	254	02	Internal error	Cycle the ignition off and on. If the fault detection repeats, replace the ABS electronic control unit.	8–3
136	254	05	ABS ECU, no loads	No modulators connected. Fault not memorized.	8–4
136	254	08	Excessive slip/ dynotester	Check the wheel sensor air gaps.	7–1
136	254	09	Solenoid Control Valve, activation time	Modulator valve was activated for too long.	2–1
136	254	12	Internal error	Cycle the ignition off and on. If the fault detection repeats, replace the ABS electronic control unit.	8–3

Table 25, Miscellaneous ABS Troubleshooting

See **Fig. 1** for a full view of the wiring diagram for the ABS valves and sensors. See **Fig. 2**, and **Fig. 3** for partial (detailed) views of the wiring diagram. See **Fig. 4** for a full view of the diagram showing additional ABS cab and chassis wiring. See **Fig. 5**, **Fig. 6** and **Fig. 7** for partial (detailed) views of the wiring diagram.

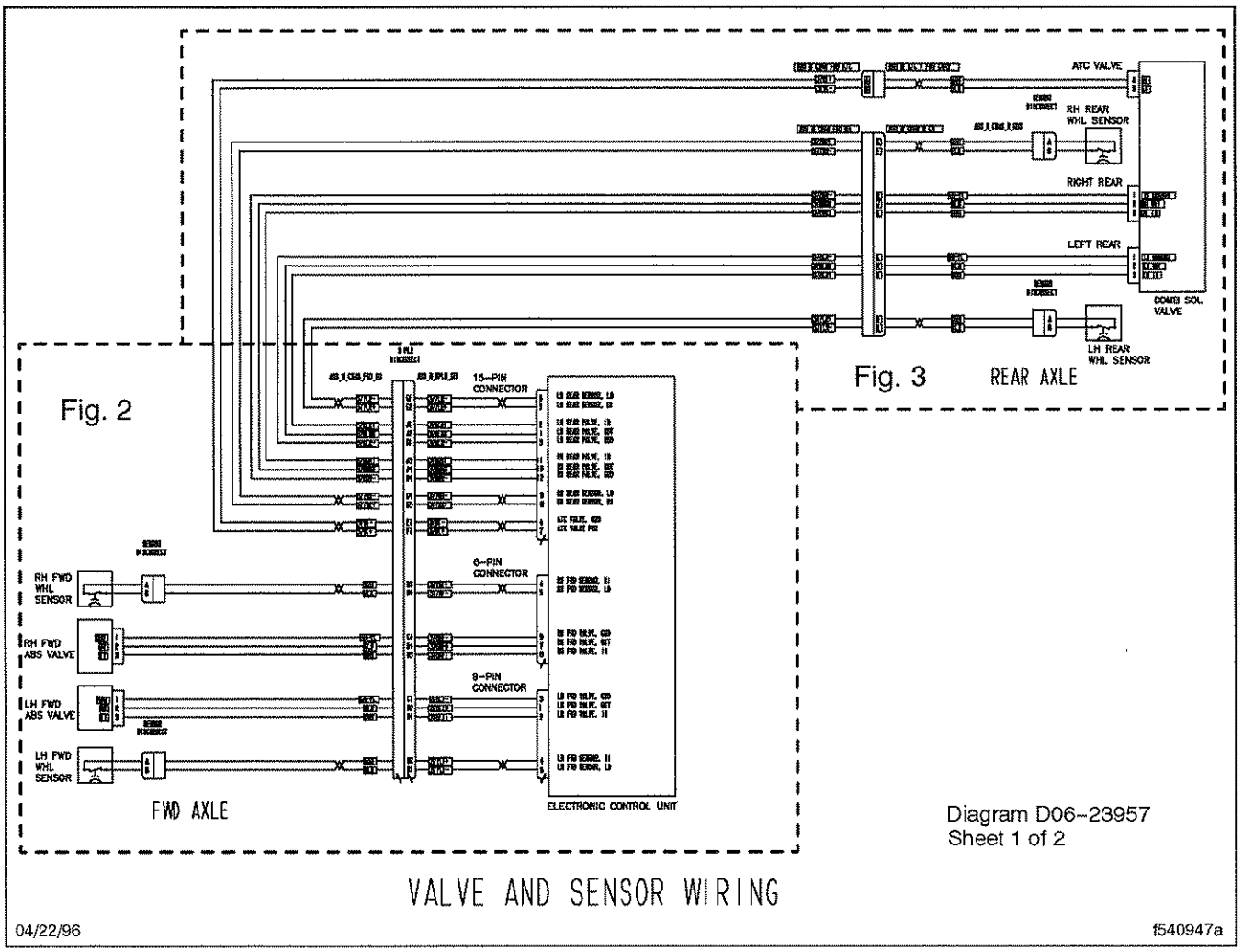


Fig. 1, Wiring Diagram for ABS Valves and Sensors

Specifications

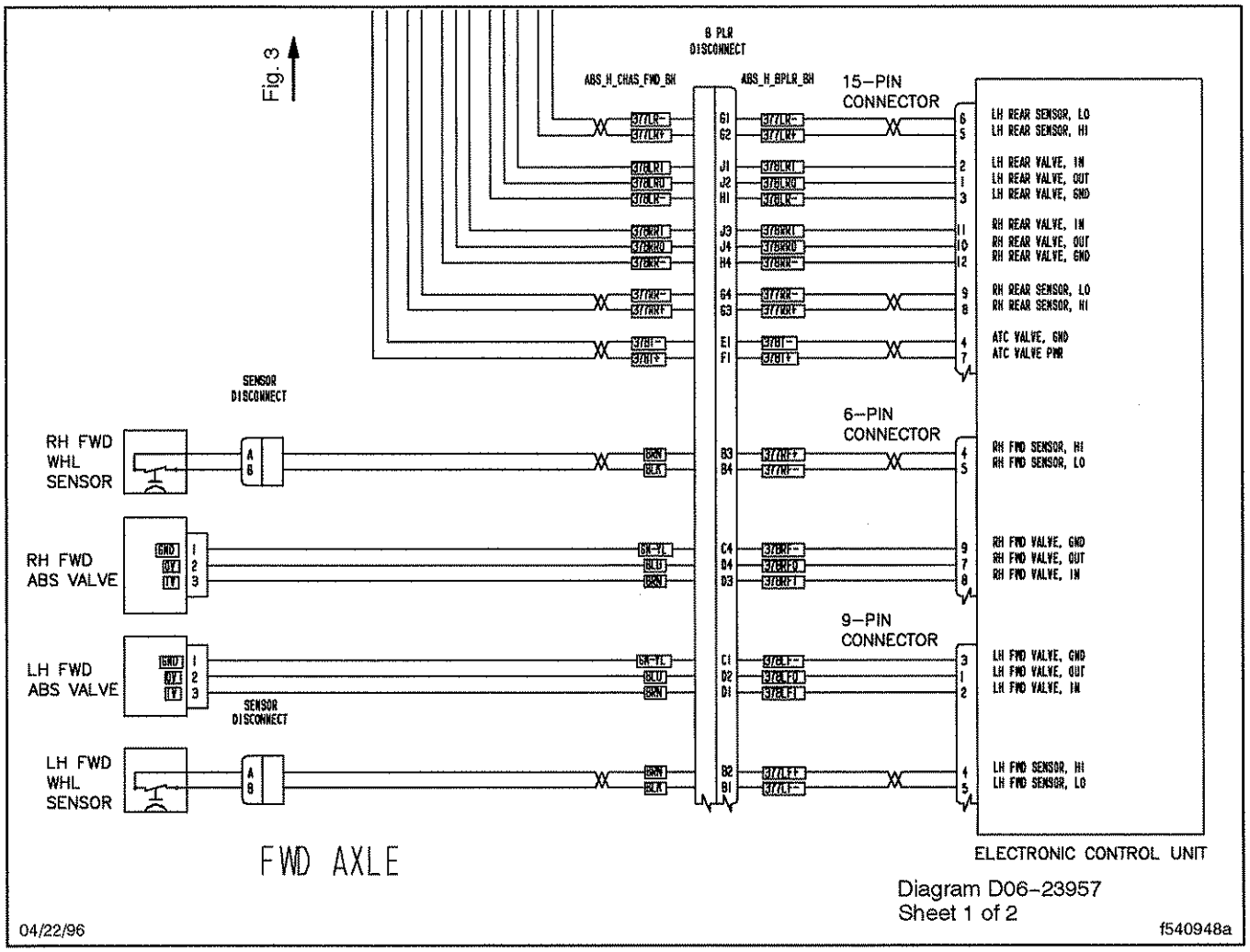


Fig. 2, Partial View Showing Front Axle Wiring

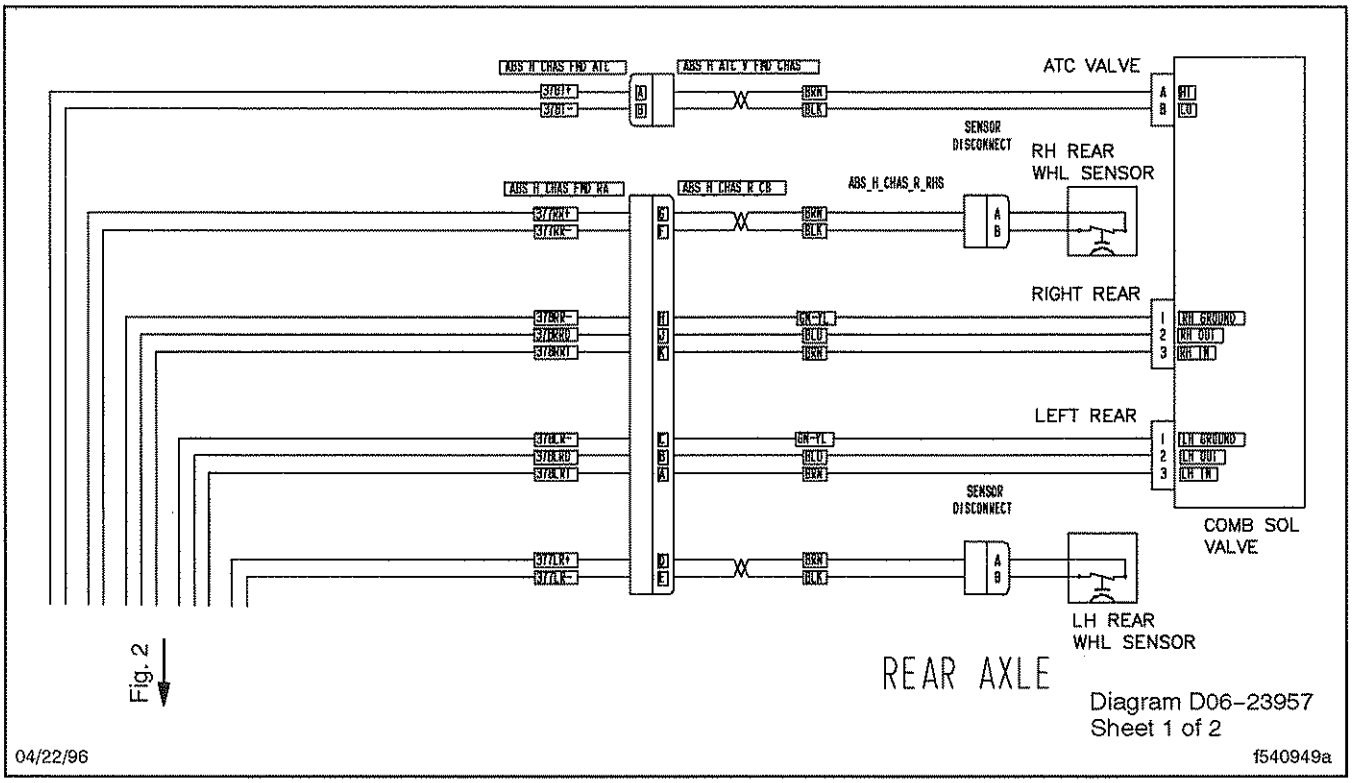


Fig. 3, Partial View Showing Rear Axle Wiring

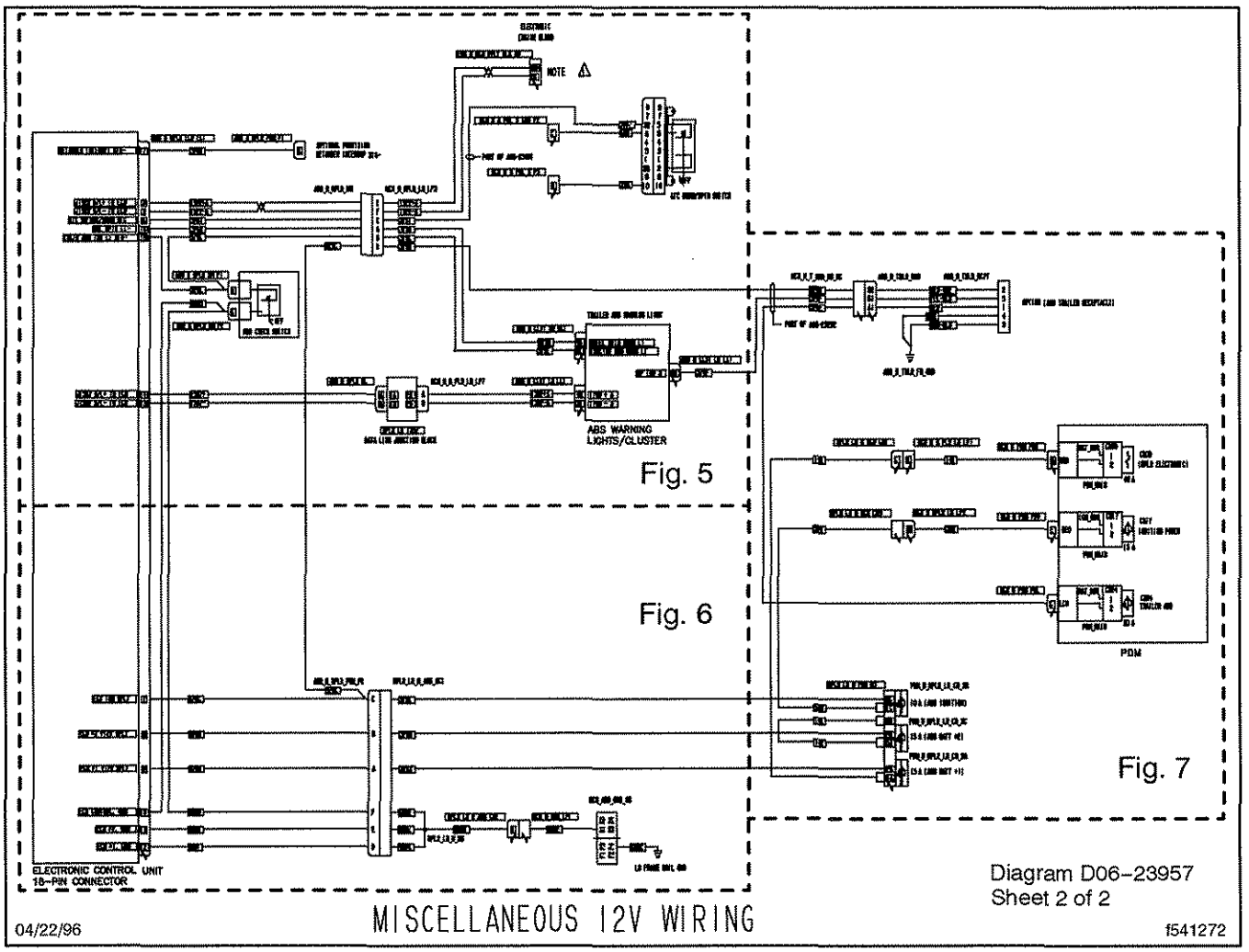


Fig. 4, Diagram Showing Additional ABS Cab and Chassis Wiring

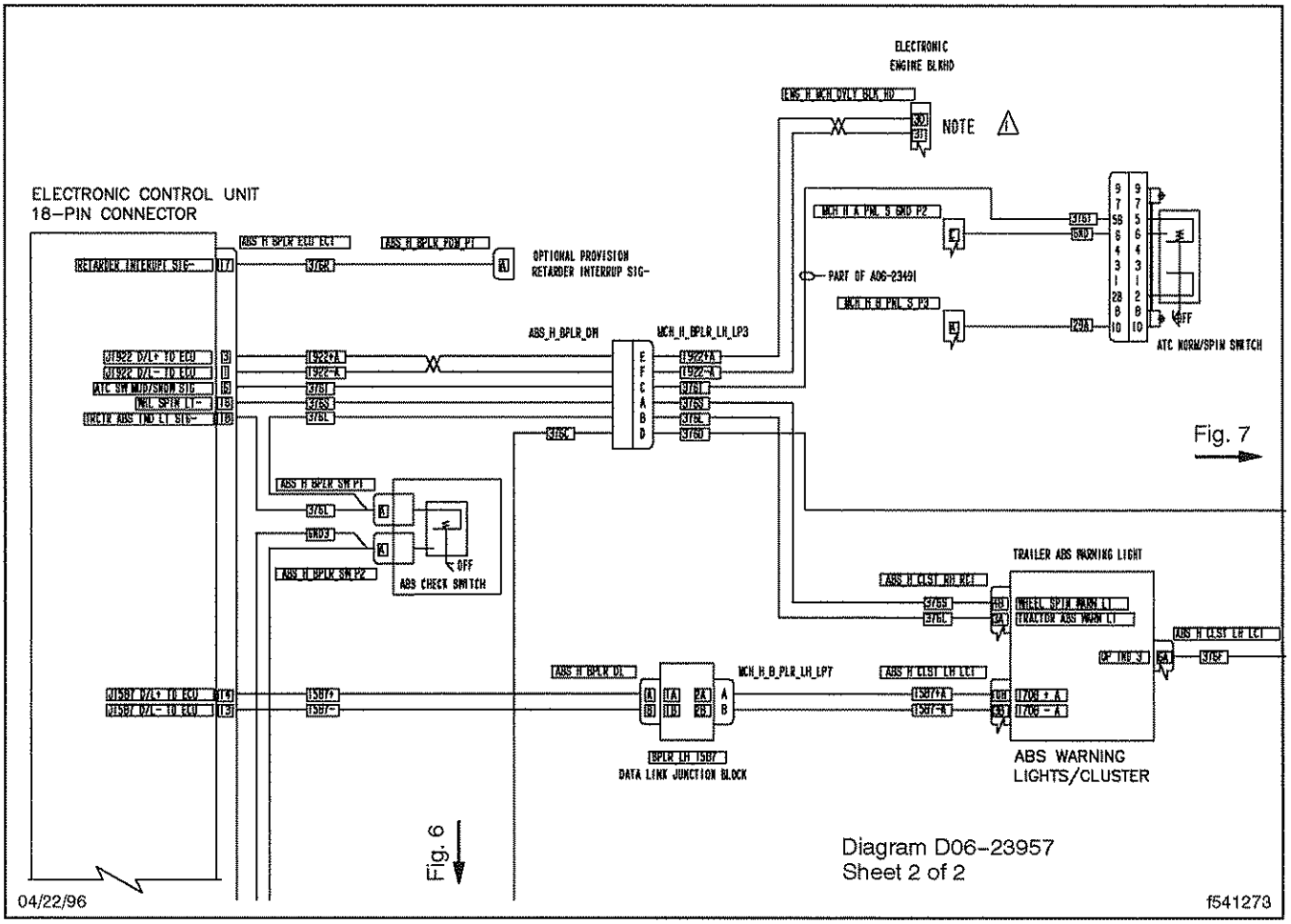


Fig. 5, Partial View of the ABS Cab and Chassis Wiring

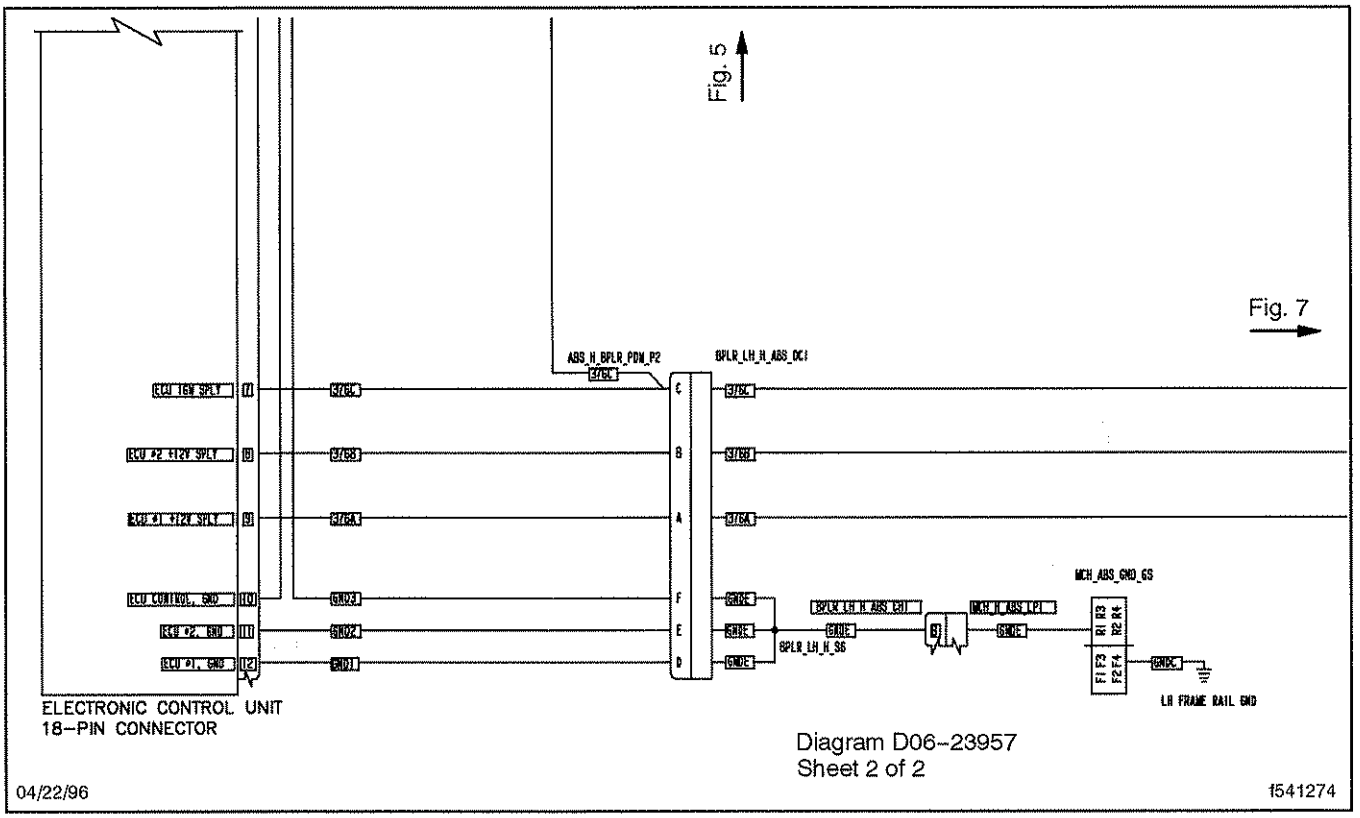


Fig. 6, Partial View of the ABS Cab and Chassis Wiring

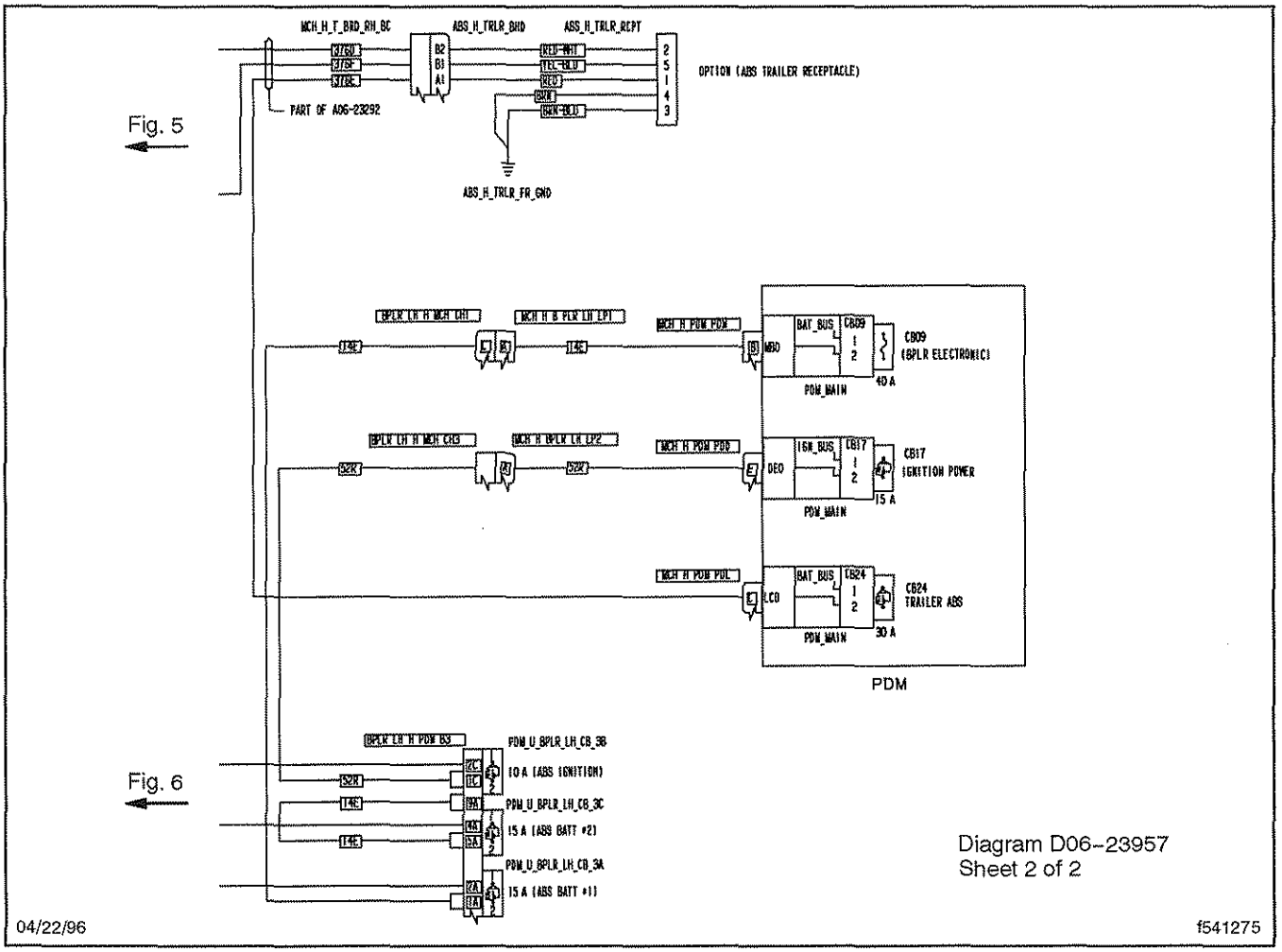


Fig. 7, Partial View of the ABS Cab and Chassis Wiring

Contents

Subject	Subject Number
General Information	050
Service Operations	
Leakage Tests	100
Drain Valve Replacement and Leak Elimination	110
Air Reservoir Replacement	120

General Information

Air reservoirs serve two main purposes:

- They store compressed air used to apply the brakes and operate other air-powered devices, such as window lifts, windshield wipers, and seats.
- They provide a place where air, heated during compression, can cool and water vapor can condense into a liquid. Also, air reservoirs collect small amounts of oil passed by the compressor.

Each vehicle is equipped with three or four air reservoirs, depending on the number of rear axles. On all vehicles, each reservoir is identified as one of three types: supply, primary, and secondary.

A supply reservoir receives compressed air directly from the compressor. Also referred to as the wet tank, its functions are to collect most of the water and oil condensate from the air, and to supply air to the other reservoirs. At the outlet port of the supply reservoir (the port leading to the primary reservoir) is a safety valve, which protects the air system against excessive air pressure build-up. The supply reservoir is usually mounted on the right-hand frame rail.

Primary reservoirs are air sources for the brakes on the rear axles. One or two primary reservoirs are installed on a vehicle, depending on the number of rear axles and the air system configuration. Each primary reservoir is usually mounted behind the supply reservoir on the right-hand frame rail.

A secondary reservoir is the air source for the front axle brakes. It is usually mounted on the left-hand frame rail, and, like the primary reservoir, is equipped with an inline check valve.

The secondary reservoir supplies air to a pressure protection valve. This valve prevents complete loss of secondary air pressure if there is an air leak in any non-brake accessory.

All air reservoirs are equipped with drain valves to eject the water and oil emulsion from the tanks.

Tests

NOTE: If equipped with an automatic moisture-ejection valve, refer elsewhere in this group for leak testing.

Be sure the air system is fully charged. Using a soap solution or leak detector, check for leaks on the outside surfaces of the reservoirs and drain valves. No leakage is permitted.

If leaks exist at the drain valve, note if they occur at the joint of the valve and coupler, or through the valve body. Proceed to **Subject 110.**

If leaks occur on the surfaces of the air reservoir, replace the tank; refer to **Subject 120.**

Drain Valve Replacement and Leak Elimination

NOTE: If equipped with an automatic moisture-ejection valve, refer elsewhere in this group for instructions.

1. Apply the parking brakes, and chock the tires.
2. Drain the air system, using the instructions in the vehicle driver's manual.
3. Using two wrenches (hold the coupler in place with one of them), unscrew the drain valve from the coupler. Clean off the threads inside the coupler on the reservoir, removing all sludge and sealant build-up.

   Obtain a new drain valve if leaks occurred through the body of the valve.

   If leaks occurred at the joint of the drain valve and coupler, clean off the sludge and sealant from the threads of the valve. Check for damaged threads on the valve and inside the coupler. Replace damaged parts. If no damage exists, leakage was probably due to inadequate tightening of the drain valve in the coupler.
4. Apply Loctite®, or an equivalent sealant, to the end threads of the drain valve or coupler, as applicable, and install finger-tight. Tighten one and one-half additional turns (use two wrenches if installing the drain valve).
5. Perform a leak test after completing the installation. If leaks occur at the joint of the drain valve and coupler, tighten the valve up to one additional turn to stop the leaks.
6. Remove the chocks from the tires.

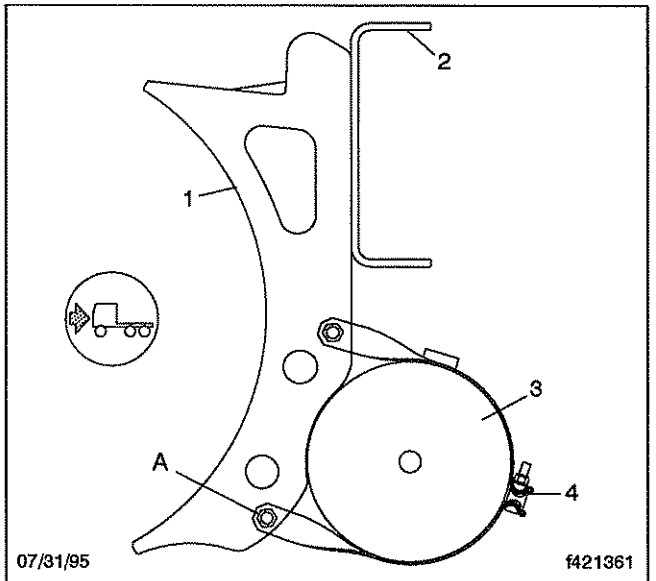
Air Reservoir Replacement

Replacement

1. Apply the parking brakes, and chock the tires.
2. Drain the air system. For instructions, refer to the vehicle driver's manual.
3. Mark all reservoir air lines, couplers, and valves for later assembly; disconnect the components. Cap the exposed ports tightly to keep out contaminants. If access is limited, remove the components after removing the reservoir from its mount.

NOTE: If the reservoir is mounted on the fuel tank bracket, loosen the bottom strap fastener first. **See Fig. 1.**

4. Remove the reservoir strap fasteners. Remove the reservoir.
5. If access is limited, do the next step first. If not, place a new reservoir in the mount, and install the strap fasteners. On frame-mounted straps **(Fig. 2),** tighten the fasteners 20 to 25 lbf·ft (27 to 34 N·m). On fuel-tank bracket mounted straps **(Fig. 1),** tighten the fasteners 30 to 40 lbf·ft (41 to 54 N·m). Tighten the lower strap fastener 136 lbf·ft (184 N·m).
6. As marked earlier, connect all air lines, couplers, and valves to the new reservoir, removing the caps as each component is installed. Tighten the connections as instructed elsewhere in this group.
7. Remove the chocks from the tires.



A. Loosen this fastener.

1. Fuel Tank Bracket
2. Right Frame Rail
3. Air Reservoir
4. 3/8–16 Strap Fastener

Fig. 1, Air Reservoir, Fuel Tank Bracket Mounting

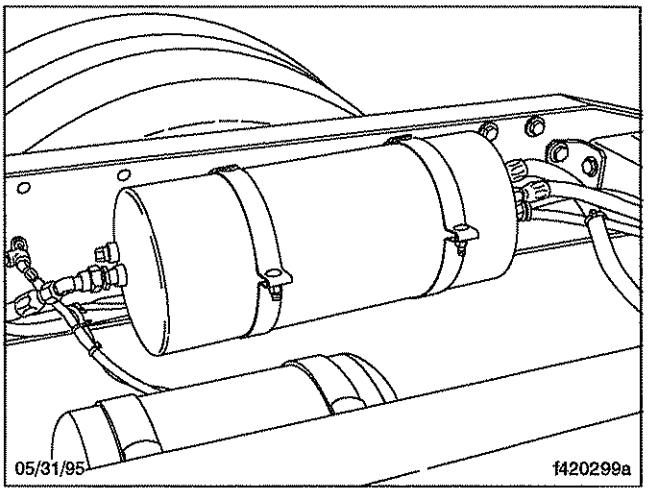


Fig. 2, Air Reservoir, Frame Rail Mounting

Air Brake System Troubleshooting 42.10

Contents

Subject	Subject Number
General Information and Safety Precautions	050
Troubleshooting	300

General Information

This troubleshooting guide is designed to help locate causes of problems originating in the air brake system. The corrective measures given are not intended to replace the detailed service information found in other sections of this manual or in the component manufacturer's service manuals. If the vehicle is equipped with ABS (antilock brake system), refer to the applicable section in this group for troubleshooting the ABS system.

Before attempting to isolate the causes of an air brake system problem, do the following.

1. Check the operation of the air compressor. Refer to the engine manufacturer's service manual.

   Check the pressure levels of the air reservoirs. Refer to the pretrip inspection and daily maintenance chapter in the vehicle driver's manual.

2. Be sure that all relay valves are operating. Refer to the brake section in the vehicle maintenance manual.

3. Check the operation of the brake chambers as instructed in the brake section in the vehicle maintenance manual.

4. Examine all tubing for kinks, dents, and other damage. Replace damaged tubing.

5. Examine all hoses for cracks, drying out, overheating, and other damage. Replace damaged hoses.

6. Examine all air line fittings. Tighten loose connections; replace fittings that are damaged. For instructions, refer elsewhere in this group.

7. Examine leaking pipe connections for cracks or thread damage; replace as needed. If there is no damage, retighten the fitting. For instructions, refer elsewhere in this group.

Safety Precautions

WARNING: Follow the manufacturer's procedures while working on any air device. Some parts are subject to mechanical (spring) or pneumatic propulsion and may cause personal injury or property damage when released. Failure to take all necessary precautions during servicing of the air brake system can result in personal injury or property damage.

Compression and storage of air in the air brake system is comparable to the energy in a coiled spring: when released, it may present a hazard. Because of this, certain precautions are required.

1. Chock the tires. This will prevent accidental rolling of the vehicle when air is released from the brake system.

2. Don't disconnect pressurized hoses because they will whip as air escapes from the line. Drain the air system before disconnecting the air hoses.

3. When draining the air system, do not look into the air jets or direct them toward another person: dirt particles or sludge may be carried in the air stream.

4. As air pressure is drained and the parking/ emergency brakes apply, keep your hands away from the brake chamber push rods and parking brake chambers, which will activate automatically with the loss of pressure.

Troubleshooting Tables

Problem—Vehicle Does Not Slow Down Quickly Enough When Brakes Are Applied

Possible Cause	Remedy
The vehicle is overloaded.	Observe the recommended maximum load limits.
There is low air pressure in the brake system, about 60 psi (413 kPa) or lower.	The drain cock on the air reservoir was left open; close the drain cock.
	Check the compressor output pressure; correct as necessary.
	Check the setting of the air governor with an accurate test gauge. Adjust the air governor to the recommended specification.
The application air lines are leaking excessively.	Check the application air lines, brake valve, and the service and parking brake chambers for air leaks. Repair or replace the damaged component(s).
Brake valve delivery pressure is below normal.	Lubricate the brake valve parts; overhaul the unit, if necessary.
Wear or glazing of the brake linings is present.	Install new brake linings on the brake shoes on both sides of the axle.
Adjustment or lubrication of the brakes is needed.	Adjust or lubricate the brakes.
The automatic slack adjusters are not operating.	Lubricate the automatic slack adjusters and check for binding, damaged, or inoperative slack adjuster parts. Replace damaged or inoperative parts, or eliminate the cause of the binding.
The cam has flipped over.	Replace the linings and the cam on each end of the axle.
Flat spots or dents on the roller surface were caused by skidding of the roller or improper handling of the wheel bearing during installation.	Clean, then inspect the bearing rollers. Replace the bearing if damaged. Ensure that the bearings to be installed are sufficiently lubricated as outlined in Group 33 and Group 35 in the vehicle maintenance manual.
One or more of the brake drums is broken or cracked.	Replace the brake drum(s).
Wrong size brake linings were installed.	Replace the brake linings with the recommended size.
Wrong size brake chambers were installed.	Replace the brake chambers with the recommended size.
A camshaft bracket or chamber mounting bracket is bent or broken.	Replace the camshaft bracket or chamber mounting bracket.
The brake chamber mounting stud nuts or brake chamber mounting bracket is loose.	Tighten the brake chamber to its mounting bracket or the mounting bracket to the foundation brake housing.
There is a ruptured diaphragm in the service brake.	Replace the diaphragm.

Problem—Service Brakes Release Too Slowly

Possible Cause	Remedy
The brake shoe anchor pins are frozen.	Inspect the anchor pins. If damaged, replace them; if not damaged, lubricate them.
Lubrication of the brake system components is inadequate.	Lubricate those components requiring periodic lubrication.
The brake foot valve is not returning to the fully released position.	Check for obstructions which might prevent the brake foot valve from returning to the fully released position. Remove any obstructions.

Troubleshooting

Possible Cause	Remedy
The exhaust port of the brake foot valve or quick-release valve is plugged.	Clear the exhaust port of obstructions.
The brake foot valve or quick-release valve is inoperative.	Overhaul or replace the inoperative valve, as needed.
The camshaft and bushings are binding.	Clean and lubricate the camshaft bushings.
The brake shoe return spring is weak or broken.	Replace the spring.
Flat spots or dents on the roller surface were caused by skidding of the roller or improper handling of the wheel bearing during installation.	Clean, then inspect the bearing rollers. Replace the bearing if damaged. Ensure that the bearings to be installed are sufficiently lubricated as outlined in Group 33 and Group 35 in the vehicle maintenance manual.

Problem—Service Brakes Do Not Apply or Apply Too Slowly

Possible Cause	Remedy
Lubrication of the foundation brake assembly is needed.	Lubricate those components requiring periodic lubrication.
There is insufficient air pressure in the brake system.	Check all parts of the air pressure system for leaks or inoperative components.
The brake foot valve or relay valve is inoperative.	Repair or replace the brake foot valve or relay valve.
The camshaft bushings are binding.	Clean and lubricate the camshaft bushings.

Problem—Service Brakes Apply When the Parking Brakes Are Released With Air Pressure

Possible Cause	Remedy
The air delivery lines to the brake chamber have been reversed.	Reverse the connections of the brake chamber air lines.
The braking mechanism is binding.	Lubricate the brake mechanism and make sure all parts are aligned with each other and are securely fastened.
	Check for obstructions; remove any obstructions.

Problem—Service Brakes Do Not Release

Possible Cause	Remedy
The brake shoes are incorrectly adjusted.	Adjust the brakes. Also, make sure the slack adjuster is operating correctly. If not, overhaul or replace the slack adjuster.
The brake foot valve may not be in the fully released position.	Lubricate the brake foot valve if needed.
The brake foot valve is inoperative.	Overhaul or replace the brake foot valve.
There is restriction in the tubing, hose, or exhaust port of the brake foot valve or quick-release valve.	Check for bends or obstructions on the exhaust side of the service brakes. Remove any obstructions; plumb the air lines so that bends are minimal.
A broken power spring may be blocking the parking brake piston movement.	Replace the power spring or replace the parking brake assembly, whichever is recommended by the parking brake manufacturer.

Problem—Service Brakes Grab or Pull

Possible Cause	Remedy
There is not enough weight on the vehicle (underloaded).	Add weight to the vehicle, reducing brake sensitivity.
Adjustment of the brakes on one axle is uneven.	Adjust the brakes.
Lubrication of the brake system components is inadequate.	Lubricate those components requiring periodic lubrication.
The brake mechanism is binding.	Lubricate the brake mechanism and make sure all parts are aligned with each other and are securely fastened.
The clevis pin or camshaft is binding at one or more wheels.	Clean and lubricate the camshaft bushings.
A brake spider is loose.	Tighten the mounting bolts or replace the brake spider.
A slack adjuster is damaged.	Replace the damaged component.
The air chamber push rods or slack adjusters are a different length.	Replace the components with the correct size and material.
The brake foot valve is inoperative.	Overhaul or replace the brake foot valve, as needed.
If equipped with cam brakes, there is a flat or dent on the S-head camshaft or on the cam roller(s).	Replace the damaged component(s).
Grease has saturated the brake linings or the linings are glazed.	Install a matched set of linings on both sets of brake shoes on that axle. Clean, turn, or replace both brake drums. For instructions on turning drums, refer to the brake manufacturer's service manual.
The brake linings are loose or broken.	Install a matched set of linings on both sets of brake shoes on that axle.
The brake linings are not a matched set. Different friction codes or different brands of brake linings are installed.	Install a new, matched set of brake linings. Clean, turn, or replace both brake drums on that axle. For instructions on turning drums, refer to the brake manufacturer's service manual.
A brake shoe is distorted or broken.	Replace the brake shoe. Install a new, matched set of linings on both sets of brake shoes on that axle.
The pilot pads are damaged, allowing the brake drum to be installed out-of-round.	Replace the wheel hub.
A brake drum is out-of-round to unacceptable limits.	Turn both the brake drums on that axle. If the maximum allowable diameter of either drum has been exceeded, replace that drum. For instructions on turning drums, refer to the brake manufacturer's service manual.
One or more brake drums is scored or broken.	Replace both of the drums on that axle.

Problem—Uneven Service Brakes

Possible Cause	Remedy
The wrong brake linings were installed, or the linings were not replaced in pairs.	Replace the brake linings with the recommended size. Install new linings on both sets of axle brake shoes.
Grease has saturated the brake linings or the linings are glazed.	Install new linings on both axle brake shoes. Clean the brake drums.
The return spring for the brake shoe release or the service brake has broken.	Replace all broken springs.

Troubleshooting

Possible Cause	Remedy
The brake drum is out-of-round to unacceptable limits.	Turn both the brake drums on that axle. If the maximum allowable diameter of either drum has been exceeded, replace that drum. For instructions on turning drums, refer to the brake manufacturer's service manual.
A service brake chamber diaphragm is leaking.	Tighten the clamp ring. If leaks persist, replace the service brake diaphragm.
The wheel bearings are out of adjustment.	Adjust the wheel bearings, or replace them if damaged. For instructions, refer to **Group 33** or **Group 35** in this manual.
A brake spider is damaged.	Replace the brake spider.
The brake shoes are bent or stretched.	Replace the axle brake shoes on each wheel.
Grease, oil, or dirt is on the linings.	Replace the linings on each set of axle brake shoes. Clean the brake drums.

Problem—Dragging Service Brake

Possible Cause	Remedy
The service brake return spring is broken.	Replace the service brake return spring.
The service-application air is not exhausting or not exhausting fast enough, due to blockage in the control valve, the quick-release valve, or the limiting and quick-release valve.	Test the air system valves for leakage and operation.
A brake shoe retracting spring is broken.	Replace the brake shoe retracting spring.
Binding is occurring in the camshaft linkage.	Lubricate the camshaft linkage. Replace bent or broken parts.

Problem—Insufficient Parking Brake Application When Dash Control Valve Is Activated

Possible Cause	Remedy
The parking brake is not set for full stroke.	Adjust the brakes.
There is a ruptured parking brake diaphragm or ineffective piston seal.	Replace the diaphragm or parking brake piston seal.
A power spring is broken.	Replace the parking/emergency brake section.
A power spring in a parking brake is manually caged.	Release the power spring by screwing in the release bolt.

Problem—Dragging Brakes Due to Parking Brake Mechanism

Possible Cause	Remedy
The system air pressure is insufficient to fully release the parking brake.	Be sure that all air lines are clear. Check that the air governor cutout settings meet recommended specifications.
A parking brake diaphragm is ruptured or a piston seal is ineffective.	Replace the diaphragm or parking brake piston seal.
There is a broken return spring in the parking brake (double-diaphragm type brake chambers only).	Replace the parking/emergency brake section.

Problem—Air Pressure Will Not Rise to Normal

Possible Cause	Remedy
The air pressure gauge(s) on the dash is (are) registering inaccurately.	Check the dash gauge(s) with an accurate test gauge. Replace the dash gauge(s) as needed.
There is excessive leakage (not including the air compressor).	Check all valves, air lines, and connections for leakage. Repair or replace valves and lines until leakage is eliminated.
The compressor is inoperative (including excessive leakage of the compressor).	Rebuild or replace the compressor.
The air reservoir drain cock has been left open.	Close the drain cock.
The air governor cutout setting is not adjusted correctly.	Check the setting with an accurate test gauge, then adjust the air governor to the recommended specification.
There is inadequate clearance at the compressor unloading valve.	Repair or adjust the compressor at the unloading valve.
If so equipped, the compressor drive belt is slipping.	Adjust or replace the compressor drive belt.
Carbon is building up in the compressor cylinder head or discharge line.	Remove the carbon. If disassembly is not recommended by the compressor manufacturer, replace the air compressor with a factory rebuilt or a new unit.

Problem—Air Pressure Rises Above Normal

Possible Cause	Remedy
The air reservoir pressure dash gauge is inaccurate.	Check the dash gauge with an accurate test gauge. Replace the dash gauge as needed.
The compressor air governor is out of adjustment.	Check the setting with an accurate test gauge, then adjust the air governor to the recommended specification.
The air governor is not operating.	Repair or replace the air governor.
There is too much clearance at the air compressor unloading valve.	Repair or adjust the compressor at the unloading valve.
The air compressor unloading valve is stuck closed.	
The air compressor unloading valve cavities or the unloading valve passage is blocked with carbon.	

Problem— Air Pressure Drops Quickly With the Engine Stopped and the Brakes Released

Possible Cause	Remedy
The brake foot valve is leaking.	Repair or replace the brake foot valve.
The air compressor discharge valve is leaking.	Repair or replace the discharge valve. If disassembly is not recommended by the compressor manufacturer, replace the air compressor with a factory-rebuilt or a new unit.
The air governor is leaking.	Repair or replace the air governor.

Troubleshooting

Problem—Air Pressure Drops Quickly With the Engine Stopped and the Brakes Fully Applied

Possible Cause	Remedy
A service or parking brake chamber is leaking.	Tighten the clamp ring(s). If leaks persist, replace the diaphragm(s) or assembly.
The brake foot valve or relay valve is leaking.	Repair or replace the component(s) or assembly.

Problem—Compressor Knocks (Continuously or Intermittently)

Possible Cause	Remedy
There is a loose drive pulley, belt, coupling, or gear (as indicated).	Tighten or replace the component. If applicable, inspect the pulley shaft for damage. Replace the shaft, if damaged.
Backlash is in the compressor drive gears on the drive coupling.	Repair or replace the compressor drive gears or drive coupling.
The air compressor bearings are damaged or worn.	Replace the bearings.
There are carbon deposits in the compressor cylinder head.	Remove the carbon deposits or replace the compressor.

Problem—Pressure Relief Valve Activates

Possible Cause	Remedy
The pressure relief valve is out of adjustment.	Adjust the pressure relief valve, or install a new one.
There is excessive air pressure in the brake system.	Refer to the problem "Air Pressure Rises Above Normal."
Draining of the air reservoirs needs to be performed more often.	Drain the air reservoirs daily.

Problem—Oil or Water in the Brake System

Possible Cause	Remedy
Excessive oil is passing through the air compressor.	Rebuild or replace the compressor.
If so equipped, the air compressor air strainer is dirty.	Clean the strainer or install a new one.

Contents

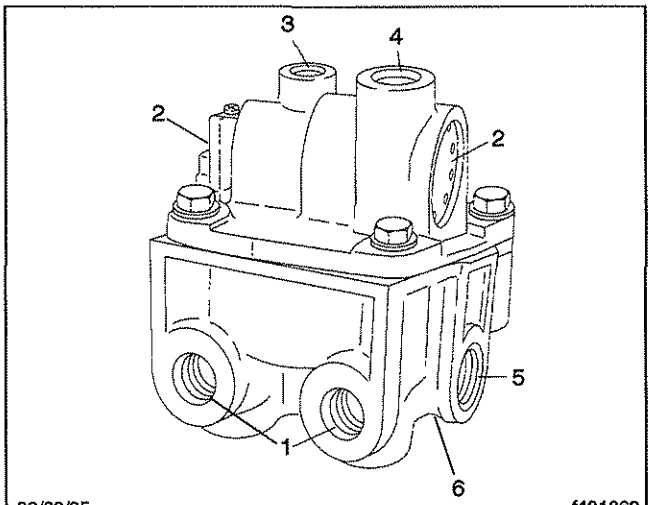
Subject	Subject Number
General Description and Principles of Operation	050
Service Operations	
Safety Precautions	100
BP–R1 Valve Operating Tests	110
BP–R1 Valve Removal and Installation	120
BP–R1 Valve Disassembly, Cleaning and Inspecting, and Assembly	130

General Description and Principles of Operation (See Fig. 1)

The BP–R1 bobtail proportioning relay valve is a combination of two individual valves in a single housing. The lower portion (body) of the BP–R1 contains a standard service brake relay valve, which functions as a relay station to speed up brake application and release. The upper portion (cover) houses a brake proportioning valve, which adjusts the proportion of normal brake application pressure to the rear brake chambers when the tractor is not towing a trailer.

Used in tractor air brake systems only, the BP–R1 is installed in place of a standard relay valve. It functions as a standard service relay during operation of a tractor-trailer combination. During bobtail tractor operation, the BP–R1 improves controllability and reduces stopping distances by limiting air pressure to the rear brake chambers, whose axle load has been greatly reduced, while retaining normal air pressure to the front brake chambers. This reduces the chance of rear wheel lock and instability in emergency stops.

The rear brake proportioning system is standard on all tractors. The valve is mounted on the crossmember between the rear brake chambers.



1. Delivery (4)
2. Exhaust
3. Control
4. Service
5. Supply (2)
6. Exhaust (on bottom)

Fig. 1, Port Locations

A control line from the control port of the BP–R1 valve is connected to the inlet supply port of the tractor protection valve. This line is charged with full line pressure when a trailer is connected and its spring brakes are released; or is completely exhausted when the tractor is bobtailed and the dash valve trailer charge knob is not applied.

TRAILER SUPPLY VALVE APPLIED (TRACTOR/TRAILER MODE)

On vehicles equipped with a proportioning system, air pressure at the control port allows full service air from the foot valve to pass through the proportioning portion of the valve. This gives full braking effort to the rear axles when a trailer is connected.

TRAILER SUPPLY VALVE PULLED OUT (BOBTAIL MODE)

When the trailer supply valve is activated to disconnect the trailer, air in the BP–R1 control port is exhausted to atmosphere. In this mode, service application air exerts force on one side of the blend-back piston and also flows through the piston to exert force on the proportioning piston. The blend-back piston remains stationary at application pressures below 80 psi (551 kPa). Air also flows through the proportioning piston to exert force on both sides of it. Proportioning occurs due to the difference in effective area on each end of the proportioning piston. Service applications of more than 80 psi (551 kPa) cause the blend-back piston to begin to move. Above 80 psi (551 kPa) the different pressures on each side of this piston cause a "blend back" from proportioned delivery to a full one-to-one delivery.

Safety Precautions

WARNING: Wear safety goggles when draining the air system or loosening an air line because dirt or sludge could fly out at high speeds. Don't direct the airstreams at anyone. Don't disconnect pressurized hoses, since they may whip as air escapes. Failure to take all necessary precautions could result in personal injury.

When working on or around air brake systems and components, observe the following precautions.

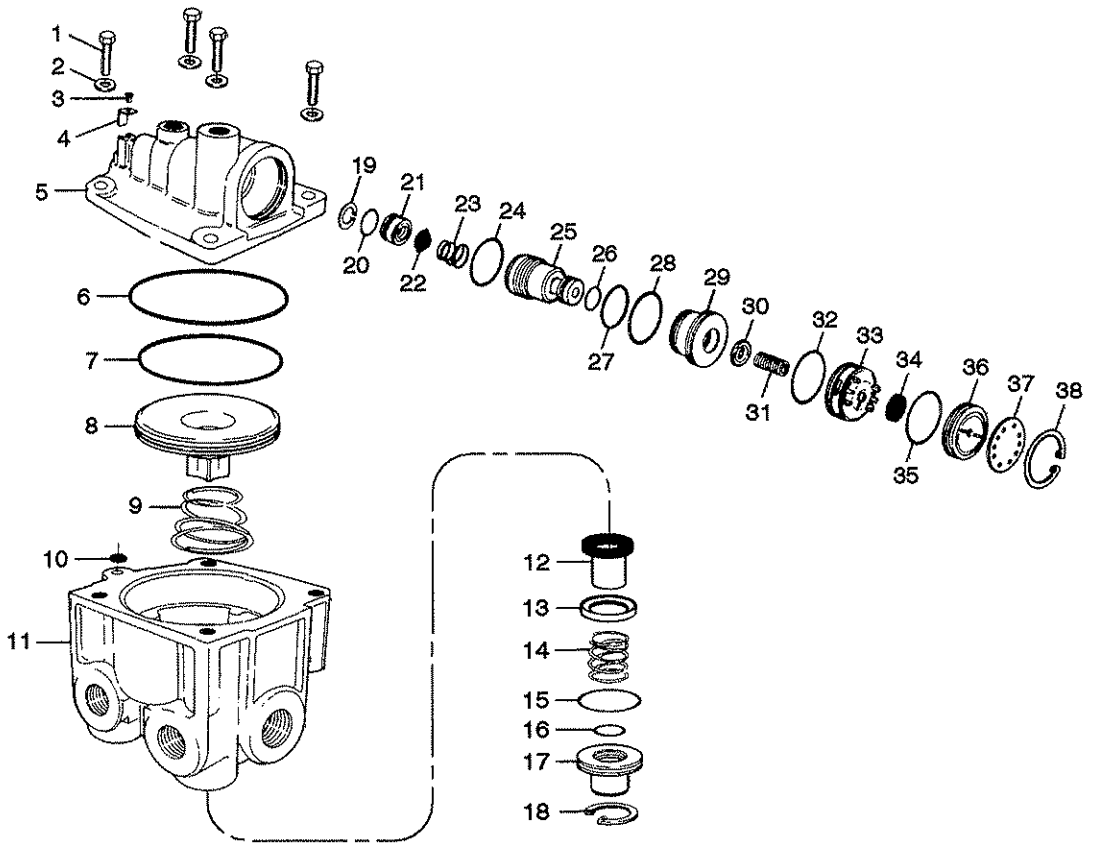
1. Apply the parking brakes, chock the tires, and stop the engine when working under the vehicle. Keep hands away from brake chamber push rods and slack adjusters, which may apply as air system pressure drops.
2. Wear safety goggles.
3. Never connect or disconnect a hose or line containing air under pressure; it may whip as air escapes. Never remove a component or pipe plug unless you are sure all system pressure has been depleted.
4. Don't disassemble a component before reading and understanding recommended procedures. Use only the correct tools and follow basic tool safety.
5. Replacement hardware, tubing, hose, fittings, etc. should be the same size, type, length, and strength as the original equipment. When replacing tubing or hose, be sure that all of the original supports, clamps, or suspending devices are installed or replaced.
6. Replace any components that have stripped threads or damaged parts. Don't attempt to repair parts by machining.
7. Never exceed recommended air pressure.

Operating Tests

1. Park the vehicle on a level surface and chock the tires.
2. Before testing the air brake proportioning system, do the following checks.
   - 2.1 Check the operation of the air compressor. Check the pressure levels of the air reservoirs.
   - 2.2 Be sure that all related valves are operating properly.
   - 2.3 Check the operation of the brake chambers following the instructions in the brake section in the vehicle maintenance manual.
   - 2.4 Inspect all tubing for kinks, dents, and other damage. Replace damaged tubing.
   - 2.5 Inspect all hoses for cracks, drying out, overheating, and other damage. Replace damaged hoses.
   - 2.6 Inspect all air line fittings. Tighten loose connections; replace fittings that are damaged.
3. Drain all air tanks to zero pressure.
4. Install a tee at the BP–R1 service port and at one of the delivery ports, then install a gauge in each.
5. Connect the tractor service and emergency gladhands to hose couplings that have been plugged; or, connect them to a trailer. Build the tractor system air pressure to governor cut-out.
6. With the dashboard trailer supply valve and system park control valve activated for tractor/trailer operation, apply, *hold,* and then release the brakes several times, varying the application pressures while watching the reaction of the gauges installed on the BP–R1. Note that a prompt application occurs and that it can be held, then promptly released.
7. Check the BP–R1 differential pressure by applying 10 psi (69 kPa) to the service port and noting the pressure registered at the delivery port. Subtract delivery port pressure from the 10 psi (69 kPa) service pressure to obtain the differential.

   NOTE: For BP–R1 valves that *don't incorporate* a relay piston spring (**Fig. 1**, Ref. 9), the measured differential should be about 4 psi (28 kPa). When a spring is in use, the differential will be higher.
8. Make and hold a full brake application of 100 psi (689 kPa) or greater, and note that full pressure is delivered to the chambers.
9. Activate the dash mounted trailer supply valve for bobtail tractor operation. Make a *slow* brake application and watch the gauges installed previously. Both gauge readings should rise until the delivery pressure is 5 to 10 psi (34 to 69 kPa). Then the service supply pressure should continue rising while delivery pressure remains constant. Hold the brake application at 20 psi (138 kPa) and check that the delivery pressure is 5 to 10 psi (34 to 69 kPa). Release the application.
10. Make another brake application and *slowly* increase the pressure at the BP–R1 service port to between 60 and 70 psi (414 to 483 kPa) while observing the gauge installed at the delivery port. Note that when service port pressure rises to between 20 and 30 psi (138 to 207 kPa), delivery pressure begins to rise above the initial pressure noted previously. The rise of delivery pressure should be at a proportioned rate of *about* three-to-one. At 70 psi (483 kPa) service pressure, delivered pressure should be 15 to 25 psi (103 to 172 kPa).
11. Make a full brake application, and note that both test gauges register the same pressure.
12. Remove the test gauges from the BP–R1.
13. Remove the chocks from the tires. Test drive the vehicle (without a trailer) in a safe area at slow speed with the trailer supply valve pulled out (bobtail position). Make several brake applications to become familiar with the feel of the system before placing the vehicle back in service.

BP–R1 Valve Operating Tests



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1. Capscrew
2. Washer
3. Exhaust Cover Screw
4. Exhaust Cover
5. Cover
6. O-Ring
7. O-Ring
8. Relay Piston
9. Relay Piston Spring
10. Sealing Ring
11. Body
12. Valve Assembly
13. Valve Retainer
14. Valve Spring
15. O-Ring
16. O-Ring
17. Exhaust Cover
18. Retaining Ring
19. Retaining Ring
20. O-Ring
21. Inlet Valve Seat
22. Inlet Valve
23. Valve Spring
24. O-Ring
25. Proportioning Piston
26. O-Ring
27. O-Ring
28. O-Ring
29. Blend-Back Piston
30. Spring Cage
31. Spring
32. O-Ring
33. Service Piston
34. Exhaust Diaphragm
35. O-Ring
36. Exhaust Piston
37. Dust Shield
38. Retaining Ring

Fig. 1, BP–R1 Valve (exploded view)

BP–R1 Valve Removal and Installation

Removal

WARNING: Wear safety goggles when draining the air system or loosening an air line because dirt or sludge could fly out at high speeds. Don't direct the airstreams at anyone. Don't disconnect pressurized hoses, since they may whip as air escapes. Failure to take all necessary precautions could result in personal injury.

1. Park the vehicle on a level surface, apply the parking brakes, chock the tires, and drain the air tanks.
2. Mark and then disconnect the air lines from the valve.
3. Remove the two bolts attaching the valve to the vehicle. Remove the valve.

Installation

1. Install the valve on the vehicle. Tighten the bolts 15 lbf·ft (20 N·m).
2. Connect the air lines to the proper ports, as marked during removal.
3. Check the proportioning valve operation using the instructions under **Subject 110.**

BP–R1 Valve Disassembly, Cleaning and Inspecting, and Assembly

Disassembly

CAUTION: The BP–R1 may be lightly clamped in a bench vise during disassembly, however, over-clamping will cause damage to the valve and result in leakage or malfunction.

If a vise is to be used, position the valve so that the jaws bear on the supply ports on opposing sides of the valve's body.

1. Remove all air fittings and plugs from the valve.
2. Mark the relationship of the valve cover to the body, and if the valve is equipped with a mounting bracket, mark the relationship of the bracket to the cover.
3. While holding the exhaust cover (**Fig. 1**, Ref. 17), remove and discard the retaining ring (Ref. 18) that secures it to the body (Ref. 11).
4. Remove and discard the exhaust cover along with both O-rings (Refs. 15 and 16).
5. Remove and discard the valve spring (Ref. 14), valve retainer (Ref. 13), and the valve assembly (Ref. 12) from the body.
6. Remove and retain the four capscrews and washers (Refs. 1 and 2) that secure the cover (Ref. 5) to the body.
7. Separate the cover from the body, then remove and discard the sealing ring and O-ring (Refs. 10 and 6).
8. Remove and retain the relay piston (Ref. 8) and relay piston spring (Ref. 9) from the body.

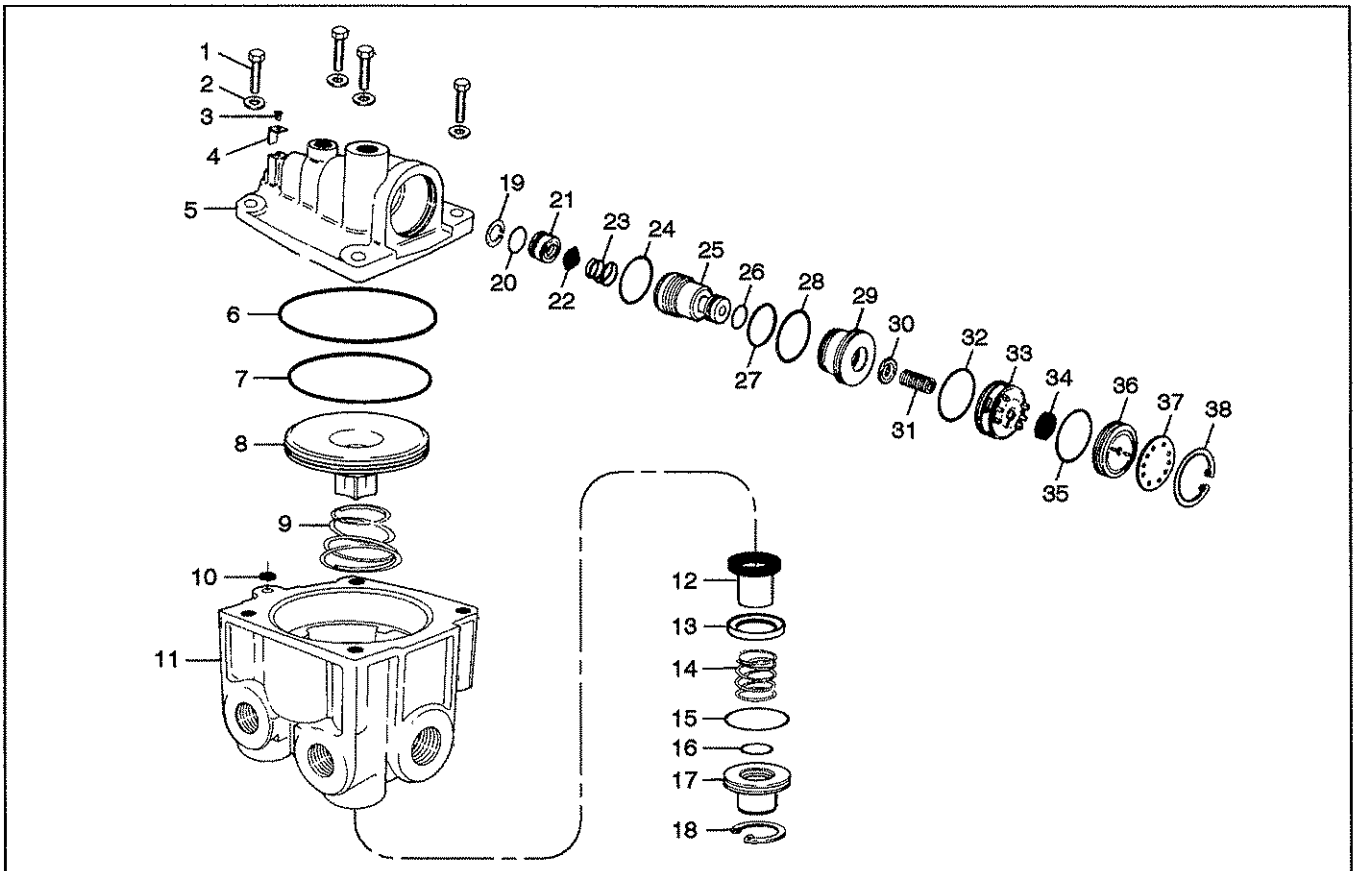
NOTE: The relay piston spring is *not used in all valves.*

9. Remove and discard the O-ring (Ref. 7) from the relay piston.
10. Remove and discard the dust shield (Ref. 37) and the retaining ring (Ref. 38) from the valve cover, then remove and save the exhaust piston (Ref. 36).
11. Remove and discard the exhaust piston O-ring (Ref. 35) and the exhaust diaphragm (Ref. 34).
12. Remove and save the service piston (Ref. 33) from the valve cover, then remove and discard the service piston O-ring (Ref. 32).
13. Remove the spring (Ref. 31) and spring cage (Ref. 30) from the valve cover. Discard the spring and retain the spring cage.
14. Remove and retain the blend-back piston (Ref. 29) from the valve cover, then remove and discard both O-rings (Refs. 27 and 28).
15. Remove and save the proportioning piston (Ref. 25) from the valve cover, then remove and discard both O-rings (Refs. 26 and 24).
16. While holding the inlet valve seat (Ref. 21) in place, remove and discard the retaining ring (Ref. 19) from the proportioning piston.
17. Remove the inlet valve seat, the inlet valve (Ref. 22), and the valve spring (Ref. 23) from the proportioning piston, then remove and discard the O-ring (Ref. 20) from the valve seat. Discard the valve and spring also.
18. Remove and discard the exhaust cover screw (Ref. 3) and exhaust cover (Ref. 4).

Cleaning and Inspection

1. Using mineral spirits or an equivalent solvent, clean and thoroughly dry all metal parts. Don't damage any bores with metal tools.
2. Wash all non-metallic parts (Refs. 8, 17, 21, 25, 29, 30, 33, and 36) in a soap and water solution, making certain to rinse and dry thoroughly.
3. Inspect the interior and exterior of all metal parts that will be re-used. Check for severe corrosion, pitting, gouges and cracks. Superficial corrosion or pitting of the exterior portion of the body and cover is acceptable. Replace the entire valve if the interior of the body or cover show signs of corrosion or pitting.
4. Inspect each non-metallic part for cracks, wear or distortion. Replace the entire valve if these conditions exist.
5. Replace all rubber parts.
6. Make certain the air channel running between the top surface of the body and its supply port is clear and free of blockages.

BP–R1 Valve Disassembly, Cleaning and Inspecting, and Assembly



1. Capscrew
2. Washer
3. Exhaust Cover Screw
4. Exhaust Cover
5. Cover
6. O-Ring
7. O-Ring
8. Relay Piston
9. Relay Piston Spring
10. Sealing Ring
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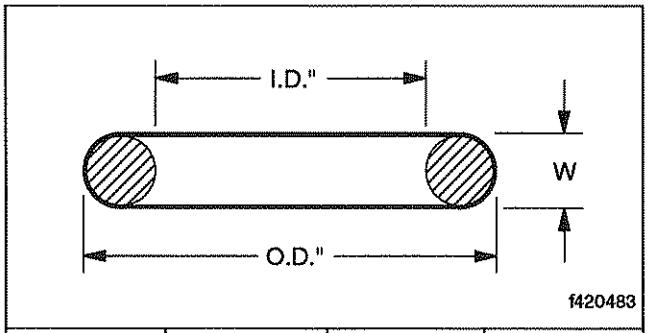
24. O-Ring
25. Proportioning Piston
26. O-Ring
27. O-Ring
28. O-Ring
29. Blend-Back Piston
30. Spring Cage
31. Spring
32. O-Ring
33. Service Piston
34. Exhaust Diaphragm
35. O-Ring
36. Exhaust Piston
37. Dust Shield
38. Retaining Ring

Fig. 1, BP–R1 Valve (exploded view)

7. Make certain all air channels and exhaust passages in the valve cover are clear and free of blockages.
8. Inspect the pipe threads in the body and valve cover. Make certain they are clean and free of thread sealant.
9. If the valve was equipped with a relay piston spring, check it for signs of corrosion, pitting, and cracks. Replace as needed.
10. Inspect all air line fittings for corrosion; replace as needed. Be sure to remove all old thread sealant before re-use.

Assembly

1. Prior to assembly, lubricate all O-rings (identify them by referring to **Table 1**), seals, and pistons, as well as body and cover bores, using the lubricant provided in the Bendix maintenance kit. Use all of the lubricant, and spread it evenly on the rubbing surfaces.



Key No.	I.D.	O.D.	W
6	3.487	3.693	0.103
7	3.234	3.512	0.139
15	1.424	1.630	0.103
16	0.862	1.068	0.103
20	0.489	0.629	0.070
24	0.739	0.879	0.070
26	0.412	0.552	0.070
27	0.737	0.943	0.103
28	1.112	1.318	0.103
32	1.176	1.316	0.070
35	1.356	1.496	0.070

Table 1, O-Ring Identification (Sectional View)

2. Install the O-ring (**Fig. 1**, Ref. 20) on the inlet valve seat (Ref. 21).
3. Install the small end of the valve spring (Ref. 23) over the rubber of the inlet valve (Ref. 22), making sure the spring coils rest on the valve's four tabs.
4. Insert the spring and valve into the valve seat, making sure the four tabs are inside the seat's bore.
5. Insert the valve, seat, and spring assembly into the proportioning piston (Ref. 25)—large end of the spring first.
6. While holding the seat in place, install the retaining ring (Ref. 19) to secure it in the piston. Make certain the retaining ring is fully seated in its groove. Make sure the valve is straight against the exhaust seat and free to move.
7. Install both the large and small diameter O-rings (Refs. 24 and 26) on the proportioning piston.
8. Install both the large and small diameter O-rings (Refs. 28 and 27) on the blend-back piston (Ref. 29), then insert the small diameter of the proportioning piston into the small diameter end of the blend-back piston.
9. Carefully insert the assembled proportioning and blend-back pistons to the edge of the bore in the cover (Ref. 5). Don't cut or pinch the O-rings.
10. With the bore of the cover facing up, install the spring cage (Ref. 30) in the blend-back piston so that its flat side rests against the blend-back piston (its depressed side out towards spring [Ref. 31]).
11. Install the O-ring (Ref. 32) on the service piston (Ref. 33), then install the spring (Ref. 31) in the cage (Ref. 30) so that its coils are in the inside diameter of the cage.
12. Install the O-ring (Ref. 35) on the exhaust piston (Ref. 36), and place the exhaust diaphragm (Ref. 34) between the six posts of the service piston.
13. Place the exhaust piston on the service piston with its six-ribbed side facing the service piston. Then install both pistons while pushing the proportioning and blend-back pistons all the way into the cover.
14. Install the dust shield (Ref. 37) in the cover.
15. While holding the dust shield in the cover, install the retaining ring (Ref. 38), making certain it is fully seated in its groove.
16. Install the exhaust cover (Ref. 4) using the screw (Ref. 3) to retain it. Torque the screw 8 to 15 lbf·in (100 to 160 N·cm).
17. Install the valve retainer (Ref. 13) on the valve assembly (Ref. 12) so that the flange of the retainer (Ref. 13) surrounds the rubber portion of the valve. Install the valve assembly in the body.
18. Install the valve spring (Ref. 14) in the body.

BP–R1 Valve Disassembly, Cleaning and Inspecting, and Assembly

19. Install the large and small diameter O-rings (Refs. 15 and 16) in the exhaust cover (Ref. 17), then install the exhaust cover in the body, taking care not to damage the O-rings. Hold the exhaust cover in place.
20. While depressing the exhaust cover, install the retaining ring (Ref. 18) in the body. Make sure this ring is fully seated in its groove in the body.
21. If the BP–R1 was equipped with a relay piston spring (Ref. 9), install the spring in the body, large diameter first.
22. Using lubricant to hold them in place, install the large O-ring and small sealing ring (Refs. 6 and 10) on the cover.
23. Install the O-ring (Ref. 7) on the relay piston (Ref. 8), then install the piston in the body.
24. After noting the relationship marks made prior to disassembly, install the mounting bracket (not shown) on the cover, then secure the cover and mounting bracket on the body using the four capscrews and washers (Refs. 1 and 2). Torque the capscrews 120 to 150 lbf·in (1360 to 1700 N·cm).

Contents

Subject	Subject Number
General Information	050
Service Operations	
Slack Adjuster Removal and Installation	100
Troubleshooting	300

General Description

The Haldex (SAB) automatic slack adjuster serves two main functions:

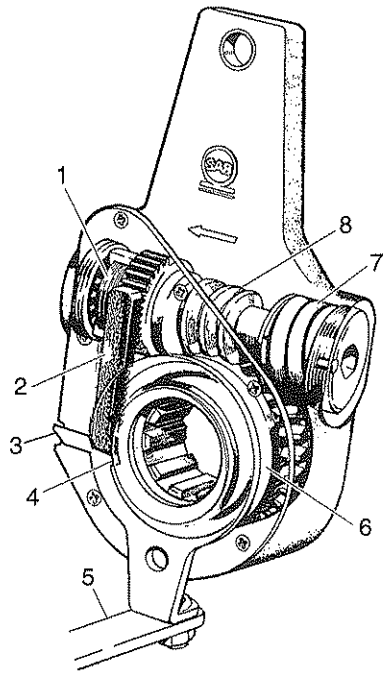
- As a lever, it converts the straight-line force of the air brake chamber pushrod to torque on the brake camshaft. Rotation of the camshaft spreads the brake shoes out against the brake drum, applying the brakes.
- As an adjuster, it maintains cam brake chamber pushrod stroke and lining-to-drum clearance automatically during normal use.

Principles of Operation

When the brakes are applied, the slack adjuster rotates and moves the shoes into contact with the drum. The clearance notch (**Fig. 1**) corresponds to the normal lining-to-drum clearance. Different notches are available to meet the requirements of various vehicles and brake duty cycles. As the brake application continues, the rack moves upward and rotates the one-way clutch which slips in this direction.

As the brake torque increases, the coil-spring load is overcome and the wormshaft is displaced axially, releasing the cone clutch.

When the brake begins its return stroke, the coil spring load returns to normal and the cone clutch is again engaged. The rack is pulled back to its original position in the notch. Any additional travel brought about by brake lining wear causes the rack to turn the locked one-way clutch and rotates the wormshaft through the locked cone clutch. The wormshaft then rotates the worm wheel and camshaft, adjusting the brakes.



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NOTE: Older slack adjusters may not have an installation indicator.

1. Clutch Assembly
2. Enclosed Rack
3. Installation Indicator (aligned with indicator notch)
4. Clearance Notch
5. Control Arm Anchor Bracket (design varies depending on the axle)
6. Worm Wheel
7. Coil Spring
8. Wormshaft

Fig. 1, Haldex Slack Adjuster

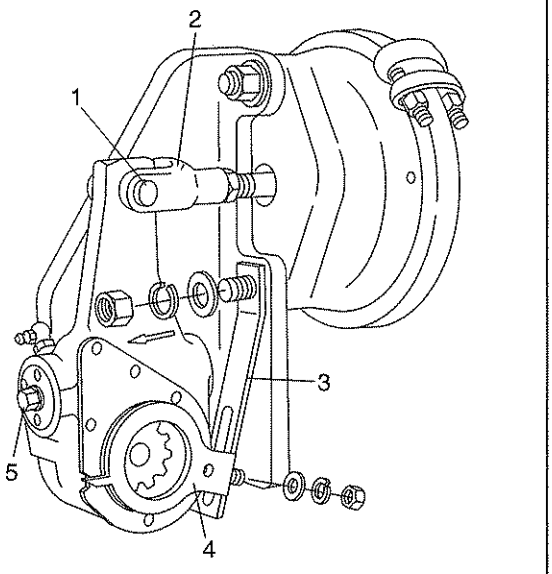
Slack Adjuster Removal and Installation

Removal

1. Park the vehicle on a level surface, set the parking brakes, and shut down the engine. Chock the front and rear tires.
2. If a rear-axle slack adjuster will be removed, release the parking brakes and cage the power spring of the parking brake chamber. For instructions, refer to the applicable brake chamber section in this group.
3. Remove the anchor bracket fasteners and the anchor bracket. See **Fig. 1**.
4. Remove the cotter pin from the clevis pin. Remove the clevis pin.
5. Remove the snap ring holding the slack adjuster to the camshaft.

⚠ CAUTION

Do not use an impact wrench on the adjusting hexnut. To do so may damage the slack adjuster or camshaft.



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1. Clevis Pin
2. Clevis
3. Anchor Bracket
4. Control Arm
5. Adjusting Hexnut

Fig. 1, Anchor Bracket Removal/Installation

6. Using a 7/16-inch box wrench, turn the adjusting hexnut counterclockwise to move the adjuster arm out of the clevis. A minimum of 13 lbf·ft (18 N·m) is required to overcome the internal clutch. You will hear a ratcheting sound.
7. Remove the slack adjuster from the camshaft.

Installation

1. Check that the brake-chamber pushrod is fully retracted.
2. Apply antiseize sealant to the camshaft splines.

IMPORTANT: When correctly installed, the brake-chamber pushrod pushes in the direction of the arrow on the slack adjuster housing.

3. Install the slack adjuster on the camshaft with the adjusting hexnut pointing away from the brake chamber. See **Fig. 2**.
4. Using a snap ring, secure the slack adjuster on the camshaft. Use at least one inner washer and enough outer washers to allow no more than 0.060-inch (1.52-mm) movement on the shaft.

IMPORTANT: Never pull the pushrod out to meet the slack adjuster or push the slack adjuster into position. Always turn the adjusting hexnut for positioning.

5. Using a 7/16-inch box wrench, turn the adjusting hexnut clockwise until the slack adjuster hole is aligned with the push-rod clevis hole. See **Fig. 2**.
6. Apply antiseize sealant to the clevis pin and insert the pin in the clevis hole. Do not install the cotter pin at this time.

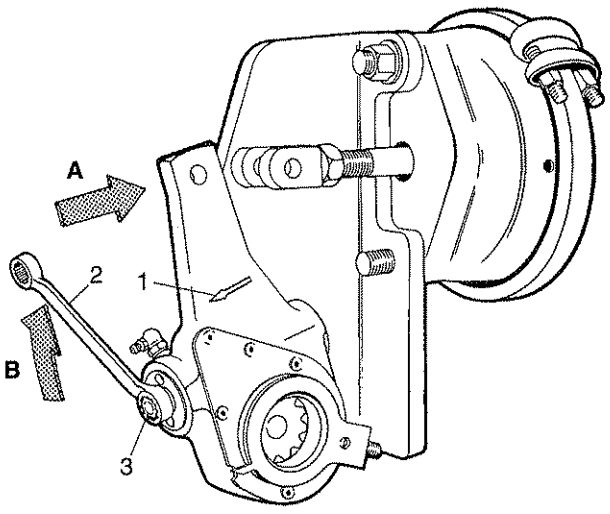
⚠ CAUTION

Never hammer the control arm. Hammering may damage the slack adjuster or camshaft splines.

7. Rotate the control arm away from the adjusting hexnut toward the brake chamber until it comes to a definite internal stop. Make sure the installation indicator is in the center of the indicator notch on the slack adjuster. See **Fig. 3**.

IMPORTANT: If the installation indicator is not aligned with the indicator notch, the brakes will be too tight.

Slack Adjuster Removal and Installation



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A. Use only the adjusting hexnut to align the slack adjuster with the push-rod clevis.
B. Turn the adjusting hexnut clockwise.

1. Direction of Applied Stroke
2. Box Wrench, 7/16 in
3. Adjusting Hexnut

Fig. 2, Slack Adjuster Installation

NOTE: The anchor bracket and slack adjuster housing design will vary, depending on the axle. The anchor bracket mounting location is determined by the length of the control arm.

8. Install the control-arm anchor bracket. See **Fig. 1**.

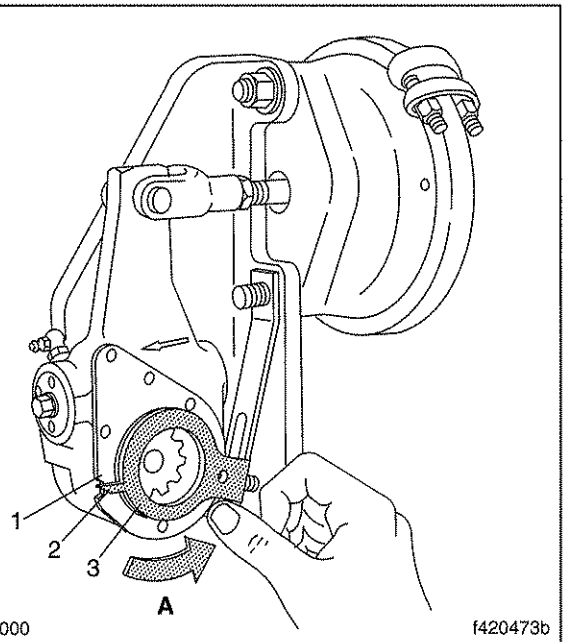
   8.1 Tighten the anchor bracket fastener at the control arm 10 to 15 lbf·ft (14 to 20 N·m), making sure the control arm does not move from its position.

   8.2 Tighten the fastener at the brake chamber mounting stud according to the brake chamber manufacturer's specifications.

9. Adjust the brake lining clearance by manually turning the adjusting hexnut clockwise until the brake lining contacts the brake drum, then back off the hexnut counterclockwise 1/2 turn. You will hear a ratcheting sound.

IMPORTANT: Incorrect installation can cause dragging brakes.

10. Make sure the brakes are still fully released, then check the slack adjuster installation.



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NOTE: The installation indicator must be aligned with the indicator notch.

A. Rotate the control arm counterclockwise until it stops.

1. Indicator Notch
2. Installation Indicator
3. Control Arm

Fig. 3, Rotate the Control Arm

- If the slack adjuster has an installation indicator, check the position of the indicator on the control arm. It must be within the indicator notch. See **Fig. 3**.

  If the indicator is out of position, loosen the control arm fasteners and repeat the control-arm adjustment procedure. Then, tighten the bracket fasteners.

- If the slack adjuster does not have an installation indicator, remove the clevis pin and push the slack adjuster into the clevis. See **Fig. 4**. If the slack adjuster hole and clevis pin hole remain in alignment on release, the installation is correct.

  If the slack adjuster and clevis pin holes are not aligned, turn the adjusting nut until the holes are aligned. Replace the clevis pin. Loosen the control arm fasteners and move the arm toward the brake chamber until it comes to a definite stop. Tighten the bracket fasteners.

⚠ WARNING

Install and lock a new cotter pin in the clevis pin. Failure to do so could allow the pushrod to disengage from the slack adjuster, causing a loss of braking ability that could result in personal injury and property damage.

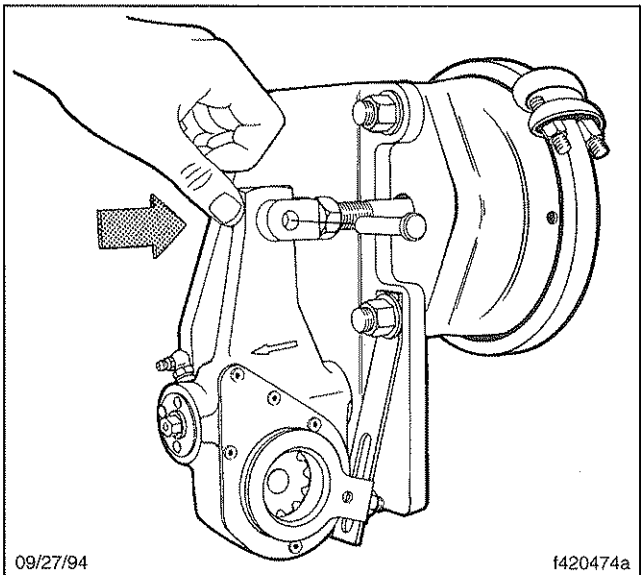
11. Install and lock a new cotter pin in the clevis pin.
12. If a rear-axle slack adjuster was installed, manually uncage the parking brake. For instructions, refer to the applicable brake chamber section in this group.

⚠ WARNING

Do not operate the vehicle until the brakes have been adjusted and checked for proper operation. To do so could result in inadequate or no braking ability, which could cause personal injury or death, and property damage.

IMPORTANT: To check the brake adjustment, measure both the applied and free strokes.

NOTE: The stroke is the distance the slack adjuster has to travel to move the brake shoes against the drum. The applied stroke is measured with the brakes applied, while a lever is used to manually move the slack adjuster to measure the free stroke.



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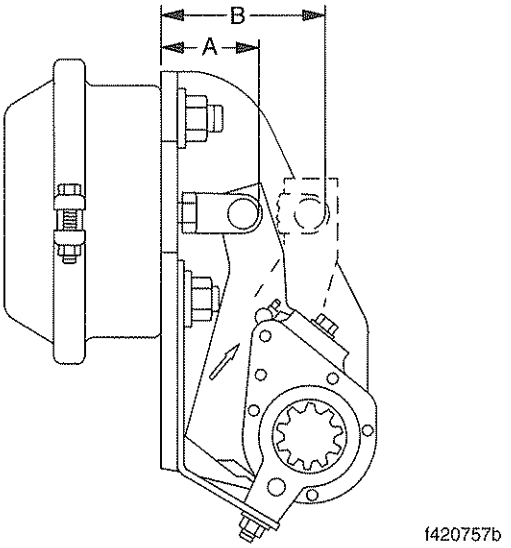
Press and release the slack adjuster; the holes should stay aligned.

Fig. 4, Installation Check (no installation indicator)

13. Measure the applied stroke.

    13.1 With the brakes released (pushrod fully retracted), measure the distance from the bottom of the brake chamber to the far side of the clevis-pin hole. See **Fig. 5**. Record the exact distance as measurement A.



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NOTE: Measurements are from the bottom of the brake chamber to the far side of the clevis-pin hole.

A. Measurement with brakes released.
B. Measurement with brakes applied at 80 psi (551 kPa).

Fig. 5, Brake Applied Stroke Check

    13.2 Apply and hold an 80 psi (551 kPa) brake application. Measure the distance from the bottom of the brake chamber to the far side of the clevis-pin hole. Record the exact distance as measurement B.

    13.3 Subtract measurement A from measurement B to determine the applied stroke. Compare this value to the value in **Table 1**.

    13.4 If the stroke varies or is greater than the maximum allowed length, see **Troubleshooting, 300**.

Slack Adjuster Removal and Installation

Chamber Size	Maximum Applied Stroke	
	inch	mm
16	1-3/4	44
20	1-3/4	44
24	1-7/8	48
30	2	51

Table 1, Maximum Applied Stroke

14. Measure the free stroke.

    14.1 With the brakes released, measure the distance from the bottom of the brake chamber to the far side of the clevis-pin hole. Record the exact distance as measurement A.

    14.2 Using a lever, move the slack adjuster until the brake shoes contact the drum. Measure the distance from the bottom of the brake chamber to the far side of the clevis-pin hole. Record the exact distance as measurement B.

    14.3 Subtract measurement A from measurement B to determine the free stroke. The free stroke should be 3/8 to 3/4 inch (10 to 19 mm). If it is not in this range, see **Troubleshooting, 300**.

15. Remove the chocks from the tires.

16. In a safe area, check for proper brake operation.

    16.1 Apply and release the brakes several times to check for correct operation of the slack adjusters.

    16.2 Perform six low-speed stops to ensure correct parts replacement and full vehicle control.

    16.3 Immediately after doing the above stops, check the drum temperatures. Any drums that are significantly cooler than the others show a lack of braking effort on those wheels.

Problem—Tight or Dragging Brakes

Possible Cause	Remedy
The control arm anchor bracket is not positioned properly.	See instructions in **Subject 100.**
System air pressure is too low to fully release the spring brake.	Check that the air governor cuts out at the recommended setting.
A spring brake diaphragm is ruptured or a piston seal is leaking.	Replace the diaphragm or spring brake piston seal.
A return spring in the brake chamber is broken.	Replace the spring brake return spring.
The push rod binds on the chamber housing.	Check for correct alignment and correct chamber mounting bracket. Adjust or replace parts as needed.
The air supply does not exhaust completely.	Test the air system valves for leakage and correct operation.
The brake drums are out-of-round.	Turn the brake drums, if possible. If the maximum allowable diameter of any brake drum has been exceeded, replace the drum. Also, turn or replace the other drum on the axle. For turning the drums, refer to the brake manufacturer's service manual.
Extreme differences exist in lining-to-drum clearances between shoes on the same wheel.	Check for proper operation of the brake mechanism. Lubricate or overhaul as needed.
The wheel bearings are out of adjustment.	Adjust the wheel bearings, or replace them if damaged. For instructions refer to **Group 33** and **Group 35** in this manual.
The brake shoe return spring is broken.	Replace the brake shoe return spring.

Problem— Brake Chamber Push Rod Travel Is Excessive

Possible Cause	Remedy
The control arm anchor bracket is loose, broken, or bent.	Tighten or replace the anchor bracket as required.
There is excessive wear between the anchor bracket bolt and the control arm slot.	Replace the worn parts.
The control arm assembly is damaged or worn, resulting in lateral movement between the control arm and the cover plate.	Replace the slack adjuster.
The camshaft bushings are worn.	Replace the worn camshaft bushings.
The camshaft binds.	Lubricate the camshaft or overhaul the brake mechanism as needed.
The brake chamber mounting is loose.	Tighten the brake chamber mounting fasteners.
The slack adjuster is bound against the camshaft housing. There is no end play.	Check that the correct camshaft and camshaft tube have been used and that they are assembled correctly. Overhaul the brake mechanism as needed.
The slack adjuster clutch assembly is worn.	Replace the slack adjuster.

Contents

Subject	Subject Number
Service Operations	
Installing Air Lines and Fittings	100
Specifications	400

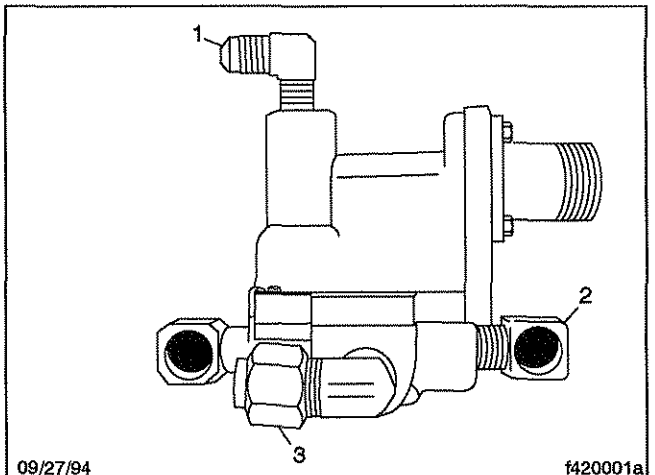
Installing Air Lines

NYLON TUBES (See Fig. 1 and Fig. 2)

When installing a nylon tube, be careful not to bend it past its minimum bend radius. For minimum bend radius values, refer to the appropriate table in **Specifications, 400.**

CAUTION: If the tubing is bent to a radius smaller than the specified minimum bend radius, it may kink, and shut off normal airflow to the component.

1. Cut the end of the tubing smooth and square.
2. Make sure the nylon tubing ends and fittings are free of grease and debris. If the tubing is crimped or otherwise damaged, replace it with new tubing.
3. Install a new sleeve in the nut.
4. Insert the squared end of the tubing in the fitting, until it bottoms in the body of the fitting. **See Fig. 3.**
5. Tighten the nut finger-tight. Then, using two wrenches to prevent twisting of the tube, tighten the nut a minimum of 2 turns (refer to the appropriate table in **Specifications, 400**) or until one thread shows on the fitting body.



1. Wire Braid Hose Fitting
2. Pipe Fitting
3. Nylon Tube Fitting

Fig. 1, Tube and Hose Fittings (for reference only)

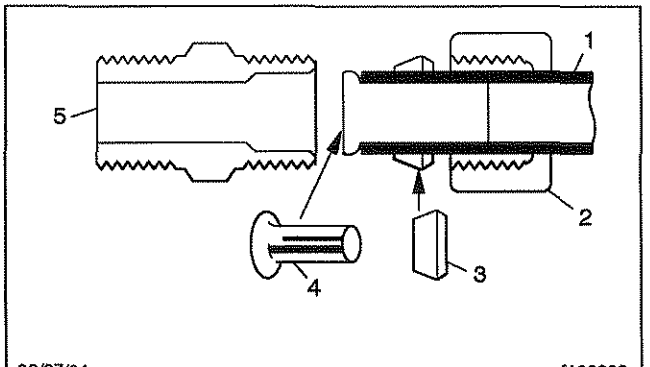
WIRE BRAID HOSES (See Fig. 1)

When installing a wire braid hose, be careful not to bend it past its minimum bend radius. For minimum bend radius values, refer to the appropriate tables in **Specifications, 400.**

CAUTION: If the hose is bent to a radius smaller than the specified minimum bend radius, it may kink, and shut off normal airflow to the component.

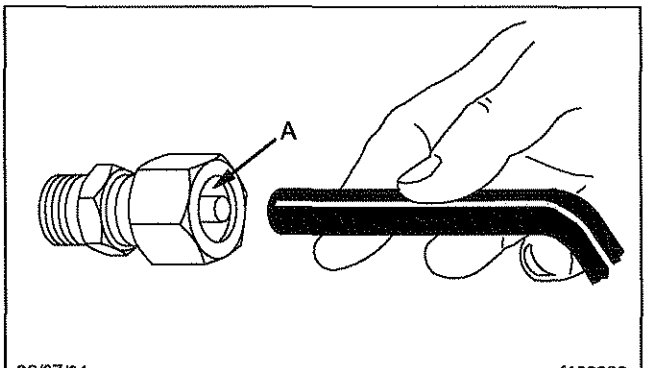
Make sure the wire braid hose assembly is free of grease and dirt. Replace the assembly if the hose or fitting is crimped or otherwise damaged.

Install the hose and tighten the nut finger-tight. Then, using two wrenches to prevent twisting of the hose,



1. Nylon Tube
2. Nut
3. Sleeve
4. Brass Insert
5. Body

Fig. 2, Nylon Tube Fitting



A. Tube end must bottom before tightening the nut.

Fig. 3, Installing Nylon Tubing

Installing Air Lines and Fittings

tighten the nut until it seats solidly. Tighten the nut one-sixth turn more.

Installing Fittings

BRASS AND STEEL PIPE FITTINGS (See Fig. 1)

For brass pipe fittings, both male and female parts, tighten as follows:

1. Make sure the fittings are free of grease, dirt, and old sealant. Apply liquid Loctite® Hydraulic Sealant (brown), or an equivalent, to the threads, then tighten securely, finger-tight.

NOTE: Always apply the sealant to the external thread, so that any excess will be scraped off externally rather than internally to the joint.

2. For fittings that must be positioned, tighten one additional turn from finger-tight using a wrench.

   Then, continue tightening until the fitting is correctly positioned.

   For fittings that do not require positioning, tighten 1-1/2 additional turns from finger-tight.

COPPER TUBE FITTINGS

For copper tube fittings, tighten the nut finger-tight. Then, using two wrenches to prevent twisting of the tube, tighten the nut the number of turns shown in the table in **Specifications, 400.**

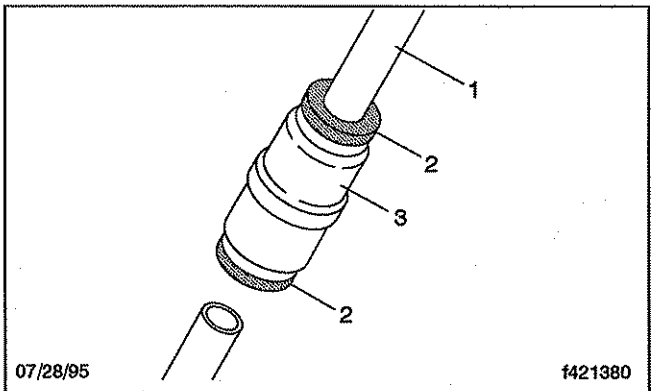
QUICK-CONNECT FITTINGS

NOTE: If damaged, quick-connect fittings must be replaced as an assembly.

1. Push in on the fitting collar to release the air line. Pull the line out of the fitting. **See Fig. 4.**
2. Push the air line all the way into the fitting. Pull the collar away from the fitting to secure the air line. Check and make sure that the air line is seated in the fitting.

TUBE AND PIPE FITTINGS ON PLASTIC COMPONENTS

For tightening specifications, refer to the table in **Specifications, 400.**



1. Air Line
2. Collar
3. Fitting

Fig. 4, Quick-Connect Fitting

Number	Inside Diameter inch	Outside Diameter inch	Minimum Bend Radius inches (mm)
4	0.170	1/4	1.00 (25)
6	0.251	3/8	1.50 (38)
8	0.376	1/2	2.00 (51)
10	0.439	5/8	2.50 (64)
12	0.566	3/4	3.00 (76)

Table 1, Nylon Tube

Tube Size (inches)	Additional Turns from Hand-Tight
1/4	3
3/8 or 1/2	4
5/8 or 3/4	3-1/2

Table 2, Additional Turns from Hand-Tight (Nylon Tube)

Number	Inside Diameter inch	Outside Diameter inch	Minimum Bend Radius inches (mm)
4	3/16	0.52	3.00 (76)
5	1/4	0.58	3.38 (86)
6	5/16	0.67	4.00 (102)
8	13/32	0.77	4.63 (118)
10	1/2	0.92	5.50 (140)
12	5/8	1.08	6.50 (165)
16	7/8	1.23	7.38 (187)
20	1-1/8	1.50	9.00 (229)

Table 3, 211 Wire Braid (Medium Pressure) Hose (211 hose is identified by part number and size; for example, part numbers 211-4, 211-5, and so on)

Number	Inside Diameter inch	Outside Diameter inch	Minimum Bend Radius inches (mm)
4	3/16	0.49	0.75 (19)
5	1/4	0.55	1.00 (25)
6	5/16	0.62	1.25 (32)
8	13/32	0.74	1.75 (44)
10	1/2	0.83	2.25 (57)
12	5/8	0.96	2.75 (70)
16	7/8	1.21	3.50 (89)
20	1-1/8	1.49	4.50 (114)

Table 4, 213 Wire Braid (Diesel) Hose (213 hose is identified by two green stripes 180 degrees apart, part numbers, and size; for example, part numbers 213-4, 213-5, and so on)

Number	Outside Diameter (Inches)	Additional Turns from Hand-Tight	
		Compression	Threaded Sleeve
2	1/8	1-1/4	1-1/2
3	3/16		
4	1/4		
5	5/16	1-3/4	
6	3/8	2-1/4	
8	1/2		
10	5/8		
12	3/4		
16	1		
20	1-1/4		

Table 5, Copper Tube Fittings

Specifications

Description	Port Size (inches)	Torque	
		N·cm (lbf·in)	N·m (lbf·ft)
Midland Quick Release Valve	3/8	680–1020 (60–90)*	—
	1/2	—	18–23 (13–17)*
Bendix MV-2/MV-3 Valve	1/4	—	14 (10)

* Tighten to the lower torque value. Then, if needed, turn the fittings to allow for the proper routing of the air lines.

Table 6, Tube and Pipe Fittings on Plastic Components

Contents

Subject	Subject Number
General Information and Principles of Operation	050
Service Operations	
Safety Precautions	100
Brake Shoe Removal and Installation	110
Brake Shoe and Lining Inspection	120
Brake Adjustment	125
Brake Shoe Lining Replacement	130
Brake Components Disassembly and Inspection, Cleaning, and Assembly	140
Specifications	400

General Information

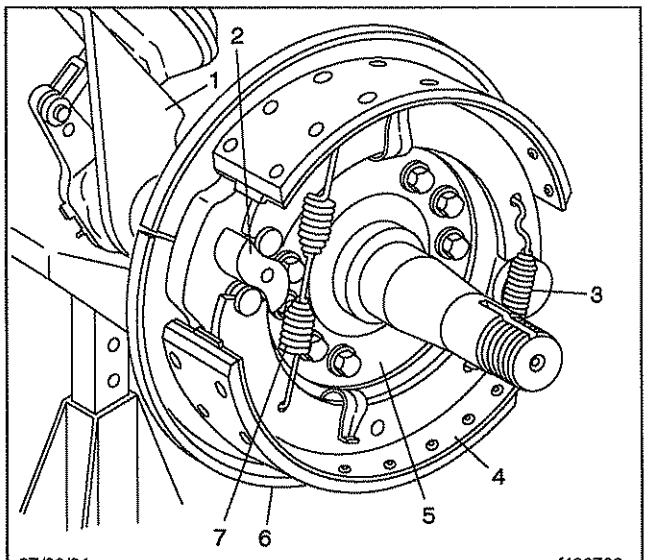
Eaton brakes **(Fig. 1)** are actuated by an S-type cam head, which is forged integrally with the camshaft and supported with nylon bushings. Cam pressure is applied through the cam rollers.

These brakes are used on both the front steer axle and rear axle.

Rockwell steer axles have seven holes for attaching the spider to the axle flange. There is an eighth hole that is left open on the brake spider, on both left and right sides of the steer axle. **See Fig. 2**, Ref. A. The seven holes used for attachment of the spider to the axle flange are 0.656 inch in diameter. The eighth hole is oversized at 0.687 inch in diameter.

Principles of Operation

When the brake pedal is depressed, compressed air enters the brake chamber, causing the diaphragm to move a push rod assembly.

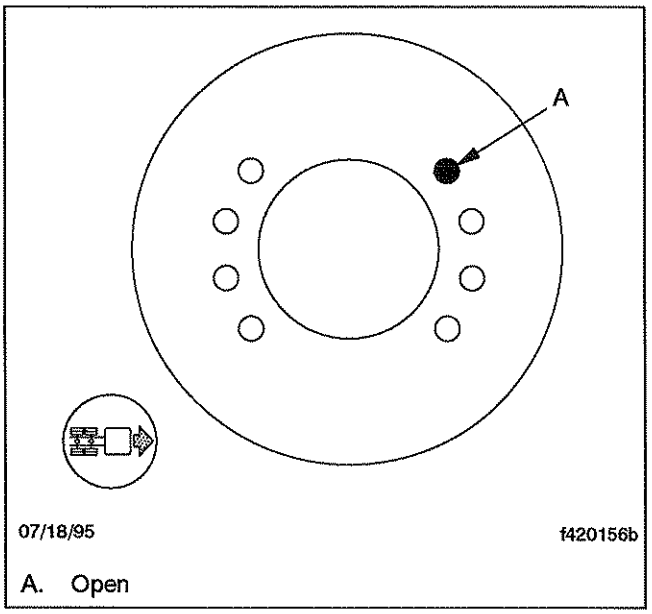


1. Air Chamber Bracket
2. Camshaft
3. Shoe Retaining Spring
4. Shoe Assembly
5. Spider
6. Dust Shield
7. Shoe Return Spring

Fig. 1, Front Axle Brake

The push rod, which is connected to a slack adjuster, turns the slack adjuster and brake camshaft. As the camshaft turns, the S-head, which is between the brake shoe rollers, forces the brake shoes against the brake drum, and braking occurs.

When the brakes are released and air is exhausted from the brake chamber, the actuator return spring (within the brake chamber) and the brake shoe return spring, return the camshaft, brake shoes, slack adjuster, and push rod to their released positions.



A. Open

Fig. 2, Open Hole Location

Safety Precautions

Because some brake linings contain asbestos, you should know the potential hazards of asbestos and the precautions to be taken. Because medical experts believe that long-term exposure to some *non-asbestos* fibers could also be a health hazard, the following precautions should also be observed if servicing non-asbestos brake linings.

Exposure to airborne brake lining dust can cause serious and possibly fatal diseases such as asbestosis (a chronic lung disease) and cancer.

During brake servicing, an air purifying respirator with high-efficiency filters must be worn. The respirator and filter must be approved by MSHA or NIOSH, and worn during all procedures.

OSHA recommends that enclosed cylinders equipped with vacuums and high-efficiency particulate air (HEPA) filters be used during brake repairs. Under this system, the entire brake assembly is placed within the cylinder and the mechanic works on the brake through sleeves attached to the cylinder. Compressed air is blown into the cylinder to clean the assembly, and the dirty air is then removed from the cylinder by the vacuum.

If such an enclosed system is not available, the brake assembly must be cleaned in the open air. During disassembly, carefully place all parts on the floor to minimize creating airborne dust. Using an industrial vacuum cleaner with a HEPA filter system, remove dust from the brake drums, brake backing plates, and brake parts. After vacuuming, any remaining dust should be removed using a rag soaked in water and wrung until nearly dry. Don't use compressed air or dry brushing to clean the brake assembly.

WARNING: Breathing brake lining dust (asbestos or non-asbestos) could cause lung cancer or lung disease. OSHA has set maximum levels of exposure and requires workers to wear an air purifying respirator approved by MSHA or NIOSH. Wear a respirator at all times when servicing the brakes, starting with removal of the wheels and continuing through assembly.

Brake Shoe Removal and Installation

Removal

WARNING: Before doing any of the work below, read the information under Safety Precautions, 100. Failure to be aware of the dangers of brake lining dust exposure could result in serious and permanent health damage.

1. Park the vehicle on a level surface, apply the parking brakes, and chock the tires.
2. Raise the front or rear axle, then place safety stands under the frame or axle. Be sure the stands will support the weight of the vehicle.
3. Remove the wheels and brake drums. For instructions, refer to **Group 33** or **Group 35** in this manual.

CAUTION: Before you back off automatic slack adjusters, refer to the applicable slack adjuster section in this manual, or to the manufacturer's service information for instructions. Failure to do so could damage the slack adjusters.

4. Back off the slack adjusters. For instuctions, refer to the applicable slack adjuster section in this manual for instructions on backing off the slack adjuster.
5. If equipped with 16-1/2 inch series brakes, go to the next step.

   On 15-inch series brakes, remove the brake shoes.

   5.1 Using a large screwdriver or lever, lift the upper shoe to stretch the return spring.

   Remove the upper cam roller. **See Fig. 1.** Repeat for the lower shoe and cam roller.

   5.2 Stretch the shoe return spring and unhook it from the upper shoe web. **See Fig. 2.**

   5.3 Rotate the lower shoe downward and turn it to allow disengagement of the shoe retaining spring from the lower shoe web. **See Fig. 3.**

   5.4 Rotate the upper shoe upward and remove the shoe and shoe retaining spring.

   5.5 Discard the cam rollers, shoe return spring, and shoe retaining spring.

NOTE: If equipped with Extended Service brakes, pry the roller retainer loops out of both shoe web holes. **See Fig. 4.** Then, pivot the roller retainer to swing the loops clear of the shoe webs.

6. On 16-1/2 inch series brakes, remove the brake shoes.

   6.1 Using a large screwdriver or lever, lift the upper shoe to stretch the return spring. Remove the cam roller and the pin or retainer, as equipped. **See Fig. 5.**

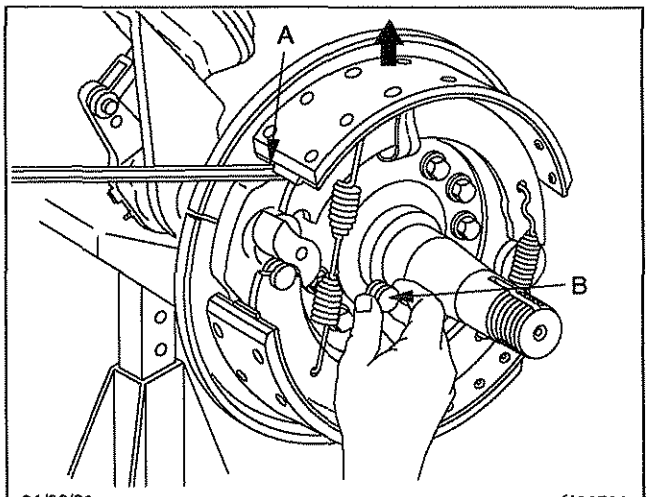
   Repeat for the lower shoe.

   6.2 Push the cam end of both shoes toward the cam and unhook the shoe return spring.

   NOTE: If equipped with Extended Service brakes, position a suitable lever to engage the rod of the spring. **See Fig. 6.** Force the lever down to stretch the spring and allow removal of the upper spring hook.

   6.3 Rotate both shoes around the anchor pin, then remove the shoes. **See Fig. 7.**

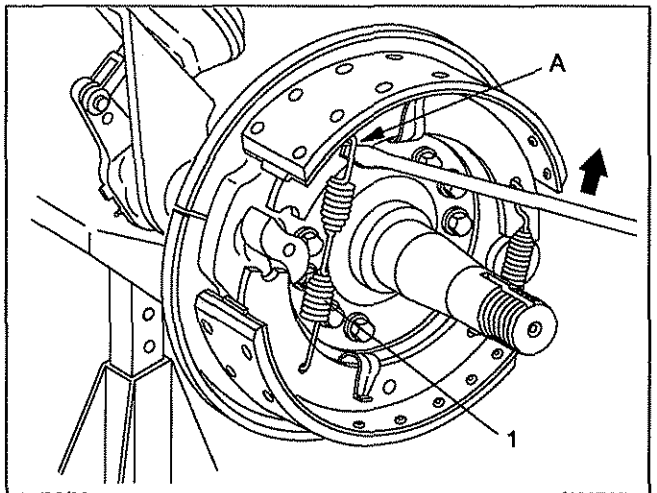
   6.4 Discard the cam rollers and pins, and the shoe return spring (or shoe retainer springs on Extended Service brakes).



A. Lift upper shoe to stretch spring.
B. Remove roller.

Fig. 1, Remove the Upper Cam Roller

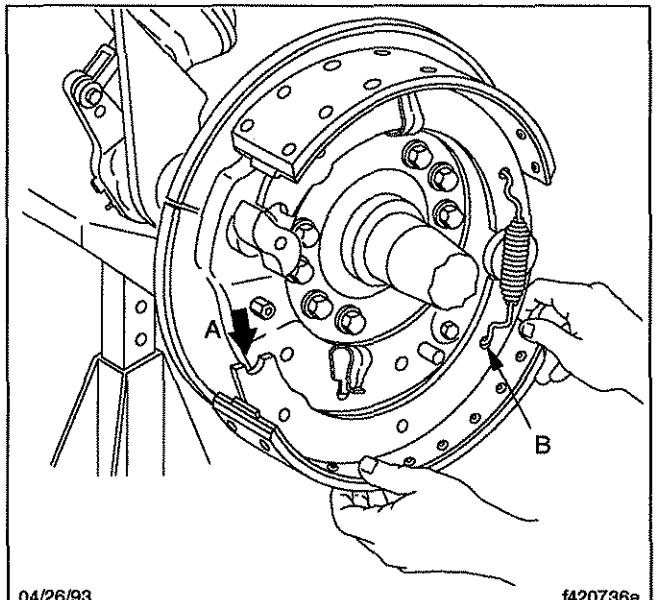
Brake Shoe Removal and Installation



A. Stretch spring to unhook from shoe web.

1. Shoe Return Spring

Fig. 2, Stretch the Shoe Return Spring



A. Rotate down.
B. Unhook retaining spring.

Fig. 3, Rotate the Lower Shoe Downward

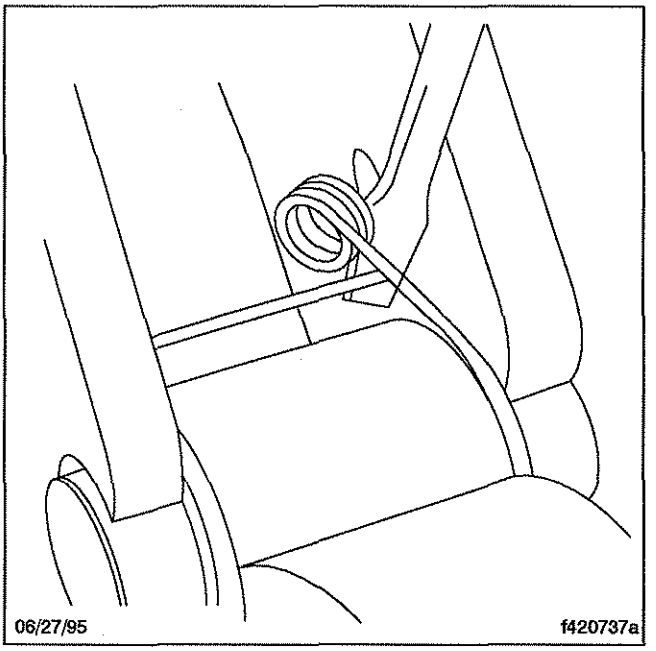
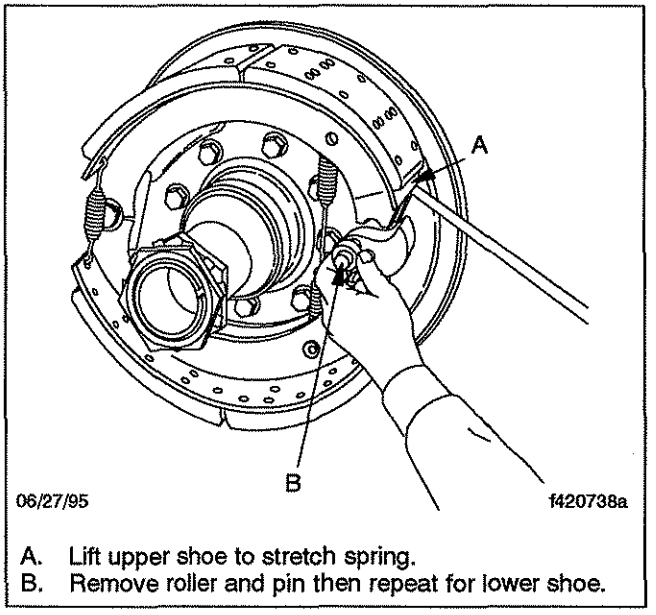


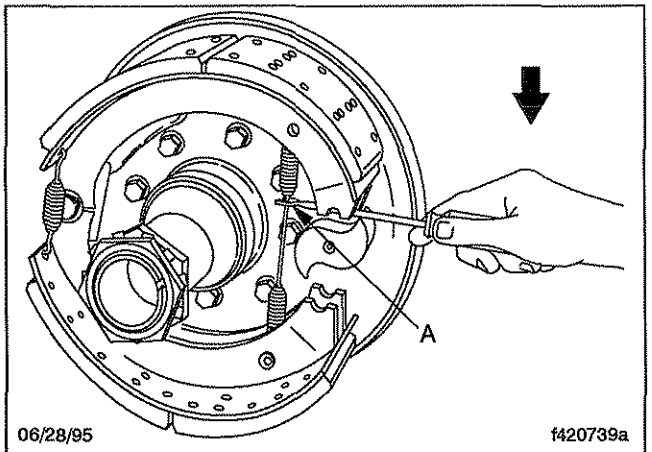
Fig. 4, Pry out the Roller Retainer Loops



A. Lift upper shoe to stretch spring.
B. Remove roller and pin then repeat for lower shoe.

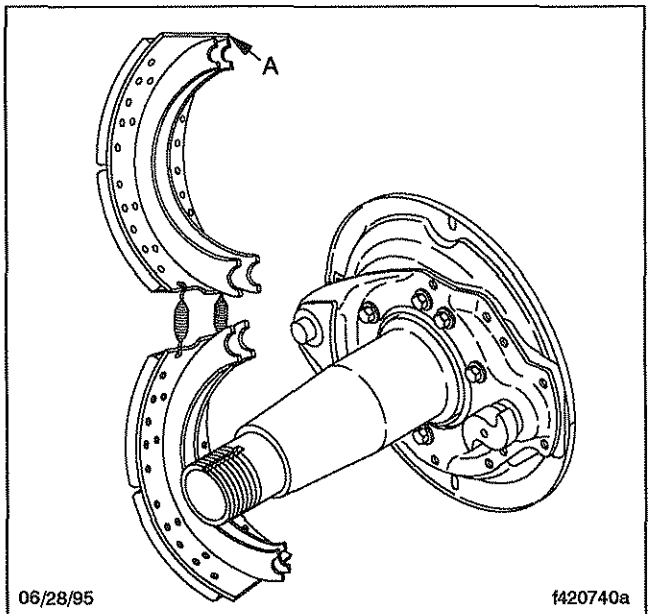
Fig. 5, Removing the Cam Rollers

7. Inspect the brake shoes and linings for wear or damage. For instructions, refer to **Subject 120**.



A. Stretch spring using suitable tool positioned as shown.

Fig. 6, Remove the Upper Spring Hook



A. Rotate both shoes around anchor pin and lift off brake shoes.

Fig. 7, Remove the Brake Shoes

Installation

IMPORTANT: For best brake performance, don't mix Extended Service brakes with other Eaton series brakes. Use the same brake series on the entire vehicle.

1. Apply a thin film of temperature resistant grease (Kendall M-621, or an equivalent) to the cam roller and, for all models except Extended Service brakes, the anchor pin recesses of each shoe web.
2. If equipped with 16-1/2 inch brakes, go to the next step.

   On 15-inch series brakes, install the brake shoes.

   2.1 Place the upper brake shoe and lining web on the anchor pin and rotate down. Continue rotation until the shoe is held in place by the shoe hold-down spring.

   2.2 Hook one end of the new shoe retaining spring into the hole in the upper shoe web so that the coil lays across the anchor pin. **See Fig. 8.**

   Hook the opposite end of the spring into the hole on the lower shoe web.

   Stretch the spring to allow positioning of the lower shoe web against the anchor pin.

   2.3 Rotate the lower shoe into position so that the shoe web rests on the barrel nut (if equipped) or against the anchor pin.

   2.4 Hook one end of the new shoe return spring in the lower shoe web hole. Using a screwdriver, stretch the shoe return spring hook in the upper shoe web hole.

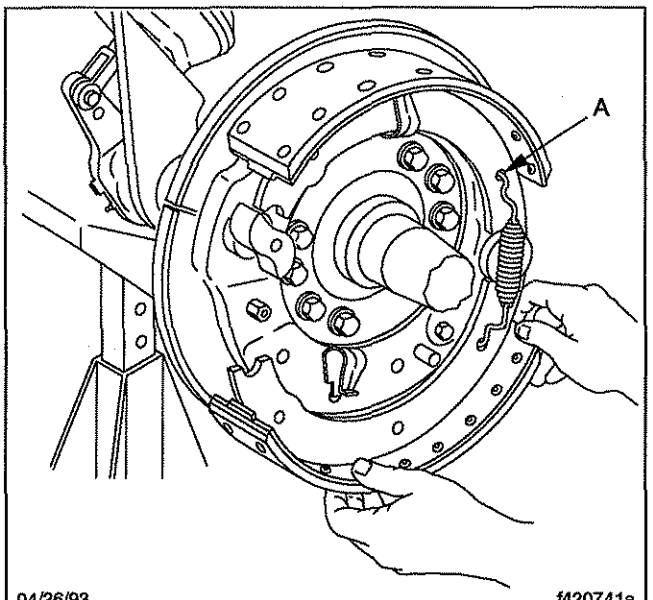
   2.5 Using a large screwdriver or lever, stretch the shoe return spring to allow insertion of the new cam roller on the upper shoe web. **See Fig. 9.** Install the new cam roller on the lower shoe web.
3. If equipped with 16-1/2 inch series brakes, install the brake shoes.

   3.1 Hook the ends of the new retainer springs into the holes in both shoe tables. Make sure that the hooks are pointing out.

   3.2 Position the upper and lower shoes around the anchor pin. **See Fig. 10.**

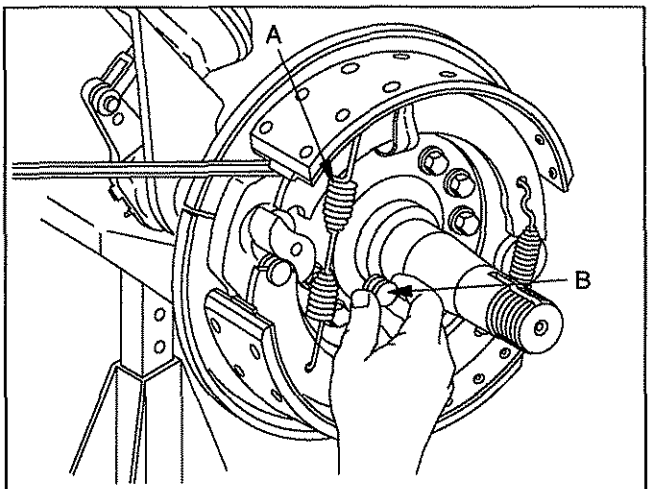
   3.3 Install a new shoe return spring.

Brake Shoe Removal and Installation



A. Hook spring into shoe web hole.

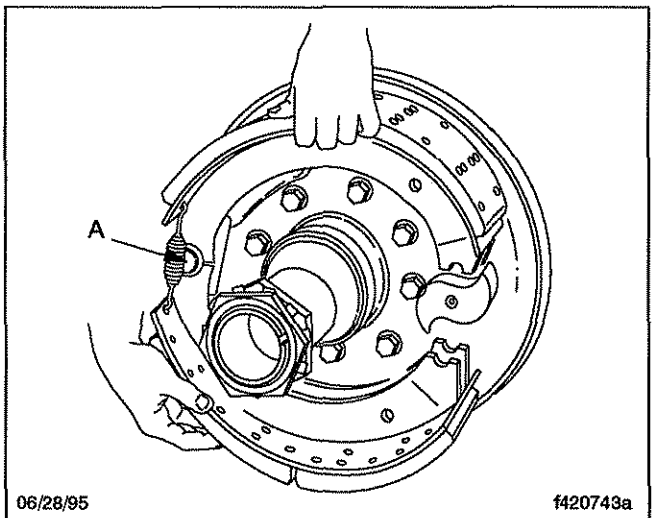
Fig. 8, Attach the New Shoe Retaining Spring



A. Install new return spring.
B. Install rollers.

Fig. 9, Install the Cam Rollers

On Extended Service brakes, position a suitable lever to engage the rod of the spring. **See Fig. 6.** Force the lever down



A. With retainer springs installed, position upper and lower shoes around anchor pin.

Fig. 10, Position the Upper and Lower Shoes

to stretch the spring and allow installation of the upper spring hook. Assemble the roller retainer on the ends of the roller. **See Fig. 11.**

3.4 Using a lever or a large screwdriver, stretch the shoe return spring to allow insertion of the new pin and roller (or the new roller and retainer assembly on

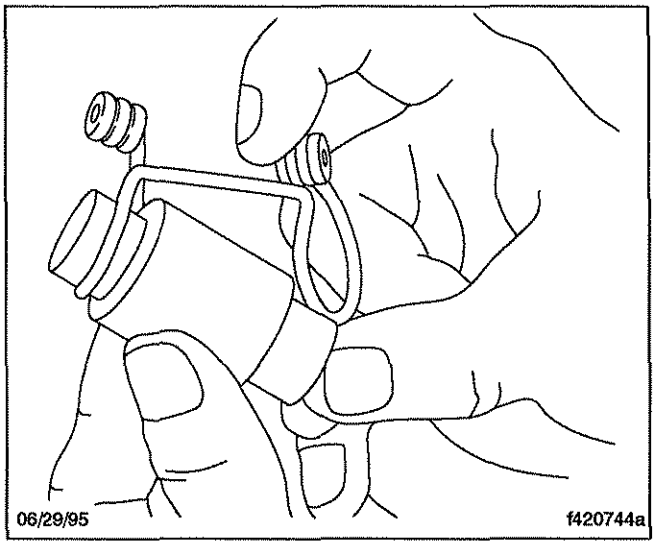


Fig. 11, Assemble the Roller Retainer

Extended Service brakes) on the lower shoe web. **See Fig. 12.**

On Extended Service brakes, squeeze the loops and swing the retainer assembly into position **(Fig. 13);** then snap the loops into the web holes. Make sure that both retainer loops are engaged in the web holes.

Repeat on the upper shoe.

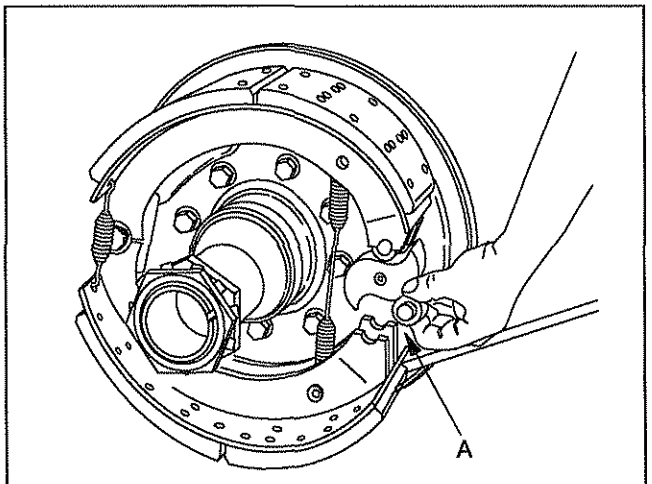
4. Install the wheels and brake drums. For instructions, refer to **Group 33** or **Group 35** in this manual.

   If working on the rear axle, manually uncage the power spring of the parking brake chamber. For instructions, refer to the applicable brake chamber section in this manual.

5. Adjust the brakes at the slack adjusters. For instructions, refer to **Subject 125.**

6. Remove the safety stands, lower the vehicle, and remove the chocks from the tires.

WARNING: Don't operate the vehicle until the brakes have been adjusted and checked for proper operation. To do so could result in inadequate or no braking ability, which could cause personal injury or death, and property damage.



A. Using a lever, stretch return spring and install cam roller and pin.

Fig. 12, Install the Cam Rollers

7. In a safe area, check for proper brake operation.

   7.1 Apply and release the brakes several times to check for air leaks and proper operation of the slack adjusters.

   7.2 Do several low speed stops to ensure proper parts replacement and full vehicle control.

   7.3 Make ten 40 to 20 mph (60 to 30 km/h) snubs to seat the linings.

   7.4 Make ten stops from 20 mph (30 km/h) at 50 percent air pressure.

   7.5 Make a full-pressure stop from 20 mph (30 km/h).

   7.6 Immediately after doing the above stops, check the drum temperatures. Any drums that are significantly cooler than the others shows a lack of braking effort on those wheels.

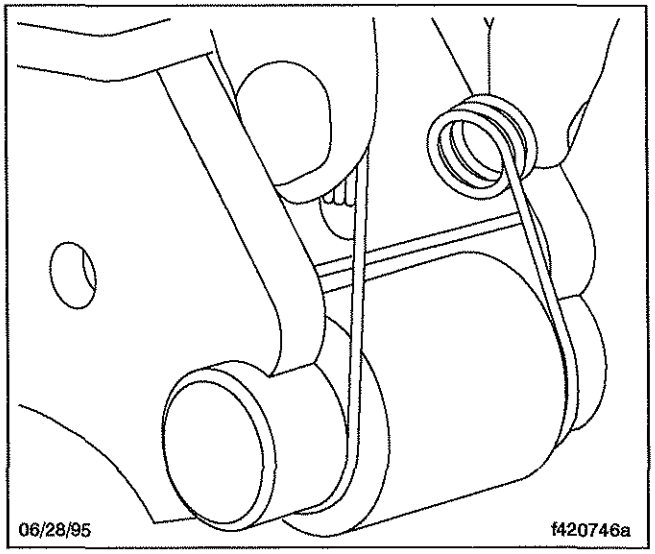


Fig. 13, Position the Retainer Assembly

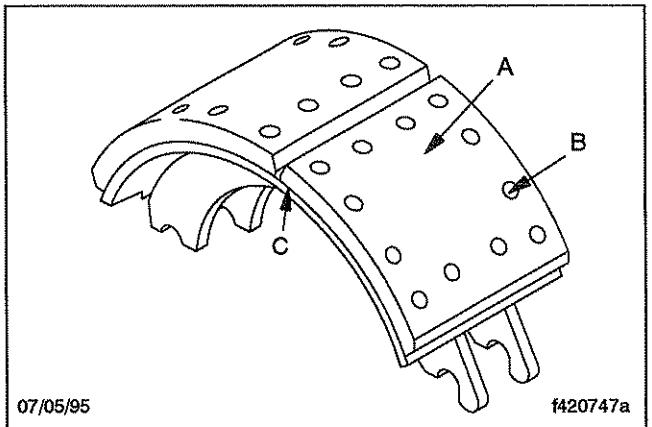
Inspection

WARNING: Before starting the procedure below, read the information in Safety Precautions, 100. Failure to be aware of the dangers of brake lining dust exposure could result in serious and permanent health damage.

1. Remove the brake shoes. Refer to **Subject 110** for instructions.
2. Check the linings.

   On 15-inch series brakes, if the linings are grease- or oil-soaked, cracked, or worn to less than 3/16-inch (4.5-mm) thickness at any point (the lining surface should be no closer than 1/16 inch [1.5 mm] to any rivet head), replace them. **See Fig. 1.**

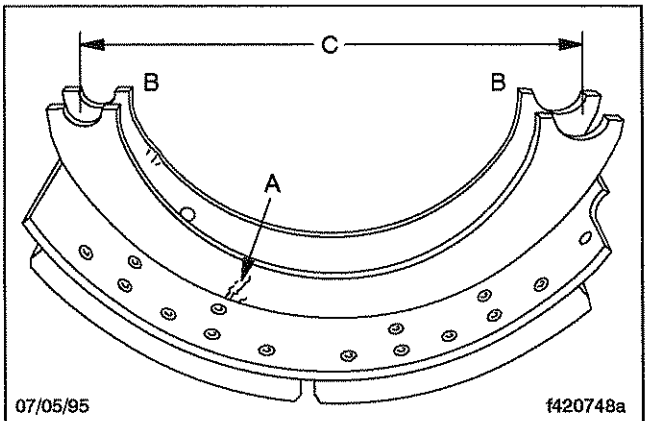
   On 16-1/2 inch series brakes, if the linings are grease- or oil-soaked, cracked, or worn to less than 1/4-inch (6.4-mm) thickness at any point, replace them.
3. Check the shoes for bent or cracked webs or tables, broken welds, loose rivets, or out-of-round rivet holes. **See Fig. 2.** Replace the shoes if any of these conditions exist.
4. Check the anchor pin for looseness and camshaft roller recesses in the shoe webs for visible wear. Replace the shoe if needed.



A. Check for cracks or contamination.
B. No closer than 1/16" (1.5 mm) to any rivet head.
C. 3/16" (4.5 mm) minimum thickness.

Fig. 1, Check the Brake Shoe (15-Inch Series shown)

5. Check the shoe span. Measure the distances between the centerlines of the anchor pin and camshaft roller pin recesses in the shoe web. **See Fig. 2.** On 15-inch series brakes, if the measurement is more than 11-3/4 inches (298 mm), replace the shoe. On 16-1/2 inch series brakes, if the measurement is more than 12-9/16 inches (319 mm), replace the shoe.



A. Check table and web for cracks or bends.
B. Check both ends for wear and elongation.
C. Measure this distance.

Fig. 2, Measuring the Shoe Span

Adjustment

ROCKWELL AUTOMATIC SLACK ADJUSTER

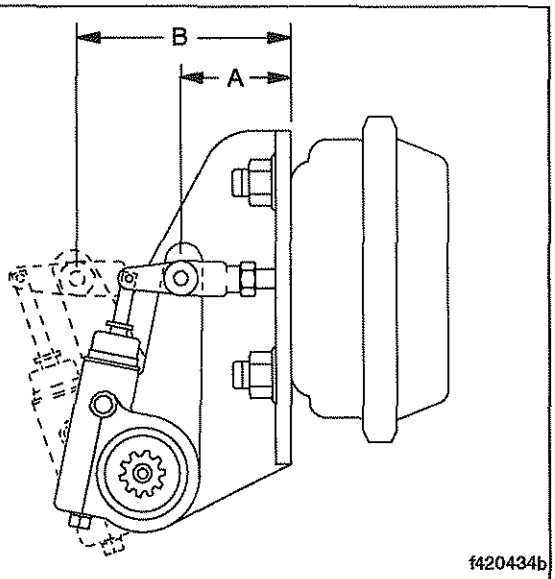
1. Check the free-stroke.

   1.1 With the brakes fully released, measure the distance from the bottom of the brake chamber to the center of the large clevis pin. **See Fig. 1**, Ref. A.

   1.2 Use a pry bar to move the slack adjuster and apply the brakes. Again, measure the distance from the bottom of the brake chamber to the center of the large clevis pin. **See Fig. 1**, Ref. B.

   1.3 The difference between the two measurements is the initial free-stroke, and sets the clearance between the linings and the drum.

   1.4 The free-stroke must be 5/8 to 3/4 inch (16 to 19 mm).



NOTE: Subtract measurement A from B.

A. Measurement With Brakes Released
B. Measurement With Brakes Applied

Fig. 1, Measuring the Initial Free-Stroke

   If the free-stroke is correct, go to the next step and check for correct brake chamber stroke.

   If the free-stroke is incorrect, remove the pressure relief capscrew (**Fig. 2**, Ref. 16), spring (Ref. 18), and pawl assembly (Ref. 19) from the slack adjuster housing. If equipped with a pull-pawl assembly **(Fig. 3),** carefully insert a screwdriver and raise the relief cap about 1/8 inch (3.2 mm).

CAUTION: Before turning the adjusting nut, remove the pressure relief capscrew, spring, and pawl assembly. If equipped with a pull-pawl assembly, raise the relief cap about 1/8 inch (3.2 mm). Failure to do so could strip the teeth on the pawl.

   1.5 Turn the adjusting nut 1/8 turn, as shown in **Fig. 4.** Measure the stroke again, and adjust until it is correct.

2. Check for correct brake chamber stroke.

   2.1 With the brakes fully released, measure the distance from the bottom of the brake chamber to the center of the large clevis pin. **See Fig. 1**, Ref. A.

   2.2 Build air pressure to 100 psi (689 kPa). Shut down the engine. Fully apply the brakes, then measure the distance from the bottom of the brake chamber to the center of the large clevis pin. **See Fig. 1**, Ref. B. The difference between the measurements is the brake chamber stroke.

   2.3 The brake chamber stroke must be less than the measurements shown in **Table 1.** If the brake chamber stroke is incorrect, remove the pressure relief capscrew (**Fig. 2**, Ref. 16), spring (Ref. 18), and pawl assembly (Ref. 19) from the slack adjuster housing. If equipped with a pull-pawl assembly **(Fig. 3),** carefully insert a screwdriver and raise the relief cap about 1/8 inch (3.2 mm).

CAUTION: Before turning the adjusting nut, remove the pressure relief capscrew, spring, and pawl assembly. If equipped with a pull-pawl assembly, raise the relief cap about 1/8 inch (3.2

mm). Failure to do so could strip the teeth on the pawl.

2.4 Turn the adjusting nut 1/8 turn, as shown in **Fig. 4.** Measure the stroke again, and adjust until correct.

If the stroke varies or remains greater than the specified range, check brake components. For instructions, refer to **Subject 140.** If necessary, replace the slack adjuster. For instructions, refer to the applicable slack adjuster section in this group.

CAUTION: Don't make the adjusted chamber stroke too short. The free-stroke must not be less than 5/8 to 3/4 inch (16 to 19 mm). If the chamber stroke is too short, the linings can drag and damage the brake.

2.5 If removed, install the pawl assembly, spring, and the pressure relief capscrew. Tighten the capscrew 15 to 20 lbf·ft (20 to 27 N·m). Or, remove the screwdriver from the pull-pawl assembly (if equipped).

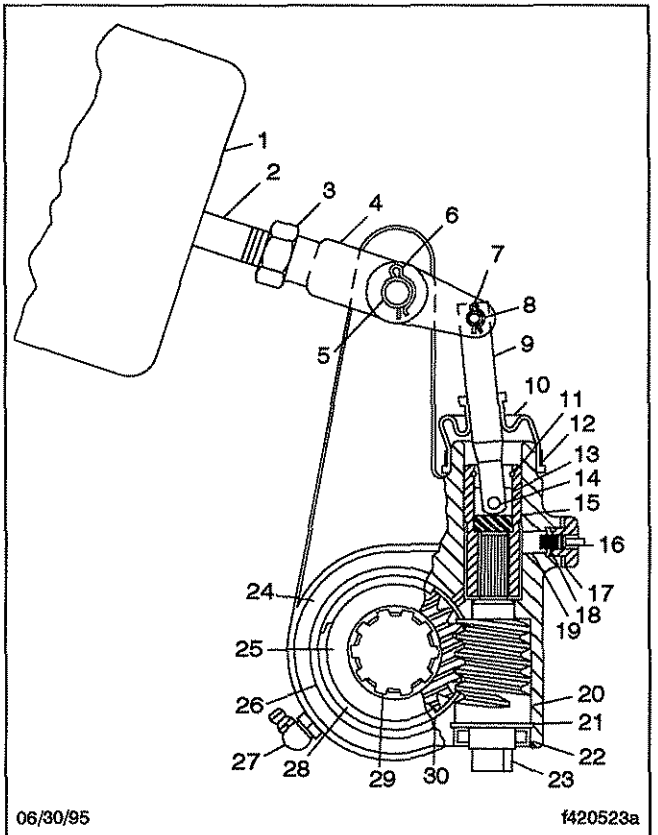
Chamber Size	Stroke inches (mm)
12	Less than 1-3/8 (35)
16, 20, 24	Less than 1-3/4 (44)
30	Less than 2 (51)

Table 1, Maximum Adjusted Brake Chamber Stroke With Automatic Slack Adjusters

HALDEX AUTOMATIC SLACK ADJUSTER

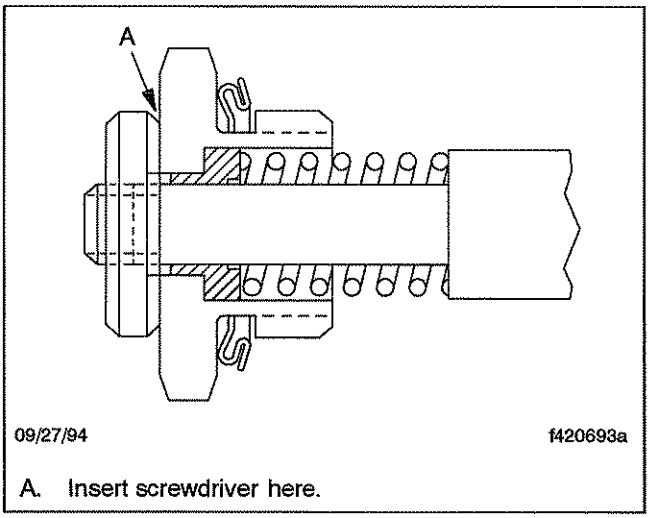
1. Turn the adjusting hexnut clockwise until the brake lining meets the brake drum, then back off counterclockwise 3/4 turn. **See Fig. 5.** There will be a ratcheting sound.
2. Measure the distance from the bottom of the air chamber to the far side of the clevis-pin hole (**Fig. 6**, Ref. A). Record the exact distance as measurement A. Apply and hold an 80 psi (551 kPa) brake application. Measure the distance from the bottom of the brake chamber to the far side of the clevis-pin hole (**Fig. 6**, Ref. B). Record the exact distance as measurement B. Subtract measurement A from measurement B to determine the applied stroke. Compare this value to the value in **Table 2.**

If the stroke varies or remains greater than the specified range, check the brake components. For instructions, refer to **Subject 140.** If neces-



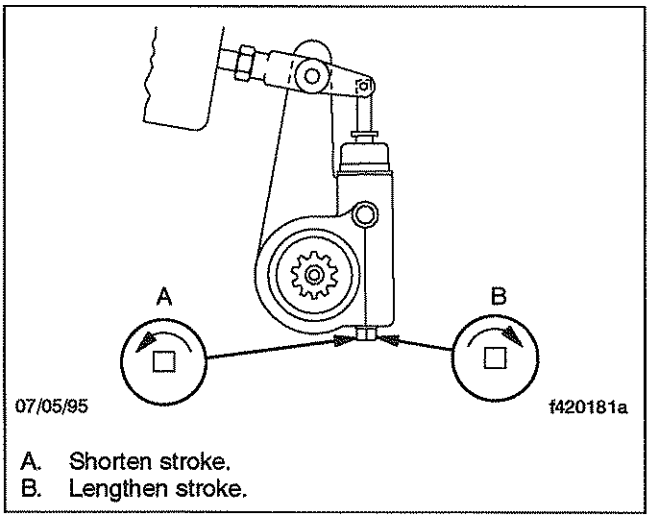
1. Brake Air Chamber
2. Brake Chamber Push Rod
3. Clevis Jam Nut
4. Clevis
5. Clevis Pin (large)
6. Cotter Pin (large)
7. Cotter Pin (small)
8. Clevis Pin (small)
9. Actuator Rod
10. Boot
11. Piston Retaining Ring
12. Boot Retaining Clamp
13. Actuator Piston
14. Roller (Pin)
15. Actuator (Adjusting Screw)
16. Pressure Relief Capscrew (shown 90 degrees out of position)
17. Gasket
18. Pawl Spring
19. Pawl Assembly
20. Worm
21. Worm Retaining Snap Ring
22. Worm Seal
23. Manual (Worm) Adjusting Nut End
24. Slack Adjuster
25. Gear
26. Gear Thrustwasher
27. Grease Fitting
28. Gear Retaining Ring
29. Camshaft Splines
30. Gear-to-Body Seal

Fig. 2, Rockwell Automatic Slack Adjuster shown



A. Insert screwdriver here.

Fig. 3, Pull-Pawl Assembly (sectional view)

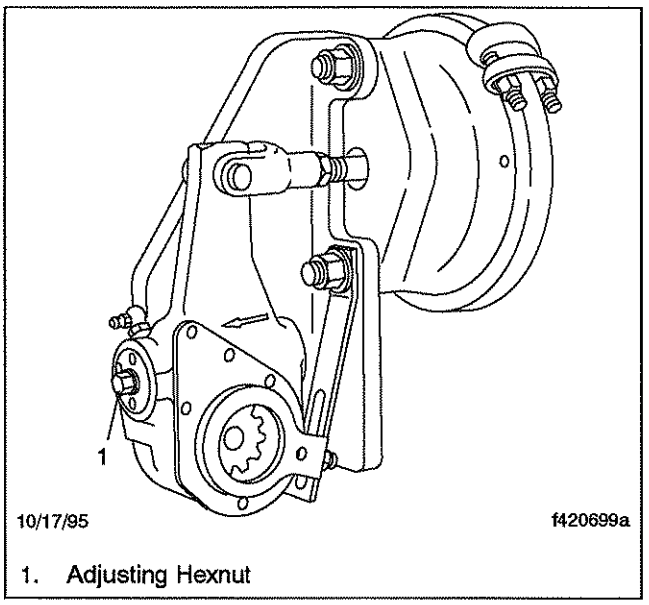


A. Shorten stroke.
B. Lengthen stroke.

Fig. 4, Turn the Adjusting Nut

sary, replace the slack adjuster. For instructions, refer to the applicable slack adjuster section in this group.

Chamber Size	Stroke inches (mm)
16	3/4 to 1-3/4 (19 to 44)
20	1 to 1-/34 (25 to 44)



1. Adjusting Hexnut

Fig. 5, Turn the Adjusting Hexnut

Chamber Size	Stroke inches (mm)
24	1 to 1-7/8 (25 to 48)
30	1-1/2 to 2 (38 to 51)

Table 2, Maximum Adjusted Brake Chamber Stroke With Haldex Automatic Slack Adjusters

Brake Adjustment

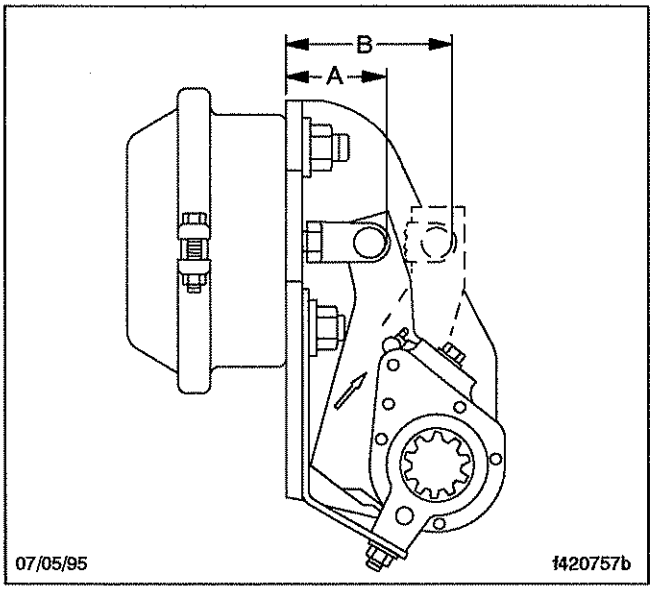


Fig. 6, Brake Stroke Check, Haldex (SAB) Automatic Slack Adjuster

Replacement

WARNING: Before starting the procedure below, read the information in Safety Precautions, 100. Failure to be aware of the dangers of brake lining dust exposure could result in serious and permanent health damage.

IMPORTANT: For the best brake performance, don't mix brake linings between axles. When relining brake shoes, both wheel ends of each axle must have the same linings. On tandem axles, all four wheel ends must also have the same linings. However, it is not necessary for the steering axle brakes to have the same linings as the rear drive axle brakes. Also, when the minimum thickness is reached for any of the brake linings on an axle, reline both brakes on that axle at the same time.

NOTE: Replace the springs each time the brakes are relined. Eaton recommends replacement of the rollers and pins at each reline.

1. Remove the brake shoes. For instructions, refer to **Subject 110.**

CAUTION: Drilling out rivets or cutting off rivet heads with a chisel can cause the rivet hole to become out-of-round. This could damage the brake shoe.

2. Using a suitable riveting mandrel, push out (do not drill out) the old rivets.
3. Clean the shoe table. For instructions, refer to **Subject 140.**

CAUTION: Make sure that the replacement lining material conforms to FMSI 1308. The FMSI number indicated is a standard for lining size and shape only. Use of an improper FMSI lining specification or friction material type may cause brake dragging, grabbing, or improper brake performance.

4. Align the brake shoe and lining rivet holes. Using a C-clamp, clamp the lining to the brake shoe.
5. Insert the correct sized rivets into all holes in the new block, and temporarily hold them in place with masking tape.

IMPORTANT: Use rivets that have the correct material, shank diameter, length, head size, and shape. Use tubular rivets that are 1/4-inch (6-mm) diameter by 1/2-inch (13-mm) long, SAE no. 10-8, made of zinc- or brass-plated steel.

6. Begin riveting at the center of each edge of the shoe and lining, and work toward each end.
7. Check for a close fit between the lining and shoe table.

   Try to insert a 0.006-inch (0.15-mm) feeler gauge between the lining and shoe table along the edges. **See Fig. 1**, Ref. A. It should not be possible to insert the gauge anywhere along the edge, except at each end beyond the last row of rivets. A larger clearance may exist in these areas.

IMPORTANT: Always adjust the brakes at the slack adjusters after replacing the linings. For instructions, refer to **Subject 125.**

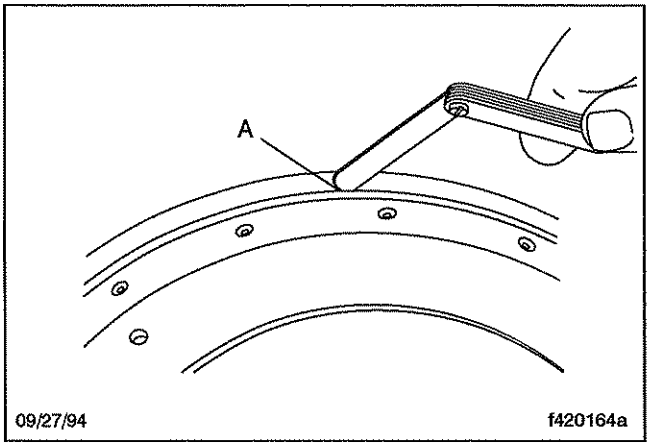
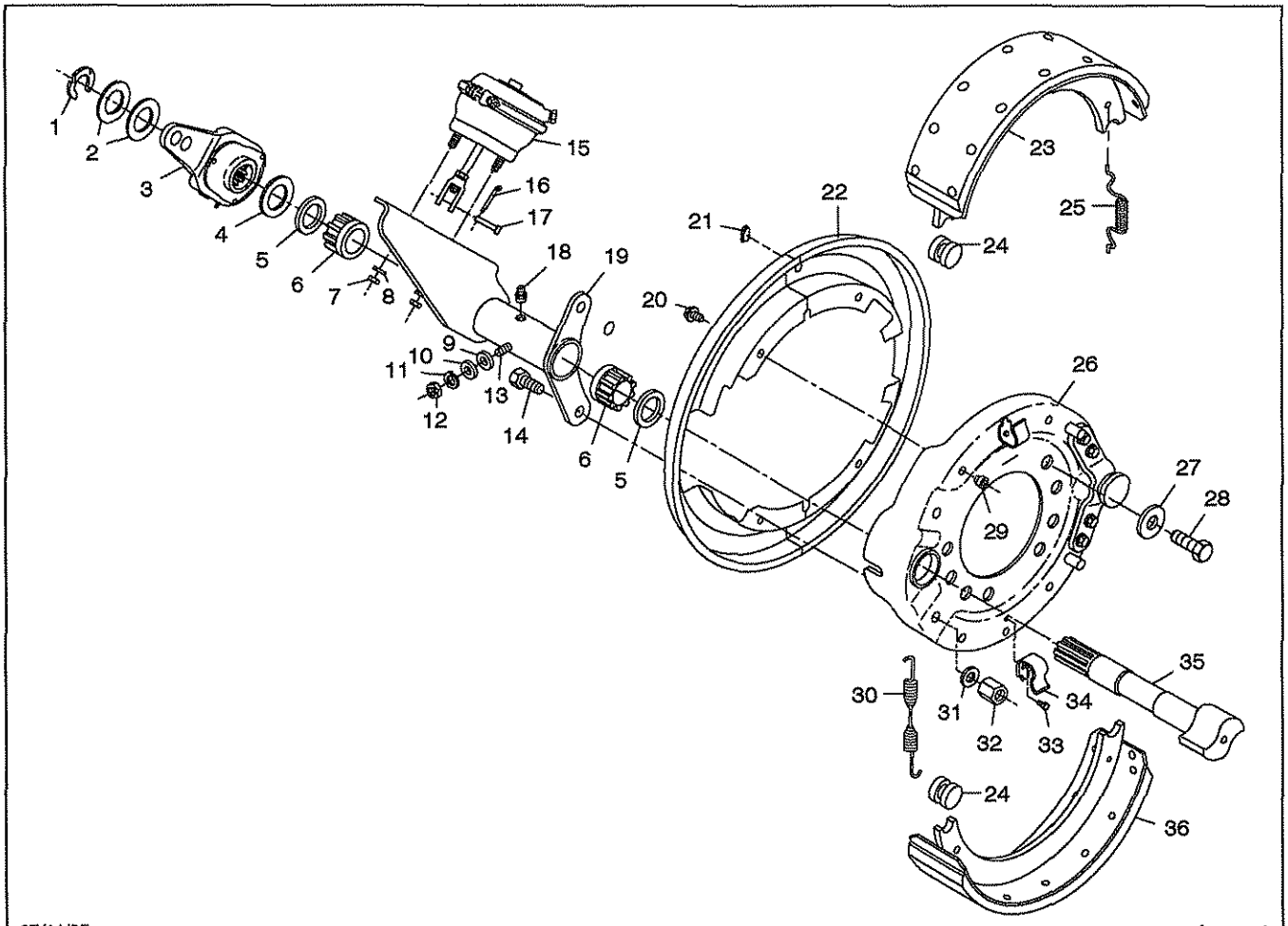


Fig. 1, Insert the Feeler Gauge between the Lining and Shoe Table

Brake Components Disassembly and Inspection, Cleaning, and Assembly

Disassembly and Inspection (See Fig. 1 or Fig. 2)



NOTE: Not all fasteners are shown.

1. Snap Ring
2. Camshaft Outer Washers
3. Slack Adjuster
4. Camshaft Inner Washer
5. Grease Seal
6. Camshaft Bushing
7. Stud Nut
8. Lockwasher
9. Spacer
10. Plain Washer
11. Lockwasher
12. Nut
13. Stabilizing Screw
14. Bracket Mounting Bolt
15. Brake Chamber
16. Cotter Key
17. Clevis Pin
18. Grease Fitting
19. Camshaft Support Bracket
20. Dust Shield Screw
21. Lining Inspection Plug
22. Dust Shield
23. Upper Brake Shoe and Lining
24. Cam Roller
25. Retaining Spring
26. Brake Spider and Anchor Pin Assembly
27. Hardened Washer
28. Spider Mounting Bolt
29. Nutsert
30. Return Spring
31. Lockwasher
32. Barrel Nut
33. Bolt
34. Shoe Hold-Down Spring
35. Camshaft
36. Lower Brake Shoe and Lining

Fig. 1, Front Axle Brake

Brake Components Disassembly and Inspection, Cleaning, and Assembly

WARNING: Before starting the procedure below, read the information in Safety Precautions 100. Failure to be aware of the dangers of brake lining dust exposure could result in serious and permanent health damage.

1. Check the drum for cracks, heat checks, glazing, grooving, run-out, and out-of-round. **See Fig. 3.**

   Measure the drum diameter. Replace the drum if it exceeds the maximum diameter stamped on it. Replace cracked drums.

   Some drums that are glazed, grooved, or out-of-round can be repaired. For detailed instructions, refer to the front or rear axle section in this manual.

2. Disconnect the slack adjuster from the push rod clevis. For instructions, refer elsewhere in this group, or to the manufacturer's service information for instructions.

3. With the brake shoes removed, use a dial indicator to measure the up-and-down and side-to-side end-play of the camshaft. Replace the bushings if there is more than 0.020 inch (0.5 mm) of movement.

CAUTION: Don't hammer on the slack adjuster to remove it. Damage to the adjuster or camshaft spline may result.

4. Remove the slack adjuster. For instructions, refer to the applicable slack adjuster section in this group, or to the manufacturer's service information for instructions.

5. Check the slack adjuster for damage and for binding.

   5.1 Check the slack adjuster clevis for cracks or bushing wear. Check the splines for chipped teeth and deformation. Replace as needed.

   5.2 Depress the locking sleeve, and turn the adjuster nut with a wrench at least one turn in each direction. If there is binding, or if excessive force is needed to turn the adjuster, replace it. For instructions, refer elsewhere in this group.

   IMPORTANT: If any slack adjuster problem is found, repair or replace the unit, depending on the manufacturer's recommendations.

6. Remove the camshaft by grasping its head and pulling the camshaft outboard.

7. Check the camshaft spline end for cracks, or worn or deformed splines. Replace the camshaft if damaged.

8. Check the camshaft bushing journals for wear or corrosion. Replace the camshaft if it is worn or if roughness is felt in the journal area.

9. Inspect the camshaft head for brinelling, cracking, or flat spots. Replace the camshaft if a ridge can be felt between the worn area and the cam head surface.

10. Remove the brake chamber stud nuts and lockwashers that attach the brake chamber to the camshaft support bracket. Check the chamber and parts for problems.

    Check the brake chamber for a cracked housing, bent push rod, loose clamp ring, loose air fitting, air leaks, or clogged vent holes. Repair or replace parts as needed. For instructions, refer elsewhere in this group.

11. Remove and inspect the camshaft support bracket. Remove and discard its gasket. Check the bracket for a bent, broken, or cracked arm, and for cracked welds. Replace the bracket if any of these conditions exist.

12. Remove and inspect the old bushing and the grease seal.

    12.1 Check the camshaft bushing for wear. The inner surface must be smooth; if rough or abrasive, replace the bushing.

    12.2 Inspect the seal. Replace it if the lip is nicked, cut, or distorted.

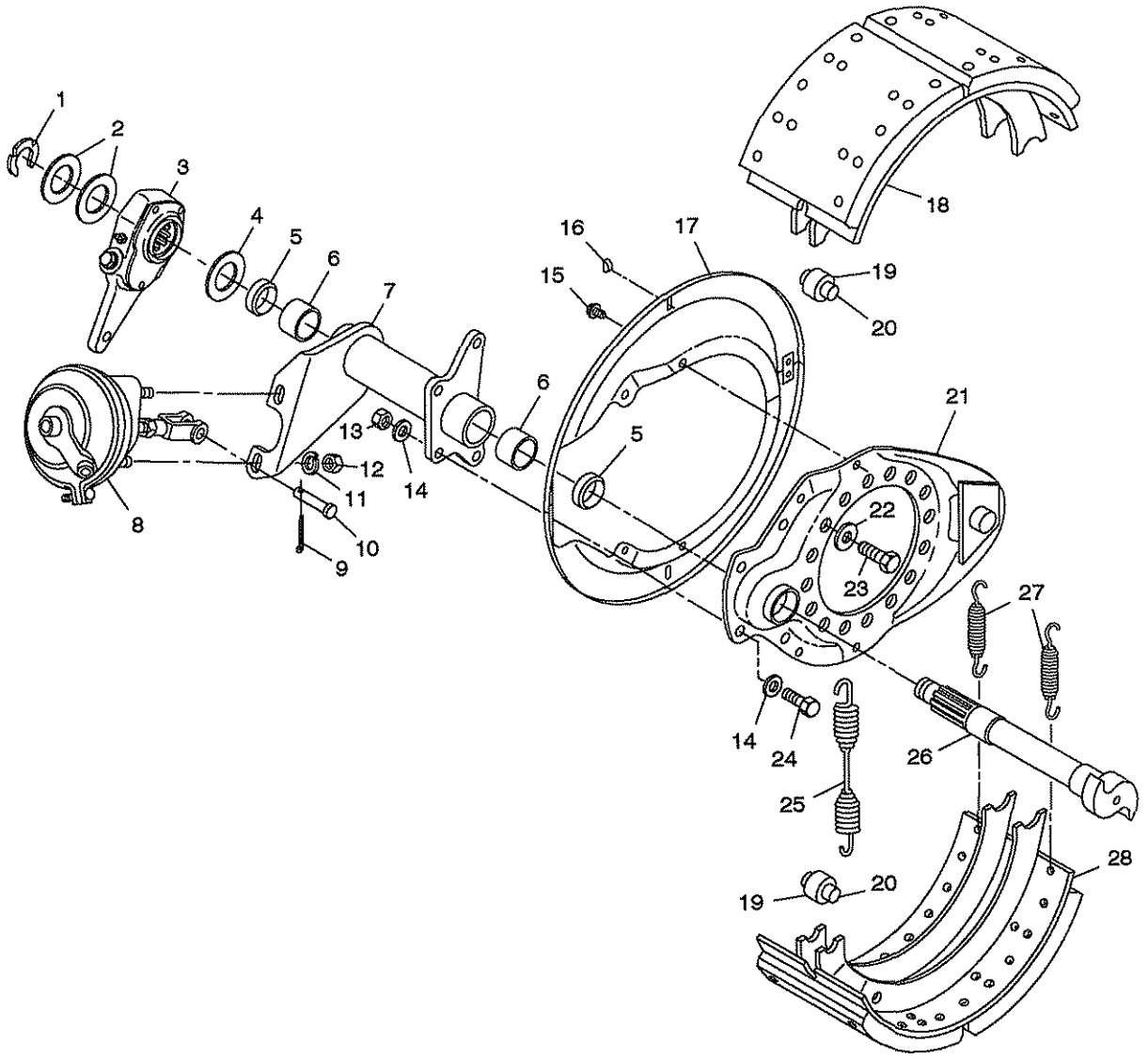
13. On 15-inch brakes, check the stabilizing screw for bends, looseness, or damaged threads.

WARNING: Wear eye protection when driving the screw into the camshaft bracket tube with a pin punch and hammer. Failure to wear eye protection could result in personal injury due to flying metal debris.

14. If necessary, replace the stabilizing screw.

    14.1 Remove the damaged screw by driving it into the camshaft bracket tube with a pin punch and hammer.

Brake Components Disassembly and Inspection, Cleaning, and Assembly



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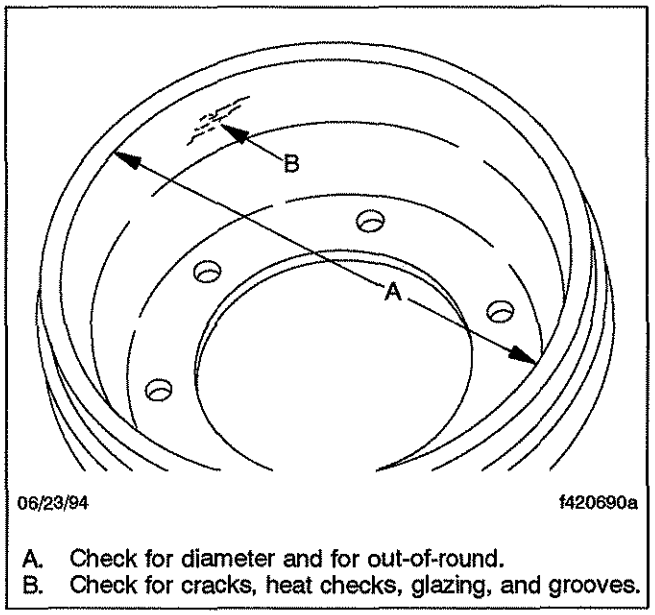
NOTE: Not all fasteners are shown.

1. Snap Ring
2. Camshaft Outer (Shim) Washers
3. Slack Adjuster
4. Camshaft Inner (Shim) Washer(s)
5. Spring-Loaded Lip Seal
6. Camshaft Bushing
7. Camshaft Mounting Bracket
8. Brake Chamber
9. Clevis Pin Cotter Pin
10. Brake Chamber Clevis Pin
11. Lockwasher
12. Stud Nut
13. Locknut
14. Washer
15. Dust Shield Capscrew
16. Dust Shield Plug
17. Dust Shield (Two-Piece)
18. Upper Brake Shoe and Lining
19. Cam Roller
20. Cam Roller Pin
21. Spider
22. Hardened Washer
23. Spider Mounting Bolt
24. Bracket Mounting Bolt
25. Return Spring
26. Camshaft
27. Retaining Springs
28. Lower Brake Shoe and Lining

Fig. 2, Rear Axle Brake

Brake Components Disassembly and Inspection, Cleaning, and Assembly



A. Check for diameter and for out-of-round.
B. Check for cracks, heat checks, glazing, and grooves.

Fig. 3, Check the Drum

14.2 Aligning the curvature of the screw head **(Fig. 4)** with the curvature of the bracket tube, install the new screw.

14.3 Install the spacer, lockwasher, and nut. Tighten the nut 23 to 27 lbf·ft (31 to 37 N·m) to draw the screw serrations uniformly through the camshaft bracket tube wall.

14.4 Remove the nut and washer before assembling the bracket on the spider.

15. Using a suitable piloted driver, install the new bushing or seal.

On 15-inch brakes, install the new bushing to a depth of 3/8 inch (9.5 mm) from each end of the bracket tube. **See Fig. 5.**

On 16-1/2 inch brakes, install the new bushing to a depth of 22/32 inch (17.5 mm) at the slack adjuster end of the bracket tube and to a depth of 9/32 inch (7.1 mm) at the cam head end of the bracket tube.

Install the grease seal flush with the end of the air chamber bracket tube.

IMPORTANT: Grease seals are installed in both the bracket and the brake spider so that the seal lip is facing toward the slack adjuster end of the bracket tube. **See Fig. 6.**

16. Remove the spider-to-axle attaching nuts, hardened washers, and bolts; remove the spider from the axle flange.

17. If equipped, remove the capscrews that attach the dust shield to the spider; remove the dust shield.

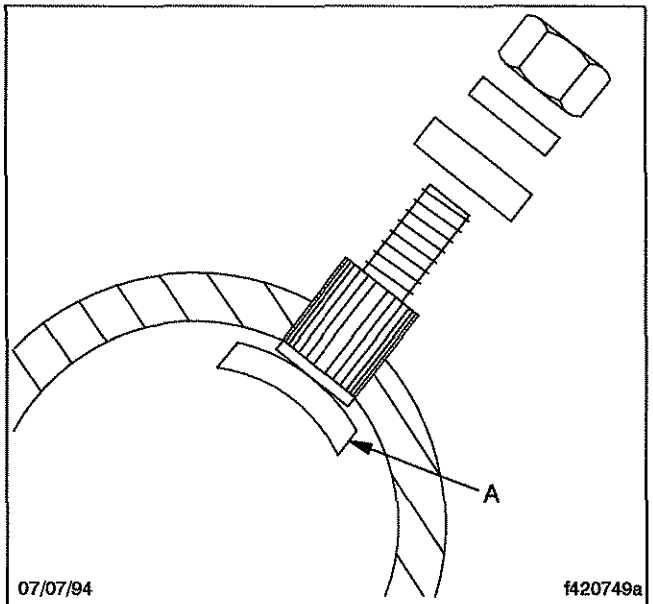
18. Inspect the spider and parts for damage; replace as needed.

18.1 Check for cracks at the bolt holes, cam area, and around the anchor pin. Replace if damaged.

18.2 Check the anchor pin **(Fig. 7).** If the pin is loose, or grooved more than 0.03 inch (0.8 mm) below the original surface, replace the spider assembly.

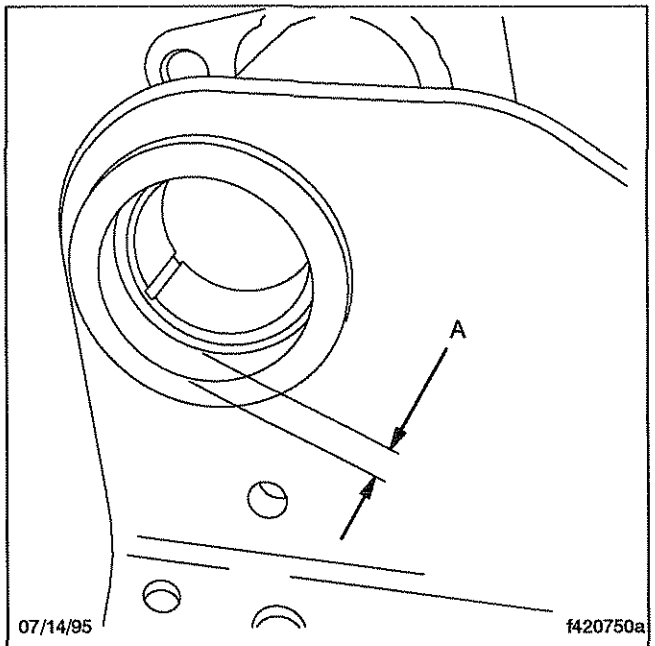
18.3 Check the anchor pin and brake spider bushings for deterioration. The inner surfaces must be smooth. If any surface is rough or abrasive, replace the part.

18.4 On 15-inch brakes, check the anchor pin reinforcement plate attaching nuts **(Fig. 8,**



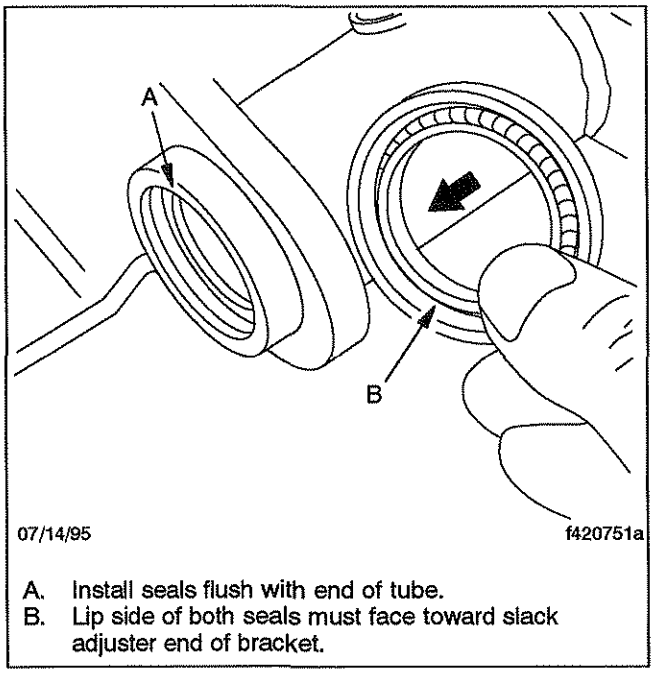
A. Align curvature of the head with the curvature of the of the camshaft bracket tube.

Fig. 4, Align the Screw Head



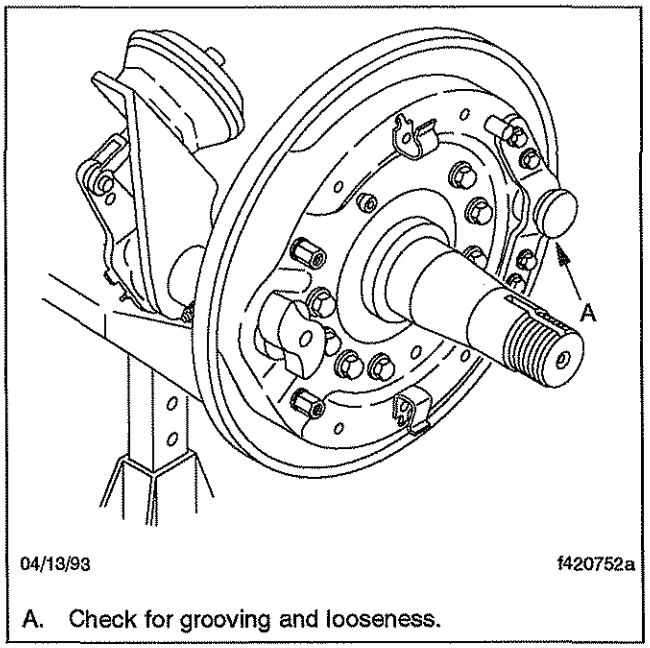
A. Recess the bushing per specifications.

Fig. 5, Install the New Bushing



A. Install seals flush with end of tube.
B. Lip side of both seals must face toward slack adjuster end of bracket.

Fig. 6, Install the Grease Seals



A. Check for grooving and looseness.

Fig. 7, Check the Anchor Pin

Ref. A) for tightness. If needed, tighten the nuts 35 to 40 lbf·ft (47 to 54 N·m).

Check the anchor pin retaining nut (**Fig. 8**, Ref. B) for tightness. If needed, tighten the nut 475 to 525 lbf·ft (644 to 712 N·m).

IMPORTANT: If the anchor pin turns while checking the retaining nut torque, replace the spider assembly. Eaton recommends replacement of the complete spi-

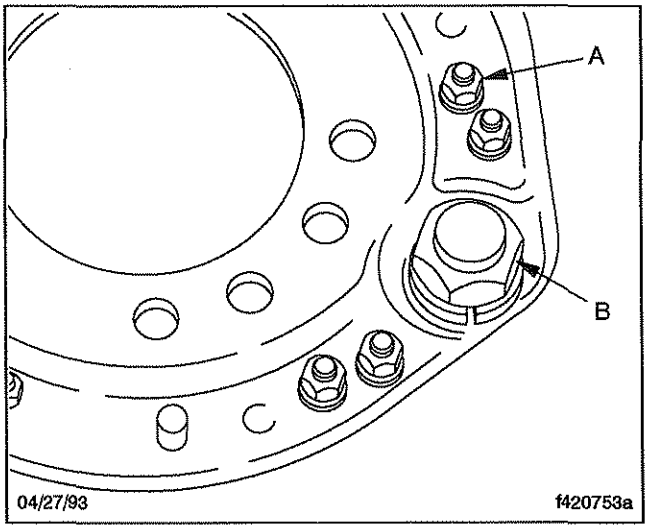


Fig. 8, Check the Anchor Pin Reinforcement Plate

Brake Components Disassembly and Inspection, Cleaning, and Assembly

der and pin assembly. Do not try to repair the spider assembly.

Cleaning

WARNING: Before starting the procedure below, read the information in Safety Precautions, 100. Failure to be aware of the dangers of brake lining dust exposure could result in serious and permanent health damage.

1. Wire brush all removed parts that have been exposed to mud, road dirt, and salt, including the exterior of the drum, spider, brake chamber bracket, and dust shields. If relining the shoes, thoroughly wire-brush the shoe tables, and paint with a rust inhibitive coating.

CAUTION: A thick layer of oxidation and dirt on the outside of a brake drum acts as an insulator and may hinder normal heat dissipation. Make sure oxidation and dirt are removed by wire brushing, or damage to brake parts could occur.

2. Using an industrial vacuum cleaner with a HEPA filter system, pick up excessive dust. Wipe the inside of the drums with a greaseless solvent to remove lining dust.

3. Thoroughly clean all remaining brake parts with a suitable shop solvent. Wipe dry with a clean, lint-free cloth, or use low-pressure filtered and compressed air.

Assembly (See Fig. 1 or Fig. 2)

WARNING: Before starting the procedure below, read the information in Safety Precautions, 100. Failure to be aware of the dangers of brake lining dust exposure could result in serious and permanent health damage.

1. Install the dust shield (if equipped).

   If installing a one-piece dust shield, position it against the spider, and install the capscrews. Tighten the capscrews 11 to 16 lbf·ft (15 to 22 N·m).

   If installing a two-piece dust shield, position both halves against the spider. Tighten the attaching screws finger-tight. Reposition the dust shield halves to allow a uniform space of 1/8 inch (3 mm) along the mating edges. **See Fig. 9.** Tighten the screws 11 to 16 lbf·ft (15 to 22 N·m).

NOTE: A designed interference fit at the upper dust shield-to-brake chamber bracket area **(Fig. 10)** may cause the need to slightly deform the upper dust shield by hand to allow the upper half to align properly with the lower half.

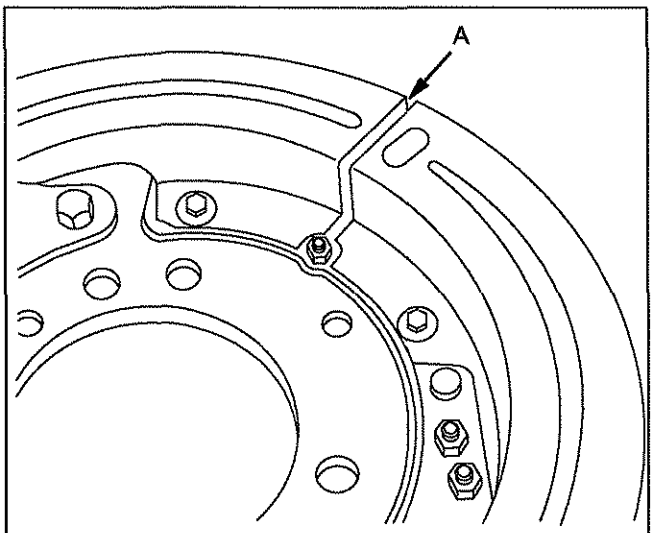
2. Install the spider.

   Place the spider on the axle flange. Using a hardened washer under the bolt head and the nut, install the mounting fasteners. Tighten the bolts in a cross pattern:

   - 1/2–13; 60 to 80 lbf·ft (81 to 108 N·m)
   - 5/8–11 (flanged hexhead capscrew); 160 to 200 lbf·ft (217 to 271 N·m)
   - 5/8–11 (hexhead capscrew); 130 to 160 lbf·ft (176 to 217 N·m)

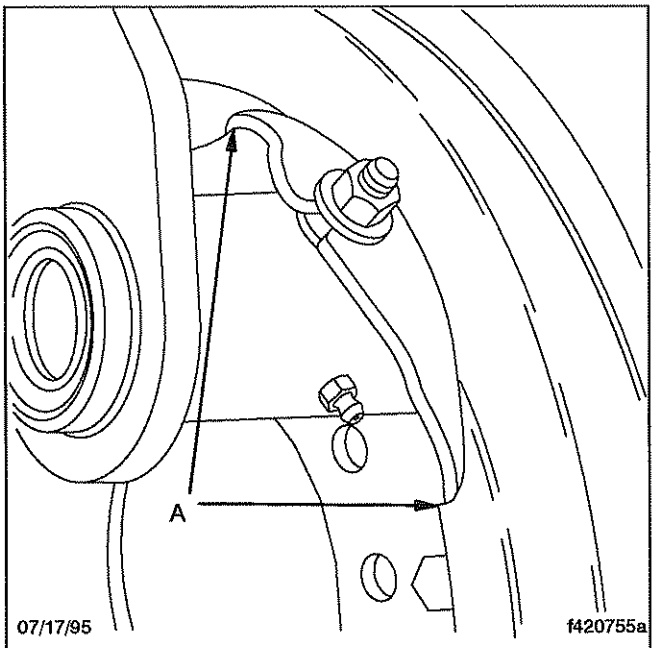
3. Install the brake chamber and bracket.

   3.1 Place the brake chamber on the mounting bracket with the chamber mounting studs through the bracket holes. Install the lockwashers and stud nuts. Tighten the



A. Ensure uniform 1/8" (3 mm) gap

Fig. 9, Position both halves of the Dust Shield against the Spider



A. Designed interference in these areas.

Fig. 10, Check the Fit at the Upper Dust Shield-to-Brake Chamber Bracket

nuts. Refer to the brake chamber mounting torque table in **Specifications, 400.**

3.2 Place the bracket against the spider, and install the lockwashers and barrel nuts. Tighten the nuts 55 to 65 lbf·ft (75 to 88 N·m).

3.3 Install the washer, lockwasher, and nut on the stabilizing screw (if equipped). Tighten the nut 23 to 27 lbf·ft (31 to 37 N·m).

4. Install the camshaft and parts in the spider; install the slack adjuster.

4.1 Apply a thin film of chassis grease on the inside of the camshaft bushings and journals. Don't grease the camshaft head area.

4.2 Apply a thin film of rust preventive grease (Rockwell 0-637, or an equivalent) on the camshaft splines.

4.3 Carefully slip the camshaft into the spider and the mounting bracket tube.

IMPORTANT: If equipped with Extended Service brakes, a special washer is installed between the cam head and the spider. **See Fig. 11** for installation instructions.

4.4 Install the thick camshaft washer on the camshaft.

4.5 Install the slack adjuster on the camshaft, with the adjuster nut on the side opposite of the brake chamber.

4.6 Install the thin outer washer(s) and snap ring.

5. Use a dial indicator to measure the end play of the camshaft. There should be no more than 0.005 to 0.045 inch (0.1 to 1.1 mm) movement. Add outer washers as needed to correct.

6. Pressure lube the camshaft bracket bushings.

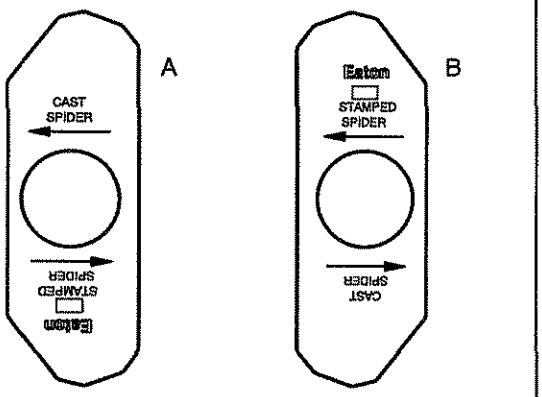
Pump multipurpose chassis grease (NLGI grade 1 or 2) into the chamber bracket until it appears at the slack adjuster end of the bracket. Use care that no grease enters the drum cavity. If grease leaks out under the cam head, the camshaft grease seal is worn or damaged, or is installed backwards.

NOTE: The use of meter-type fittings, having a maximum 40 psi (276 kPa) pressure relief at shutoff, is recommended.

7. Adjust the brakes at the slack adjusters. For instructions, refer to **Subject 125.**

8. Install the brake shoes. For instructions, refer to **Subject 110.**

Brake Components Disassembly and Inspection, Cleaning, and Assembly



A. CAST SPIDER: Position cam head washer under cam head with "CAST SPIDER" arrow pointing toward center of spider.
B. STAMPED SPIDER: Position cam head washer under cam head with "STAMPED SPIDER" arrow pointing toward center of spider.

Fig. 11, Install the Special Washer

Description	Size	Torque lbf·ft (N·m)
Camshaft Support Bracket Mounting Nuts	1/2–13	55–65 (75–88)
Spider Mounting Flanged Nuts:		
Front or Rear Axle	1/2–13	60–80 (81–108)
Front or Rear Axle (Hexhead Capscrew)	5/8–11	130–160 (176–217)
Front or Rear Axle (Flanged Hexhead Capscrew)	5/8–11	160–200 (217–271)
Dust Shield Mounting Capscrews	—	11–16 (15–22)
Anchor Pin Reinforcement	—	35–40 (47–54)
Anchor Pin Retaining Nut	—	475–525 (644–712)

Table 1, Torque Values

Manufacturer	Chamber Size (square inches)	Torque lbf·ft (N·m)
Midland	12, 16	30 (41)
	20, 24, 30, 36	100 (136)
MGM	24, 30, 36	100–115 (136–156)

Table 2, Brake Chamber Mounting Torques

Trailer Brake Control Valve, Midland 42.15

Contents

Subject	Subject Number
General Description and Principles of Operation	050
Service Operations	
Trailer Brake Control Valve Safety Precautions	100
Trailer Brake Control Valve Operating and Leakage Test	110
Trailer Brake Control Valve Replacement	120

General Description

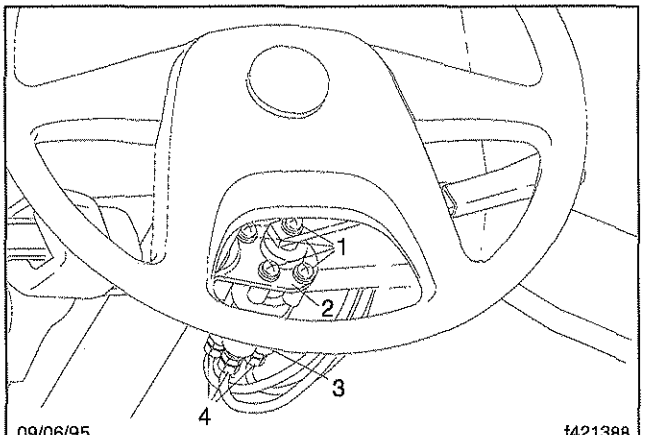
A hand-operated brake valve is included in some air brake systems for tractor units pulling trailers, in addition to the standard foot brake valve and related equipment. This valve allows the driver independent control of the trailer brakes, which can be useful when checking trailer brakes, or changing adjustable fifth wheel locations.

The brake valve is mounted on the right side of the steering column. See **Fig. 1.**

Principles of Operation (See Fig. 2)

When the valve's control handle is moved in a clockwise direction, the cam compresses the graduating spring, which in turn forces the piston to move down. As the piston moves down, compressed air from the supply port flows to the delivery port, applying the trailer brakes through the trailer service line.

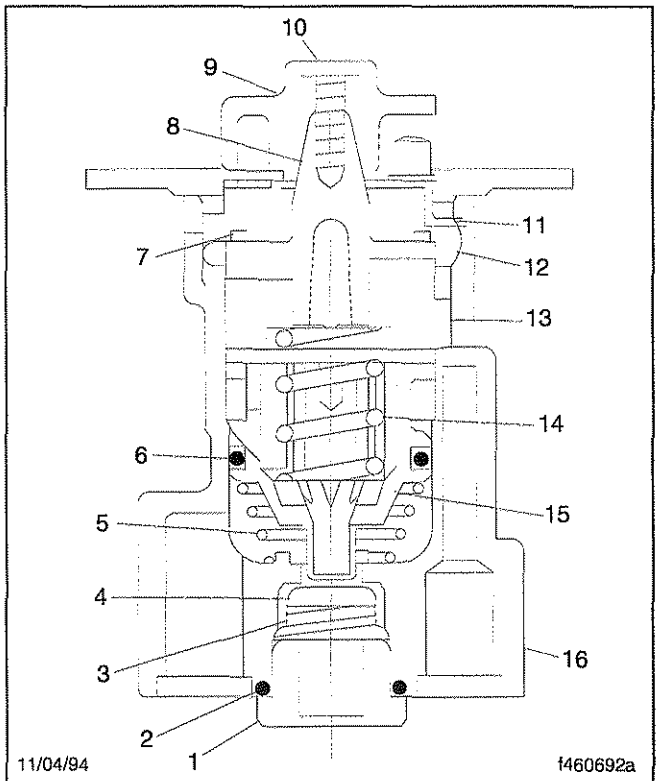
As air pressure builds in the trailer air system, the pressure under the piston will match the pressure of the compressed graduating spring. This moves the piston up enough to stop air flow through the valve, allowing air pressure in the trailer service brake system to remain constant.



1. Phillips Screws
2. Mounting Bracket
3. Trailer Brake Control Valve
4. Air Line Connections

Fig. 1, Trailer Brake Control Valve Installed on the Steering Column

When the control handle is moved counterclockwise, the cam moves up, releasing tension on the graduating spring. This allows the pressure below the piston to increase. The air pressure will then move the piston up and allow air in the service line to flow out of the exhaust port, releasing the trailer brakes.



1. End Cap
2. O-Ring
3. Valve Spring
4. Valve Disc Assembly
5. Piston Return Spring
6. Piston O-Ring
7. Bushing
8. Camshaft
9. Cover
10. Handle Screw
11. Lock
12. Bearing
13. Cam
14. Graduating Spring
15. Piston
16. Body

Fig. 2, Trailer Brake Control Valve (sectional view)

Trailer Brake Control Valve Safety Precautions

Safety Precautions

When working on or around air brake systems and components, observe the following precautions.

1. Chock the tires and stop the engine before working under a vehicle. Depleting air system pressure may allow the vehicle to roll. Keep hands away from brake chamber push rods and slack adjusters; they may apply as air system pressure drops.
2. Never connect or disconnect a hose or line containing compressed air—it may whip as air escapes. Never remove a component or pipe plug unless you are certain all system pressure has been released. Even when compressed air has been released at the reservoirs, residual air may still be trapped in the air lines.
3. Never exceed recommended air pressure, and always wear safety glasses when working with compressed air. Never look into air jets or direct them at anyone.
4. Never attempt to disassemble a component until you have read and understood the recommended procedures. Some components contain powerful springs, and injury can result if not properly disassembled. Use only proper tools and observe all precautions pertaining to the use of those tools.

WARNING: Don't use the hand brake valve to apply the trailer brakes for parking. It is not designed for this purpose. The air could bleed out of the trailer air tank allowing the vehicle to roll, which could cause personal injury, property damage, or damage to the vehicle.

Trailer Brake Control Valve Operating and Leakage Test

Test

1. Park the vehicle on a level surface and chock the tires.
2. Connect an accurate test gauge to the delivery port of the valve, or connect the gauge to the service hose coupling located behind the cab. When the gauge is connected to the service hose coupling, install a dummy hose coupling on the supply (emergency) hose coupling, and place the dash valve in the trailer charge position. When the valve control handle is moved to the fully applied position, the gauge should register full reservoir pressure.

NOTE: Midland valves are set to deliver full reservoir pressure. Intermediate positions should deliver proportional intermediate pressures. Upon manual release, the gauge should immediately register zero.

3. Locate the exhaust port or exhaust line and apply a soap solution.
4. With the valve in the released position, exhaust leakage should not exceed a 1-inch (2.5-cm) bubble in 5 seconds.

   With the valve fully applied, exhaust leakage should not exceed a 1-inch (2.5-cm) bubble in 5 seconds.
5. If the valve does not function properly or if leakage is excessive, replace the valve following the instructions in **Subject 120.**
6. Remove the chocks from the tires.

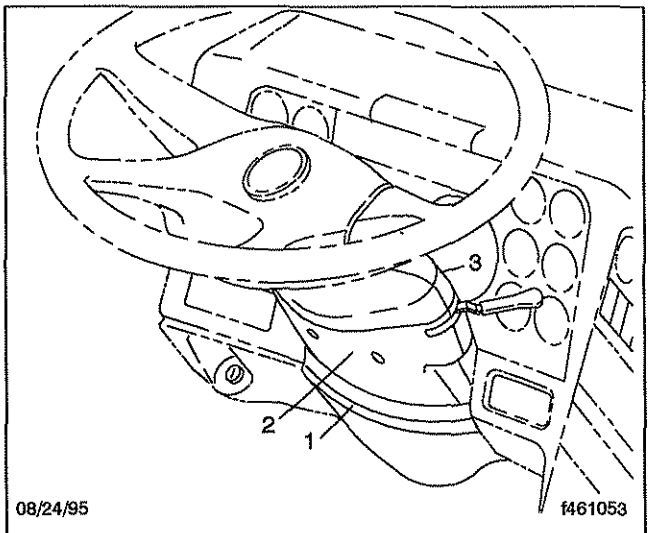
Trailer Brake Control Valve Replacement

WARNING: Before starting the procedure below, read the information in Safety Precautions, 100. Failure to be aware of the safety precautions could result in personal injury.

Replacement

1. Chock the tires or hold the vehicle on a level surface by means other than the air brakes.
2. Drain the air system.
3. Remove the lower steering column cover seal. **See Fig. 1.**

   Remove the steering column cover panels from the front and back of the column.
4. For later assembly reference, mark the three air lines connected to the valve. **See Fig. 2.** Disconnect the air lines from the valve.
5. Remove the two screws which hold the valve and the valve mounting bracket to the steering column. Remove the control valve (and the horn ground wire) and the mounting bracket from the steering column.
6. Remove the three screws that attach the valve to the mounting bracket.

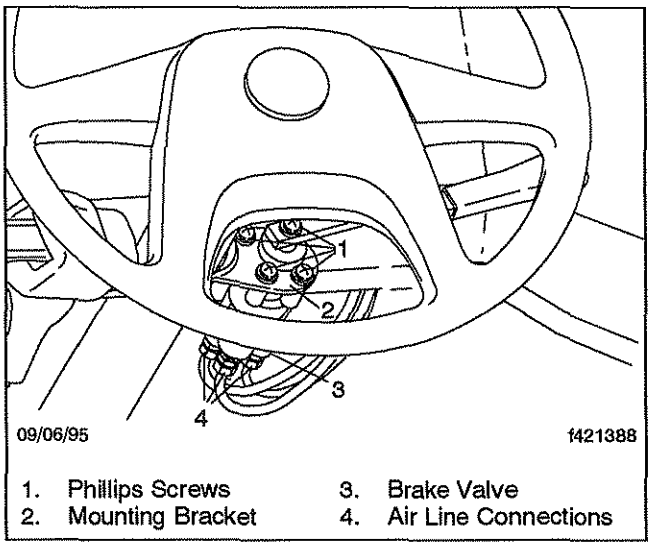


1. Lower Steering Column Cover Seal
2. Lower Steering Column Cover
3. Upper Steering Column Cover

Fig. 1, Steering Column Covers

7. If necessary, remove the valve control handle.
8. Install the mounting bracket on the new valve. Tighten the three screws firmly.
9. If removed, install the control handle. Tighten the handle mounting screw firmly.
10. Position the mounting bracket and the valve on the steering column. Insert the horn ground wire through the bracket. Install and firmly tighten the mounting screws.
11. Attach the air lines to the valve. Using two wrenches, tighten the lines firmly.
12. Do the operating and leakage test in **Subject 110.**
13. Install the lower steering column cover seal.

    Position the steering column cover panels on the front and back of the column. Both panels have fittings that should snap into the column. Install two fasteners and attach the two panels together.



1. Phillips Screws
2. Mounting Bracket
3. Brake Valve
4. Air Line Connections

Fig. 2, Trailer Brake Control Valve Mounting

Contents

Subject	Subject Number
General Information and Principles of Operation	050
Service Operations	
Safety Precautions	100
Operating and Leakage Tests	110
Drain Valve Removal and Installation	120
Drain Valve Disassembly, Cleaning and Inspection, and Assembly	130
Specifications	400

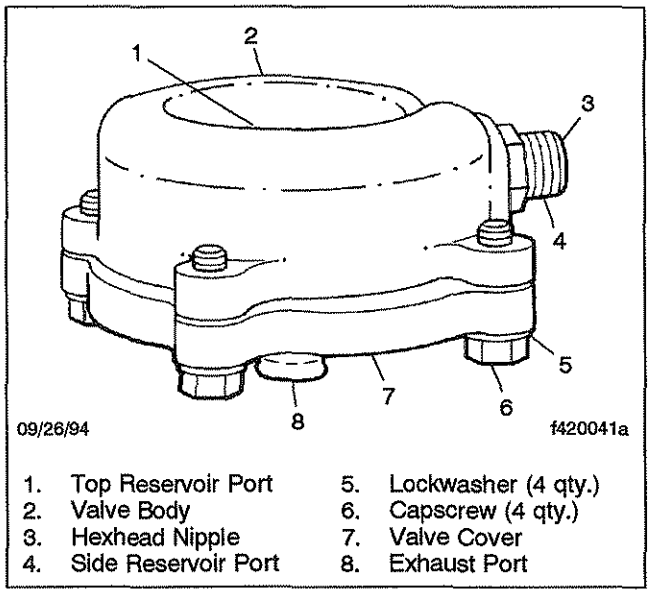
General Information

The DV–2 automatic reservoir drain valve **(Fig. 1)** automatically removes contaminants and water from the wet-air tank each time the brakes are applied. The drain valve is attached to a drain cock located on the bottom of either end of the wet-air tank. Since the brake application valve is protected by a check valve between the wet-and dry-air tanks, any leak or failure will not reduce the supply of air that is in the dry part of the system. If the leak is severe, it could prevent the continued resupply of air as it is used up when applying the brakes. A failed drain valve will allow moisture to build up in the wet tank which in turn could reach the dry tank, and then travel into the air brake system where it could cause brake failure. A leaking drain valve allows wet tank leakdown which in turn can cause premature wear on the air compressor during vehicle operation as the air compressor continues to run to maintain wet tank air pressure.

Principles of Operation

With no pressure in the system, the drain valve's inlet and exhaust valves are closed. **See Fig. 2.** Upon charging the system, a slight pressure opens the inlet valve which permits air and contaminants to collect in the sump. **See Fig. 3.** The inlet valve remains open when pressure is rising in the system until the air compressor cuts off, allowing the spring action of the valve guide in the sump cavity to close the inlet valve. The inlet valve and the exhaust valve are now both closed. **See Fig. 4.** When the wet tank pressure drops approximately 2 psi (14 kPa), the air pressure in the sump cavity opens the exhaust valve and allows moisture and contaminants to be ejected from the sump cavity until pressure in the sump cavity drops sufficiently to close the exhaust valve. **See Fig. 5.**

The length of time the exhaust valve remains open and the amount of moisture and contaminants ejected



1. Top Reservoir Port
2. Valve Body
3. Hexhead Nipple
4. Side Reservoir Port
5. Lockwasher (4 qty.)
6. Capscrew (4 qty.)
7. Valve Cover
8. Exhaust Port

Fig. 1, DV–2 Valve

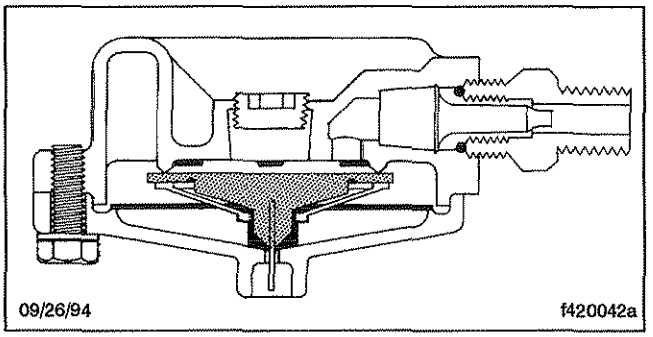


Fig. 2, No System Pressure

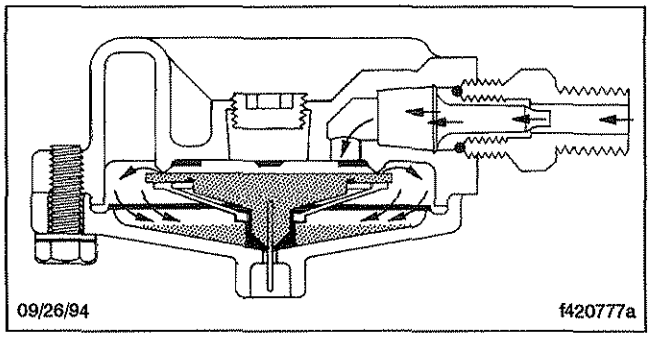


Fig. 3, Start of System Pressure Charging

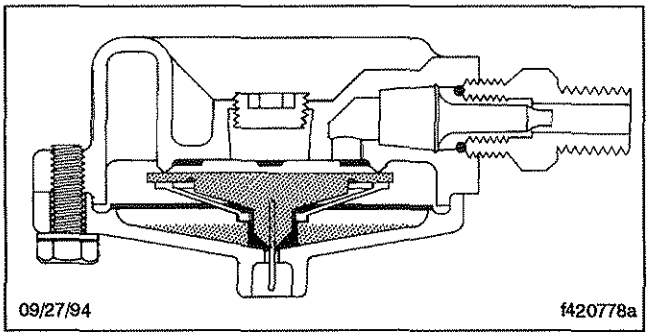


Fig. 4, System Pressure Rising

General Information and Principles of Operation

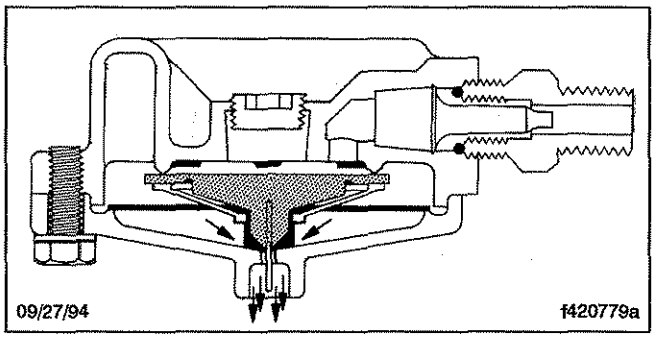


Fig. 5, Exhaust Cycle

depends upon the sump pressure and the wet tank pressure drop that occurs each time air is used from the system.

Safety Precautions

When working on or around air brake systems and components, observe the following precautions.

1. Always chock the vehicle's wheels and stop the engine when working under a vehicle. Depleting vehicle air system pressure may cause the vehicle to roll. Keep hands away from brake chamber push rods and slack adjusters; they may apply as air system pressure drops.
2. Never connect or disconnect a hose or line containing air pressure. It may whip as air escapes. Never remove a component or pipe plug unless you are certain all system pressure has been depleted.
3. Never exceed recommended air pressure and always wear safety glasses when working with air pressure. Never look into air jets or direct them at anyone.
4. Never attempt to disassemble a component until you have read and understood the recommended procedures. Some components contain powerful springs and injury can result if not properly disassembled. Use only proper tools and observe all precautions pertaining to use of those tools.

Operating Test

IMPORTANT: Before working on or around air brake systems and components, review **Safety Precautions, 100.**

Perform the following test after repairing or replacing the DV–2 valve to ensure that the valve is functioning properly.

With the system charged, apply the brakes several times. Each time the brakes are applied, an exhaust of air should occur from the exhaust port of the drain valve. If no air comes out, push the wire stem located inside the exhaust port. If no air comes out after pushing the wire stem, there may be a plugged filter in the adapter which should be replaced.

If the drain valve does not function properly, repair or replace it following instructions in this section.

Leakage Test

Perform the following test after repairing or replacing the DV–2 valve to ensure that the valve is functioning properly.

With the system charged and pressure stabilized in the system, there should be no leaks at the drain valve exhaust port. A constant slight exhaust of air at the drain valve exhaust port could be caused by excessive leakage in the air brake system.

If the drain valve is leaking excessively, repair or replace it following instructions in this section.

Removal

IMPORTANT: Before working on or around air brake systems and components, review **Safety Precautions, 100.**

1. Chock the tires, and drain the air system.
2. Remove the drain valve assembly from the end of the wet tank air reservoir.

Installation

IMPORTANT: Before working on or around air brake systems and components, review **Safety Precautions, 100.**

1. Using a cleaning solvent, thoroughly flush and clean the wet tank reservoir to avoid early fouling at the drain valve. Aerate the wet tank thoroughly if solvents were used during cleaning.
2. Install the drain valve assembly on the wet tank by tightening the hexagonal nipple until the drain valve is positioned so that the valve body is parallel to the bottom of the wet tank with the exhaust port facing straight down. Make sure that the exhaust port is clear of any air, electric, or fuel lines. Make sure the drain valve is attached tight enough to prevent leakage.
3. Close the drain cocks to the wet and dry air reservoirs. Start the vehicle engine to pressurize the air system.
4. Leak test the drain valve following the instructions in **Subject 110.**

Drain Valve Disassembly, Cleaning and Inspection, and Assembly

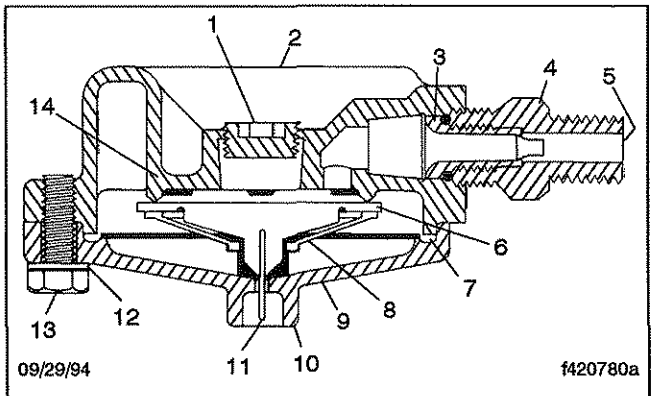
Disassembly (See Fig. 1)

IMPORTANT: Before working on or around air brake systems and components, review **Safety Precautions, 100.**

1. Remove the drain valve following the instructions in **Subject 120.**
2. Remove the four capscrews (Ref. 11) that hold the valve cover (Ref. 7) to the valve body (Ref. 1).
3. Remove the valve cover and sealing ring (Ref. 5).
4. Remove the valve guide (Ref. 6), and the inlet and exhaust valve (Ref. 4) from the valve body.
5. Remove the hexhead nipple (Ref. 3) from the valve body.

Cleaning and Inspection

IMPORTANT: Before working on or around air brake systems and components, review **Safety Precautions, 100.**



1. Top Reservoir Port
2. Valve Body
3. Filter Retainer
4. Hexhead Nipple
5. Side Reservoir Port
6. Inlet and Exhaust Valve
7. Valve Sealing Ring
8. Valve Guide
9. Valve Cover
10. Exhaust Port
11. Wire Stem
12. Lockwasher (4 qty.)
13. Capscrew (4 qty.)
14. Inlet Valve Seat

Fig. 1, DV–2 Valve, Cutaway View

WARNING: Use eye protection when using compressed air to clean or dry parts, as permanent harm to eyes could result from flying debris.

1. Wash all metal parts of the drain valve in an approved cleaning solvent. Dry the metal parts of the disassembled moisture ejection valve with compressed air.
2. Wipe all rubber parts clean with a clean cloth. Examine all rubber parts for wear cracks, tears, or other deterioration. If any rubber parts are worn, cracked, torn or otherwise deteriorated, replace them with new parts.
3. Examine all metal parts for wear, cracks, or other damage. If any metal parts are worn, cracked, or otherwise damaged, replace them with new parts.
4. Clean and examine the filter. If it will not clean completely, or is torn or damaged, replace it with a new filter.

CAUTION: Do not reassemble the drain valve with a dirty filter; to do so could result in failure of the drain valve in service.

Assembly (See Fig. 1)

IMPORTANT: Before working on or around air brake systems and components, review **Safety Precautions, 100.**

Before assembling the drain valve, apply a light film of grease on the inlet valve seat. See Ref. 12.

CAUTION: Do not apply oil to the inlet and exhaust valve.

1. Install the valve sealing ring (Ref. 5) into its groove in the valve cover.
2. Install the valve guide (Ref. 6) over the inlet and exhaust valve (Ref. 4).
3. Install the valve guide, and the inlet and exhaust valve as an assembly into the valve cover. The wire stem (Ref. 9) will project through the exhaust port (Ref. 8).
4. Install the valve body on the valve cover and install the lockwashers and capscrews. Tighten the capscrews 72 to 96 lbf·in (820 to 1080 N·cm).

Drain Valve Disassembly, Cleaning and Inspection, and Assembly

5. Install the hexhead nipple onto the valve body, and tighten it 48 to 72 lbf·in (540 to 820 N·cm).
6. Install the drain valve on the wet tank following the instructions in **Subject 120.**

Description	Torque lbf·in (N·cm)
Valve Cover Capscrews	72–96 (820–1080)
Hexhead Nipple (to valve body)	48-72 (540-820)

Table 1, Torque Values

Contents

Subject	Subject Number
General Information and Principles of Operation	050
Service Operations	
Power Spring Manual Compression and Reset	100
Service Brake Diaphragm Replacement	110
Parking Brake Diaphragm Replacement	115
Combination Service and Parking Brake Chamber Removal and Installation	120
Specifications	400

DANGER: Don't attempt to remove the factory-sealed clamp ring (see Fig. 1) for any purpose at any time. The parking/emergency brake section is not intended to be serviced. Serious injury or death may result from the sudden release of the power spring.

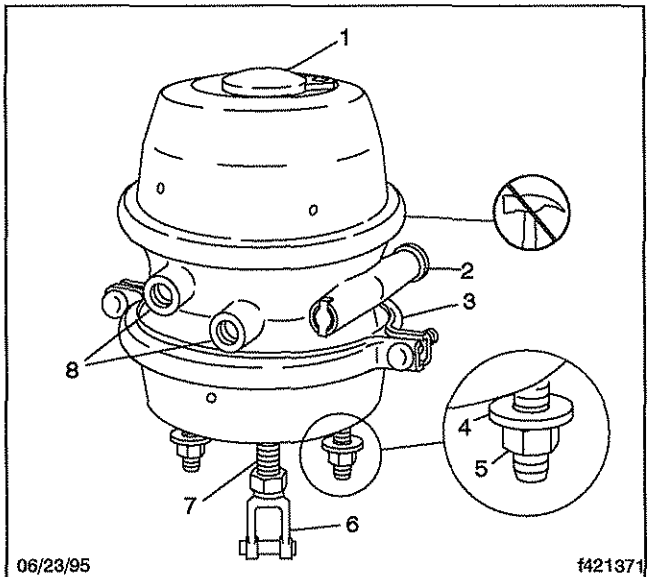
IMPORTANT: The parking/emergency brake section is factory sealed (no clamp ring) and is a *non-serviceable* unit.

General Information

Anchorlok brake chambers consist of a service brake section and a parking/emergency spring brake section. **See Fig. 1.** The service brake section is the smaller section near the clevis assembly.

In the service brake section, the service brake chamber contains a service return spring, piston rod assembly, and service brake diaphragm.

In the parking/emergency brake section, the adaptor and the parking brake chamber contain a return spring, a push rod assembly, a parking (spring) brake diaphragm, a pressure plate, a power spring, and a detachable release bolt.



1. Dust Plug
2. Release Bolt Storage Pocket
3. Service Brake Clamp Ring
4. Hardened Flatwasher
5. Prevailing Torque Locknut
6. Clevis Assembly
7. Piston Rod
8. Air Inlet Ports

Fig. 1, Brake Chamber

All Anchorlok brake chambers are mounted to the frame using prevailing torque locknuts and hardened flatwashers.

Periodic maintenance of the brake chambers is required. Also, whenever the service brake chamber is disassembled (*do not attempt to disassemble the parking brake chamber*), the parts should be inspected for damage. For maintenance schedules and procedures, and for inspection of brake chamber parts, refer to the vehicle maintenance manual.

Principles of Operation

SERVICE BRAKES

As the brake pedal is depressed, compressed air enters the service brake chamber through a port. Air pressure acts upon a diaphragm, which forces the piston rod toward the non-pressure chamber, applying a straight-line force to the slack adjuster, which converts it to a rotational force. This in turn rotates the camshaft and applies the brakes. **See Fig. 2.**

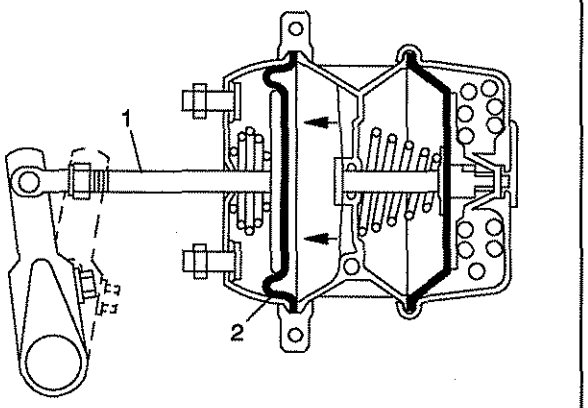
Then, when the brake pedal is released **(see Fig. 3),** air is exhausted from the service brake chamber, and the return spring allows the diaphragm, piston rod assembly, and slack adjuster to return to their normal positions, releasing the brakes.

PARKING/EMERGENCY BRAKES

During parking brake release, compressed air enters the parking/emergency brake chamber below the diaphragm, forcing the diaphragm against the pressure plate to compress the power spring and release the parking/emergency brake. **See Fig. 4.** During parking brake application, a control valve in the cab exhausts air from the parking/emergency brake chamber. This allows the power spring to extend and apply the brakes. **See Fig. 5.**

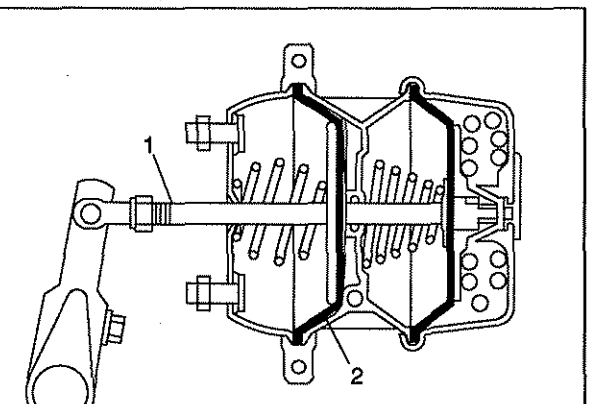
Emergency brake application begins when air pressure in the service brake reservoir drops below about 80 to 85 psi (550 to 585 kPa). Maximum parking brake force is applied when air is entirely exhausted fom the parking/emergency brake chamber.

General Information and Principles of Operation



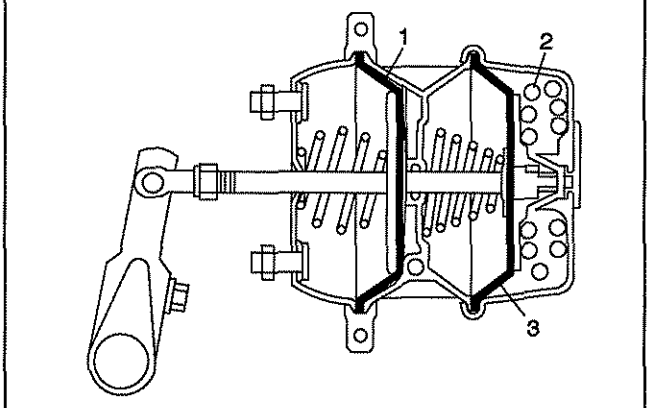
1. Piston Rod Assembly
2. Service Brake Diaphragm

Fig. 2, Service Brakes Applied



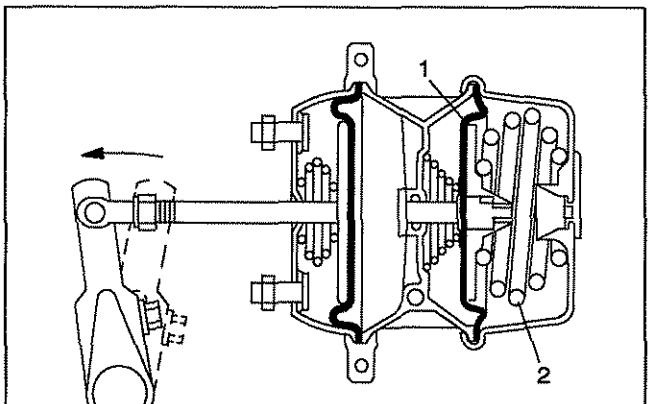
1. Piston Rod Assembly
2. Service Brake Diaphragm

Fig. 3, Service Brakes Released



1. Service Brake Diaphragm
2. Power Spring
3. Parking/Emergency Brake Diaphragm

Fig. 4, Parking/Emergency Brakes Released



1. Parking/Emergency Brake Diaphragm
2. Power Spring

Fig. 5, Parking/Emergency Brakes Applied

Power Spring Manual Compression and Reset

⚠ DANGER

Don't attempt to remove the factory-sealed clamp ring (see Fig. 1) for any purpose at any time. The parking/emergency brake section is not intended to be serviced. Serious injury or death may result from the sudden release of the power spring.

Manual Compression (Parking Brake Release)

1. Chock the tires.
2. Remove the dust plug from the center-hole in the head of the chamber. See **Fig. 2**.

⚠ DANGER

Do not attempt to cage the power spring if the parking brake chamber is damaged severely enough to lose its structural integrity. If the power spring were to break loose, it could result in death, severe personal injury, or property damage.

A DAMAGED PARKING BRAKE CHAMBER IS EXTREMELY DANGEROUS! Only qualified service personnel should attempt to remove and disarm a damaged chamber.

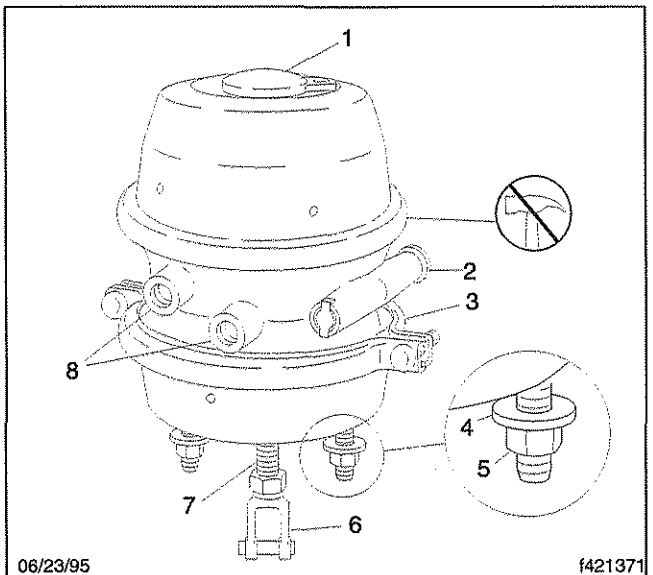
3. Using a torch, burn off the piston rod in the space between the clevis and the base of the service chamber. Remove the chamber carefully from its bracket, and disarm it inside a suitable container. For disarming procedures, consult the Anchorlok installation instructions.
4. Manually release the parking brake (cage the power spring).

   4.1 Using a hand wrench, (*don't use an impact wrench*), unscrew the release nut, and remove the nut, flatwasher, and release bolt from the storage pocket on the side of the chamber. See **Fig. 3**.

   IMPORTANT: If these parts are not stored on the chamber, they must be otherwise obtained or purchased; the parking brake cannot be manually released without them.

   4.2 Insert the release bolt into the center-hole in the chamber head (see **Fig. 4**). Continue to insert the bolt until it bottoms out into the hole in the pressure plate inside the chamber.

   IMPORTANT: If you are not absolutely sure that the formed end of the bolt has engaged the



1. Dust Plug
2. Release Bolt Storage Pocket
3. Service Brake Clamp Ring
4. Hardened Flatwasher
5. Prevailing Torque Locknut
6. Clevis Assembly
7. Piston Rod
8. Air Inlet Ports

Fig. 1, Brake Chamber

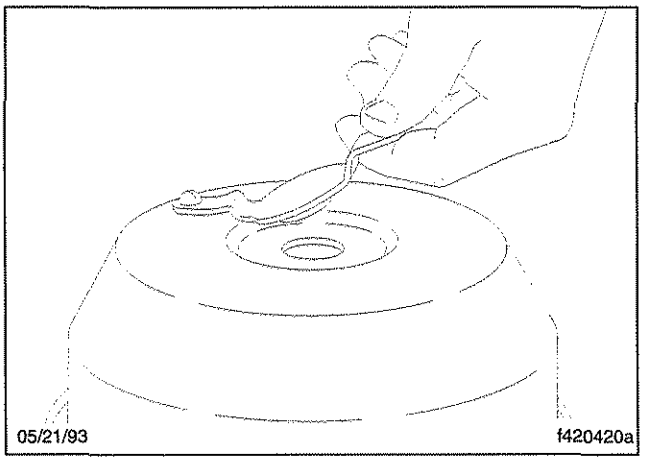


Fig. 2, Remove the Dust Plug

Power Spring Manual Compression and Reset

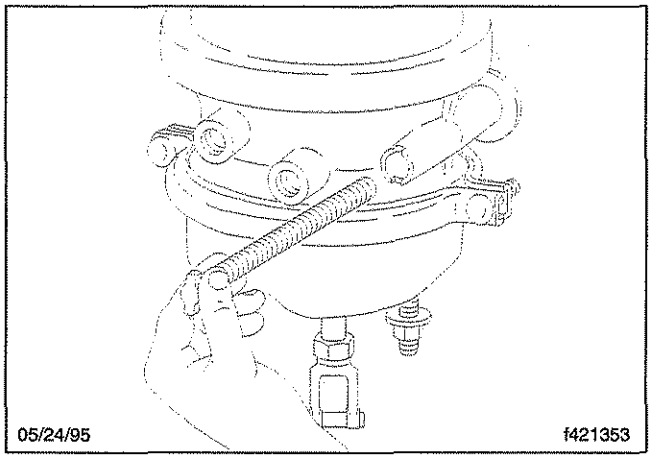


Fig. 3, Remove the Release Bolt

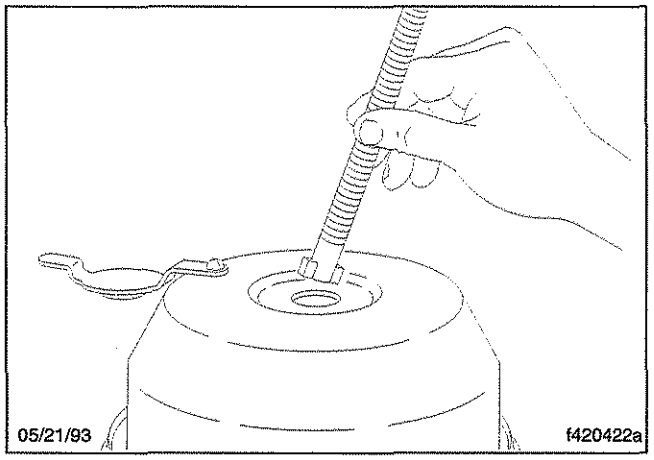


Fig. 4, Insert the Release Bolt

pressure plate correctly, repeat this step. Repeat it until you are absolutely sure.

4.3 Turn the release bolt one-quarter turn clockwise. Pull to seat the formed end of the release bolt in the recess of the pressure plate.

4.4 Holding the release bolt locked into the pressure plate, install the flatwasher and release nut on the end of the bolt, and turn down the nut against the flatwasher until it is finger-tight. See **Fig. 5**.

⚠ DANGER

Exhaust all air pressure before tightening the release nut more than finger-tight. Tightening this nut under pressure can damage the pressure plate and result in sudden release of the power spring, causing death or severe personal injury.

⚠ CAUTION

If equipped with S-cam, don't exceed 35 lbf·ft (47 N·m) torque on the release nut; if equipped with wedge brakes, don't exceed 20 lbf·ft (27 N·m) torque on the release nut.

4.5 Using a hand wrench (*don't use an impact wrench*), turn the release nut clockwise until the power spring is caged (see **Fig. 6**).

The bolt should extend above the nut at least 2.9 inches (74 mm) on 24-inch chambers, or 2.875 inches (73 mm) on 30-inch chambers.

IMPORTANT: Do not exceed these bolt lengths. If the bolt lengths can't be obtained without exceeding the recommended maximum torque values, replace the tandem brake chamber.

Manual Reset (Parking Brake Reset)

1. Uncage the power spring.

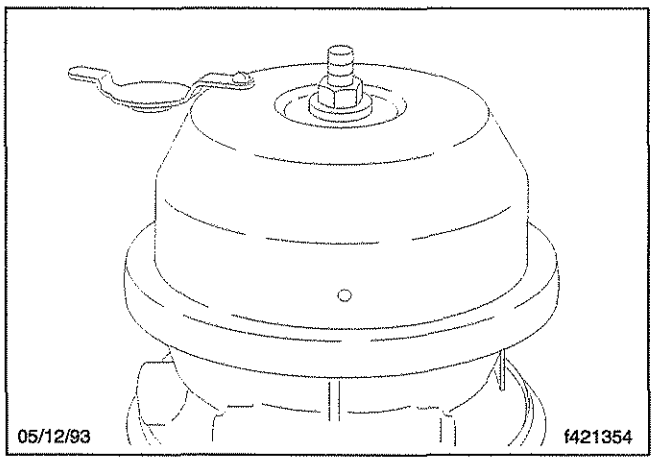
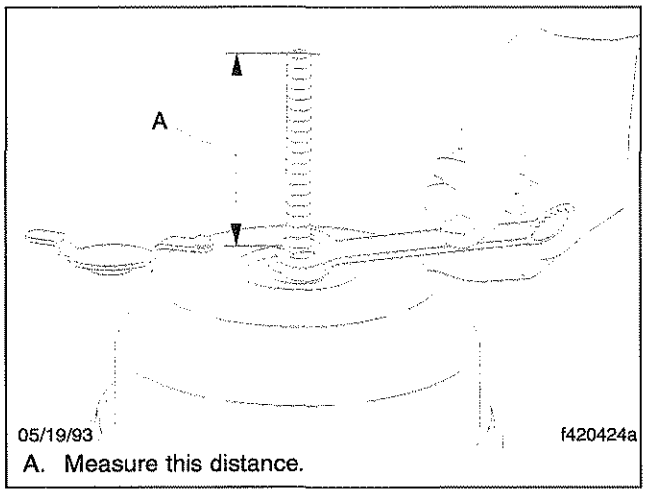


Fig. 5, Flatwasher and Release Nut Installed

Power Spring Manual Compression and Reset



A. Measure this distance.

Fig. 6, Turn the Release Nut

⚠ CAUTION

Don't use an impact wrench on this nut. Too much torque could damage the pressure plate and prevent manual release of the parking brake.

1.1 With air applied to the parking brake section (the parking brake control valve is in the "release" position), use a hand wrench to turn the release nut *counterclockwise* until the power spring extends back into the parking/emergency brake chamber.

NOTE: When the power spring is fully extended, force will no longer be felt on the release nut.

1.2 Remove the nut and flatwasher.

1.3 Turn the release bolt one-quarter turn counterclockwise and unlock the bolt from the receptacle in the pressure plate. Remove the release bolt from the center-hole of the chamber.

2. Using a hand wrench, (*don't use an impact wrench*), install the release bolt, flatwasher, and release nut in the storage pocket. Tighten the nut 60 to 96 lbf·in (680 to 1080 N·cm). See **Fig. 7**.

3. Snap the dust plug in place over the center-hole in the chamber head. See **Fig. 8**.

⚠ CAUTION

If a dust plug is missing or incorrectly installed, road dirt and debris can enter the brake chamber and cause the internal parts to deteriorate.

4. Check the plastic dust plug periodically, and replace it with a new one at once if damaged or missing. For intervals, refer to the vehicle maintenance manual.

5. Remove the chocks from the tires.

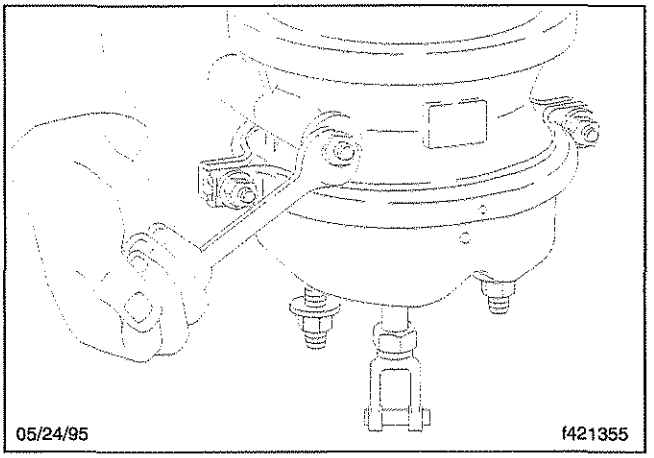


Fig. 7, Tighten the Release Nut

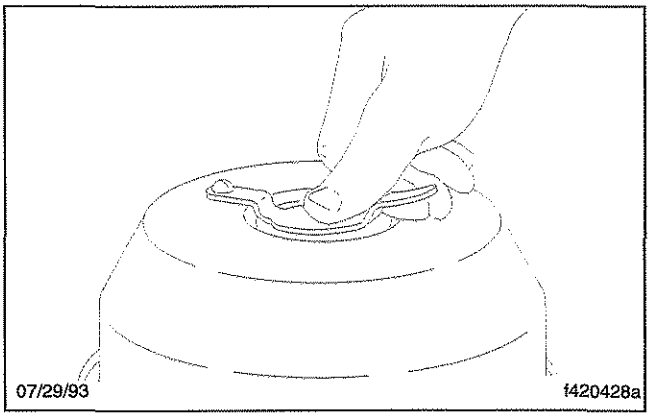


Fig. 8, Snap the Dust Plug in Place

DANGER: Don't attempt to remove the factory-sealed clamp ring (see Fig. 1) for any purpose at any time. The parking/emergency brake section is not intended to be serviced. Serious injury or death may result from the sudden release of the power spring.

Removal

1. To make removal and installation of the parking brake section easier (without removing the service brake chamber), lock off the service chamber piston rod.

   1.1 Apply the service brakes by actuating the driver's foot brake treadle valve.

   1.2 With the brakes applied, clamp a pair of locking-jaw pliers on the piston rod to lock the rod in place when the air pressure is released **(see Fig. 2).**

WARNING: Before caging (compressing) the power spring, chock the vehicle tires and read the warnings and instructions in this section (see Subject 100). When the power spring is caged, the vehicle may be without brakes, allowing it to roll out of control, possibly resulting in personal injury or property damage.

2. Manually release the parking brake (cage the power spring). For instructions, refer to **Subject 100.**

3. Mark the air lines for later reference. Then carefully disconnect them from the brake chamber.

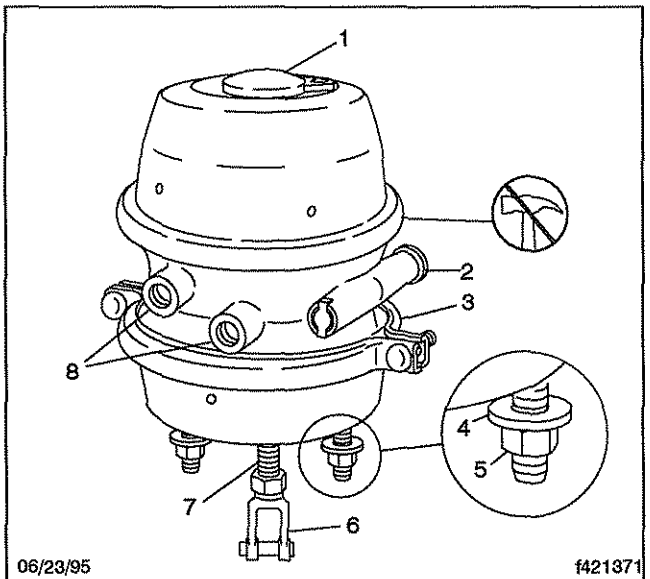
DANGER: Don't attempt to remove the factory-sealed clamp ring (see Fig. 1) for any purpose at any time. The parking/emergency brake section is not intended to be serviced. Serious injury or death may result from the sudden release of the power spring.

4. Remove the parking brake and adaptor from the service brake section.

   4.1 Using a hand wrench (*don't use an impact wrench*), remove the clamp nuts on the *service* brake clamp ring (*do not disassemble the parking brake section*).

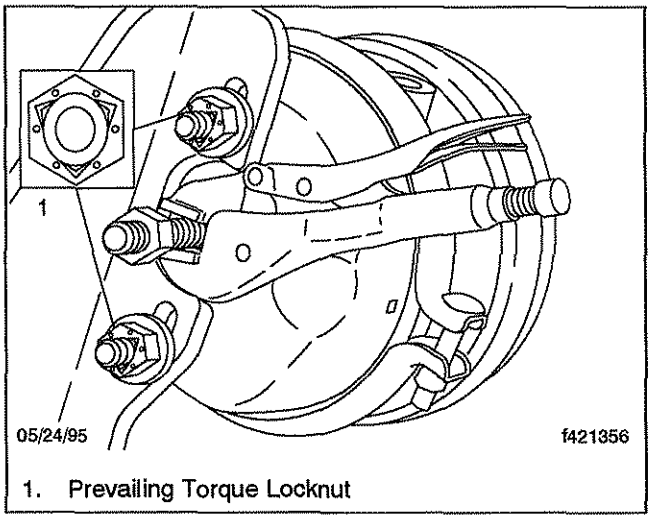
   4.2 While holding the parking brake section securely in place, remove the service clamp ring. Then remove the parking brake section from the service brake non-pressure chamber **(see Fig. 3).**

5. Remove the service brake diaphragm from the bottom of the parking brake section.



1. Dust Plug
2. Release Bolt Storage Pocket
3. Service Brake Clamp Ring
4. Hardened Flatwasher
5. Prevailing Torque Locknut
6. Clevis Assembly
7. Piston Rod
8. Air Inlet Ports

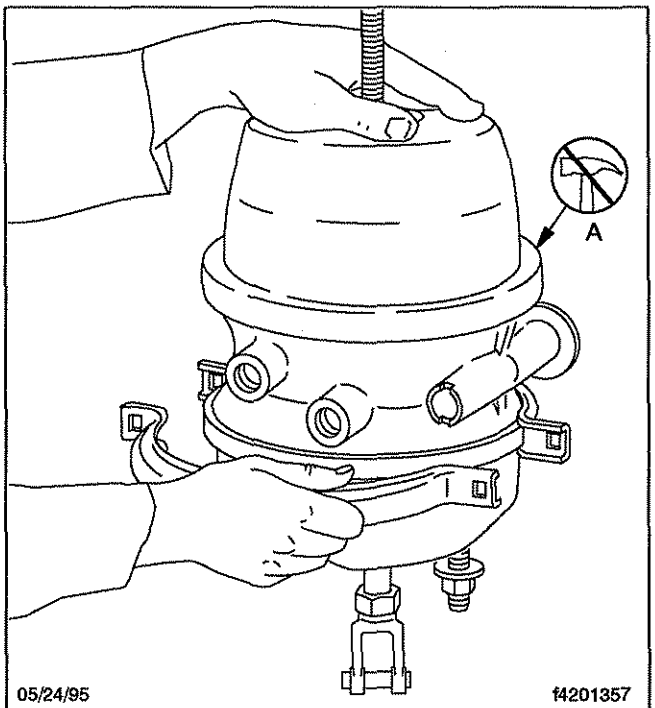
Fig. 1, Brake Chamber



1. Prevailing Torque Locknut

Fig. 2, Lock the Piston Rod in Place

Service Brake Diaphragm Replacement



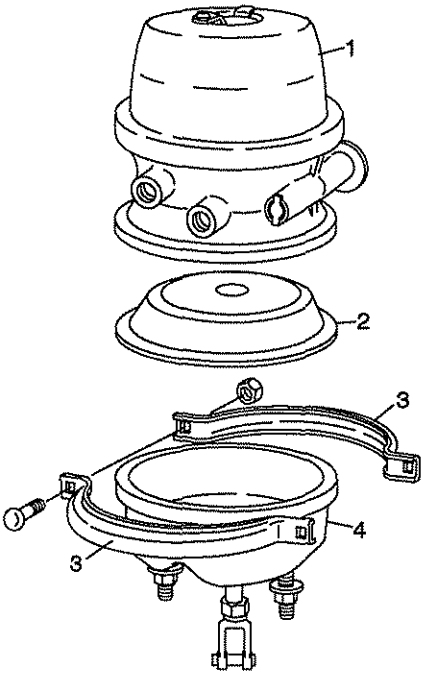
A. Do not remove the factory-sealed clamp ring.

Fig. 3, Remove the Service Clamp Ring

Installation

IMPORTANT: At this time, take the opportunity to inspect the parking/emergency brake section, and replace it if it shows signs of damage, corrosion, or rust. Follow the detailed inspection instructions in the vehicle maintenance manual.

1. Inspect all parts in the service (non-pressure) chamber. Replace any damaged or worn parts.
2. Place the new service brake diaphragm in the bottom recess of the adaptor **(see Fig. 4).**
3. Install the (new, if needed) parking/emergency brake section.
   - 3.1 If installing a new parking brake section, be sure it is the same size and make as the old one.
   - 3.2 Check that the release bolt is fully extended outward. For instructions, refer to **Subject 100.**
   - 3.3 Install the parking brake section on the service chamber so that all mating parts are aligned straight and the air lines are positioned to mate with the vehicle air supply lines.
4. Install the service brake clamp ring.
   - 4.1 With the service brake clamp ring in place, install the clamp bolts and nuts.
   - 4.2 Using a hand wrench (*don't use an impact wrench*), alternately tighten each clamp nut 18 to 25 lbf·ft (24 to 34 N·m) while constantly rechecking the alignment of mating parts.
   - 4.3 Lightly tap around the circumference of the service clamp ring with a rubber mallet to ensure full seating of the clamp. If realignment is needed, loosen the nuts again, and repeat this step.



1. Parking/Emergency Brake and Adaptor
2. Service Brake Diaphragm
3. Service Brake Clamp Ring
4. Service Brake (Non-Pressure) Chamber

Fig. 4, Brake Chamber Parts

5. Make sure the air hose fittings are free of grease, dirt, and other debris. Then, apply Loctite® 242 sealant, or an equivalent, to the fittings, and install, as referenced earlier. Using a hand wrench (*don't use an impact wrench*), tighten the fittings 25 lbf·ft (34 N·m).

6. Using the vehicle system air, charge the parking brake with full line pressure—at least 100 psi (690 kPa). Using only soapy water (*never any type of oil,* which could deteriorate rubber parts), check for air leaks at the air lines and fittings. If bubbles or leaks appear, tighten the fittings slightly, but not over 25 lbf·ft (34 N·m).

7. With the parking brake still charged with full line pressure, apply and hold the foot brake treadle valve down to charge the service brake chamber. Remove the locking-jaw pliers from the service piston rod so that the piston returns to a normal position in the chamber.

DANGER: Don't attempt to remove the factory-sealed clamp ring (see Fig. 1) for any purpose at any time. The parking/emergency brake section is not intended to be serviced. Serious injury or death may result from the sudden release of the power spring.

8. Test for air leaks around the circumference of the *service* brake clamp ring. If bubbles or leaks appear, release all air pressure from the chamber, then retighten the clamp nuts until leaks cease (*do not touch the parking brake section*). Anchorlok recommends 18 to 25 lbf·ft (24 to 34 N·m) torque on the clamp hexnuts.

9. With air pressure now exhausted from the service brake chamber, but held on the parking brake, reset the parking brakes by uncaging the power spring, and snap the dust plug in place. For instructions, refer to **Subject 100.**

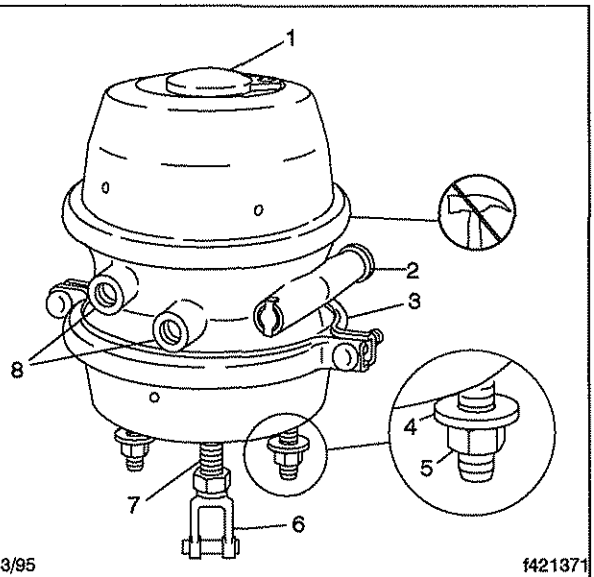
10. Adjust the brakes at the slack adjuster.

IMPORTANT: After replacing any brake chamber components, check the piston rod stroke and actuating alignment to ensure correct installation and foundation brake adjustment. No foundation brake adjustments, parking brake or service brake, can be made at the chamber and all "stroke" adjustments must be made at the slack adjuster. For instructions, refer to the applicable slack adjuster section in this group.

Replacement

DANGER: Don't attempt to remove the factory-sealed clamp ring (see Fig. 1) for any purpose at any time. The parking/emergency brake section is not intended to be serviced. Serious injury or death may result from the sudden release of the power spring.

IMPORTANT: The parking/emergency brake section can be replaced as a unit. For instructions, refer to **Subject 110.**



1. Dust Plug
2. Release Bolt Storage Pocket
3. Service Brake Clamp Ring
4. Hardened Flatwasher
5. Prevailing Torque Locknut
6. Clevis Assembly
7. Piston Rod
8. Air Inlet Ports

Fig. 1, Brake Chamber

Combination Service and Parking Brake Chamber Removal and Installation

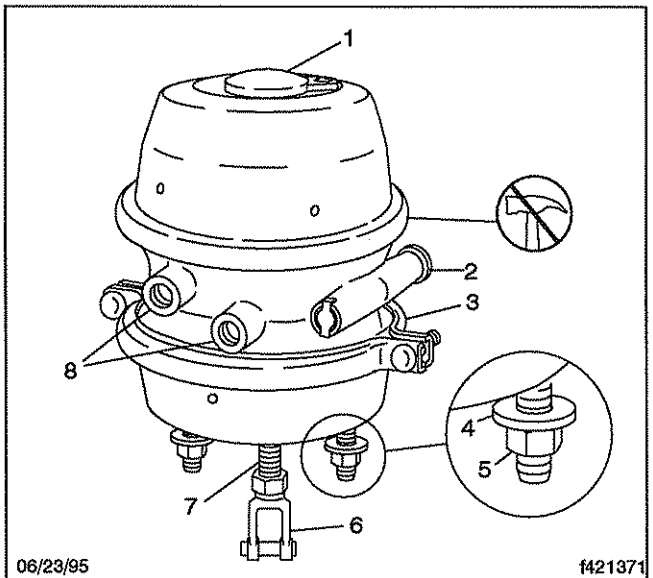
DANGER: Don't attempt to remove the factory-sealed clamp ring (see Fig. 1) for any purpose at any time. The parking/emergency brake section is not intended to be serviced. Serious injury or death may result from the sudden release of the power spring.

Removal

WARNING: Before caging (compressing) the power spring, chock the vehicle tires and read the warnings and instructions in this section (see Subject 100). When the power spring is caged, the vehicle may be without brakes, allowing it to roll out of control, possibly resulting in personal injury or property damage.

1. Manually release the parking brake (cage the power spring). For instructions, refer to **Subject 100.**

2. Mark the air lines for later reference. Then carefully disconnect them from the brake chambers.



1. Dust Plug
2. Release Bolt Storage Pocket
3. Service Brake Clamp Ring
4. Hardened Flatwasher
5. Prevailing Torque Locknut
6. Clevis Assembly
7. Piston Rod
8. Air Inlet Ports

Fig. 1, Brake Chamber

3. Remove the brake chamber from the vehicle.

   3.1 Remove the cotter pin(s) from the clevis pin(s), then remove the clevis pin(s) from the clevis. Disconnect the clevis from the slack adjuster.

   NOTE: Automatic slack adjusters have two clevis pins, one large and one small, each locked by a cotter pin.

   3.2 From each mounting stud, remove any installed nuts and washers. Then, cautiously remove the brake chamber from the mounting bracket.

Installation

1. If installing a new brake chamber unit, do the following steps:

   1.1 First, make sure the power spring is caged (release bolt fully extended outward). If not, go to **Subject 100** and do the applicable steps.

   1.2 Make sure that the piston rod is the same length as the rod on the old unit (measure the rods when *both* chambers are caged).

   1.3 Be sure the new chamber is the same size and make as the brake chamber installed on the other side of the axle.

   1.4 Remove the prevailing torque locknut and hardened flatwasher from each of the mounting studs on the chamber.

2. Clean the face of the mounting bracket, and position the chamber on the bracket. Pay close attention to positioning the chamber air inlet ports for correct alignment to the vehicle air lines.

WARNING: Tighten the mounting nuts with a hand wrench, not an impact wrench. An impact wrench could damage the mounting fasteners, reducing the force of the brakes. This could result in personal injury or property damage.

3. Install one hardened flatwasher and prevailing torque locknut on each mounting stud. Using a hand wrench (*don't use an impact wrench*), tighten the nuts 110 to 150 lbf·ft (149 to 203 N·m). Make sure that the hardened flatwasher is

Combination Service and Parking Brake Chamber Removal and Installation

installed between the locknut and the mounting bracket.

4. Check mating and alignment with the vehicle air lines.

   DANGER: Don't attempt to remove the factory-sealed clamp ring (see Fig. 1) for any purpose at any time. The parking/emergency brake section is not intended to be serviced. Serious injury or death may result from the sudden release of the power spring.

   4.1 Using a hand wrench (*don't use an impact wrench*), loosen the clamp nuts on the *service* clamp ring (*do not disassemble the parking brake section*).

   4.2 Reposition the air inlet ports, as needed, to mate with vehicle air supply lines.

   Alternately tighten each clamp nut in increments of 18 to 25 lbf·ft (24 to 34 N·m) while constantly rechecking the alignment of mating parts.

   If realignment is needed, loosen the nuts again, and repeat this substep.

   4.3 Lightly tap around the circumference of the service clamp ring to ensure full seating of the clamp.

5. Connect the slack adjuster. Refer to the applicable slack adjuster section in this group for installation instructions.

6. Inspect the piston rod to be sure it is working free, not binding, and is square with the chamber bottom from zero to full stroke. If there is misalignment, make corrections by loosening the locknuts and repositioning the chamber on the mounting bracket, or by shimming the slack adjuster to the right or left on the camshaft.

7. Make sure the air hose fittings are free of grease, dirt, and other debris. Then, apply Loctite® 242 sealant, or an equivalent, to the fittings, and install, as referenced earlier. Using a hand wrench (*don't use an impact wrench*), tighten the fittings 25 lbf·ft (34 N·m).

8. Using the vehicle system air, charge the parking brake with full line pressure, at least 100 psi (690 kPa). Using only soapy water (*never any type of oil,* which could deteriorate rubber parts), check for air leaks at the air lines and fittings. If bubbles or leaks appear, tighten the fittings slightly, but not over 25 lbf·ft (34 N·m).

DANGER: Don't attempt to remove the factory-sealed clamp ring (see Fig. 1) for any purpose at any time. The parking/emergency brake section is not intended to be serviced. Serious injury or death may result from the sudden release of the power spring.

IMPORTANT: If the service brake clamp ring was loosened to reposition the air inlet ports, apply air to the parking brake, and then apply and hold the foot brake treadle valve down to charge the service brake chamber. Now test for air leaks around the circumference of the *service* brake clamp ring. If bubbles or leaks appear, release all air pressure from the chamber, then retighten the clamp nuts until leaks cease (*do not touch the parking brake section*). Anchorlok recommends 18 to 25 lbf·ft (24 to 34 N·m) torque on the clamp hexnuts.

9. With air pressure now exhausted from the service brake chamber, but held on the parking brake, reset the parking brakes by uncaging the power spring, and snap the dust plug in place. For instructions, refer to **Subject 100.**

10. Adjust the brakes at the slack adjuster. For instructions, refer to the applicable slack adjuster section in this group.

IMPORTANT: After replacing any brake chamber, check the piston rod stroke and actuating alignment to ensure correct installation and foundation brake adjustment. No foundation brake adjustments, parking brake or service brake, can be made at the chamber and all "stroke" adjustments must be made at the slack adjuster. For instructions, refer to the applicable slack adjuster section in this group.

Specifications

Torque Values		
Description	**Torque**	
	lbf.ft (N.m)	**lbf.in (N.cm)**
Spring Brake Release Bolt Nut: (in storage pocket)	—	60 to 96 (680 to 1080)
(caged—on S-cam brakes)	35 (47)	—
(caged—on wedge brakes)	20 (27)	—
Service Brake Clamp Ring Nut	18 to 25 (24 to 34)	—
Brake Chamber Mounting Stud Locknut	110 to 150 (149 to 203)	—
Air Hose Fitting-to-Chamber	25 (34)	—

Table 1, Torque Values

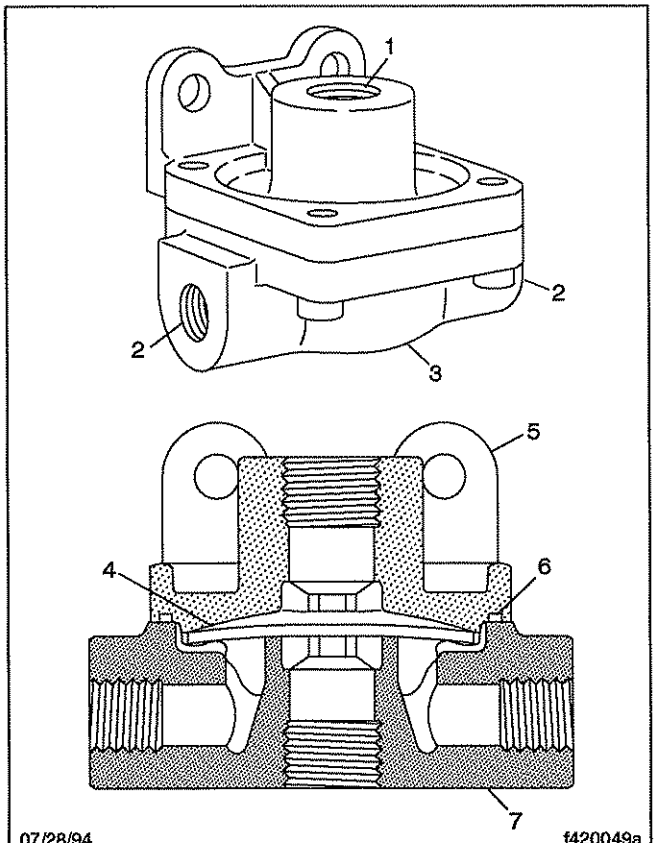
Contents

Subject	Subject Number
General Information and Principles of Operation	050
Service Operations	
Safety Precautions	100
QR–1 Quick Release Valve Operating and Leakage Tests	110
QR–1 Quick Release Valve Removal and Installation	120
QR–1 Quick Release Valve Disassembly, Cleaning and Inspection, and Assembly	130

General Information

The function of the QR–1 quick release valve **(Fig. 1)** is to speed up the release of air pressure from the brake chambers. If the front brake chambers are equipped with a QR–1 valve, and a foot brake application is released, the exhaust port of the quick release valve opens and the air from the front brake chambers is exhausted through the quick release valve. This accelerates the release of the front brakes.

When the front brake chambers are equipped with a QR–1 valve, it is located on the forward face of the crossmember just aft of the transmission. A delivery line from the foot valve is connected to the port on top of the QR–1 quick release valve; the two side ports are for brake chamber connections, and the exhaust port is located at the bottom of the valve.



1. Brake Valve Port
2. Brake Chamber Port
3. Exhaust Port
4. Diaphragm
5. Cover
6. O-Ring
7. Body

Fig. 1, QR–1 Valve and Cross Section

Principles of Operation (See Fig. 1)

When the foot brake control is applied, delivery air enters the brake valve port on the QR–1 quick release valve; the diaphragm moves down, sealing the exhaust port. At the same time, air pressure forces the edges of the diaphragm down, allowing air to flow out the brake chamber ports, filling the chambers and applying the front axle brakes.

When the brake chamber air pressure (beneath the diaphragm) equals the air pressure being delivered by the foot valve (above the diaphragm), the outer edge of the diaphragm will seal against the valve body seat. The exhaust port is still sealed by the center portion of the diaphragm. When the foot brake is released, the air above the diaphragm is released back through the foot brake valve exhaust, while the air beneath the diaphragm forces the diaphragm to rise, opening the exhaust port, and allowing air in the brake chambers to exhaust.

Safety Precautions

When working on or around air brake systems and components, observe the following precautions.

1. Chock the tires and stop the engine before working under a vehicle. Depleting air system pressure may cause the vehicle to roll. Keep hands away from brake chamber push rods and slack adjusters; they may apply as air system pressure drops.
2. Never connect or disconnect a hose or line containing compressed air. It may whip as air escapes. Never remove a component or pipe plug unless you are certain all system pressure has been released.
3. Never exceed recommended air pressure and always wear safety glasses when working with compressed air. Never look into air jets or direct them at anyone.
4. Never attempt to disassemble a component until you have read and understood recommended procedures. Some components contain powerful springs, and injury can result if not properly disassembled. Use only proper tools and observe all precautions pertaining to use of those tools.

Operating and Leakage Tests

The following tests should also be performed after repairing or replacing the QR–1 valve to ensure that it is functioning properly.

1. With the foot brake applied (pedal pushed in) perform the following checks.

   1.1 Coat the exhaust port with a soap solution; leakage of a one-inch bubble in three seconds is allowable.

   1.2 Coat the valve body and cover with a soap solution. No leakage is permitted between the valve body and cover.

2. If the valve does not function properly, or if leakage is excessive, repair or replace it following the instructions in this section.

QR–1 Quick Release Valve Removal and Installation

Removal (See Fig. 1)

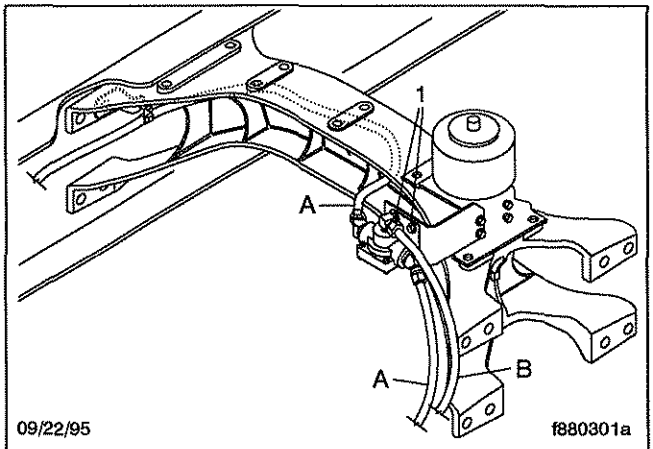
IMPORTANT: Before working on or around air brake systems and components, review **Safety Precautions, 100.**

1. Chock the tires or hold the vehicle by means other than air brakes.
2. Drain the air brake system by opening the reservoir drain cocks.
3. Mark and disconnect the air lines from the quick release valve.
4. Remove the mounting bolts and the valve.

Installation (See Fig. 1)

IMPORTANT: Before working on or around air brake systems and components, review **Safety Precautions, 100.**

1. Install the quick release valve with the exhaust port facing down. Securely tighten the mounting bolts.



A. To the brake chamber.
B. To the foot valve.

1. Mounting Fasteners

Fig. 1, QR–1 Valve Mounting (day cab mounting shown)

2. Connect the air lines to the quick release valve in the locations previously marked.
3. Perform the operating and leakage tests **in Subject 110.**

QR–1 Quick Release Valve Disassembly, Cleaning and Inspection, and Assembly

Disassembly

1. Remove the quick release valve from the vehicle following the instructions in **Subject 120.**
2. Remove the four screws holding the valve cover on the valve body.
3. If equipped, remove the spring and spring seat.
4. Remove the diaphragm.
5. Remove the cover O-ring.

Cleaning and Inspection

1. Clean all metal parts in mineral spirits. Wipe all rubber parts clean.
2. It is recommended that all rubber parts and any other part showing signs of wear or deterioration be replaced with genuine Bendix parts.

Assembly

1. If the quick release valve is not equipped with a spring, install the diaphragm into the valve body.

   If the quick release valve is equipped with a spring, position the spring in the valve body. Then, position the diaphragm over the spring seat.
2. Install the O-ring in the valve cover groove and install the valve cover. Tighten the screws 30 to 60 lbf·in (340 to 680 N·cm) evenly and securely.
3. Install the quick release valve, following the instructions **in Subject 120.**

Contents

Subject	Subject Number
General Information	050
Service Operations	
Safety Precautions	100
Relay Valve Operation and Leakage Tests	110
Relay Valve Removal and Installation	120
Relay Valve Disassembly, Cleaning and Inspection, and Assembly	130
Specifications	400

General Information

The R–12 (**Fig. 1**) and R–14 (**Fig. 2**) relay valves are control relay stations in the air brake system to speed the application and release of the brakes. Mounted at the rear of the vehicle, they are operated by remote control and give about the same amount of air pressure to the brake chambers as they receive from the service brake foot valve or other source.

The valves are piston operated and have an insert-type inlet and exhaust valve that can be serviced.

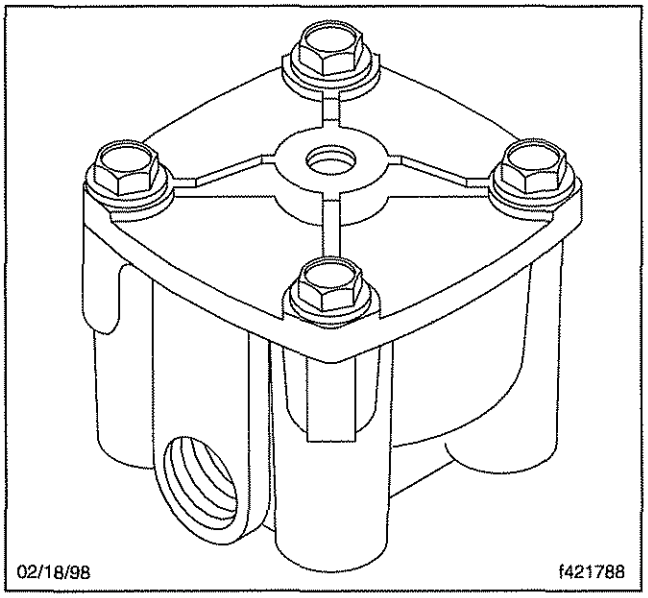


Fig. 1, R-12 Relay Valve

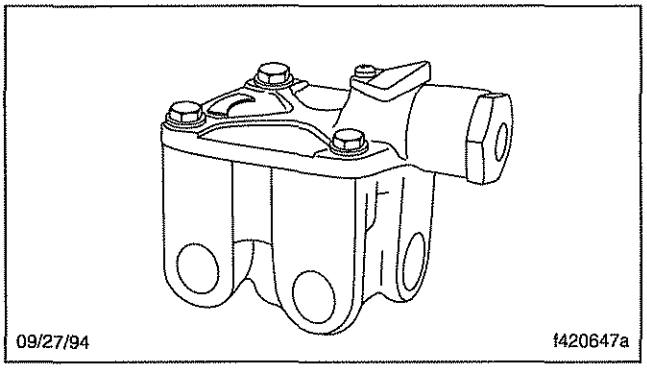


Fig. 2, R-14 Relay Valve

Principles of Operation (See Fig. 3 and Fig. 4)

APPLICATION

Air pressure delivered to the service port enters the small cavity above the piston and moves the piston down. The exhaust seat moves down with the piston and seats on the inner or exhaust portion of the inlet/exhaust valve, sealing off the exhaust passage. At the same time, the outer or inlet portion of the inlet/exhaust valve moves off its seat, permitting supply air to flow from the reservoir, past the open inlet valve and into the brake chambers.

BALANCE

The air pressure being delivered by the open inlet valve also is effective on the bottom area of the relay piston. When air pressure beneath the piston equals the service air pressure above, the piston lifts slightly and the inlet spring returns the inlet valve to its closed position. The exhaust remains closed as the service line pressure balances the delivery pressure. As delivered air pressure is changed, the valve reacts to the change, holding the brake application at the level.

EXHAUST OR RELEASE

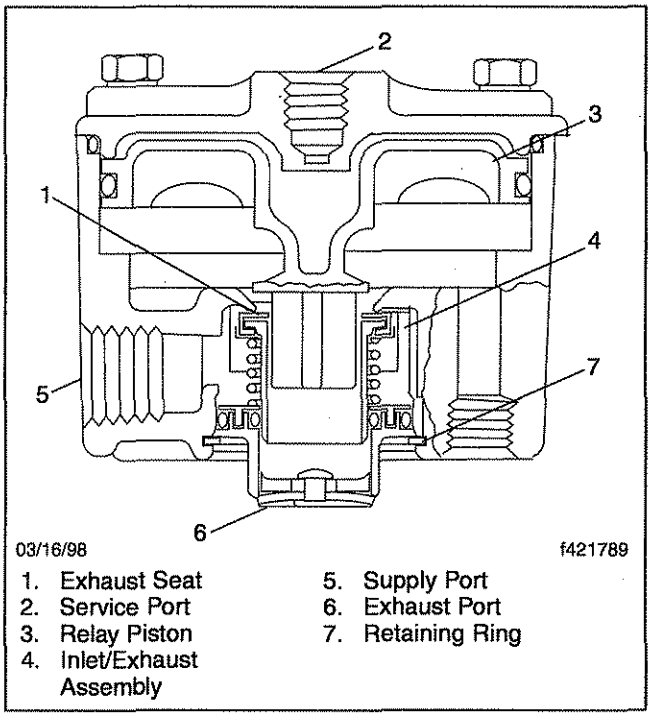
When air pressure is released from the service port and air pressure in the cavity above the relay piston is exhausted, air pressure beneath piston lifts the relay piston and the exhaust seat moves away from the exhaust valve, opening the exhaust passage. With the exhaust passage open, the air pressure in the brake chambers is then permitted to exhaust through the exhaust port, releasing the brakes.

ANTI-COMPOUNDING (SIMULTANEOUS SERVICE AND PARK APPLICATION), R–14 VALVE

An "anti-compound" feature allows the R–14 valve to be used as either a service or spring brake relay valve. An exhaust cover is installed that protects the 1/8-inch balance port when the R–14 anti-compound feature is not in use. See **Fig. 4**.

In applications where the R–14 is used to control spring brake chambers, the anti-compound feature may be utilized. To utilize, the exhaust cover of the

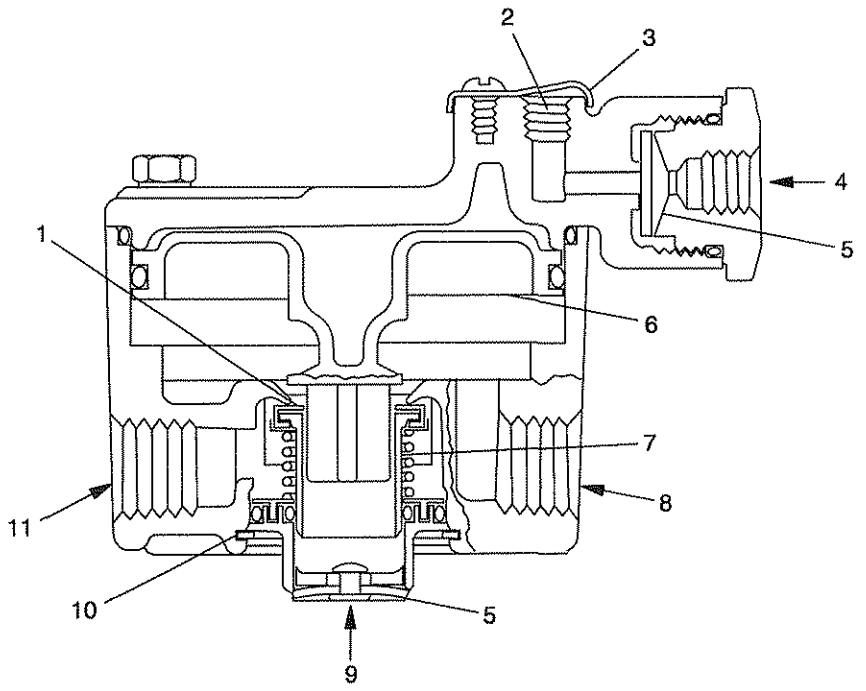
General Information



1. Exhaust Seat
2. Service Port
3. Relay Piston
4. Inlet/Exhaust Assembly
5. Supply Port
6. Exhaust Port
7. Retaining Ring

Fig. 3, R-12 Relay Valve (sectional view)

quick release portion of the R–14 is removed and a line is installed, which is connected to the delivery of the service brake valve or relay valve. With no air pressure at the service port of the R–14, the parking brakes apply. When a service brake application is made, air from the service brake valve enters the exhaust port of the quick release of the R–14 and moves the diaphragm, blocking the service port. Air then proceeds into the cavity above the relay piston, forces the piston down, closing the exhaust and opening the inlet to deliver air to the spring brake cavity.



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1. Exhaust Seat
2. Balance/Quick Exhaust Port (Anti-Compound)
3. Exhaust Cover
4. Service Port
5. Double-Check Diaphragm
6. Relay Piston
7. Inlet/Exhaust Valve
8. Delivery Port
9. Retaining Ring
10. Exhaust Port
11. Supply Port

Fig. 4, R-14 Relay Valve (sectional view)

Safety Precautions

When working on or around air brake systems and components, observe the following precautions:

A. Chock the tires and stop the engine before working under the vehicle. Releasing air from the system may cause the vehicle to roll. Keep hands away from brake chamber push rods and slack adjusters; they will apply as air pressure drops.

B. Never connect or disconnect a hose or line containing compressed air. It may whip as air escapes. Never remove a component or pipe plug unless you are certain all system pressure has been released.

C. Never exceed recommended air pressure and always wear safety glasses when working with compressed air. Never look into air jets or direct them at anyone.

D. Never attempt to disassemble a component until you have read and understood recommended procedures. Some components contain powerful springs and injury can result if not correctly disassembled. Use only correct tools and observe all precautions regarding use of those tools.

Relay Valve Operation and Leakage Tests

Operation Test

IMPORTANT: Before working on or around air brake systems and components, see **Safety Precautions, 100**.

1. Start the vehicle and build the brake system to cut-out pressure, about 130 psi (827 kPa).
2. Using a soap and water solution, check all air line fittings on the valve for leakage. If the fittings or air lines are leaking, replace the fittings. For instructions, see **Section 42.13**.
3. Make several service brake applications and check for prompt application and release of the brakes.
4. If brake response is slow, troubleshoot the brake system. For instructions, see **Section 42.10** in this group. If the valve is malfunctioning, repair or replace it.

Leakage Test

IMPORTANT: Before working on or around air brake systems and components, see **Safety Precautions, 100**.

1. Start the vehicle and build the brake system to cut-out pressure,about 130 psi (827 kPa).
2. Using a soap and water solution, check for inlet valve and O-ring leakage.
   - 2.1 Make this check with the service brakes released when the R–12 or R–14 is used to control the service brakes.
   - 2.2 Make the check with the spring brakes (parking brakes) applied when the R–14 is used to control the spring brakes.
3. While holding a full service brake application, apply a soap solution to the exhaust port. Leakage at the exhaust port should not exceed a 1-inch (2.5-cm) bubble in three seconds.

NOTE: If the anti-compound feature is in use, the line attached to the balance port must be disconnected to perform this test.

4. Coat the outside of the valve where the cover joins the body to check for O-ring leakage; no leakage is permitted.
5. If the R–14 is used to control the spring brakes, release the parking brake, apply a soap solution to the balance port. Leakage at the balance port should not exceed a 1-inch (2.5-cm) bubble in three seconds.

IMPORTANT: If the valves do not function as described in the above test, or if leakage is excessive, replace it. For instructions, see **Subject 120**.

Removal

IMPORTANT: Before working on or around air brake systems and components, see **Safety Precautions, 100.**

1. Chock the tires, and drain the air system.
2. Remove all air hoses from the valve. Cap the hoses and mark them for reassembly.
3. Remove the valve mounting bolts. Remove the valve.

Installation

IMPORTANT: Before working on or around air brake systems and components, see **Safety Precautions, 100.**

1. Attach the valve to the vehicle, using the bolts, washers, and nuts. Tighten the nuts 132 to 180 lbf·in (1500 to 2040 N·cm).
2. Remove the caps from the air lines, then depending on the type of air hose, do one of the following.

   Nylon Tubing: Connect the air line fittings to the valve ports, and tighten the nuts finger-tight. Using a wrench, tighten the nuts at least two turns, or until one thread shows on the fittings.

   Wire Braid Hoses: Connect the hose fittings to the valve ports, and hand-tighten the nuts. Using a wrench, tighten the nuts until resistance is felt. Tighten one-sixth turn more. Do not overtighten.
3. Close the air reservoir drain cocks. Start the vehicle engine to pressurize the air system.
4. Test the valve following the instructions in **Subject 110.**

Relay Valve Disassembly, Cleaning and Inspection, and Assembly

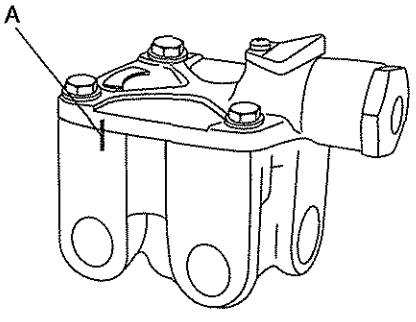
Disassembly

IMPORTANT: Before working on or around air brake systems and components, see **Safety Precautions, 100**.

1. Remove the valve from the vehicle. For instructions, see **Subject 120**.

NOTE: Prior to disassembly, draw an alignment mark across the valve cover and body, for reassembly alignment. See **Fig. 1**.

2. Disassemble the valve.
   - 2.1 Referring to **Fig. 2**, remove the four cover capscrews and integral lockwashers.
   - 2.2 Remove the valve cover and O-ring.
   - 2.3 Remove the relay piston, and the O-ring.
   - 2.4 While depressing the exhaust cover, remove the retainer ring; slowly remove the exhaust cover and the valve spring. Remove the O-rings from the exhaust cover.
   - 2.5 Remove the inlet/exhaust valve. Remove the valve retainer from the inlet/exhaust valve.
3. On the R–14 valves, remove the Phillips head screw and the exhaust cover. Then, remove the service port cap nut, the O-ring, and the diaphragm located inside the service port.



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A. Mark the valve housing for reassembly alignment.

Fig. 1, Valve Marked for Reassembly (R-14 valve shown)

Cleaning and Inspection

⚠ WARNING

Wear goggles when using compressed air to clean or dry parts, as permanent harm to eyes could result from flying debris.

IMPORTANT: Before working on or around air brake systems and components, see **Safety Precautions, 100**.

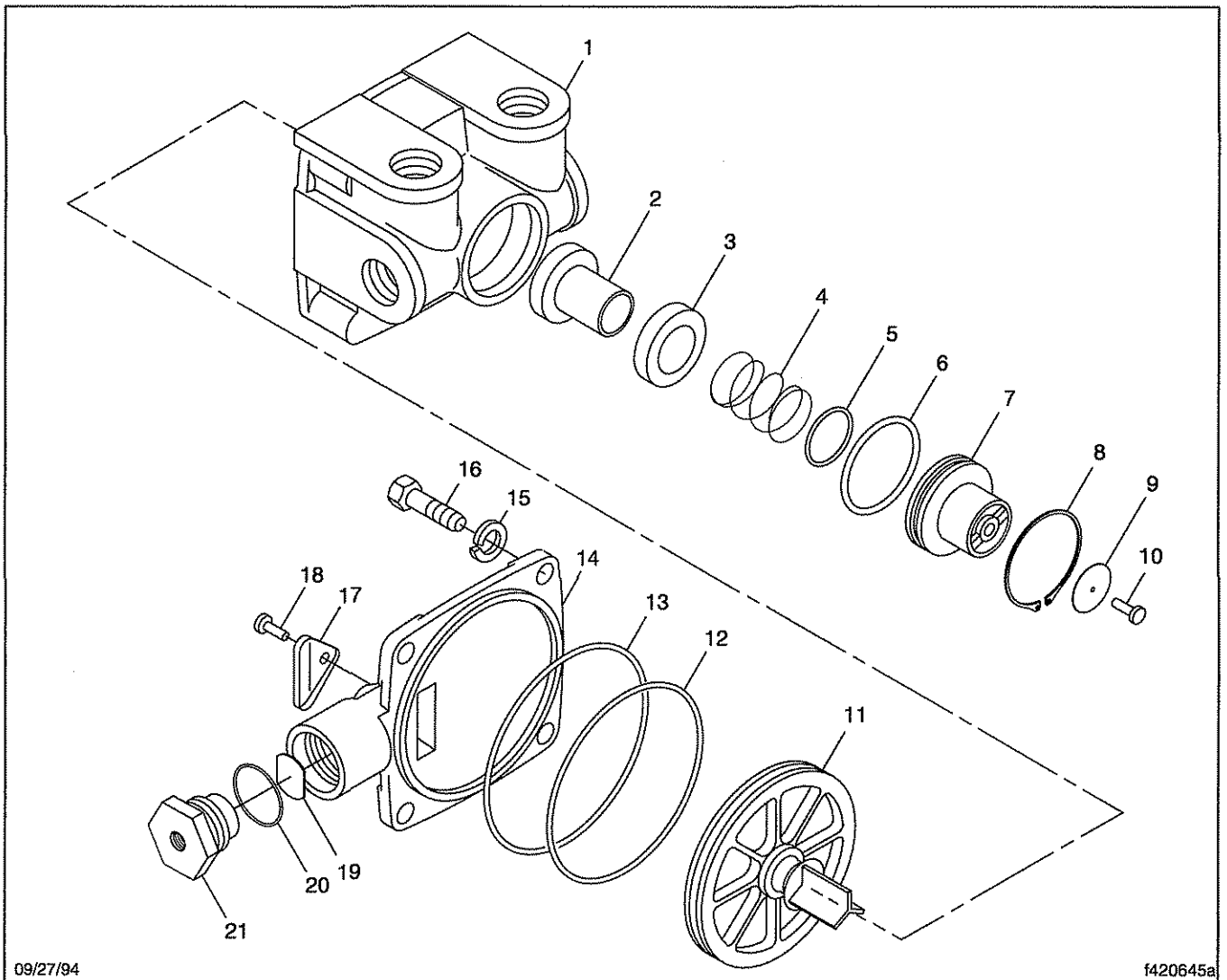
1. Wash all metal parts of the valve in cleaning solvent. Dry the metal parts of the disassembled valve with compressed air.
2. Wipe all rubber parts clean with a clean cloth. Examine all rubber parts for cracks, tears, or other deterioration. If any rubber parts are worn, cracked, torn or otherwise damaged, replace them with new parts.
3. Examine all metal parts for wear, cracks, or other damage. If any metal parts are worn, cracked or otherwise damaged, replace them with new parts.
4. Check the springs for distortion and corrosion. If the springs are distorted or corroded, replace them.
5. Inspect the exhaust seat of the quick release diaphragm in the R–14 cover and make sure all internal air passages in the area are open and clean and free of nicks and scratches.

Assembly

IMPORTANT: Before working on or around air brake systems and components, refer to **Safety Precautions, 100**.

1. Lubricate the O-rings and all sliding parts with Dow Corning 55-M pneumatic grease or equivalent. Assemble the valve (**Fig. 2**).
   - 1.1 Install the O-ring on the relay piston.
   - 1.2 Install the inner and outer O-rings on the exhaust cover.
   - 1.3 Install the O-ring on the valve cover.
   - 1.4 Install the relay piston in the body, taking care not to damage the piston O-ring.

Relay Valve Disassembly, Cleaning and Inspection, and Assembly



1. Body
2. Inlet/Exhaust Valve
3. Valve Retainer
4. Valve Spring
5. O-Ring
6. O-Ring
7. Exhaust Cover
8. Retainer Ring
9. Diaphragm
10. Rivet
11. Relay Piston
12. O-Ring
13. O-Ring
14. Valve Cover
15. Lockwasher (4 qty)
16. Capscrew (4 qty)
17. Exhaust Cover
18. Screw, Phillips #10–24
19. Diaphragm
20. O-Ring
21. Cap Nut

Fig. 2, R-14 Valve (R-12 similar)

1.5 Noting the reference mark made during disassembly, secure the valve cover with four capscrews and lockwashers. Torque the capscrews 80 to 120 lbf·in (900 to 1360 N·cm).

1.6 Install the valve retainer and spring on the inlet/exhaust valve assembly. Install the inlet/exhaust valve assembly in the body.

1.7 Install the exhaust cover. While depressing the exhaust cover, install the retaining ring,

making sure the retaining ring is completely seated in the groove.

1.8 On R–14 valves, place the diaphragm in the service port making sure it is positioned between the guide ribs. Install the service port cap nut and O-ring, then tighten to 150 lbf·in (1700 N·cm).

1.9 Position the exhaust cover, then install the Phillips head screw. Tighten the screw 25 lbf·in (280 N·cm).

2. Install the relay valve on the vehicle following the instructions in **Subject 120**.

3. Test the valve following the instructions in **Subject 110**.

Specifications

Torque Values	
Description	**Torque: lbf.in (N.cm)**
Valve Cover Capscrews	80–120 (900–1360)
Valve Mounting Capscrews	132–180 (1500–2040)
Service Port Cap nut	150 (1700)
Phillips Screw, no. 10–24	25 (280)

Table 1, Torque Values

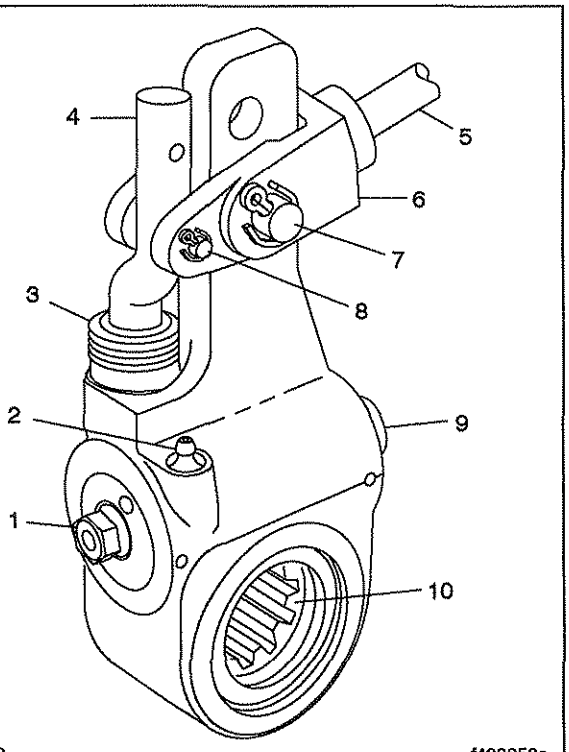
Contents

Subject	Subject Number
General Information	050
Service Operations	
Slack Adjuster Removal and Installation	100
Specifications	400

General Information (See Fig. 1)

The Gunite[1] automatic slack adjuster has two main functions:

- As a lever it converts the straight-line force of the brake chamber push rod to torque on the brake camshaft. Rotation of the camshaft forces the brake shoes against the drum.
- As an automatic slack adjuster, it maintains the lining-to-drum clearance needed for proper brake chamber push rod stroke.



1.	7/16-Inch Adjusting Hexnut	6.	Clevis
2.	Grease Fitting	7.	1/2-Inch Clevis Pin
3.	Boot	8.	1/4-Inch Clevis Pin
4.	Link	9.	Grease Relief Opening
5.	Brake Chamber Push Rod	10.	Slack Adjuster Spline

Fig. 1, Gunite Slack Adjuster

[1] Formerly Kelsey-Hayes

The slack adjuster is installed between the brake chamber push rod and the brake camshaft. A clevis connects the brake chamber push rod to the top of the slack adjuster. The bottom of the slack adjuster is splined to the brake camshaft. The splines hold the slack adjuster internal gear to the camshaft, so the camshaft turns when the slack adjuster moves. When the brakes are applied, the brake chamber push rod moves outward forcing the slack adjuster and camshaft to rotate. This movement forces the brake shoes against the drum.

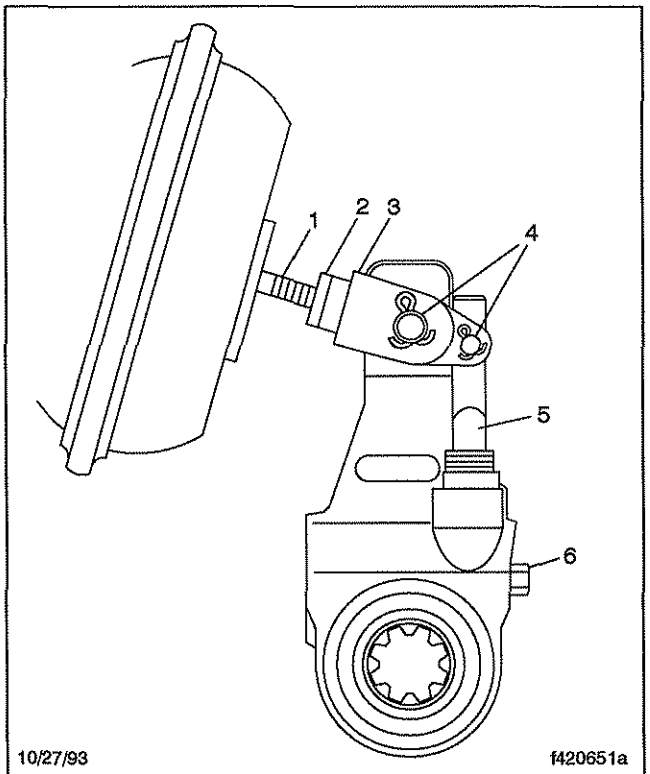
The brakes are adjusted when the slack adjuster senses an increase in the lining-to-drum clearance. The slack adjuster's internal worm shaft and ratchet shorten excessive lining-to-drum clearance. This provides maximum leverage for the brake chamber push rod. The automatic slack adjuster adjusts the brakes at the beginning of the brake application.

Slack Adjuster Removal and Installation

IMPORTANT: This automatic slack adjuster cannot be rebuilt. If it is damaged or inoperative, replace the unit. Also, when installing or replacing a Gunite automatic slack adjuster, a new clevis must be installed.

Removal (See Fig. 1)

1. Park the vehicle on a level surface, and chock the tires. If you are removing a rear slack adjuster, release the parking brake, then cage the parking brake power spring. For instructions, refer to the applicable brake chamber section in this group.
2. Back off the clevis jam nut.
3. Remove the cotter pins and clevis pins.



1. Brake Chamber Push Rod
2. Jam Nut
3. Clevis
4. Cotter Pins and Clevis Pins
5. Link
6. Adjusting Hexnut

Fig. 1, Slack Adjuster

4. Rotate the adjusting hexnut counterclockwise until the slack adjuster clears the clevis.
5. Remove the snap ring from the brake camshaft, then slide the slack adjuster off the camshaft.
6. Remove the clevis from the brake chamber push rod.

Installation (See Fig. 2)

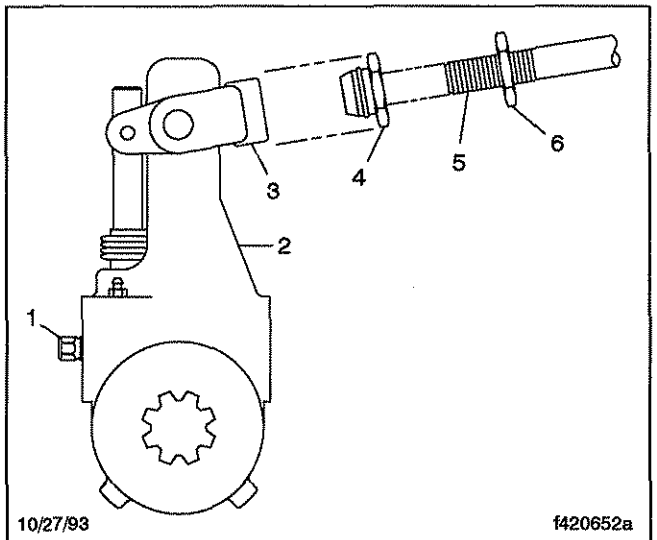
1. Coat the end of the brake chamber push rod, the camshaft splines, and the splines of the slack adjuster gear with an anticorrosive grease.
2. Make sure that the jam nut is on the brake chamber push rod. Install a new snap nut on the push rod and turn it until the nut is flush with the end of the push rod. Do not tighten the jam nut yet.
3. Using the cotter pins and clevis pins, install a new clevis on the slack adjuster.
4. Using the old snap ring, install the automatic slack adjuster on the brake camshaft.
5. Turn the adjusting hexnut (Ref. 1) clockwise to rotate the slack adjuster toward the brake chamber until the clevis (Ref. 3) contacts the snap nut. Then, push the clevis and snap nut together.

WARNING: Make sure that the snap nut contacts the clevis and that there is proper engagement. If the snap nut and clevis are not installed correctly, the brakes may not work properly. This could result in an accident causing personal injury and property damage.

CAUTION: Once attached to the clevis, the snap nut cannot be removed from the clevis. If the snap nut is removed, the clevis and/or snap nut will be damaged.

6. Pull on the clevis to make sure that it and the snap nut are properly engaged.
7. Using the gauge supplied with the new slack adjuster, adjust the clevis. **See Fig. 3.**
   - 7.1 Position the 1/2-inch hole in the gauge over the end of the 1/2-inch clevis pin.
   - 7.2 Align the applicable 1/4-inch hole in the bottom of the gauge over the center hole of the camshaft.

Slack Adjuster Removal and Installation



1. Adjusting Hexnut
2. Slack Adjuster
3. Clevis
4. Quick-Connect Snap Nut
5. Push Rod
6. Jam Nut

Fig. 2, Slack Adjuster Installation

7.3 Turn the snap nut and adjust the clevis so all of the 1/4-inch pin is visible in the notched area of the gauge. Make sure the push rod doesn't extend into the clevis opening more than 1/16 inch (1.5 mm) past the snap nut.

7.4 Tighten the jam nut.

CAUTION: Be sure to tighten the jam nut. Failure to do so may allow the snap nut to turn, which could prevent the automatic slack adjuster from working correctly.

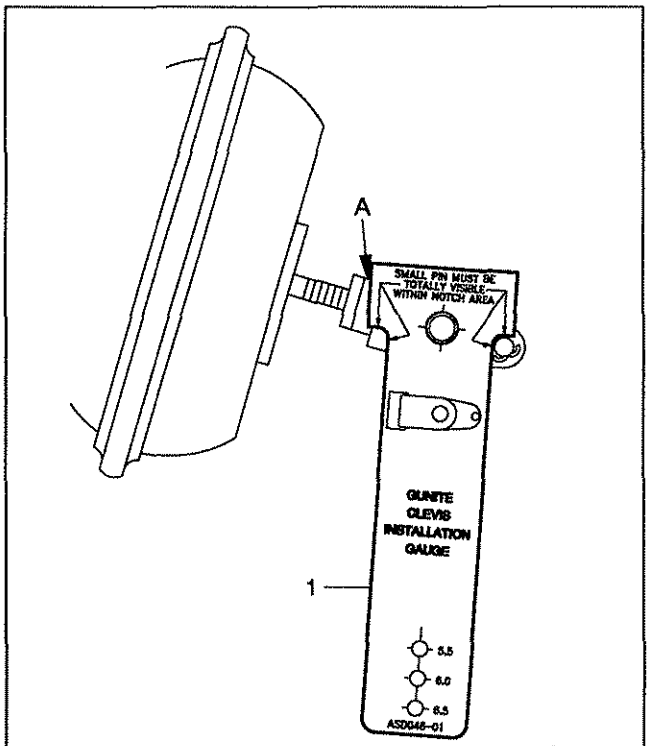
NOTE: Make sure there is clearance between the slack adjuster and other vehicle components when the brakes are applied and the push rod travels its maximum stroke.

8. Set the initial free-stroke.

8.1 Turn the adjusting hexnut clockwise until the brake linings contact the drum.

8.2 Turn the adjusting hexnut counterclockwise one-half turn. There should be about 30 lbf·ft (41 N·m) resistance, and a ratcheting sound will be heard.

9. Measure the brake chamber stroke.



A. Turn the snap nut to position the 1/4-inch clevis pin within the notched area of the gauge.

1. Installation Gauge

Fig. 3, Adjust the Clevis

9.1 With the brakes fully released, use a ruler to measure the distance from the bottom of the brake chamber to the center of the large clevis pin. **See Fig. 4**, Ref. A.

9.2 Build air pressure to at least 85 psi (586 kPa). Apply the brakes, then measure the distance from the bottom of the brake chamber to the center of the large clevis pin. **See Fig. 4**, Ref. B. The difference between the measurements is the brake chamber stroke.

9.3 The brake chamber stroke must be less than the measurements shown in the appropriate table in **Specifications, 400.** If it isn't, check the foundation brakes for problems such as worn cams, bushings, pins and rollers, or broken springs. Repair or replace as needed. For instruc-

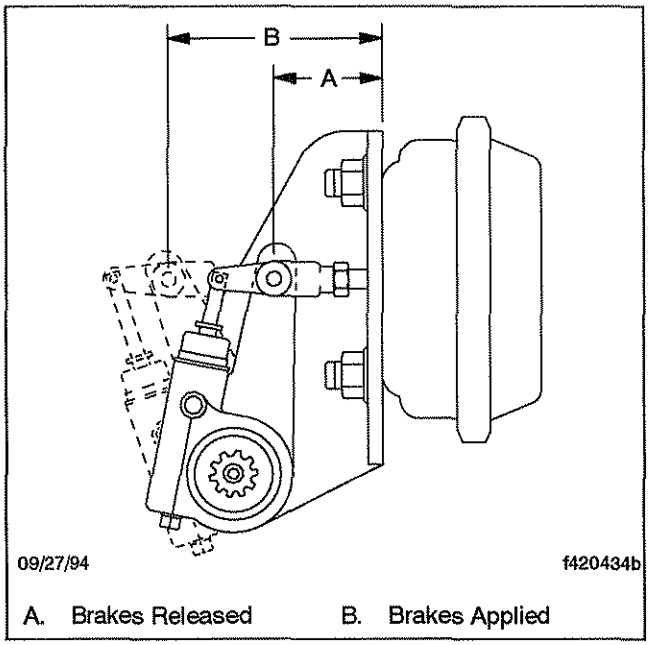


Fig. 4, Make these Measurements

tions, refer to the applicable brake section in this group. Then, repeat the two previous steps.

10. If a rear axle slack adjuster was installed, manually uncage the parking brake. For instructions, refer to the applicable brake chamber section in this group.

11. Apply the parking brakes. Remove the chocks from the tires.

Lubricant Type	Temperature
Lubriplate Aero	Above –40°F (–40°C)
Texaco Multifak EP–2 Mobil Grease 77	Above –20°F (–29°C)

Table 1, Approved Lubricants

Chamber Size	Maximum Chamber Stroke
16 20 24	Less than 1-3/4 inches (44 mm)
24* 30	Less than 2 inches (51 mm)

* Long Stroke

Table 2, Maximum Adjusted Brake Chamber Strokes

Contents

Subject	Subject Number
General Information and Principles of Operation	050
Service Operations	
Safety Precautions	100
Double Check Valve Operating and Leakage Test	110
Double Check Valve Removal and Installation	120
Double Check Valve Disassembly, Cleaning and Inspection, and Assembly	130

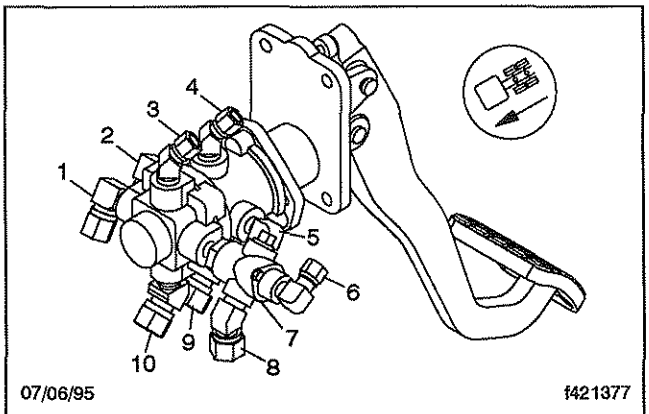
General Information (See Fig. 1)

Freightliner vehicles use one or two shuttle type double check valves. If a vehicle is equipped with a trailer control valve it has two double check valves. Otherwise, most other vehicles will only have one. A shuttle type valve has a movable shuttle to seal off the lower pressure source. The valves are screwed into the forward side of the foot brake valve.

Double check valves are used in the air brake system to direct a flow of air into a common line from either of two sources, whichever is at the higher pressure.

Principles of Operation

As pressurized air enters either end of the double check valve inlet port, the moving shuttle responds to the greater pressure source and seals the opposite port. The air flow continues out the delivery port of the valve. The position of the shuttle will reverse if the pressure levels are reversed. Double check valves are designed so the shuttle cannot interfere with the backflow of air in the exhaust mode.



1. Secondary Supply Circuit to Front Brake Valve
2. Delivery Circuit to Rear Brake Valve
3. Secondary Supply Circuit to Dash Valve
4. Primary Supply Circuit to Dash Valve
5. Primary Delivery Circuit to Tractor Protection Valve
6. Delivery Circuit to Trailer Hand Valve
7. Double Check Valve
8. Secondary Delivery Circuit to Tractor Protection Valve
9. Primary Supply Circuit to Primary Supply Reservoir
10. Secondary Supply Circuit to Secondary Supply Reservoir

Fig. 1, Brake Valve and Double Check Valve Plumbing Circuits

Safety Precautions

When working on or around air brake systems and components, observe the following precautions:

1. Chock the tires and stop the engine before working under a vehicle. Dropping air system pressure may cause the vehicle to roll. Keep hands away from brake chamber push rods and slack adjusters; they will apply as air pressure drops.
2. Never connect or disconnect a hose or line containing compressed air. It may whip as air escapes. Never remove a component or pipe plug unless you are certain all system pressure has been released.
3. Never exceed recommended air pressure and always wear safety glasses when working with compressed air. Never look into air jets or direct them at anyone.
4. Never attempt to disassemble a component until you have read and understood recommended procedures. Some components contain powerful springs, and injury can result if they are not correctly disassembled. Use only the correct tools, and observe all precautions regarding use of those tools.

Double Check Valve Operating and Leakage Test

Operating and Leakage Test

1. If the vehicle is not a tractor with a trailer, go to the next step.

   If the vehicle is a tractor with a trailer, proceed as follows:

   1.1 Push in and release the foot brake pedal while checking that the brakes apply and release on both the tractor and trailer.

   1.2 Apply and release the trailer control valve while checking that only the trailer brakes apply and release.

   1.3 Apply the trailer control valve and check the exhaust port of the foot brake valve for leakage using a soap solution. A 1-inch (2.5-cm) bubble or less in five seconds is allowable. Release the valve.

   1.4 Disconnect the air line from the trailer control valve exhaust port. Push the foot brake pedal until it stops and hold it in place. Check the trailer control valve exhaust port for leakage using a soap solution. A 1-inch (2.5-cm) bubble or less in five seconds is allowable.

   1.5 Connect the air line to the trailer control valve exhaust port.

   1.6 Go to the next step.

2. If the double check valve is to be tested on the bench, connect two separately controlled air supplies to the inlet ports.

3. Connect an accurate test gauge to the double check valve outlet port or to a line from the outlet port.

4. Apply and release air to one inlet port (foot brake pedal) while checking that the test gauge registers the application and release.

5. Apply and release air to the other inlet port (trailer control valve) while checking that the gauge registers the application and release.

6. Disconnect the line from one of the double check valve inlet ports. Apply air to the opposite inlet port while checking the first port for leakage using a soap solution. A 1-inch (2.5-cm) bubble or less in five seconds is allowable. Connect the line to the inlet port. Repeat this step, checking the opposite inlet port for leaks.

7. If the double check valve does not function as described, or if the leakage is excessive, replace it. Refer to **Subject 120** for instructions.

   If the valve cannot be replaced, repair it using Bendix parts. Refer to **Subject 130** for instructions.

Double Check Valve Removal and Installation

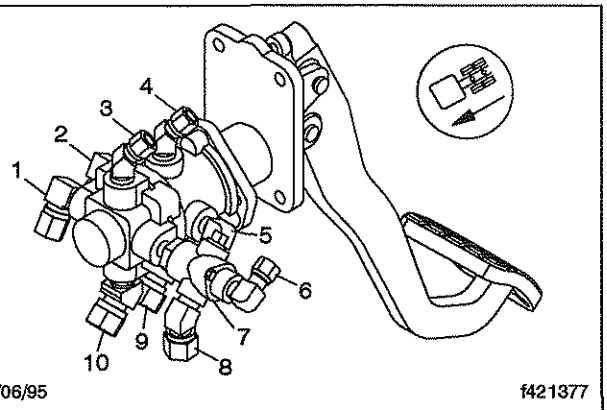
Removal

WARNING: Wear safety goggles when draining the air system or disconnecting an air line because dirt or sludge particles could fly out at high speeds. Don't direct the airstreams at other people. Don't disconnect pressurized hoses, since they may whip as air escapes. Failure to take all necessary precautions could result in personal injury.

1. Drain the air from the air reservoirs.
2. Disconnect the air lines from the double check valve. **See Fig. 1.**
3. Unscrew the double check valve from the foot brake valve.

Installation

1. Screw the double check valve into the foot brake valve. Tighten the valve firmly.



1. Secondary Supply Circuit to Front Brake Valve
2. Delivery Circuit to Rear Brake Valve
3. Secondary Supply Circuit to Dash Valve
4. Primary Supply Circuit to Dash Valve
5. Primary Delivery Circuit to Tractor Protection Valve
6. Delivery Circuit to Trailer Hand Valve
7. Double Check Valve
8. Secondary Delivery Circuit to Tractor Protection Valve
9. Primary Supply Circuit to Primary Supply Reservoir
10. Secondary Supply Circuit to Secondary Supply Reservoir

Fig. 1, Brake Valve and Double Check Valve Plumbing Circuits

2. Connect the air lines to the double check valve as marked. Tighten the air lines firmly.

Double Check Valve Disassembly, Cleaning and Inspection, and Assembly

Disassembly (See Fig. 1)

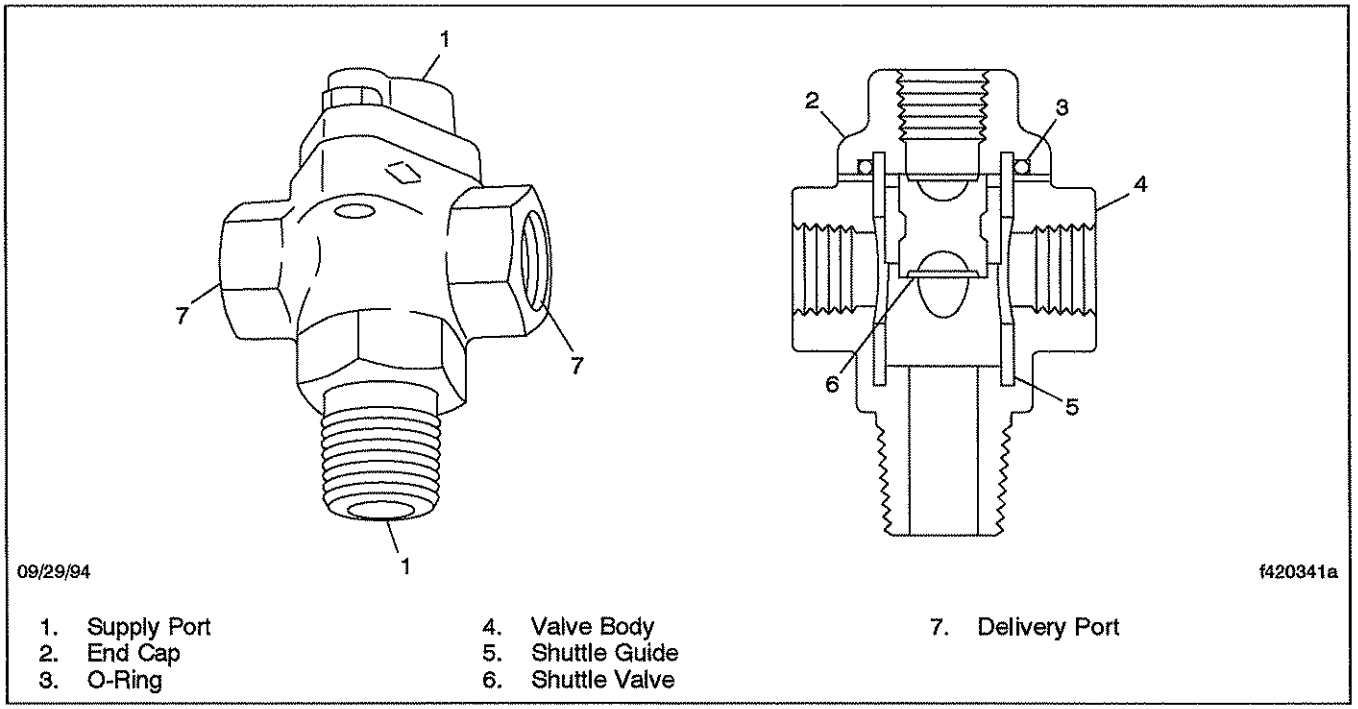
1. Remove the valve from the vehicle. Refer to **Subject 120** for instructions.
2. Remove the end cap from the valve.
3. Remove the O-ring.
4. Remove the shuttle valve and shuttle guide.

Cleaning and Inspection

1. Clean all metal parts in a cleaning solvent.
2. Inspect all metal parts for signs of cracks, wear, or deterioration. Replace all parts not considered serviceable.
3. Replace all rubber parts.

Assembly

1. Install the shuttle valve and shuttle guide in the valve body.
2. Coat the O-ring with BW 650M silicone lubricant (BW 291126). It is not necessary to lubricate the shuttle valve.
3. Install the O-ring.
4. Install the end cap on the valve body.
5. Install the valve on the vehicle. Refer to **Subject 120** for instructions.
6. Test the valve. Refer to **Subject 110** for instructions.



1. Supply Port
2. End Cap
3. O-Ring
4. Valve Body
5. Shuttle Guide
6. Shuttle Valve
7. Delivery Port

Fig. 1, Double Check Valve

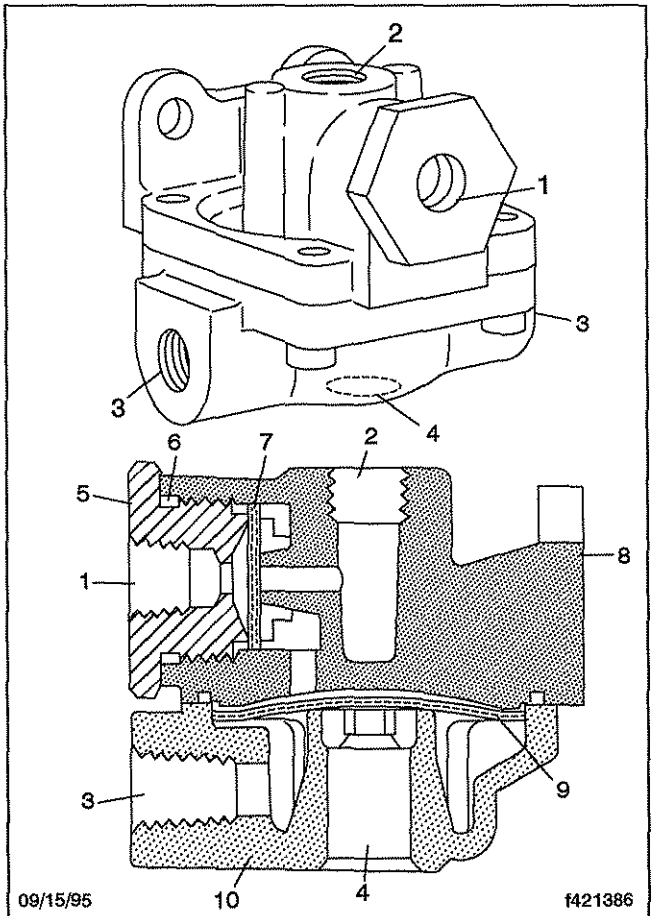
Contents

Subject	Subject Number
General Information and Principles of Operation	050
Service Operations	
Safety Precautions	100
QR–1C Quick Release Valve Operating and Leakage Tests	110
QR–1C Quick Release Valve Removal and Installation	120
QR–1C Quick Release Valve Disassembly, Cleaning and Inspection, and Assembly	130

General Information

The QR–1C quick release valve **(Fig. 1)** is a dual function valve. Its primary function is to speed up the release of air pressure from the service brake chambers. Additionally, the valve works as an anti-compound device. The double check valve feature prevents a service and parking brake application from occuring at the same time.

The QR–1C valve is generally mounted near the rear axle. A balance line from the relay valve delivery port (port 2 on the WABCO combination valve) is connected to the balance port on top of the QR–1C quick release valve; the two side ports are for brake chamber connections; the supply port is connected to the delivery port of the parking brake control valve, and the exhaust port is located at the bottom of the valve.



1. Supply Port
2. Balance Port
3. Delivery Port
4. Exhaust
5. Cap Nut
6. Sealing Ring
7. Double Check Diaphragm
8. Body
9. Quick Release Diaphragm
10. Cover

Fig. 1, QR–1C Valve and Cross Section

Principles of Operation (See Fig. 1)

PARKING BRAKES RELEASED

When the parking brakes are released, air from the parking brake control valve flows through the QR–1C valve. This forces the double check diaphragm and the quick release diaphragm to flex and seal the balance and exhaust ports. Air flows into the inlet ports of the parking brake chambers from the QR–1C valve delivery ports.

PARKING BRAKES APPLIED

When the parking brakes are applied, supply line air pressure to the QR–1C valve is exhausted through the parking brake control valve. As air pressure is exhausted from one side of the double check diaphragm and the quick release diaphragm, both diaphragms flex in the opposite direction to open the balance and exhaust ports. Parking brake pressure is released at the exhaust port of the QR–1C valve while a small amount of air trapped between the two diaphragms is released through a relay valve or the foot valve exhaust port.

ANTI-COMPOUNDING

When a service brake application is made with the parking brakes applied, service air enters the balance port and flows through the QR–1C valve into the inlet ports of the parking brake chambers. This prevents application of the service and parking brakes at the same time. Service air passing through the QR–1C valve flexes the double check and quick release diaphragms, sealing the supply and exhaust ports. When the service brake application is released, air is exhausted from the parking brakes.

Safety Precautions

When working on or around air brake systems and components, observe the following precautions.

1. Chock the tires and stop the engine before working under a vehicle. Depleting air system pressure may cause the vehicle to roll. Keep hands away from brake chamber push rods and slack adjusters; they may apply as air system pressure drops.
2. Never connect or disconnect a hose or line containing compressed air. It may whip as air escapes. Never remove a component or pipe plug unless you are certain all system pressure has been released.
3. Never exceed recommended air pressure and always wear safety glasses when working with compressed air. Never look into air jets or direct them at anyone.
4. Never attempt to disassemble a component until you have read and understood recommended procedures. Some components contain powerful springs, and injury can result if not properly disassembled. Use only proper tools and observe all precautions pertaining to use of those tools.

Operating and Leakage Tests

WARNING: Before working on or around air brake systems and components, review the safety precautions in Subject 100. Failure to do so could result in personal injury.

The following tests should also be performed after repairing or replacing the QR–1C valve to ensure that it is functioning properly.

1. Chock the tires.
2. Drain the air system.
3. Release the parking brakes.
4. Remove the air line from the valve balance port. Build system air pressure to 120 psi (827 kPa). Coat the exhaust and balance ports with a soap solution; leakage of a one-inch bubble in five seconds at either port is allowable. Install the air line at the balance port.
5. Apply the parking brakes. Step on the foot brake; the QR–1C valve should exhaust air at the exhaust port.
6. Drain the air system.
7. Remove the air line from the valve supply port. Build system air pressure to 120 psi (827 kPa). With the foot valve depressed, coat the supply port and the seam between the body and cover with a soap solution; leakage of a one-inch bubble in five seconds at the supply port is allowable. No leakage between the body and cover is permitted. Install the air line at the supply port.
8. If the valve does not function properly, or if leakage is excessive, repair or replace it following the instructions in this section.

QR–1C Quick Release Valve Removal and Installation

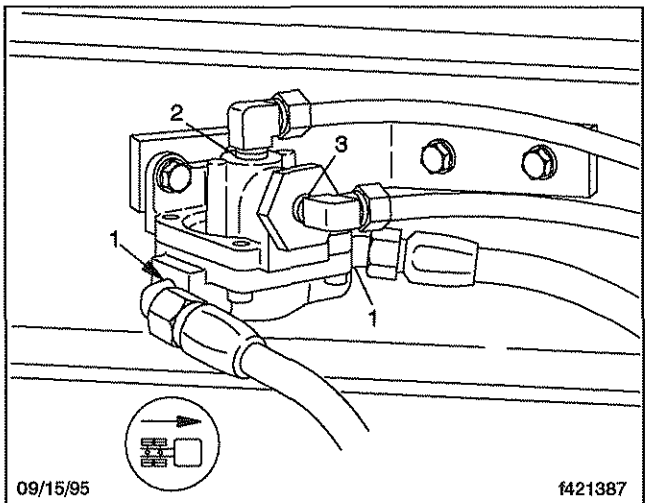
Removal (See Fig. 1)

WARNING: Before working on or around air brake systems and components, review the safety precautions in Subject 100. Failure to do so could result in personal injury.

1. Chock the tires or hold the vehicle by means other than air brakes.
2. Drain the air brake system.
3. Mark and disconnect the air lines from the quick release valve.
4. Remove the mounting bolts and the valve.

Installation (See Fig. 1)

WARNING: Before working on or around air brake systems and components, review the safety precautions in Subject 100. Failure to do so could result in personal injury.



NOTE: Valve mounting inside the left frame rail shown.

1. Delivery Port
2. Balance Port
3. Supply Port

Fig. 1, QR–1C Valve Mounting (plumbing and location will vary depending on vehicle configuration)

1. Install the quick release valve with the exhaust port facing down. Securely tighten the mounting bolts.
2. Connect the air lines to the quick release valve in the locations previously marked.
3. Perform the operating and leakage tests in **Subject 110.**

Vehicles Equipped With One Dash Valve

See **Fig. 1** for a full view of the plumbing diagram with one dash valve. See **Fig. 2**, and **Fig. 3** for partial (detailed) views of **Fig. 1**.

See **Fig. 4** for a detailed view of the air manifold and pressure switch assembly.

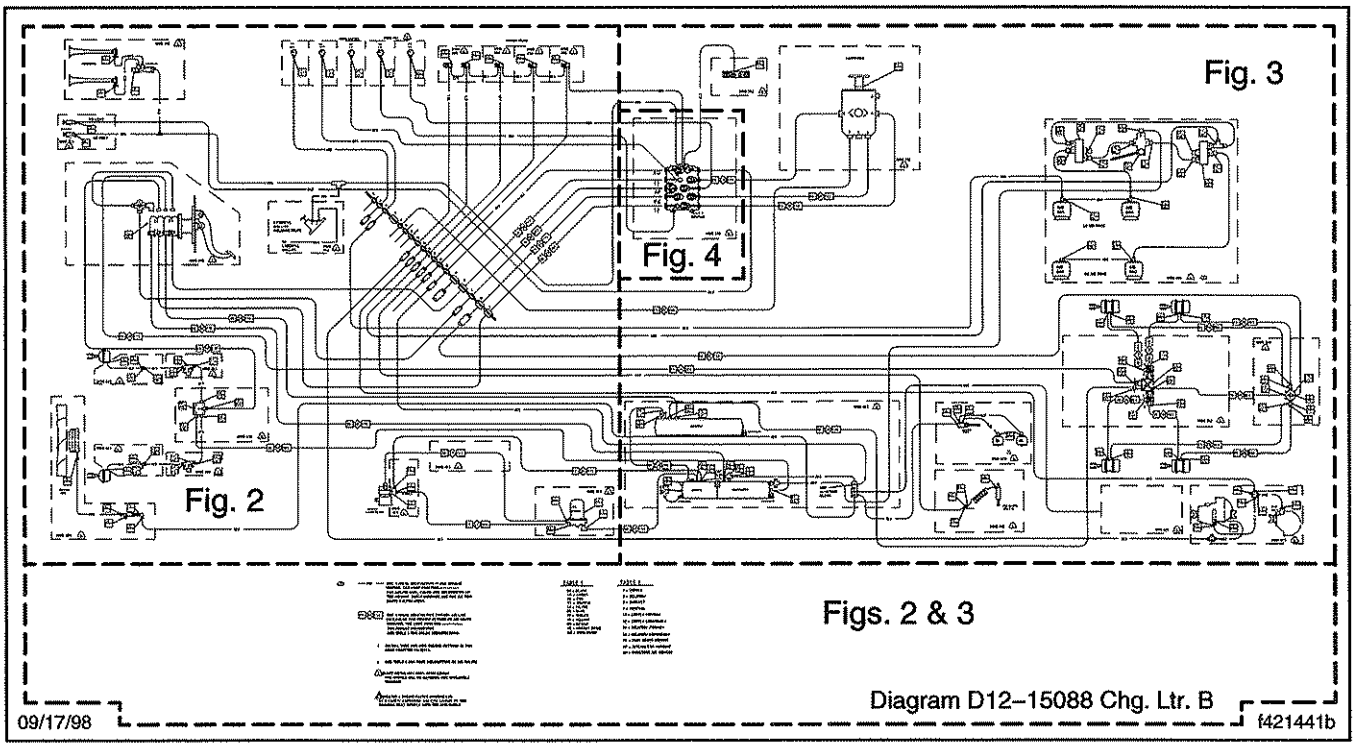


Fig. 1, Vehicles Equipped With One Dash Valve (full view)

Vehicles Equipped With One Dash Valve

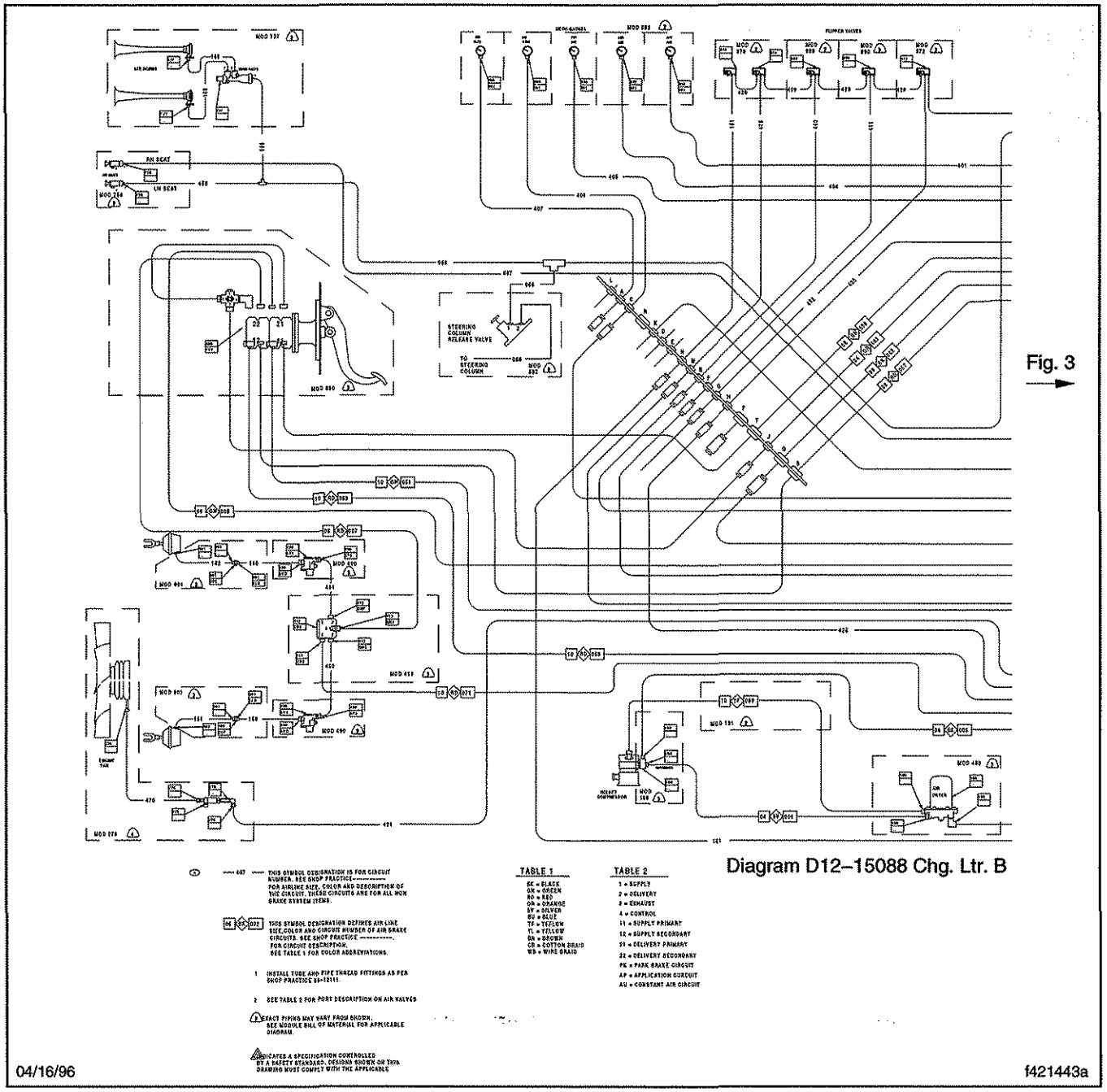


Fig. 2, Vehicles Equipped With One Dash Valve (partial view)

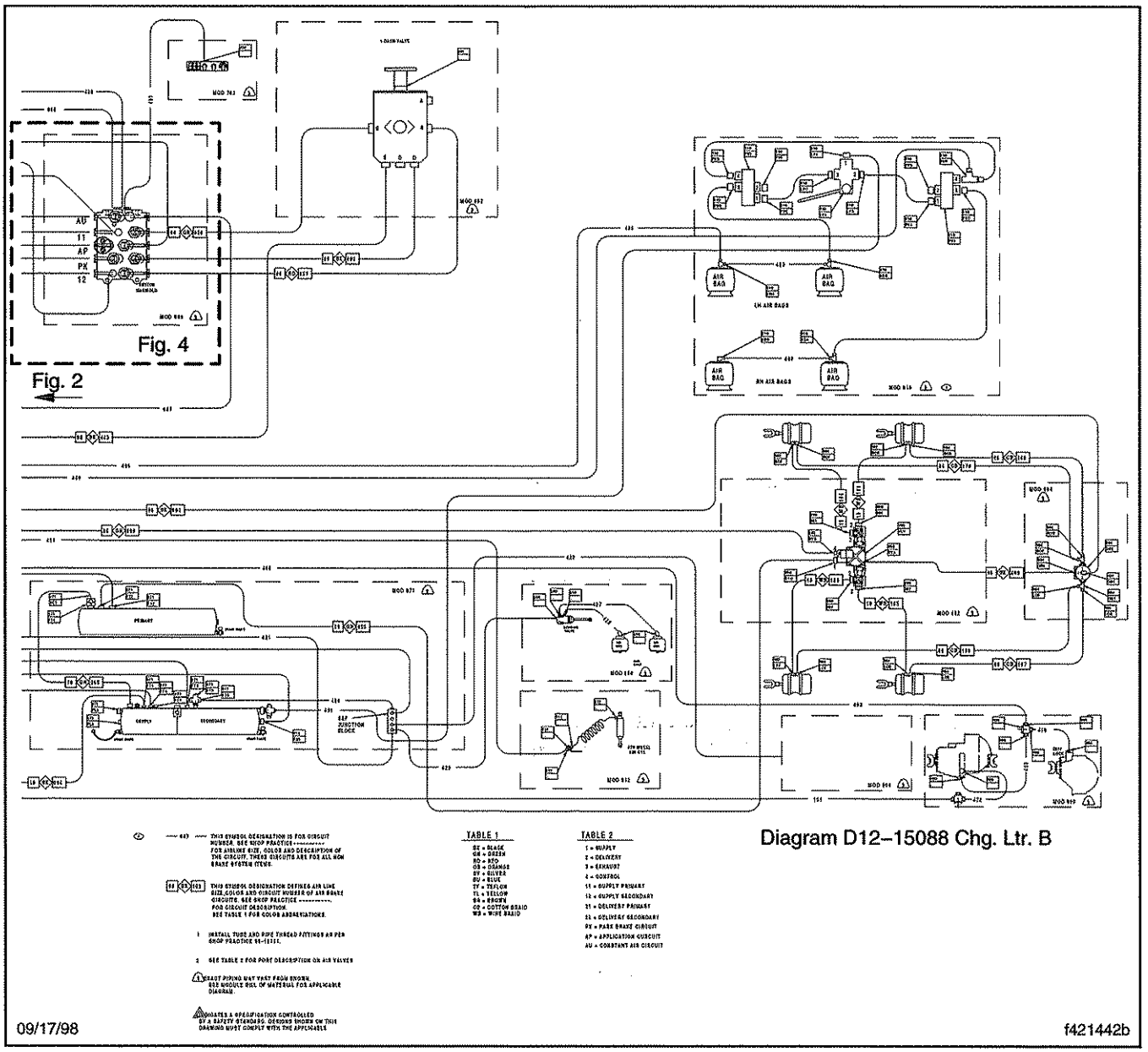
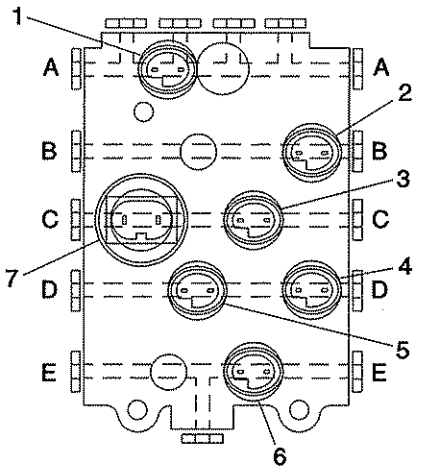


Fig. 3, Vehicles Equipped With One Dash Valve (partial view)

Vehicles Equipped With One Dash Valve



A. Auxiliary Air Pressure Circuit
B. Primary Air Pressure Circuit
C. Application Air Pressure Circuit
D. Parking Brake Air Pressure Circuit
E. Secondary Air Pressure Circuit

1. Fan Pressure Switch
2. Primary Low Air Warning Pressure Switch
3. Cruise Control Cutout Pressure Switch
4. Engine Idle Timer Pressure Switch
5. Daytime Running Lights Pressure Switch
6. Secondary Low Air Warning Pressure Switch
7. Stop Light Pressure Switch

Fig. 4, Air Manifold and Pressure Switch Assembly

Vehicles Equipped With Two Dash Valves

See **Fig. 1** for a full view of the plumbing diagram with two dash valves. See **Fig. 2**, and **Fig. 3** for partial (detailed) views of **Fig. 1**.

See **Fig. 4** for a detailed view of the air manifold pressure switch assembly.

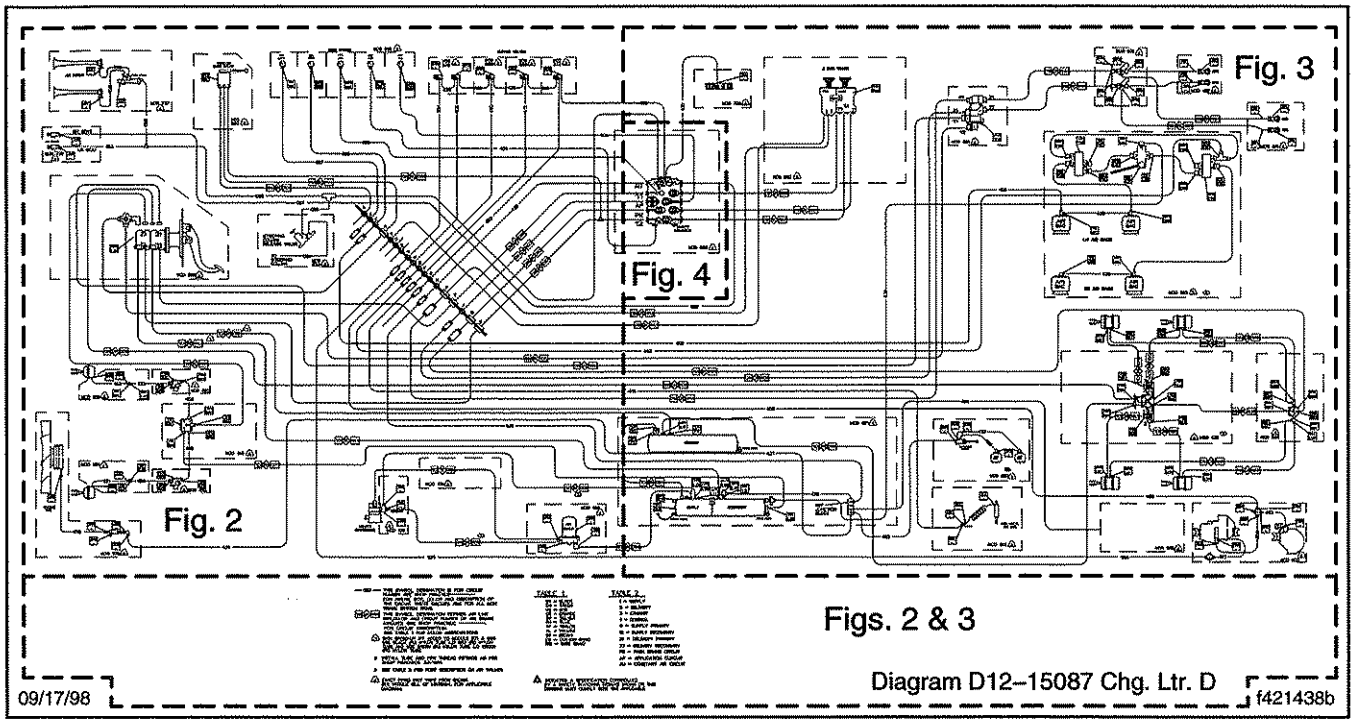


Fig. 1, Vehicles Equipped With Two Dash Valves (full view)

Vehicles Equipped With Two Dash Valves

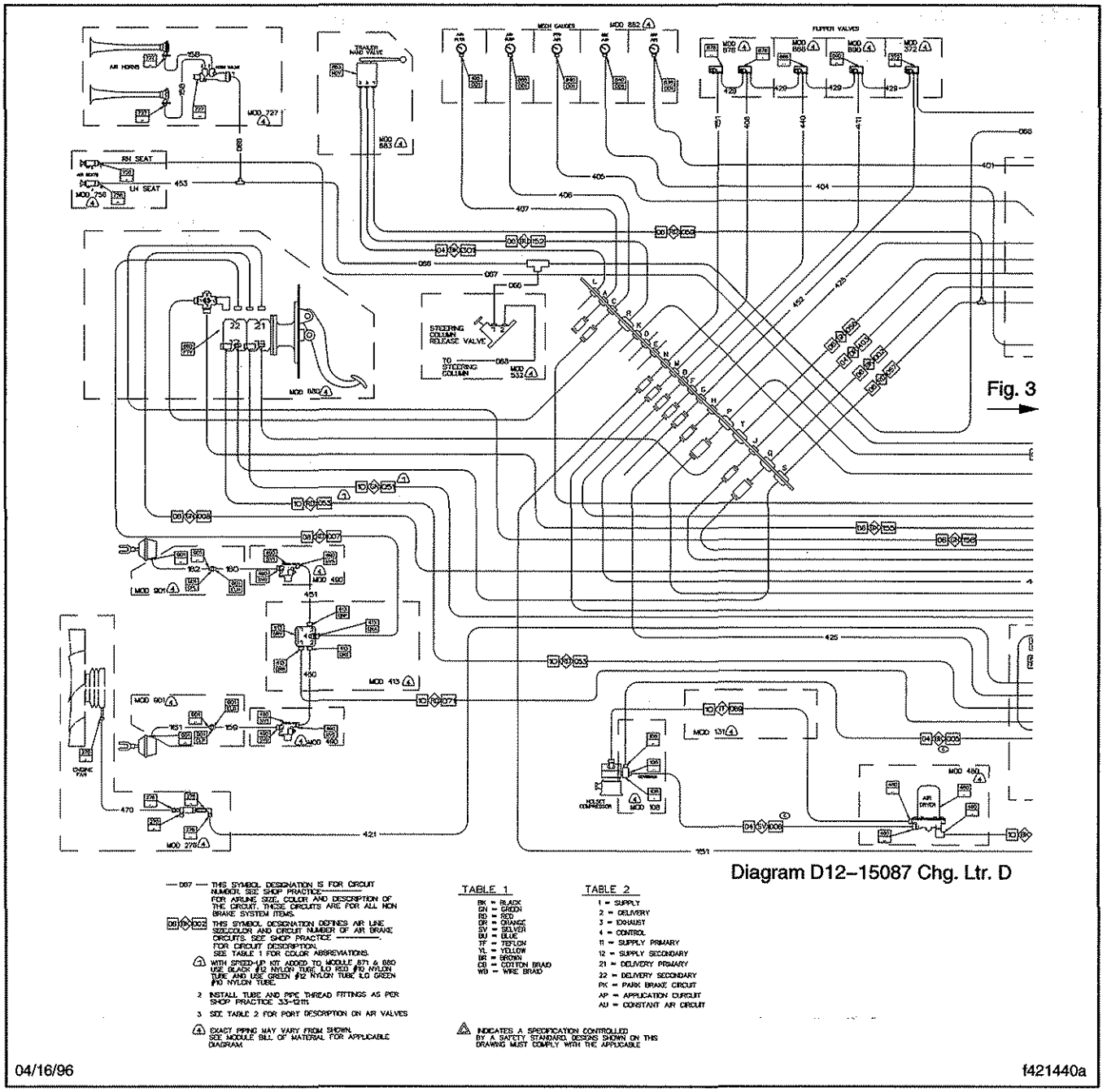


Fig. 2, Vehicles Equipped With Two Dash Valves (partial view)

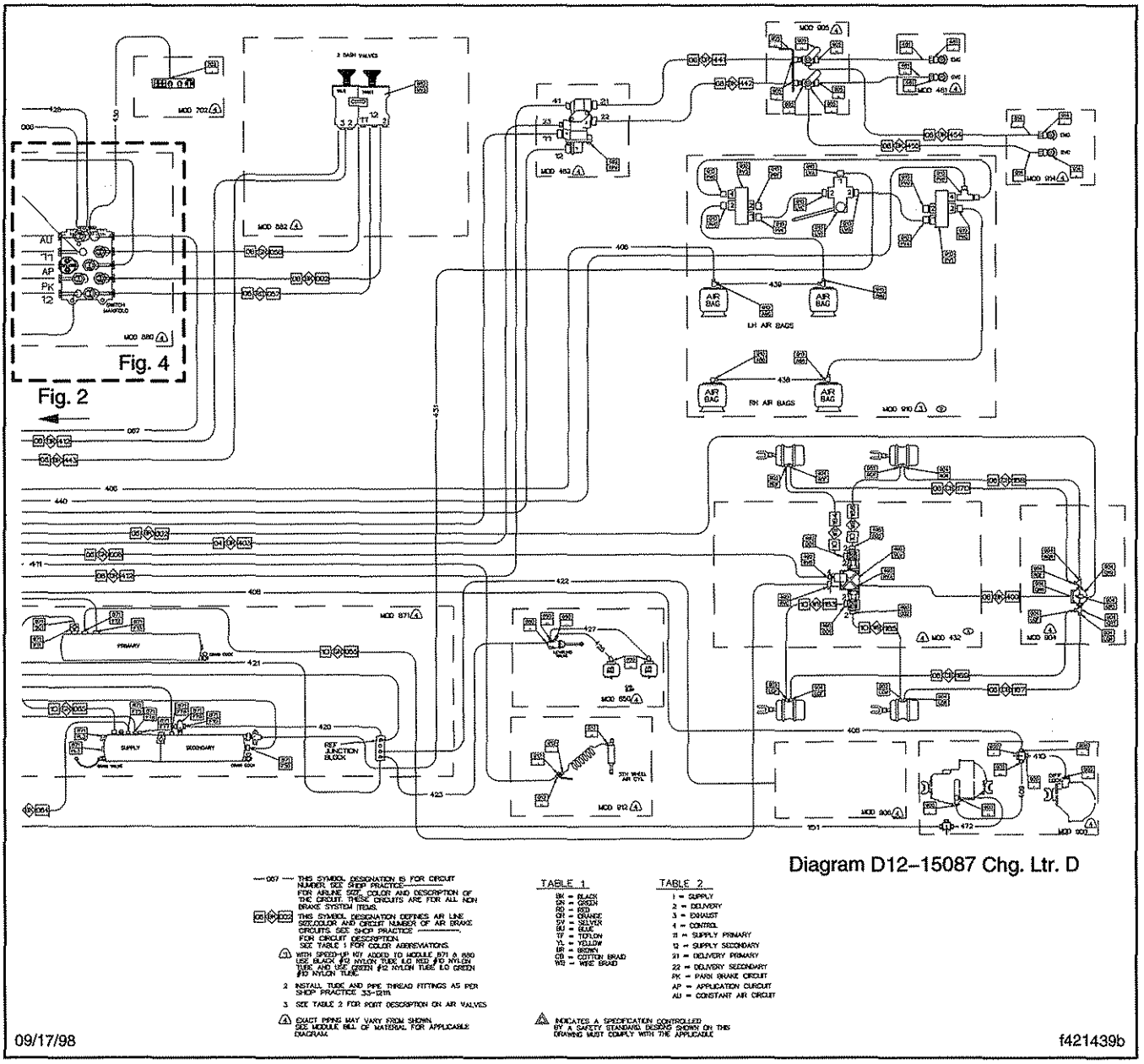
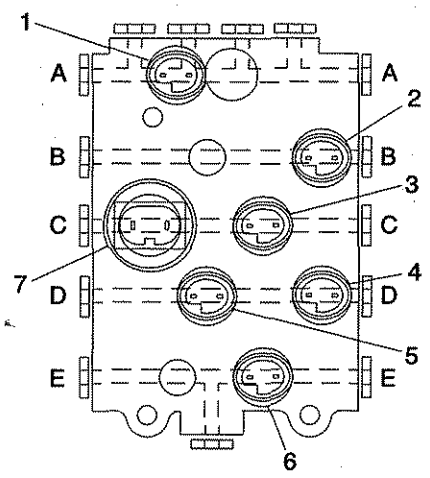


Fig. 3, Vehicles Equipped With Two Dash Valves (partial view)

Vehicles Equipped With Two Dash Valves



A. Auxiliary Air Pressure Circuit
B. Primary Air Pressure Circuit
C. Application Air Pressure Circuit
D. Parking Brake Air Pressure Circuit
E. Secondary Air Pressure Circuit

1. Fan Pressure Switch
2. Primary Low Air Warning Pressure Switch
3. Cruise Control Cutout Pressure Switch
4. Engine Idle Timer Pressure Switch
5. Daytime Running Lights Pressure Switch
6. Secondary Low Air Warning Pressure Switch
7. Stop Light Pressure Switch

Fig. 4, Air Manifold and Pressure Switch Assembly

Contents

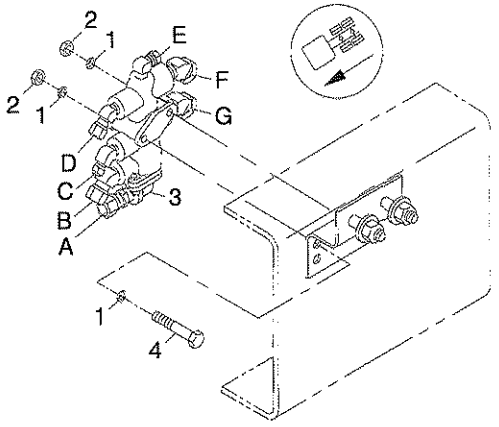
Subject	Subject Number
General Information and Principles of Operation	050
Service Operations	
Safety Precautions	100
Leakage Test	110
Removal and Installation	120
Disassembly, Cleaning and Inspection, and Assembly	130
Specifications	400

General Information

The Allied Signal/Bendix TP–3DC is a tractor protection valve which includes an integral double check valve. The TP–3DC serves two purposes. First, as required by Federal law, the valve protects the tractor brakes in the event of trailer breakaway or a severe air system leak. Second, when used with a dash-mounted trailer supply control valve, the TP–3DC valve can be used to shut off the trailer control line before the trailer is disconnected.

The TP–3DC also includes an integral single check valve which prevents air from getting trapped in the trailer control line. Trapped air in this line could cause service/spring brake compounding and, if the trailer is parked with air applied, a trailer roll-away situation.

The TP–3DC tractor protection valve is mounted either under the left hand deck or in the frame rail channel (see **Fig. 1**).



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A. From service brake foot valve, primary circuit
B. From service brake foot valve, secondary circuit
C. To air manifold (stop lamp switch)
D. From trailer supply valve
E. To proportioning relay (if installed)
F. To trailer emergency port
G. To trailer service port

1. 1/4" Flatwasher
2. 1/4–20 Locknut
3. TP–3DC Tractor Protection Valve
4. 1/4–20 Capscrew

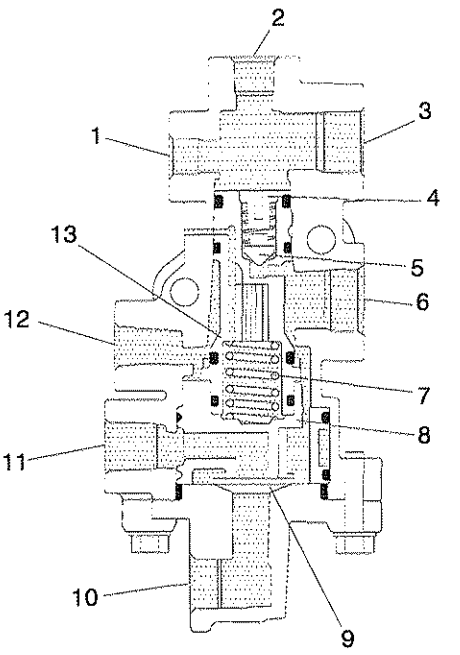
Fig. 1, TP–3DC Mounting Location and Connections

TP–3DC valve port designations and internal components are shown in **Fig. 2**.

Principles of Operation

INITIAL CHARGE **(See Fig. 3)**

Pushing in the red trailer air supply knob (Ref. 1) on the instrument panel causes air to flow into the TP–3DC valve at the tractor supply port (Ref. 2). Air flows through the valve housing, exiting via the auxiliary supply port (if used) and the trailer supply port (Ref. 4), to pressurize the trailer brake system and release the trailer parking brakes.



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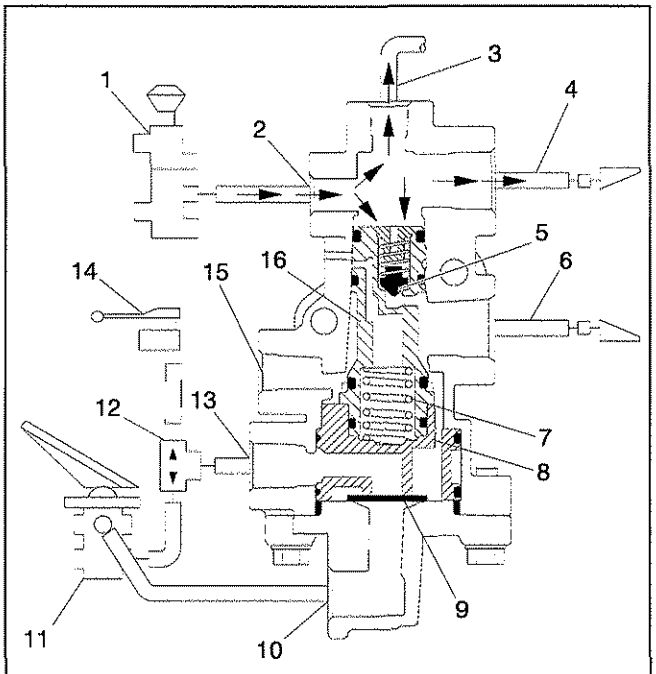
1. Tractor Supply
2. Auxiliary Supply
3. Trailer Supply
4. Tee Plug and Spring
5. Single Check Valve
6. Trailer Control
7. Spring
8. Guide
9. Diaphragm (Double Check Valve)
10. Tractor Control (Primary)
11. Tractor Control (Secondary)
12. Stop Lamp Switch Port
13. Plunger

Fig. 2, TP–3DC, Sectional View

General Information and Principles of Operation



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1. Trailer Air Supply Valve
2. Tractor Supply Port
3. Auxiliary Supply Port
4. Trailer Supply Port
5. Single Check Valve
6. Trailer Control Port
7. Spring
8. Guide
9. Diaphragm (Double Check Valve)
10. Tractor Control Port (Primary)
11. Foot Valve
12. Double Check Valve
13. Tractor Control Port (Secondary)
14. Hand Valve
15. Stop Lamp Switch Port
16. Plunger

Fig. 3, Initial Charge

As air pressure builds in the trailer supply circuit, the single check valve (Ref. 5) seats, and the valve plunger (Ref. 16) begins to move (against spring pressure) toward the guide (Ref. 8). When pressure reaches about 45 psi (310 kPa), the plunger bottoms against the guide and the inlet valve is open.

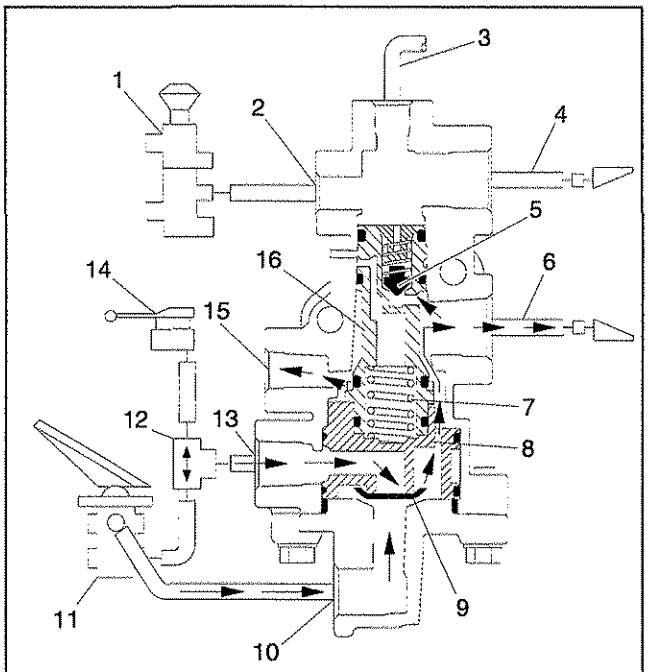
The TP–3DC valve is in the "run" mode, and ready to receive and deliver a service brake application from either the foot valve or the hand valve.

SERVICE BRAKE APPLICATION **(See Fig. 4)**

When the foot pedal is pressed, air flows to the TP–3DC valve tractor control primary (Ref. 10) and secondary (Ref. 13) ports. If the trailer control valve (Ref. 14) is also used, the external double check (Ref. 12) delivers the higher pressure (trailer control or foot valve secondary) to the TP–3DC Tractor Control secondary port.

Inside the TP–3DC valve, the higher pressure (primary or secondary) moves the diaphragm (Ref. 9) to seal off the port at the lower pressure.

With the plunger bottomed against the guide and the inlet valve open (as described earlier), the higher pressure air flows through the valve to the trailer control port (Ref. 6) and the stop lamp switch, applying the brakes and activating the stop lamps.



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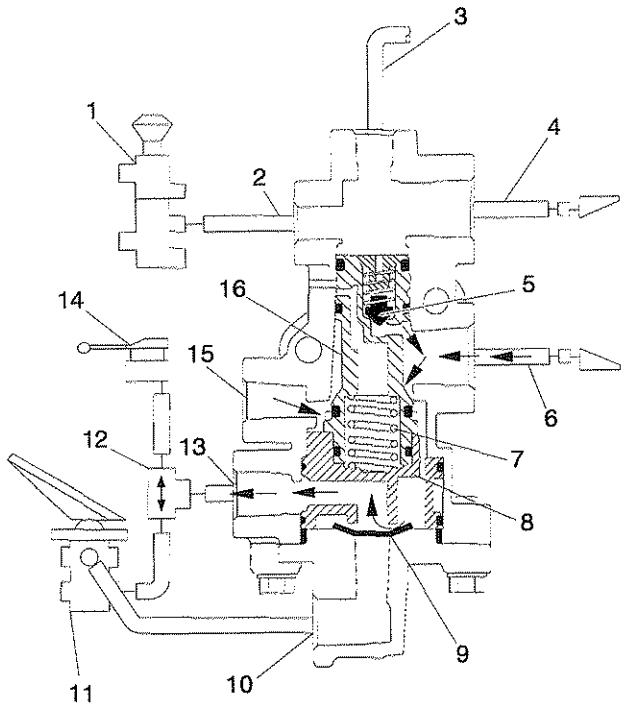
1. Trailer Air Supply Valve
2. Tractor Supply Port
3. Auxiliary Supply Port
4. Trailer Supply Port
5. Single Check Valve
6. Trailer Control Port
7. Spring
8. Guide
9. Diaphragm (Double Check Valve)
10. Tractor Control Port (Primary)
11. Foot Valve
12. Double Check Valve
13. Tractor Control Port (Secondary)
14. Hand Valve
15. Stop Lamp Switch Port
16. Plunger

Fig. 4, Service Brake Application

NOTE: While air pressure also reaches the TP–3DC single check valve, the valve stays closed because supply pressure is acting on the other side.

SERVICE BRAKE RELEASE (See Fig. 5)

When the foot pedal is released, air stops flowing into the TP–3DC valve at the tractor control primary (Ref. 10) or secondary (Ref. 13) port. At the same time, air in the trailer control line (Ref. 6) returns to the valve, flowing back through the open inlet valve.



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1. Trailer Air Supply Valve
2. Tractor Supply Port
3. Auxiliary Supply Port
4. Trailer Supply Port
5. Single Check Valve
6. Trailer Control Port
7. Spring
8. Guide
9. Diaphragm (Double Check Valve)
10. Tractor Control Port (Primary)
11. Foot Valve
12. Double Check Valve
13. Tractor Control Port (Secondary)
14. Hand Valve
15. Stop Lamp Switch Port
16. Plunger

Fig. 5, Service Brake Release

The air forces the diaphragm (Ref. 9) to seat, sealing off the tractor control primary port. The air then exits the valve at the tractor control (secondary) port (Ref. 13) and flows to the foot valve or hand valve where it is exhausted.

TRACTOR PROTECTION (See Fig. 6)

If the red trailer air supply knob on the instrument panel is pulled out (or if a large leak develops in the trailer supply circuit), pressure in the trailer supply circuit (and the auxiliary supply circuit, if used) is vented. When pressure drops to about 20 to 30 psi (138 to 207 kPa), the pressure can no longer overcome the spring force inside the TP–3DC valve and the inlet valve closes.

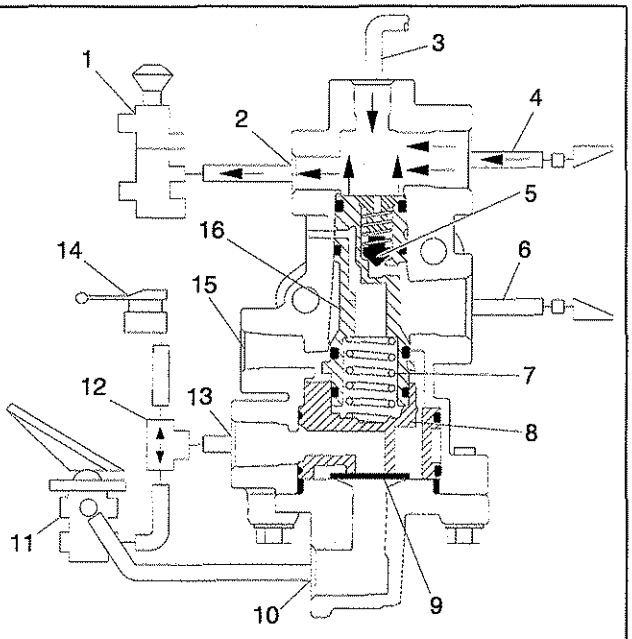
With the inlet valve closed, air pressure from the brake foot or hand control valves will not reach the trailer control circuit when the brakes are applied.

ANTI-COMPOUNDING (See Fig. 7)

If the red trailer air supply knob on the instrument panel is pulled out while the service brakes are applied, the single check valve (Ref. 5) in the TP–3DC prevents simultaneous spring and service brake application. As pressure in the trailer supply circuit drops, the spring (Ref. 7) in the TP–3DC valve forces the inlet valve closed (as described above in "Tractor Protection." Any pressure in the trailer control circuit (Ref. 6) is relieved by passing first through the single check valve and then exhausting at the trailer supply valve.

If the service brakes (hand or foot) are released and applied again, the closed inlet valve prevents air pressure from reaching the trailer control circuit.

General Information and Principles of Operation



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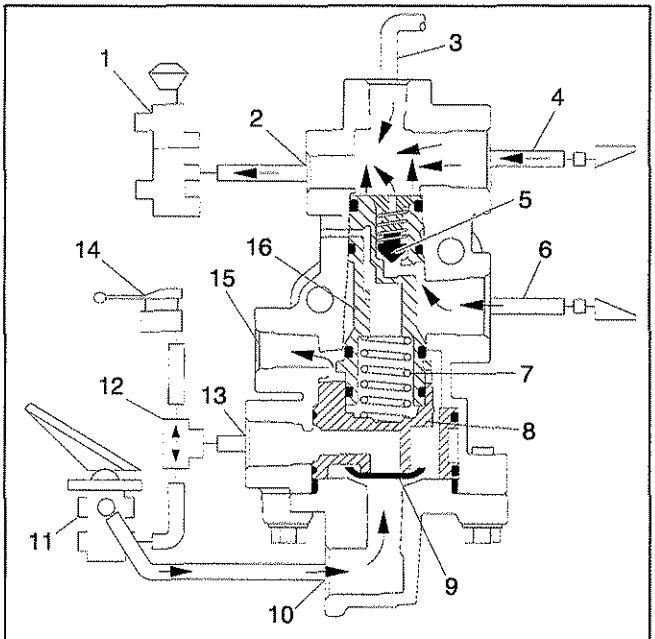
1. Trailer Air Supply Valve
2. Tractor Supply Port
3. Auxiliary Supply Port
4. Trailer Supply Port
5. Single Check Valve
6. Trailer Control Port
7. Spring
8. Guide
9. Diaphragm (Double Check Valve)
10. Tractor Control Port (Primary)
11. Foot Valve
12. Double Check Valve
13. Tractor Control Port (Secondary)
14. Hand Valve
15. Stop Lamp Switch Port
16. Plunger

Fig. 6, Tractor Protection



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1. Trailer Air Supply Valve
2. Tractor Supply Port
3. Auxiliary Supply Port
4. Trailer Supply Port
5. Single Check Valve
6. Trailer Control Port
7. Spring
8. Guide
9. Diaphragm (Double Check Valve)
10. Tractor Control Port (Primary)
11. Foot Valve
12. Double Check Valve
13. Tractor Control Port (Secondary)
14. Hand Valve
15. Stop Lamp Switch Port
16. Plunger

Fig. 7, Anti-Compounding

Safety Precautions

When working on or around air brake systems and components, observe the following precautions.

1. Chock the tires and stop the engine before working under the vehicle. Releasing air from the system may cause the vehicle to roll. Keep hands away from brake chamber push rods and slack adjusters; they will apply as air pressure drops.
2. Never connect or disconnect a hose or line containing compressed air. It may whip as air escapes. Never remove a component or pipe plug unless you are certain all system pressure has been released.
3. Never exceed recommended air pressure and always wear safety glasses when working with compressed air. Never look into air jets or direct them at anyone.
4. Never attempt to disassemble a component until you have read and understood recommended procedures. Some components contain powerful springs, and injury can result if not correctly disassembled. Use only correct tools and observe all precautions regarding use of those tools.

Leakage Test

IMPORTANT: Before working on or around air brake systems and components, review **Safety Precautions, 100.**

1. Chock the tires, start the engine, and run it until the air system is fully charged.
2. Shut down the engine and place the trailer air supply valve in the emergency position.
3. Disconnect the trailer control line hose coupling and apply a soap-water solution to the coupling.
4. With tractor reservoirs charged to at least 100 psi (689 kPa) make and hold a full service brake application using either the foot valve or the trailer control valve. Leakage at the hose coupling should not exceed a 1-inch (2.5-cm) bubble in five seconds.
5. Release the service brake application and place the trailer supply valve in the "run" position. Connect the trailer control valve to a test gauge.
6. Make a service brake application and note that service air pressure is present at the trailer control line hose coupling.
7. Disconnect the air line at the TP–3DC tractor control port (primary), plug the line, and apply a soap-water solution to the valve.
8. Make a service brake application and check for leakage at the open tractor control port. Leakage should not exceed a 1-inch (2.5-cm) bubble in five seconds.
9. Reconnect the air line to the tractor control port (primary) and disconnect the air line at the tractor control port (secondary). Then, plug the disconnected line and apply a soap-water solution to the valve.
10. Make and service brake application and check for leakage at the open tractor control port. Leakage should not exceed a 1-inch (2.5-cm) bubble in five seconds.

IMPORTANT: If the valve does not function as described, or if leakage is excessive, repair or replace the valve.

Removal

IMPORTANT: Before working on or around air brake systems and components, review **Safety Precautions, 100**.

1. Chock the tires, and open the air reservoir drain cocks to bleed the air from the system.
2. Remove the trailer hose assemblies from the TP–3DC valve. Disconnect the tractor service and supply lines. Mark the lines for later assembly reference. Cap the air lines tightly to keep out contaminants.
3. Remove the fasteners attaching the TP–3DC valve to the vehicle, and remove the valve.

Installation

IMPORTANT: Before working on or around air brake systems and components, review **Safety Precautions, 100**.

1. Place the TP–3DC valve on the vehicle, and attach it with bolts, washers, and nuts. Tighten the nuts 11 to 15 lbf·ft (15 to 20 N·m).

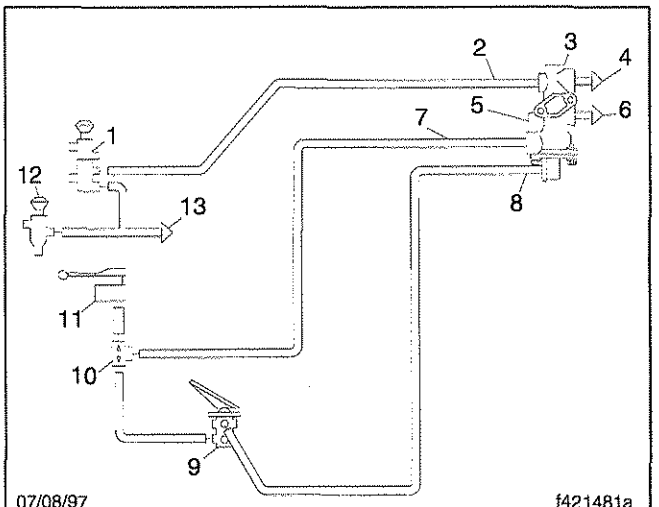
NOTE: The delivery line from the trailer air supply valve is connected to the tractor emergency port of the TP–3DC valve. See **Fig. 1**. The delivery line from the brake valve (double check valve) is connected to the tractor service port of the TP–3DC valve. Trailer hose assemblies are installed in the trailer emergency and trailer service ports of the TP–3DC valve.

2. Remove the caps from the air lines, and depending on the type of air hose, use the following instructions to connect the air hoses to the TP–3DC valve:

   If equipped with nylon tube air hoses, connect the hose fittings to the valve ports, and tighten the nuts finger-tight. Then, using a wrench, tighten the nuts at least two turns, or until no threads show on the fitting.

   If equipped with wire braid hoses, connect the hose fittings to the valve ports, and hand-tighten the nuts. Using a wrench, tighten the nuts until there is resistance. Tighten one-sixth turn more. Do not overtighten.

3. Close the drain cocks to the air reservoirs. Start the vehicle engine to pressurize the air system.
4. Leak test the TP–3DC valve following the instructions in **Subject 110**.



1. Trailer Air Supply Valve
2. Tractor Supply
3. Auxiliary Supply Port
4. Trailer Supply
5. Stop Lamp Switch Port
6. Trailer Control
7. Tractor Control (Secondary)
8. Tractor Control (Primary)
9. Foot Brake Valve
10. Double Check Valve
11. Trailer Control Valve
12. Parking Brake Valve
13. To Tractor Spring Brakes

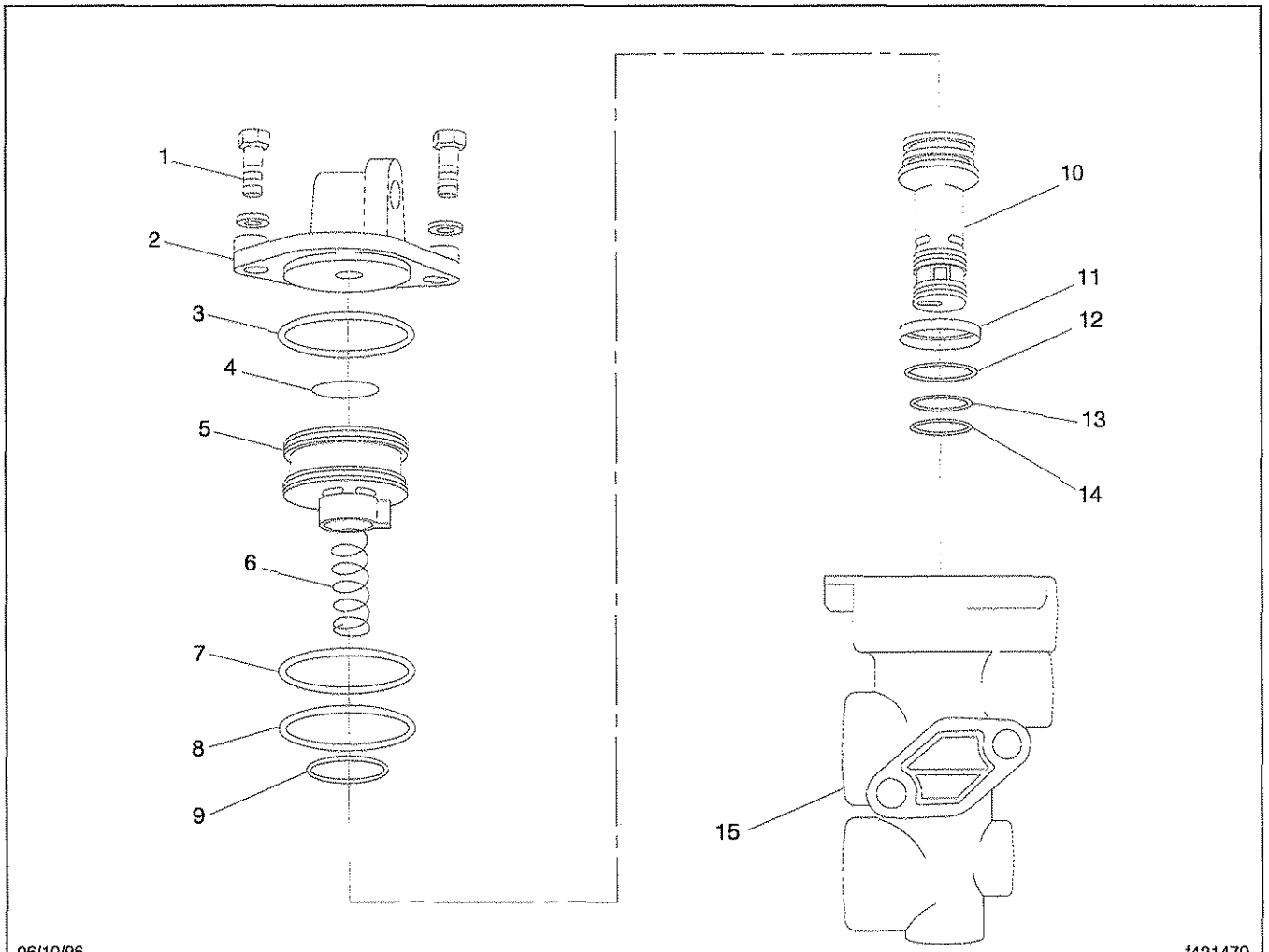
Fig. 1, Partial Plumbing Diagram, With TP–3DC

Disassembly, Cleaning and Inspection, and Assembly

Disassembly (See Fig. 1)

IMPORTANT: Before working on or around air brake systems and components, review **Safety Precautions, 100**.

1. Remove the valve from the vehicle, retaining the mounting hardware. For instructions, see **Subject 120**.
2. Scribe a line across the valve cover (Ref. 2) and valve body (Ref. 15) to ensure proper alignment during assembly.
3. Remove the two 1/4-inch screws (Ref. 1) which secure the valve cover to the valve body and allow the valve spring to expand until the valve cover can be removed.
4. Remove the cover O-ring (Ref. 3) and discard it.



1. 1/4" Hex/Torx Screw
2. Valve Cover
3. Cover O-Ring
4. Diaphragm
5. Guide
6. Valve Spring
7. Guide O-Ring
8. Guide O-Ring
9. Plunger O-Ring
10. Plunger
11. Collar
12. O-Ring
13. Plunger O-Ring
14. Plunger O-Ring
15. Valve Body

Fig. 1, Exploded View of TP–3DC Valve

Disassembly, Cleaning and Inspection, and Assembly

5. Remove the diaphragm (Ref. 4) from the valve body and discard it.
6. Remove the guide (Ref. 5) from the valve body.
7. Remove the O-rings (Refs. 7 and 8) from the guide and discard them.
8. Remove the valve spring from the plunger, then the plunger from the valve body.
9. Remove the O-rings (Refs. 9, 13, and 14) from the plunger and discard them.
10. Remove the collar (Ref. 11) and the O-ring (Ref. 12) from the plunger. Discard the O-ring, but keep the collar.

Cleaning and Inspection

IMPORTANT: Before working on or around air brake systems and components, review **Safety Precautions, 100.**

⚠ WARNING

Wear goggles when using compressed air to clean or dry parts, as permanent harm to eyes could result from flying debris.

1. Wash all metal parts of the TP–3DC valve in cleaning solvent, then dry them using compressed air.
2. Examine the cover, body, guide, and plunger for corrosion, excessive wear, cracks, or other damage. If any of these conditions are found on a part, replace the part with a new one.
3. Check the spring for distortion and corrosion. If the spring is distorted or corroded, replace it.
4. Check the valve body bores for deep scratches or gouging

Assembly

IMPORTANT: Before working on or around air brake systems and components, review **Safety Precautions, 100.**

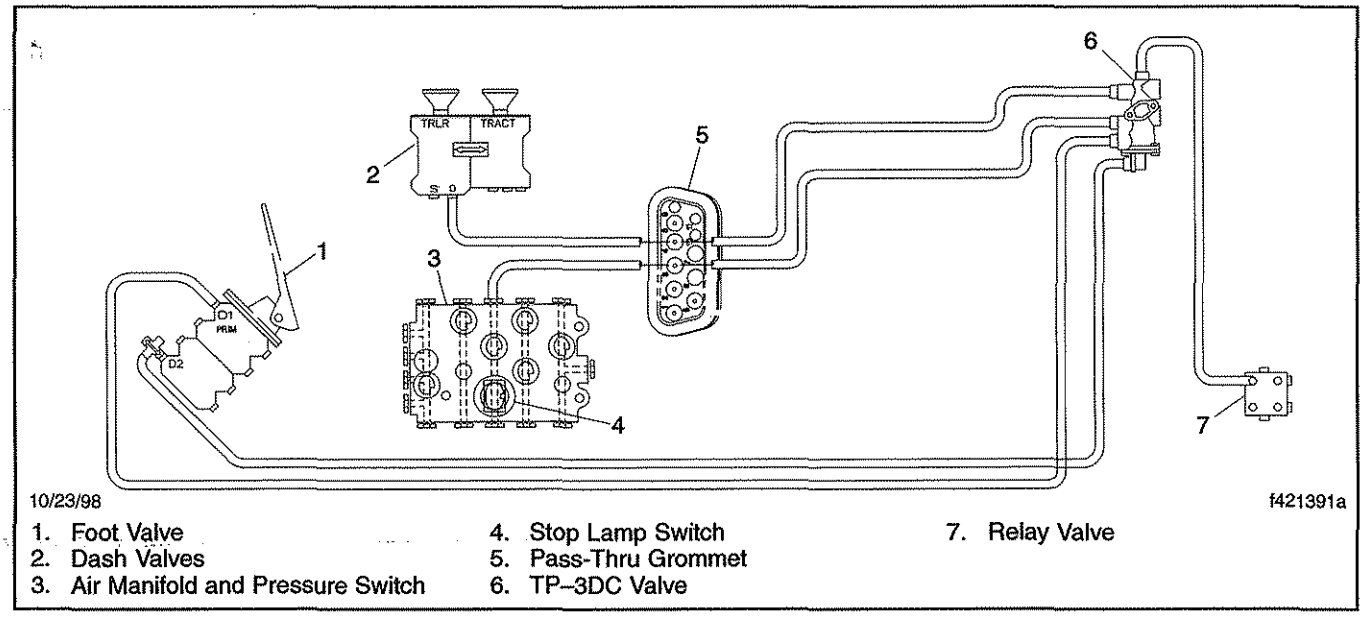
1. Lubricate the O-rings, O-ring grooves, body bores, and all sliding parts with the lubricant provided in the overhaul kit (Bendix silicone lubricant #291126 or equivalent).
2. Install the O-rings (Refs. 9, 13, and 14) on the plunger.
3. Install the O-ring (Ref. 12) on the plunger and then the collar (Ref. 11) over the O-ring. Make sure that the collar is fully seated and firmly in place over the O-ring.
4. Install the plunger into the valve body and the spring (Ref. 6) into the plunger.
5. Install the O-rings (Refs. 7 and 8) in their grooves on the guide.
6. Align the indexing tab on the guide with the notch in the valve body and install the guide in the valve body.
7. Place the diaphragm (Ref. 4) in its recess on the guide.
8. Place the O-ring (Ref. 3) on the cover.
9. Place the cover on the guide and press them down, against spring pressure, until the cover is seated against the valve body.
10. Install the two 1/4-inch screws and tighten them 30 to 60 lbf·in (340 to 675 N·cm).
11. Install the TP–3DC valve on the vehicle following the instructions in **Subject 120.**

Specifications

See **Fig. 1** for a TP–3DC plumbing diagram.

Torque Values		
Description	**Torque lbf·in (N·cm)**	**Torque lbf·ft (N·m)**
Valve Cover Capscrews	30–60 (340–675)	—
Valve Mounting Capscrews	—	11–15 (15–20)

Table 1, Torque Values



1. Foot Valve
2. Dash Valves
3. Air Manifold and Pressure Switch
4. Stop Lamp Switch
5. Pass-Thru Grommet
6. TP–3DC Valve
7. Relay Valve

Fig. 1, TP–3DC Plumbing Diagram

Contents

Subject	Subject Number
General Information and Principles of Operation	050
Service Operations	
Safety Precautions	100
Air Dryer Removal and Installation	110
Turbocharger Cutoff Valve Replacement	120
Purge Valve Replacement	130
Outlet Check Valve Assembly Replacement	140
Desiccant Cartridge Replacement	150
Heater/Thermostat Assembly Replacement	160
Regeneration Valve Replacement	170
Silencer (Muffler) Replacement	180
Pressure Relief Valve Replacement	190
Pressure-Controlled Check Valve Replacement	200
Operating Tests	210
Troubleshooting	300
Specifications	400

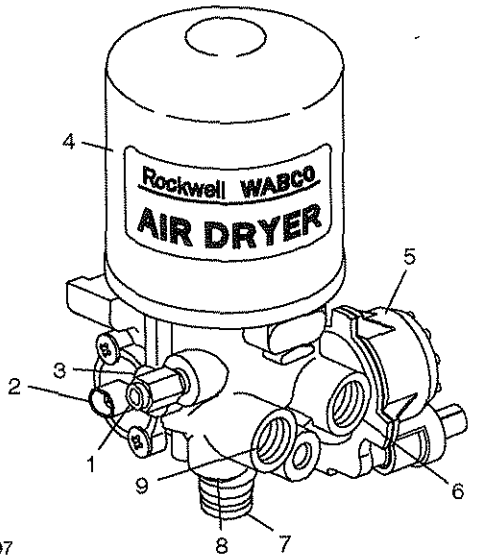
General Information

The System Saver 1200 air dryer **(Fig. 1)** is a desiccant air dryer, mounted vertically between the air compressor and the supply reservoir. The air dryer receives hot compressed air, which it cools and filters before sending it to the supply reservoir, reducing the build-up of dirt and moisture in the vehicle air system.

The air dryer consists of a light weight aluminum and steel body. The desiccant cartridge is contained in a spinoff canister at the top of the air dryer.

The bottom half of the air dryer houses the following components.

- Pressure Relief Valve–this valve protects the air dryer from over pressurization. The valve is attached directly to the air dryer.
- Desiccant Canister–a cylindrical steel housing that contains the filter elements and the desiccant needed to filter and dry the air that passes through it.
- Heater/Thermostat Assembly–located in the air dryer base, this assembly is designed to prevent the collected moisture from freezing.
- Outlet Check Valve–this valve prevents air in the system from flowing back through the air dryer and escaping out the purge valve during the compressor unload cycle.
- Pressure-Controlled Check Valve–this valve is separate from the air dryer and is installed on the system air tank. The valve allows air to back flow from the system tank to the supply tank as long as air system pressure remains between the normal cut in and cut out range of the air governor.
- Purge Valve–this valve allows the collected moisture and contaminants to be expelled from the air dryer during the purge cycle.
- Regeneration Valve–this valve allows air from the supply and system tanks to bypass the outlet check valve and flow into the regeneration valve. Air then flows through an orifice where the air expands and back flushes moisture off of the desiccant. The air is then exhausted through the purge valve.
- Silencer (Muffler)–an optional component that is attached to the purge valve and used to eliminate most of the noise during the air dryer purge cycle.
- Turbocharger Cut-Off Valve–this valve closes the path between the air compressor and the air dryer purge valve to help maintain boost pressure for maximum engine horsepower during the compressor unload cycle.



1. Pressure Relief Valve
2. Heater/Thermostat Assembly
3. Governor Port (to air governor)
4. Desiccant Canister
5. Regeneration Valve Assembly
6. Outlet Port (to air supply reservoir)
7. Exhaust Port (Purge Valve Assembly)
8. Turbocharger Cutoff Valve
9. Inlet Port (from air compressor)

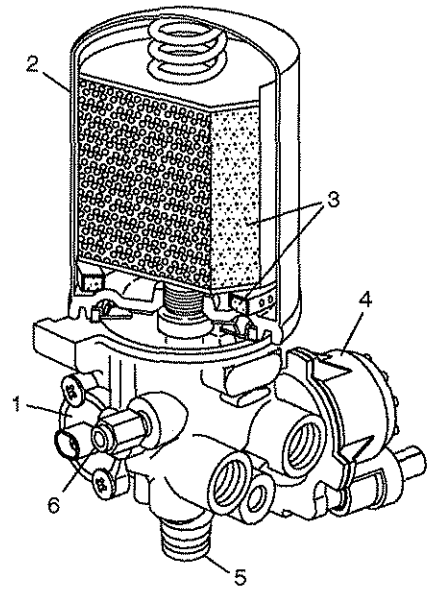
Fig. 1, WABCO System Saver 1200

Principles of Operation

Hot, compressed air enters the air dryer through the inlet port. As the hot air is forced into the desiccant cartridge, the temperature of the compressed air falls to nearly ambient. Oil and water vapor condense and initially settle into the base of the dryer. The moisture-laden air also passes through the desiccant bed, where any remaining moisture is retained by the desiccant. The clean air then passes through the air dryer outlet port to the supply reservoir. See **Fig. 2.**

General Information and Principles of Operation

When the compressor reaches 125 psi (862 kPa), the purge valve opens allowing the initial decompression of the dryer and expels the water and contaminants collected in the base of the dryer. The regeneration valve, along with the pressure-controlled check valve, allows the system air to flow back through the dryer. This back flow dries the desiccant for the next cycle.



1. Heater/Thermostat Assembly
2. Desiccant Canister
3. Filter
4. Regeneration Valve Assembly
5. Exhaust Port (Purge Valve Assembly)
6. Pressure Relief Valve

Fig. 2, Sectional View

Safety Precautions

⚠ WARNING

When draining the air system, don't look into the air jets or direct them toward another person, as dirt or sludge particles may be in the airstream. Don't disconnect pressurized hoses because they may whip as air escapes from the line. Failure to take all necessary precautions during service operations of the air brake system can cause personal injury.

When working on or around air brake systems and components, observe the following precautions.

1. Apply the parking brake, chock the tires, and stop the engine when working under the vehicle. Draining the air system may cause the vehicle to roll. Keep hands away from brake chamber push rods and slack adjusters, which may apply as air system pressure drops.
2. Wear safety goggles.
3. Never connect or disconnect a hose or line containing air under pressure; it may whip as air escapes. Never remove a component or pipe plug unless you are sure all system pressure has been depleted.
4. Don't disassemble a component before reading and understanding recommended procedures. Use only the correct tools and follow basic tool safety.
5. Replacement hardware, tubing, hose, fittings, etc. should be the same size, type, length, and strength as the original equipment. When replacing tubing or hose, be sure that all of the original supports, clamps, or suspending devices are installed or replaced.
6. Replace any components that have stripped threads or damaged parts. Don't attempt to repair parts by machining.
7. Never exceed recommended air pressure.

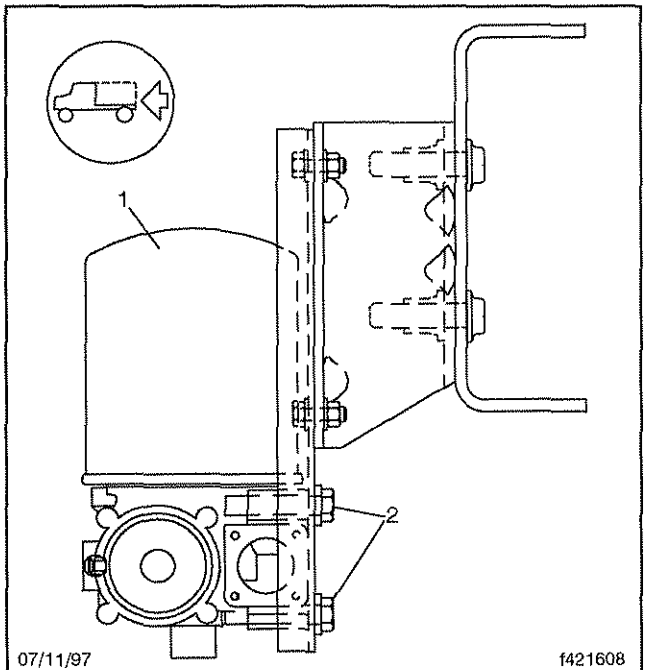
Air Dryer Removal and Installation

⚠ WARNING

Before starting the procedures below, read the information in Safety Precautions, 100. Failure to follow the safety precautions during service operations on the air brake system can cause personal injury.

Removal (See Fig. 1)

1. Drain the air system.
2. Disconnect the wiring harness from the air dryer.
3. Mark the air lines for later reference; then, disconnect them from the air dryer.
4. Remove the capscrews, washers, and spacers that attach the air dryer to the mounting bracket.
5. Remove the air dryer.



1. Desiccant Canister
2. 1/2" Capscrew, Washer, and Spacer

Fig. 1, Air Dryer Installation (outboard rail mounting shown)

Installation (See Fig. 1)

1. Position the air dryer on the mounting bracket. Install the spacers, washers, and capscrews. Tighten them 22 to 30 lbf·ft (30 to 41 N·m).
2. Make sure the air lines are clean. Replace any line or fitting that is crimped or damaged.
3. Connect the remaining air lines to the air dryer as previously marked. Tighten the nut on each fitting finger-tight. Then, using two wrenches to prevent twisting the hose, further tighten the nut until there is firm resistance.
4. Connect the air dryer wiring harness.

Replacement

⚠ WARNING

Before starting the procedures below, read the information in Safety Precautions, 100. Failure to follow the safety precautions during service operations on the air brake system can cause personal injury.

1. Drain the air system.
2. Remove the snap ring at the bottom of the valve assembly. The valve cover and spring may fall out of the cavity when the snap ring is removed. See **Fig. 1**.
3. Using a strap wrench, turn the desiccant cartridge counterclockwise and remove it.
4. Using a wooden stick, push the piston, spring, and the cover out of the valve cavity.
5. Clean the valve cavity with a commercial cleaning solvent.
6. Install new O-rings on the piston and the cover.

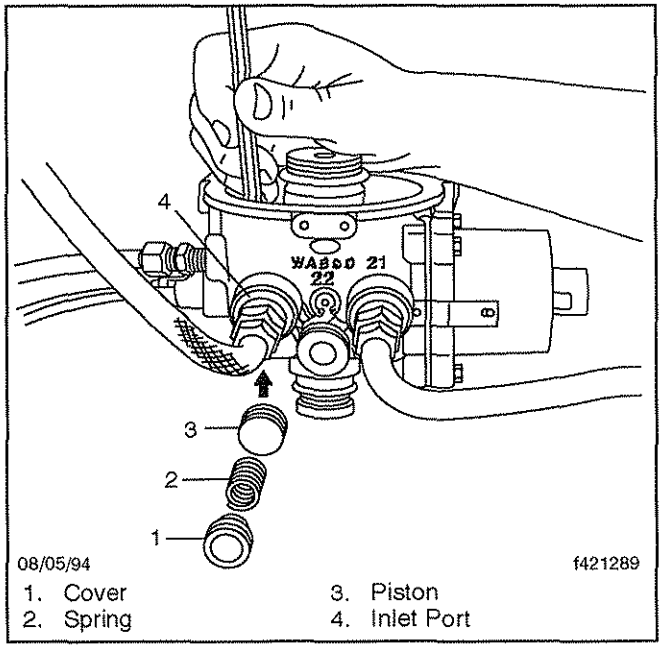


Fig. 1, Push the Piston, Spring, and Cover out of the Valve Cavity.

7. Using a multipurpose, high-temperature grease that resists water, steam, and alkali, lightly coat the surfaces of the new O-rings and the valve cavity.
8. Install the new piston with its hollow side facing out.

IMPORTANT: If the valve cavity is damaged, preventing a tight seal, replace the air dryer.

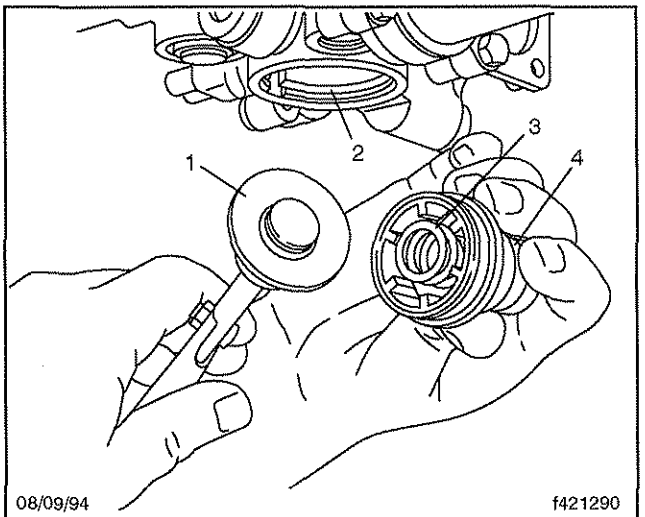
9. Install the new spring, cover, and snap ring to hold the components in place.
10. Thread the desiccant cartridge onto the dryer base (turn clockwise). When the seal contacts the base, tighten the cartridge one complete turn more. Do not over tighten.

Replacement (See Fig. 1)

⚠ WARNING

Before starting the procedures below, read the information in Safety Precautions, 100. Failure to follow the safety precautions during service operations on the air brake system can cause personal injury.

1. Drain the air system.
2. Remove the snap ring, valve head, and the spring from the exhaust port.
3. Pull the valve assembly out of the exhaust port.
4. Remove the O-ring from the base of the exhaust port.
5. Clean the purge valve cavity area with a commercial cleaning solvent.
6. Using a multipurpose, high-temperature grease that resists water, steam, and alkali, lightly coat the surfaces of the valve cavity and to all of the new O-rings. Install the O-rings in the base of the exhaust port and on the valve head.



1. Valve Assembly
2. Exhaust Port
3. Spring
4. Valve Head

Fig. 1, Remove the Valve Assembly

7. Position the new valve assembly in the valve cavity.

IMPORTANT: If the valve cavity is damaged, preventing a tight seal, replace the air dryer.

8. Install the spring in the valve head, and position them in the valve cavity.
9. Install the snap ring to secure the valve head in position.

Outlet Check Valve Assembly Replacement

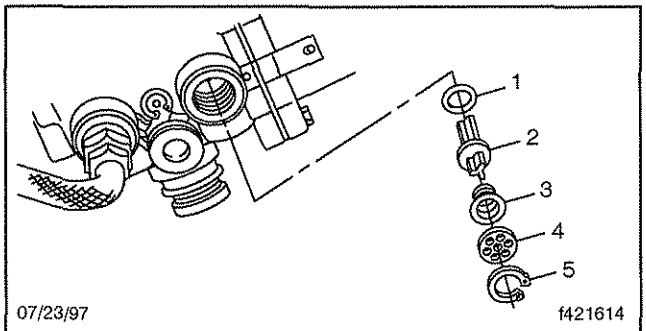
Replacement (See Fig. 1)

⚠ WARNING

Before starting the procedures below, read the information in Safety Precautions, 100. Failure to follow the safety precautions during service operations on the air brake system can cause personal injury.

1. Drain the air system.
2. Disconnect the air line from the outlet port.
3. Remove the snap ring, washer, valve body, and the O-ring.
4. Clean the cavity area with a commercial cleaning solvent.
5. Install a new O-ring on the valve body.
6. Using a multipurpose, high-temperature grease that resists water, steam, and alkali, lightly coat the surfaces of the new O-ring and the valve cavity.
7. Install the new valve body. Make sure that the long end of the body is inserted first into the valve cavity.
8. Install the new spring with its small end around the "Y" shaped fins on the valve body.

IMPORTANT: If the valve cavity is damaged, preventing a tight seal, replace the air dryer.



1. O-Ring
2. Valve Body
3. Spring
4. Washer
5. Snap Ring

Fig. 1, Outlet Check Valve Assembly

9. Install a new washer and snap ring to secure the assembly in the valve cavity.
10. Connect the air line to the outlet port. Tighten the nut on the fitting finger-tight. Then, using two wrenches to prevent twisting the hose, further tighten the nut until there is firm resistance. Tighten the nut one-sixth turn more.

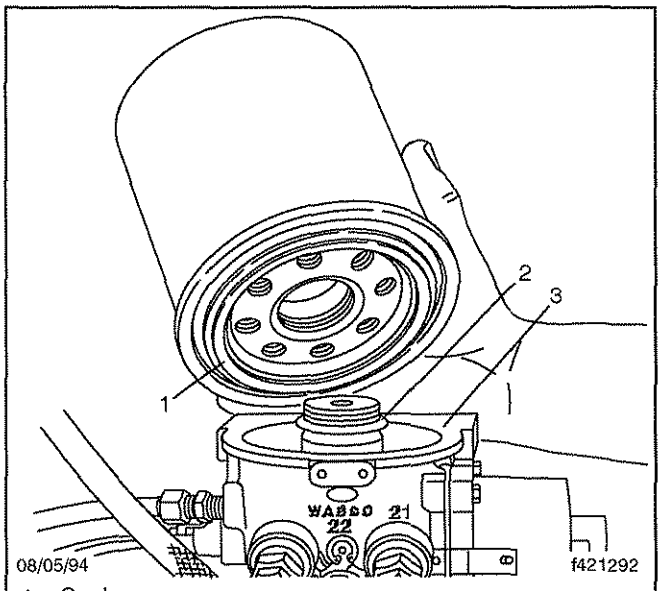
Replacement (See Fig. 1)

⚠ WARNING

Before starting the procedures below, read the information in Safety Precautions, 100. Failure to follow the safety precautions during service operations on the air brake system can cause personal injury.

1. Drain the air system.
2. Using a strap wrench, turn the desiccant cartridge counterclockwise and remove it.
3. Remove and discard the O-ring.
4. Clean the top surface of the dryer base with a commercial cleaning solvent.
5. Using a multipurpose, high-temperature grease that resists water, steam, and alkali, lightly coat the surfaces of the new O-ring and the dryer base. Install the O-ring.
6. Thread the desiccant cartridge onto the dryer base (turn clockwise). When the seal contacts the base, tighten the cartridge one complete turn more. Do not over tighten.

IMPORTANT: If the air dryer base is damaged, preventing a tight seal, replace the air dryer.



1. Seal
2. O-Ring
3. Air Dryer Base

Fig. 1, Desicant Cartridge Replacement

Replacement (See Fig. 1)

⚠ WARNING

Before starting the procedures below, read the information in Safety Precautions, 100. Failure to follow the safety precautions during service operations on the air brake system can cause personal injury.

1. Drain the air system.
2. Disconnect the wiring harness.
3. Remove the screws that attach the heater/thermostat receptacle. Remove the receptacle and the O-ring.
4. Remove the retaining screw that holds the assembly in place. Remove and discard the heater/thermostat assembly.
5. Clean the heater/thermostat assembly area with a commercial cleaning solvent.
6. Position the new heater/thermostat assembly in the cavity. Install the retaining screw.
7. Position the new receptacle and O-ring, and install the screws. Tighten the screws securely.
8. Connect the wiring harness.

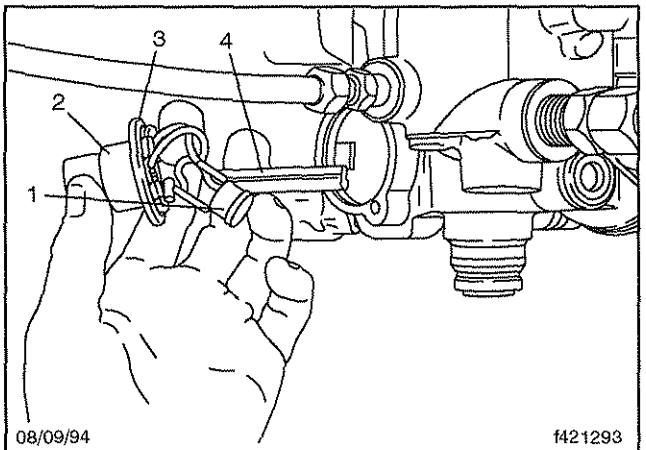


Fig. 1, Heater/Thermostat Replacement

Replacement (See Fig. 1)

⚠ WARNING

Before starting the procedures below, read the information in Safety Precautions, 100. Failure to follow the safety precautions during service operations on the air brake system can cause personal injury.

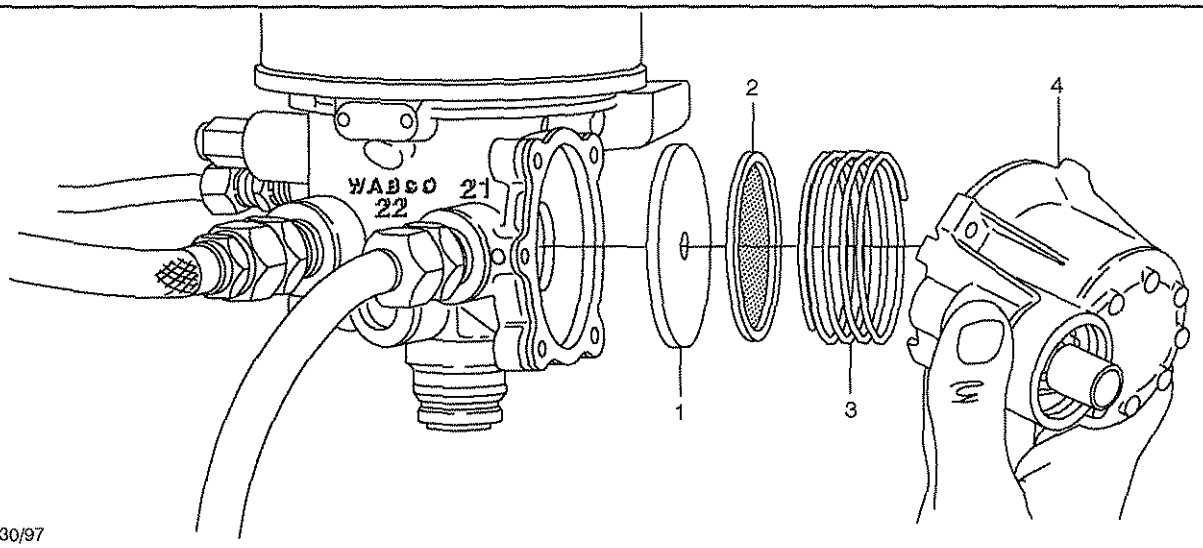
1. Drain the air system.

NOTE: When the valve housing is removed, the spring and the retainer will fall out of the housing.

2. Remove the four mounting bolts and remove the valve housing assembly.
3. Remove the rubber diaphragm.
4. Clean the groove where the diaphragm lip fits with a commercial cleaning solvent.
5. Install a new diaphragm with its lip in the groove.

IMPORTANT: If the groove is damaged, preventing a tight seal, replace the air dryer.

6. Install the new spring and retainer (with the retainer lip facing out).
7. Position the valve housing on the air dryer. Install the bolts and tighten them to 53 lbf·in (600 N·cm).



1. Diaphragm
2. Retainer
3. Spring
4. Valve Housing Assembly

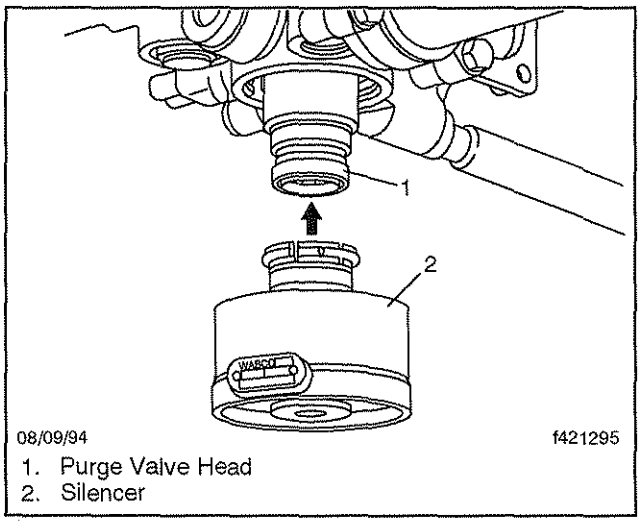
Fig. 1, Regeneration Valve Assembly

Replacement (See Fig. 1)

⚠ WARNING

Before starting the procedures below, read the information in Safety Precautions, 100. Failure to follow the safety precautions during service operations on the air brake system can cause personal injury.

1. Using snap ring pliers, expand the snap ring and pull the silencer off of the purge valve head.
2. Push the new silencer onto the purge valve head until the silencer snaps into place.



1. Purge Valve Head
2. Silencer

Fig. 1, Silencer Replacement

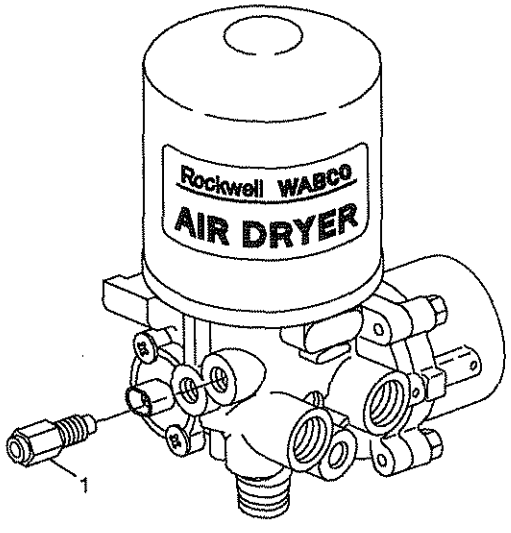
Replacement (See Fig. 1)

⚠ WARNING

Before starting the procedures below, read the information in Safety Precautions, 100. Failure to follow the safety precautions during service operations on the air brake system can cause personal injury.

1. Drain the air system.
2. Unscrew and remove the old valve from the dryer.
3. Screw the replacement valve into the dryer base. Do not exceed a torque of 30 lbf·ft (41 N·m) for a 3/8 inch thread, or 65 lbf·ft (88 N·m) for 1/2 inch thread.

NOTE: The threads on the replacement pressure relief valve provided by Rockwell WABCO are coated with sealant. They do not require any additional sealant.



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1. Pressure Relief Valve

Fig. 1, Pressure Relief Valve Replacement

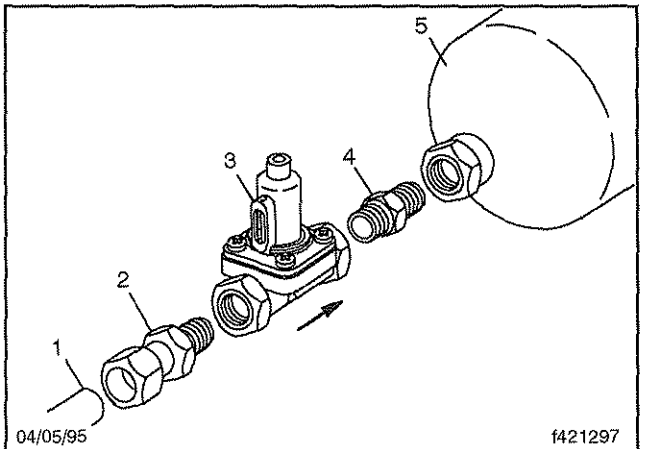
Replacement (See Fig. 1)

⚠ WARNING

Before starting the procedures below, read the information in Safety Precautions, 100. Failure to follow the safety precautions during service operations on the air brake system can cause personal injury.

1. Drain the air system.
2. Disconnect the air line from the pressure-controlled check valve.
3. Remove the valve and the hex nipple fitting from the air tank .
4. Install the pipe fitting on the new valve.
5. Install the new valve on the air tank with the arrow on the valve pointing towards the tank.
6. Apply liquid Loctite® Hydraulic Sealant (brown), or an equivalent, to the air line threads. Connect the air line to the valve. Tighten the air line securely.

NOTE: Always apply sealant to the external threads so that any excess will be scraped off externally rather that internally to the joint.



1. Air Line
2. Nylon Tube Connector
3. Pressure-Controlled Check Valve
4. Hex Nipple Pipe Fitting
5. Air Tank

Fig. 1, Check Valve Assembly Replacement

Operating Tests

⚠ WARNING

Before starting the procedures below, read the information in Safety Precautions, 100. Failure to follow the safety precautions during service operations on the air brake system can cause personal injury.

AIR DRYER OPERATING CHECK

1. Drain the air system.
2. Start the engine and build the air pressure to as close to cutout pressure as possible (about 125 psi [162 kPa]).
3. When the compressor reaches the unload cycle, the air dryer purges, beginning regeneration of the air dryer.
4. During the purge cycle, which lasts about 10 to 15 seconds, the wet tank and system tank sith pressure-controlled check valve will drop about 10 psi (69 kPa). Check the system air gauge in the cab dash panel.
5. If the gauge needle does not show a pressure drop of about 10 psi (69 kPa), one of the following problems may exist.
   - A pressure-controlled check valve is not installed.
   - The pressure-controlled check valve is installed in the wrong air tank.
   - The pressure-controlled check valve is installed on a one-way check valve, instead of in place of a one-way check valve.
   - There is an extra check valve located somewhere between the air dryer and the secondary air tank (usually at the wet tank).
   - The system air gauge is not plumbed to the correct air system.
6. If system air pressure drops 15 psi (103 kPa) or more during the purge cycle, and there are no other air-operated components in use, then there are air leaks or other system problems. Refer to **Troubleshooting, 300** for other possible causes.

PRESSURE-CONTROL CHECK VALVE OPERATING CHECK

IMPORTANT: Install a calibrated air gauge (accurate to within 1 psi [7 kPa]) in the system air tank with the pressure-controlled check valve to check the valve. Do not use the cab air gauges.

1. Start the engine and build the air pressure to as close to cutout pressure as possible (about 125 psi [862 kPa]).
2. Stop the engine after the air compressor has unloaded.
3. Drain the opposite system air tank(s) down to about 80 psi (552 kPa).
4. Check the calibrated air gauge. It should read 95 ± 5 psi (655 ± 34 kPa).

   If the gauge reading is less that 85 psi (586 kPa), either the pressure-control check valve is installed backwards, it is damaged, or there are air leaks in the system tank air system.

   If the gauge reading does not change, or the reading does not fall below 105 psi (724 kPa), make the checks under "Air Dryer Operating Check." If none of those problems exist, replace the control valve.

Troubleshooting Tables

Problem—Purge Cycle is too Long (more than 30 seconds)

Problem—Purge Cycle is too Long (more than 30 seconds)	
Possible Cause	**Remedy**
The air dryer outlet check valve is stuck open.	Replace the check valve assembly.
The turbocharger cutoff valve is leaking.	Replace the turbocharger cutoff valve.
The regeneration valve is not working correctly.	Replace the regeneration valve.

Problem—Purge Cycle is too Short (less than 8 seconds)

Problem—Purge Cycle is too Short (less than 8 seconds)	
Possible Cause	**Remedy**
The air governor is not working.	Replace the air governor.
The pressure-control check valve is not working correctly.	Replace the pressure-control check valve.
The regeneration valve is not working correctly.	Replace the regeneration valve.

Problem—System Air Pressure Drops Rapidly

Problem—System Air Pressure Drops Rapidly	
Possible Cause	**Remedy**
Fittings are loose or damaged.	Tighten or replace loose or damaged fittings.
Air reservoir, tubing, or hoses are damaged.	Repair or replace damaged items.
The air dryer outlet check valve is stuck open.	Clean or replace the outlet check valve assembly.

Problem—Excessive Cycling of the Air Dryer

Problem—Excessive Cycling of the Air Dryer	
Possible Cause	**Remedy**
Fittings are loose or damaged.	Tighten or replace loose or damaged fittings.
Air reservoir, tubing, or hoses are damaged.	Repair or replace damaged items.
The air dryer outlet check valve is leaking or stuck open.	Replace the outlet check valve assembly.

Troubleshooting

Problem—Excessive Cycling of the Air Dryer	
Possible Cause	**Remedy**
High air usage or demand for a particular system.	Increase air system capacity or reduce air demand.
The governor is not working properly.	Replace the air governor.
The air compressor needs to be serviced or replaced.	Rebuild or replace the air compressor.

Problem—Water and/or Oil in the Vehicle Air Reservoirs

Problem—Water and/or Oil in the Vehicle Air Reservoirs	
Possible Cause	**Remedy**
The desiccant cartridge contains excessive contaminants.	Replace the desiccant cartridge.
Purge cycle is too short.	Refer to "Problem—Purge Cycle is too Short (less than 8 seconds)."
The pressure relief valve is leaking.	Replace the pressure relief valve.
Too much oil is pumped from the air compressor.	Rebuild or replace the air compressor.
The regeneration valve is not working correctly.	Replace the regeneration valve.
The air dryer is mounted too close to a heat source.	Locate the air dryer away from heat sources and where air can flow around it.
Discharge line is of improper length or material.	Discharge line must consist of at least 6 ft. (1.8 m) of wire braid Teflon hose, copper tubing, or a combination of both between the discharge port of the compressor and the air dryer supply port. Discharge line lengths and inside diameter requirements are dependent on the vehicle application. Contact your local Rockwell WABCO representative for further information.

Problem—The Air Compressor Runs Continuously (System Pressure Will Not Build Up)

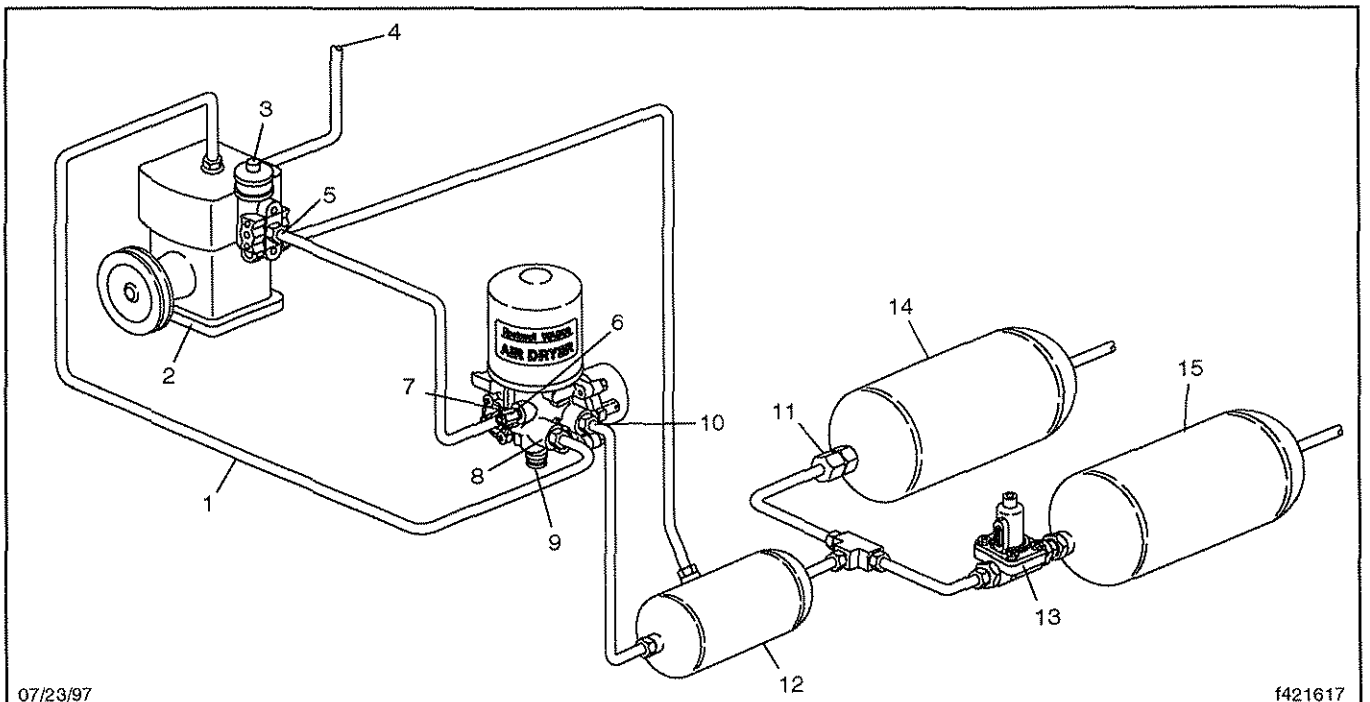
Problem—The Air Compressor Runs Continuously (System Pressure Will Not Build Up)	
Possible Cause	**Remedy**
Fittings are loose or damaged.	Tighten or replace loose or damaged fittings.
Air reservoir, tubing, or hoses are damaged.	Repair or replace damaged items.
The air compressor needs to be serviced or replaced.	Rebuild or replace the air compressor.
The purge valve is stuck open.	Replace the purge valve.
The line between the air compressor and the air dryer is blocked, leaks, or is plumbed incorrectly.	Repair or replace the line as needed.
The governor is not working properly.	Replace the air governor.

Problem—The Air Compressor Runs Continuously (System Pressure Will Not Build Up)	
Possible Cause	**Remedy**
The turbocharger cutoff valve or the outlet check valve is stuck in the closed position.	Replace the turbocharger cutoff valve or the outlet check valve.
The desiccant cartridge or cartridge seal is leaking.	Tighten or replace the desiccant cartridge.
The wrong air line is connected to port 4 on the air dryer.	Correct the air line plumbing.
The air dryer outlet port is plumbed incorrectly.	Connect the outlet port line to the supply air tank.
The air dryer base is cracked.	Replace the air dryer.

Problem—The Air Dryer Does Not Unload When the Air Compressor Goes Into Standby Mode

Problem—The Air Dryer Does Not Unload When the Air Compressor Goes Into Standby Mode	
Possible Cause	**Remedy**
The line between the air governor and the air dryer purge port is missing, loose, or damaged.	Install or replace the air line, or tighten the fittings.
The heater/thermostat assembly is not working.	Replace the heater/thermostat assembly or check the electrical connections.

See **Fig. 1** for the plumbing diagram.



1. Compressor Discharge Line
2. Air Compressor
3. Air Governor
4. Compressor Intake Line
5. Unloader Port
6. Pressure Relief Valve
7. Air Governor Port
8. Air Dryer Inlet
9. Purge Valve
10. Air Dryer Outlet
11. Check Valve
12. Supply Tank
13. Pressure-Control Check Valve
14. System Reservoir
15. System Reservoir

Fig. 1, Air Dryer Plumbing Diagram

Contents

Subject	Subject Number
General Information	050
Service Operations	
Safety Precautions	100
Air Dryer Replacement	110
Desiccant Cartridge Replacement	120
Delivery Check Valve and Governor Replacement	130
Purge Valve Replacement	140
Heater and Thermostat Replacement	150
Air Rerservoir Replacement	160
Operational Tests	170
Troubleshooting	300

General Information (See Fig. 1)

The function of the dryer reservoir module (DRM) is to provide the vehicle with an integrated air dryer, secondary reservoir, purge volume, and governor.

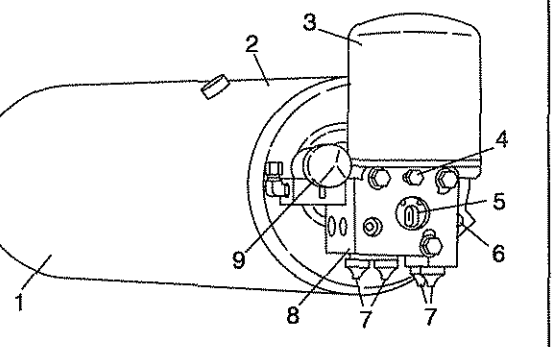
Principles of Operation

The air dryer collects and removes air system contaminants in solid, liquid, and vapor form before they enter the brake system. It provides clean, dry air to the components of the brake system which increases the life of the system.

CHARGE CYCLE (See Fig. 2)

When the compressor is loaded, compressed air, oil, oil vapor, water, and water vapor flow through the compressor discharge line to the supply port of the air dryer body.

As air travels through the air dryer assembly, its temperature falls, causing some of the contaminants to condense and drop to the bottom of the air dryer assembly, ready to be expelled at the next purge cycle.



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1. Secondary Reservoir
2. Integrated Purge Volume
3. Desiccant Cartridge
4. Safety Valve
5. Heater/Thermostat Assembly
6. Auxiliary Delivery Port
7. Pressure Protection Valves
8. AD-IS Air Dryer
9. Governor

Fig. 1, Dryer Reservoir Module

The air then flows into the desiccant cartridge. Once in the desiccant cartridge, air flows through an oil separator which removes oil and solid contaminants.

Air then flows into the desiccant drying bed. Air flowing through the desiccant becomes progressively dryer as water vapor adheres to the desiccant material.

Dry air exits the bottom of the desiccant cartridge and flows through the center of the base assembly. The air then flows to the delivery check valve, to the safety valve and also through an orifice plug into the purge volume reservoir. Air traveling through the delivery check valve flows to the governor and two pressure protection valves.

As pressure builds during the initial charge, the purge volume fills. When the air pressure reaches 103 psi (710 kPa), the first pressure protection valve opens, filling the primary reservoir. When the primary reservoir pressure reaches 109 psi (752 kPa) the second pressure protection valve opens and air is supplied to the secondary reservoir and accessory pressure protection valves. When air pressure in the secondary reservoir reaches 55 and 85 psi (379 to 586 kPa) respectively, the two remaining pressure protection valves open and supply air to the accessories.

NOTE: There is no external air line from the air dryer to the secondary reservoir. Air is supplied by a line passing through the purge reservoir.

The air dryer will remain in the charge cycle until the air brake system pressure builds to the governor cutout setting of approximately 130 psi (896 kPa).

PURGE CYCLE (See Fig. 3)

When air brake system pressure reaches the cutout setting of the governor, the governor unloads the compressor and the purge cycle begins. When the governor unloads the compressor, it pressurizes the compressor unloader mechanism and the dryer control port. The purge piston moves in response to air pressure, causing the purge valve to open and the turbo cutoff valve to close. When the purge valve opens, water and contaminants are expelled. Air flowing through the desiccant cartridge changes direction and begins to flow toward the open purge valve. Oil and solid contaminants collected in the oil separator are removed by air flowing from the purge volume, through the desiccant drying bed, and out through the open purge valve.

General Information

The purge cycle lasts only a few seconds and is detected by an audible burst of air at the air dryer exhaust.

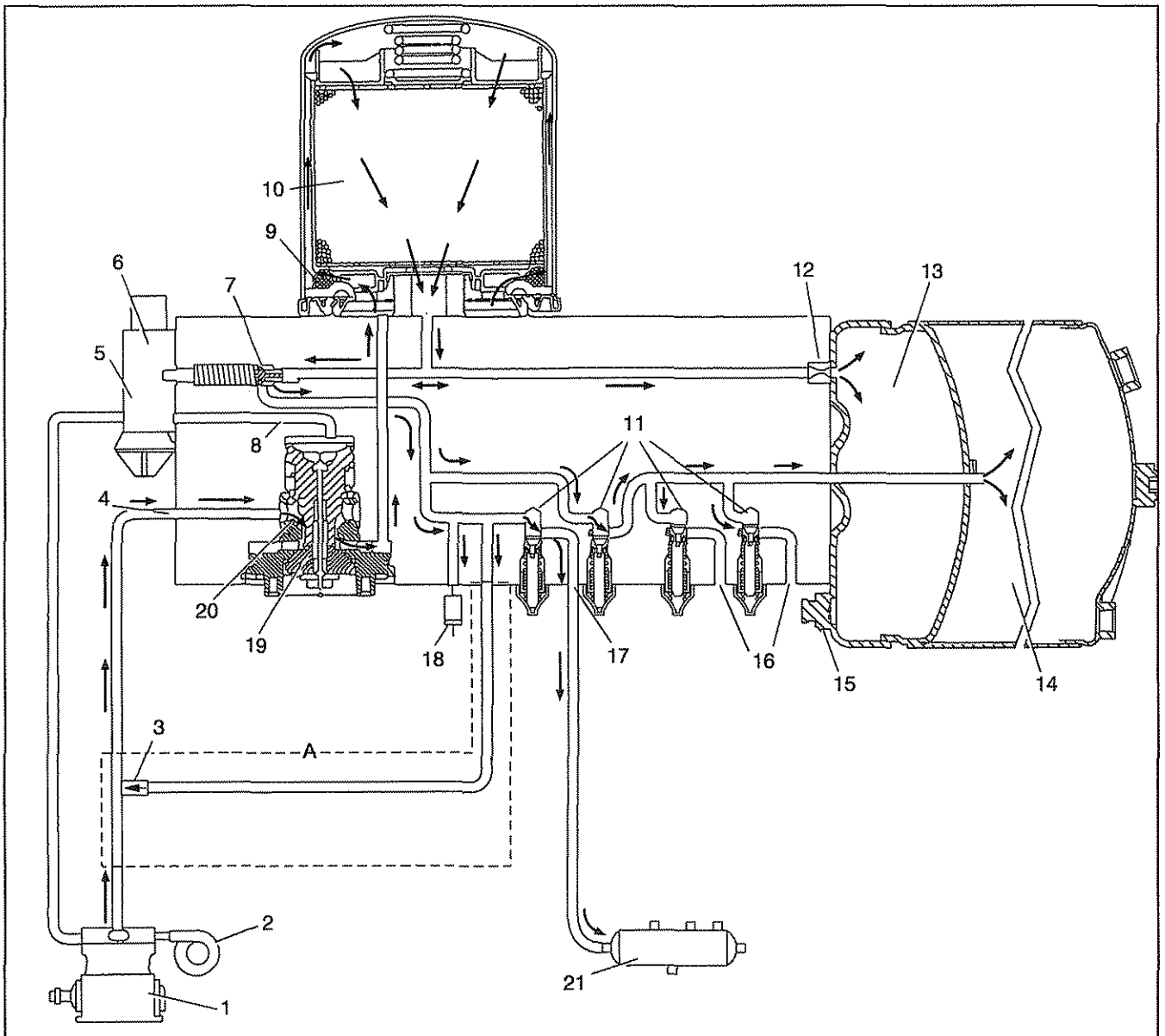
The reactivation of the desiccant drying bed begins as dry air flows from the purge volume, through the purge orifice, and into the desiccant bed. Pressurized air from the purge volume expands after passing through the purge orifice; its pressure is lowered and its volume is increased. The flow of dry air through the drying bed reactivates the desiccant material by removing the water vapor adhering to it. Approximately 30 seconds is required for the entire purge volume of a standard air dryer to flow through the desiccant dryer bed.

The delivery check valve assembly prevents air pressure in the brake system from returning to the air dryer during the purge cycle. After the purge cycle is complete, the air dryer is ready for the next charge cycle to begin.

Turbo Cutoff Feature

The primary function of the turbo cutoff valve is to prevent loss of turbocharger air pressure through the air dryer in systems where the compressor intake is connected to the engine turbocharger.

During the purge cycle, the downward travel of the purge piston is stopped when the turbo cutoff valve contacts its mating metal seat in the purge valve housing. With the turbo cutoff valve seated (closed position), air in the compressor discharge line and air dryer inlet port cannot enter the air dryer. This maintains turbocharger boost pressure to the engine.

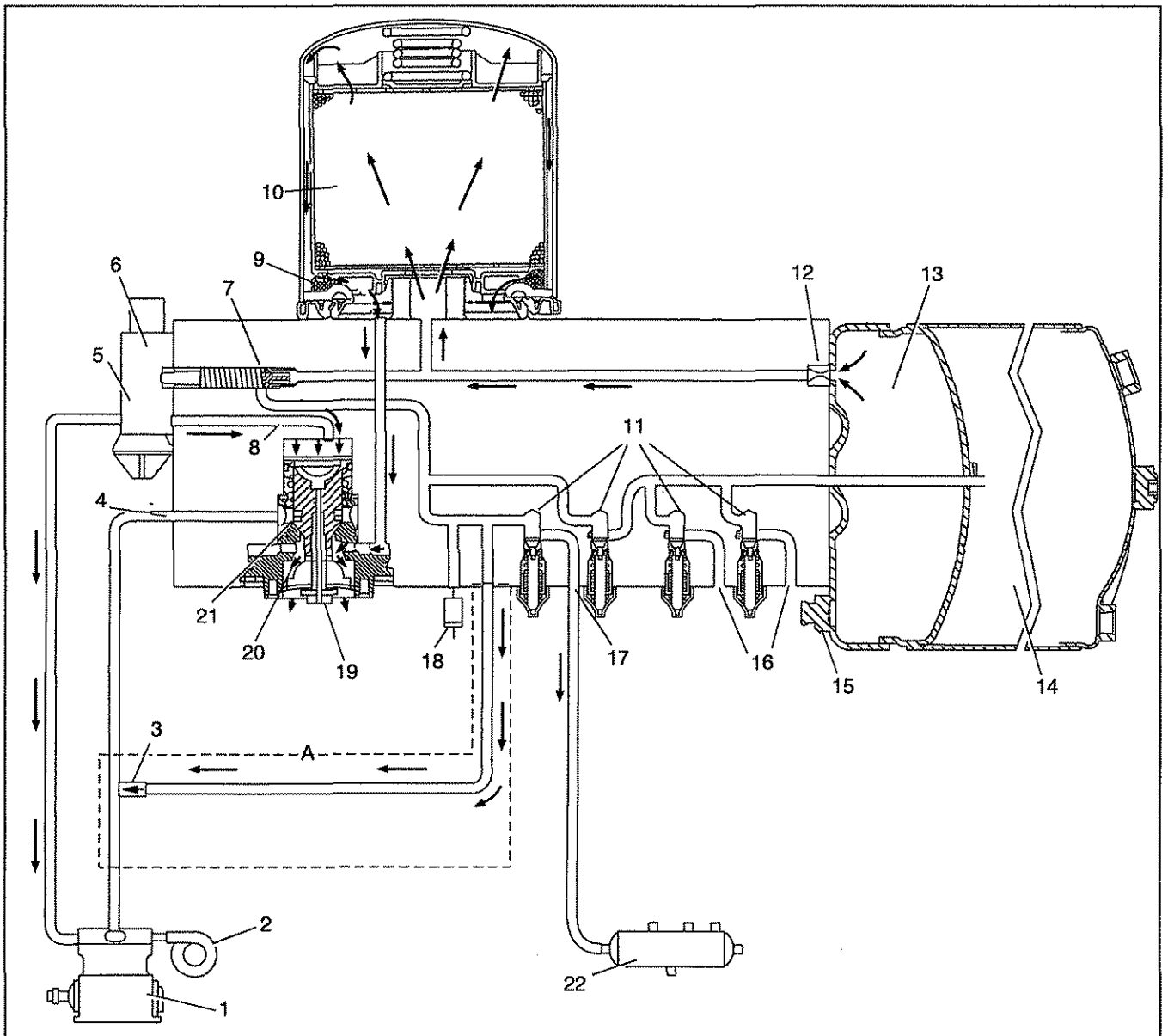


A. Feedback Line: Used only with Type E and QE Holset Compressors.

1. Compressor
2. Engine Turbo
3. Check Valve
4. Inlet Port
5. Unloader Port
6. Governor
7. Delivery Check Valve
8. Purge Control Line
9. Oil Separator
10. Desiccant Bed
11. Pressure Protection Valves
12. Purge Orifice
13. Purge Volume
14. Secondary Reservoir
15. Purge Volume Drain Cock
16. Auxiliary Ports
17. Primary Port
18. Safety Valve
19. Purge Valve (closed)
20. Turbo Cutoff Valve (open)
21. Primary Reservoir

Fig. 2, Air Dryer Charge Cycle

General Information



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13. Purge Volume
14. Secondary Reservoir
15. Purge Volume Drain Cock
16. Auxiliary Ports
17. Primary Port
18. Safety Valve
19. Exhaust
20. Purge Valve (open)
21. Turbo Cutoff Valve (closed)
22. Primary Reservoir

Fig. 3, Air Dryer Purge Cycle

Safety Precautions

When working on or around air brake systems and components, observe the following precautions:

A. Chock the tires and stop the engine before working under the vehicle. Releasing air from the system may cause the vehicle to roll. Keep hands away from brake chamber push rods and slack adjusters; they will apply as air pressure drops.

B. Never connect or disconnect a hose or line containing compressed air. It may whip as air escapes. Never remove a component or pipe plug unless you are certain all system pressure has been released.

C. Never exceed recommended air pressure and always wear safety glasses when working with compressed air. Never look into air jets or direct them at anyone.

D. Never attempt to disassemble a component until you have read and understood recommended procedures. Some components contain powerful springs and injury can result if not correctly disassembled. Use only correct tools and observe all precautions regarding use of those tools.

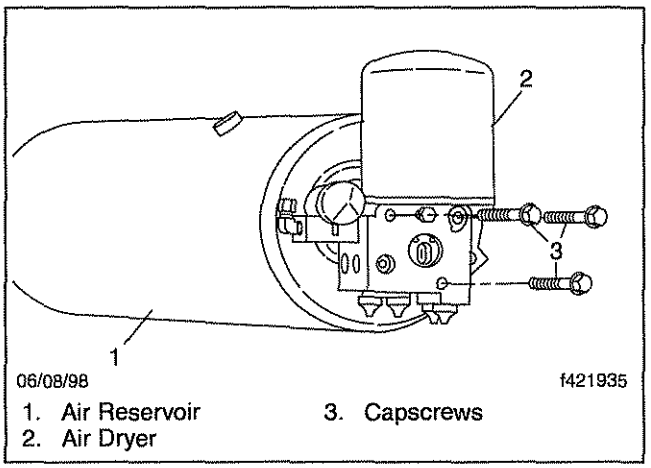
Replacement

IMPORTANT: Before working on or around air brake systems and components, see **Safety Precautions, 100**.

1. Park the vehicle on a level surface, shut down the engine, apply the parking brake, and chock the tires.
2. Drain the air reservoirs.
3. Mark and remove the air lines from the air reservoir.
4. Unplug the wiring harness from the heater/thermostat assembly.
5. Remove the three capscrews fastening the air dryer to the air reservoir. See **Fig. 1**.
6. Remove the air dryer.
7. Remove the governor and delivery check valve from the air dryer. For instructions, see **Subject 130**.
8. Remove the desiccant cartridge. For instructions, see **Subject 120**.

Installation

1. Install the delivery check valve and governor onto the air dryer. For instructions, see **Subject 130**.



1. Air Reservoir
2. Air Dryer
3. Capscrews

Fig. 1, Air Dryer Removal and Installation

2. If removed, install the desiccant cartridge. For instructions, see **Subject 120**.
3. Install the air dryer, making sure the two O-rings are installed between the air dryer and air reservoir. Use the three capscrews to fasten the air dryer to the reservoir. Tighten the capscrews 30 to 35 lbf·ft (41 to 47 N·m). See **Fig. 1**.
4. Connect the air lines and plug the wiring harness into the heater/thermostat assembly.
5. Perform the operational tests in **Subject 170**.

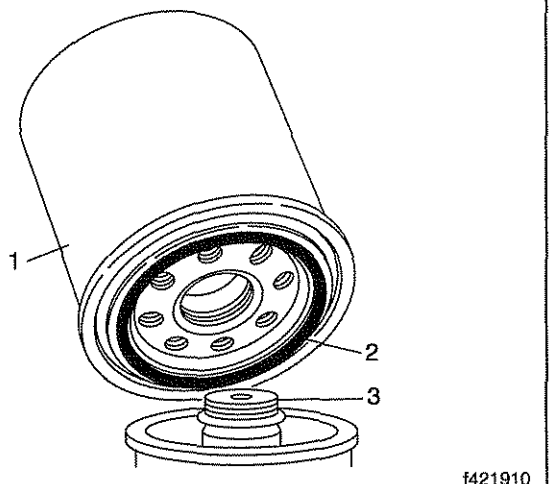
Replacement (See Fig. 1)

IMPORTANT: Before working on or around air brake systems and components, see **Safety Precautions, 100**.

1. Park the vehicle, shut down the engine, apply the parking brake, and chock the tires.
2. Drain the air reservoirs.
3. Using a strap wrench or equivalent, loosen the desiccant cartridge. Spin the cartridge off by hand and discard it.
4. On the new desiccant cartridge, lubricate the sealing rings with silicone grease.

IMPORTANT: Only use the silicone grease supplied with AlliedSignal replacement kits.

5. Screw the desiccant cartridge onto the body, by hand, until the seal makes contact with the body. Rotate the cartridge clockwise about one full turn. If necessary, use a strap wrench to tighten the cartridge.
6. Remove the chocks from the tires.



1. Desiccant Cartridge
2. Cartridge Sealing Ring
3. Threaded Base Post

Fig. 1, Desiccant Cartridge Replacement

Delivery Check Valve and Governor Replacement

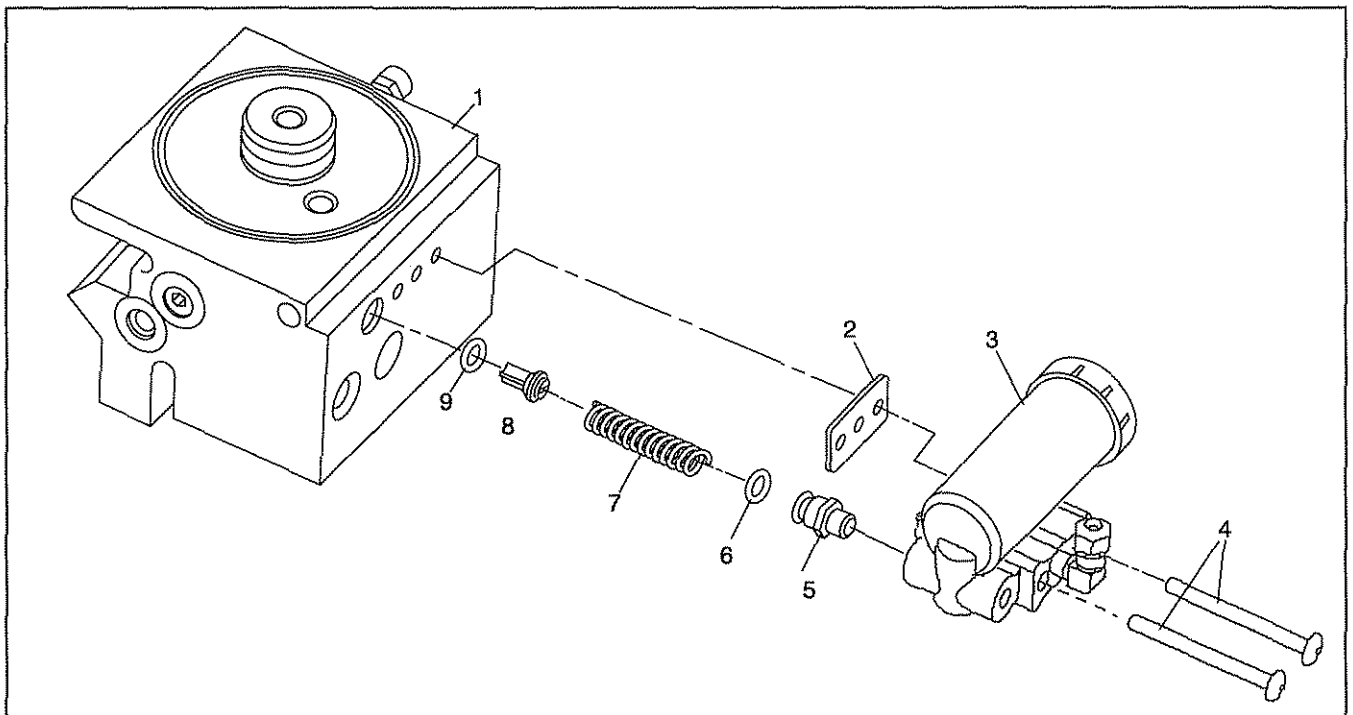
Replacement

IMPORTANT: Before working on or around air brake systems and components, see **Safety Precautions, 100**.

1. Park the vehicle on a level surface, shut down the engine, apply the parking brake, and chock the tires.
2. Drain the air reservoirs.
3. Disconnect the air line from the governor and mark it for later reference. Remove the capscrews attaching the governor to the air dryer.
4. Remove the governor, adaptor fitting, and the adaptor O-ring. Remove the governor gasket and discard.
5. Remove the spring and check valve.
6. Lubricate the new smaller O-ring and check valve body with silicone grease.

IMPORTANT: Only use the silicone grease supplied with AlliedSignal replacement kits.

7. Install the O-ring on the check valve body and push the O-ring down, over the longer set of three guide lands, until it is in the O-ring groove of the check valve body.
8. Install one end of the check valve spring over the check valve's shorter set of three guide lands. Turn the valve about 1/4 turn while holding the spring, if necessary, to secure the valve in place. Install the assembled check valve body, O-ring, and spring in the delivery port so the O-ring rests on its seat and the free end of the spring is visible.
9. Install the adaptor fitting into the governor. Using the silicone grease, lubricate the remaining larger O-ring, and install it into the groove of the adaptor. Install the gasket supplied in the kit. Install the governor and torque the capscrews 10 lbf·ft (14 N·m).



1. Air Dryer Base
2. Gasket
3. Governor
4. Capscrews
5. Adaptor
6. O-Ring
7. Spring
8. Check Valve Body
9. O-Ring

Fig. 1, Delivery Check Valve Replacement

Delivery Check Valve and Governor Replacement

10. Perform the operational tests in **Subject 170**.
11. Remove the chocks

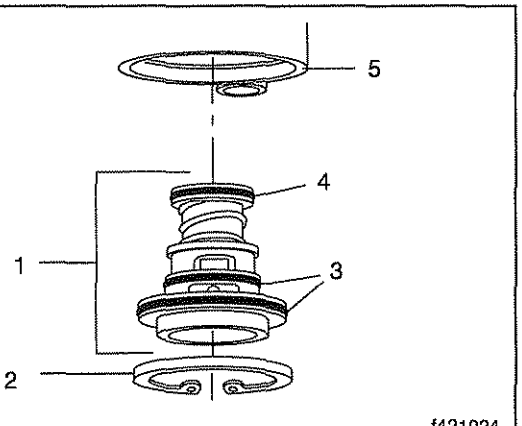
Replacement (See Fig. 1)

IMPORTANT: Before working on or around air brake systems and components, see **Safety Precautions, 100**.

1. Shut down the engine, apply the parking brake, and chock the tires.
2. Drain the vehicle air reservoirs.
3. Remove the purge valve assembly from the air dryer end cover.
   - 3.1 Remove and discard the snap ring that secures the purge valve assembly in the end cover.
   - 3.2 Remove the purge valve assembly.
4. Lubricate the new O-rings and O-ring grooves of the new purge valve assembly.
5. Lubricate the end cover bore of the new purge valve assembly.

IMPORTANT: Use only the silicone grease supplied with the AlliedSignal replacement kit.

6. Install the two new O-rings on the purge valve housing cover and the new quad-ring on the purge piston.



1. Purge Valve Assembly
2. Retaining Ring
3. O-Rings
4. Quad-Ring
5. Air Dryer

Fig. 1, Purge Valve Replacement

7. Install the new purge valve assembly in the end cover while making sure the purge valve housing is fully seated against the end cover.
8. Install the new retaining ring in its groove in the end cover.
9. Perform the operational tests in **Subject 170**.
10. Remove the chocks from the tires.

Heater and Thermostat Replacement

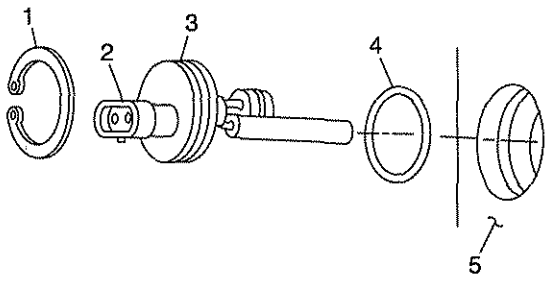
Replacement (See Fig. 1)

IMPORTANT: Before working on or around air brake systems and components, see **Safety Precautions, 100**.

1. Shut down the vehicle, apply the parking brake, and chock the tires.
2. Lift the lock tab on the vehicle wiring harness connector and disconnect it from the air dryer base.
3. Remove and discard the retaining ring that secures the heater and thermostat assembly in the air dryer body.
4. Carefully pull the heater and thermostat assembly straight out of the air dryer body and discard it.
5. Using the grease provided with the AlliedSignal replacement kit, lubricate the O-ring groove and O-ring of the new assembly with silicone grease.

IMPORTANT: Do not lubricate the heater stick or thermostat.

6. Install the O-ring on the heater/thermostat assembly. Then, slide the assembly into the air dryer body, making sure not to scrape insulation from the wires.



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1. Retaining Ring
2. Heater/Thermostat Connector Plug
3. Heater/Thermostat Assembly
4. O-Ring
5. Air Dryer Body

Fig. 1, Heater and Thermostat Assembly

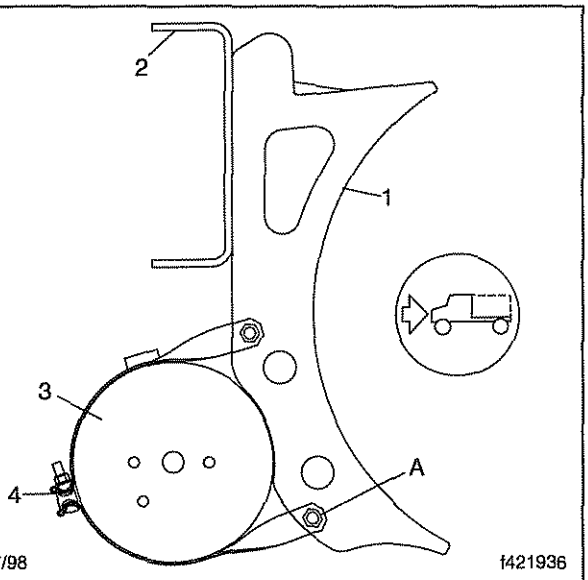
7. Install the retaining ring in the groove of the air dryer body, making certain that it is fully seated in the groove.
8. Remove the protective cover from the assembly.
9. Before proceeding, turn the ignition on without starting the engine. Make sure vehicle power is present at the contacts of the vehicle wire harness.
10. Remove the chocks from the tires.

Replacement

1. Shut down the engine, apply the parking brakes, and chock the tires.
2. Drain the air system.
3. Mark and disconnect all reservoir air lines and couplers for later assembly. Cap the exposed ports tightly to keep out contaminants. If access is limited, remove the components after removing the reservoir from its mount.
4. Remove the air dryer. For instructions, see **Subject 110**.

NOTE: Loosen the bottom strap fastener first. See **Fig.** .

5. Remove the reservoir strap fasteners. Remove the reservoir.
6. If access is limited, do the next step first. If not, place a new reservoir in the mount, and install the strap fasteners. Tighten the fasteners 30 to 40 lbf·ft (41 to 54 N·m). Tighten the lower strap fastener 136 lbf·ft (184 N·m).



A. Loosen this fastener.
1. Fuel Tank Bracket
2. Right Frame Rail
3. Air Reservoir
4. 3/8–16 Strap Fastener

Fig. 1, Air Reservoir, Fuel Tank Bracket Mounting

7. As marked earlier, connect all air lines and couplers to the new reservoir, removing the caps as each component is installed. Tighten the connections as instructed elsewhere in this group.

   Install the air dryer. For instructions, see **Subject 110**.
8. Perform operational test in **Subject 170**.
9. Remove the chocks from the tires.

Operational Tests

IMPORTANT: Before working on or around air brake systems and components, see **Safety Precautions, 100**.

1. Park the vehicle, shut down the engine, and chock the tires.
2. Install a pressure gauge in one of the spare governor ports labeled "RES."
3. Close all drain cocks and start the engine. Build the air system to governor cutout and shut down the engine.
4. Check all air lines and fittings leading to and from the air dryer for leakage. Note the pressure on the air gauge after the governor cutout pressure is reached, a rapid loss of pressure could indicate a leaking delivery port check valve or turbo cut-off valve.
5. To check for delivery check valve leakage, allow the system air pressure to charge and listen for the air dryer to purge. The purge should last about 30 seconds.
6. Gradually open the drain cock on the purge tank and exhaust any residual pressure.
7. Coat the drain cock with a soap solution. If leakage does not exceed a 1-inch (25.4-mm) bubble in 1 second, no further tests are needed. Remove the chocks from the tires.

   If leakage does exceed a 1-inch (25.4-mm) bubble in one second, proceed with the following step.
8. Apply the brakes a few times, bring the air pressure to a point below governor cut-in (about 95 psi [655 kPa]). The governor will then signal the end of the purge cycle, closing the turbo cut-off valve. Allow any delivery line air pressure to drain, then check again for leakage at the purge tank drain cock. If excessive leakage has stopped, the turbo cut-off valve should be checked.

NOTE: If after replacing the delivery check valve, rapid loss of system air pressure continues, the delivery check valve and turbo cut-off valve are still leaking. Check the valves.

9. Check the operation of the end cover heater and thermostat assembly during cold weather operation as follows:

   9.1 Check the electric power to the air dryer. With the ignition or engine kill switch in the ON position, check for voltage to the heater and thermostat assembly using a voltmeter or test-light. Unplug the electrical connector at the air dryer and place the test leads on each of the connections of the female connector on the vehicle power lead. If there is no voltage, look for a blown fuse, broken wires, or corrosion in the vehicle wiring harness. Check to see if a good ground path exists.

   9.2 Test the thermostat and heater operation. Turn off the ignition switch and cool the thermostat and heater assembly to below 40°F (4°C). Using an ohmmeter, check the resistance between the electrical pins in the air dryer connector half. The resistance should be 1.5 to 3.0 ohms for the 12-volt heater assembly and 6 to 9 ohms for the 24-volt heater assembly.

   Warm the thermostat and heater assembly to about 90°F (32°C) and check the resistance again. The resistance should exceed 1000 ohms. If the resistance values obtained are within the stated limits, the thermostat and heater assembly is operating properly. If the resistance values obtained are outside the stated limits, replace the heater and thermostat assembly. For instructions, see **Subject 150**.
10. Check the pressure protection valves. Observe the pressure gauges of the vehicle as system pressure builds from zero. The primary gauge should rise until it reaches approximately 109 psi (752 kPa), then level off as the second pressure protection valve opens and allow the secondary volume to build. When the secondary pressure gauge passes through approximately 55 and 85 psi (379 and 586 kPa) there should be an associated leveling off of pressure as the third and fourth pressure protection valves open. Then, both the primary and secondary gauges should reach their full pressure of about 130 psi (896 kPa)
11. Remove the chocks.

Troubleshooting Tables

Problem—Air Dryer is Constantly Purging (Cycling)

Problem—Air Dryer is Constantly Purging (Cycling) or Purging Excessively	
Possible Cause	**Remedy**
There is excessive system leakage.	Using a soap and water solution, test for leakage at the air line fittings, drain cock (or valve), and the safety valve in the primary reservoir. Repair or replace as necessary. NOTE: A drop of 3 psi (21 kPa) in system air pressure per minute is normal.
The application air lines are leaking excessively.	Check the application air line, brake valve, and the service and parking brake chambers for air leaks. Repair or replace the damaged component(s).
The delivery check valve leaking excessively	Replace the Check Valve. See **Subject 130.**
The compressor unloader O-rings are leaking excessively	Troubleshoot the compressor. See **Group 13.**

Problem—There is Water in the Air Reservoirs

Problem—There is Water in the Air Reservoirs	
Possible Cause	**Remedy**
Maximum air dryer inlet temperature is exceeded due to improper discharge line length or improper line material.	Check the length of the air lines. The lines should not have excessive slack. If excessive slack exists in any air lines, replace the lines. For instructions, see **Section 42.13.**
The air dryer is not purging.	See **Problem—System Will Not Charge**
Purge time is insufficient due to excessive system leakage.	See **Problem—Air Dryer is Constantly Purging (Cycling)**
The air by-passes the desiccant cartridge assembly.	If the vehicle uses a Holset compressor, inspect the feedback check valve for proper installation and operation.
The compressor is running loaded for long periods of time.	Check the vehicle air system for leakage.
The desiccant cartridge requires replacement	Replace the desiccant cartridge. See **Subject 120.**

Problem—Safety Valve on the Air Dryer is Exhausting Air

Problem—Safety Valve on the Air Dryer is Exhausting Air	
Possible Cause	**Remedy**
There is a defective delivery check valve in the end cover of the air dryer.	Test to determine if air is passing through the check valve. Repair or replace the check valve. For replacement, see **Subject 130.**
The air system pressure is over 140 psi (965 kPa).	Replace the governor.
The safety valve setting is too low.	Replace the safety valve.

Troubleshooting

Problem—Constant Exhaust of Air at the Air Dryer Purge Valve

Problem—Constant Exhaust of Air at the Air Dryer Purge Valve	
Possible Cause	**Remedy**
The air dryer purge valve is leaking excessively.	Test for leakage. With the compressor loaded, apply soap solution on the purge valve exhaust. If necessary, replace the purge valve. For instructions, see **Subject 140**.
The governor is defective.	Check the governor for proper "cut-in" and "cut-out" pressure, and excessive leakage in both positions. Repair or Replace the governor. For replacement instructions, see **Section 13.01**.
The purge valve is frozen open. The heater and thermostat, wiring, or blown fuse.	Perform the heater operating test in **Subject 160**.
There is excessive system leakage.	See **Problem—Air Dryer is Constantly Purging (Cycling)**
The air dryer delivery check valve is defective.	See **Problem—Air Dryer is Constantly Purging (Cycling)**
The turbo cutoff valve is leaking.	Repair or replace the turbo cutoff valve. For instructions, see **Subject 140**.
The purge valve control piston is leaking.	Repair or replace the purge valve. For instructions, see **Subject 140**.

Problem—The Air System Will Not Charge

Problem—The Air System Will Not Charge	
Possible Cause	**Remedy**
The inlet and outlet air connections are reversed.	Connect the compressor discharge to the air dryer supply port. Reconnect the lines properly.
Kinked or blocked discharge line.	Check to determine if air passes through the discharge line. Check for kinks, bends, excessive carbon deposits, or ice blockage.
There are excessive bends in the discharge line (water collects and freezes).	The discharge line should be constantly sloping from the compressor to the air dryer with as few bends as possible.
The turbo cutoff valve is stuck closed.	Repair or replace the turbo cutoff valve. For instructions, see **Subject 140**.
The purge valve is leaking excessively.	Repair or replace the purge valve. For instructions, see **Subject 140**.

Problem—The Air Dryer Does Not Purge or Exhaust Air

Problem—The Air Dryer Does Not Purge or Exhaust Air	
Possible Cause	**Remedy**
The governor adaptor is plugged.	Test to determine if air flows through the purge control port when the compressor is unloaded. Check for adaptor obstruction. See **Problem—Constant Exhaust of Air at the Air Dryer Purge Valve**
The air dryer purge valve is faulty.	If air is flowing through the purge valve in the "Remedy" above, repair or replace the purge valve. For replacement instructions, see **Subject 140**.
There are excessive bends in the discharge line (water collects and freezes).	The discharge line should be constantly sloping from the compressor to the air dryer with as few bends as possible.

Problem—The Air Dryer Does Not Purge or Exhaust Air	
Possible Cause	**Remedy**
The governor is defective.	Check the governor for proper "cut-in" and "cut-out" pressure, and excessive leakage in both positions. Repair or Replace the governor. For replacement instructions, see **Section 13.01**.
The purge valve control piston is leaking.	Repair or replace the purge valve. For instructions, see **Subject 140**.

Problem—Desiccant Material is Being Expelled from the Air Dryer Purge Valve Exhaust

Problem—Desiccant Material is Being Expelled from the Air Dryer Purge Valve Exhaust	
Possible Cause	**Remedy**
The air dryer is not securely mounted.	Replace the air dryer. For instructions, see **Subject 110**.
The desiccant cartridge is saturated or malfunctioning.	Replace the air dryer. For instructions, see **Subject 110**.
The compressor is passing excessive oil.	Troubleshoot the compressor. See **Group 13**. If necessary, replace the air dryer. For instructions, see **Subject 110**.

Problem—"Pinging" Noise is Excessive During Compressor Loading Cycle

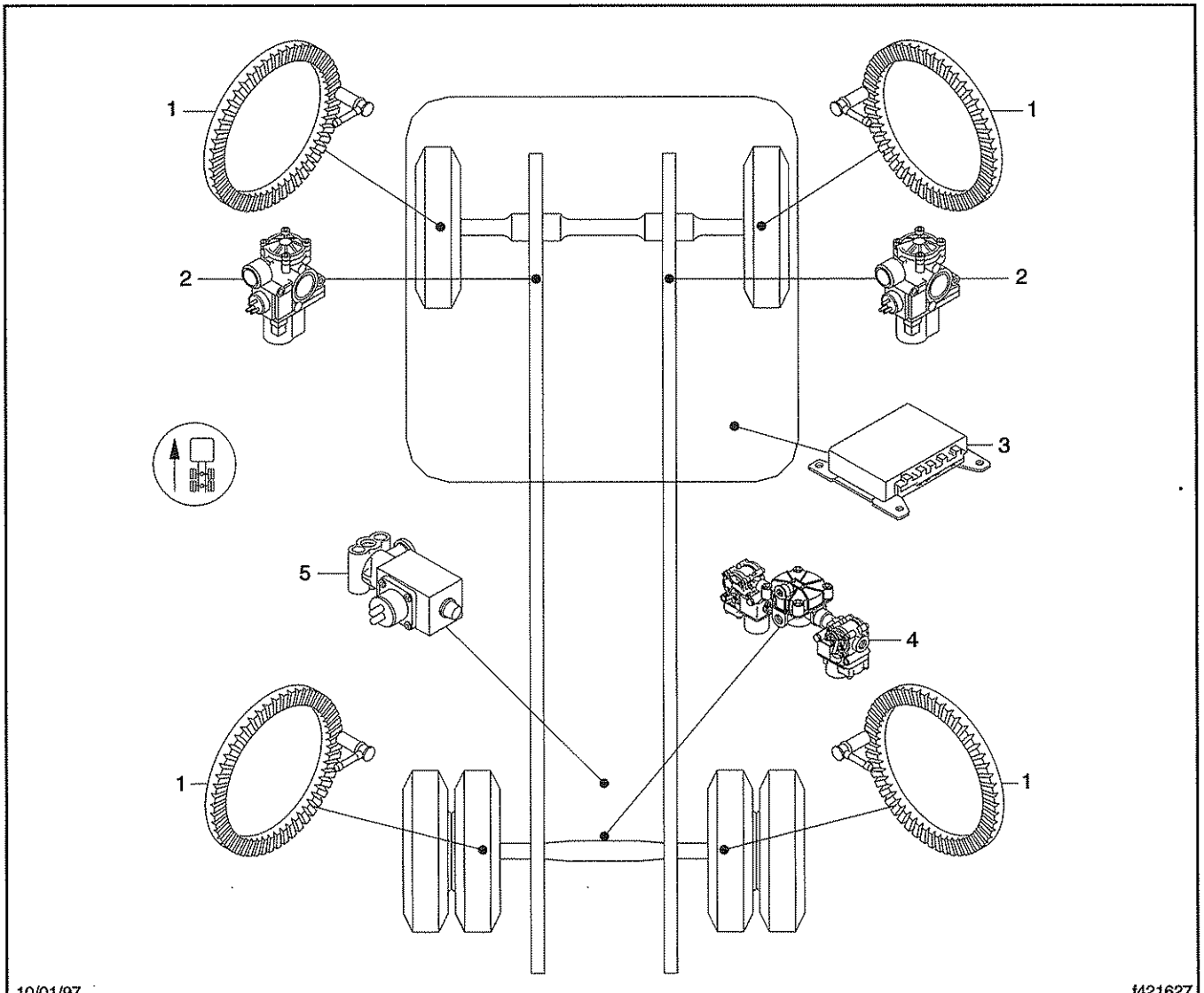
Problem—"Pinging" Noise is Excessive During Compressor Loading Cycle	
Possible Cause	**Remedy**
The compressor is a single cylinder with high pulse cycles.	A slight "pinging" sound may be heard during system build up when a single cylinder compressor is used. No remedy is needed.

Contents

Subject	Subject Number
General Information	050
Service Operations	
Wheel Speed Sensor Replacement	100
Pressure Modulator Valve Replacement	110
Combination (Rear Axle Module) Valve Disassembly and Assembly	120
ATC Valve Replacement	130
Troubleshooting	300
Specifications	400

General Description (See Fig. 1)

The Eaton Antilock Braking System (ABS) is an electronic wheel speed monitoring and control system that works with the standard air brake system. Its advanced electronic technology prevents wheel lock-ups by maintaining precise control of vehicle brake pressure. This ensures optimum vehicle stability while minimizing the stopping distance. During vehicle operation, the ABS Electronic Control Unit (ECU) continuously monitors all the wheel speed sensors. This wheel speed data allows the ECU to: detect an impending wheel lock; maintain an optimum wheel slip; and maximize the overall braking effectiveness.



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1. Wheel End Sensor and Tone Wheel
2. Front (Steer) Pressure Modulator Valve
3. Electronic Control Unit (ECU)
4. Combination (Rear Axle Module) Pressure Modulator Valve Assembly
5. Automatic Traction Control (ATC) Valve

Fig. 1, Location of ABS/ATC Components

General Information

The ABS system monitors and controls the brake pressure as follows:

- Each wheel speed sensor monitors and communicates wheel rotation information (speed signal pulses) to the ECU;
- The signals from the wheel speed sensors are then received and interpreted by the ECU. The ECU constantly calculates the relationship of wheel speed, acceleration and deceleration;
- Then, based on this wheel speed information, the ECU operates the ABS pressure modulator valves to regulate the air pressure in the brake chambers;
- During normal braking, air flows freely through the modulator valves to the brake chambers;
- During an emergency braking situation, the ECU signals the pressure modulator valves to increase, reduce, or maintain air pressure supply in the brake chamber.

The ABS indicator lamp reveals the condition of the ABS system. Under normal conditions, whenever the ignition is turned on, the ABS indicator lamp lights steadily for a two-second bulb check. If there are no problems, the ABS indicator lamp goes out. If it remains on, or lights during vehicle operation, then the ABS system requires service.

NOTE: In the case of a speed sensor failure which has been corrected, the ABS indicator lamp will remain on until the speed sensor output has been verified by the ECU. In this case it is necessary to operate the vehicle above a speed of five miles per hour before the indicator light goes out.

The Automatic Traction Control (ATC) System is an option on all ABS applications. The ATC system helps improve traction on slippery or unstable driving surfaces by reducing drive wheel overspin. This system consists of two control circuits; the brake control circuit and the engine throttle control circuit. If only one drive wheel slips, the ATC brake control circuit is activated, and then braking force is applied to the slipping wheel which adds torque to the traction wheel. Brake pressure is increased until the speed of the slipping is the same as the non slipping wheel. To prevent overheating of the brakes, the ATC system automatically deactivates after being applied for an extended amount of time. Then, after allowing sufficient time to cool the brakes, the ATC system will automatically reactivate.

As an added safety feature, the brake controller is deactivated at speeds above 19 mph (30 km/h). If both driving wheels slip equally, the engine controller is activated, and then the engine torque is reduced to minimize the drive wheel spin. This option requires the addition of an ATC valve and an SAE J1922 engine interface. The ECU configures itself for traction control when it detects the presence of the ATC valve.

There are three ATC modes of operation:

- During the high-speed mode (highway speed operation), the engine is throttled back to control spin out;
- During the low-speed mode (low speed operation), both the engine controls and the brake controls are used to enhance vehicle traction;
- During the mud and snow mode (optional), a dash switch allows the driver to select more engine power and wheel spin if needed.

The ATC system can not increase traction to a particular wheel, it can only utilize the available traction.

The ATC (Wheel Spin) indicator lamp reveals the condition of the ATC system. The indicator lamp lights when the ignition is switched on and remains lit until the driver applies the brake pedal. The light flashes rapidly in the ATC mode, and it flashes slowly when the "mud and snow" mode is selected.

Principles of Operation

ABS and ATC MAJOR COMPONENTS

Electronic Control Unit (ECU)

The ECU monitors and controls the ABS/ATC system. It receives and evaluates wheel speed information from four speed sensors, and if necessary, transmits control signals to the modulator valves. If the ECU detects no impending wheel lockups, the standard braking system is in effect. The ECU operates actively through the ABS release and hold modes of operation during emergency braking situations. The ABS release and hold modes are activated by the ECU as it signals the appropriate modulator valve to reduce braking force at that halting wheel until the threat of a skid is eliminated. With automatic traction control (ATC), the ECU also sends control signals to the ATC valve and engine control interface. If a drive wheel slips, the ECU signals the ATC valve to release supply air to the brake

chamber of the slipping wheel. This adds braking force to the slipping wheel, which results in the transfer of torque from the wheel with less traction to the wheel with more traction. If both drive wheels slip, the ECU signals the engine controller to reduce engine torque, which will reduce the drive wheel slip. Also, the ECU monitors the ABS/ATC system for malfunctions and stores fault codes into memory. The ECU is mounted inside the left rear compartment of the cab behind the driver's seat. It is mounted in the B-pillar. See **Fig. 2**.

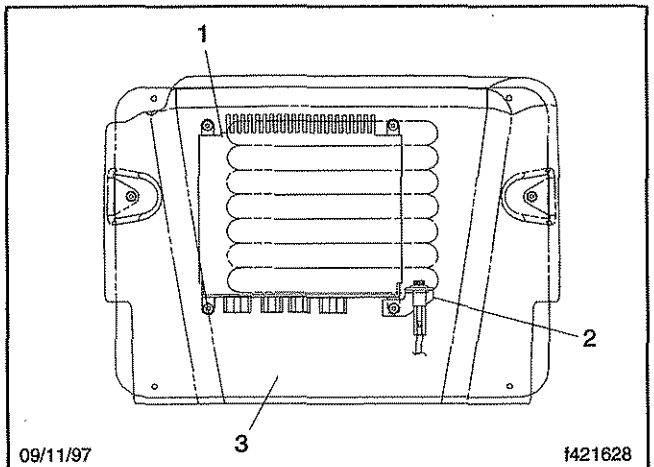
Speed Sensors

Each wheel of an axle under ABS control is monitored by a speed sensor. Speed sensors for drive axles and steer axles are mounted at the wheel ends.

The Eaton ABS uses standard wheel end sensors (**Fig. 3**). The sensors generate an alternating current signal in response to the movement of the teeth on the tone wheel. Either front sensor is accessible on the inboard side of the steering knuckle. Either rear drive axle sensor is accessible by removing the wheel and drum assembly.

Modulator Valves

The ABS air modulator valves control air pressure to the individual brake assemblies. The system utilizes four modulator valves. The steer axle uses separate modulator valves (**Fig. 4**) and the drive axles incorporate two modulator valves into a combination (rear axle module) valve (**Fig. 5**).



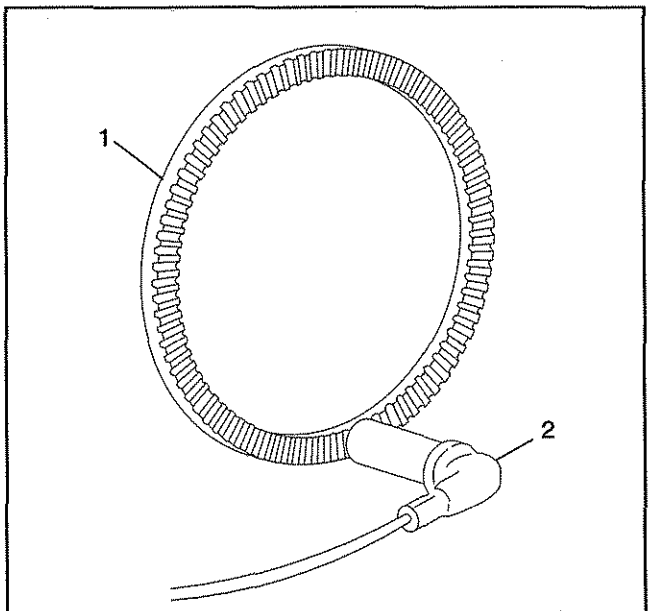
1. Electronic Control Unit
2. Diagnostic Switch
3. B-Pillar

Fig. 2, Electronic Control Unit (ECU)

The pressure modulator valves regulate air pressure to the brake chambers. A pressure modulator valve is located near each brake chamber or pair of brake chambers on any ABS equipped axle. Each modulator valve contains two solenoids for air control. The hold solenoid maintains air pressure; the release solenoid removes (vents) pressure from the brake chamber. The ECU signals each modulator valve to hold or release air by activating the appropriate solenoid. Each modulator valve carries a three pin terminal connection that connects with the ECU harness. See **Fig. 4**.

The combination (rear axle module) valve (**Fig. 5**) is an assembly of two pressure modulator valves and a standard relay valve. These assemblies have four solenoids which are controlled in the same manner as the solenoids housed in the front axle pressure modulator valves. These valves are available with a crack pressure setting between 4.0 and 5.0 psi (27.5 and 34.5 kPa). The crack pressure is the ascending input pressure flow required to initiate output pressure flow. Pressure is identified on a stamped washer mounted on the relay valve.

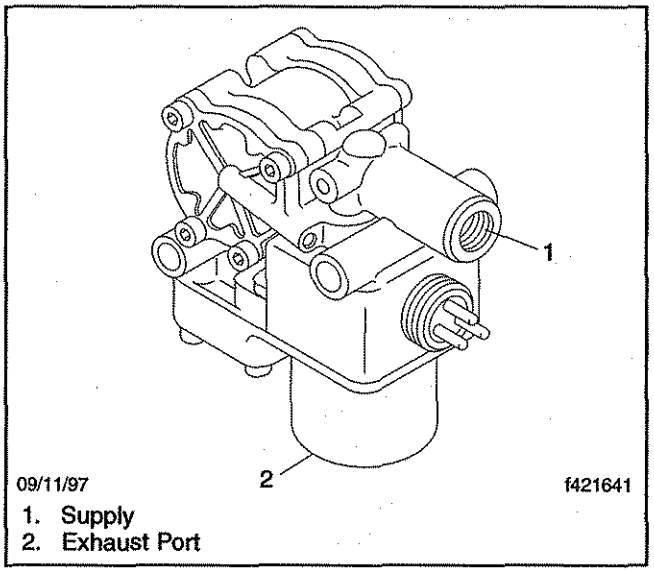
The modulator valves have four modes of operation: the normal and ABS apply mode; the normal release mode; the ABS hold mode; and the ABS release mode.



1. Tone Wheel
2. Wheel End Sensor

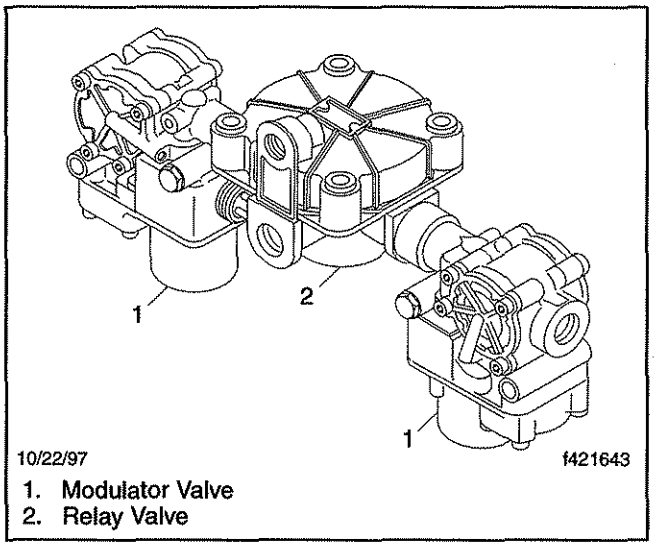
Fig. 3, Wheel End Sensor Assembly

General Information



1. Supply
2. Exhaust Port

Fig. 4, Pressure Modulator Valve



1. Modulator Valve
2. Relay Valve

Fig. 5, Combination (rear axle module) Valve

The normal apply and ABS apply mode operates as follows (see **Fig. 6**):

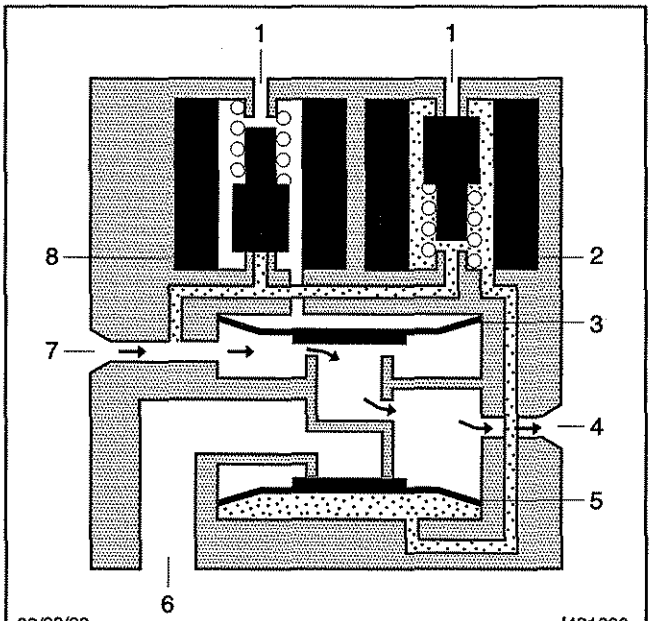
- Neither solenoid is activated;
- The supply air enters the inlet port;
- Inlet air is routed through solenoid #2 which then forces the release diaphragm to block the exhaust port;
- At the same time, the hold diaphragm is vented through solenoid #1, which allows supply air to flow to the outlet;
- Supply air flows from the inlet port to the outlet port.

The normal release mode operates as follows (see **Fig. 7**):

- Neither solenoid is activated;
- The hold diaphragm is vented through solenoid #1 and there is no pressure at the inlet port;
- The release diaphragm is not pressurized and the outlet pressure forces the exhaust port open;
- Pressurized air flows from the outlet port to the inlet port and also from the outlet port to the exhaust port.

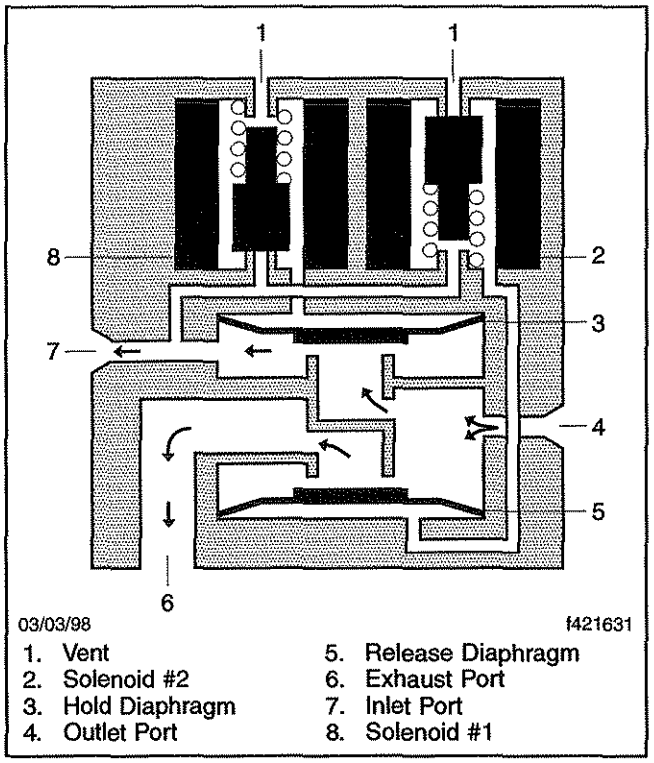
The ABS hold mode operates as follows (see **Fig. 8**):

- Solenoid #1 is activated;
- Supply air enters the inlet port;



1. Vent
2. Solenoid #2
3. Hold Diaphragm
4. Outlet Port
5. Release Diaphragm
6. Exhaust Port
7. Inlet Port
8. Solenoid #1

Fig. 6, Normal Apply and ABS Apply Mode



1. Vent
2. Solenoid #2
3. Hold Diaphragm
4. Outlet Port
5. Release Diaphragm
6. Exhaust Port
7. Inlet Port
8. Solenoid #1

Fig. 7, Normal Release Mode

- Inlet air routes through both the #1 and #2 solenoids;
- Both the hold and release diaphragm cavities become pressurized;
- The hold diaphragm closes off the air passage between the inlet and outlet port and the release diaphragm closes off the exhaust port;
- No air flows through the valve.

The ABS release mode operates as follows (see **Fig. 9**):

- Both solenoids are activated;
- Supply air enters the inlet port;
- Inlet air routes through solenoid #1;
- The hold diaphragm cavity becomes pressurized;
- The hold diaphragm closes off the air passage between the inlet and outlet port;
- The release diaphragm is vented through solenoid #2, which allows the outlet air pressure to force open the exhaust port;
- Pressurized air flows from the outlet port to the exhaust port.

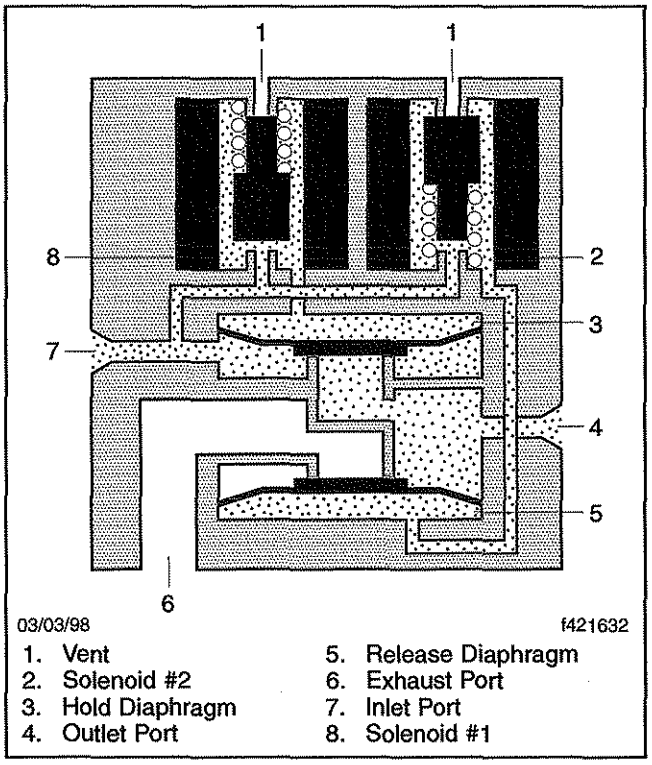
Automatic Traction Control (ATC) Valve

When in the traction control mode of operation, the ATC valve (**Fig. 10**) applies full system pressure to the relay valve to provide differential (side to side) braking. The valve is located near the rear axle.

ABS and ATC (Wheel Spin) Indicator Lamps

The amber ABS indicator lamp is located on the driver's instrument panel. The indicator lamp warns the driver of any ABS malfunctions. It is also capable of blinking diagnostic fault codes when the ECU is in the diagnostic mode.

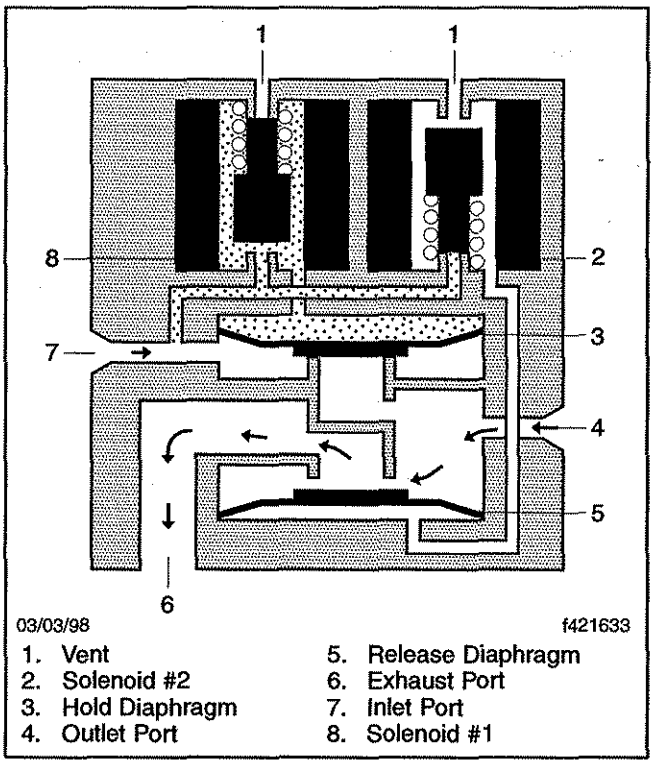
The ATC (Wheel Spin) indicator lamp is located on the driver's instrument panel. This indicator lights when a loss of traction condition exists and the ATC system is activated.



1. Vent
2. Solenoid #2
3. Hold Diaphragm
4. Outlet Port
5. Release Diaphragm
6. Exhaust Port
7. Inlet Port
8. Solenoid #1

Fig. 8, ABS Hold Mode

General Information



1. Vent
2. Solenoid #2
3. Hold Diaphragm
4. Outlet Port
5. Release Diaphragm
6. Exhaust Port
7. Inlet Port
8. Solenoid #1

Fig. 9, ABS Release Mode

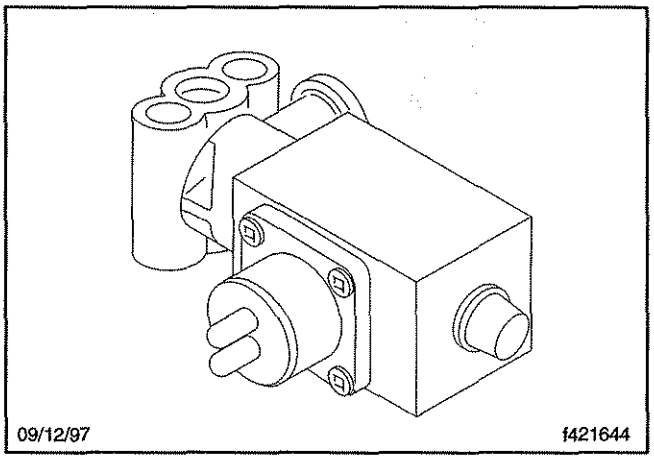


Fig. 10, ATC Valve

NOTE: In some cases, vehicles without ATC are equipped with an ATC (Wheel Spin) indicator lamp. In these cases, the lamp indicates a slip condition but no control action is taken.

Diagnostic Port Connector

The diagnostic port connector is an industry standard connector, which is used to provide a connector to the J1587 diagnostic link. This connector also provides power and ground to the diagnostic test equipment.

Front Axle Speed Sensor Replacement

NOTE: Wire repairs may require the use of special tools for certain connectors and terminals. See **Section 54.00, Subject 100** in this manual for information on special terminals and connectors, and special tools.

1. Apply the parking brakes. Chock the rear tires to prevent vehicle movement.
2. Disconnect the sensor cable from the harness.

NOTE: While conducting the next step, avoid pulling on the cable.

3. Using a twisting and pulling motion, remove the speed sensor from the bushing in the steering knuckle (**Fig. 1**).
4. Remove the speed sensor friction sleeve from the bushing in the steering knuckle (**Fig. 2**).
5. Install the speed sensor friction sleeve into the bushing (in the steering knuckle) with the flange stops toward the inboard side of the vehicle.

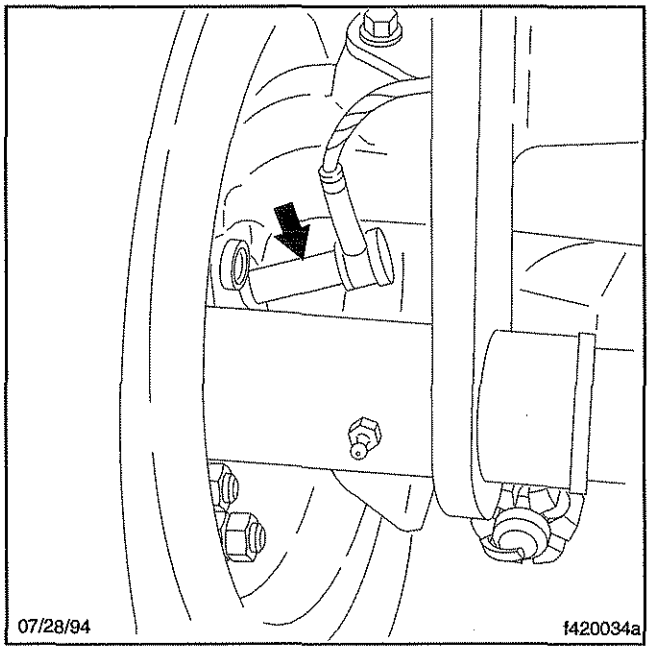


Fig. 1, Remove the Wheel Speed Sensor

⚠ CAUTION

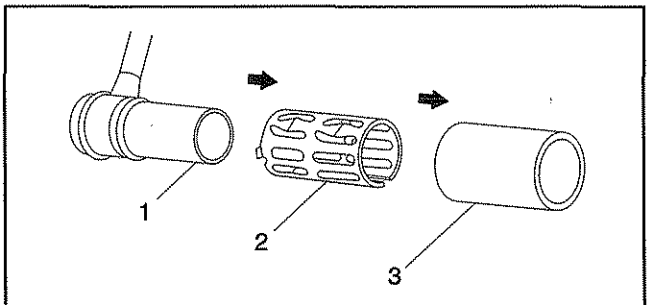
The speed sensor must slide freely in and out of the mounting sleeve bore. Operating the vehicle with seized components will damage the speed sensor and the tone wheel.

6. Lubricate the body of the speed sensor with Penzoil 707L, Valvoline LP, or Mobil HP.
7. By hand, push the speed sensor completely into the bushing (in the steering knuckle) until the speed sensor stops against the tone wheel.

   The speed sensor is properly installed and adjusted when it is touching the tone wheel.
8. Connect the sensor cable to the harness.
9. Remove the chocks from the rear tires.

Rear Axle Speed Sensor Replacement

1. Chock the front tires to prevent vehicle movement. Release the parking brakes.
2. Raise the rear of the vehicle until the tires clear the ground. Place safety stands under the axle.
3. Back off the slack adjuster to release the rear axle brake shoes.
4. Remove the wheel and tire assembly from the rear axle. For instructions, see **Group 40** in this manual.



1. Sensor
2. Friction Sleeve
3. Bushing (in the steering knuckle)

Fig. 2, Front Wheel Speed Sensor Components

Wheel Speed Sensor Replacement

5. Remove the brake drum. For instructions, see **Group 35** in this manual.

NOTE: While conducting the next step, avoid pulling on the cable.

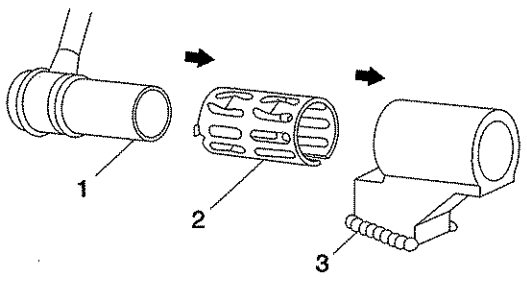
6. Using a twisting and pulling motion, remove the speed sensor from the mounting block on the axle housing.
7. Remove the friction sleeve from the mounting block on the axle housing (**Fig. 3**).
8. Disconnect any fasteners that attach the speed sensor cable to other components and disconnect the speed sensor from the harness.
9. Install the friction sleeve on the mounting block (on the axle housing) with the flange stops toward the inboard side of the vehicle.

⚠ CAUTION

The speed sensor must slide freely in and out of the mounting sleeve bore. Operating the vehicle with seized components will damage the speed sensor and the tone wheel.

10. Lubricate the body of the speed sensor with Penzoil 707L, Valvoline LP, or Mobil HP.
11. By hand, push the speed sensor completely into the bushing (on the axle housing) until the speed sensor stops against the tone wheel.

    The speed sensor is properly installed and adjusted when it is touching the tone wheel.



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1. Sensor
2. Friction Sleeve
3. Mounting Block (on axle housing)

Fig. 3, Rear Wheel Speed Sensor Components

12. Route the cable to the frame.
13. Connect sensor cable to harness and install fasteners to hold sensor cables in position.
14. Install the brake drum on the wheel hub. For instructions, see **Group 35** in this manual.
15. Adjust the rear axle brakes. For instructions, see **Group 42** in this manual.
16. Install the wheel and tire assembly to the rear axle and tighten the wheel nuts. For instructions, see **Group 40** in this manual.
17. Remove the safety stands, lower the vehicle, set the parking brake, and remove the chocks from the tires.

Pressure Modulator Valve Replacement

Replacement (See Fig. 1 and Fig. 2)

NOTE: Wire repairs may require the use of special tools for certain connectors and terminals. See **Section 54.00, Subject 100** in this manual for information on special terminals and connectors, and special tools.

1. Turn the ignition switch to the off position.
2. Apply the parking brakes. Chock the front and rear tires to prevent vehicle movement.
3. Release the pressure from the air reservoirs.
4. Disconnect the wiring from the pressure modulator valve or the combination (rear axle module) valve.
5. Mark the air lines for ease of installation. Disconnect the air lines.
6. Remove the two mounting capscrews, washers, and nuts.
7. Remove the pressure modulator valve or combination (rear axle module) valve.

NOTE: The combination (rear axle module) valve can be disassembled, if the relay valve or one of the pressure modulator valves need replacing. For disassembly and assembly instructions, see **Subject 120**.

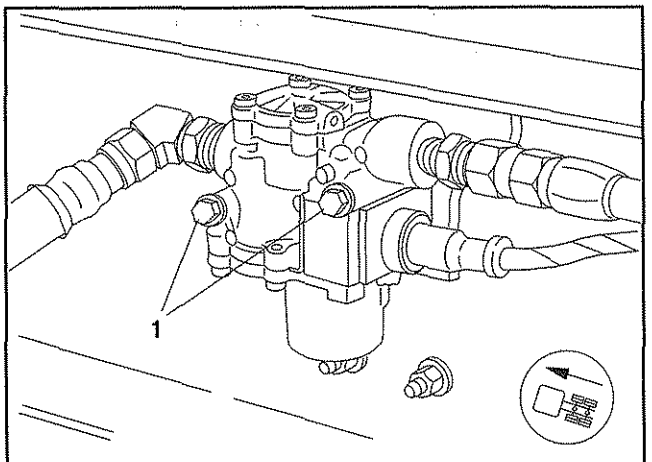


Fig. 1, Front Pressure Modulator Valve Mounting (inside right-hand rail mounting shown)

8. Install the pressure modulator valve or the combination valve using the above instructions in reverse order. Tighten the mounting nuts 18 lbf·ft (24 N·m).
9. Test the pressure modulator valve.
   - 9.1 Check the pressure modulator valve for leaks by applying and holding the brakes. No audible air leaks are permitted.
   - 9.2 Using a MPSI Pro-Link 9000® hand-held tester, go to component test (#4) menu screen (on the hand-held tester) and select the valve routines option. This will verify the operation and the proper location of the pressure modulator valve. For more information on the use of the hand-held tester, see **Troubleshooting, 300**.

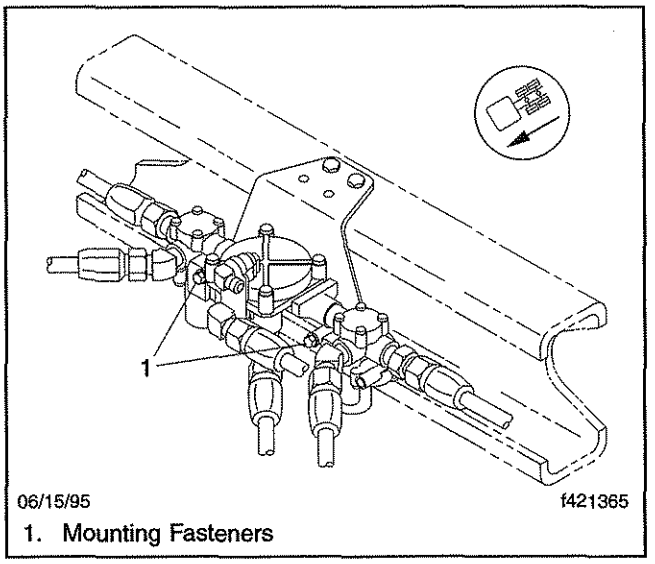


Fig. 2, Combination (rear axle module) Valve Mounting

Combination (Rear Axle Module) Valve Disassembly and Assembly

Disassembly (See Fig. 1)

1. Remove the combination valve. For instructions, see **Subject 110**.
2. Carefully separate the pressure modulator valves from the relay valve.

Assembly (See Fig. 1)

1. Plug any unused ports on the replacement valve(s).

IMPORTANT: Before installing the pipe nipples into the valves, apply a small quantity of Loctite® Pipe Sealant (with Teflon® 59241), or an equivalent sealant, to the male threads of each side of the pipe nipples.

2. Using the pipe nipples, attach the ABS control valve(s) to the relay valve.
3. Install the combination valve. For instructions, see **Subject 110**.
4. Test the relay valve assembly.

   4.1 With the front and rear wheels chocked, fully charge the air system (governor cut out point). Then, release the parking brake.

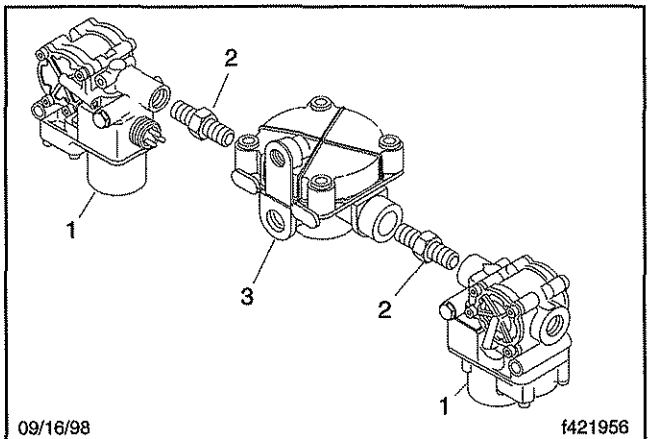
   4.2 With the engine off, apply the service brake several times, then hold and check all the wheels for prompt application and release. If a sluggish response is noted at all of the wheels, inspect for a kinked or obstructed air line leading to or from the valve.

   4.3 Check for air leaks.

   Apply and hold the brakes. Coat the outside of the relay valve (where the cover joins the body and where the pressure modulator valves meet the body) with a soap solution. No air leakage is permitted.

   Increase the system air pressure to the governor cut-off. Turn the engine off. With the brakes released, coat the exhaust port of the relay valve with a soap solution. Leakage of a 1-inch (2.5-cm) bubble in five seconds is permissible.

   4.4 Depress the foot valve. Coat the exhaust port with a soap solution. Leakage of a 1-inch (2.5-cm) bubble in three seconds is permissible. Release the foot valve.



1. Modulator Valve
2. Pipe Nipple
3. Relay Valve

Fig. 1, Combination (rear axle module) Valve

ATC Valve Replacement

Replacement (See Fig. 1)

⚠ WARNING

Do not start and engage the transmission with one wheel raised from the floor. For vehicles equipped with ATC, if the transmission is engaged with one of the drive axles raised, all the driving torque from the transmission will go to the wheel on the floor (the drive axle not raised). This could cause the vehicle to move on its own and result in personal injury or property damage.

NOTE : Wire repairs may require the use of special tools for certain connectors and terminals. See **Section 54.00, Subject 100** in this manual for information on special terminals and connectors, and special tools.

1. Apply the parking brakes. Chock the front and rear tires to prevent vehicle movement.
2. Release the pressure from the air reservoirs.
3. Disconnect the wiring from the ATC valve.
4. Mark the air lines for ease of installation. Disconnect the air lines.
5. Remove the two mounting capscrews, washers, and nuts.
6. Remove the ATC valve.

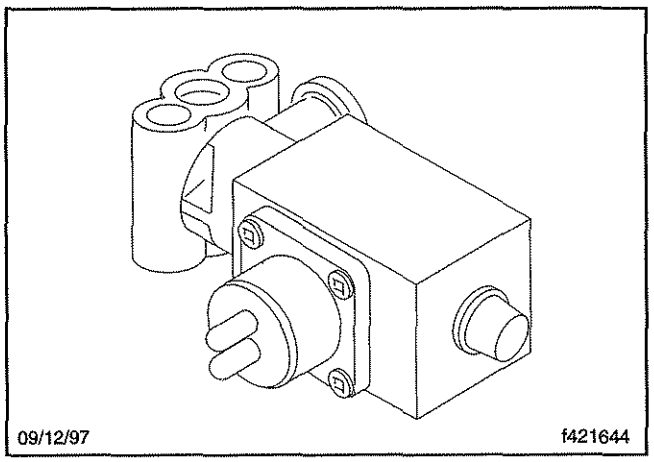


Fig. 1, ATC Valve Mounting

7. Install the ATC valve using the above instructions in reverse order. Tighten the mounting nuts 18 lbf·ft (24 N·m).
8. Test the ATC valve.
   - 8.1 Check ATC valve for leaks by applying and holding the brakes. No audible air leaks are permitted.
   - 8.2 Using a MPSI Pro-Link 9000® hand-held tester, go to test (#4) menu screen (on the hand-held tester) and select the TCV option. This will verify the operation of the ATC (wheel spin) indicator light and the operation of the ATC valve. For more information on the use of the hand-held tester, see **Troubleshooting, 300.**

Troubleshooting

Eaton recommends the use of a MPSI Pro-Link 9000® hand-held tester and a multimeter or digital volt-ohmmeter (DVOM) to troubleshoot the ABS system. An important part of the Eaton Antilock Brake System is the system diagnostics. The electronic control unit internally checks the systems components and, if necessary, stores retrievable diagnostic fault codes. The fault codes and the MPSI Pro-Link 9000® hand-held tester can pinpoint solutions to any system faults. The wiring schematics (in **Specifications, 400**) and the multimeter can be used to check sensor and solenoid resistance, and determine component or wiring harness faults. A test adaptor may be required to use the multimeter.

Configuration Code, Fault Codes, and Diagnostic Methods

If the ABS indicator lamp lights and stays lit, then a system malfunction (configuration conflict) has occurred. It signifies that a fault code may exist.

The configuration code defines what system components are equipped on the vehicle. It is stored and retrieved as a four digit number.

A fault code defines what type of malfunction has occurred, and it is stored and retrieved as a group of two numbers. The possible combinations of the two numbers in a fault code include:

- two 2-digit numbers;
- one 2-digit number and one 1-digit number;
- or, two one-digit numbers.

There are two ways to retrieve and display a configuration and/or fault code(s); the automatic diagnostics method, or the manual blink code diagnostics method.

AUTOMATIC DIAGNOSTICS METHOD

The automatic diagnostics method uses either an MPSI Pro-Link 9000® hand-held tester or the Freightliner ServiceLink PC platform to automatically display a fault code(s) (two numbers) on the tester display screen. For more information on using the ServiceLink computer and ServiceLink software, see **Service Bulletin 00-20.**

The MPSI Pro-Link 9000® hand-held tester, along with Eaton's proprietary cartridge, employs menu-driven tests for diagnosing malfunctions in the ABS system. This method can be used to: obtain short descriptions of the failures; retrieve and clear fault codes; and report the systems configuration code. Also, the tester can initiate test sequences to invoke ECU outputs and can read system parameters such as wheel speeds. A standard heavy-duty truck cartridge may be used to retrieve the fault codes, but cannot initiate test sequences. The Eaton proprietary cartridge has nine functions in its menu.

When retrieving fault codes, the hand-held tester illuminates four lines of text on its display. The first three lines of text display a short description of the failure and the last line displays the fault code. If more than one code is active, arrows appear on line 4 to indicate that you can scroll the list. If arrows do not appear, there is only one actual fault present.

NOTE: If troubleshooting the system with the Pro-Link 9000, use the instruction booklet that is supplied with the data cartridge.

Retrieving the Configuration Code, and Retrieving and Clearing Fault Codes

For a listing of possible configuration code reports, see **Table 1**. For a list of fault codes, see **Table 3, Table 4, Table 5, Table 6, Table 7, Table 8** and **Table 9.**

1. Assemble the MPSI Pro-Link 9000® Hand-held Tester.
2. Turn the ignition switch to the on position, but don't start the engine.
3. If the tester powers up and displays the Eaton copyright screen (the tester identifies the Eaton Generation 4 ABS ECU), then go to the next step. Otherwise, locate the cause of the tester not powering up (identifying the ECU).
   - 3.1 Check that the tester is in good working condition.
   - 3.2 Check that all the J1587 wiring and connections are complete.
   - 3.3 If the tester is in good working condition and the J1587 circuitry is okay, then there must be an open circuit in the ECU. Replace the ECU.

Troubleshooting

Displays (automatic retrieval)/flashes (manual retrieval)	Configuration Code Description
1 2 1 2/ 1 (1.5 second pause) 2 (4.5 second pause) 1 (1.5 second pause) 2	12 volt system, 4 Sensors/4 Modulator Valves, Engine Interface Not Equipped and Retarder Relay Not Equipped and Interaxle Lock Not Equipped, ATC Engine Control Not Equipped and ATC Brake Control Not Equipped
1 2 2 2/ 1 (1.5 second pause) 2 (4.5 second pause) 2 (1.5 second pause) 2	12 volt system, 4 Sensors/4 Modulator Valves, Engine Interface Equipped and Retarder Relay Not Equipped and Interaxle Lock Not Equipped, ATC Engine Control Not Equipped and ATC Brake Control Not Equipped
1 2 3 2/ 1 (1.5 second pause) 2 (4.5 second pause) 3 (1.5 second pause) 2	12 volt system, 4 Sensors/4 Modulator Valves, Engine Interface Not Equipped and Retarder Relay Equipped and Interaxle Lock Not Equipped, ATC Engine Control Not Equipped and ATC Brake Control Not Equipped
1 2 4 2/ 1 (1.5 second pause) 2 (4.5 second pause) 4 (1.5 second pause) 2	12 volt system, 4 Sensors/4 Modulator Valves, Engine Interface Equipped and Retarder Relay Equipped and Interaxle Lock Not Equipped, ATC Engine Control Not Equipped and ATC Brake Control Not Equipped
1 2 1 5/ 1 (1.5 second pause) 2 (4.5 second pause) 1 (1.5 second pause) 5	12 volt system, 4 Sensors/4 Modulator Valves, Engine Interface Not Equipped and Retarder Relay Not Equipped and Interaxle Lock Not Equipped, ATC Engine Control Equipped and ATC Brake Control Equipped
1 2 2 5/ 1 (1.5 second pause) 2 (4.5 second pause) 2 (1.5 second pause) 5	12 volt system, 4 Sensors/4 Modulator Valves, Engine Interface Equipped and Retarder Relay Not Equipped and Interaxle Lock Not Equipped, ATC Engine Control Equipped and ATC Brake Control Equipped
1 2 3 5/ 1 (1.5 second pause) 2 (4.5 second pause) 3 (1.5 second pause) 5	12 volt system, 4 Sensors/4 Modulator Valves, Engine Interface Not Equipped and Retarder Relay Equipped and Interaxle Lock Not Equipped, ATC Engine Control Equipped and ATC Brake Control Equipped
1 2 4 5/ 1 (1.5 second pause) 2 (4.5 second pause) 4 (1.5 second pause) 5	12 volt system, 4 Sensors/4 Modulator Valves, Engine Interface Equipped and Retarder Relay Equipped and Interaxle Lock Not Equipped, ATC Engine Control Equipped and ATC Brake Control Equipped

Table 1, Configuration Code Reports

4. After the Eaton copyright screen is displayed on the tester, press enter to display the menu options.
5. After the menu screen is displayed on the tester, select either #2 (fault codes) or #5 (system setup).
6. If #2 was selected, choose either actual fault codes, extended fault codes, or clear memory. If #5 was selected, then choose system configuration to display the configuration code.

NOTE: The fault codes are stored either as two 2-digit numbers, one 2-digit number and one 1-digit number, or two one-digit numbers. The configuration code is stored as a 4-digit number.

MANUAL BLINK CODE DIAGNOSTICS METHOD

The manual blink code diagnostics method uses the diagnostic switch (fastened to the ABS ECU inside the right rear compartment of the cab), the ignition switch, the brake light switch, the ABS indicator lamp, and the ATC (wheel spin) indicator lamp to report configuration codes, report and clear fault codes, and disable the ATC for dynamometer testing.

A blink code is a flash sequence displayed at the ABS indicator lamp. The diagnostic switch is used to recall the system configuration code and/or fault code input (stored in memory) through flash sequences (blink codes) at the ABS indicator lamp.

The configuration code is reported by four blink codes (a 4-digit number), which consist of four flash sequences. The configuration code is stored as a 4-digit number. See **Table 1** for a listing of possible configuration reports.

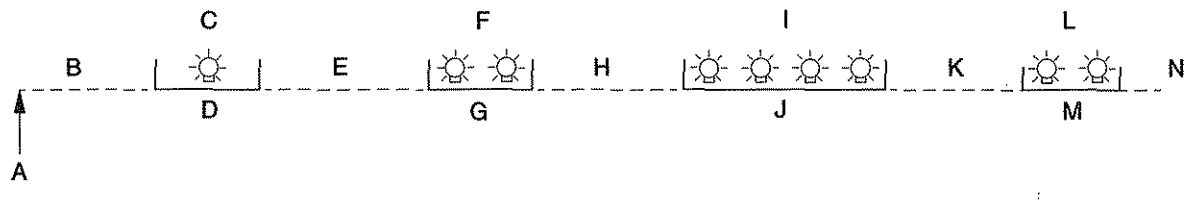
The fault codes are reported by a pair of blink codes (two 2-digit numbers, one two-digit number and one 1-digit number, or two 1-digit numbers), which consist of two flash sequences. The fault code reporting process consists of: the first flash sequence; a 1.5 second pause; and finally the second flash sequence. There is a 1.5 second pause between the two flash sequences in a fault code. Also, there is a 4.5 second pause between fault codes. The flash sequence pairs

continue, with 4.5 second pauses between them, until all fault codes are reported. See **Fig. 1**.

Reading the Configuration Code, Reading and Clearing Fault Codes, and Disabling the ATC for Dynamometer Testing

NOTE: When pressing the diagnostic switch for a designated amount of time (from 1 to 3 seconds), use a counting method such as one thousand one, one thousand two, etc. for the time (second) interval. This will allow more accurate configuration and/or fault code retrieval and reduce the possibility of misreading blink code information.

1. Read and record the configuration code.
   - 1.1 Turn the ignition key to the on position (engine off).
   - 1.2 Press and hold the diagnostic switch closed for at least one second but less than three seconds and then release the switch.
   - 1.3 Immediately press the diagnostic switch closed a second time (for at least one second but less than three seconds) and then release the switch.
   - 1.4 Read and record the flashing pulses at the ABS indicator lamp.
2. Read and record the fault code(s). See **Fig. 1**.
   - 2.1 Turn the ignition key to the on position (engine off).
   - 2.2 If the vehicle is equipped with ATC, apply and release the brakes once before proceeding. This will turn off the ATC (wheel spin) indicator lamp.
   - 2.3 Press and hold the diagnostic switch for at least one second but less than three seconds and then release the switch (remember, count one thousand one).
   - 2.4 Read and record the flashing pulses at the ABS indicator lamp (in pairs).
   - 2.5 Continue reading and recording the flashing pulses (in pairs) until all the fault codes are recorded.
   - 2.6 After retrieving and recording all the fault codes, see **Table 3**, **Table 4**, **Table 5**, **Table 6**, **Table 7**, **Table 8** and **Table 9** for a list of fault codes.
3. Clear fault code(s).
   - 3.1 With the ignition key in the off position, press and hold the diagnostic switch closed. Turn the ignition key to the on position.
   - 3.2 Wait two seconds and then release the diagnostic switch.



07/29/98 f150380b

A. Diagnostic Switch Activated Here
B. Retrieval Starts
C. First Flash Sequence (first number, 1)
D. First Blink Code Begins
E. 1-1/2 Second Pause
F. Second Flash Sequence (second number, 2)
G. First Blink Code Ends
H. 4-1/2 Second Pause
I. First Flash Sequence (first number, 4)
J. Next Blink Code Begins
K. 1-1/2 Second Pause
L. Second Flash Sequence (second number, 2)
M. Next Blink Code Ends
N. 4-1/2 Second Pause (then go to next blink code)

Fig. 1, Typical Blink Code Report (1-2 4-2)

3.3 If the vehicle is equipped with ATC, apply and release the brakes once before proceeding. This will turn off the ATC (wheel spin) indicator lamp.

3.4 The fault codes are now cleared.

3.5 To verify that the fault codes are cleared, repeat the step on reading fault codes.

4. Disable the ATC system for dynamometer testing.

4.1 Turn the ignition key to the on position (engine on).

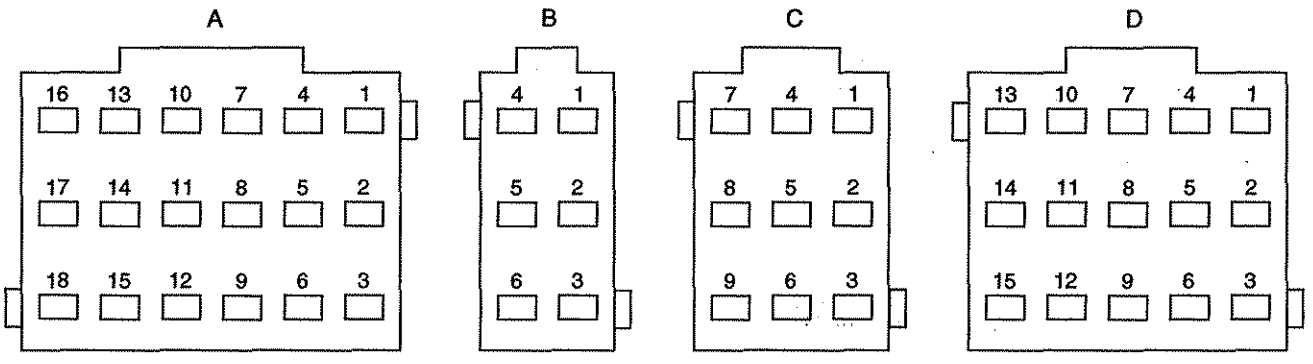
4.2 Press and hold the diagnostic switch closed for at least three seconds and then release it.

4.3 The ATC (wheel spin) light turns on and the ABS light flashes 17 times, then pauses and flashes 8 times. These blink codes indicate that the ATC is disabled.

NOTE: At the next ignition cycle the ATC will be reactivated.

ECU Harness Connectors

When checking for either open circuits or short circuits in the ABS circuitry, see **Fig. 2** and **Table 2** for circuit descriptions and connector pinouts.



A. 18-Pin Connector
B. 6-Pin Connector
C. 9-Pin Connector
D. 15-Pin Connector

Fig. 2, ECU Harness Connectors

Circuit Descriptions and Associated Pin Numbers for ECU Harness Connectors			
ECU Connector	**Pin Number**	**Freightliner Wire Number**	**Circuit Description (Related Fault Code Table)**
A (18-Pin)	1	1992–A	SAE 1922– (ECU Fault Codes Table)
A (18-Pin)	2		No Connection
A (18-Pin)	3	1992+A	SAE 1922+ (ECU Fault Codes Table)
A (18-Pin)	4		No Connection
A (18-Pin)	5		No Connection
A (18-Pin)	6	376T	(Mud and Snow) Traction Control Switch (ATC Fault Code Table)

Circuit Descriptions and Associated Pin Numbers for ECU Harness Connectors			
ECU Connector	**Pin Number**	**Freightliner Wire Number**	**Circuit Description (Related Fault Code Table)**
A (18-Pin)	7	376C	Ignition, Switched (Power [Battery] Fault Code Table)
A (18-Pin)	8	376B	System Voltage B2 (Power [Battery] Fault Code Table)
A (18-Pin)	9	376A	System Voltage B1 (Power [Battery] Fault Code Table)
A (18-Pin)	10	GND3	Ground-ECU
A (18-Pin)	11	GND2	Ground-Diagonal 1 (Power [Battery] Fault Code Table)
A (18-Pin)	12	GND1	Ground-Diagonal 2 (Power [Battery] Fault Code Table)
A (18-Pin)	13	1587–A	SAE J1587–
A (18-Pin)	14	1587+A	SAE J1587+
A (18-Pin)	15		No Connection, Warning Light Interlock
A (18-Pin)	16	376S	ATC (Wheel Spin) Indicator Lamp (ATC Fault Code Table)
A (18-Pin)	17	376R	Retarder Relay
A (18-Pin)	18	376	ABS Indicator Lamp/Diagnostic Switch
B (6-Pin)	4	377LF–	Speed Sensor 1 (Left Steer –) (Speed Sensor Fault Codes Table)
B (6-Pin)	1	378LFO	Pressure Modulator Valve (PMV) 1 (Left Steer), Release Solenoid (Pressure Modulator Valve Fault Code Table)
B (6-Pin)	2	378LFI	Pressure Modulator Valve (PMV) 1 (Left Steer), Hold Solenoid (Pressure Modulator Valve Fault Code Table)
B (6-Pin)	3	378LF–	Pressure Modulator Valve (PMV) 1 (Left Steer), Common (Pressure Modulator Valve Fault Code Table)
B (6-Pin)	5	377LF+	Speed Sensor 1 (Left Steer +) (Speed Sensor Fault Codes Table)
B (6-Pin)	6	376J	Brake Light Switch
C (9-Pin)	1		No Connection
C (9-Pin)	2		No Connection
C (9-Pin)	3		No Connection
C (9-Pin)	4	377RF+	Speed Sensor 2 (Right Steer +) (Speed Sensor Fault Codes Table)
C (9-Pin)	5	377RF–	Speed Sensor 2 (Right Steer –) (Speed Sensor Fault Codes Table)
C (9-Pin)	6		No Connection
C (9-Pin)	7	378RFO	Pressure Modulator Valve (PMV) 2 (Right Steer), Release Solenoid (Pressure Modulator Valve Fault Code Table)
C (9-Pin)	8	378RFI	Pressure Modulator Valve (PMV) 2 (Right Steer), Hold Solenoid (Pressure Modulator Valve Fault Code Table)
C (9-Pin)	9	378RF–	Pressure Modulator Valve (PMV) 2 (Right Steer), Common (Pressure Modulator Valve Fault Code Table)

Troubleshooting

Circuit Descriptions and Associated Pin Numbers for ECU Harness Connectors			
ECU Connector	**Pin Number**	**Freightliner Wire Number**	**Circuit Description (Related Fault Code Table)**
D (15-Pin)	1	378LRO	Pressure Modulator Valve (PMV) 3 (Left Rear), Release Solenoid (Pressure Modulator Valve Fault Code Table)
D (15-Pin)	2	378LRI	Pressure Modulator Valve (PMV) 3 (Left Rear), Hold Solenoid (Pressure Modulator Valve Fault Code Table)
D (15-Pin)	3	378LR–	Pressure Modulator Valve (PMV) 3 (Left Rear), Common (Pressure Modulator Valve Fault Code Table)
D (15-Pin)	4	378T–	ATC Valve – (ATC Fault Code Table)
D (15-Pin)	5	377LR+	Speed Sensor 3 (Left Rear +) (Speed Sensor Fault Codes Table)
D (15-Pin)	6	377LR–	Speed Sensor 3 (Left Rear –) (Speed Sensor Fault Codes Table)
D (15-Pin)	7	378T+	ATC Valve + (ATC Fault Code Table)
D (15-Pin)	8	377RR+	Speed Sensor 4 (Right Rear +) (Speed Sensor Fault Codes Table)
D (15-Pin)	9	377RR–	Speed Sensor 4 (Right Rear –) (Speed Sensor Fault Codes Table)
D (15-Pin)	10	378RRO	Pressure Modulator Valve (PMV) 4 (Right Rear), Release Solenoid (Pressure Modulator Valve Fault Code Table)
D (15-Pin)	11	378RRI	Pressure Modulator Valve (PMV) 4 (Right Rear), Hold Solenoid (Pressure Modulator Valve Fault Code Table)
D (15-Pin)	12	378RR–	Pressure Modulator Valve (PMV) 4 (Right Rear), Common (Pressure Modulator Valve Fault Code Table)
D (15-Pin)	13		No Connection
D (15-Pin)	14		No Connection
D (15-Pin)	15		No Connection

Table 2, Circuit Descriptions and Associated Pin Numbers for ECU Harness Connectors

Fault Code Tables

To locate and correct any ABS malfunctions, follow these four basic guidelines.

A. Access the active fault codes using either the blink code procedure, the MPSI Pro-Link 9000® Hand-held Tester, or the Freightliner ServiceLink computer and software.

B. Using the fault code tables, look up the code description, the possible causes of the fault condition, and the recommended procedures to repair the fault condition.

C. Perform the recommended repair procedures.

D. After the repairs are completed, clear all the codes and check for any additional codes.

See **Fig. 2** and **Table 2** for ECU harness connector information, which corresponds to the fault code tables.

No Faults			
First Blink Code (manual retrieval)/ First Number (automatic retrieval)	**Second Blink Code (manual retrieval)/ Second Number (automatic retrieval)**	**Condition**	**Action**
1	1	No Faults	No Action

Table 3, No Faults

Speed Sensor Fault Codes			
First Blink Code (manual retrieval)/ First Number (automatic retrieval)*	**Second Blink Code (manual retrieval)/ Second Number (automatic retrieval)**	**Condition**	**Action†**
2 (left front), 3 (right front), 4 (left rear), or 5 (right rear) NOTE: The first blink code of the speed sensor fault codes represents which speed sensor is at fault.	1	The sensor air gap is too large.	If necessary, clean and lubricate the sensor. Press the sensor into the mounting hole until it bottoms against the tone wheel. Clear the fault code and verify that the fault code is corrected by test driving the vehicle. The warning light will remain on until proper speed sensor outputs are detected even though the fault has been cleared. See **Subject 100** in this section for lubrication requirements.
2 (left front) NOTE: The first blink code of the speed sensor fault codes represents which speed sensor is at fault.	2	The air gap is too large or the sensor is shorted.	Using a multimeter, check the resistance in the left steer speed sensor (1) circuit. Unplug connector B at the ECU and measure the resistance between pin B-4 and pin B-5. Unplug the speed sensor cable from the connector at the wheel location and measure the resistance between the two pins. The correct resistance for the speed sensor circuit is between 950 to 1900 ohms. If the sensor resistance is out of range, replace the sensor. Clean and lubricate the sensor. Press the sensor into the mounting hole until it bottoms against the tone wheel. Clear the fault code and verify that the fault code is corrected by test driving the vehicle. The warning light will remain on until proper speed sensor outputs are detected even though the fault has been cleared. See **Subject 100** in this section for lubrication requirements.

Troubleshooting

Speed Sensor Fault Codes			
First Blink Code (manual retrieval)/ First Number (automatic retrieval)*	**Second Blink Code (manual retrieval)/ Second Number (automatic retrieval)**	**Condition**	**Action†**
3 (right front) NOTE: The first blink code of the speed sensor fault codes represents which speed sensor is at fault.	2	The air gap is too large or the sensor is shorted.	Using a multimeter, check the resistance in the right steer speed sensor (2) circuit. Unplug connector C at the ECU and measure the resistance between pin C-4 and pin C-5. Unplug the speed sensor cable from the connector at the wheel location and measure the resistance between the two pins. The correct resistance for the speed sensor circuit is between 950 to 1900 ohms. If the sensor resistance is out of range, replace the sensor. Clean and lubricate the sensor. Press the sensor into the mounting hole until it bottoms against the tone wheel. Clear the fault code and verify that the fault code is corrected by test driving the vehicle. The warning light will remain on until proper speed sensor outputs are detected even though the fault has been cleared. See **Subject 100** in this section for lubrication requirements.
4 (left rear) NOTE: The first blink code of the speed sensor fault codes represents which speed sensor is at fault.	2	The air gap is too large or the sensor is shorted.	Using a multimeter, check the resistance in the left rear speed sensor (3) circuit. Unplug connector D at the ECU and measure the resistance between pin D-5 and pin D-6. Unplug the speed sensor cable from the connector at the wheel location and measure the resistance between the two pins. The correct resistance for the speed sensor circuit is between 950 to 1900 ohms. If the sensor resistance is out of range, replace the sensor. Clean and lubricate the sensor. Press the sensor into the mounting hole until it bottoms against the tone wheel. Clear the fault code and verify that the fault code is corrected by test driving the vehicle. The warning light will remain on until proper speed sensor outputs are detected even though the fault has been cleared. See **Subject 100** in this section for lubrication requirements.
5 (right rear) NOTE: The first blink code of the speed sensor fault codes represents which speed sensor is at fault.	2	The air gap is too large or the sensor is shorted.	Using a multimeter, check the resistance in the right rear speed sensor (4) circuit. Unplug connector D at the ECU and measure the resistance between pin D-8 and pin D-9. Unplug the speed sensor cable from the connector at the wheel location and measure the resistance between the two pins. The correct resistance for the speed sensor circuit is between 950 to 1900 ohms. If the sensor resistance is out of range, replace the sensor. Clean and lubricate the sensor. Press the sensor into the mounting hole until it bottoms against the tone wheel. Clear the fault code and verify that the fault code is corrected by test driving the vehicle. The warning light will remain on until proper speed sensor outputs are detected even though the fault has been cleared. See **Subject 100** in this section for lubrication requirements.

Speed Sensor Fault Codes			
First Blink Code (manual retrieval)/ First Number (automatic retrieval)*	**Second Blink Code (manual retrieval)/ Second Number (automatic retrieval)**	**Condition**	**Action†**
2 (left front), 3 (right front), 4 (left rear), or 5 (right rear) NOTE: The first blink code of the speed sensor fault codes represents which speed sensor is at fault.	3	The speed sensor signal is noisy.	Examine the tone wheel for damage. Replace the tone wheel and/or hub if necessary. Check the wheel bearing adjustment. Adjust the wheel bearing if necessary. Clear the fault code and verify that the fault code is corrected by test driving the vehicle. The warning light will remain on until proper speed sensor outputs are detected even though the fault has been cleared.
2 (left front), 3 (right front), 4 (left rear), or 5 (right rear) NOTE: The first blink code of the speed sensor fault codes represents which speed sensor is at fault.	4	The wheel locked for an excessive period of time during the ABS cycle.	Check the mechanical function of the brakes. Check for kinked or restricted hoses. Make any necessary repairs. Clear the fault code and verify that the fault code is corrected by test driving the vehicle. The warning light will remain on until proper speed sensor outputs are detected even though the fault has been cleared.
2 (left front), 3 (right front), 4 (left rear), or 5 (right rear) NOTE: The first blink code of the speed sensor fault codes represents which speed sensor is at fault.	5	An excessive rate of deceleration is found at the wheel or the sensor is shorted.	Check the sensor resistance (see codes 2 2, 3 2, 4 2, and 5 2) to see if it is shorted. Clear the fault code and test drive the vehicle. The warning light will remain on until the proper speed sensor output is detected even though the fault has been cleared. If the fault recurs, check the tone wheel for excessive runout or damage. Repair tone wheel and/or adjust wheel bearings.
2 (left front), 3 (right front), 4 (left rear), or 5 (right rear) NOTE: The first blink code of the speed sensor fault codes represents which speed sensor is at fault.	6	The sensor connection is shorted low or high, or the sensor is open.	Use multimeter to verify proper sensor resistance. See fault codes 2 2, 3 2, 4 2, and 5 2 for speed sensor resistance testing procedures. Check the harness for shorts or opens. Repair the harness and/or replace the sensor as necessary. Clear the fault code and verify that the fault code is corrected by test driving the vehicle. The warning light will remain on until proper speed sensor outputs are detected even though the fault has been cleared.

Troubleshooting

Speed Sensor Fault Codes			
First Blink Code (manual retrieval)/ First Number (automatic retrieval)*	**Second Blink Code (manual retrieval)/ Second Number (automatic retrieval)**	**Condition**	**Action†**
2 (left front), 3 (right front), 4 (left rear), or 5 (right rear) NOTE: The first blink code of the speed sensor fault codes represents which speed sensor is at fault.	7	There is an internal error at the sensor port of the ECU	Clear the fault code and test drive the vehicle. The warning light will remain on until the proper speed sensor output is detected even though the fault has been cleared. If the fault recurs, or cannot be cleared, replace the ECU.
2 (left front), 3 (right front), 4 (left rear), or 5 (right rear) NOTE: The first blink code of the speed sensor fault codes represents which speed sensor is at fault.	8	A sensor has been found in the wrong location.	Check the control unit configuration and verify that the sensors are wired in the proper locations for the configuration. See the electrical schematics in **Specifications, 400** for wiring information.

* The first blink code of the speed sensor fault codes represents which speed sensor is at fault. 2 indicates the left steer speed sensor; 3 indicates the right steer speed sensor; 4 indicates the left rear speed sensor; 5 indicates the right rear speed sensor.

† When harnesses and components are being measured for proper resistance values, always measure the resistance at both the ECU harness connector and at the component.

Table 4, Speed Sensor Fault Codes

Pressure Modulator Valve Fault Codes			
First Blink Code (manual retrieval)/ First Number (automatic retrieval)*	**Second Blink Code (manual retrieval)/ Second Number (automatic retrieval)**	**Condition**	**Action†**
8 (left front) NOTE: The first blink code of the pressure modulator valve fault codes represents which pressure modulator valve is at fault.	1	There is a short circuit between the release solenoid and supply voltage.	Use a multimeter to check that the left steer pressure modulator valve resistances are correct. Unplug connector B at the ECU and measure the resistance between pin B-3 (common) and pin B-1 (release), pin B-3 (common) and pin B-2 (hold), and, pin B-1 (release) and pin B-2 (hold). Unplug the connector at the pressure modulator valve and measure the resistance between pin 1 (common [grn/yel]) and pin 2 (release [blu]), pin 1 (common [grn/yel]) and pin 3 (hold [brn]), and, pin 2 (release [blu]) and pin 3 (hold [brn]). The resistance between the common connection and the release connection, and, the common connection and the hold connection should range between 3 to 8 ohms. The resistance between the release connection and the hold connection should be between 6 to 16 ohms. If the resistances are correct at the valve and not correct at the ECU connector, then check the harness for a short circuit in the wiring. See **Fig. 3** for pressure modulator valve connector pin locations.
9 (right front) NOTE: The first blink code of the pressure modulator valve fault codes represents which pressure modulator valve is at fault.	1	There is a short circuit between the release solenoid and supply voltage.	Use a multimeter to check that the right steer pressure modulator valve resistances are correct. Unplug connector C at the ECU and measure the resistance between pin C-9 (common) and pin C-7 (release), pin C-9 (common) and pin C-8 (hold), and, pin C-7 (release) and pin C-8 (hold). Unplug the connector at the pressure modulator valve and measure the resistance between pin 1 (common [grn/yel]) and pin 2 (release [blu]), pin 1 (common [grn/yel]) and pin 3 (hold [brn]), and, pin 2 (release [blu]) and pin 3 (hold [brn]). The resistance between the common connection and the release connection, and, the common connection and the hold connection should range between 3 to 8 ohms. The resistance between the release connection and the hold connection should be between 6 to 16 ohms. If the resistances are correct at the valve and not correct at the ECU connector, then check the harness for a short circuit in the wiring. See **Fig. 3** for pressure modulator valve connector pin locations.

Troubleshooting

Pressure Modulator Valve Fault Codes			
First Blink Code (manual retrieval)/ First Number (automatic retrieval)*	**Second Blink Code (manual retrieval)/ Second Number (automatic retrieval)**	**Condition**	**Action†**
10 (left rear) NOTE: The first blink code of the pressure modulator valve fault codes represents which pressure modulator valve is at fault.	1	There is a short circuit between the release solenoid and supply voltage.	Use a multimeter to check that the left rear pressure modulator valve resistances are correct. Unplug connector D at the ECU and measure the resistance between pin D-3 (common) and pin D-1 (release), pin D-3 (common) and pin D-2 (hold), and, pin D-1 (release) and pin D-2 (hold). Unplug the connector at the pressure modulator valve and measure the resistance between pin 1 (common [grn/yel]) and pin 2 (release [blu]), pin 1 (common [grn/yel]) and pin 3 (hold [brn]), and, pin 2 (release [blu]) and pin 3 (hold [brn]). The resistance between the common connection and the release connection, and, the common connection and the hold connection should range between 3 to 8 ohms. The resistance between the release connection and the hold connection should be between 6 to 16 ohms. If the resistances are correct at the valve and not correct at the ECU connector, then check the harness for a short circuit in the wiring. See **Fig. 3** for pressure modulator valve connector pin locations.
11 (right rear) NOTE: The first blink code of the pressure modulator valve fault codes represents which pressure modulator valve is at fault.	1	There is a short circuit between the release solenoid and supply voltage.	Use a multimeter to check that the right rear pressure modulator valve resistances are correct. Unplug connector D at the ECU and measure the resistance between pin D-12 (common) and pin D-10 (release), pin D-12 (common) and pin D-11 (hold), and, pin D-10 (release) and pin D-11 (hold). Unplug the connector at the pressure modulator valve and measure the resistance between pin 1 (common [grn/yel]) and pin 2 (release [blu]), pin 1 (common [grn/yel]) and pin 3 (hold [brn]), and, pin 2 (release [blu]) and pin 3 (hold [brn]). The resistance between the common connection and the release connection, and, the common connection and the hold connection should range between 3 to 8 ohms. The resistance between the release connection and the hold connection should be between 6 to 16 ohms. If the resistances are correct at the valve and not correct at the ECU connector, then check the harness for a short circuit in the wiring. See **Fig. 3** for pressure modulator valve connector pin locations.
8 (left front), 9 (right front), 10 (left rear), or 11 (right rear) NOTE: The first blink code of the pressure modulator valve fault codes represents which pressure modulator valve is at fault.	2	There is a short circuit between the release solenoid and ground.	Use a multimeter to check that the valve resistances are correct. See fault codes 8 1, 9 1, 10 1, and 11 1 for pressure modulator valve resistance testing procedures.

Pressure Modulator Valve Fault Codes			
First Blink Code (manual retrieval)/ First Number (automatic retrieval)*	**Second Blink Code (manual retrieval)/ Second Number (automatic retrieval)**	**Condition**	**Action†**
8 (left front), 9 (right front), 10 (left rear), or 11 (right rear) NOTE: The first blink code of the pressure modulator valve fault codes represents which pressure modulator valve is at fault.	3	There is an open circuit at the release solenoid.	Use a multimeter to check that the valve resistances are correct. See fault codes 8 1, 9 1, 10 1, and 11 1 for pressure modulator valve resistance testing procedures.
8 (left front), 9 (right front), 10 (left rear), or 11 (right rear) NOTE: The first blink code of the pressure modulator valve fault codes represents which pressure modulator valve is at fault.	4	There is an open circuit in the common line to the valve.	Use a multimeter to check that the valve resistances are correct. See fault codes 8 1, 9 1, 10 1, and 11 1 for pressure modulator valve resistance testing procedures.
8 (left front), 9 (right front),10 (left rear), or 11 (right rear) NOTE: The first blink code of the pressure modulator valve fault codes represents which pressure modulator valve is at fault.	5	There is a short between the hold solenoid and the supply voltage.	Use a multimeter to check that the valve resistances are correct. See fault codes 8 1, 9 1, 10 1, and 11 1 for pressure modulator valve resistance testing procedures.
8 (left front), 9 (right front), 10 (left rear), or 11 (right rear) NOTE: The first blink code of the pressure modulator valve fault codes represents which pressure modulator valve is at fault.	6	There is a short between the hold solenoid and ground.	Use a multimeter to check that the valve resistances are correct. See fault codes 8 1, 9 1, 10 1, and 11 1 for pressure modulator valve resistance testing procedures.

Troubleshooting

Pressure Modulator Valve Fault Codes			
First Blink Code (manual retrieval)/ First Number (automatic retrieval)*	**Second Blink Code (manual retrieval)/ Second Number (automatic retrieval)**	**Condition**	**Action†**
8 (left front), 9 (right front), 10 (left rear), or 11 (right rear) NOTE: The first blink code of the pressure modulator valve fault codes represents which pressure modulator valve is at fault.	7	There is an open circuit at the hold solenoid.	Use a multimeter to check that the valve resistances are correct. See fault codes 8 1, 9 1, 10 1, and 11 1 for pressure modulator valve resistance testing procedures.
8 (left front), 9 (right front), 10 (left rear), or 11 (right rear) NOTE: The first blink code of the pressure modulator valve fault codes represents which pressure modulator valve is at fault.	8	A valve has been found wired in the wrong location.	Check the control unit configuration and verify that the valves are wired in the proper location for the configuration. See the electrical schematics in **Specifications, 400** for wiring information.
10 (diagonal 1, [right front, left rear])	10	A short to the supply voltage has been found on the common line of one or more of the valves that are connected to the diagonal one circuit (right steer and left rear valves).	Unplug the ECU and check for a short to the supply voltage (12 volts) on pins C-9, or D-3. If any of these pins are shorted to the supply voltage, then repair the harness. If no short to the supply voltage is found in the harness, then replace the ECU. See the electrical schematics in **Specifications, 400** for wiring information. NOTE: Before replacing the ECU, clear the fault codes and verify that the fault is still present.
10 (diagonal 1, [right front, left rear])	11	A short to ground has been found on the common line of one or more of the valves that are connected to the diagonal one circuit (right steer and left rear valves).	Unplug the ECU and check for a short to ground on pins C-9 or D-3. If any of these pins are shorted to ground, then repair the harness. If no short to ground is found in the harness, then replace the ECU. See the electrical schematics in **Specifications, 400** for wiring information. NOTE: Before replacing the ECU, clear the fault codes and verify that the fault is still present.

Pressure Modulator Valve Fault Codes			
First Blink Code (manual retrieval)/ First Number (automatic retrieval)*	**Second Blink Code (manual retrieval)/ Second Number (automatic retrieval)**	**Condition**	**Action†**
11 (diagonal 2 [left front, right rear])	10	A short to the supply voltage has been found on the common line of one or more of the valves that are connected to the diagonal two circuit (left steer and right rear valves).	Unplug the ECU and check for a short to the supply voltage (12 volts) on pins B-3 or D-12. If any of these pins are shorted to the supply voltage, then repair the harness. If no short to the supply voltage is found in the harness, then replace the ECU. See the electrical schematics in **Specifications, 400** for wiring information. NOTE: Before replacing the ECU, clear the fault codes and verify that the fault is still present.
11 (diagonal 2 [left front, right rear])	11	A short to ground has been found on the common line of one or more of the valves that are connected to the diagonal two circuit (left steer and right rear valves).	Unplug the ECU and check for a short to ground on pins B-3 or D-12. If any of these pins are shorted to ground, then repair the harness. If no short to ground is found in the harness, then replace the ECU. See the electrical schematics in **Specifications, 400** for wiring information. NOTE: Before replacing the ECU, clear the fault codes and verify that the fault is still present.

* The first blink code of the pressure modulator valve fault codes represents which pressure modulator valve is at fault. 8 indicates the left steer (PMV 1); 9 indicates the right steer (PMV 2); 10 indicates the left rear (PMV 3); 11 indicates the right rear (PMV 4).

† When harnesses and components are being measured for proper resistance values, always measure the resistance at both the ECU harness connector and at the component.

Table 5, Pressure Modulator Valve Fault Codes

Automatic Traction Control (ATC) Fault Codes			
First Blink Code (manual retrieval)/ First Number (automatic retrieval)	**Second Blink Code (manual retrieval)/ Second Number (automatic retrieval)**	**Condition**	**Action***
14	5	The solenoid in the ATC valve is shorted to the supply voltage.	Use a multimeter to check that the ATC valve resistance is correct. Unplug connector D at the ECU and measure the resistance between pins D-4 and D-7. Unplug the connector at the ATC valve and measure the resistance at the ATC valve. The correct resistance for the ATC circuit is between 9 to 15 ohms. If the resistance at the valve is correct and is incorrect at the ECU connector, then check the harness for a short in the wiring.
14	6	The solenoid in the ATC valve is shorted to ground.	Use a multimeter to check that the ATC valve resistance is correct. Unplug connector D at the ECU and measure the resistance between pins D-4 and D-7. Unplug the connector at the ATC valve and measure the resistance at the ATC valve. The correct resistance for the ATC circuit is between 9 to 15 ohms. If the resistance at the valve is correct and is incorrect at the ECU connector, then check the harness for a short in the wiring.

Troubleshooting

Automatic Traction Control (ATC) Fault Codes			
First Blink Code (manual retrieval)/ First Number (automatic retrieval)	**Second Blink Code (manual retrieval)/ Second Number (automatic retrieval)**	**Condition**	**Action***
14	7	There is an open circuit in the ATC valve.	Use a multimeter to check that the ATC valve resistance is correct. Unplug connector D at the ECU and measure the resistance between pins D-4 and D-7. Unplug the connector at the ATC valve and measure the resistance at the ATC valve. The correct resistance for the ATC circuit is between 9 to 15 ohms. If the resistance at the valve is correct and is incorrect at the ECU connector, then check the harness for an open circuit in the wiring.
14	8	An ATC valve is found when it should not be present.	Verify proper system configuration and components. Clear the faults. If an error cannot be cleared or recurs, replace the control unit.

* When harnesses and components are being measured for proper resistance values, always measure the resistance at both the ECU harness connector and at the component.

Table 6, Automatic Traction Control (ATC) Fault Codes

ECU Fault Codes			
First Blink Code (manual retrieval) / First Number (automatic retrieval)	**Second Blink Code (manual retrieval)/ Second Number (automatic retrieval)**	**Condition**	**Action***
14	9	The engine interface (ECU) is shorted to ground or to the supply voltage.	Use multimeter to check the vehicle harness for shorts. See the vehicle wiring schematic for wiring information. If the wiring is okay and the fault cannot be cleared, then replace the ECU.
14	10	An error has been reported from the engine data link.	Check the engine control unit for proper diagnostic link function.
14	11	The engine interface (ECU) is shorted to ground or to the supply voltage.	Use multimeter to check for vehicle harness for shorts. See the vehicle wiring schematic for wiring information. If the wiring is okay and the fault cannot be cleared, then replace the ECU.
14	12	No connection found to diagnostic link (J1922)	Check for proper connections between the J1922 data link and pins A1 and A3 of the ABS ECU. Verify that the polarity is correct. A3 is positive (+) polarity and A1 is negative (–) polarity. If the vehicle is not equipped with a J1922 engine link, use a diagnostic tool to change the configuration of the ECU.
15	1,2,3,4,5,6,7,8,9,10, or 11	ECU internal fault.	If the fault cannot be cleared, then replace the ECU.

* When harnesses and components are being measured for proper resistance values, always measure the resistance at both the ECU harness connector and at the component.

Table 7, ECU Fault Codes

Power (Battery) Fault Codes			
First Blink Code (manual retrieval)/ First Number (automatic retrieval)	**Second Blink Code (manual retrieval)/ Second Number (automatic retrieval)**	**Condition**	**Action***
16	1	Excessive voltage found on diagonal 1.	Verify that the vehicle system voltage is okay (9 to 16 volts). If the voltage is out of range, correct the system voltage problem. Unplug connector A at the ECU and turn on the ignition switch. If voltage at pin A-9 is different than the system voltage, repair the wiring. Clear the faults and verify that the warning light turns off after the bulb check.
16	2	Low voltage on diagonal 1.	Verify that the vehicle system voltage is okay (9 to 16 volts). If the voltage is out of range, correct the system voltage problem. Unplug connector A at the ECU and turn on the ignition switch. If voltage at pin A-9 is different than the system voltage, repair the wiring. Clear the faults and verify that the warning light turns off after the bulb check.
16	3	No voltage found on diagonal 1.	Verify that the vehicle system voltage is okay (9 to 16 volts). If the voltage is out of range, correct the system voltage problem. Unplug connector A at the ECU and turn on the ignition switch. If voltage at pin A-9 is different than the system voltage, repair the wiring. Clear the faults and verify that the warning light turns off after the bulb check.
16	4	No ground found on diagonal 1.	Unplug connector A at the ECU and measure the resistance to ground at pin A-12. If continuity to ground is not present, repair the harness.
16	5	Excessive voltage found at diagonal 2.	Verify that the vehicle system voltage is okay (9 to 16 volts). If the voltage is out of range, correct the system voltage problem. Unplug connector A at the ECU and turn on the ignition switch. If voltage at pin A-8 is different than the system voltage, repair the wiring. Clear the faults and verify that the warning light turns off after the bulb check.
16	6	Low voltage at diagonal 2.	Verify that the vehicle system voltage is okay (9 to 16 volts). If the voltage is out of range, correct the system voltage problem. Unplug connector A at the ECU and turn on the ignition switch. If voltage at pin A-8 is different than the system voltage, repair the wiring. Clear the faults and verify that the warning light turns off after the bulb check.
16	7	No voltage found at diagonal 2.	Verify that the vehicle system voltage is okay (9 to 16 volts). If the voltage is out of range, correct the system voltage problem. Unplug connector A at the ECU and turn on the ignition switch. If voltage at pin A-8 is different than the system voltage, repair the wiring. Clear the faults and verify that the warning light turns off after the bulb check.

Troubleshooting

Power (Battery) Fault Codes			
First Blink Code (manual retrieval)/ First Number (automatic retrieval)	**Second Blink Code (manual retrieval)/ Second Number (automatic retrieval)**	**Condition**	**Action***
16	8	No ground found at diagonal 2.	Unplug connector at the ECU and measure the resistance to ground at pin A-11. If continuity to ground is not present, repair the harness.
16	9	Excessive voltage found on the switched ignition input.	Verify that the vehicle system voltage is okay (9 to 16 volts). If the voltage is out of range, correct the system voltage problem. Unplug connector A at the ECU and turn on the ignition switch. If voltage at pin A-7 is different than the system voltage, repair the wiring. Clear the faults and verify that the warning light turns off after the bulb check.
16	10	Low voltage found on the switched ignition input.	Verify that the vehicle system voltage is okay (9 to 16 volts). If the voltage is out of range, correct the system voltage problem. Unplug connector A at the ECU and turn on the ignition switch. If voltage at pin A-7 is different than the system voltage, repair the wiring. Clear the faults and verify that the warning light turns off after the bulb check.
16	11	Voltage difference between diagonal 1 and diagonal 2 supply is too high.	Verify that the vehicle system voltage is okay (9 to 16 volts). If the voltage is out of range, correct the system voltage problem. Unplug connector A at the ECU and turn on the ignition switch. If voltage at pin A-8 is different than the voltage at pin A-9, by greater than 0.5 volts, repair the wiring. Check the circuit breakers and/or fuses on the diagonal supply line. Clear the faults and verify that the warning light turns off after the bulb check.

* When harnesses and components are being measured for proper resistance values, always measure the resistance at both the ECU harness connector and at the component.

Table 8, Power (Battery) Fault Codes

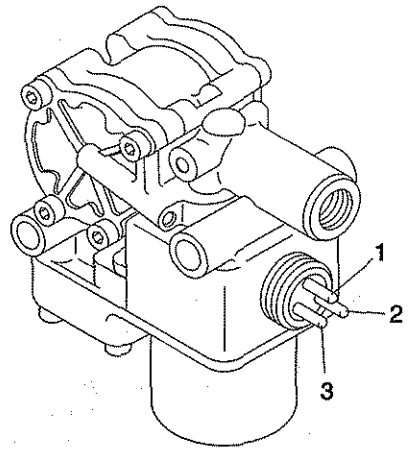
Miscellaneous Fault Codes			
First Blink Code (manual retrieval)/ First Number (automatic retrieval)	**Second Blink Code (manual retrieval)/ Second Number (automatic retrieval)**	**Condition**	**Action***
17	1	The retarder control relay is shorted to the supply voltage or has an open circuit.	Use multimeter to verify proper voltage at the retarder control relay.
17	2	The retarder relay is shorted to ground.	Use multimeter to verify proper voltage at the retarder control relay.
17	3	The J1922 data link is not functioning.	Unplug connector A. The voltage should measure between 0 to 2.5 volts on pin A-1 and the voltage should measure between 2.5 to 5 volts on pin A-3. Make any necessary wiring harness corrections.

Miscellaneous Fault Codes			
First Blink Code (manual retrieval)/ First Number (automatic retrieval)	**Second Blink Code (manual retrieval)/ Second Number (automatic retrieval)**	**Condition**	**Action***
17	4	J1922 data link time out.	Unplug connector A. The voltage should measure between 0 to 2.5 volts on pin A-1 and the voltage should measure between 2.5 to 5 volts on pin A-3. Make any necessary wiring harness corrections.
17	5	Tire size, front to rear, out of range.	There is too great a distance in the rolling radius of the front and rear tires. Steer axle tire radius cannot be more than 20% above the rear axle tire radius or 10% below. If the static loaded radius of the rear tires is outside the range of 15.9 to 21.5 inches (40.4 to 54.6 cm), then the ECU must be re-calibrated using a diagnostic tool.
17	6	Tire size out of range or parameter fault.	There is too great a distance in the rolling radius of the front and rear tires. Steer axle tire radius cannot be more than 20% above the rear axle tire radius or 10% below. If the static loaded radius of the rear tires is outside the range of 15.9 to 21.5 inches (40.4 to 54.6 cm), then the ECU must be re-calibrated using a diagnostic tool.
17	7	Brake light switch not pushed at this power cycle.	Press brake pedal. If error does not clear, check for missing connection at brake light switch. If the brake is not applied, you should measure the resistance at the brake light bulb (is the bulb broken?). If the brake is applied, you should measure vehicle system voltage (9 to 16 volts) at the brake light bulb.
17	8	ATC system is disabled for dynamometer test.	Cycle the ignition switch to re-enable the ATC system.

* When harnesses and components are being measured for proper resistance values, always measure the resistance at both the ECU harness connector and at the component.

Table 9, Miscellaneous Fault Codes

Troubleshooting



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1. Pin 1-common (the resistance specification between pin 1 to pin 2 is 3 to 8 ohms and the resistance specification between pin 1 to pin 3 is 3 to 8 ohms)
2. Pin 2-release (the resistance specification between pin 2 and pin 3 is 6 to 16 ohms)
3. Pin 3-hold

Fig. 3, Pressure Modulator Valve Connector Pin Locations

See **Fig. 1** for a full view of the wiring diagram for the ABS valves and sensors. See **Fig. 2**, and **Fig. 3** for partial (detailed) views of the wiring diagram. See **Fig. 4** for a full view of the diagram showing additional ABS cab and chassis wiring. See **Fig. 5**, **Fig. 6** and **Fig. 7** for partial (detailed) views of the wiring diagram.

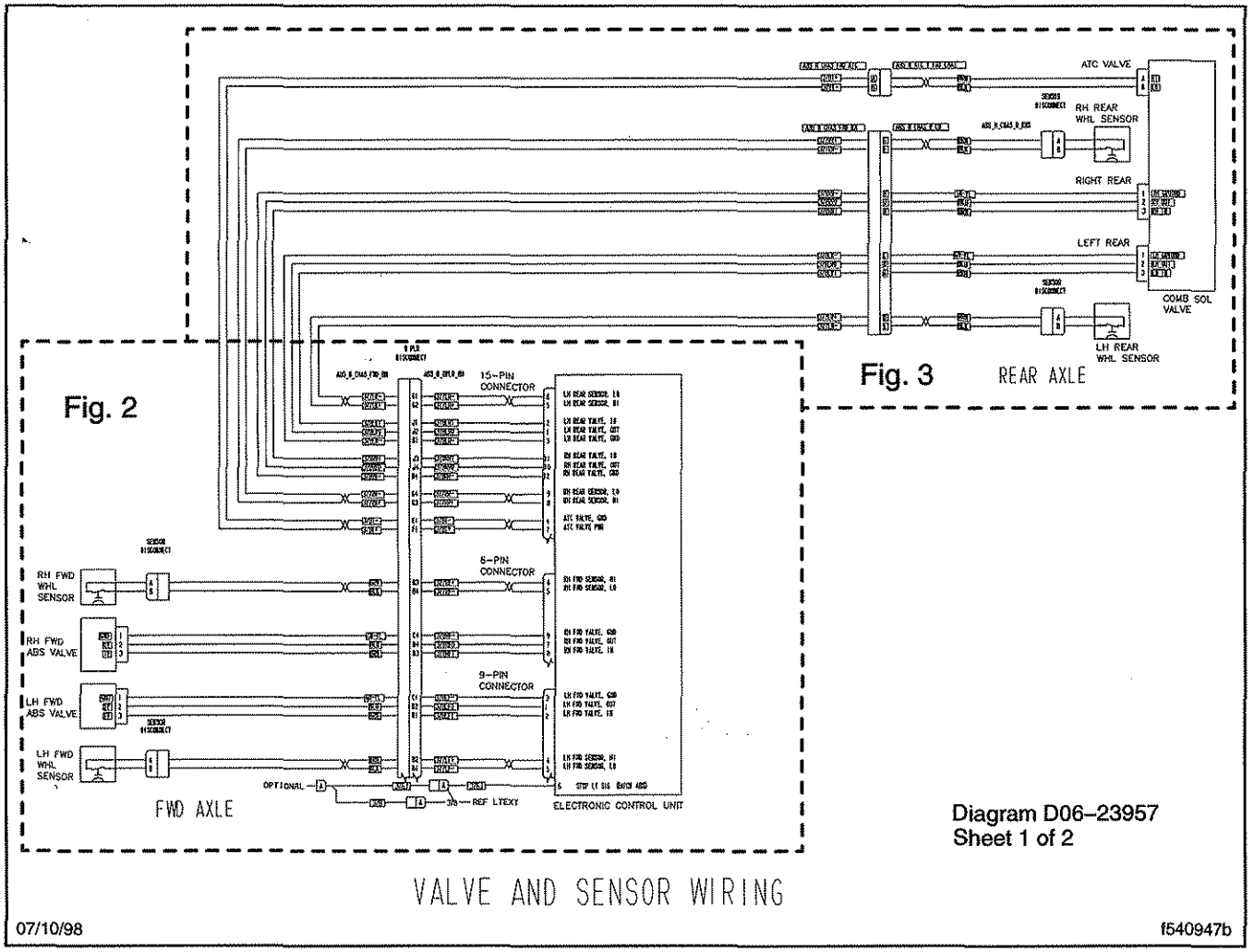


Fig. 1, Wiring Diagram for ABS Valves and Sensors

Specifications

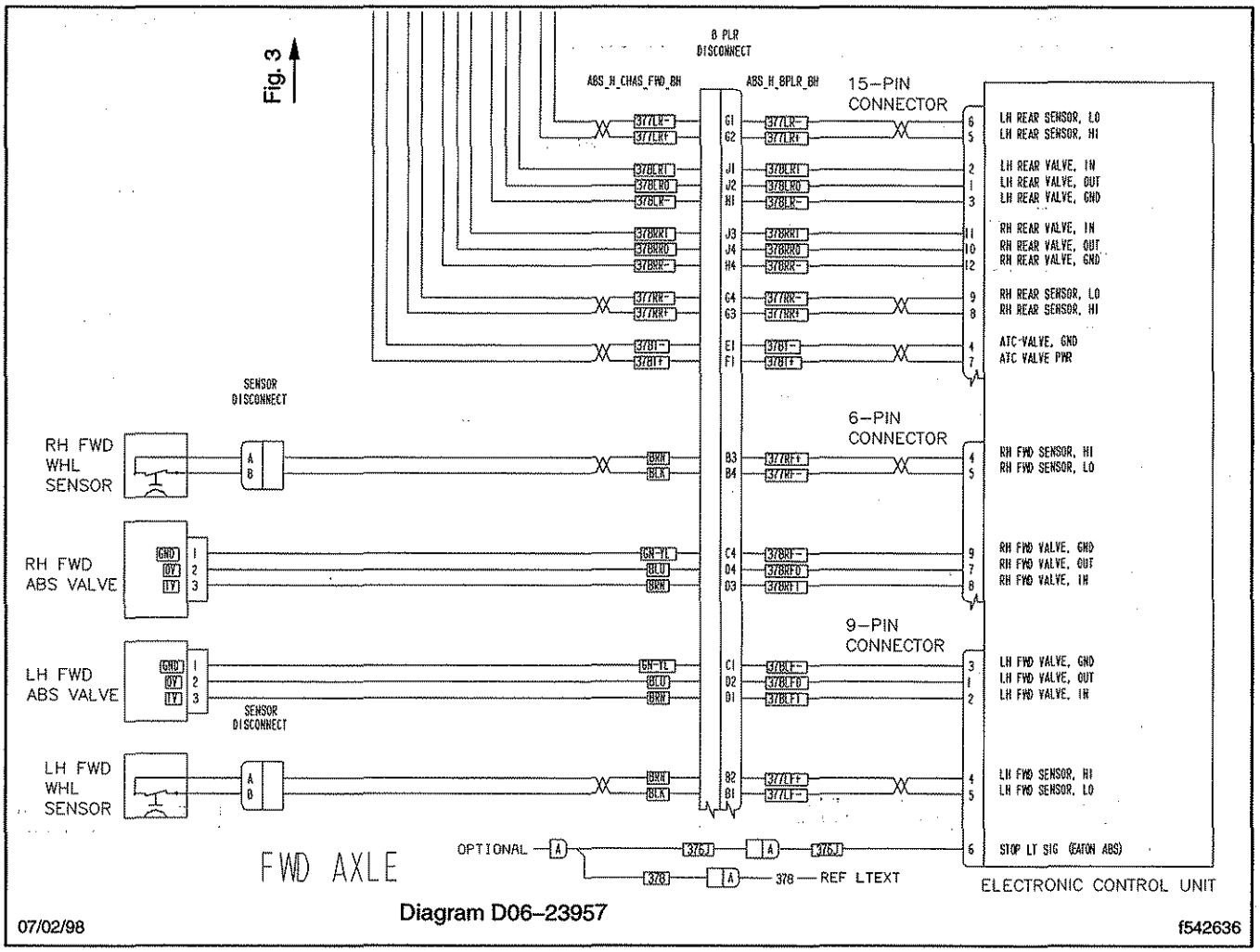


Fig. 2, Front Axle Wiring (partial view)

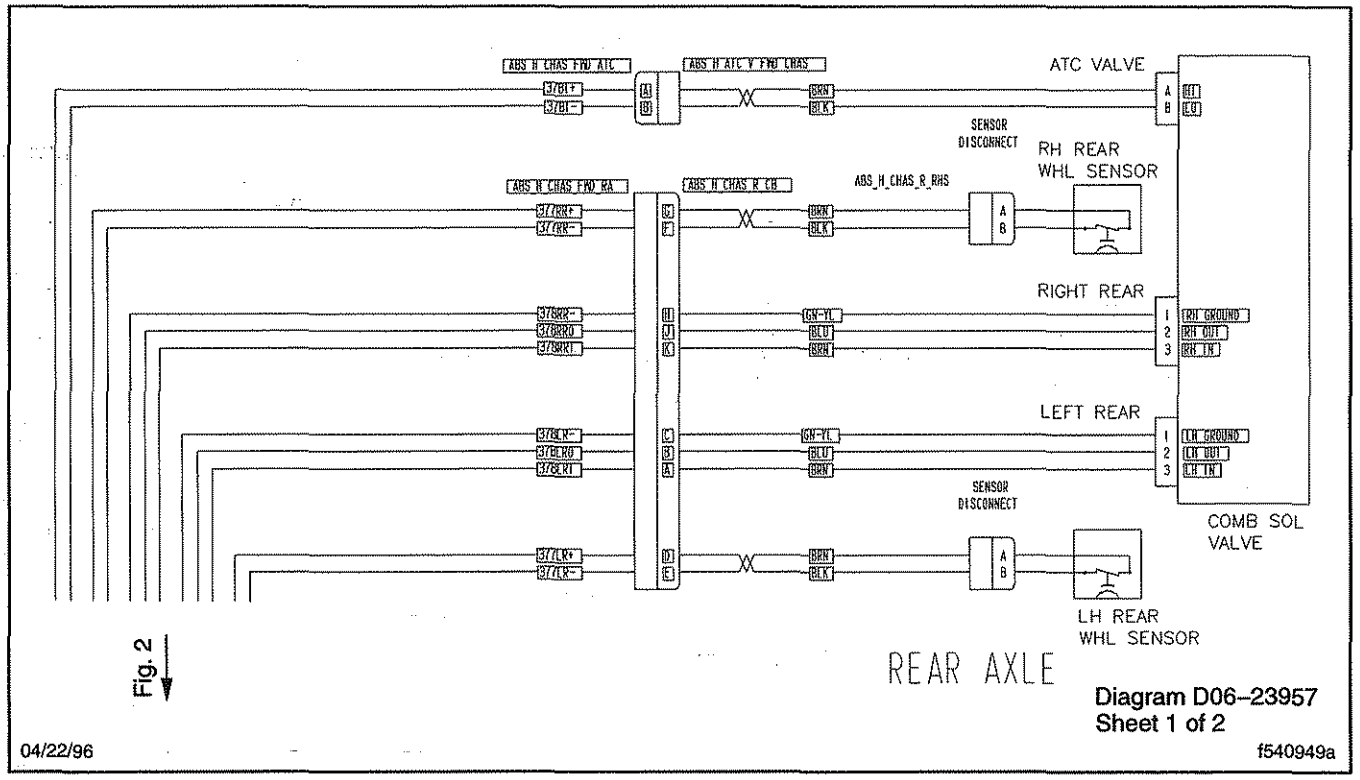


Fig. 3, Rear Axle Wiring (partial view)

Specifications

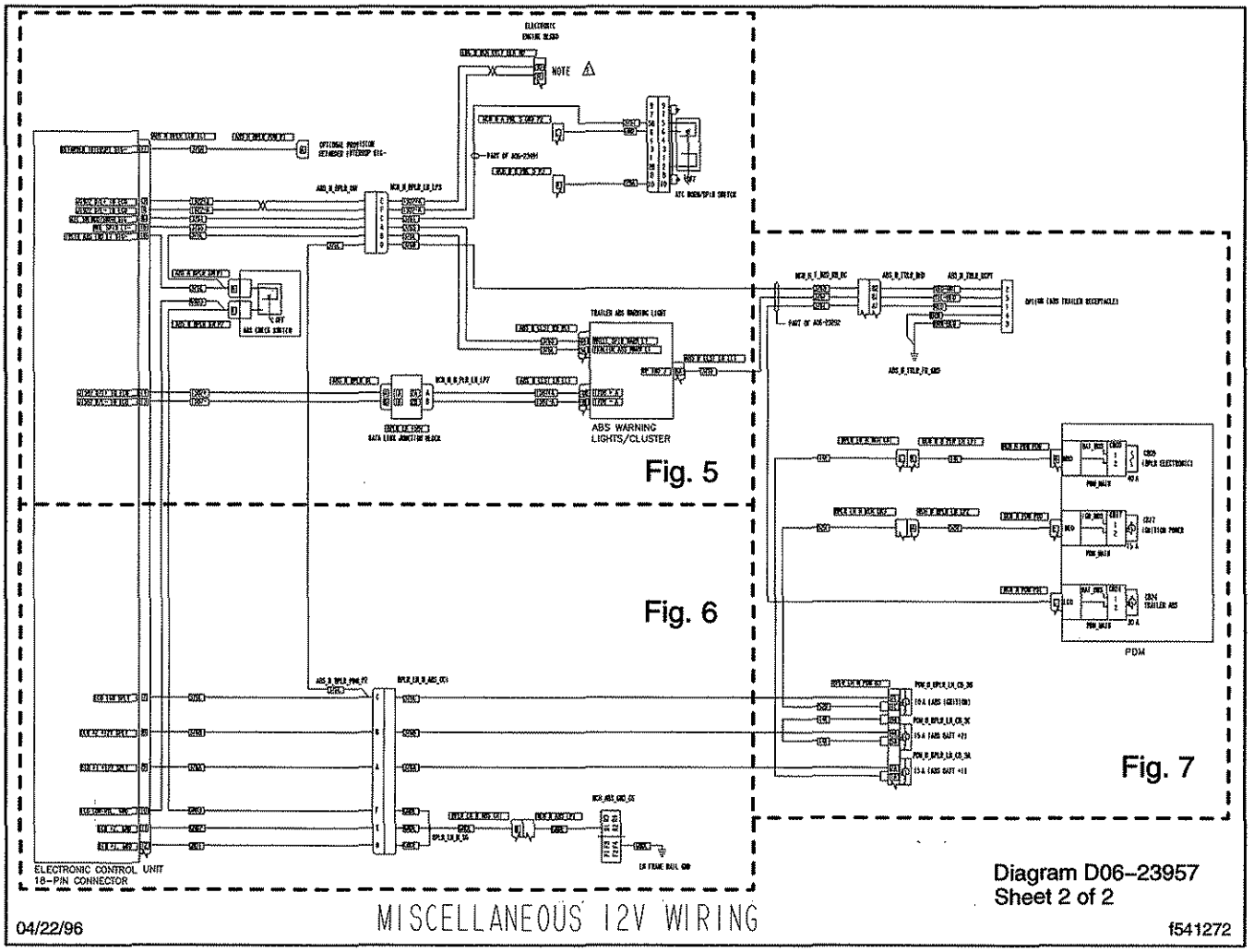


Fig. 4, ABS Cab and Chassis Wiring

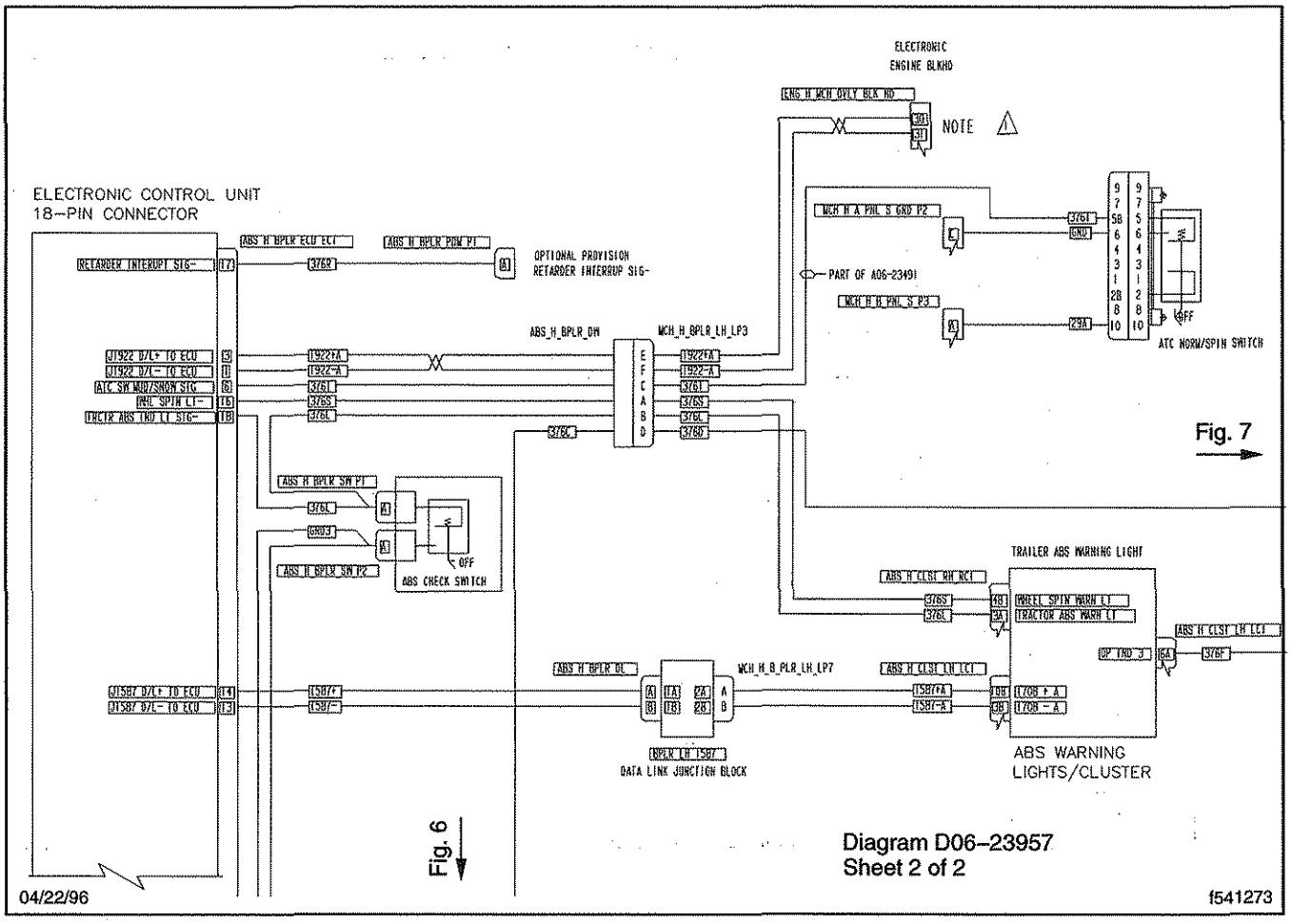


Fig. 5, ABS Cab and Chassis Wiring (partial view)

Specifications

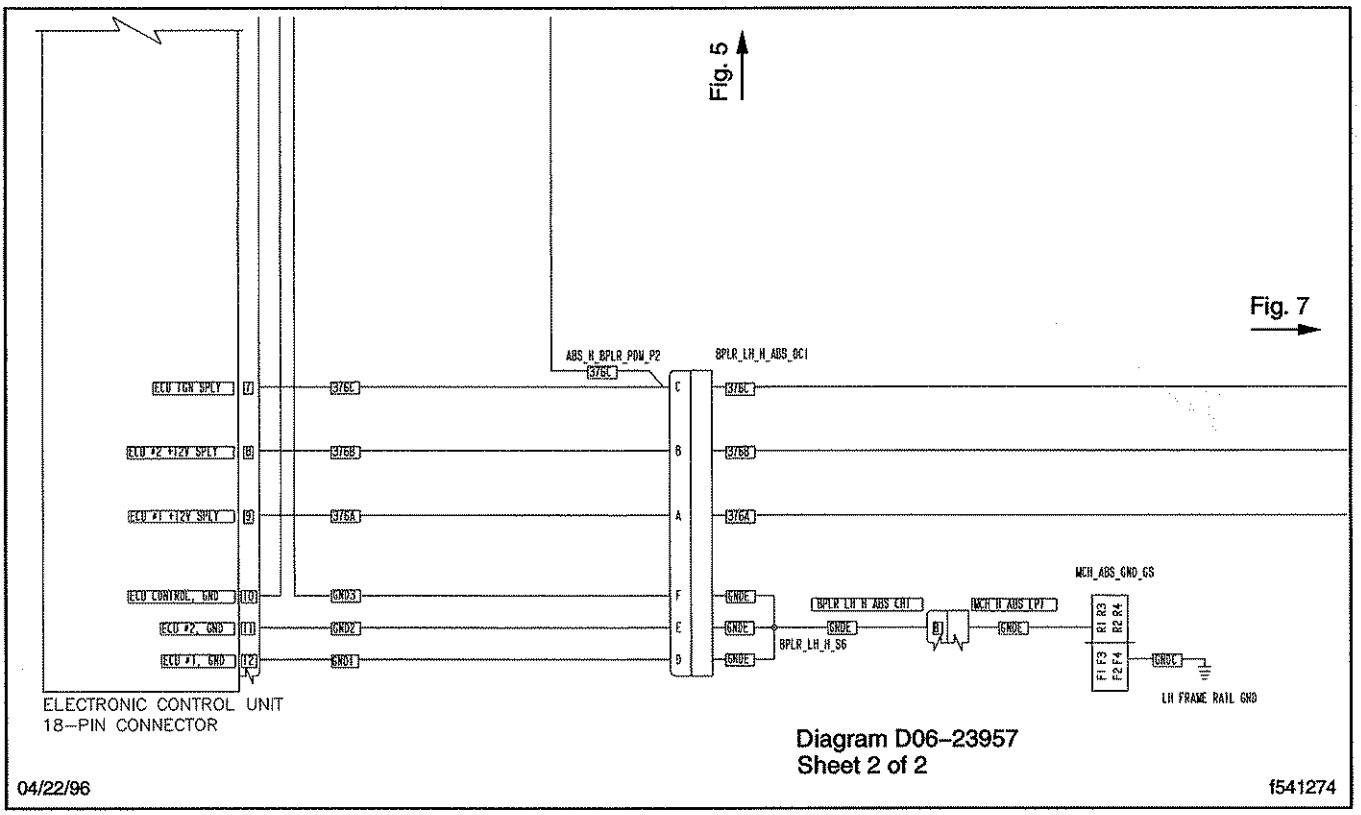


Fig. 6, ABS Cab and Chassis Wiring (partial view)

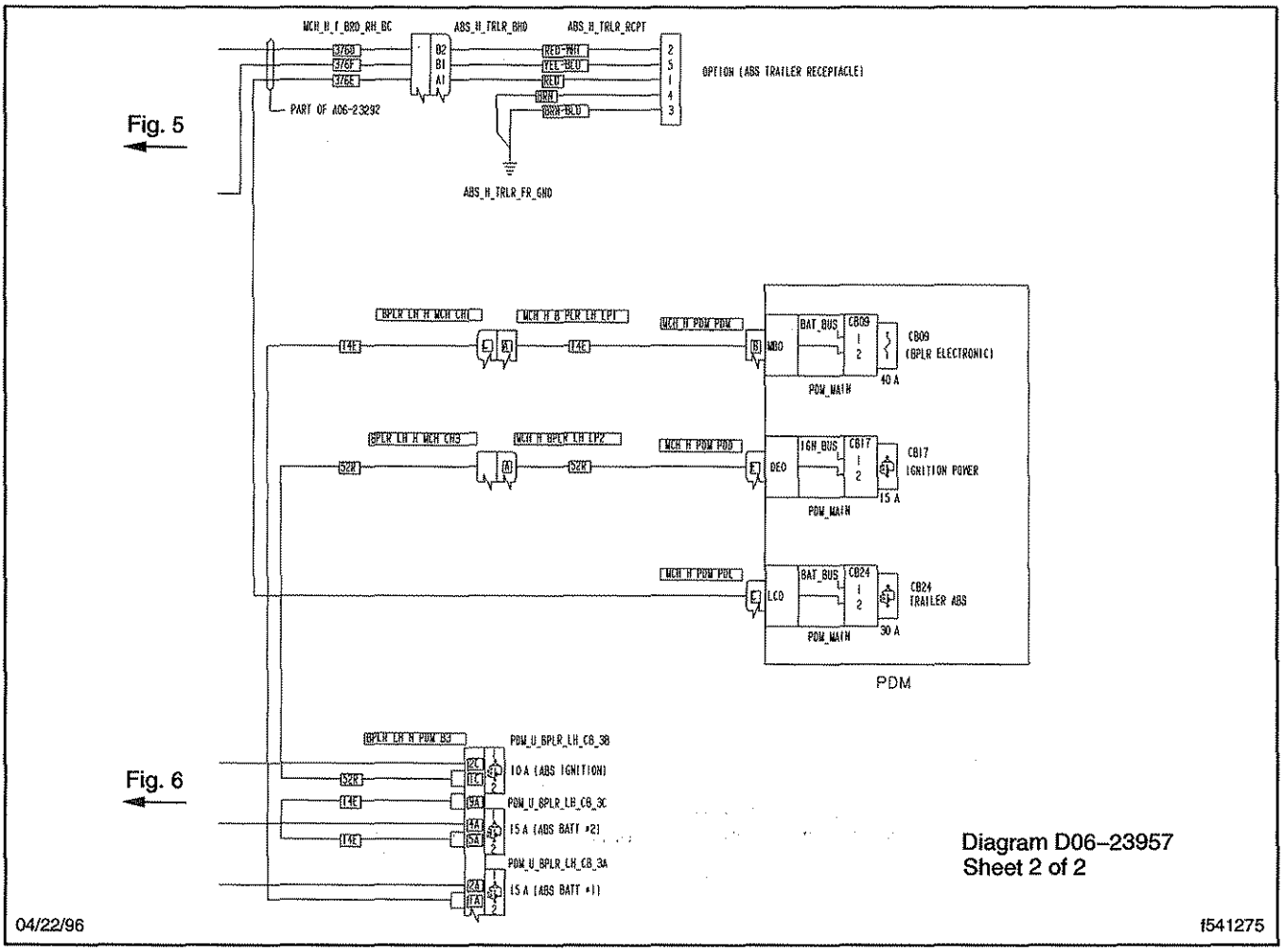


Fig. 7, ABS Cab and Chassis Wiring (partial view)

Contents

Subject	Subject Number
General Information	050
Service Operations	
Wheel Speed Sensor Replacement	100
Modulator Valve Replacement	110
Rear Axle Wheel Speed Sensor Adjustment	120
Troubleshooting	300
Specifications	400

General Description (See Fig. 1)

The Bendix Antilock Braking System (ABS) is an electronic wheel-speed monitoring and control system that works with the standard air brake system. ABS passively monitors vehicle wheel speed at all times, and controls wheel speed during emergency stops. In normal braking applications, the standard air brake system is in effect.

ABS includes signal-generating tone wheels and sensors located in the wheel hubs of each sensed wheel. The sensors transmit vehicle wheel speed information to an electronic control unit. According to programmed specifications, the control unit signals the appropriate modulator valve to increase, reduce, or maintain air

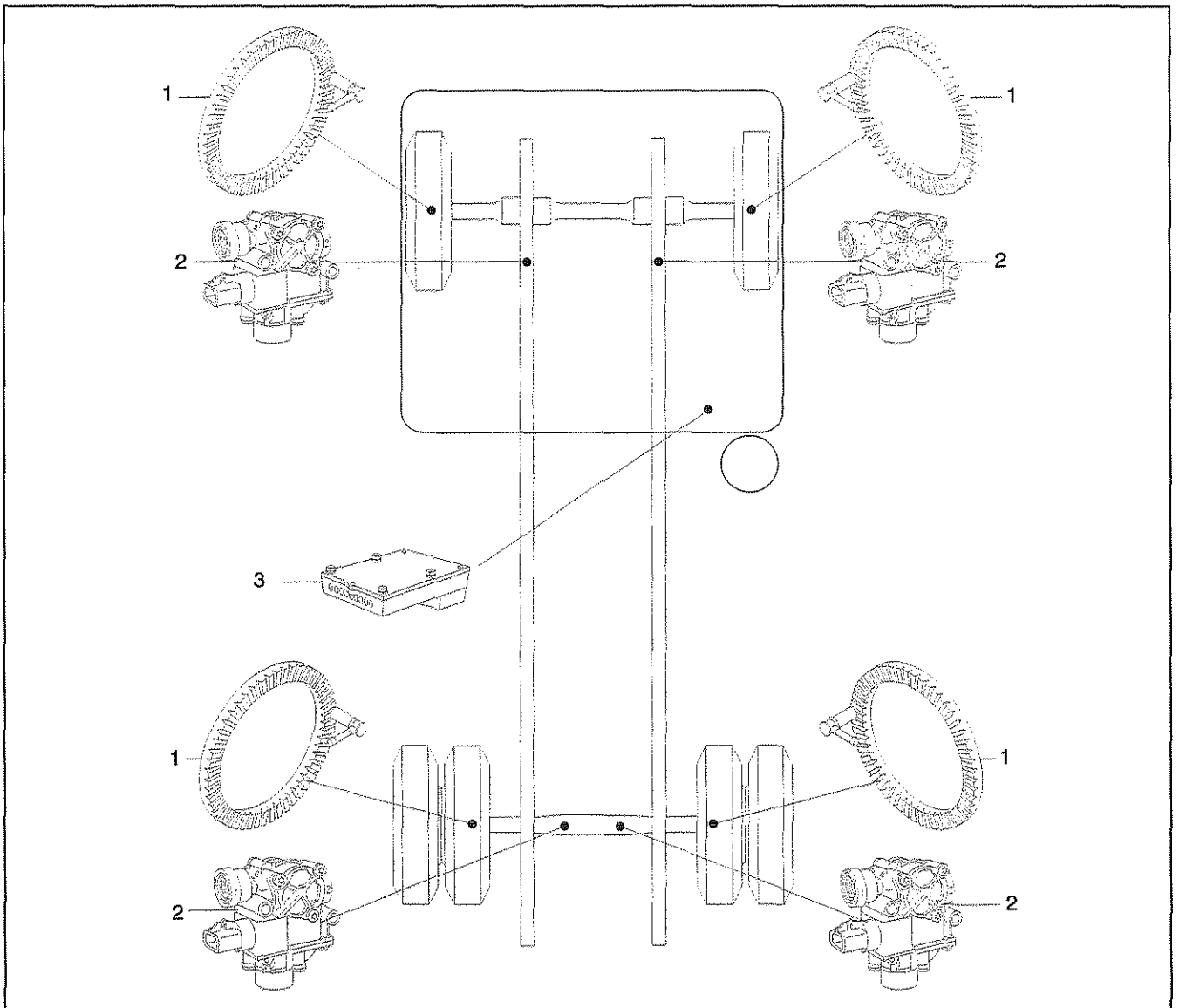


Fig. 1, Location of ABS Components, Four-Channel System

pressure supply in the brake chamber. This prevents front and rear wheel lockup, and enhances steering control during emergency braking situations.

Principles of Operation

The ABS electronic control unit (ECU) is a digital microcomputer that serves as the information processing and command center for the antilock braking system. See **Fig. 2**. The ECU receives and processes vehicle wheel speed information from the sensors. During emergency brake applications, the ECU regulates the braking force applied to each wheel by sending control signals to the modulator valve. See **Fig. 3**.

ABS MAJOR COMPONENTS

Wheel Speed Sensor

The wheel speed sensors use pulse feedback from 100-tooth tone wheels located in the front and rear axle wheel hubs. When the vehicle is moving, the teeth of the tone wheel cause interruptions in a magnetic field created by the sensor. The interruptions created in the magnetic field in turn create electrical pulses that are sent by the sensor to the ECU.

Electronic Control Unit (ECU)

The ECU receives speed sensor pulses and interprets these signals to calculate wheel speed and a vehicle reference speed. If the calculations indicate wheel slip or lockup, the appropriate control circuit signals the modulator valve to increase or decrease braking pressure.

There are three versions of the ECU. The older versions (EC-15 and EC-16) are factory programmed with vehicle particulars, such as the number of speed sensors, if the traction control feature was enabled and the type of traction control (torque limiting, differential braking, or both).

The current, self-configuring ECU (EC-17) can be most easily identified while installed on the vehicle. Identification can be made by observing the reaction of the diagnostic display when the ignition is turned on and power is applied to the ECU. The current configuration of the ECU is displayed via the troubleshooting LEDs and occurs during the normal self test sequence. Only the LEDs that correspond to the sensors identified during the self-configuration will illuminate. If all antilock components are working properly, the red LEDs will turn off and the single, green, VLT LED will be illuminated. This configuration review is repeated each time the ignition is turned on.

IMPORTANT: The LED display is optional on the EC-17. The EC-17N control unit does not have an LED display and the AlliedSignal Bendix Diagnostic Communication Interface (DCI) must be used for diagnostics or reconfiguration.

On the older versions of the ECU, *all* diagnostic LEDs will illuminate and then go out if all antilock components are working properly. During normal operation, all the red LEDs will be off and the single, green, VLT LED will be illuminated. See **Troubleshooting, 300** for more information on the LED display.

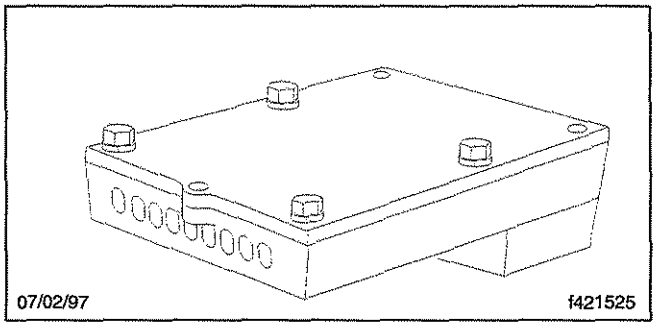


Fig. 2, ABS Electronic Control Unit (ECU)

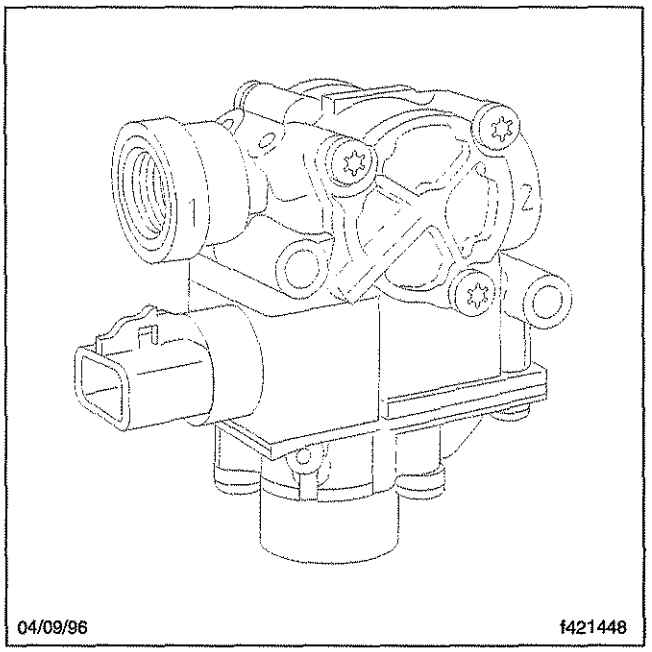


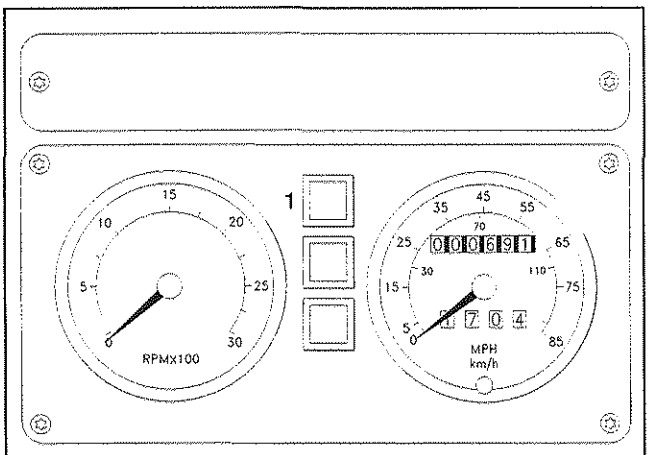
Fig. 3, Modulator Valve

The ECU contains a safety circuit to constantly monitor the wheel sensors, modulator assemblies, and the electrical circuitry. After the ignition is switched on, the tractor warning light (TRAC ABS) comes on. See **Fig. 4**. On vehicles with newer ECUs, the TRAC ABS light will go out shortly after the ignition is turned on. On vehicles with the older ECUs, the TRAC ABS light will stay lit until the vehicle reaches 7 mph (11 km/h). The TRAC ABS light will stay on if the tractor's ABS components are not working properly.

When vehicle power is supplied to the EC-17, a modulator "chuff" test is performed. When the brake pedal is depressed while the ECU is powered up, the modulator "chuff" test can be heard. This test will verify if the modulator is connected correctly and is functional. The modulators will exhaust air in the sequence of right front, left front, right rear and left rear. If they don't follow this sequence, proceed with modulator troubleshooting. See **Troubleshooting, 300**.

If, during vehicle operation, the safety circuit senses a failure in any part of the ABS system (a sensor, modulator valve, wiring connection, short circuit, etc.), the TRAC ABS light comes on, and the control circuit where the failure occurred is switched to normal braking action. Remaining control circuits will retain the ABS effect. Even if the ABS system is completely inoperative, normal braking is maintained. The vehicle is not disabled.

IMPORTANT: If the ABS warning lights do not work as described above, there is a possible system malfunction. If this occurs, the vehicle will continue to have normal braking ability, but without ABS. Service the ABS as soon as possible. See **Troubleshooting, 300** for fault diagnosis.



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1. TRAC ABS

Fig. 4, Indicator Light

Modulator Valve

Depending on the signal received from the ECU, the modulator valve prevents wheel lockup by reducing, maintaining, or increasing brake chamber air pressure. During normal braking applications, compressed air flows freely to the brake chamber through the modulator valve.

If the ECU receives signals indicating wheel lockup during a brake application, the ECU energizes both the supply and exhaust solenoids in the modulator valve. See **Fig. 5**. Energizing the supply solenoid causes its exhaust to close and inlet to open. With the inlet of the supply solenoid open, application air is permitted to flow to the control side of the supply diaphragm. Air pressure acting on the supply diaphragm causes it to close the supply diaphragm and prevent further delivery of air to the brake chamber.

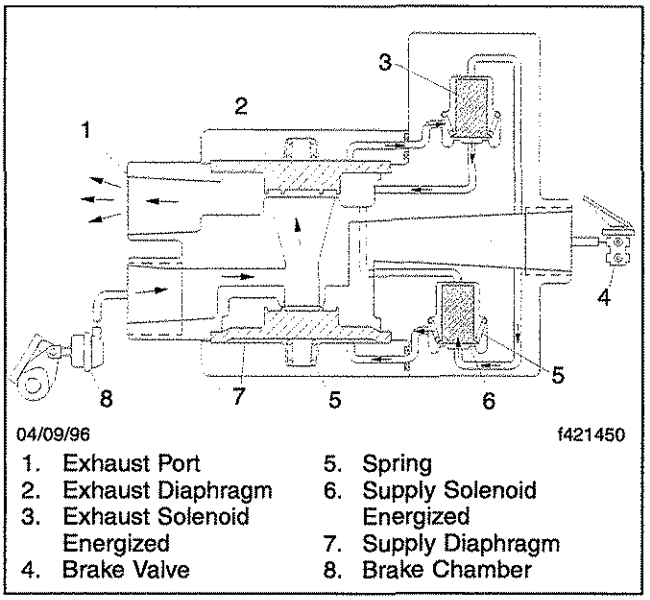
Energizing the exhaust solenoid closes its inlet and opens its exhaust. By closing the exhaust solenoid inlet, application air is prevented from flowing to the control side of the exhaust diaphragm. Air pressure, which was present on the control side of the exhaust diaphragm flows out the exhaust port of the modulator valve. With control air pressure removed from the exhaust diaphragm, brake application air forces the exhaust diaphragm to unseat which allows it to flow out the modulator exhaust port.

As wheel speed increases, the modulator valve alternately increases, then maintains brake pressure until the proper wheel speed is obtained, or until wheel lockup occurs and the control cycle starts again.

During the pressure increase cycle (**Fig. 6**), brake application air enters the supply port of the modulator valve and flows to, and through, the open exhaust solenoid, then to the exhaust diaphragm. Air pressure, along with spring force, seats the exhaust diaphragm on the exhaust passage thus preventing the escape of service air. At the same time, application air flows to the supply diaphragm and forces it away from its seat. Air flows past the open supply and out the modulator valve delivery port to the service brake chambers.

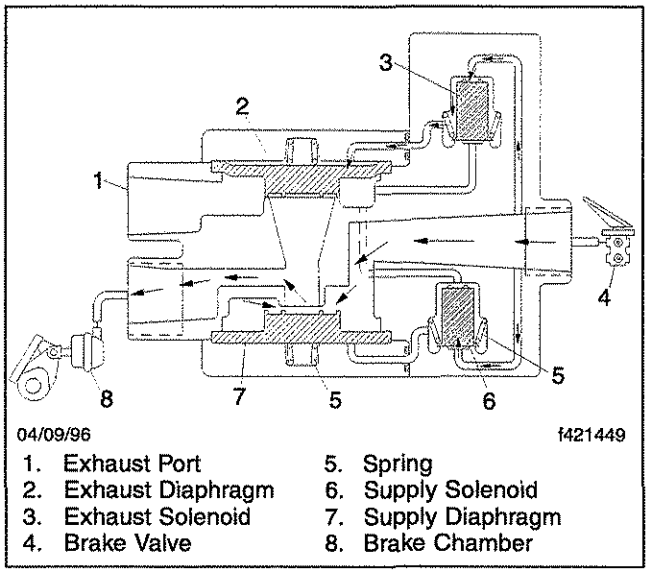
If maintaining brake air pressure (**Fig. 7**), the ECU energizes the supply solenoid and de-energizes the exhaust solenoid. This seats both diaphragms and prevents further exhaust of brake chamber air pressure

General Information



1. Exhaust Port
2. Exhaust Diaphragm
3. Exhaust Solenoid Energized
4. Brake Valve
5. Spring
6. Supply Solenoid Energized
7. Supply Diaphragm
8. Brake Chamber

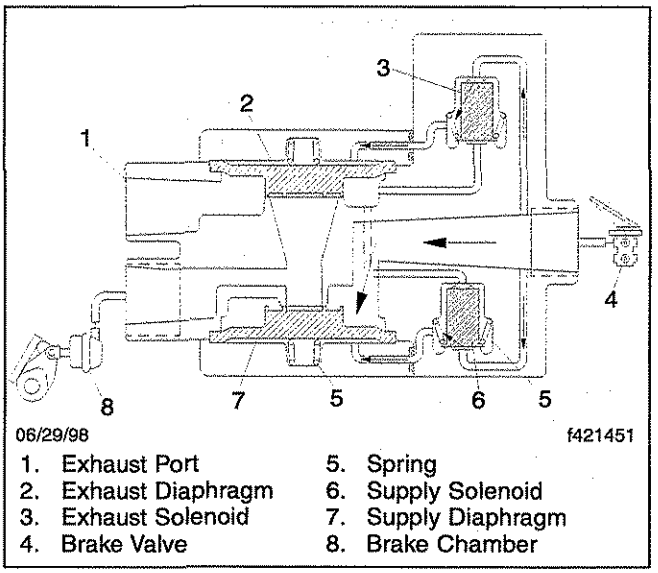
Fig. 5, Wheel Lockup



1. Exhaust Port
2. Exhaust Diaphragm
3. Exhaust Solenoid
4. Brake Valve
5. Spring
6. Supply Solenoid
7. Supply Diaphragm
8. Brake Chamber

Fig. 6, Pressure Increase

and prevents the application air from flowing out of the delivery port to the brake chamber.



1. Exhaust Port
2. Exhaust Diaphragm
3. Exhaust Solenoid
4. Brake Valve
5. Spring
6. Supply Solenoid
7. Supply Diaphragm
8. Brake Chamber

Fig. 7, Maintaining Pressure

Wheel Speed Sensor Replacement

Replacement

NOTE: Wire repairs may require the use of special tools for certain connectors and terminals. See **Group 54** in this manual for information on special terminals and connectors, and on ordering tools for them.

FRONT AXLE

1. Chock the rear tires to prevent vehicle movement. Apply the parking brakes.
2. Twist and pull the sensor to remove it from the steering knuckle. See **Fig. 1**
3. Remove the sensor cable from the steering knuckle top cap.
4. Disconnect the sensor cable from the chassis harness.
5. Remove the clamping bushing from the brake spider hole.
6. Connect the sensor cable to the chassis harness.
7. Attach the sensor cable to the steering knuckle top cap.
8. Push the clamping bushing into the brake spider hole until it stops.

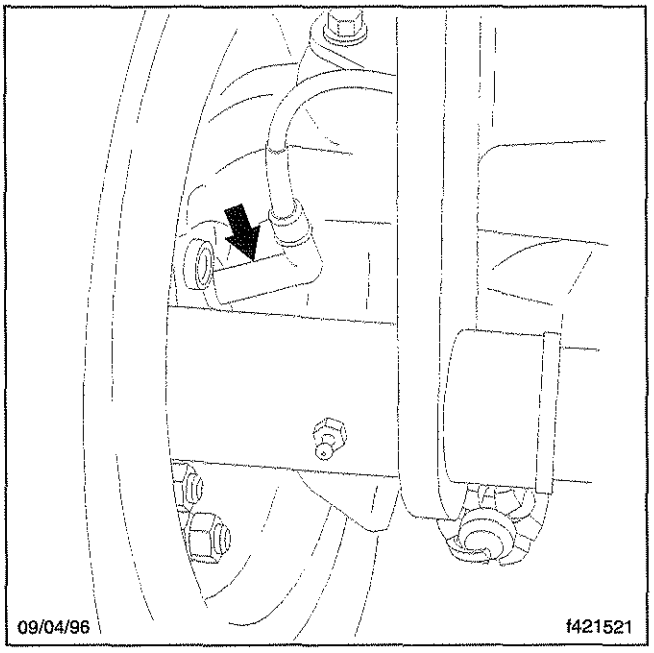


Fig. 1, Wheel Speed Sensor

9. Coat the sensor with Mobil HP, Valvoline EP 633, Penzoil 707L, or an equivalent grease. Push the sensor into the clamping bushing until it is stopped by the tone wheel.
10. Remove the chocks from the rear tires.

REAR AXLE

1. Chock the front tires to prevent vehicle movement.
2. Raise the rear of the vehicle until the tires clear the ground. Place safety stands under the axle.
3. Back off the slack adjuster to release the rear axle brake shoes.
4. Remove the wheel and tire assembly from the rear axle. For instructions, see **Group 40** in this manual.
5. Remove the brake drum. For instructions, see **Group 35** in this manual.
6. Twist and pull the sensor, to remove it from the mounting block in the axle housing.
7. Remove the clamping bushing.
8. Remove the capscrew that attaches the sensor cable and the hose clamp to the axle tube.
9. Disconnect the sensor cable from the chassis harness.
10. Connect the sensor cable to the chassis harness.
11. Attach the hose clamp and sensor cable to the axle tube located between the backing plate and the spring plate.
12. Push the clamping bushing into the mounting block until it stops.
13. Coat the sensor with Mobil HP, Valvoline EP633, Penzoil 707L, or an equivalent grease. Push the sensor into the clamping bushing until it is stopped by the tone wheel.
14. Install the brake drum on the wheel hub.
15. Adjust the rear axle brakes. For instructions, see **Group 42** in this manual.
16. Install the wheel and tire assembly, and tighten the wheel nuts. Use the tightening sequence and torque values listed in **Group 40** in this manual.

Wheel Speed Sensor Replacement

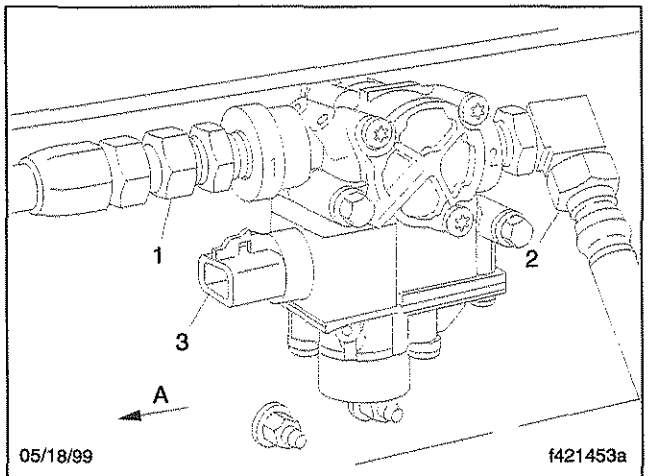
17. Remove the safety stands, lower the vehicle, and remove the chocks from the front tires.

Replacement

NOTE: Wire repairs may require the use of special tools for certain connectors and terminals. See **Group 54** in this manual for information on special terminals and connectors, and on ordering tools for them.

NOTE: The subject displays the Bendix M-22 modulator valve. See **Fig. 1**. Vehicles built prior to 1997 may be equipped with the M-21 modulator valve. This valve is very similar except that the electrical connection is on the other side of the valve, the same side of the valve as the delivery (outlet) port (2) instead of the supply (inlet) port (1).

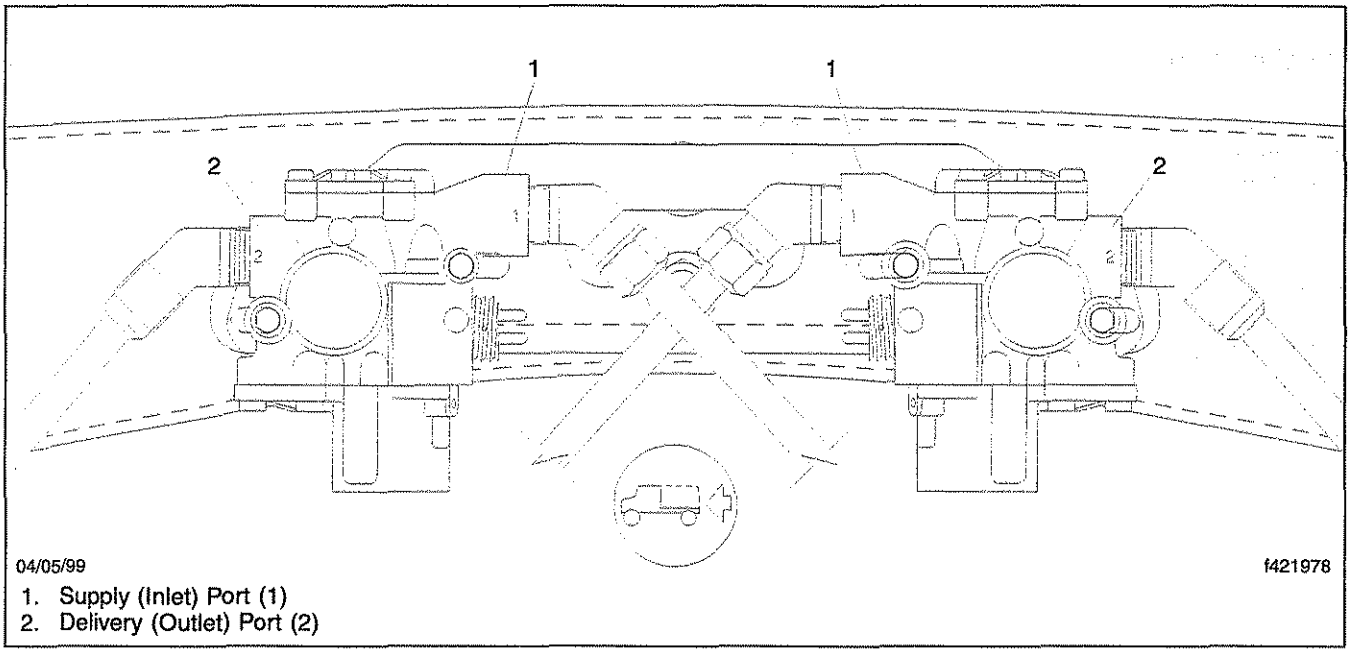
1. Chock the front and rear tires.
2. Drain the air reservoirs.
3. Disconnect the wiring from the electrical connection on the modulator valve.
4. Mark the air lines and disconnect them from the appropriate valve(s). See **Fig. 1** and **Fig. 2**.
5. Remove the mounting capscrews and nuts.
6. Remove the modulator valve.
7. Position the modulator valve(s) and install the mounting capscrews and nuts. Tighten the mounting nuts 18 lbf·ft (24 N·m)
8. Connect the air lines to the ports as marked and removed.
9. Connect the electrical connector to the valve.
10. Remove the chocks from the tires.



A. Forward
1. Supply (Inlet) Port (1) (from steer axle quick release)
2. Delivery (Outlet) Port (2) (to brake chamber)
3. Electrical Connection

Fig. 1, Front ABS Modulator Valve Plumbing (M-22 valve shown)

Modulator Valve Replacement



1. Supply (Inlet) Port (1)
2. Delivery (Outlet) Port (2)

Fig. 2, Bendix Rear Modulator Valve

Rear Axle Wheel Speed Sensor Adjustment

Adjustment

NOTE: The following adjustment procedure requires the use of special tool T11-17556-000. Use of this tool, available through the PDCs, eliminates the time-consuming task of removing the wheel and tire assembly, and the brake drum. See **Fig. 1**.

1. Park the vehicle on level ground, set the parking brake, and shut down the engine.
2. Chock the front tires.
3. Find the sensor access hole in the rear axle flange.
   - 3.1 View the brake drum and axle from the rear. The ABS sensor wiring harness should be visible passing through a hole in the 12 o'clock position.
   - 3.2 Find the S-cam at either the 3 o'clock or 9 o'clock position.
   - 3.3 Just opposite the S-cam is the sensor access hole, approximately 3/4 inch (19 mm) diameter.
4. Insert service tool T11-17556-000 into this hole.
5. Position the slide of the tool on the axle flange to align the tool. See **Fig. 2**.
6. Tap the tool lightly with the palm of your hand. This will ensure the sensor is touching the tone wheel.
7. Remove the tool from the wheel and repeat the procedure on the other rear axle speed sensor.
8. Remove the chocks from the tires.

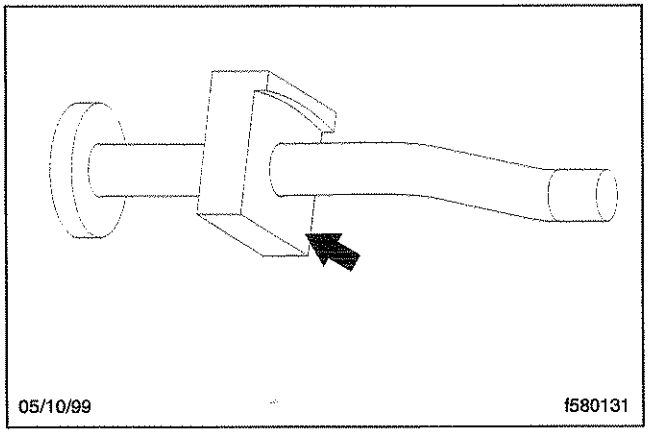
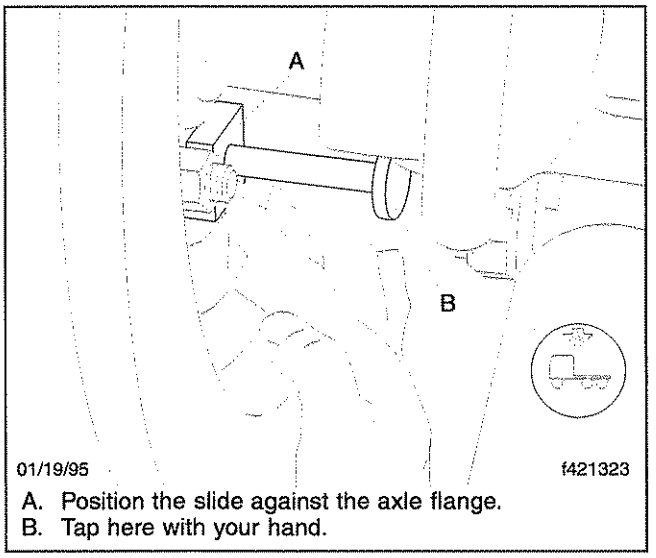


Fig. 1, ABS Sensor Adjustment Tool Slide



A. Position the slide against the axle flange.
B. Tap here with your hand.

Fig. 2, Position the Tool

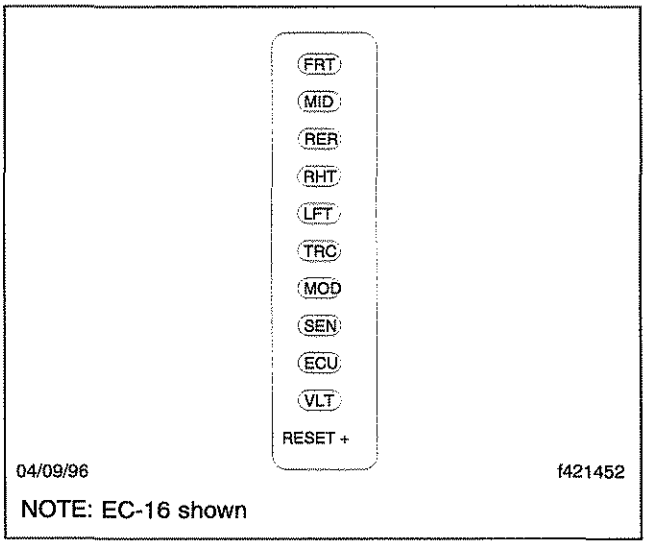
Using the Electronic Control Unit (ECU) Panel Lights (LEDs)

This system has built-in diagnostics to ensure that all components are operating properly. After the ignition is turned on, the tractor warning light (TRAC ABS) comes on. On vehicles with newer ECUs, the TRAC ABS light will go out shortly after the ignition is turned on. On vehicles with the older ECUs, the TRAC ABS light will stay lit until the vehicle reaches 7 mph (11 km/h). The TRAC ABS light will go out if the tractor's ABS components are working properly. See "Electronic Control Unit (ECU)" in **Subject 050** for more information. If the light stays on, or comes back on later, a problem within the ABS system has occurred. The vehicle can continue to be driven, but the ABS system could be partially or completely inoperative. However, normal braking ability is maintained. To check the type of fault code recorded, stop the vehicle and turn off the engine. Then, turn on the ignition switch, but do not start the engine. If the warning light is still on, there is a system fault that must be repaired to ensure proper system operation. Faults are displayed by the ECU panel lights. See **Fig. 1**. If the warning light is not on, an "intermittent" fault has occurred. An intermittent fault could involve a power surge, taking the system out of voltage range for a moment. In such cases, the problem basically corrects itself; the ECU memory is cleared and the system is restored to full ABS capability.

NOTE: LED lamps are not serviceable.

Following is a list of the faults displayed by the ECU panel lights (**Fig. 1**). Once a fault has been recorded, turn on the ignition switch, but do not start the engine.

- FRT (front): This red lighted display indicates the location of a malfunctioning component or its wiring. This light will always come on with either the right (RHT) or left (LFT) display light, and the modulator (MOD) or sensor (SEN) display light.
- MID (middle or forward sensed rear axle on 6S/4M systems only): This red lighted display indicates the location of a malfunctioning sensor or its wiring. This light will always come on with either the right RHT or left LFT display light, and the sensor SEN display light.
- RER (rear): This red lighted display indicates the location of a malfunctioning component or its wiring. This light will always come on with either the right RHT or left LFT display light, and the modulator MOD or sensor SEN display light.
- RHT: This red lighted display indicates the location of a malfunctioning component or its wiring. This light will always come on with either the front FRT or rear RER display light, and the modulator MOD or sensor SEN display light.
- LFT: This red lighted display indicates the location of a malfunctioning component or its wiring. This light will always come on with either the front FRT or rear RER display light, and the modulator MOD or sensor SEN display light.
- TRC (traction control, if equipped): This red lighted display indicates a problem within the traction control system. This light may come on by itself, or with the modulator MOD display light (indicating a problem within the automatic traction control relay valve).
- MOD: This red lighted display indicates an open or short circuit in the solenoid(s) of one of the modulators. This light will always come on with two positioning display lights RHT or LFT plus FRT or RER. The light may also come on with the traction control TRC display light which would indicate a problem within the automatic traction control relay valve or its wiring. Also, the red MOD light will come on if:
  - the traction enable/disable switch is in the wrong position.
  - traction engine serial communication is lost.



NOTE: EC-16 shown

Fig. 1, ECU Panel Lights (LEDs)

Troubleshooting

– the traction solenoid is not connected or bad.

- SEN: This red lighted display indicates an open or short circuit in the sensor circuit. This light will always come on with two positioning display lights RHT or LFT plus FRT, MID, or RER.
- ECU: This red lighted display indicates that the ECU is inoperative.
- VLT (voltage): This green lighted display is always on during vehicle operation. The light indicates proper system voltage. If vehicle power is out of range (below 11 or above 17 volts), the light will flash until the power problem is corrected.
- RESET: Beneath the reset display is a magnetically sensitive switch used to clear fault codes and reset the ABS diagnostic system. This switch is also used to self-configure the ECU.

A system fault cannot be cleared from ECU memory until the fault is corrected. Once corrected, faults can be cleared one at a time from ECU memory. To clear a fault, pass a small magnet (capable of lifting a three ounce weight) over the RESET display on the ECU (**Fig. 1**). Once all of the lights on the ECU come on, remove the magnet. Holding the magnet against the RESET display for longer than 10 to 20 seconds could cause the ECU to go into a self-configuration mode.

Before troubleshooting, check all fuses in the control unit panel, and replace if necessary. Check the wiring to the warning lights. See **Table 1** and repair or replace the wiring as needed. Make sure that a charged 12-volt battery is available (the ABS system needs at least 11 volts to work).

IMPORTANT: The key switch must be on when doing the tests in **Table 1**.

Once a fault code has been identified, use a volt/ohmmeter to check the electrical harness at the ECU's 30-pin or 18-pin connector. See **Fig. 2** and **Fig. 3**. Touch the ohmmeter leads to the applicable terminals on the connector, not the ECU.

IMPORTANT: The ignition switch must be off when connecting or disconnecting the ECU.

Refer to the problem charts for a listing of all diagnostic panel displays (system faults), terminals to be tested, and the correct volt/ohmmeter readings. Repair or replace the components and/or wiring if the readings are not correct.

NOTE: If a dealer has Freightliner Service Link, fault code information can be read from Service Link. For more information, see **Service Bulletin 00-20**.

NOTE: Wire repairs may require the use of special tools for certain connectors and terminals.

See **Group 54** of this manual for information on special terminals and connectors, and on ordering tools for them.

See the appropriate wiring diagram in **Specifications, 400** when troubleshooting the ABS system.

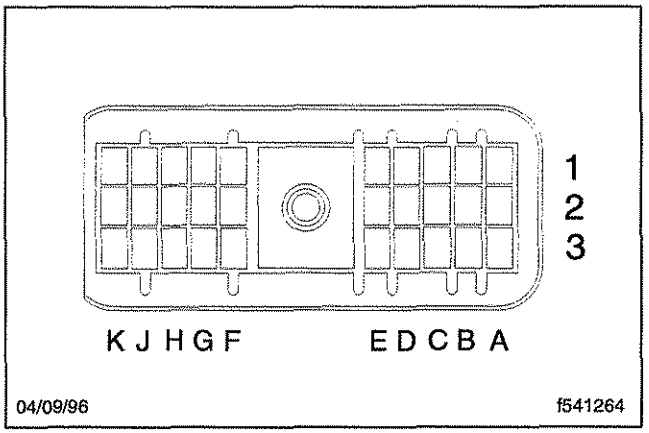


Fig. 2, 30-Pin Connector (Terminal View)

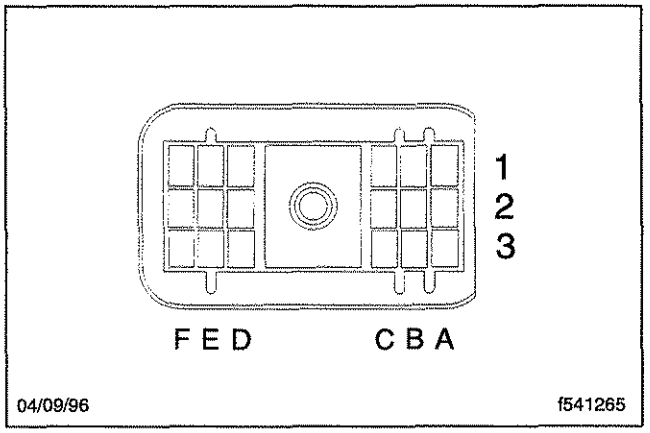


Fig. 3, 18-Pin Connector (Terminal View)

Warning Lamp Wiring Check				
Wiring Tested	**Test These Pins**	**Volt/Ohmmeter Reading**	**Possible Cause**	**Remedy**
Tractor Warning (TRAC ABS) Light	On the 30-pin connector, pins E3 and A1, E3 and A2, and E3 and A3.	Voltage should be the same as battery voltage.	Wiring to the light is shorted or open; or the bulb needs replacing.	Repair the wiring, or replace the bulb.
WHL SPIN Light (if equipped with ATC)	On the 30-pin connector, pin C2.			

Table 1, Warning Lamp Wiring Check

Problem—Battery Voltage is Too Low or Too High (Green VLT LED is flashing)

Problem—Battery Voltage is Too Low or Too High (Green VLT LED is flashing)	
Possible Cause	**Remedy**
Damaged ECU or unsatisfactory battery voltage and wiring continuity	If VLT or ECU is displayed, test the voltage on the 30-pin connector between battery terminals B1, K2, K3, and ground terminals A1, A2, and A3. Voltage between the terminals should be 11 to 17 volts. If the voltage readings are okay, replace the ECU. If the voltage readings are incorrect, check the battery voltage and wiring continuity. Repair or replace as needed.

Problem—Sensor Out of Adjustment, Wheel Speed Erratic, or Sensor Circuit Damage (Red SEN LED is On)

Problem—Sensor Out of Adjustment, Wheel Speed Erratic, or Sensor Circuit Damage (Red SEN LED is On)	
Possible Cause	**Remedy**
Damage to the tone wheel, wheel sensor, and/or sensor wiring to the ECU on the axle	If RHT or LFT and FRT plus SEN is displayed, measure the resistance on the 30-pin connector between terminals J1 and J2 (left front), and H2 and H3 (right front). If the readings are not 1500 to 2500 ohms, measure the resistance between the terminals at the sensor. Repair or replace as needed. If RHT or LFT and RER plus SEN is displayed, measure the resistance on the 18-pin connector between terminals F2 and F3 (left rearmost), and E2 and E3 (right rearmost). If the readings are not 1500 to 2500 ohms, measure the resistance between the terminals at the sensor. Repair or replace as needed. If RHT or LFT and MID plus SEN is displayed on the 18-pin connector, measure the resistance between terminals C2 and C3 (left rear), and B2 and B3 (right rear). If the readings are not 1500 to 2500 ohms, measure the resistance between the terminals at the sensor. Repair or replace as needed.
A sensor may be out of adjustment, or there is excessive hub runout	
Tire size is mismatched	Repair or replace as needed.

Troubleshooting

Problem—Open or Short Circuit in the Modulator, and/or Wiring to the Ground Connection (The Red MOD LED is On)

Problem—Open or Short Circuit in the Modulator, and/or Wiring to the Ground Connection (The Red MOD LED is On)	
Possible Cause	**Remedy**
Damage to the modulator valve and cab wiring connections on the axle	If RHT or LFT and FRT plus MOD is displayed, measure the resistance on the 30-pin connector between terminals G1 and H1 (left front), C1 and D1 (right front), F1 and H1 (left front), and C1 and E1 (right front). The resistance between the terminals should read 3.5 to 5.0 ohms. Measure the resistance between terminals G1 and F1 (left front), and D1 and E1 (right front). Resistance between the terminals should read 7 to 10 ohms. Also, there should be no continuity between any of the previously referenced terminals, and ground terminals A1, A2, A3, and J3. If the above readings are not correct, check the resistance between the pins at the modulator valve (see **Fig. 4**). Resistance between pins A and B, and B and C should be 3.5 to 5.0 ohms. Resistance between pins A and C should be 7 to 10 ohms. There should be no continuity between any of these pins and ground. Repair or replace as needed. If RHT or LFT and RER plus MOD is displayed, measure the resistance on the 18-pin connector between terminals E1 and F1 (left rear), A1 and B1 (right rear), D1 and F1 (left rear), and A1 and C1 (right rear). Resistance should read 3.5 to 5.0 ohms. Measure the resistance between terminals D1 and E1 (left rear), and B1 and C1 (right rear). Resistance between the terminals should read 7 to 10 ohms. Also, there should be no continuity between any of the previously referenced terminals, and ground terminals A1, A2, A3, and J3. If the above readings are not correct, check the resistance between the pins at the modulator valve (see **Fig. 4**). Resistance between pins A and B, and B and C should be 3.5 to 5.0 ohms. Resistance between pins A and C should be 7 to 10 ohms. There should be no continuity between any of these pins and ground. Repair or replace as needed.

Problem—Open or Short Circuit in the Traction Control Relay Valve and/or Wiring to the Ground Connection (Red TRC LED and RED MOD LED are On)

Problem—Open or Short Circuit in the Traction Control Relay Valve and/or Wiring to the Ground Connection	
Possible Cause	**Remedy**
Open or shorted circuit in the traction control relay valve and/or cab wiring connections	If TRC and MOD is displayed, measure the resistance on the 18-pin connector between terminals D2 and D3. Resistance between the terminals should be 10 to 12 ohms. Check continuity at the 30-pin connector between terminals A1, A2, A3, and terminals D2 and D3. There should be no continuity between these terminals. If the above readings are not correct, check the resistance between the pins at the connector at the relay valve. Resistance between the pins should be 10 to 12 ohms. There should be no continuity between ground pins A1, A2, and A3 (on the 30-pin connector), and the pins D2 and D3 at the valve connector. Repair or replace as needed.

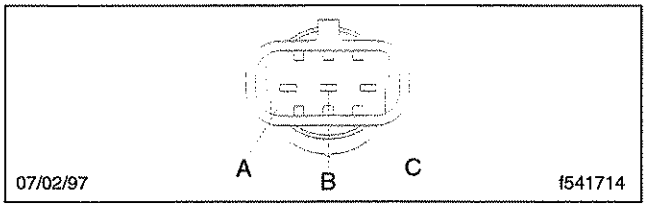


Fig. 4, Modulator Valve Connector Pin Identification

Problem—J 1922 Electronic Engine Data Link is Not Working Properly (Red TRC LED is On)

Problem—J 1922 Electronic Engine Data Link is Not Working Properly (Red TRC LED is On)	
Possible Cause	**Remedy**
Damage to the data link and/or data link wiring	If TRC is displayed, check for continuity between terminals B2 and B3 on the 30-pin connector, and the two corresponding terminals on the engine's electronic control module. Repair or replace as needed.

See **Fig. 1** for a full view of the wiring diagram for the Bendix ABS system. See **Fig. 2** and **Fig. 3** for partial (detailed) views of **Fig. 1**.

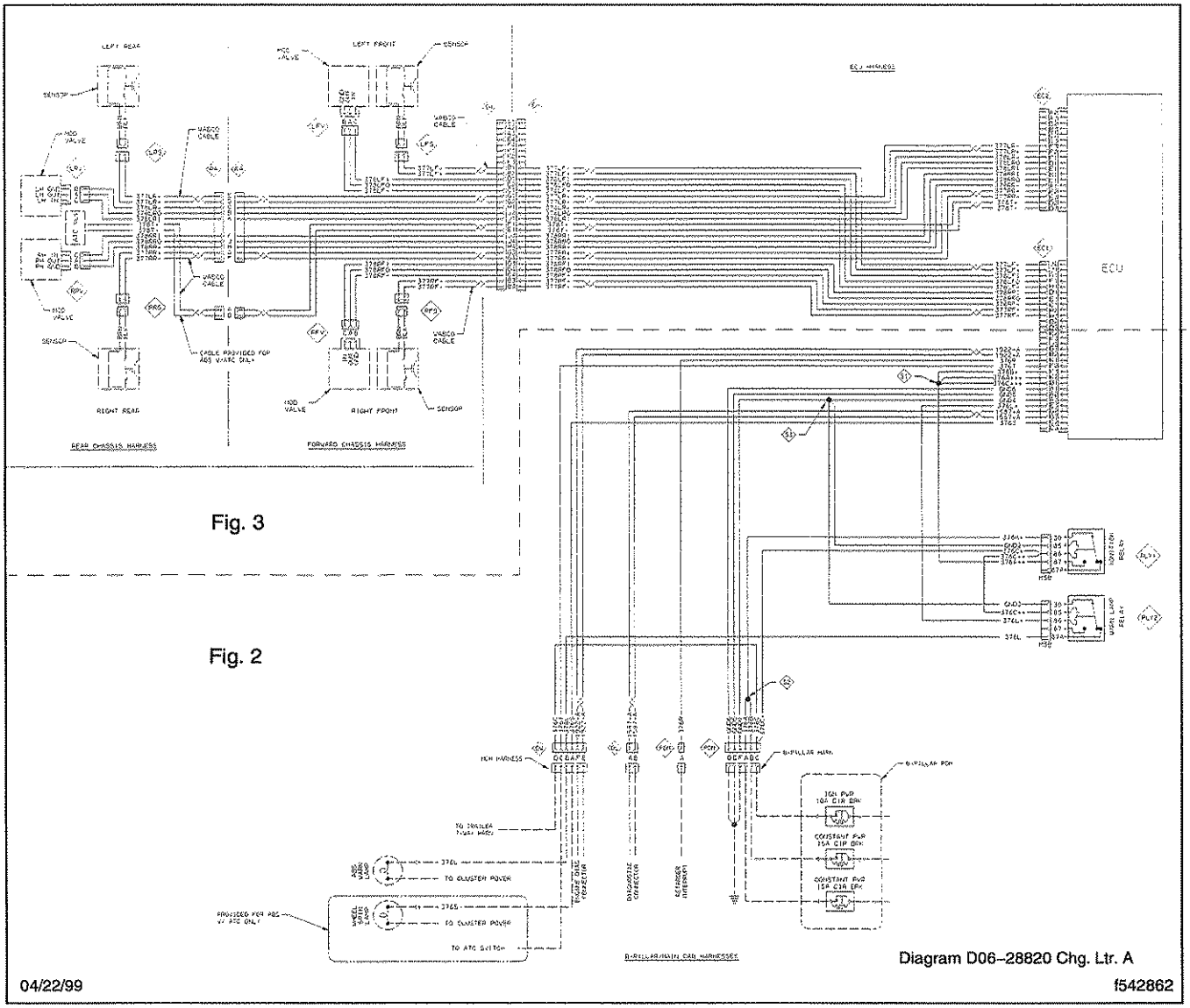


Fig. 1, Bendix ABS System Wiring Diagram

Specifications

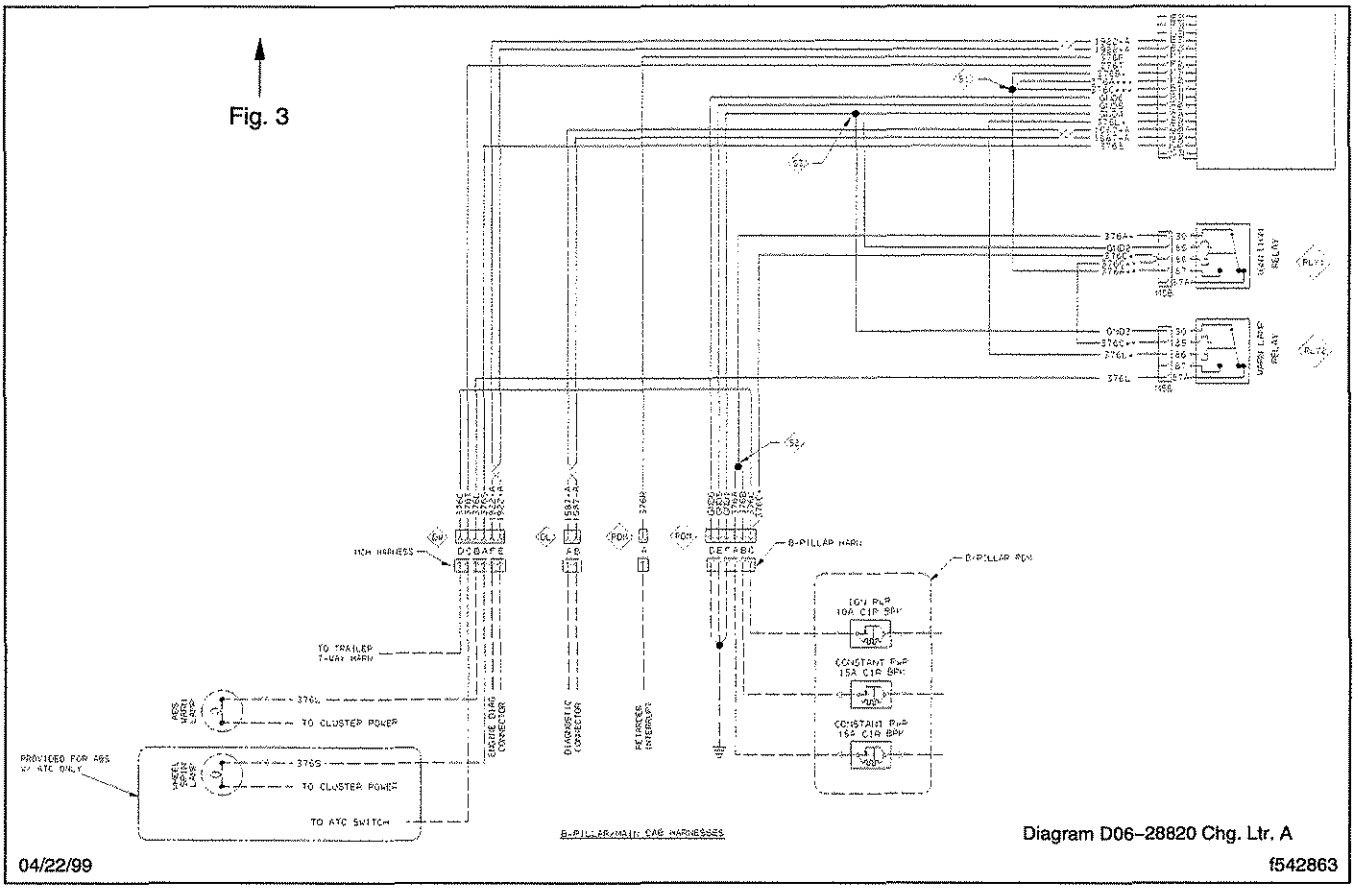


Fig. 2, Bendix ABS System Wiring Diagram (partial view)

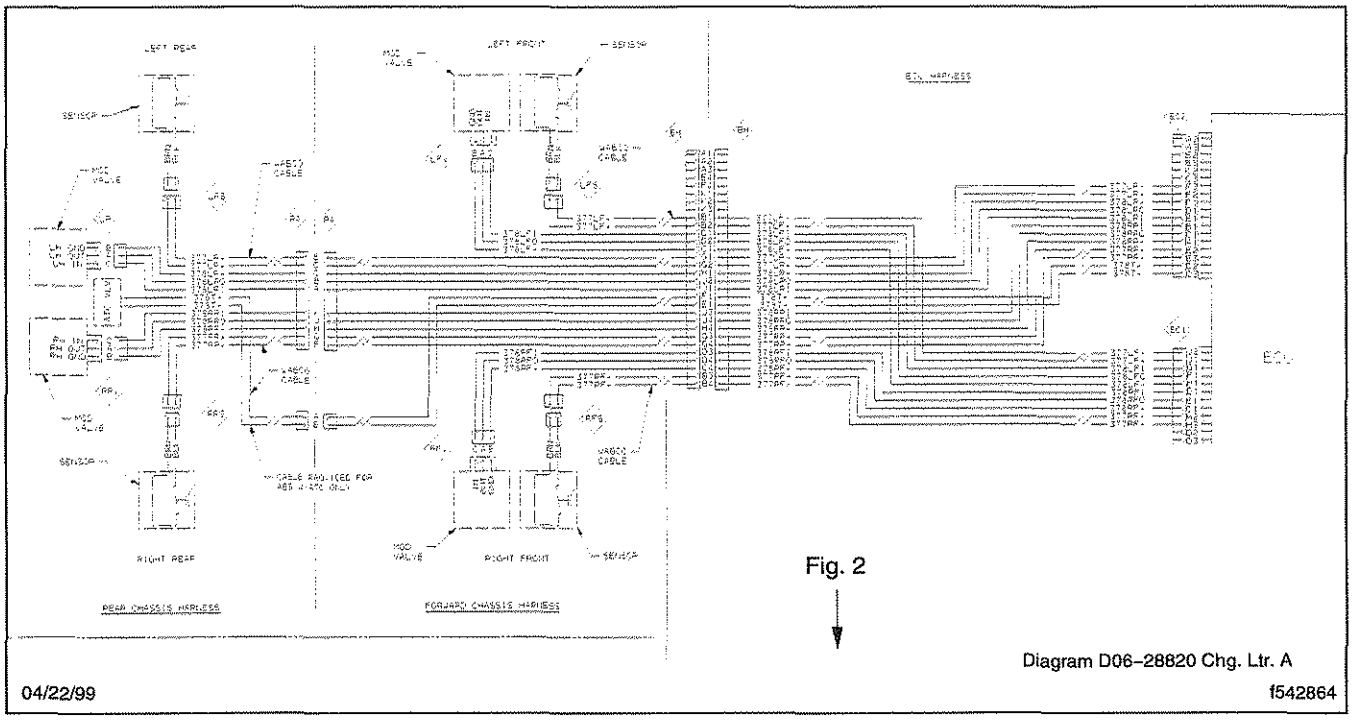


Fig. 3, Bendix ABS System Wiring Diagram (partial view)

Contents

Subject	Subject Number
General Information	050
Service Operations	
Safety Precautions	100
Brake Shoe Removal and Installation	110

General Description

The CamLaster air drum-brake is a cam-actuated, leading-trailing shoe brake with sliding shoes. The brake uses a crank/rod/slider expander mechanism (or "Z" cam) and a clearance- and force-sensing internal automatic adjuster. See **Fig. 1** and **Fig. 2**.

The camshaft rotates, moving both push rods outward, causing outward movement of the pistons with their tappets. The tappets then transfer braking force to the shoes.

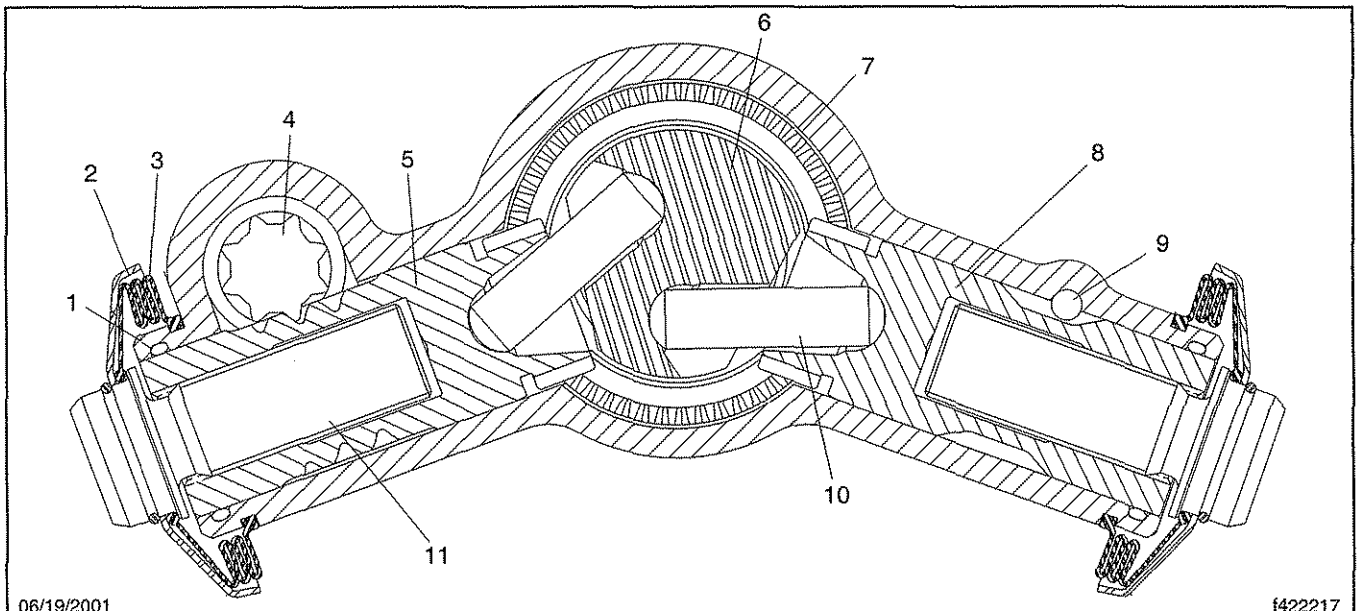
An internal automatic adjuster maintains a specified lining-to-drum clearance. To compensate for lining wear, the pistons can rotate, unscrewing the tappets from the pistons and reducing the lining clearance. The tappets do not rotate since the brake shoe web engages the tappet slot. Since the adjustment occurs between the expander mechanism and the brake shoes, the expander mechanism geometry is not affected by brake lining wear.

The adjuster assembly (**Fig. 3**) consists of a bi-directional wrap-spring style clutch. The clutch transfers torque between the adjuster shaft and the adjuster bushing. The clutch will slip in one direction with a high torque load and in the other direction with a low torque load. During normal brake usage, the bias spring prevents the adjuster bushing cone seat from becoming unseated.

Principles of Operation

Brake with Correct Lining-to-Drum Clearance

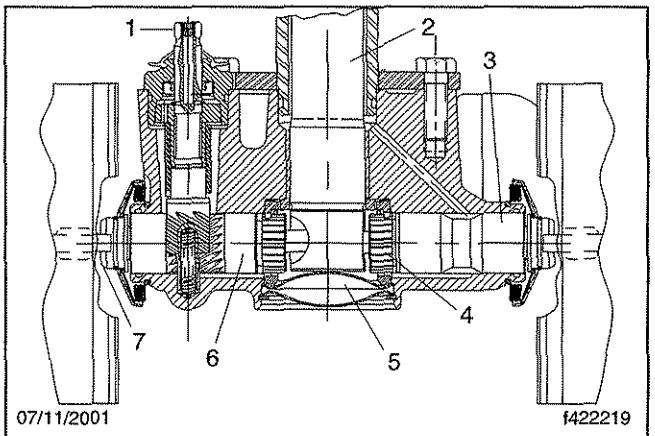
When the brake is applied, the adjuster piston moves outward to take up internal gear clearance. As the brake linings contact the drum, the extra force on the tappets rapidly increases the tappet/piston thread friction torque to a level greater than the high torque level of the wrap spring. Continued motion causes the adjuster shaft to rotate and to slip the wrap spring in the high torque direction.



1. O-ring
2. Shield
3. Dust Boot
4. Adjuster Shaft
5. Adjuster Piston
6. Camshaft
7. Ring Gear
8. Secondary Piston
9. Stop Pin
10. Push Rod
11. Tappet

Fig. 1, Expander Mechanism (view A)

General Information



1. Adjuster Shaft
2. Camshaft
3. Secondary Piston
4. Ring Gear
5. Breather Assembly
6. Adjuster Piston
7. Tappet

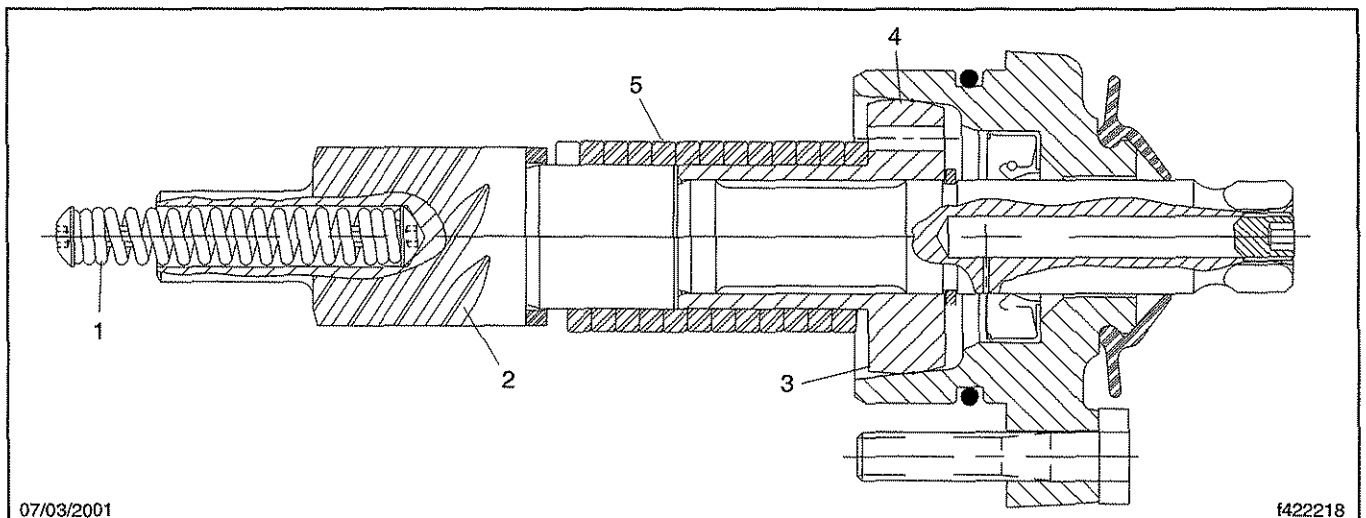
Fig. 2, Expander Mechanism (view B)

When the brake is released, the piston retracts and returns the internal gear clearance. The adjuster shaft then returns to the original position because the tappet/piston thread friction torque caused by the return spring is greater than the low torque of the wrap spring.

Brake with Excessive Lining-to-Drum Clearance

When the brake is applied, the adjuster piston moves outward to take up internal gear clearance. Since the wrap spring torque is greater than the tappet/piston thread torque, the adjuster piston rotates. The secondary piston also rotates since it is linked to the adjuster piston by the ring gear. Rotating the pistons unscrews the tappets and reduces the lining-to-drum clearance. When the lining contacts the drum, the tappet/piston thread friction increases rapidly and continued motion rotates the adjuster shaft as with a properly adjusted brake.

When the brake is released, the adjuster shaft rotates back to the original position, plus the incremental amount used to advance the tappets before the lining contacted the drum. Each brake application reduces the excess clearance a percentage of the existing excess clearance.



1. Bias Spring
2. Adjuster Shaft
3. Adjuster Bushing
4. Cone Seat
5. Wrap Spring "Bi-Directional" Clutch

Fig. 3, Adjuster Shaft Assembly

⚠ WARNING

Breathing brake lining dust (asbestos or non-asbestos) could cause lung cancer or lung disease. OSHA has set maximum levels of exposure and requires workers to wear an air purifying respirator approved by MSHA or NIOSH. Wear a respirator at all times when servicing the brakes, starting with the removal of the wheels and continuing through assembly.

Safety Precautions

Because some brake linings contain asbestos, know the potential hazards of asbestos and the precautions to take. Exposure to airborne asbestos brake lining dust can cause serious and possibly fatal diseases such as asbestosis (a chronic lung disease) and cancer. Because medical experts believe that long-term exposure to some *non-asbestos* fibers could also be a health hazard, also observe the following precautions if servicing non-asbestos brake linings.

If possible, do brake work in a separate area. Display a sign at the entrance indicating the health hazard as required by OSHA regulations.

During brake servicing and during all procedures, wear an air purifying respirator with high-efficiency filters. The respirator and the filter must be approved by MSHA or NIOSH.

OSHA recommends the use of enclosed cylinders equipped with vacuums and High Efficiency Particulate Arrestance (HEPA) filters during brake repairs. With this system, the entire brake assembly is contained within the cylinder and the mechanic works on the brake parts through sleeves attached to the cylinder. Compressed air is blown into the cylinder to clean the assembly. Dirty air is then removed from the cylinder by the vacuum.

If such an enclosed system isn't available, the brake assembly must be cleaned in the open air. During disassembly, carefully place all parts on the floor to minimize creating airborne dust. Using an industrial vacuum cleaner with a HEPA filter system, remove dust from the brake drums, the brake backing plates, and the other brake parts. After vacuuming, remove any remaining dust using a rag soaked in water and wrung until nearly dry. Don't use compressed air or dry brushing to clean the brake assembly.

If grinding or other machining of the brake linings is necessary, you must take other precautions because exposure to asbestos dust is highest during such operations. In addition to the use of an approved respirator there must be local exhaust ventilation, so that worker exposures are kept as low as possible.

Clean work areas using industrial vacuums with HEPA filters or by wet wiping. Never use compressed air or dry sweeping for cleaning. Seal, label, and dispose of asbestos-containing waste, such as dirty rags, as required by EPA and OSHA regulations. Wear respirators when emptying vacuum cleaners and handling asbestos waste products.

When working with brakes, wash before eating, drinking, or smoking, shower after work, and do not wear work clothes home. Vacuum work clothes after use and launder them, without shaking, to prevent the release of asbestos fibers into the air.

Brake Shoe Removal and Installation

⚠ WARNING

Before beginning the procedure below, read the safety precaution information in Subject 100. Failure to be aware of the dangers of brake lining dust exposure could result in serious and permanent health damage.

Brake Shoe Removal

1. Park the vehicle on a level surface.
2. Shut down the engine, set the parking brake, and chock the tires.
3. Raise the front or the rear axle, then place safety stands under the frame or axle. Be sure that the stands will support the weight of the vehicle.

⚠ WARNING

When work is being done on a spring chamber, carefully follow the service instructions of the chamber manufacturer. The sudden release of a compressed spring can cause serious personal injury.

4. If the brakes have spring chambers, carefully cage and lock the springs so that the springs cannot actuate during disassembly.
5. Remove the wheels. For instructions, see **Group 40** in this manual.

IMPORTANT: Do not exceed 30 lbf·ft (40 N·m) torque on the brake adjuster shaft. Do not use power tools. There may be an initial torque spike felt when disengaging the internal cone clutch. This is normal.

6. For each wheel end, rotate the brake shoe adjuster shaft counter-clockwise to increase the lining clearance of (or de-adjust) the brake shoes sufficiently for the brake drum to clear the brake linings. See **Fig. 1**.
7. Remove the brake drum. For instructions, see **Group 33** or **Group 35** in this manual.
8. Remove the brake shoes.

   IMPORTANT: Do not exceed 30 lbf·ft (40 N·m) torque on the brake adjuster shaft. Do not use power tools.

   8.1 Rotate the adjuster shaft clockwise until you can insert (through the holes and under the brake shoe return spring) a 3/8 x 2-inch bolt at the top and at the bottom of the spider. See **Fig. 2**.

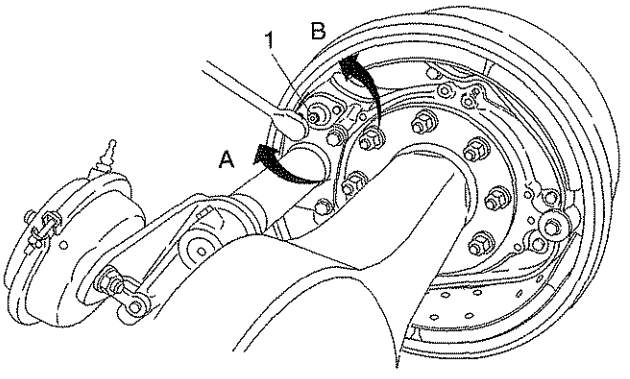
   8.2 Ensure that both bolts extend past the spring. See **Fig. 3**. Then, rotate the brake adjuster shaft counter-clockwise until both brake shoes are fully collapsed and the bolts retain the spring load.

   8.3 Push on the cam end of the brake shoes to ensure that the tappets are fully collapsed. See **Fig. 4**.

   8.4 Firmly grasp one brake shoe and slide it toward the cam until the shoe pin is clear of the brake shoe return spring. See **Fig. 5**. Remove the shoe. Repeat for the remaining shoe.

   IMPORTANT: Do not rotate the tappets, turn the adjuster shaft, or actuate the brakes after the brake shoes are removed. Doing any of these actions will require resetting the tappets.

9. Inspect the brake shoes, the brake linings, and the spider for wear or damage.

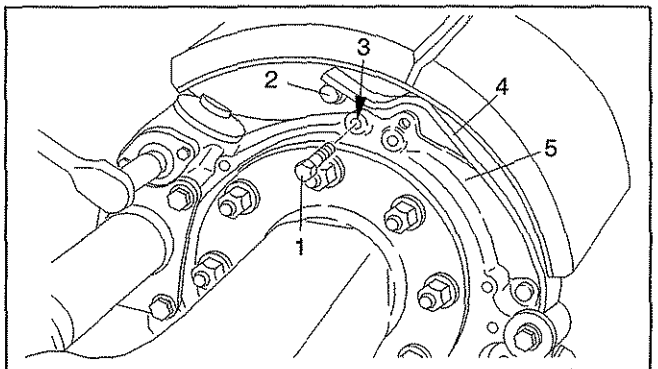


07/03/2001 f430194a

A. Clockwise Rotation
B. Counter-Clockwise Rotation
1. Adjuster Shaft

Fig. 1, Increase Lining Clearance

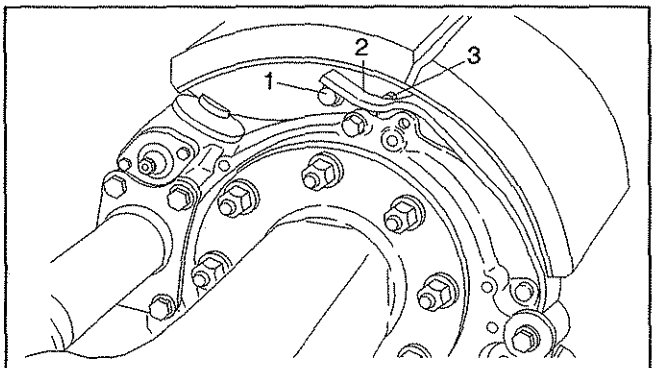
Brake Shoe Removal and Installation



07/02/2001 f430195

1. Spring Retaining Bolt (3/8 x 2 inches)
2. Shoe Pin
3. Hole for Retaining Bolt
4. Shoe Return Spring
5. Brake Spider

Fig. 2, Shoe Return Spring Retaining Bolts



07/02/2001 f430196

1. Shoe Pin
2. Shoe Return Spring
3. Spring Retaining Bolt

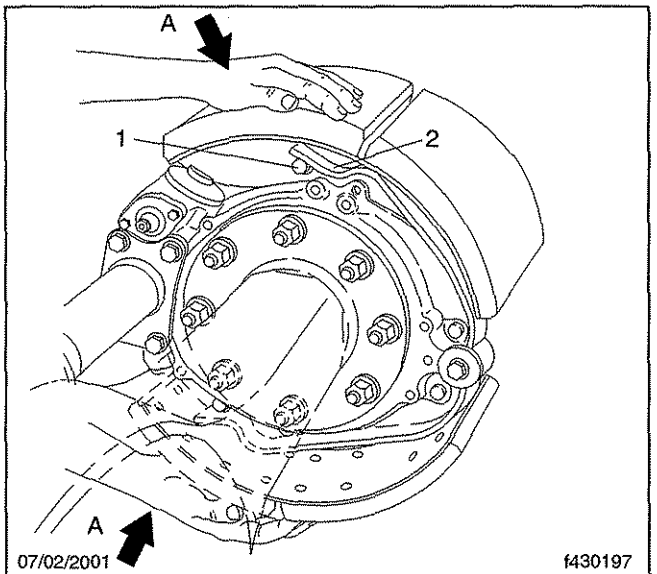
Fig. 3, Retain the Shoe Return Spring

Resetting the Tappets (only if required)

1. Rotate both of the tappets clockwise until they are fully seated. See **Fig. 6**.

NOTE: If necessary, release the dust boot from the spider to aid rotation.

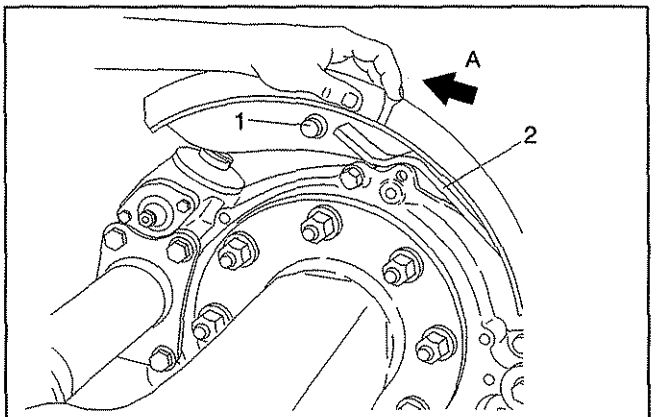
2. Rotate both tappets counter-clockwise no more than 1/2 turn to align the slots with the shoe webs.



07/02/2001 f430197

A. Push Here
1. Shoe Pin
2. Shoe Return Spring

Fig. 4, Push on the Cam End of the Brake Shoes



06/29/2001 f430198

A. Slide This Direction
1. Shoe Pin
2. Shoe Return Spring

Fig. 5, Remove the Brake Shoes

3. Rotate the secondary piston tappet (the tappet farthest from the adjuster shaft) counter-clockwise an additional 1/2 turn.

Shoe Pin Replacement

⚠ WARNING

Wear eye protection when using a drift to remove the old shoe pins. A piece of the pin could break off and cause serious eye injury.

NOTE: The shoe pins are made of a molded plastic material.

1. Remove both shoe pins with a brass drift. See **Fig. 7**.

⚠ WARNING

Wear eye protection when installing the new shoe pins. A piece of the pin could break off and cause serious eye injury.

2. Tap two new shoe pins into position and ensure that they are fully seated against the spider. See **Fig. 8**.

Brake Shoe Installation

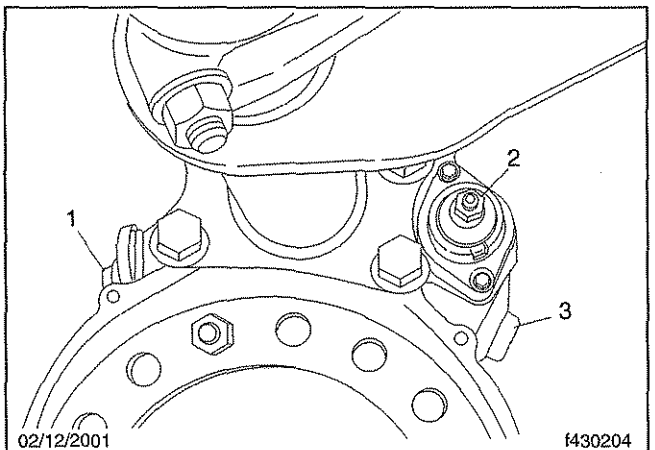
1. Install the brake shoes.

   1.1 Place a new brake shoe in position with the web aligned with the tappet slot. See **Fig. 9**. Slide the shoe so that the shoe spring is over the shoe pin and so that the shoe web is retained in both the anchor slot and the tappet slot. Repeat for the other shoe.

   1.2 While holding the web of the lower shoe in position in the tappet slot, rotate the adjuster shaft clockwise until the brake spring is clear of the two spring retaining bolts. See **Fig. 2**. Remove the bolts.

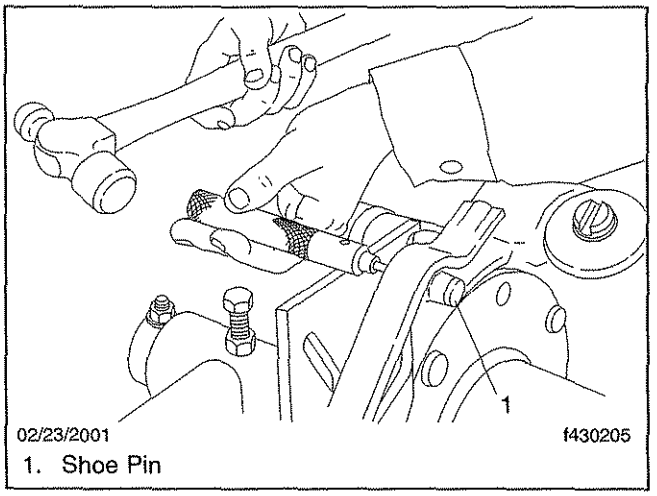
   1.3 Rotate the adjuster shaft counter-clockwise until the shoes are fully collapsed.

2. Install the brake drum. For instructions, see **Group 33** or **Group 35** in this manual.



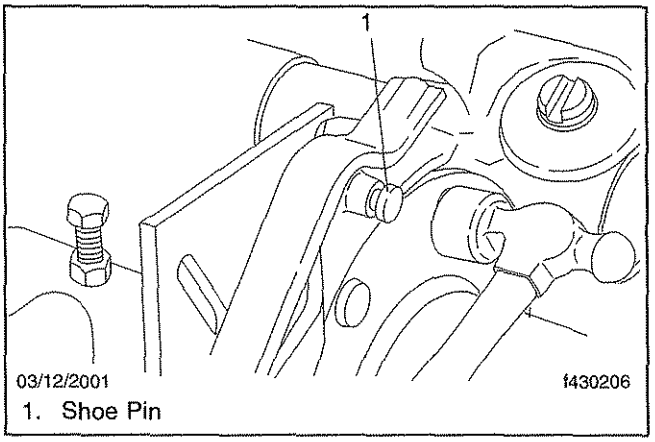
1. Secondary Tappet (farthest from adjuster shaft)
2. Adjuster Shaft
3. Primary Tappet

Fig. 6, Reset the Tappets (if required)



1. Shoe Pin

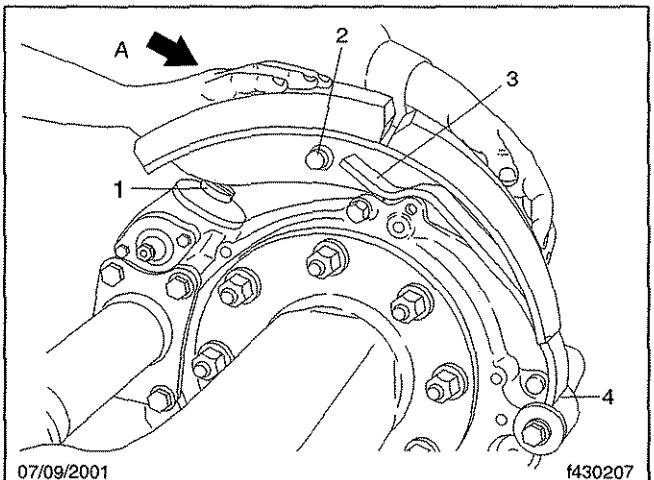
Fig. 7, Remove the Shoe Pins



1. Shoe Pin

Fig. 8, Install New Shoe Pins

Brake Shoe Removal and Installation



A. Slide Shoe
1. Tappet Slot
2. Shoe Pin
3. Shoe Return Spring
4. Anchor Slot

Fig. 9, Install New Brake Shoes

⚠ WARNING

When work is being done on a spring chamber, carefully follow the service instructions of the chamber manufacturer. The sudden release of a compressed spring can cause serious personal injury.

IMPORTANT: Ensure that the air chamber is installed before attempting the following steps. Also, do not exceed 30 lbf·ft (40 N·m) torque on the brake adjuster shaft and do not use power tools.

3. Rotate the adjuster shaft clockwise until the brake shoes snugly contact the brake drum. See **Fig. 1.**

NOTE: If a shoe is not centered in the drum, apply the brakes to achieve this. Then, repeat the previous step.

4. Rotate the adjuster shaft counter-clockwise 1-1/2 turns to set the initial running clearance.
5. Check the air chamber stroke and then rotate the drum and check for a dragging brake.
6. Install the wheels. For instructions, see **Group 40** in this manual.
7. Remove the safety stands, lower the vehicle, and remove the chocks from the tires.

⚠ WARNING

When work is being done on a spring chamber, carefully follow the service instructions of the chamber manufacturer. The sudden release of a compressed spring can cause serious personal injury.

8. If the brake has spring chambers, carefully release the springs.

⚠ DANGER

Don't operate the vehicle until the brakes have been adjusted and checked for proper operation. To do so could result in inadequate or no braking ability, which could cause personal injury or death, and property damage.

9. Before you put the vehicle in service, in a safe area, check for proper brake operation.
   - 9.1 Apply and release the brakes several times to check for air leaks and for proper operation of the adjusters.
   - 9.2 Do several low speed stops to ensure proper parts replacement and full vehicle control.
   - 9.3 Make ten 40 to 20 mph (60 to 30 km/h) snubs to seat the linings.
   - 9.4 Make ten stops from 20 mph (30 km/h) at 50 percent air pressure.
   - 9.5 Make a full-pressure stop from 20 mph (30 km/h).
   - 9.6 Immediately after doing the above stops, check the drum temperatures. Any drums that are significantly cooler than others show a lack of braking effort on those wheels.

TROUBLESHOOTING FOR WABCO D VERSION ABS FRAME ECU FREIGHTLINER COLUMBIA VEHICLES

Table 1. J1587 Troubleshooting Table Index for Freightliner Columbia Wabco ABS			
MID	**SID**	**Troubleshooting Table Description**	**Table**
136	001	Wheel Sensor, Left Front	3
	002	Wheel Sensor, Right Front	4
	003	Wheel Sensor, Left Rear	5
	004	Wheel Sensor, Right Rear	6
	005	Wheel Sensor, Left Third/Tag Axle (6S/4M and 6S/6M Only)	7
	006	Wheel Sensor, Right Third/Tag Axle (6S/4M and 6S/6M Only)	8
	007	Modulator Valve, Left Front	9
	008	Modulator Valve, Right Front	10
	009	Modulator Valve, Left Rear	11
	010	Modulator Valve, Right Rear	12
	013	Retarder	13
	014	Ground-Diagonal 1	14
	015	Ground-Diagonal 2	15
	018	ATC Valve	16
	019	Not Used	17
	023	Warning Lamp	18
	231	J1939 Datalink	19
	248	J1939 Datalink	19
	249	J1922 Datalink	20
	251	Voltage Diagonal 1 or 2	21
	253	Configuration Errors	22
	254	Miscellaneous Faults	23

Preliminary

Table 2. Blink Code Troubleshooting Table Index for Freightliner Columbia Wabco ABS		
Blink Code	**Blink Code Description**	**Tables**
1-1	No Faults, System OK	-
2-1	Modulator Valve, Right Front	10
2-2	Modulator Valve, Left Front	9
2-3	Modulator Valve, Right Rear	12
2-4	Modulator Valve, Left Rear	11
2-5	Not Used (6M Only)	-
2-6	Not Used (6M Only)	-
3-1	Wheel Sensor Air Gap, Right Front	4
3-2	Wheel Sensor Air Gap, Left Front	3
3-3	Wheel Sensor Air Gap, Right Rear	6
3-4	Wheel Sensor Air Gap, Left Rear	5
3-5	Wheel Sensor Air Gap, Right Third/Tag Axle (6S/4M Only)	8
3-6	Wheel Sensor Air Gap, Left Third/Tag Axle (6S/4M Only)	7
4-1	Wheel Sensor Short/Open, Right Front	4
4-2	Wheel Sensor Short/Open, Left Front	3
4-3	Wheel Sensor Short/Open, Right Rear	6
4-4	Wheel Sensor Short/Open, Left Rear	5
4-5	Wheel Sensor Short/Open, Right Third/Tag Axle (6S/4M Only)	8
4-6	Wheel Sensor Short/Open, Left Third/Tag Axle (6S/4M Only)	7
5-1	Wheel Sensor Erratic Signal, Right Front	4
5-2	Wheel Sensor Erratic Signal, Left Front	3
5-3	Wheel Sensor Erratic Signal, Right Rear	6
5-4	Wheel Sensor Erratic Signal, Left Rear	5
5-5	Wheel Sensor Erratic Signal, Right Third/Tag Axle (6S/4M Only)	8
5-6	Wheel Sensor Erratic Signal, Right Third/Tag Axle (6S/4M Only)	7
6-1	Tooth Wheel, Right Front	4
6-2	Tooth Wheel, Left Front	3
6-3	Tooth Wheel, Right Rear	6
6-4	Tooth Wheel, Left Rear	5
6-5	Tooth Wheel, Right Third/Tag Axle (6S/4M Only)	8
6-6	Tooth Wheel, Right Third/Tag Axle (6S/4M Only)	7
7-1	J1922 or J1939 Datalink	19, 20, 23
7-2	ATC Valve	16
7-3	Retarder Relay	13
7-4	ABS Warning Lamp	18
7-5	ATC Configuration	22
7-6	Not Used	17
8-1	ECU Low voltage	14, 15
8-2	ECUHigh voltage	21
8-3	ECU Internal Fault	14, 15, 19, 23
8-4	ECU System Configuration Error	22, 23
8-5	ECU Ground (Not Applicable for Frame ECU)	-

Table 3

(SID 001) WHEEL SENSOR, LEFT FRONT

MID	SID	FMI	FAULT DESCRIPTION	TEST	TEST RESULT	ACTION	Blink Code
136	001	01	Incorrect sensor air gap	1. Adjust sensor. Check AC voltage across pins 7 and 8 of the black X2 ECU connector while rotating the LF wheel 30 RPM.	**Voltage greater than or equal 0.2 volts AC**	Sensor adjustment solved problem. <END OF TEST>	3-2
					Voltage below 0.2 volts AC	Check for excessive wheel bearing endplay and hub runout. Repair as necessary. <END OF TEST>	
		02	Incorrect tire size			Check for correct tire size and mixed tire sizes. Check for correct number of teeth on tone wheel. Correct as necessary. <END OF TEST>	5-2
		03	Sensor shorted to power	2. Measure the voltage across pin 7 of the X2 (black) connector and a good chassis ground. Repeat test between pin 8 and ground.	**Voltage at either pin**	Repair short to power in circuit(s) 377LF- and 377LF+ in chassis harness and sensor cable. If problem is in sensor harness, replace the sensor. <END OF TEST>	4-2
					No voltage at either pin.	Repeat test and check for intermittent short to power in circuits 377LF+ and 377LF-. Suspect ECU at fault if problem persists. <END OF TEST>	
		04	Short to ground	3. Measure the resistance between pin 7 of the X2 (black) connector and a good chassis ground. Repeat test between pin 8 and ground.	**The resistance between either pin and ground is less than 100,000 ohms.**	Repair short to ground in circuit(s) 377LF+ and 377LF- in chassis harness or sensor cable. If problem is in sensor harness, replace the sensor. <END OF TEST>	
					The resistance between either pin and ground is more than 100,000 ohms.	Repeat test and check for intermittent short to ground in circuits 377LF- and 377LF+. Suspect ECU at fault if problem persists. <END OF TEST>	
		05	Open circuit	4. Measure the resistance between pins 7and 8 of the X2 (black) connector.	**Resistance is 900-2000 ohms.**	Repeat test and check for intermittent open or short in circuits 377LF+ and 377LF-. Suspect ECU at fault if problem persists. <END OF TEST>	
		06	Short circuit *Note: Perform tests 4 & 5 for either fault.*		**Resistance is above 2000 ohms OR below 900 ohms.**	<GOTO TEST 5>	
				5. Disconnect the sensor connector from the chassis harness. Measure the resistance between the pins on the sensor connector.	**Resistance is 900-2000 ohms**	Repair open or short in circuit(s) 377LF+ and 377LF- in chassis harness. <END OF TEST>	
					Resistance is above 2000 ohms OR below 900 ohms.	Replace sensor. <END OF TEST>	
		07	Damaged tone ring			Inspect tone ring for damage and missing teeth. Make sure correct tooth wheel is installed (100 tooth normal application). Repair as necessary. <END OF TEST>	6-2
		08	Excessive wheel slip			Check sensor adjustment. This fault usually occurs when there is excessive tire spin for more than 16 sec. <END OF TEST>	3-2
		09	Wire mismatch	6. Check for mixed sensor connection. This can be done using Meritor PC diagnostics by spinning each wheel individually and observing whether the output is from the proper sensor.		Correct wiring connections as necessary. <END OF TEST>	5-2
		10	Intermittent signal	7. Adjust the sensor. Use the wheel sensor output screen in Meritor PC Diagnotics and spin the wheel or drive the vehicle and observe for intermittent /erratic signal.	**Signal output OK**	Adjustment solved problem. Make sure brake chatter is not causing the problem. <END OF TEST>	3-2
		11	Erratic signal *Note: Perform test 10 for either fault*		**Signal output not OK**	Check for intermittent wheel sensor circuit connections. Cause could be due to brake chatter. Repair as necessary. <END OF TEST>	5-2
		12	Frequency too high	8. Check sensor wiring and connectors for intermittent contact.	**Wiring OK**	Suspect ECU at fault if problem persists. <END OF TEST>	
					Wiring not OK	Repair wheel sensor circuit as necessary. <END OF TEST>	

Table 4

(SID 002) WHEEL SENSOR, RIGHT FRONT

MID	SID	FMI	FAULT DESCRIPTION	TEST	TEST RESULT	ACTION	Blink Code
136	002	01	Incorrect sensor air gap	1. Adjust sensor. Check AC voltage across pins 5 and 6 of the X2 (black) ECU connector while rotating the RF wheel 30 RPM.	**Voltage greater than or equal 0.2 volts AC**	Sensor adjustment solved problem. <END OF TEST>	3-1
					Voltage below 0.2 volts AC	Check for excessive wheel bearing endplay and hub runout. Repair as necessary. <END OF TEST>	
		02	Incorrect tire size			Check for correct tire size and mixed tire sizes. Check for correct number of teeth on tone wheel. Correct as necessary. <END OF TEST>	5-1
		03	Sensor shorted to power	2. Measure the voltage across pin 5 of the X2 (black) connector and a good chassis ground. Repeat test between pin 6 and ground.	**Voltage at either pin**	Repair short to power in circuit(s) 377RF- and 377RF+ in chassis harness and sensor cable. If problem is in sensor harness, replace the sensor. <END OF TEST>	4-1
					No voltage at either pin.	Repeat test and check for intermittent short to power in circuits 377RF+ and 377RF-. Suspect ECU at fault if problem persists. <END OF TEST>	
		04	Short to ground	3. Measure the resistance between pin 5 of the X2 (black) connector and a good chassis ground. Repeat test between pin 6 and ground.	**The resistance between either pin and ground is less than 100,000 ohms.**	Repair short to ground in circuit(s) 377RF+ and 377RF- in chassis harness or sensor cable. If problem is in sensor harness, replace the sensor. <END OF TEST>	
					The resistance between either pin and ground is more than 100,000 ohms.	Repeat test and check for intermittent short to ground in circuits 377RF- and 377RF+. Suspect ECU at fault if problem persists. <END OF TEST>	
		05 06	Open circuit Short circuit *Note: Perform tests 4 & 5 for either fault.*	4. Measure the resistance between pins 5and 6 of the X2 (black) connector.	**Resistance is 900-2000 ohms.**	Repeat test and check for intermittent open or short in circuits 377RF+ and 377RF-. Suspect ECU at fault if problem persists. <END OF TEST>	
					Resistance is above 2000 ohms OR below 900 ohms.	<GOTO TEST 5>	
				5. Disconnect the sensor connector from the chassis harness. Measure the resistance between the pins on the sensor connector.	**Resistance is 900-2000 ohms**	Repair open or short in circuit(s) 377RF+ and 377RF- in chassis harness. <END OF TEST>	
					Resistance is above 2000 ohms OR below 900 ohms.	Replace sensor. <END OF TEST>	
		07	Damaged tone ring			Inspect tone ring for damage and missing teeth. Make sure correct tooth wheel is installed (100 tooth normal application). Repair as necessary. <END OF TEST>	6-1
		08	Excessive wheel slip			Check sensor adjustment. This fault usually occurs when there is excessive tire spin for more than 16 sec. <END OF TEST>	3-1
		09	Wire mismatch	6. Check for mixed sensor connection. This can be done using Meritor PC diagnostics by spinning each wheel individually and observing whether the output is from the proper sensor.		Correct wiring connections as necessary. <END OF TEST>	5-1
		10	Intermittent signal	7. Adjust the sensor. Use the wheel sensor output screen in Meritor PC Diagnotics and spin the wheel or drive the vehicle and observe for intermittent/erratic signal.	**Signal output OK**	Adjustment solved problem. Make sure brake chatter is not causing the problem. <END OF TEST>	3-1
		11	Erratic signal *Note: Perform test 10 for either fault*		**Signal output not OK**	Check for intermittent wheel sensor circuit connections. Cause could be due to brake chatter. Repair as necessary. <END OF TEST>	5-1
		12	Frequency too high	8. Check sensor wiring and connectors for intermittent contact.	**Wiring OK**	Suspect ECU at fault if problem persists. <END OF TEST>	
					Wiring not OK	Repair wheel sensor circuit as necessary. <END OF TEST>	

Table 5

(SID 003) WHEEL SENSOR, LEFT REAR

MID	SID	FMI	FAULT DESCRIPTION	TEST	TEST RESULT	ACTION	Blink Code
136	003	01	Incorrect sensor air gap	1. Adjust sensor. Check AC voltage across pins 1 and 2 of the X3 (green) ECU connector while rotating the LR wheel 30 RPM.	**Voltage greater than or equal 0.2 volts AC**	Sensor adjustment solved problem. <END OF TEST>	3-4
					Voltage below 0.2 volts AC	Check for excessive wheel bearing endplay and hub runout. Repair as necessary. <END OF TEST>	
		02	Incorrect tire size			Check for correct tire size and mixed tire sizes. Check for correct number of teeth on tone wheel. Correct as necessary. <END OF TEST>	5-4
		03	Sensor shorted to power	2. Measure the voltage across pin 1 of the X3 (green) connector and a good chassis ground. Repeat test between pin 2 and ground.	**Voltage at either pin**	Repair short to power in circuit(s) 377LR- and 377LR+ in chassis harness and sensor cable. If problem is in sensor harness, replace the sensor. <END OF TEST>	4-4
					No voltage at either pin.	Repeat test and check for intermittent short to power in circuits 377LR+ and 377LR-. Suspect ECU at fault if problem persists. <END OF TEST>	
		04	Short to ground	3. Measure the resistance between pin 1 of the X3 (green) connector and a good chassis ground. Repeat test between pin 2 and ground.	**The resistance between either pin and ground is less than 100,000 ohms.**	Repair short to ground in circuit(s) 377LR+ and 377LR- in chassis harness or sensor cable. If problem is in sensor harness, replace the sensor. <END OF TEST>	
					The resistance between either pin and ground is more than 100,000 ohms.	Repeat test and check for intermittent short to ground in circuits 377LR- and 377LR+. Suspect ECU at fault if problem persists. <END OF TEST>	
		05 06	Open circuit Short circuit *Note: Perform tests 4 & 5 for either fault.*	4. Measure the resistance between pins 1 and 2 of the X3 (green) connector.	**Resistance is 900-2000 ohms.**	Repeat test and check for intermittent open or short in circuits 377LR+ and 377LR-. Suspect ECU at fault if problem persists. <END OF TEST>	
					Resistance is above 2000 ohms OR below 900 ohms.	<GOTO TEST 5>	
				5. Disconnect the sensor connector from the chassis harness. Measure the resistance between the pins on the sensor connector.	**Resistance is 900-2000 ohms**	Repair open or short in circuit(s) 377LR+ and 377LR- in chassis harness. <END OF TEST>	
					Resistance is above 2000 ohms OR below 900 ohms.	Replace sensor. <END OF TEST>	
		07	Damaged tone ring			Inspect tone ring for damage and missing teeth. Make sure correct tooth wheel is installed (100 tooth normal application). Repair as necessary. <END OF TEST>	6-4
		08	Excessive wheel slip			Check sensor adjustment. This fault usually occurs when there is excessive tire spin for more than 16 sec. <END OF TEST>	3-4
		09	Wire mismatch	6. Check for mixed sensor connection. This can be done using Meritor PC diagnostics by spinning each wheel individually and observing whether the output is from the proper sensor.		Correct wiring connections as necessary. <END OF TEST>	5-4
		10 11	Intermittent signal Erratic signal *Note: Perform test 10 for either fault*	7. Adjust the sensor. Use the wheel sensor output screen in Meritor PC Diagnotics and spin the wheel or drive the vehicle and observe for intermittent/erratic signal.	**Signal output OK**	Adjustment solved problem. Make sure brake chatter is not causing the problem. <END OF TEST>	3-4
					Signal output not OK	Check for intermittent wheel sensor circuit connections. Cause could be due to brake chatter. Repair as necessary. <END OF TEST>	5-4
		12	Frequency too high	8. Check sensor wiring and connectors for intermittent contact.	**Wiring OK**	Suspect ECU at fault if problem persists. <END OF TEST>	
					Wiring not OK	Repair wheel sensor circuit as necessary. <END OF TEST>	

Table 6

(SID 004) WHEEL SENSOR, RIGHT REAR

MID	SID	FMI	FAULT DESCRIPTION	TEST	TEST RESULT	ACTION	Blink Code
136	004	01	Incorrect sensor air gap	1. Adjust sensor. Check AC voltage across pins 3 and 4 of the X3 (green) ECU connector while rotating the RR wheel 30 RPM.	**Voltage greater than or equal 0.2 volts AC**	Sensor adjustment solved problem. <END OF TEST>	3-3
					Voltage below 0.2 volts AC	Check for excessive wheel bearing endplay and hub runout. Repair as necessary. <END OF TEST>	
		02	Incorrect tire size			Check for correct tire size and mixed tire sizes. Check for correct number of teeth on tone wheel. Correct as necessary. <END OF TEST>	5-3
		03	Sensor shorted to power	2. Measure the voltage across pin 3 of the X3 (green) connector and a good chassis ground. Repeat test between pin 4 and ground.	**Voltage at either pin**	Repair short to power in circuit(s) 377RR- and 377RR+ in chassis harness and sensor cable. If problem is in sensor harness, replace the sensor. <END OF TEST>	4-3
					No voltage at either pin.	Repeat test and check for intermittent short to power in circuits 377RR+ and 377RR-. Suspect ECU at fault if problem persists. <END OF TEST>	
		04	Short to ground	3. Measure the resistance between pin 3 of the X3 (green) connector and a good chassis ground. Repeat test between pin 4 and ground.	**The resistance between either pin and ground is less than 100,000 ohms.**	Repair short to ground in circuit(s) 377RR+ and 377RR- in chassis harness or sensor cable. If problem is in sensor harness, replace the sensor. <END OF TEST>	
					The resistance between either pin and ground is more than 100,000 ohms.	Repeat test and check for intermittent short to ground in circuits 377RR- and 377RR+. Suspect ECU at fault if problem persists. <END OF TEST>	
		05 06	Open circuit Short circuit *Note: Perform tests 4 & 5 for either fault.*	4. Measure the resistance between pins 3 and 4 of the X3 (green) connector.	**Resistance is 900-2000 ohms.**	Repeat test and check for intermittent open or short in circuits 377RR+ and 377RR-. Suspect ECU at fault if problem persists. <END OF TEST>	
					Resistance is above 2000 ohms OR below 900 ohms.	<GOTO TEST 5>	
				5. Disconnect the sensor connector from the chassis harness. Measure the resistance between the pins on the sensor connector.	**Resistance is 900-2000 ohms**	Repair open or short in circuit(s) 377RR+ and 377RR- in chassis harness. <END OF TEST>	
					Resistance is above 2000 ohms OR below 900 ohms.	Replace sensor. <END OF TEST>	
		07	Damaged tone ring			Inspect tone ring for damage and missing teeth. Make sure correct tooth wheel is installed (100 tooth normal application). Repair as necessary. <END OF TEST>	6-3
		08	Excessive wheel slip			Check sensor adjustment. This fault usually occurs when there is excessive tire spin for more than 16 sec. <END OF TEST>	3-3
		09	Wire mismatch	6. Check for mixed sensor connection. This can be done using Meritor PC diagnostics by spinning each wheel individually and observing whether the output is from the proper sensor.		Correct wiring connections as necessary. <END OF TEST>	5-3
		10	Intermittent signal	7. Adjust the sensor. Use the wheel sensor output screen in Meritor PC Diagnotics and spin the wheel or drive the vehicle and observe for intermittent/erratic signal.	**Signal output OK**	Adjustment solved problem. Make sure brake chatter is not causing the problem. <END OF TEST>	3-3
		11	Erratic signal *Note: Perform test 10 for either fault*		**Signal output not OK**	Check for intermittent wheel sensor circuit connections. Cause could be due to brake chatter. Repair as necessary. <END OF TEST>	5-3
		12	Frequency too high	8. Check sensor wiring and connectors for intermittent contact.	**Wiring OK**	Suspect ECU at fault if problem persists. <END OF TEST>	
					Wiring not OK	Repair wheel sensor circuit as necessary. <END OF TEST>	

Table 7

(SID 005) WHEEL SENSOR, LEFT THIRD/TAG AXLE (6S/4M and 6S/6M ONLY)

MID	SID	FMI	FAULT DESCRIPTION	TEST	TEST RESULT	ACTION	Blink Code
136	005	01	Incorrect sensor air gap	1. Adjust sensor. Check AC voltage across pins 3 and 4 of the X4 (brown) ECU connector while rotating the LT wheel 30 RPM.	**Voltage greater than or equal 0.2 volts AC**	Sensor adjustment solved problem. <END OF TEST>	3-6
					Voltage below 0.2 volts AC	Check for excessive wheel bearing endplay and hub runout. Repair as necessary. <END OF TEST>	
		02	Incorrect tire size			Check for correct tire size and mixed tire sizes. Check for correct number of teeth on tone wheel. Correct as necessary. <END OF TEST>	5-6
		03	Sensor shorted to power	2. Measure the voltage across pin 3 of the X4 (brown) connector and a good chassis ground. Repeat test between pin 4 and ground.	**Voltage at either pin**	Repair short to power in circuit(s) 377LT- and 377LT+ in chassis harness and sensor cable. If problem is in sensor harness, replace the sensor. <END OF TEST>	4-6
					No voltage at either pin.	Repeat test and check for intermittent short to power in circuits 377LT+ and 377LT-. Suspect ECU at fault if problem persists. <END OF TEST>	
		04	Short to ground	3. Measure the resistance between pin 3 of the X4 (brown) connector and a good chassis ground. Repeat test between pin 4 and ground.	**The resistance between either pin and ground is less than 100,000 ohms.**	Repair short to ground in circuit(s) 377LT+ and 377LT- in chassis harness or sensor cable. If problem is in sensor harness, replace the sensor. <END OF TEST>	
					The resistance between either pin and ground is more than 100,000 ohms.	Repeat test and check for intermittent short to ground in circuits 377LT- and 377LT+. Suspect ECU at fault if problem persists. <END OF TEST>	
		05	Open circuit	4. Measure the resistance between pins 3 and 4 of the X4 (brown) connector.	**Resistance is 900-2000 ohms.**	Repeat test and check for intermittent open or short in circuits 377LT+ and 377LT-. Suspect ECU at fault if problem persists. <END OF TEST>	
		06	Short circuit *Note: Perform tests 4 & 5 for either fault.*		**Resistance is above 2000 ohms OR below 900 ohms.**	<GOTO TEST 5>	
				5. Disconnect the sensor connector from the chassis harness. Measure the resistance between the pins on the sensor connector.	**Resistance is 900-2000 ohms**	Repair open or short in circuit(s) 377LT+ and 377LT- in chassis harness. <END OF TEST>	
					Resistance is above 2000 ohms OR below 900 ohms.	Replace sensor. <END OF TEST>	
		07	Damaged tone ring			Inspect tone ring for damage and missing teeth. Make sure correct tooth wheel is installed (100 tooth normal application). Repair as necessary. <END OF TEST>	6-6
		08	Excessive wheel slip			Check sensor adjustment. This fault usually occurs when there is excessive tire spin for more than 16 sec. <END OF TEST>	3-6
		09	Wire mismatch	6. Check for mixed sensor connection. This can be done using Meritor PC diagnostics by spinning each wheel individually and observing whether the output is from the proper sensor.		Correct wiring connections as necessary. <END OF TEST>	5-6
		10	Intermittent signal	7. Adjust the sensor. Use the wheel sensor output screen in Meritor PC Diagnotics and spin the wheel or drive the vehicle and observe for intermittent/erratic signal.	**Signal output OK**	Adjustment solved problem. Make sure brake chatter is not causing the problem. <END OF TEST>	3-6
		11	Erratic signal *Note: Perform test 10 for either fault*		**Signal output not OK**	Check for intermittent wheel sensor circuit connections. Cause could be due to brake chatter. Repair as necessary. <END OF TEST>	5-6
		12	Frequency too high	8. Check sensor wiring and connectors for intermittent contact.	**Wiring OK**	Suspect ECU at fault if problem persists. <END OF TEST>	
					Wiring not OK	Repair wheel sensor circuit as necessary. <END OF TEST>	

Table 8

(SID 006) WHEEL SENSOR, RIGHT THIRD/TAG AXLE (6S/4M and 6S/6M ONLY)

MID	SID	FMI	FAULT DESCRIPTION	TEST	TEST RESULT	ACTION	Blink Code
136	006	01	Incorrect sensor air gap	1. Adjust sensor. Check AC voltage across pins 5 and 6 of the X4 (brown) ECU connector while rotating the RT wheel 30 RPM.	**Voltage greater than or equal 0.2 volts AC**	Sensor adjustment solved problem. <END OF TEST>	3-5
					Voltage below 0.2 volts AC	Check for excessive wheel bearing endplay and hub runout. Repair as necessary. <END OF TEST>	
		02	Incorrect tire size			Check for correct tire size and mixed tire sizes. Check for correct number of teeth on tone wheel. Correct as necessary. <END OF TEST>	5-5
		03	Sensor shorted to power	2. Measure the voltage across pin 5 of the X4 (brown) connector and a good chassis ground. Repeat test between pin 6 and ground.	**Voltage at either pin**	Repair short to power in circuit(s) 377RT- and 377RT+ in chassis harness and sensor cable. If problem is in sensor harness, replace the sensor. <END OF TEST>	4-5
					No voltage at either pin.	Repeat test and check for intermittent short to power in circuits 377RT+ and 377RT-. Suspect ECU at fault if problem persists. <END OF TEST>	
		04	Short to ground	3. Measure the resistance between pin 5 of the X4 (brown) connector and a good chassis ground. Repeat test between pin 6 and ground.	**The resistance between either pin and ground is less than 100,000 ohms.**	Repair short to ground in circuit(s) 377RT+ and 377RT- in chassis harness or sensor cable. If problem is in sensor harness, replace the sensor. <END OF TEST>	
					The resistance between either pin and ground is more than 100,000 ohms.	Repeat test and check for intermittent short to ground in circuits 377RT- and 377RT+. Suspect ECU at fault if problem persists. <END OF TEST>	
		05 06	Open circuit Short circuit *Note: Perform tests 4 & 5 for either fault.*	4. Measure the resistance between pins 5 and 6 of the X4 (brown) connector.	**Resistance is 900-2000 ohms.**	Repeat test and check for intermittent open or short in circuits 377RT+ and 377RT-. Suspect ECU at fault if problem persists. <END OF TEST>	
					Resistance is above 2000 ohms OR below 900 ohms.	<GOTO TEST 5>	
				5. Disconnect the sensor connector from the chassis harness. Measure the resistance between the pins on the sensor connector.	**Resistance is 900-2000 ohms**	Repair open or short in circuit(s) 377RT+ and 377RT- in chassis harness. <END OF TEST>	
					Resistance is above 2000 ohms OR below 900 ohms.	Replace sensor. <END OF TEST>	
		07	Damaged tone ring			Inspect tone ring for damage and missing teeth. Make sure correct tooth wheel is installed (100 tooth normal application). Repair as necessary. <END OF TEST>	6-5
		08	Excessive wheel slip			Check sensor adjustment. This fault usually occurs when there is excessive tire spin for more than 16 sec. <END OF TEST>	3-5
		09	Wire mismatch	6. Check for mixed sensor connection. This can be done using Meritor PC diagnostics by spinning each wheel individually and observing whether the output is from the proper sensor.		Correct wiring connections as necessary. <END OF TEST>	5-5
		10	Intermittent signal	7. Adjust the sensor. Use the wheel sensor output screen in Meritor PC Diagnotics and spin the wheel or drive the vehicle and observe for intermittent /erratic signal.	**Signal output OK**	Adjustment solved problem. Make sure brake chatter is not causing the problem. <END OF TEST>	3-5
		11	Erratic signal *Note: Perform test 10 for either fault*		**Signal output not OK**	Check for intermittent wheel sensor circuit connections. Cause could be due to brake chatter. Repair as necessary. <END OF TEST>	5-5
		12	Frequency too high	8. Check sensor wiring and connectors for intermittent contact.	**Wiring OK**	Suspect ECU at fault if problem persists. <END OF TEST>	
					Wiring not OK	Repair wheel sensor circuit as necessary. <END OF TEST>	

Table 9

MODULATOR VALVE, LEFT FRONT (SID 007)

MID	SID	FMI	FAULT DESCRIPTION	TEST	TEST RESULT	ACTION	Blink Code
136	007	01	Open circuit in inlet or outlet valve circuit	1. Check the modulator valve inlet and outlet circuit resistance. Disconnect the connector from the valve and perform the MODULATOR VALVE RESISTANCE test as outlined in Subject 200.	**Resistance in both circuits is within 4-8 ohms.**	Check harness wiring circuits 378LFI, 378LFO, and 378LF- for open circuit or poor connections. Repair as necessary. <END OF TEST>	2-2
					Resistance in either circuit exceeds 8 ohms.	Replace modulator valve. <END OF TEST>	
		03	Short to power	2. Measure the voltage between pins 2, 10, 11 of the X2 (black) connector and a good chassis ground.	**No voltage**	Repeat test. Check circuits 378LFI, 378LFO, and 378LF- for intermittent short to power. If problem persists suspect ECU is at fault. <END OF TEST>	
					Voltage	Repair short to power in circuit 378LFI, 378LFO, or 378LF-. <END OF TEST>	
		05	Open circuit	3. Check the modulator valve inlet and outlet circuit resistance. Disconnect the connector from the valve and perform the MODULATOR VALVE RESISTANCE test as outlined in Subject 200.	**Resistance in both circuits is within 4-8 ohms.**	Check harness wiring circuits 378LFI, 378LFO, and 378LF- for open circuit or poor connections. Repair as necessary. <END OF TEST>	
					Resistance in either circuit exceeds 8 ohms.	Replace modulator valve. <END OF TEST>	
		06	Short to ground	4. Check the modulator valve inlet and outlet circuit resistance. Disconnect the connector from the valve and perform the MODULATOR VALVE RESISTANCE test as outlined in Subject 200.	**Resistance in both circuits is within 4-8 ohms.**	Check harness wiring circuits 378LFI and 378LFO for short to ground. Repair as necessary. <END OF TEST>	
					Resistance in either circuit is below 4 ohms.	Replace modulator valve. <END OF TEST>	

Table 10

MODULATOR VALVE, RIGHT FRONT (SID 008)

MID	SID	FMI	FAULT DESCRIPTION	TEST	TEST RESULT	ACTION	Blink Code
136	008	01	Open circuit in inlet or outlet valve circuit	1. Check the modulator valve inlet and outlet circuit resistance. Disconnect the connector from the valve and perform the MODULATOR VALVE RESISTANCE test as outlined in Subject 200.	**Resistance in both circuits is within 4-8 ohms.**	Check harness wiring circuits 378RFI, 378RFO, and 378RF- for open circuit or poor connections. Repair as necessary. <END OF TEST>	2-1
					Resistance in either circuit exceeds 8 ohms.	Replace modulator valve. <END OF TEST>	
		03	Short to power	2. Measure the voltage between pins 3, 4, and 9 of the X2 (black) connector and a good chassis ground.	**No voltage**	Repeat test. Check circuits 378RFI, 378RFO, and 378RF- for intermittent short to power. If problem persists suspect ECU is at fault. <END OF TEST>	
					Voltage	Repair short to power in circuit 378RFI, 378RFO, or 378RF-. <END OF TEST>	
		05	Open circuit	3. Check the modulator valve inlet and outlet circuit resistance. Disconnect the connector from the valve and perform the MODULATOR VALVE RESISTANCE test as outlined in Subject 200.	**Resistance in both circuits is within 4-8 ohms.**	Check harness wiring circuits 378RFI, 378RFO, and 378RF- for open circuit or poor connections. Repair as necessary. <END OF TEST>	
					Resistance in either circuit exceeds 8 ohms.	Replace modulator valve. <END OF TEST>	
		06	Short to ground	4. Check the modulator valve inlet and outlet circuit resistance. Disconnect the connector from the valve and perform the MODULATOR VALVE RESISTANCE test as outlined in Subject 200.	**Resistance in both circuits is within 4-8 ohms.**	Check harness wiring circuits 378RFI and 378RFO for short to ground. Repair as necessary. <END OF TEST>	
					Resistance in either circuit is below 4 ohms.	Replace modulator valve. <END OF TEST>	

Table 11

MODULATOR VALVE, LEFT REAR (SID 009)

MID	SID	FMI	FAULT DESCRIPTION	TEST	TEST RESULT	ACTION	Blink Code
136	009	01	Open circuit in inlet or outlet valve circuit	1. Check the modulator valve inlet and outlet circuit resistance. Disconnect the connector from the valve and perform the MODULATOR VALVE RESISTANCE test as outlined in Subject 200.	**Resistance in both circuits is within 4-8 ohms.**	Check harness wiring circuits 378LRI, 378LRO, and 378LR- for open circuit or poor connections. Repair as necessary. <END OF TEST>	2-4
					Resistance in either circuit exceeds 8 ohms.	Replace modulator valve. <END OF TEST>	
		03	Short to power	2. Measure the voltage between pins 10, 11, and 12 of the X3 (green) connector and a good chassis ground.	**No voltage**	Repeat test. Check circuits 378LRI, 378LRO, and 378LR- for intermittent short to power. If problem persists suspect ECU is at fault. <END OF TEST>	
					Voltage	Repair short to power in circuit 378LRI, 378LRO, or 378LR-. <END OF TEST>	
		05	Open circuit	3. Check the modulator valve inlet and outlet circuit resistance. Disconnect the connector from the valve and perform the MODULATOR VALVE RESISTANCE test as outlined in Subject 200.	**Resistance in both circuits is within 4-8 ohms.**	Check harness wiring circuits 378LRI, 378LRO, and 378LR- for open circuit or poor connections. Repair as necessary. <END OF TEST>	
					Resistance in either circuit exceeds 8 ohms.	Replace modulator valve. <END OF TEST>	
		06	Short to ground	4. Check the modulator valve inlet and outlet circuit resistance. Disconnect the connector from the valve and perform the MODULATOR VALVE RESISTANCE test as outlined in Subject 200.	**Resistance in both circuits is within 4-8 ohms.**	Check harness wiring circuits 378LRI and 378LRO for short to ground. Repair as necessary. <END OF TEST>	
					Resistance in either circuit is below 4 ohms.	Replace modulator valve. <END OF TEST>	

Table 12

MODULATOR VALVE, RIGHT REAR (SID 010)

MID	SID	FMI	FAULT DESCRIPTION	TEST	TEST RESULT	ACTION	Blink Code
136	010	01	Open circuit in inlet or outlet valve circuit	1. Check the modulator valve inlet and outlet circuit resistance. Disconnect the connector from the valve and perform the MODULATOR VALVE RESISTANCE test as outlined in Subject 200.	**Resistance in both circuits is within 4-8 ohms.**	Check harness wiring circuits 378RRI, 378RRO, and 378RR- for open circuit or poor connections. Repair as necessary. <END OF TEST>	2-3
					Resistance in either circuit exceeds 8 ohms.	Replace modulator valve. <END OF TEST>	
		03	Short to power	2. Measure the voltage between pins 7, 8, and 9 of the X3 (green) connector and a good chassis ground.	**No voltage**	Repeat test. Check circuits 378RRI, 378RRO, and 378RR- for intermittent short to power. If problem persists suspect ECU is at fault. <END OF TEST>	
					Voltage	Repair short to power in circuit 378RRI, 378RRO, or 378RR-. <END OF TEST>	
		05	Open circuit	3. Check the modulator valve inlet and outlet circuit resistance. Disconnect the connector from the valve and perform the MODULATOR VALVE RESISTANCE test as outlined in Subject 200.	**Resistance in both circuits is within 4-8 ohms.**	Check harness wiring circuits 378RRI, 378RRO, and 378RR- for open circuit or poor connections. Repair as necessary. <END OF TEST>	
					Resistance in either circuit exceeds 8 ohms.	Replace modulator valve. <END OF TEST>	
		06	Short to ground	4. Check the modulator valve inlet and outlet circuit resistance. Disconnect the connector from the valve and perform the MODULATOR VALVE RESISTANCE test as outlined in Subject 200.	**Resistance in both circuits is within 4-8 ohms.**	Check harness wiring circuits 378RRI and 378RRO for short to ground. Repair as necessary. <END OF TEST>	
					Resistance in either circuit is below 4 ohms.	Replace modulator valve. <END OF TEST>	

Table 13

RETARDER (SID 013)

MID	SID	FMI	FAULT DESCRIPTION	TEST	TEST RESULT	ACTION	Blink Code
136	013	03	Short to Power	1. Remove the retarder relay in the main power distribution module (PDM). Turn the ignition switch to ON. Measure voltage between the relay cavity connector C2 (corresponding to terminal 86 of the relay....circuit 376R) and ground.	**No voltage**	<GOTO TEST 2>	7-3
					Voltage	Check circuit 376R between the retarder relay and the ABS ECU for short to power, repair as necessary. <END OF TEST>	
				2. Check for shorted retarder relay coil. Measure the resistance between relay terminals 85 and 86.	**Resistance is less than 76 ohms.**	Retarder relay is shorted. Replace relay. <END OF TEST>	
					Resistance is 76 to 92 ohms.	Check circuit 376R between the retarder relay and the ABS ECU for intermittent short to power. Repeat Test 1 while turning various accessories on (i.e lights, turn signals, etc.) Repair as necessary. <END OF TEST>	
		05	Open Circuit	3. Check for open retarder relay coil. Remove the retarder relay from the main power distribution module. Measure the resistance between relay terminals 85 and 86.	**Resistance is 76 to 92 ohms.**	<GOTO TEST 4>	
					Resistance is greater than 92 ohms	Relay is open, replace relay. <END OF TEST>	
				4. Check for open in circuit 376R between the retarder relay and ABS ECU. Remove the retarder relay in the power distribution module and remove the X1 connector at the ABS ECU. Measure the resistance between cavity C2 of the relay connector and pin 5 of the X1 connector	**Resistance is greater than 1.4 ohms**	Repair high resistance or open in circuit 376R. <END OF TEST>	
					Resistance is less than or equal to 1.4 ohms	Resistance in circuit 376R is acceptable. Check for open in circuit 81C (the power side of the retarder relay coil.) <END OF TEST>	
		06	Short to ground	5. Check for short to ground in circuit 376R. Remove the retarder relay from the power distribution module and disconnect the X1 connector from the ABS ECU. Check for continuity between cavity C2 of the relay connector and ground.	**Continuity**	Repair short to ground in circuit 376R. <END OF TEST>	
					No continuity	Check for intermittent short to ground in circuit 376R. Check ABS ECU. Repair or replace as necessary. <END OF TEST>	

Table 14

GROUND-DIAGONAL 1 (SID 014)

MID	SID	FMI	FAULT DESCRIPTION	TEST	TEST RESULT	ACTION	Blink Code
136	014	04	Low voltage or open circuit	1. Disconnect the X1 (gray) connector at the ABS ECU. With the ignition ON, measure the voltage between pins 2 and 11 (circuits 376C and XGRD).	**Voltage is 9.5 to 14 volts**	System voltage is acceptable. Check for intermittent low voltage. Check the batteries and charging system. Voltage may have been temporarily too low. Repair as necessary. <END OF TEST>	8-1
					Voltage is less than 9.5 volts	<GOTO TEST 2>	
				2. With the ignition ON, measure the voltage between pin 2 of the X1 connector (circuit 376C) and a good chassis ground.	**Voltage is 9.5 to 14 volts**	Check the ground circuit (XGRD) from pin 11 of the X1 connector. Repair as necessary. <END OF TEST>	
					Voltage is less than 9.5 volts	Check the 10A breaker in position G2 of the B-pillar PDM. Check circuit 376C between pin 2 of the X1 connector at the ABS ECU and PDM for open circuit (note 376C changes to 376A in the B-pillar). <END OF TEST>	
		07	Internal relay fault			If fault repeats, replace the ABS ECU. <END OF TEST>	8-3

Table 15

GROUND-DIAGONAL 2 (SID 015)

MID	SID	FMI	FAULT DESCRIPTION	TEST	TEST RESULT	ACTION	Blink Code
136	015	04	Low voltage or open circuit	1. Disconnect the X1 (gray) connector at the ABS ECU. With the ignition ON, measure the voltage between pins 1 and 12 (circuits 376C and XGRD).	**Voltage is 9.5 to 14 volts**	System voltage is acceptable. Check for intermittent low voltage. Check the batteries and charging system. Voltage may have been temporarily too low. Repair as necessary. <END OF TEST>	8-1
					Voltage is less than 9.5 volts	<GOTO TEST 2>	
				2. With the ignition ON, measure the voltage between pin 1 of the X1 connector (circuit 376C) and a good chassis ground.	**Voltage is 9.5 to 14 volts**	Check the ground circuit (XGRD) from pin 12 of the X1 connector. Repair as necessary. <END OF TEST>	
					Voltage is less than 9.5 volts	Check the 10A breaker in position G1 of the B-pillar PDM. Check circuit 376C between pin 1 of the X1 connector at the ABS ECU and PDM for open circuit (note 376C changes to 376B in the B-pillar). <END OF TEST>	
		07	Internal relay fault			If fault repeats, replace the ABS ECU. <END OF TEST>	8-3

Table 16

ATC VALVE (SID 018)

MID	SID	FMI	FAULT DESCRIPTION	TEST	TEST RESULT	ACTION	Blink Code
136	018	03	Short to power	1. Disconnect the X3 (green) connector from the ABS ECU. Disconnect the ATC valve connector. Measure the voltage between pin 5 of the X3 (green) connector and a good chassis ground.	**Voltage**	Circuit 378T+ is shorted to power. Repair as necessary. <END OF TEST>	7-2
					No voltage	<GOTO TEST 2>	
				2. Measure the voltage between pin 6 of the X3 (green) connector and a good chassis ground.	**Voltage present**	Circuit 378T- shorted to power. Repair as necessary. <END OF TEST>.	
					Voltage not present	Verify fault. Check for intermittent short to power. Check for possible shorts in the ATC and X3 connectors. Reconfigure ECU. <END OF TEST>	
		05	Open circuit	3. Disconnect the ATC valve connector. Measure the resistance across the two pins of the ATC valve	**Resistance is 6.4 – 12 ohms**	<GOTO TEST 4>	
					Resistance is greater than 12 ohms	Replace ATC valve. <END OF TEST>	
				4. Reconnect the ATC valve connector. Measure the resistance across pins 5 and 6 of the X3 (green) connector.	**Resistance is 6.4 – 12 ohms**	Verify fault. Check for intermittent open circuit in 376T+ and 376T-. Reconfigure ECU. <END OF TEST>	
					Resistance is greater than 12 ohms	Pinpoint source of high resistance in circuit 376T+ or 376T-. Repair as necessary. <END OF TEST>	
		06	Short to ground	5. Disconnect the ATC valve connector. Measure the resistance across the two pins of the ATC valve	**Resistance is 6.4 – 12 ohms**	<GOTO TEST 6>	
					Resistance is less than 6.4 ohms	ATC valve is shorted internally. Replace ATC valve. <END OF TEST>	
				6. Reconnect the ATC valve connector. Disconnect the X3 (green) connector from the ABS ECU. Measure the resistance between pin 5 of the X3 connector and a good chassis ground.	**Resistance is less than 6.4 ohms**	Circuit 376T+ is shorted to ground. Repair as necessary. <END OF TEST>	
					Resistance is 6.4 to 12 ohms	Circuit 376T- is shorted to ground. Repair as necessary. <END OF TEST>	

Table 17

NOT USED (SID 019)

MID	SID	FMI	FAULT DESCRIPTION	TEST	TEST RESULT	ACTION	Blink Code
136	019	03	Short to power			This fault should not appear. Reconfigure the ECU. If fault continues to appear, check the wiring in the X2 (black) ABS ECU connector. Pins 1 and 12 of this connector should be unused. Make sure there are no connections to these pins. If incorrect wiring is found, correct it and reconfigure the ECU. If this does not correct the problem, contact Meritor Wabco. <END OF TEST>	7-6
		06	Short to ground			This fault should not appear. Reconfigure the ECU. If fault continues to appear, check the wiring in the X2 (black) ABS ECU connector. Pins 1 and 12 of this connector should be unused. Make sure there are no connections to these pins. If incorrect wiring is found, correct it and reconfigure the ECU. If this does not correct the problem, contact Meritor Wabco. <END OF TEST>	

Table 18

WARNING LAMP (SID 023)

MID	SID	FMI	FAULT DESCRIPTION	TEST	TEST RESULT	ACTION	Blink Code
136	023	05	Open circuit	1. Was the ABS CHECK SWITCH pressed longer than 16 seconds?	**Yes**	This fault can occur if the ABS CHECK SWITCH is pressed for more than 16 seconds. In this case, the ECU sees no load in the ABS lamp relay control circuit. Clear the fault. <END OF TEST>	7-4
					No	<GOTO TEST 2>	
				2. With the ignition switch OFF, remove the ABS lamp relay located in the B-pillar. Measure the resistance across relay coil (terminals 85 and 86 of the relay).	**Resistance is 70 – 84 ohms**	<GOTO TEST 3>	
					Resistance is greater than 84 ohms	ABS lamp relay coil is open. Replace relay. <END OF TEST>	
				3. With the ABS lamp relay removed, turn the ignition switch ON and measure voltage between the relay connector cavity C1 (corresponds to relay terminal 86/circuit 376C) and a good chassis ground.	**Voltage (should be same as battery voltage)**	Make sure the 10A breaker in position G3 of the b-pillar PDM is not switching off under load. If it is, locate the problem and correct. If okay, <GOTO TEST 4>	
					No voltage	Check the 10A breaker in position G3 of the B-pillar PDM. Check for open or short to ground in circuit 376C between the breaker and the relay (see wiring schematics). <END OF TEST>	
				4. Disconnect the X1 connector from the ABS ECU. With the ABS lamp relay removed, check for continuity between the ABS lamp relay connector cavity C2 (corresponds to terminal 85/ circuit 376L) and a good chassis ground.	**Continuity**	Check for short to ground in circuit 376L : a) between the ABS lamp relay and the ABS check switch, b) between the ABS check switch and the ABS ECU. Repair as necessary. <END OF TEST>	
					No Continuity	<GOTO TEST 5>	
				5. With the ABS lamp relay removed and the X1 connector at the ABS ECU disconnected, measure the resistance between cavity C2 (corresponds to terminal 85/circuit 376L) and pin 10 of the X1 ABS ECU connector.	**Resistance is less than or equal to 2 ohms**	Make sure ABS CHECK switch was not depressed more than 16 seconds. Check for intermittent open circuit or short to ground in circuit 376L. Check ECU. <END OF TEST>	
					Resistance is more than 2 ohms	Check for open in circuit 376L: a) between the ABS lamp relay and the ABS CHECK switch, b) between the ABS CHECK switch and the ABS ECU. Check for ABS CHECK switch stuck or shorted in the ON position. <END OF TEST>	

Table 19

J1939 DATALINK (SID 231 or 248)

MID	SID	FMI	FAULT DESCRIPTION	TEST	TEST RESULT	ACTION	Blink Code
136	231 OR 248	02	J1939 plausibility error			Check the speedometer calibration. Check for tire size mismatch. The vehicle speed reported on the J1939 databus does not agree with the wheel sensor speeds. <END OF TEST>	7-1
		05	J1939 open/short *Note: This fault can occur from one of the following:* *1) an open in either the J1939+ or J1939-* *2) J1939+ or J1939- shorted to battery voltage.* *3) J1939+ shorted to ground.* *4) J1939+ and J1939- shorted together.* *If items 2, 3, or 4 are the case, a J1587 fault of MID 136 SID 248 FMI 06 will occur.*	See SB54-75 for troubleshooting the J1939 datalink.		Repair J1939 datalink as necessary. <END OF TEST>	
		06	J1939 short to ground	See SB54-75 for troubleshooting the J1939 datalink. Also, see Fault Description for FMI 05 above.		Repair J1939 datalink as necessary. <END OF TEST>	
		09	J1939 time out *The ABS ECU is not able to establish communication with the engine.*	See SB54-75 for troubleshooting the J1939 datalink.		Check J1939 datalink. Check engine ECU for J1939 parameter settings and communication. Repair as necessary. <END OF TEST>	
		12	J1939 internal error			Verify accuracy of fault code. Clear code from ECU memory. If fault persists, replace ABS ECU. <END OF TEST>	8-3

Table 20

J1922 DATALINK (SID 249)

MID	SID	FMI	FAULT DESCRIPTION	TEST	TEST RESULT	ACTION	Blink Code
136	249	05	J1922 open circuit	1. Disconnect the X1 (gray) connector from the ABS ECU. Turn the ignition to ON. Measure voltage between pin 6 and a good chassis ground. Repeat for pin 7.	**Voltage (pin 6 to grd) is 0-2.5 volts** **And** **Voltage (pin 7 to grd) is 2.5 to 5 volts**	Check wiring for intermittent open circuit. Verify fault. Repair as necessary. <END OF TEST>	7-1
					Voltage is 0 volts at either or both pins.	Check J1922 wiring for open circuit. Repair as necessary. <END OF TEST>	
		06	J1922 short to ground	2. Disconnect the X1 (gray) connector from the ABS ECU. With the ignition OFF, measure the resistance between pin 6 of the X1 connector and a good chassis ground.	**Resistance is less than 50 ohms**	Locate short to ground in J1922- circuit. Repair as necessary. <END OF TEST>	
					Resistance is 50 ohms or greater	<GOTO TEST 3>	
				3. Disconnect the J1922 wiring from the engine and transmission (if J1922 is present on the transmission). Check for continuity between pin 6 of the X1 connector and a good chassis ground.	**Continuity**	Locate and repair short to ground in J1922- wiring. <END OF TEST>	
					No continuity	<GOTO TEST 4>	
				4. REPEAT TEST 3 (substitute pin 7 for pin 6)	**Continuity**	Locate and repair short to ground in J1922+ wiring. <END OF TEST>	
					No continuity	Check other engine and transmission (if applicable) ECUs. Replace as necessary. <END OF TEST>	
		10	J1922 databus not free			Check other ECUs. The databus cannot be accessed due to heavy traffic. <END OF TEST>	

Table 21

VOLTAGE DIAGONAL 1 OR 2 (SID 251)

MID	SID	FMI	FAULT DESCRIPTION	TEST	TEST RESULT	ACTION	Blink Code
136	251	03	Overvoltage *Voltage to ECU was too high for more than 5 seconds.*	1. Using Meritor PC Diagnostics, check the diagonal voltages with the engine running at governed speed, or measure the voltage at the batteries with the engine running at governed speed.	**Voltage is 9.5 to 14 Volts**	Check for intermittent sources of high voltage. Check condition of charging system and batteries. Verify fault. <END OF TEST>	8-2
					Voltage is greater than 14 Volts	Check charging system. Repair as necessary. <END OF TEST>	

Table 22

CONFIGURATION ERRORS(SID 253)

MID	SID	FMI	FAULT DESCRIPTION	TEST	TEST RESULT	ACTION	Blink Code
136	253	01	ATC configuration error. *Note: ATC valve is detected without engine datalink (J1922 or J1939).*			Check J1922 or J1939 for proper wiring. Reversed polarity on J1922 can cause this fault. Check engine ECU for communication. Repair as necessary, then reconfigure ECU. <END OF TEST>	7-5
		02	ABS configuration / wheel parameter incorrect			Reconfigure ECU. If fault repeats then wrong ECU is installed. Replace with correct ECU. <END OF TEST>	8-4
		12	Checksum error			Check parameter setting. Check is diagnostic device was disconnected during active diagnosis. <END OF TEST>	8-4

Table 23

MISCELLANEOUS FAULTS (SID 254)

MID	SID	FMI	FAULT DESCRIPTION	TEST	TEST RESULT	ACTION	Blink Code
136	254	02	Internal error			If fault persists, replace the ABS ECU. <END OF TEST>	8-3
		05	ABS/ATC ECU, no loads			No modulators valves connected. Fault may have resulted from end of line testing at the factory. <END OF TEST>	8-4
		08	Excessive wheel slip.			Check wheel sensor air gaps. One wheel was much faster than the other. May have been caused by testing vehicle on a dynomometer. May be caused by driver error in vehicles without ATC (excessive tire spinning). <END OF TEST>	7-1
		09	Modulator valve actuated too long.			Modulator valve was activated too long (more than 3 minutes. After a delay, function will return to normal. <END OF TEST>	2-1
		12	Internal error			If fault persists, replace the ABS ECU. <END OF TEST>	8-3

Group Index, Alphabetical

Section	Section Number
Air Bag System	46.09
Power Steering Gear, Sheppard M100	46.05
Power Steering Gear, TRW PCF60	46.11
Power Steering Gear, TRW TAS65/85	46.01
Power Steering Pump, LuK Automotive Hydraulics LF 73	46.00
Power Steering Pump, LuK Automotive Hydraulics LF 80	46.10
Power Steering Pump, TRW PS Series	46.02
Power Steering Pump, Vickers V20F	46.08
Steering Drag Link	46.03
Steering Driveline, TRW	46.04
Steering Driveline, ZF	46.12
Steering Wheel and Column Assembly	46.07
Tilt Steering Column Assembly	46.06

Contents

Subject	Subject Number
General Description	050
Service Operations	
Steering Pump Removal and Installation	100
Steering Pump Shaft Seal Replacement	110
Troubleshooting	300
Specifications	400

General Description

The Luk-Automotive Hydraulics (formerly Vickers) LF 73 power steering pump supplies power steering fluid for the operation of the power steering gear.

The pump is mounted on the left side of the engine, at the rear of the gear case, or the air compressor. See **Fig. 1**. It is powered by an adaptor gear in the engine.

The main parts of the power steering pump are the housing, driveshaft, cam ring, rotor, vanes, and control valve. See **Fig. 2**.

Principles of Operation (See Fig. 3)

The driveshaft, powered by the adaptor gear in the engine gear case, turns the rotor, which is inside the cam ring. As the rotor turns, centrifugal force pushes the vanes out toward the surface of the cam ring. As fluid enters the cam ring through the inlet port, the rotor vanes force it out through the outlet port, and into the system. The fluid operates the steering gear. Eventually the fluid returns to the power steering reservoir, and then back to the power steering pump.

If the system pressure gets too high, a poppet inside the control valve is forced off its seat, shunting fluid into a relief passage connected to the inlet port. The fluid then recirculates inside the pump instead of going to the outlet port. When the system pressure drops to the correct level, the poppet seats, closing off the relief passage to the inlet port. The fluid flow returns to normal, flowing from the inlet port to the outlet port and then into the power steering system.

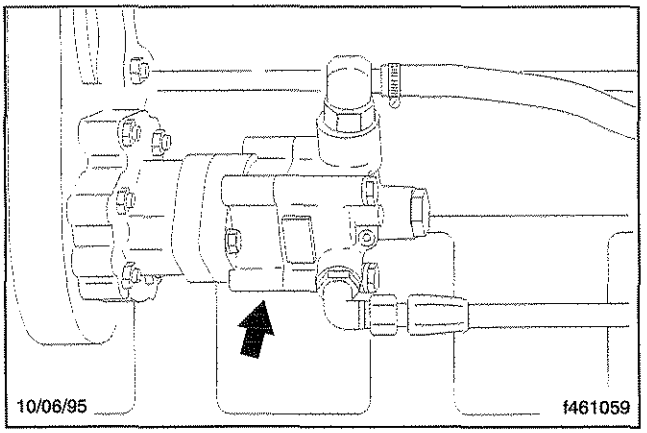
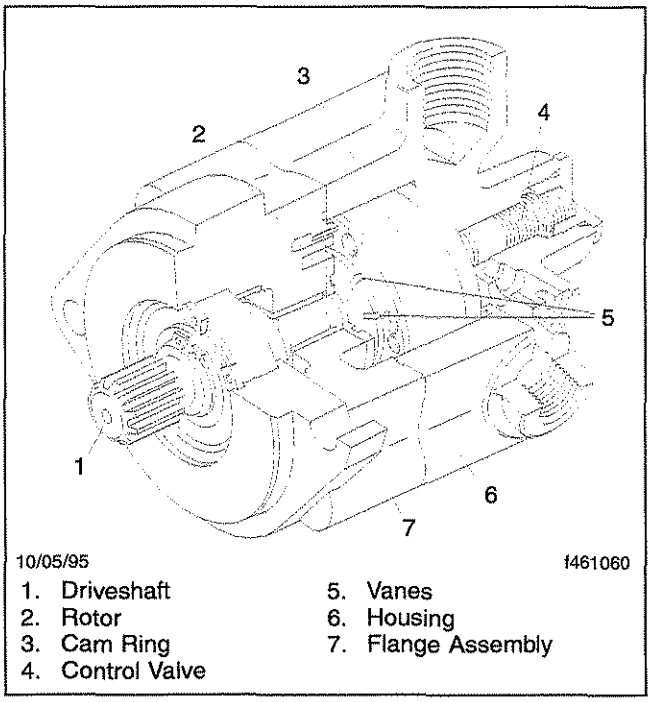
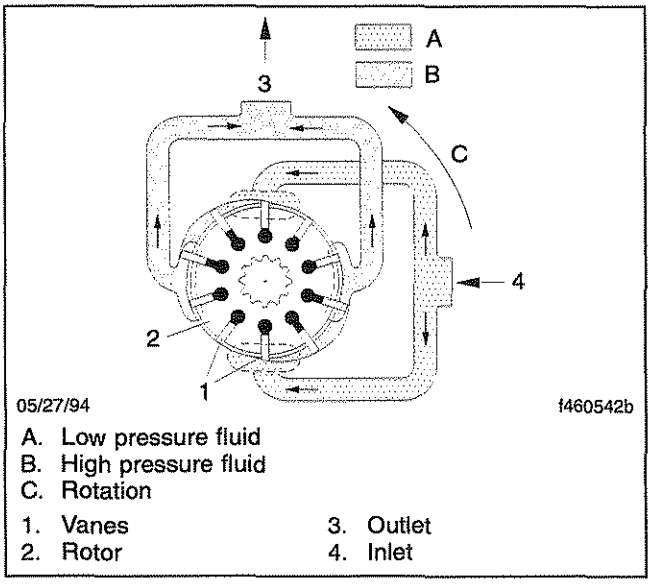


Fig. 1, Pump Mounting (at the rear of the gear case)



1. Driveshaft
2. Rotor
3. Cam Ring
4. Control Valve
5. Vanes
6. Housing
7. Flange Assembly

Fig. 2, Pump Components



A. Low pressure fluid
B. High pressure fluid
C. Rotation

1. Vanes
2. Rotor
3. Outlet
4. Inlet

Fig. 3, Pump Fluid Flow Diagram

Steering Pump Removal and Installation

Removal

1. Park the vehicle on a level surface.
2. Shut down the engine, set the parking brake, and chock the tires.

⚠ DANGER

Before doing the work below on an Argosy vehicle, review the cab-tilting information in Section 60.15, Subject 060. Failure to read the warnings and to be aware of the dangers of tilting and returning the cab could result in serious injury or death.

3. Open the hood or tilt the cab. For cab tilting instructions, see **Section 60.15**, Subject 060.
4. Clean all dirt from around the fittings and hose connections.
5. Put a container under the inlet port of the pump, then disconnect the fitting. Plug the hose to keep out dirt and to prevent fluid from leaking.

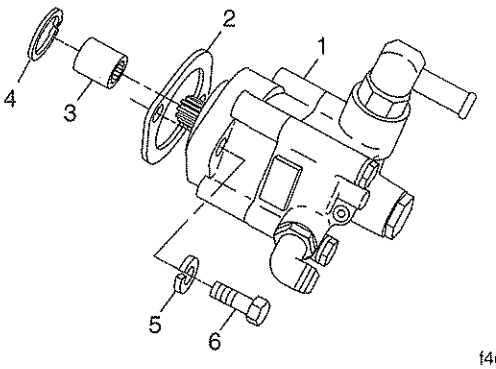
   Repeat this step at the pump outlet port.
6. On Cummins and Caterpillar engines, remove the mounting bolts that attach the pump to the engine accessory drive mounting flange. See **Fig. 1**. Slide the pump out of the shaft coupling or sleeve, and remove the pump from the engine.

   On Detroit Diesel Series 50 and 60 engines, remove the two pump-mounting bolts that attach the pump to the adaptor flange. See **Fig. 2**. Slide the pump out of the coupling. Remove the sprocket from the shaft if necessary. Check around the adaptor flange for oil leaks. If there are leaks, remove the adaptor flange from the engine. Remove all old gasket material.

Installation

1. Using engine oil, lightly lubricate a new gasket and the pump shaft.
2. On Cummins and Caterpillar engines, install the new gasket on the pump mounting flange, then place the pump on the engine's accessory drive mounting. See **Fig. 1**. Turn the pump or shaft as needed to mesh the shaft with the shaft coupling or sleeve. Seat the pilot of the pump mounting flange in the accessory drive mounting, without applying unnecessary force. Install the lock washers and mounting bolts. Tighten the bolts 32 to 37 lbf·ft (43 to 50 N·m).

   On Detroit Diesel Series 50 and 60 engines, make sure that the clip is installed in the sprocket, and that the coupling and sprocket are installed in the engine's accessory drive. See **Fig. 2**. If the adaptor flange was removed, use engine oil to lightly lubricate a new O-ring. Install the O-ring on the flange, and install the flange on the engine. Cross tighten the six mounting bolts 22 to 25 lbf·ft (30 to 34 N·m). Install the new gasket on the pump mounting flange, then position the pump on the adaptor flange. Turn the pump or shaft as needed to mesh the shaft with the sprocket. Seat the pump mounting flange pilot in the adaptor flange without applying unnecessary force. Apply Loctite® 242, or an equivalent sealant, to the pump mounting bolts. Install the pump mounting washers and bolts. Tighten the bolts 30 to 50 lbf·ft (41 to 68 N·m).
3. Connect the hoses to the pump inlet and outlet ports.
4. Check the fluid level of the power steering reservoir and add fluid if necessary. Start the engine and let it idle for two minutes. Do not turn the steering wheel; doing so can cause air to enter the system.

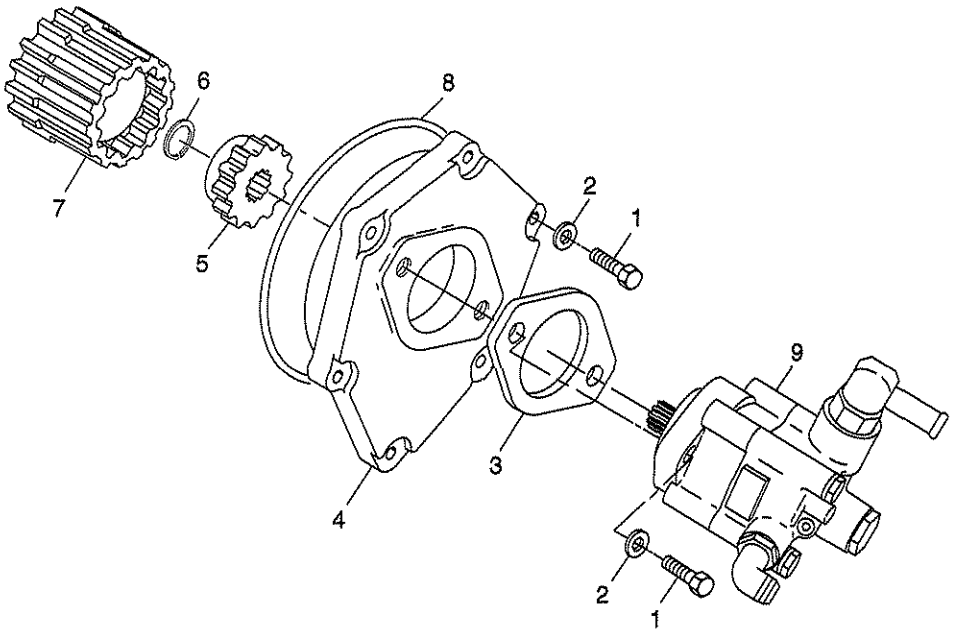


10/06/95 f461061

1. Pump
2. Gasket
3. Coupling
4. Coupling Clip
5. Lock Washer
6. Mounting Bolt

Fig. 1, Cummins and Caterpillar Pump Mounting

Steering Pump Removal and Installation



1. Mounting Bolt
2. Washer
3. Gasket
4. Adaptor Flange
5. Sprocket
6. Clip
7. Coupling
8. O-Ring
9. Pump

Fig. 2, Detroit Diesel Pump Mounting

Turn off the engine, and check the fluid level in the reservoir.

5. Start the engine again. To remove air from the system, steer the vehicle from full-left to full-right several times.

   Add fluid as necessary to the full line on the reservoir dipstick.

6. If the steering gear doesn't have a manual bleed screw, turn the steering wheel from full lock to full lock two or three times with the engine running at idle. Repeat this step, and add fluid as necessary until there are no bubbles in the reservoir.

   If the steering gear is equipped with a manual bleed screw, turn the steering wheel from full lock to full lock two or three times with the engine running at idle. Then, loosen the manual bleed screw about one turn and look for clear fluid or fluid mixed with bubbles at the threaded area of the bleed screw. Repeat this step and add fluid as necessary until only clear fluid shows. Tighten the manual bleed screw 27 to 33 lbf·in (300 to 360 N·cm). Refill the reservoir if necessary to the full line on the dipstick.

⚠ DANGER

Before lowering the cab on an Argosy vehicle, review the cab-tilting information in Section 60.15, Subject 060. Failure to read the warnings and to be aware of the dangers of tilting and returning the cab could result in serious injury or death.

7. Lower the hood or return the cab to the operating position. For cab lowering instructions, see **Section 60.15**, Subject 060.

8. Remove the chocks from the tires.

9. Test drive the vehicle and ensure that the steering pump and the steering system operate properly.

Steering Pump Shaft Seal Replacment

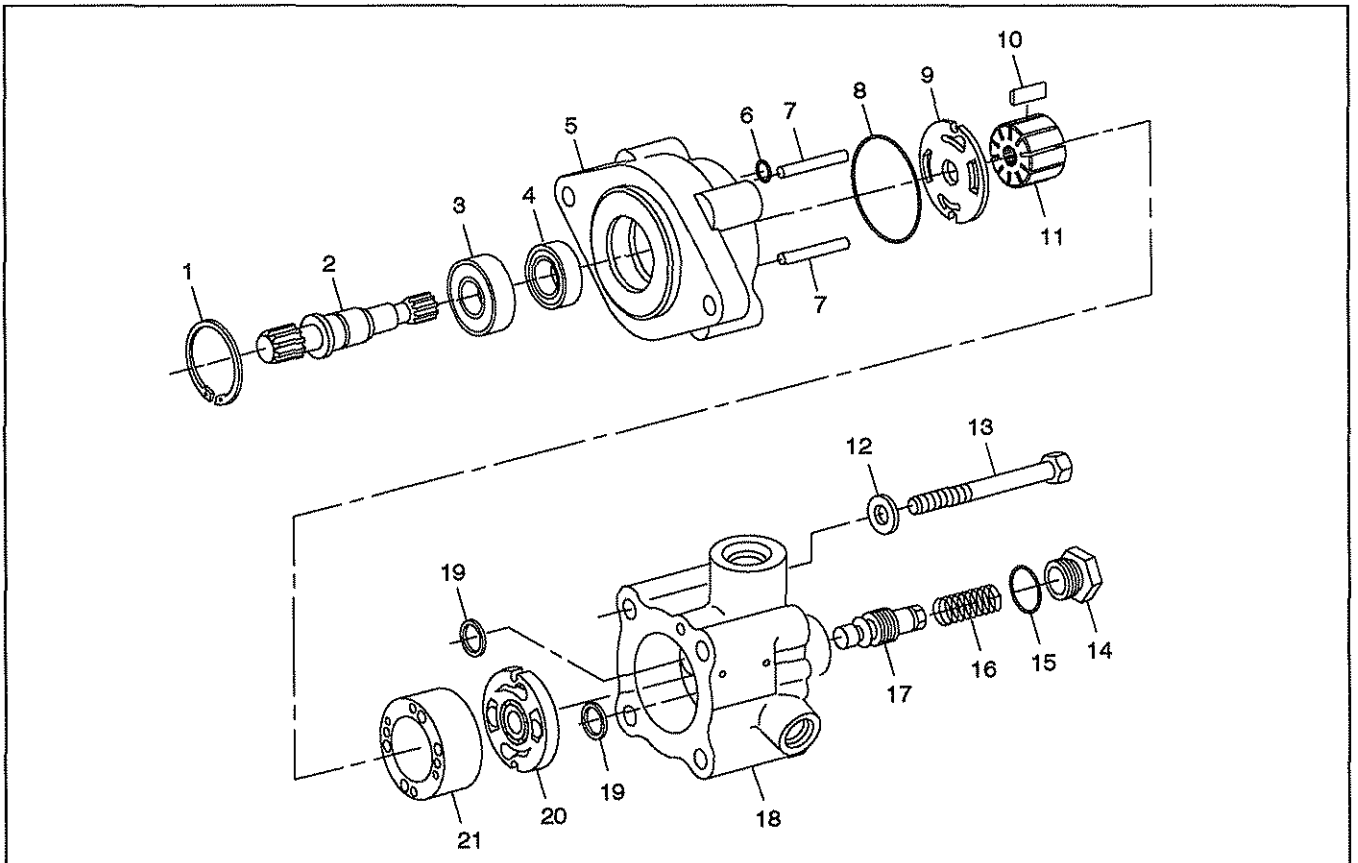
CAUTION: Be careful when working on the pump housing; it is aluminum, and can be easily damaged. When putting it in a vise, pad the vise jaws; tighten the vise just enough to hold the pump.

Replacement (See Fig. 1)

WARNING: Wear safety goggles or glasses when disassembling the power steering pump. Some of the parts are held in place by springs or snap rings, which can release with considerable force, possibly causing injury.

NOTE: The shaft seal kit contains a replacement seal for LF and VT series pumps. The seal for the LF-series pump is smaller.

1. Remove the power steering pump from the engine, following the instructions under **Subject 100.**



1. Snap Ring
2. Driveshaft
3. Driveshaft Bushing
4. Shaft Seal
5. Flange Assembly
6. Small O-Ring
7. Guide Pin
8. Large O-Ring
9. Wear Plate
10. Vane
11. Rotor
12. Washer (4 qty.)
13. Hexbolt (4 qty.)
14. End Plug
15. End Plug O-Ring
16. Spring
17. Control Valve
18. Pump Housing
19. Combination O-Ring/Back-up Ring
20. Pressure Plate
21. Cam Ring

Fig. 1, Steering Pump Assembly

Steering Pump Shaft Seal Replacment

2. Carefully remove the end plug (There is a spring underneath it) from the pump body. Remove the spring, then, slide out the control valve, as shown in **Fig. 2.** Be careful not to scratch the control valve.
3. Remove and discard the O-ring from the plug.
4. Put the pump housing in a padded vise, then remove the four screws holding the housing and the flange assembly together. **See Fig. 3.**
5. Remove and discard the combination O-rings/ back-up rings from the pump housing. **See Fig. 4.**
6. Remove the pressure plate, guide pins, cam ring, rotor, vanes, and wear plate as a unit and set aside.
7. Remove and discard the small and large O-rings from the flange assembly. **See Fig. 5.**

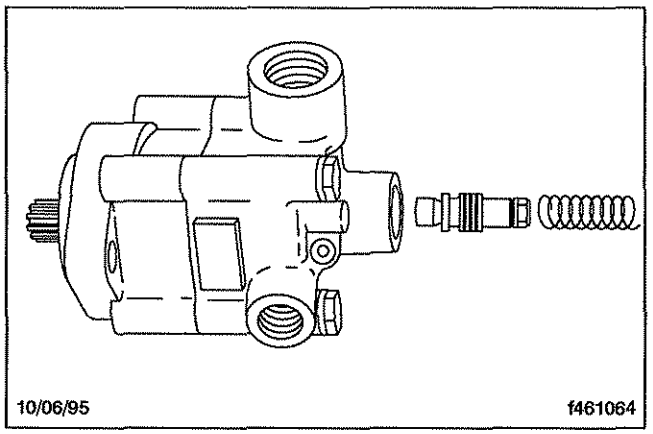


Fig. 2, Slide Out the Control Valve

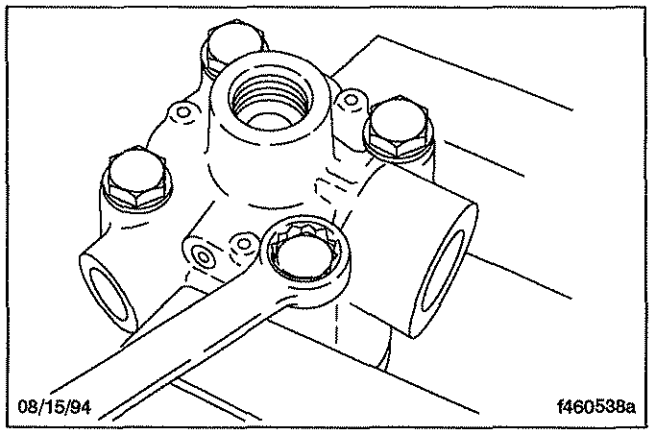


Fig. 3, Remove the Screws

8. Remove the snap ring holding the shaft seal in place. Discard the snap ring. **See Fig. 6.**
9. Put the flange assembly in a vise with the inner end of the shaft pointing up. Carefully tap out the driveshaft. **See Fig. 7.**
10. Remove and discard the shaft seal.
11. Clean all the parts, using a solvent compatible with the power steering fluid. Then, using filtered compressed air, dry all the parts.
12. Coat all the parts with clean power steering fluid. See the power steering fluid table in **Specifications, 400.**
13. Place the spacer over the outer (drive) end of the shaft with the cupped side of the spacer facing the inner end of the shaft.
14. Using power steering fluid, lubricate the new shaft seal. Carefully place the seal over the outer

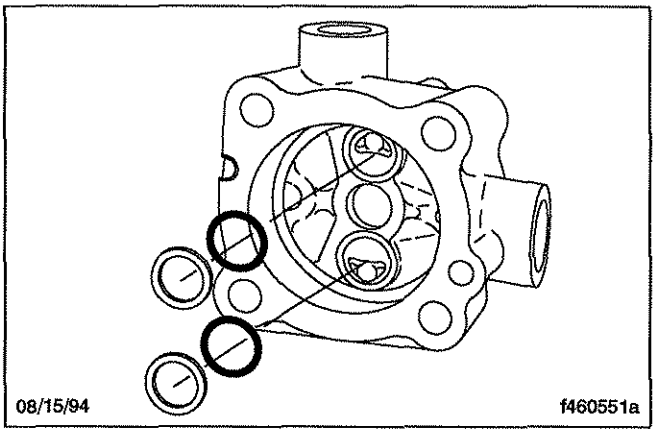


Fig. 4, Remove the Two Combination O-Ring/ Back-Up Rings

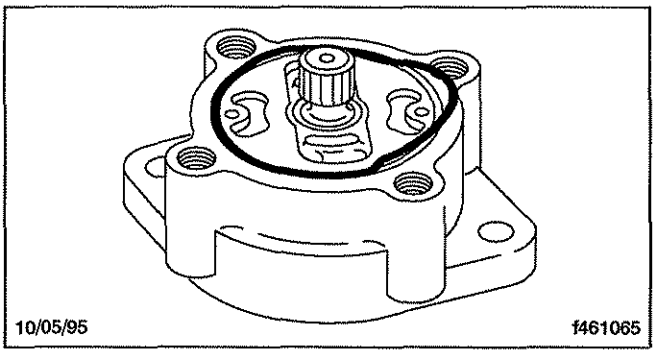


Fig. 5, Remove the Large O-Ring

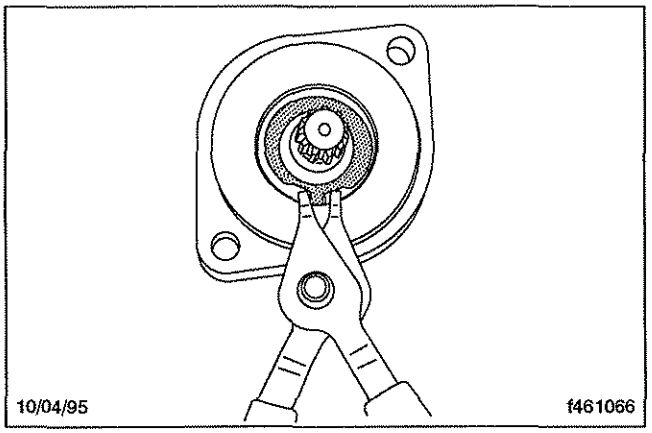


Fig. 6, Remove the Snap Ring

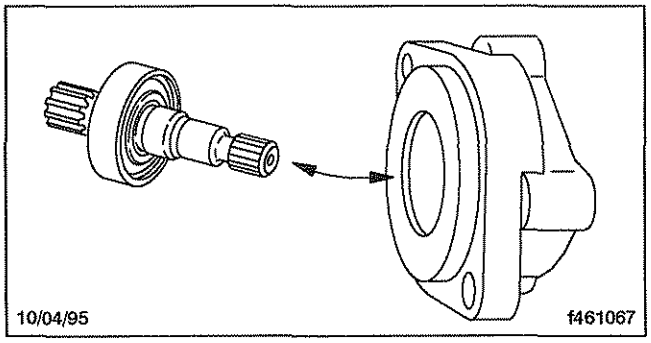
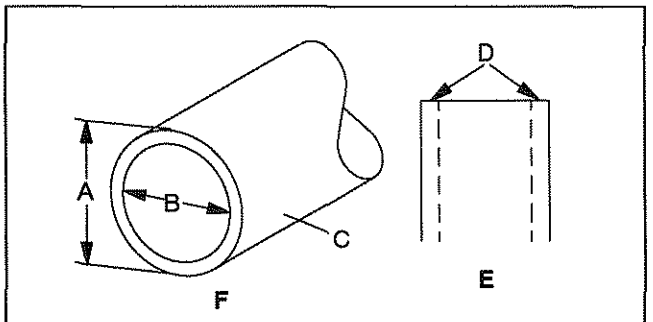


Fig. 7, Tap Out the Driveshaft

(drive) end of the shaft, up against the spacer. The lettered side of the seal should be visible.

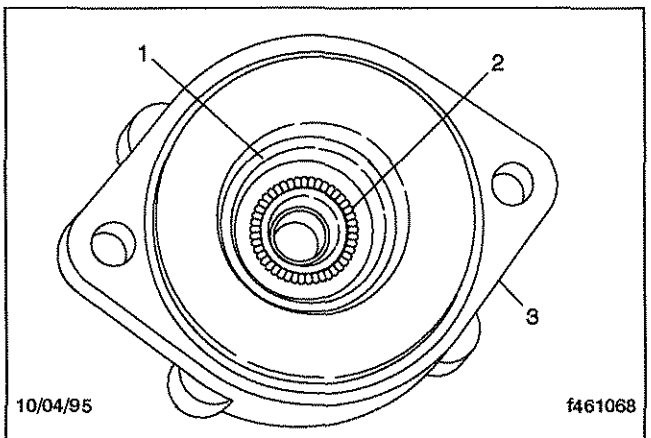
NOTE: To correctly install the driveshaft seal, it is necessary to make a suitable driver from tubular stock. **See Fig. 8** for the applicable dimensions.

15. Using a suitable driver, install the shaft seal into the bore in the flange assembly. Make sure the spring side of the seal faces the flange. **See Fig. 9.** Seat the seal firmly against the shoulder in the bore.
16. Install the small snap ring in its groove on the driveshaft, with the sharp edge facing toward the bushing.
17. Put the flange assembly in a padded vise with the drive end of the shaft pointing up. Install a new large O-ring in the flange assembly.
18. Install a new small O-ring in the flange assembly.
19. Install the pressure plate, guide pins, cam ring, rotor, vanes, and wear plate as a unit. Make sure that the two guide pins are seated in the flange assembly.
20. Using power steering fluid, lubricate the new combination O-ring/back-up rings. Install the rings in the pump housing with the black side facing the housing, and the white-plastic side exposed.
21. Install the pump housing over the flange assembly, lining up the mounting holes.



A. Slightly smaller than the o.d. of the shaft seal.
B. Slightly larger than the o.d. of the driveshaft.
C. To be made of tubular stock.
D. The ends must be square.
E. Side View
F. Front View

Fig. 8, Shaft Seal Installation Tool



1. Shaft Seal
2. Garter Spring
3. Flange

Fig. 9, Install the Shaft Seal

Steering Pump Shaft Seal Replacment

22. Install the four hexbolts and washers in the pump housing. Tighten them in a cross pattern 29 to 37 lbf·ft (40 to 50 N·m).

23. Install the control valve in the pump housing.

    CAUTION: Make sure you install the control valve correctly in its bore. If it's installed backwards, the power steering pump won't work, and will quickly overheat, which could cause severe damage to the pump.

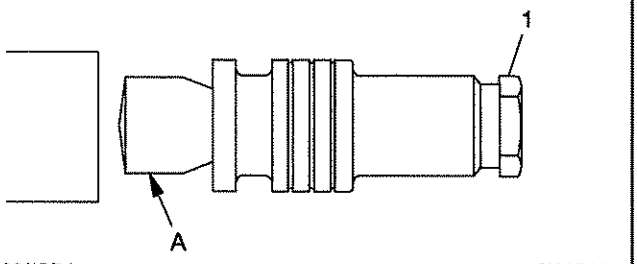
    23.1 Lubricate the control valve with power steering fluid (see the power steering fluid table in **Specifications, 400**), then install it—with the hex-plug end up—into the bore in the pump housing. **See Fig. 10.**

    23.2 Install the spring over the hex-plug end of the control valve.

    23.3 Install a new O-ring on the end plug, then install the end plug. Tighten it 33 to 40 lbf·ft (45 to 55 N·m).

24. Turn the shaft by hand; it should turn smoothly and without binding.

25. Install the power steering pump on the engine. For instructions, refer to **Subject 100.**



A. Insert this end first.

1. Hex Plug

Fig. 10, Install the Control Valve

Problem—The Power Steering Pump Doesn't Deliver Fluid

Possible Cause	Remedy
The pump driveshaft is broken, or not engaging.	Replace the pump.
The control valve is stuck open.	Remove the pump. Carefully remove the end plug. Check and see if the control valve is binding in the housing. If it is binding, remove the control valve. If the valve feels gritty, replace it. If not, clean it in a solvent. Install the control valve, then check for any binding in the bore. If the control valve continues to bind, replace it.
Incorrect power steering fluid is used.	Check for the type of fluid used. If it's incorrect, drain, flush, and fill the system with power steering fluid. See the power steering fluid table in **Specifications, 400.**
The pump intake port is blocked.	Drain and flush the system. Fill the system with clean power steering fluid. See the power steering fluid table in **Specifications 400.**
The air vent in the power steering reservoir is clogged, or the filter is dirty.	Remove the filter cap from the reservoir, then clean the air slot. Check the filter and replace it if needed.
A power steering hose is kinked or blocked.	Repair or replace the hose.

Problem—The Power Steering Pump Is Making Noise

Possible Cause	Remedy
The intake line or filter is plugged.	Drain the system. Clear the intake line if needed, then check the filter. Replace it if needed. Fill the system. See the power steering fluid table in **Specifications 400.**
There is an air leak at the pump connections, the fittings, the reservoir connections, or the shaft seal.	Check all the connections by pouring power steering fluid over them, then listen for a reduction in sound. Tighten all the connections as needed. If the problem persists, remove the pump, then disassemble it and replace the shaft seal.

Model Code Description*	
Model Code	**Description**
LF73V	Flange Type
21	Displacement (cubic cm/rev)
16	Control Flow (L/min)
163	Pressure Limit
L	Direction of Rotation
P	Inlet Port Connection
U	Pressure Port Connection
D	Pressure Port View from Cover End
02	Shaft
11	Design Number
GE11	With Gear and Locknut

* Model codes contain specifications in metric units.

Table 1, Model Code Description

Pump Specifications			
LuK Model Code	**Pump Displacement cubic inch/rev (cubic cm/rev)**	**Control Flow gpm (L/min)**	**Maximum Pressure psi (kPa)**
LF73V-21-16-163-L-P-U-D-02-11-GE11	1.28 (21)	4.2 (16)	2396 (16 520)

Table 2, Pump Specifications

Pump Port Specifications			
Code	**Size**	**Shaft Minor Diameter: inches (mm)**	**O-Ring Chamfer**
Inlet Port			
M	M26 x 1.5	0.63 (16)	—
P	1-1/16–12	0.79 (20)	SAE J514
U	1-5/16–12		
Outlet Port			
M	M16 x 1.5	0.55 (14)	—
N	M18 x 1.5		—
U	3/4–16		SAE J514

Table 3, Pump Port Specifications

Specifications

Fastener Torques	
Description	**Torque: lbf.ft (N.m)**
Pump Mounting Bolts	Cummins Engines: 32–37 (43–50)
	Caterpillar Engines: 32–37 (43–50)
	Detroit Diesel Engines: 30–50 (41–68)
Pump Housing-to-Flange Assembly Hexbolts	29–37 (40–50)
Pump End-Plug	33–40 (45–55)
Pump Inlet Connection	26 (35)
Pump Outlet Connection	22 (30)

Table 4, Fastener Torques

Approved Power Steering Fluids	
Fluid Type	**Approved Fluid**
Automatic Transmission Fluid*	Dexron® II Dexron® III
Heavy-Duty Engine Oil* IMPORTANT: Do not use heavy-duty engine oil in vehicles built from November 4, 2002.	15W–40

* Do not mix engine oil with automatic transmission fluid (ATF). Use the same lubricant for parts as is in the power steering system.

Table 5, Approved Power Steering Fluids

Pressure Settings	
Code	**Pressure in psi (kPa)**
80	1116.5–1261.5 (7700–8700)
100	1406.5–1551.5 (9700–10 700)
110	1551.5–1696.5 (10 700–11 700)
115	1624–1769 (11 200–12 200)
120	1696.5–1841.5 (11 700–12 700)
130	1841.5–1986.5 (12 700–13 700)
135	1914–2059 (13 200–14 200)
140	1986.5–2131.5 (13 700–14 700)
145	2059–2204 (14 200–15 200)
150	2131.5–2276.5 (14 700–15 700)
155	2204–2349 (15 200–16 200)

Pressure Settings	
Code	**Pressure in psi (kPa)**
163	2320–2465 (16 000–17 000)
000	—

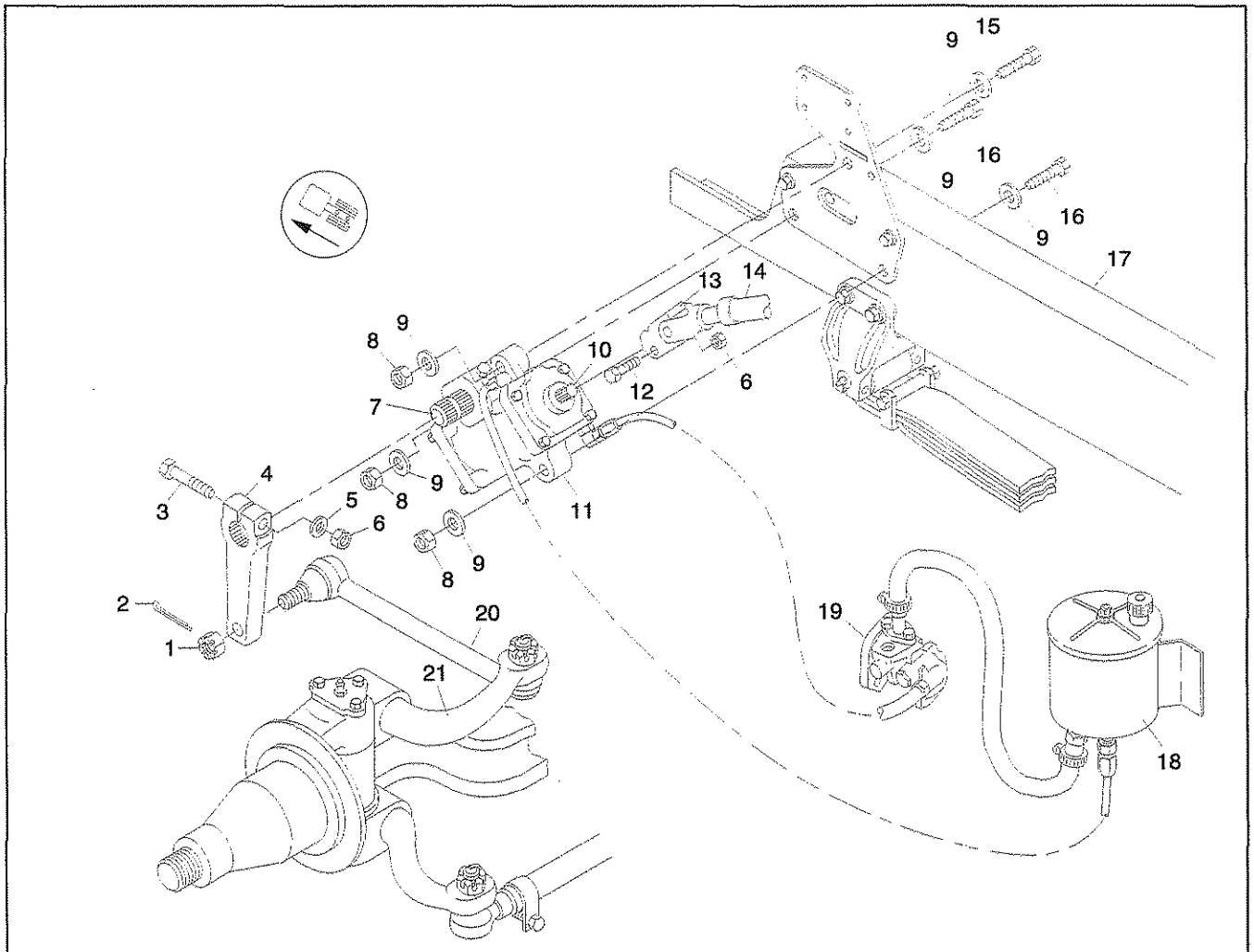
Table 6, Pressure Settings

Contents

Subject	Subject Number
General Information	050
Service Operations	
In-Vehicle Adjustments	100
Steering Gear Removal and Installation	110
Steering Gear Disassembly, Inspection, Assembly, and Final Adjustments	120
Input Shaft Seal Replacement	130
Post-Service Checks	140
Troubleshooting and Diagnostic Checks	300
System Setup for Hydraulic Checks	305
Specifications	400

General Information

The TRW TAS65 and TAS85 power steering gears use pressurized hydraulic fluid to help the driver turn the front wheels. Both models operate in the same way. On left-hand drive (LH DR) vehicles, both models mount on the left frame rail. See **Fig. 1** or **Fig. 2**. On right-hand drive (RH DR) vehicles, both models are mounted on the right frame rail. The difference between the two gears is size. The TAS65 is used for front axle capacities up to 14,000 lbs (6350 kg), and



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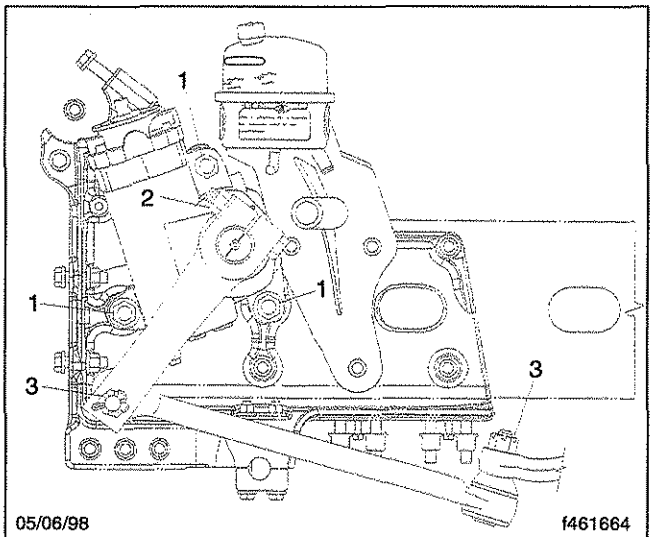
1. Castle Nut
2. Cotter Pin
3. Pitman Arm Pinch Bolt
4. Pitman Arm
5. Washer
6. Pinch Bolt Nut
7. Sector (output) Shaft
8. Mounting Hexnut
9. Hardened Washer
10. Input (worm) Shaft
11. Steering Gear
12. Lower End Yoke Pinch Bolt
13. Lower End Yoke
14. Steering Driveline
15. 7/8–9 x 4-1/4 Capscrew
16. 7/8–9 x 4-3/4 Capscrew
17. Left Frame Rail
18. Power Steering Reservoir
19. Power Steering Pump
20. Drag Link
21. Axle Steering Arm

Fig. 1, TRW TAS65 Steering Gear Installation, LH DR Century Class Conventional

General Information



1. Steering Gear Mounting Bolt
2. Pitman Arm Pinch Bolt Nut
3. Drag Link Nut

Fig. 2, Steering Gear Mounting, LH DR Argosy COE

the TAS85 is for front axle capacities up to 18,000 lbs (8200 kg).

The steering gear incorporates a manual steering mechanism, hydraulic control valve, and a hydraulic power cylinder. The control valve is a rotary design, which directs oil flow from the power steering pump to the upper or lower cylinder cavity.

⚠ CAUTION

Never steam clean or high-pressure wash the steering gear. Internal damage to gear seals and ultimately the steering gear can result.

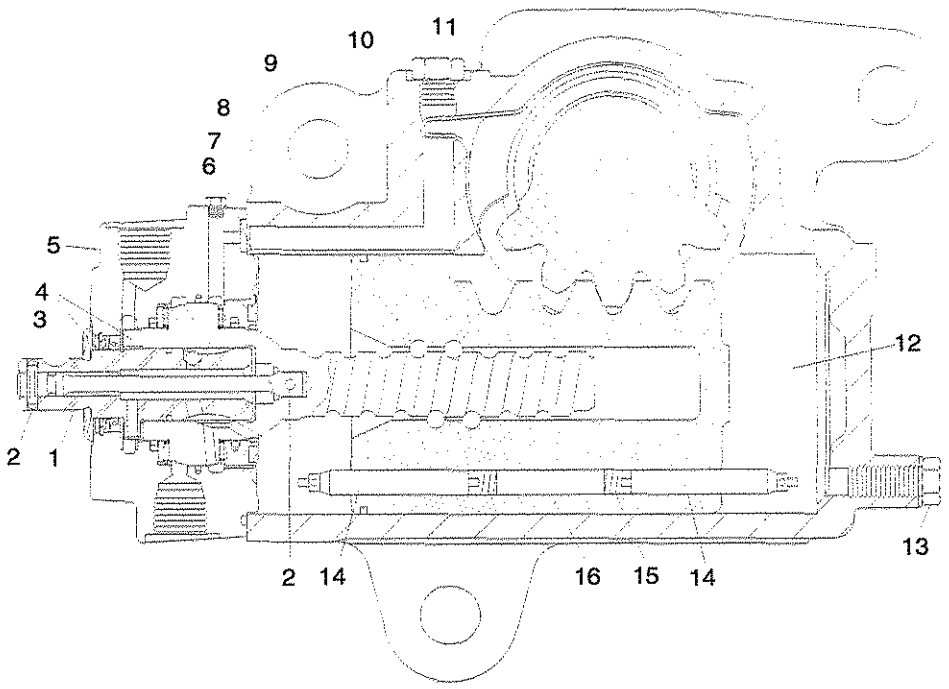
Principles of Operation (See Fig. 3)

When the steering wheel is turned, force is transmitted from the steering wheel to the steering gear input shaft. A torsion bar, pinned at one end to the input shaft, and at the other to the worm shaft, turns with the input shaft and exerts a rotational force on the worm shaft. In response, the worm shaft, acting through the recirculating ball mechanism, tries to move the rack piston up or down (as applicable) in the gear housing cylinder bore.

The rack piston's movement is resisted by its engagement to the sector shaft, which is linked to the steered wheels. Because of this resistance, the torsion bar is twisted by the input shaft, thereby actuating the control valve. Pressurized fluid, directed by the control valve to the upper or lower cylinder cavity (depending on the direction of turn), assists in moving the rack piston up or down (as applicable) in the cylinder bore. The rack piston then turns the sector shaft to steer the vehicle.

If the steered wheels receive a shock load, the shock forces are transmitted through the sector shaft to the rack piston, and on to the worm shaft. The internal construction of the steering gear causes the control valve to send high-pressure fluid to the correct cylinder cavity to resist the shock forces. By absorbing the shock forces hydraulically, the steering gear prevents kickback at the steering wheel.

On each end of the rack piston is a poppet (unloading valve). The appropriate poppet will trip as the steered wheels approach the axle stop for that direction of turn. The tripped poppet reduces pressure in the gear, heat generated by the pump, and outside forces acting on the steering linkage.



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1. Input Shaft
2. Pin
3. Torsion Bar
4. Control Valve
5. Valve Housing
6. Worm Shaft
7. Upper Cylinder Cavity
8. Ball (recirculating)
9. Rack Piston
10. Gear Housing
11. Sector Shaft
12. Lower Cylinder Cavity
13. Poppet Fixed Stopscrew
14. Poppet Assembly
15. Poppet Spring
16. Push Tube

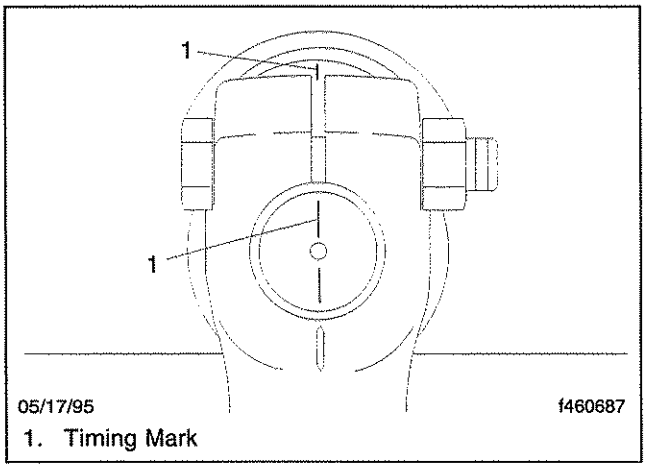
Fig. 3, Steering Gear Sectional View

Sector (Output) Shaft Adjustment

1. Position the sector shaft at its center of travel by turning the steering wheel until the alignment mark on the sector shaft is at a right angle to the input shaft centerline, and in line with the timing mark on the end of the housing trunnion. See **Fig. 1**.
2. Disconnect the drag link from the pitman arm.

   The input shaft/valve/worm assembly must not be turned more than 1-1/2 turns in either direction from its center of travel while the drag link is disconnected from the pitman arm. Turning the input shaft more than 1-1/2 turns from center will cause misadjustment of the automatic poppets. This may require the installation of a service poppet adjustment tool to manually reset the poppets.
3. With the sector shaft in the center position, grasp the pitman arm and gently try to move it back and forth. Fingertip force is adequate to detect lash (free play) of a loose sector shaft. See **Fig. 2**. There may be *no movement* of the input shaft or sector shaft. If no lash is detected, no adjustment is needed.

   If lash is detected, find the sector shaft adjusting screw, in the center of the sector shaft cover, on the inboard side of the gear housing. Loosen the adjusting screw jam nut, and move the adjusting screw clockwise until the sector shaft and rack piston are in contact. Use no more than 10 lbf·ft (14 N·m) of torque. Then, turn the adjusting screw counterclockwise one turn. At this point, there should be lash at the pitman arm.
4. To adjust, slowly turn the adjusting screw clockwise until no lash is felt at the pitman arm, then turn it clockwise an additional one-eighth turn. Hold the adjusting screw in place and tighten the jam nut 40 to 45 lbf·ft (54 to 61 N·m).
5. Check the pitman arm for lash. Turn the steering wheel one-quarter turn each side of center. No lash should be felt. If lash exists, readjust the sector shaft.
6. Connect the drag link to the pitman arm. For instructions, refer elsewhere in this group.



1. Timing Mark

Fig. 1, Position the Sector Shaft

Poppet Valves Adjustments

The TAS65 and TAS85 steering gears have automatic poppet valves that reset themselves if the axle stops are reset for increased steering travel.

However, if the axle stops are reset for *decreased* steering travel, the poppet valves must be adjusted manually, through the use of a special service poppet adjusting screw and sealing jam nut kit, unless they were reset while the steering gear was disassembled.

Use the following procedure for manually resetting the poppet valves:

1. Verify correct axle stop adjustment. For instructions, refer to **Group 33** in this manual.

   If both axle stops were set for increased travel, the steering gear poppets have reset automatically and gear adjustments are complete. No further action is required.

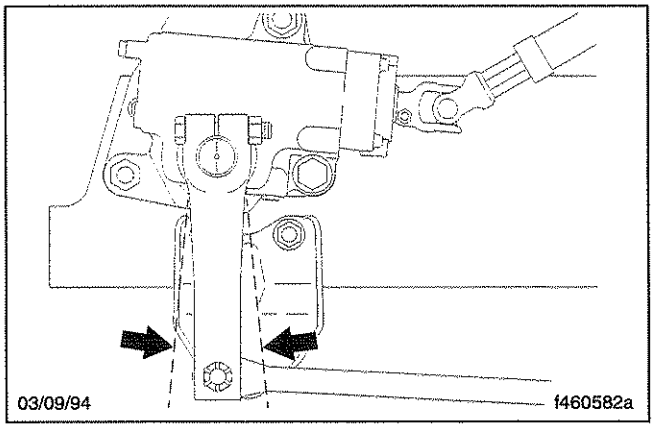


Fig. 2, Checking Sector Shaft Free Play

In-Vehicle Adjustments

If either axle stop was set for decreased travel, the steering gear poppets must be set manually. Continue to the next step.

IMPORTANT: The axle stops must be set so that there are at least 1-3/4 steering wheel turns from a straight-ahead position to both a full-left and a full-right turn; otherwise the poppet valves will not work.

2. Install the steering gear manual poppet adjusting screw.

   2.1 Screw the special poppet adjusting screw (from TRW kit number 021407-X1) into the nonsealing end of the sealing jam nut, until the drive end of the screw is flush with the nut. See **Fig. 3**.

   2.2 With the vehicle unloaded, the engine off, and the front wheels in the straight-ahead position, remove and discard the poppet fixed stopscrew and washer from the lower end of the steering gear housing. See **Fig. 4**.

   NOTE: With the wheels in the straight-ahead position, and the timing marks on the sector shaft and gear housing aligned (**Fig. 1**), the steering gear is centered.

   2.3 Using an allen wrench, turn the adjusting screw and nut without rotating the nut, into the steering gear housing until the nut is firmly against the housing (**Fig. 5**). Tighten the nut 38 to 42 lbf·ft (52 to 57 N·m).

   NOTE: It may be necessary to move the sector shaft slightly from the "straight-ahead position" to assemble the service adjusting screw as instructed and then return it to "straight ahead."

3. Adjust the poppets manually.

   3.1 Check the fluid level and fill the power steering reservoir with Dexron II type ATF if required.

   3.2 Make sure the engine is off.

   3.3 Place a jack under the center of the front axle, and raise the steer tires off the ground.

   3.4 Turn the steering wheel to the right until the axle stopscrew contacts the axle stop, or the end of the gear travel is reached.

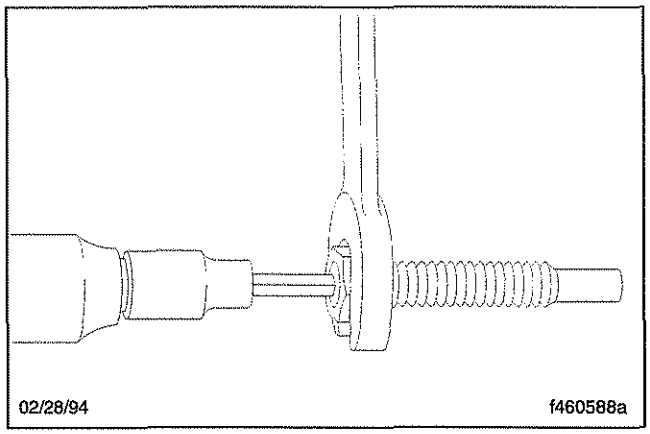


Fig. 3, Screw in the Poppet Adjusting Screw

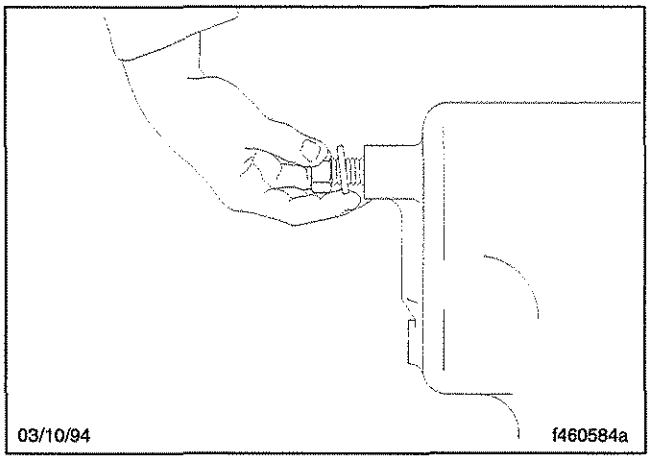


Fig. 4, Remove the Poppet Fixed Stopscrew and Washer

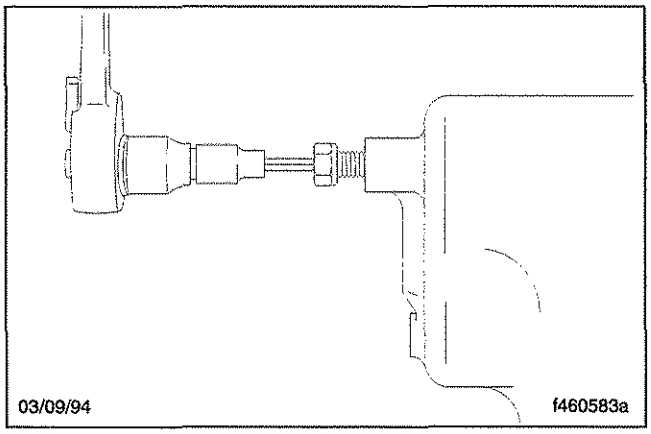


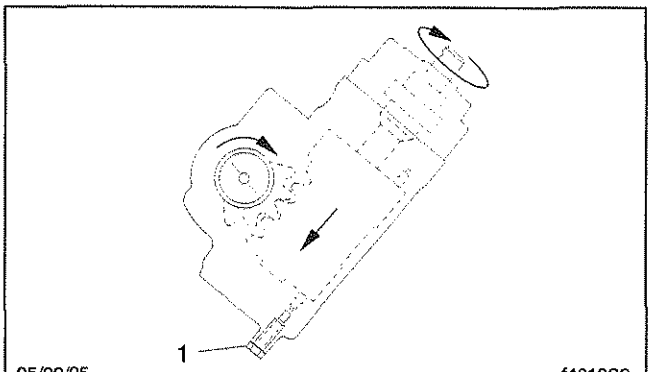
Fig. 5, Turn the Adjusting Screw

This pushes out the left-hand turn poppet to prepare it for setting. See **Fig. 6**.

3.5 Turn the steering wheel to the left until the left-hand stop makes contact. This sets the left-turn poppet. Release the steering wheel, and do not steer again until after the adjusting nut has been backed out and the sealing nut tightened.

3.6 Loosen the sealing nut on the gear housing, and back out the adjusting screw until it is 1 to 1-1/16 inches (25 to 27 mm) beyond the sealing nut. See **Fig. 7**. Tighten the sealing nut 38 to 42 lbf·ft (52 to 57 N·m).

Make sure the adjusting screw does not protrude more than 1-1/16 inches (27 mm) beyond the sealing nut.



1. Adjustable Poppet Screw

Fig. 6, Preparing the Poppet for Setting

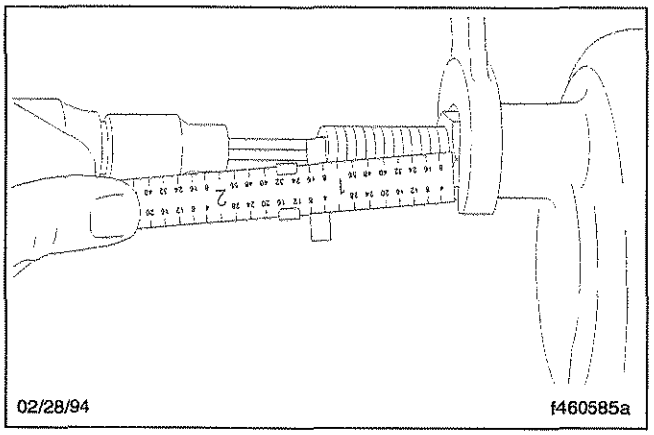


Fig. 7, Back Out the Adjusting Screw and Measure

3.7 Have someone turn the steering wheel all the way to the right, and hold it in place when the axle stops are contacted.

3.8 With the steering wheel held in place, loosen the sealing nut one turn, and while holding the sealing nut, turn the adjusting screw using an allen wrench. Don't force the screw. Use one or two fingers and turn the allen wrench until it comes to a stop. When this happens contact has been made with the poppet seat; *don't turn it any further.* Back out the screw four complete turns. Have the steering wheel released at this time.

3.9 While holding the adjusting screw in place, tighten the sealing nut firmly against the gear housing. See **Fig. 8**. Tighten it 38 to 42 lbf·ft (52 to 57 N·m).

Check the adjusting screw. If it extends more than 1-1/16 inches (27 mm) from the sealing nut, loosen the sealing nut, and turn the adjusting screw in as needed. Tighten the sealing nut 38 to 42 lbf·ft (52 to 57 N·m). See **Fig. 7** and **Fig. 8**.

⚠ WARNING

If the adjusting screw protrudes more than 1-1/16 inches (27 mm) from the sealing nut, the screw could fall out of the steering gear, resulting in loss of power steering. This could cause an accident resulting in serious personal injury or property damage.

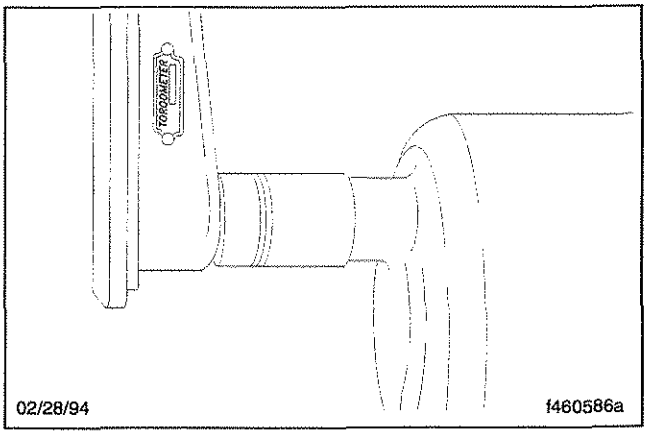


Fig. 8, Tightening the Sealing Nut

In-Vehicle Adjustments

IMPORTANT: Once the poppet adjusting screw and sealing nut are in place and the poppet valves have been manually adjusted, the adjustment procedure must be repeated if steering travel is either increased or decreased in the future.

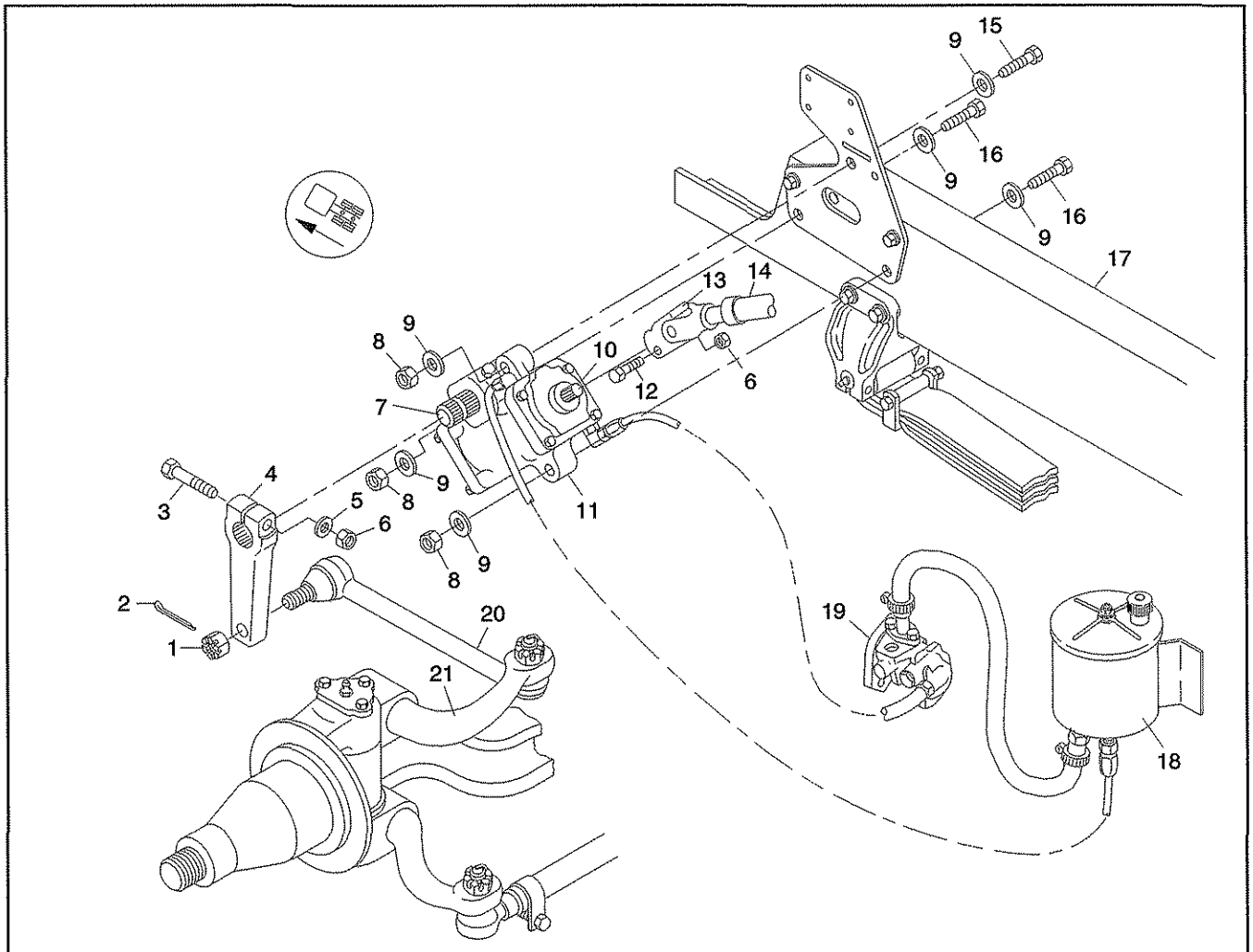
Steering Gear Removal and Installation

NOTE: This subject covers both the Century Class Conventional and the Argosy COE vehicles. Go to the heading that applies to your vehicle.

Century Class Conventional

Removal

See **Fig. 1** for an illustration of the steering gear installation.



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1. Castle Nut
2. Cotter Pin
3. Pitman Arm Pinch Bolt
4. Pitman Arm
5. Washer
6. Pinch Bolt Nut
7. Sector (output) Shaft
8. Mounting Hexnut
9. Hardened Washer
10. Input (worm) Shaft
11. Steering Gear
12. Lower End Yoke Pinch Bolt
13. Lower End Yoke
14. Steering Driveline
15. 7/8–9 x 4-1/4 Capscrew
16. 7/8–9 x 4-3/4 Capscrew
17. Left Frame Rail
18. Power Steering Reservoir
19. Power Steering Pump
20. Drag Link
21. Axle Steering Arm

Fig. 1, TRW TAS65 Steering Gear Installation, Century Class Conventional (left-hand drive)

Steering Gear Removal and Installation

1. Verify correct axle stop adjustment. For instructions, refer to **Group 33** in this manual. Ensuring correct axle stop adjustment now will eliminate the possibility of resetting steering gear poppet valves after the gear is reinstalled.
2. Place the front tires in the straight-ahead position. If possible, drive the vehicle in a straight line for a short distance, stopping at the spot where the work is to be done. Apply the parking brakes and chock the tires.

⚠ CAUTION

Do not turn the steering wheel or the steering shaft more than a half turn (except for alignment purposes) during the removal and installation procedures. Doing so may damage the clockspring in a vehicle equipped with an air bag.

3. Clean all outside dirt from around the fittings and hose connections.
4. Drain the power steering system. Disconnect all hydraulic lines from the gear, marking the lines for later assembly reference. Seal the lines and the fittings to keep out dirt.
5. Remove the drag link.
6. Disconnect the steering driveline from the steering gear input shaft as follows.

   6.1 Remove the pinch bolt from the steering driveline lower end yoke.

⚠ CAUTION

Do not pound the U-joint or lower end yoke on or off the input shaft. Internal damage to the steering gear can result.

   6.2 Remove the end yoke from the input shaft.

7. Clean the entire assembly before removing the gear.

⚠ WARNING

The TAS65 steering gear weighs 80 pounds (36 kg) dry, and the TAS85 gear weighs 110 pounds (50 kg) dry. Use caution when removing, lifting, and carrying the steering gear to avoid injury.

8. Remove the fasteners that attach the steering gear to the frame rail and frame rail extension. Remove the spacers and the steering gear.

Installation

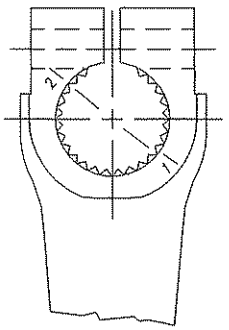
⚠ WARNING

The TAS65 steering gear weighs 80 pounds (36 kg) dry, and the TAS85 gear weighs 110 pounds (50 kg) dry. Use caution when removing, lifting, and carrying the steering gear to avoid injury.

1. Install the steering gear and fasteners.

   Tighten the fasteners to the torque values in the steering gear torque table in **Specifications 400**.
2. If not previously done, center the steering gear. The sector (output) shaft alignment mark must be at a right angle to the steering gear input shaft center line. Make sure the steering gear remains centralized as the service work continues.
3. If the pitman arm was removed, install the pitman arm on the steering gear, aligning the timing marks as shown in **Fig. 2**.

NOTE: The pitman arm may not fit over the splines on the sector shaft without spreading the slot in the arm. To wedge the slot open, clamp the pitman arm in a vise with the slot at the top. Use a ball peen hammer to drive a chisel into the slot. Hold the chisel in place, remove the pitman arm from the vise, and install the pitman arm on the sector shaft. Remove the chisel from the slot.



A. Timing Mark No. 2 Aligned

Fig. 2, Typical Pitman Arm and Timing

⚠ WARNING

Never leave a chisel wedged in the pitman arm slot. When using a chisel to spread the slot in the pitman arm, maintain a firm grip on the chisel at all times. Otherwise the chisel may fly loose, which could cause an injury.

4. Install a new pitman arm pinch bolt, washer (if applicable), and a new nut. Tighten the nut 230 lbf·ft (312 N·m).
5. Connect the steering driveline to the steering gear input shaft.
   - 5.1 Clean the input shaft and the inside of the driveline yoke.
   - 5.2 Position the steering wheel so that it is within ±10 degrees of center as shown in **Fig. 3.**
   - 5.3 Slide the yoke onto the input shaft, and install the yoke pinch bolt and a new pinch bolt locknut. Tighten the pinch bolt nut 45 to 55 lbf·ft (60 to 75 N·m).
6. Connect the drag link to the pitman arm.
   - 6.1 Connect the pitman arm end of the drag link to the pitman arm, and install the castle nut.
   - 6.2 Tighten the castle nut 160 to 300 lbf·ft (220 to 400 N·m). If necessary, continue tightening the castle nut until a slot on the nut aligns with a hole in the ball stud; *do not back off the nut.*
   - 6.3 Install a new cotter pin through the ball stud and the castle nut, then lock the cotter pin in place.
   - 6.4 Wipe the grease fittings clean at both ball stud sockets, then fill the sockets with chassis grease using a pressure gun.
7. If they were removed, attach the hydraulic line elbow fittings to the steering gear. Tighten the fittings 37 lbf·ft (51 N·m). Tighten the pressure-line fitting jam nut 41 lbf·ft (56 N·m) maximum.
8. Remove the plugs from the hydraulic lines. Connect the hydraulic lines to the steering gear as previously marked. Tighten the nut on each fitting finger-tight. Then use a wrench to tighten the nut until there is firm resistance. Tighten one-sixth turn more.
9. Fill and bleed the steering system.

   IMPORTANT: For the next two substeps, do not turn the steering wheel. Doing so can cause air to enter the system, which can make it more difficult and time-consuming to bleed air from the system.
   - 9.1 Fill the power steering reservoir nearly full. Refer to the approved hydraulic fluids table in **Specifications 400.**

     Crank the engine for 10 seconds without allowing it to start. If the engine does start, shut it down immediately. Check and fill the reservoir as needed.

     Repeat this procedure three times, each time checking and filling the reservoir.
   - 9.2 Start the engine and let it idle for two minutes. Shut down the engine and check the fluid level in the reservoir.
   - 9.3 Start the engine again. Steer the vehicle from full-left to full-right several times. As necessary, add fluid to the full line on the reservoir dipstick.

IMPORTANT: If the poppet adjuster seat and sleeve assemblies were not set for automatic adjustment during the assembly of the steering gear, *and* if the axle stops have been adjusted for *decreased* steering travel or the steering gear is installed on a different

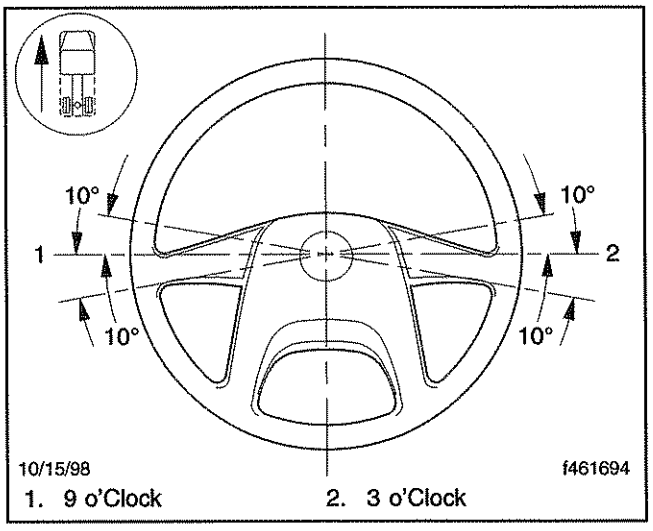


Fig. 3, Steering Wheel Centered

Steering Gear Removal and Installation

vehicle, the poppets must be set manually following the procedure under **Subject 100.**

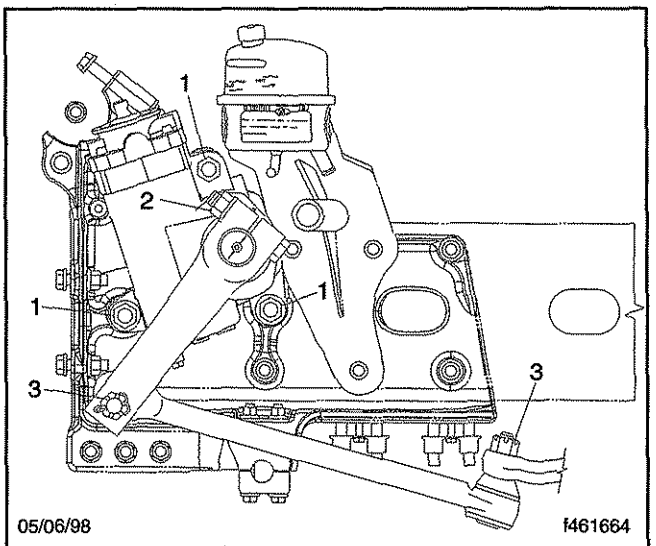
10. Go to **Subject 140** and do the checks as instructed.
11. Test drive the vehicle or take a ride with the driver. Check the steering wheel spoke position. If during straight-ahead driving on a level road, the steering wheel spokes aren't within ±10 degrees of the 9 o'clock and 3 o'clock positions, remove the steering wheel and reposition it.

Argosy COE

See **Fig. 4** for an illustration of the steering gear installation.

Removal

1. Place the front tires in the straight-ahead position. If possible, drive the vehicle in a straight line for a short distance, stopping at the spot where the work is to be done. Apply the parking brakes and chock the tires.



1. Steering Gear Mounting Bolt
2. Pitman Arm Pinch Bolt Nut
3. Drag Link Nut

Fig. 4, Steering Gear Mounting, Argosy COE (left-hand drive)

⚠ CAUTION

Do not turn the steering wheel or the steering shaft more than a half turn (except for alignment purposes) during the removal and installation procedures. Doing so may damage the clockspring in a vehicle equipped with an air bag.

2. Clean all outside dirt from around the fittings and hose connections.
3. Drain the power steering system. Disconnect all hydraulic lines from the gear, marking the lines for later assembly reference. Seal the lines and the fittings to keep out dirt.
4. Remove the drag link.
5. Disconnect the steering driveline from the steering gear input shaft.
   - 5.1 Disconnect the driveline boot from the steering gear and push it up out of the way.
   - 5.2 Remove the pinch bolt from the input shaft end yoke.

⚠ CAUTION

Do not pound the end yoke on or off. Damage to the steering linkage can result.

   - 5.3 Remove the yoke from the input shaft.
6. Clean the entire assembly before removing the gear.

⚠ WARNING

The TAS65 steering gear weighs 80 pounds (36 kg) dry, and the TAS85 gear weighs 110 pounds (50 kg) dry. Use caution when removing, lifting, and carrying the steering gear to avoid injury.

7. Remove the fasteners that attach the steering gear to the frame rail and frame rail extension. Remove the spacers and the steering gear.

Note: On the TAS85 steering gear, 1/4-inch spacers are used between the frame rail casting and the steering gear. These spacers are not used on the TAS65. See **Fig. 5.**

Installation

⚠ WARNING

The TAS65 steering gear weighs 80 pounds (36 kg) dry, and the TAS85 gear weighs 110 pounds (50 kg) dry. Use caution when removing, lifting, and carrying the steering gear to avoid injury.

1. Install the steering gear, and fasteners, and connect the steering fluid lines.

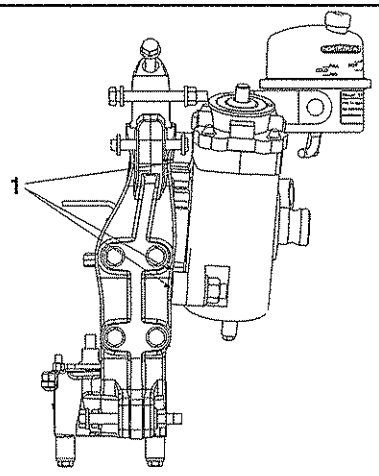
   Tighten the fasteners 388 lbf·ft (526 N·m).

2. If the pitman arm was removed, install the pitman arm on the steering gear aligning the timing marks as shown in **Fig. 2**.

NOTE: The pitman arm may not fit over the splines on the sector shaft without spreading the slot in the arm. To wedge the slot open, clamp the pitman arm in a vise with the slot at the top. Use a ball peen hammer to drive a chisel into the slot. Hold the chisel in place, remove the pitman arm from the vise, and install the pitman arm on the sector shaft. Remove the chisel from the slot.

⚠ WARNING

Never leave a chisel wedged in the pitman arm slot. When using a chisel to spread the slot in the pitman arm, maintain a firm grip on the chisel at all times. Otherwise the chisel may fly loose, which could cause an injury.



1. 1/4-Inch Spacers

Fig. 5, TAS85 Installation With Spacers

3. Install a new pitman arm pinch bolt, washer (if applicable), and a new nut. Tighten the nut 230 lbf·ft (312 N·m).
4. Connect the drag link to the pitman arm.
   - 4.1 Connect the pitman arm end of the drag link to the pitman arm and install the castle nut.
   - 4.2 Tighten the castle nut 160 to 300 lbf·ft (220 to 400 N·m). If necessary, continue tightening the castle nut until a slot on the nut aligns with a hole in the ball stud; *do not back off the nut.*
   - 4.3 Install a new cotter pin through the ball stud and the castle nut, then lock the cotter pin in place.
   - 4.4 Wipe the grease fittings clean at both ball stud sockets, then fill the sockets with chassis grease using a pressure gun.
5. Connect the steering driveline to the steering gear.
   - 5.1 Clean the gear input shaft splines and the inside of the driveline yoke.
   - 5.2 Slide the yoke onto the input shaft and install the yoke pinch bolt and a new pinch bolt locknut. Tighten the pinch bolt nut 45 to 55 lbf·ft (60 to 75 N·m).
6. Install the driveline boot on the top of the steering gear.
7. Remove the plugs from the hydraulic lines. Connect the hydraulic lines to the steering gear as previously marked. Tighten the nut on each fitting finger-tight. Then use a wrench to tighten the nut until there is firm resistance. Tighten one-sixth turn more.
8. Fill and bleed the steering system.

   IMPORTANT: For the next two substeps, do not turn the steering wheel. Doing so can cause air to enter the system, which can make it more difficult and time-consuming to bleed air from the system.
   - 8.1 Fill the power steering reservoir nearly full. Refer to the approved hydraulic fluids table in **Specifications 400**.

Steering Gear Removal and Installation

Crank the engine for 10 seconds without allowing it to start. If the engine does start, shut it down immediately. Check and fill the reservoir as needed.

Repeat this procedure three times, each time checking and filling the reservoir.

8.2 Start the engine and let it idle for two minutes. Shut down the engine and check the fluid level in the reservoir.

8.3 Start the engine again. Steer the vehicle from full-left to full-right several times. As necessary, add fluid to the full line on the reservoir dipstick.

IMPORTANT: If the poppet adjuster seat and sleeve assemblies were not set for automatic adjustment during the assembly of the steering gear, *and* if the axle stops have been adjusted for *decreased* steering travel or the steering gear is installed on a different vehicle, the poppets must be set manually, following the procedure under **Subject 100**.

9. Go to **Subject 140** and do the checks as instructed.

10. Test drive the vehicle or take a ride with the driver. Check the steering wheel spoke position. If during straight-ahead driving on a level road, the steering wheel spokes aren't within ±10 degrees of the 9 o'clock and 3 o'clock positions, remove the steering wheel and reposition it.

Steering Gear Disassembly, Inspection, Assembly, and Final Adjustments

Disassembly (See Fig. 1)

⚠ WARNING

All steering mechanisms are safety items. Because of this, follow the instructions in this subject exactly. Failure to do so may result in loss of steering, which could cause an accident resulting in personal injury or property damage.

Be sure that required tools are available before beginning the service procedures described here. See the special tools table in **Specifications, 400**. The special tools required for disassembly and assembly of the steering gear components are available from the Kent-Moore Tool Division, or an affiliated dealer.

IMPORTANT: When the sector shaft is disconnected from the vehicle steering linkage, don't allow the input shaft to move more than 1-1/2 turns from the straight-ahead position. If the input shaft moves more than 1-1/2 turns, the initial setting of the poppet valves will be changed.

Make sure that the steering gear is placed on a clean surface. Clean and dry the gear before disassembly. As the gear is disassembled, clean all parts in a clean, petroleum-based solvent, and blow them dry only.

Never steam clean or high-pressure wash the hydraulic steering components. Do not force or abuse closely fitted parts. Doing so could cause damage to steering system parts.

Keep each part separate to avoid nicks and burrs. Discard all seals, O-rings, and gaskets, and replace them with new parts.

1. Place the steering gear in a vise so that the output shaft is horizontal. Clamp the gear at the mounting flange.
2. Put a basin under the hydraulic ports, and remove both hydraulic port plugs from the gear.
3. Using a 3/4-inch or 11/16-inch socket wrench, turn the input shaft so that the timing mark on the end of the sector shaft is lined up with the timing mark on the end of the housing trunnion. See **Fig. 2**.
4. Using a small screwdriver, remove and discard the water seal from the housing trunnion. See **Fig. 3**. Remove any dirt, paint, or corrosion from the sector shaft with a piece of fine emery cloth. See **Fig. 4**.
5. Tape the splines and the bolt groove of the sector shaft, using one layer of masking tape. See **Fig. 5**.
6. Using a 3/4-inch socket, remove the jam nut from the sector shaft adjusting screw. See **Fig. 6**.
7. Put a container under the side cover to catch any drainage, then remove the six special bolts from the side cover. See **Fig. 7**.

IMPORTANT: These special bolts are equipped with either an integral ring or washer on the underside of the head. See **Fig. 8**. If replacing one or more bolts, use bolts of the *same special type and length as those that were removed.* Do not use a substitute. Don't mix different types of bolts.

8. Remove the side cover and the sector shaft assembly, as a unit, from the steering gear housing. See **Fig. 9**. If necessary, start the removal by tapping the end of the sector shaft with a rubber or wooden mallet.

   Remove and discard the side cover gasket.
9. Using a screwdriver, screw the sector shaft adjusting screw into the side cover. See **Fig. 10**.
10. Remove the sector shaft from the side cover.
11. Remove the side-cover seal:

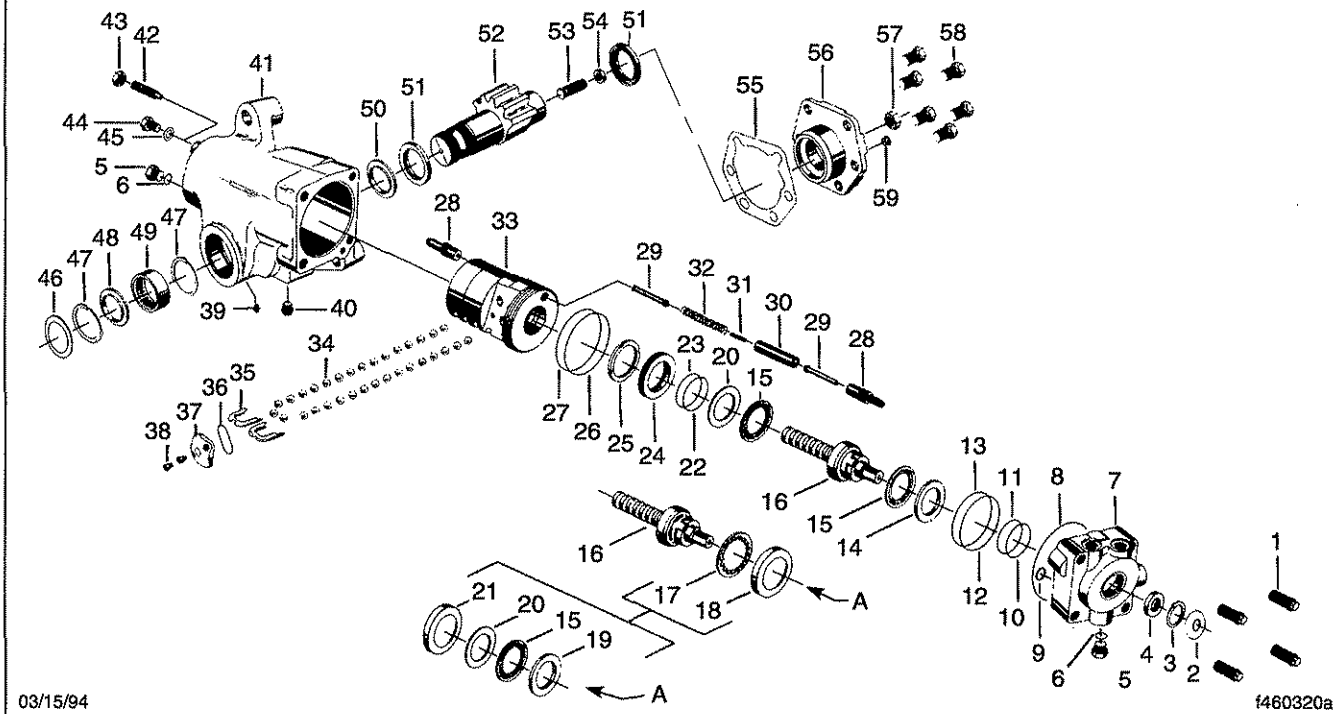
    IMPORTANT: Be careful when you are removing the side-cover seal, or you may damage the side-cover bore, the *"DU"* bushing (on a TAS65 gear), or the bearing (on a TAS85 gear).

    11.1 Screw a 1/2–20 x 3 bolt into the hole in the side cover where the sector shaft adjusting screw was.

    Make sure the bolt is in far enough so that it will support a rolling head (ladyfoot) type pry bar. See **Fig. 11**.

    11.2 With the pry bar supported by the bolt end, pry up the side-cover seal, and remove it. Discard the side-cover seal, and remove the 3-inch bolt from the side cover.
12. Remove and discard the vent plug from the side cover.
13. Put the sector shaft in a padded vise, and using a chisel, unstake the adjusting-screw retainer. See

Steering Gear Disassembly, Inspection, Assembly, and Final Adjustments



NOTE: The side cover for TAS65 steering gears contains a bushing. The side cover for a TAS85 gear contains a bearing and is secured with eight special bolts.

A. Alternate Construction

1. Bolts, Valve Housing (4 qty.)
2. Dirt and Water Seal
3. Retaining Ring
4. Seal
5. Auxiliary Port Plug (2 qty.)
6. O-Ring, Auxiliary Port Plug (2 qty.)
7. Valve Housing and Ball Plug Assembly
8. Seal Ring, Large
9. Seal Ring, Small
10. O-Ring
11. Seal Ring
12. O-Ring, Valve Housing
13. Seal Ring
14. Thrustwasher, Thick
15. Roller Thrust Bearing (1 or 2 qty.)
16. Input Shaft/Valve/Worm Assembly
17. Ball Bearing Assembly (valve/worm)
18. Ball Bearing Race
19. Thrustwasher, Thick
20. Thrustwasher, Thin
21. Spacer Sleeve
22. Seal Ring
23. O-Ring
24. Bearing Adjuster
25. Adjuster Locknut
26. Seal Ring, Rack Piston
27. O-Ring (backup)
28. Poppet Adjuster Seat and Sleeve Assembly (2 qty.)
29. Poppet (2 qty.)
30. Push Tube
31. Spacer Rod
32. Poppet Spring
33. Rack Piston
34. Steel Ball (32 or 34 qty.)
35. Ball Return Guide Halves (2 qty.)
36. Seal, Ball Return Guide Cap
37. Ball Return Guide Cap
38. Torx® Screws (2 qty.)
39. Grease Fitting
40. Plug, Auto-Bleed
41. Gear Housing
42. Service Poppet Adjusting Screw
43. Service Sealing Jam Nut
44. Fixed Stopscrew, Poppet
45. Washer, Stopscrew
46. Dirt and Water Seal (trunnion)
47. Retaining Ring (2 qty.)
48. Dirt Seal
49. Roller Bearing
50. Washer (spacer)
51. Seal, Output (2 qty.)
52. Sector Shaft
53. Adjusting Screw, Shaft
54. Retainer, Adjusting Screw
55. Gasket, Side Cover
56. Side Cover and Bushing/Bearing Assembly
57. Jam Nut
58. Special Bolts, Side Cover (6 or 8 qty.)
59. Vent Plug, Side Cover

Fig. 1, Steering Gear Components

Steering Gear Disassembly, Inspection, Assembly, and Final Adjustments

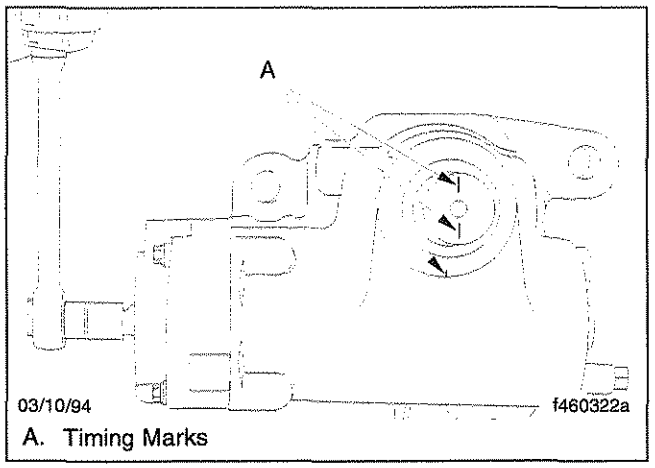


Fig. 2, Line Up the Timing Marks

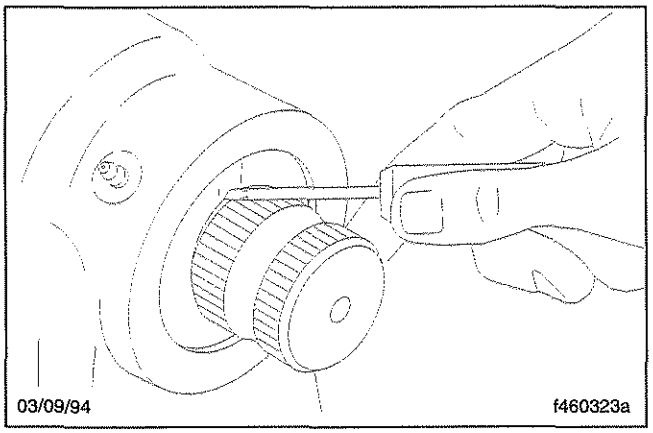


Fig. 3, Remove the Water Seal

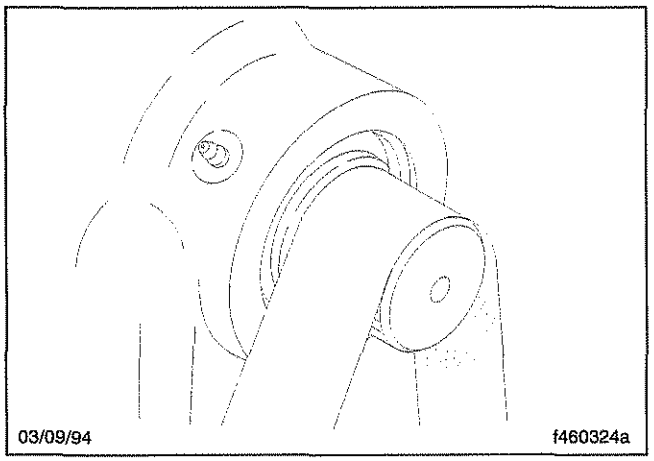


Fig. 4, Remove Dirt, Paint, or Corrosion

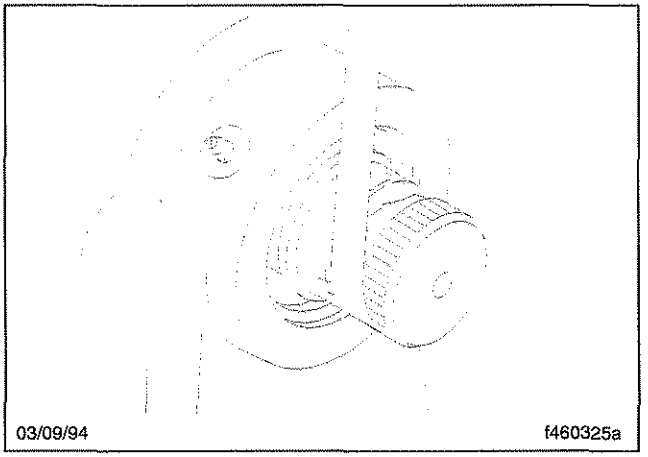


Fig. 5, Tape the Splines

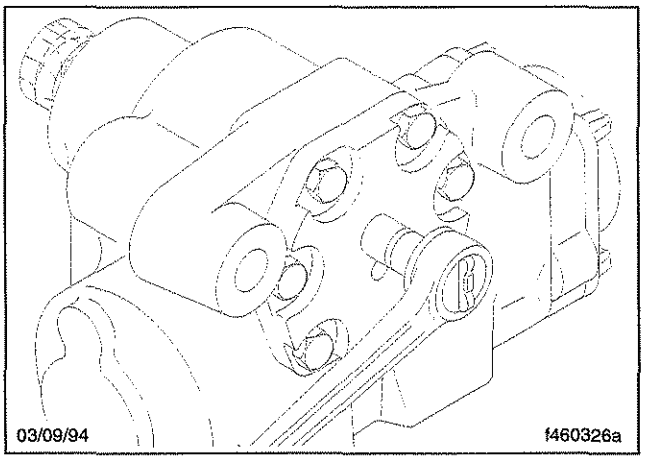


Fig. 6, Remove the Jam Nut

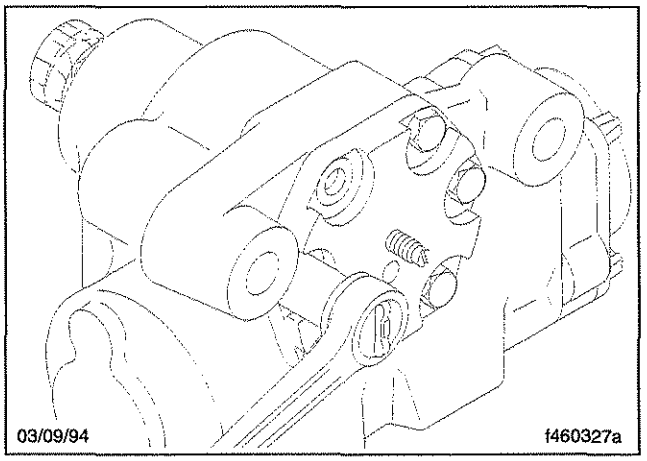


Fig. 7, Remove the Special Bolts

Steering Gear Disassembly, Inspection, Assembly, and Final Adjustments

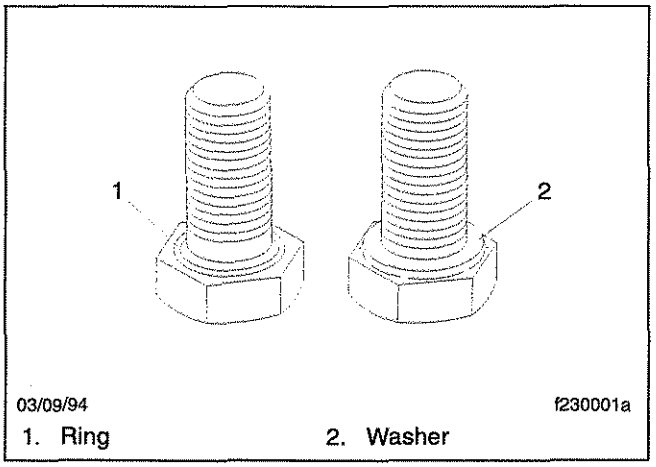


Fig. 8, Integral Ring and Washer

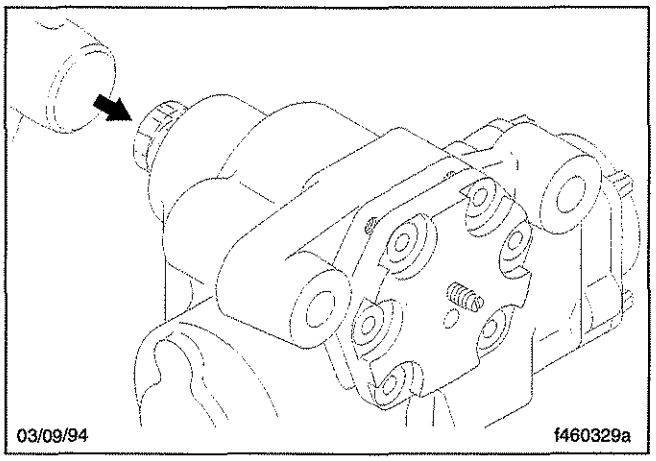


Fig. 9, Remove the Side Cover and Sector Shaft

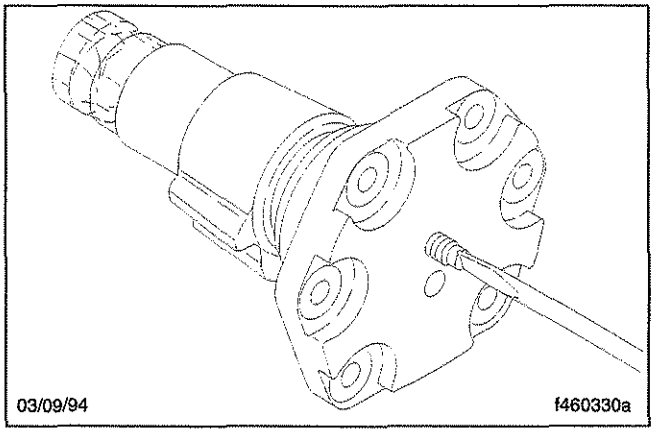


Fig. 10, Screw the Sector Shaft Adjusting Screw into the Side Cover

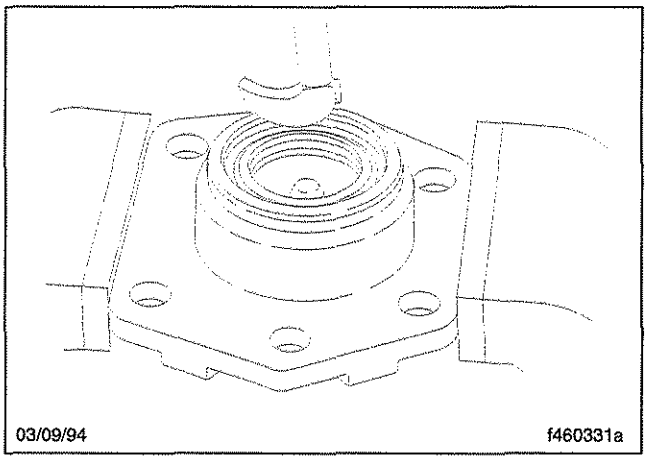


Fig. 11, Check the Bolt for Support

Fig. 12. Unscrew the retainer, remove it from the sector shaft, then remove the adjusting screw. Discard the retainer.

14. Remove and discard the dirt and water seal from the input shaft. Clean the exposed part of the input shaft, using a fine grade emery cloth. See **Fig. 13**.

15. Using an E-16 Torx® socket wrench, remove the four valve housing bolts. See **Fig. 14**.

16. Remove the valve housing from the main gear housing, together with the worm shaft and rack piston assembly. See **Fig. 15**. Set the assembly on a clean bench.

NOTE: It may be easier to remove the rack piston from the gear housing if the Teflon® ring on the rack piston is cut first. See **Fig. 16**.

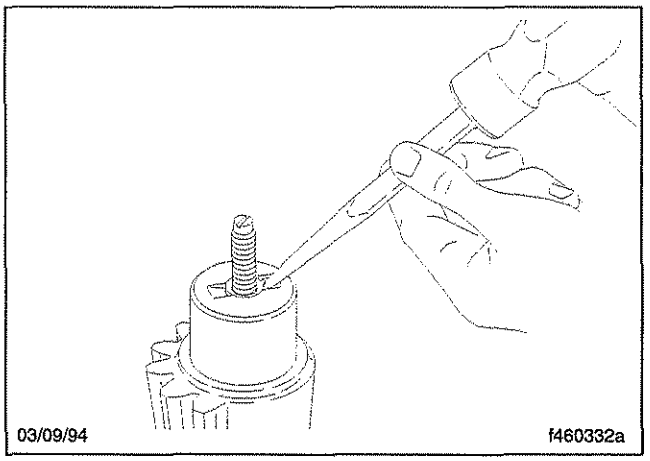


Fig. 12, Unstake the Adjusting-Screw Retainer

Steering Gear Disassembly, Inspection, Assembly, and Final Adjustments

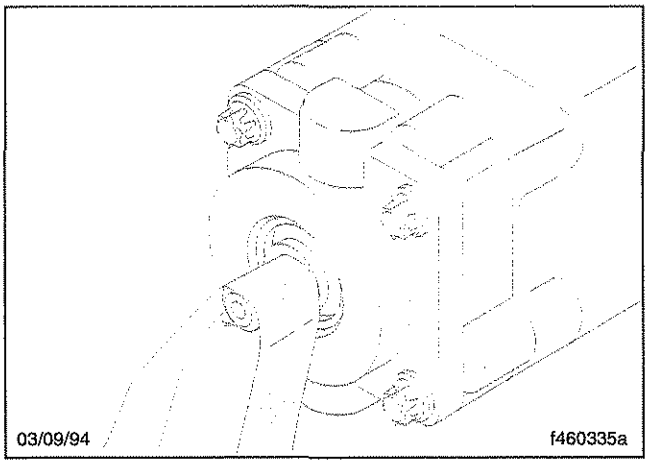


Fig. 13, Remove the Dirt and Water Seal

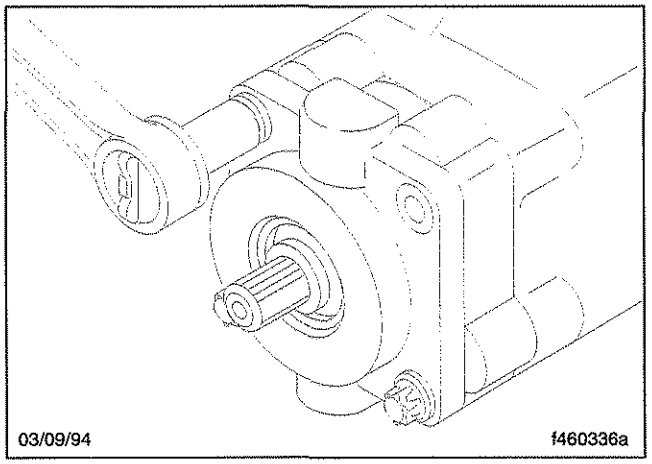


Fig. 14, Remove the Valve Housing Bolts

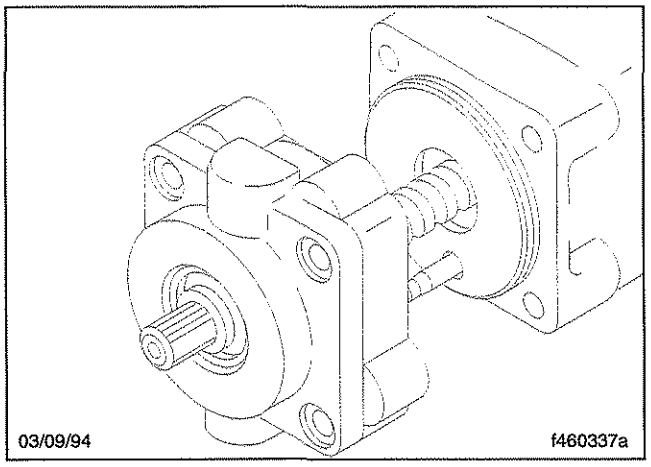


Fig. 15, Remove the Valve Housing

17. Remove and discard the seal rings from the valve housing.

IMPORTANT: If you are not going to remove, reset, or replace the poppet valves on the steering gear, make sure that the setting for them isn't accidentally changed. Mark the gear, identifying the vehicle from which it was removed, and note that the poppet valve adjustments are for that particular vehicle.

18. Using a 5/32-inch allen socket (or a T-30 Torx® wrench), remove the two sealing screws holding the ball return guide cap to the rack piston. See **Fig. 17**. Remove the cap and its seal. See **Fig. 18**. Discard the two screws and the seal.

19. Remove the ball return guide halves from the rack piston by carefully prying up on them with a screwdriver. See **Fig. 19**.

20. Remove the 32 (TAS65), or 34 (TAS85) steel balls from the rack piston by turning the worm shaft until all of them are out. See **Fig. 20**. *Do not lose any of these balls, or you will have to replace the entire set.*

⚠ WARNING

Never mix different sets of steel balls. To do so may cause a loss of steering control, which could cause an accident resulting in serious injury or property damage.

21. Remove the worm shaft and valve housing assembly from the rack piston. See **Fig. 21**.

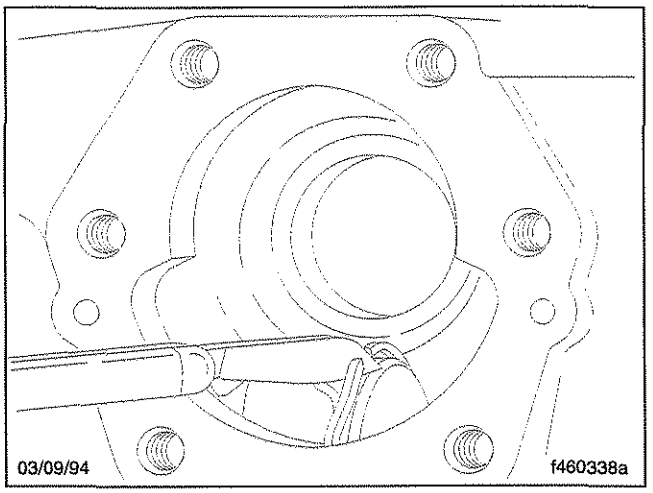


Fig. 16, Cut the Teflon® Ring

Steering Gear Disassembly, Inspection, Assembly, and Final Adjustments

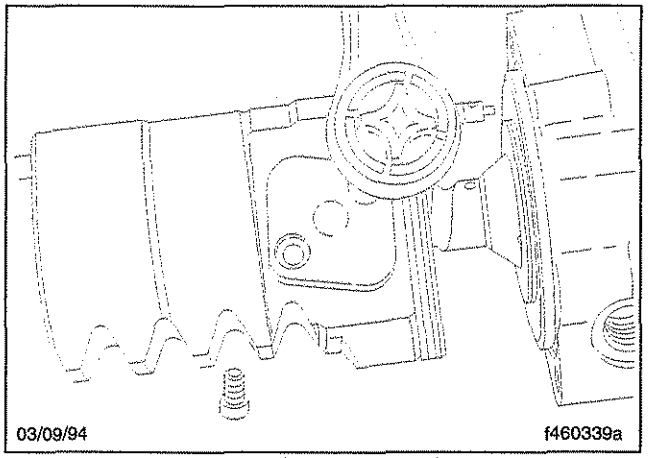


Fig. 17, Remove the Two Sealing Screws

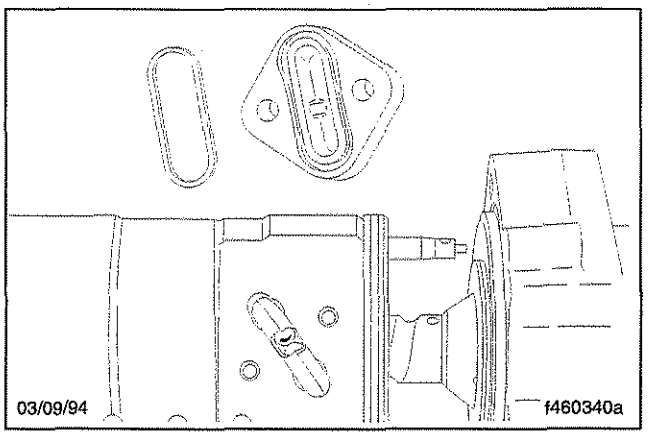


Fig. 18, Remove the Cap and Seal

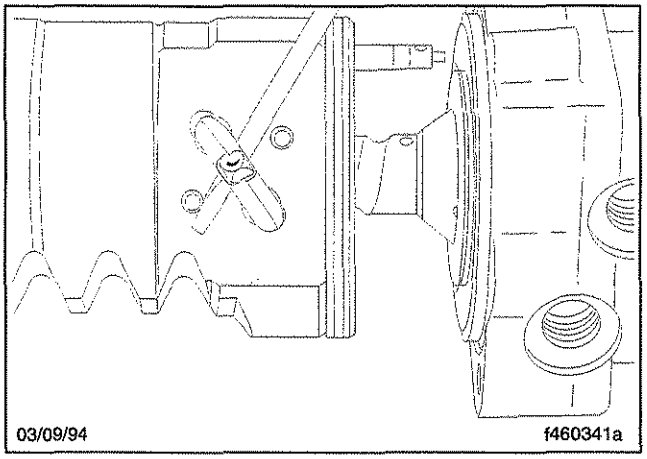


Fig. 19, Remove the Ball Return Guide Halves

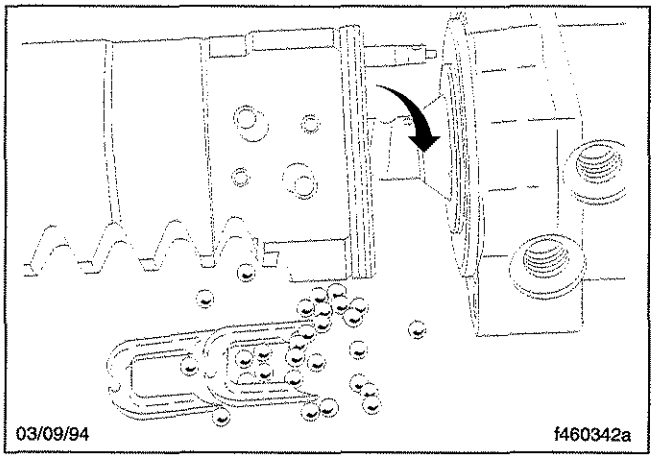


Fig. 20, Remove the Steel Balls

22. If not already done, cut and remove the Teflon® seal ring and the O-ring from the rack piston. See **Fig. 22**.

23. Remove the poppet valve assemblies:

⚠ CAUTION

The poppet valve assemblies are installed with Loctite®. Be careful when removing them, and use only special tool J36452 or J38713. Failure to do so may damage the rack piston, which would require replacing the rack piston, steel ball kit, and the poppet valve assemblies.

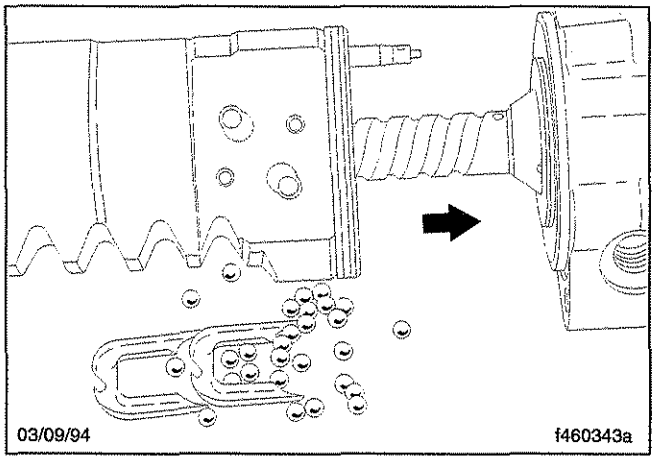


Fig. 21, Remove the Worm Shaft and Valve Housing Assembly

Steering Gear Disassembly, Inspection, Assembly, and Final Adjustments

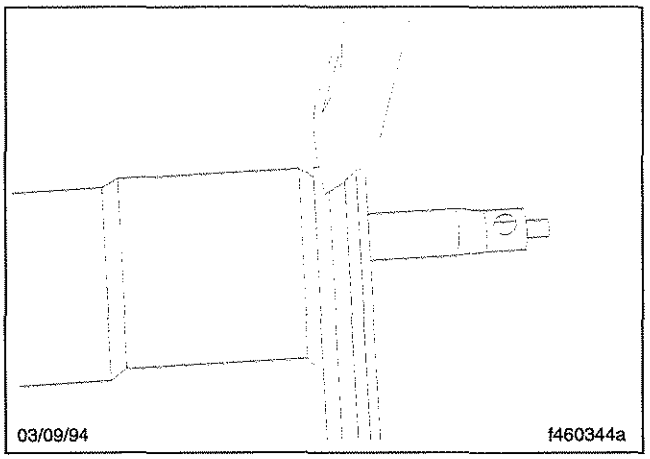


Fig. 22, Cut the Teflon® Seal Ring

IMPORTANT: Don't use special tool J38713 on a rack piston that doesn't have a counterbore in the hole for the seat and sleeve assembly.

23.1 Put the rack piston in a padded vise.

23.2 Slide the special tool J36452 or J38713 over the poppet adjuster seat (see **Fig. 23**), then turn the tool so that its prongs fit into the slot on the threaded adjustment sleeve. Hit the end of the tool firmly four or five times with a 16 oz. hammer to loosen the Loctite®. See **Fig. 24**.

23.3 Using a breaker bar, unscrew the adjuster seat and sleeve assemblies from the rack piston.

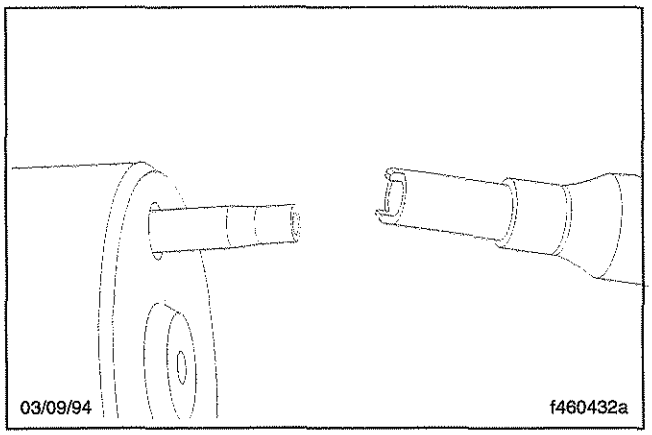


Fig. 23, Slide the Special Tool Over the Poppet Adjuster Seat

23.4 Remove both poppets, and the spring, spacer rod, and push tube. See **Fig. 25**.

23.5 Repeat the previous steps for the other poppet adjuster seat and sleeve assembly.

24. If it's necessary to disassemble the valve housing, do the following:

IMPORTANT: Don't disassemble the valve housing unless you find signs of extreme heat, internal

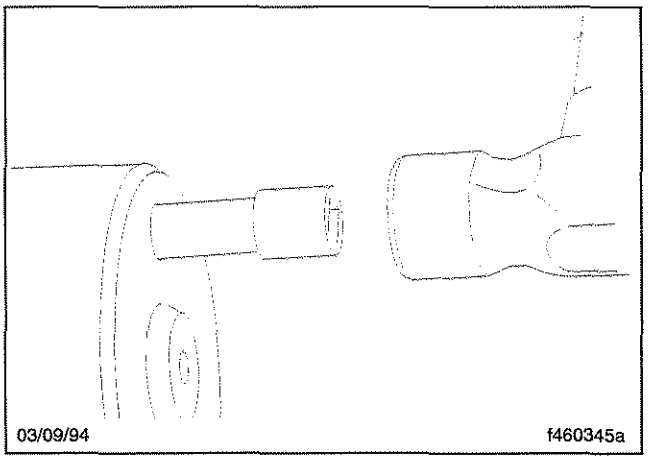
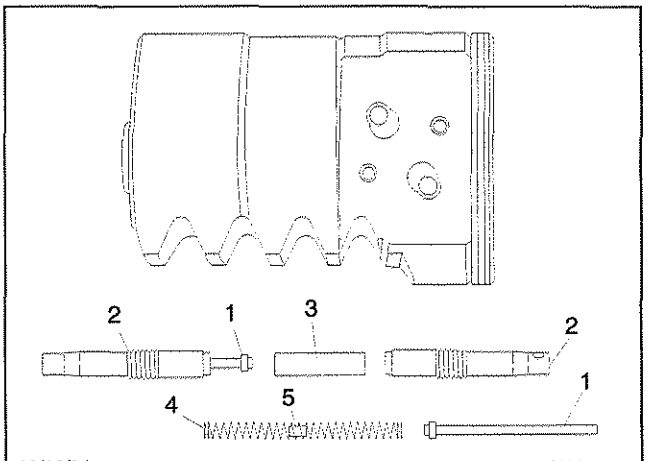


Fig. 24, Hit the End of the Tool with a Hammer



1. Poppet
2. Adjuster Seat and Sleeve Assembly
3. Push Tube
4. Poppet Spring
5. Nylon Spacer Rod (inside poppet spring)

Fig. 25, Remove the Poppets, Spring, Spacer Rod, and Push Tube

Steering Gear Disassembly, Inspection, Assembly, and Final Adjustments

leakage, bearing damage or roughness, or if worm shaft preload adjustment is necessary.

24.1 Put the worm shaft and valve housing assembly into a padded vise, with the worm shaft in a vertical position, as shown in **Fig. 26**.

24.2 Unstake the adjuster locknut, using a punch. See **Fig. 26**.

24.3 Using special tools J37464 and J37070, unscrew the adjuster locknut, then the bearing adjuster from the valve housing. See **Fig. 27**.

NOTE: The bearing adjuster has either two slots (new-style), or two drill points (old-style) on its face. Special tool J37070 can be used for removing and installing either style of bearing adjuster. See **Fig. 27**.

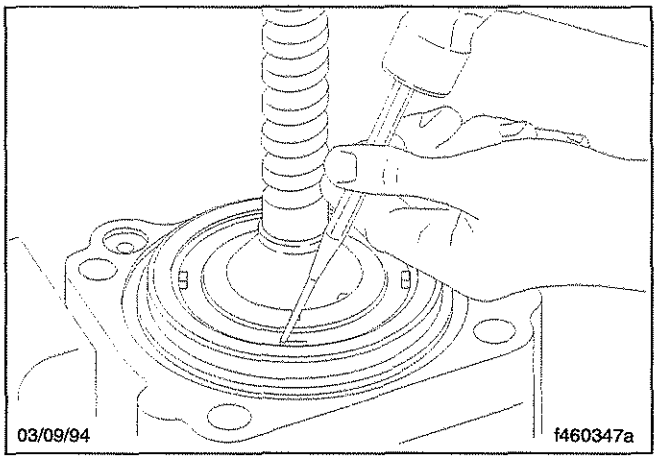


Fig. 26, Unstake the Adjuster Locknut

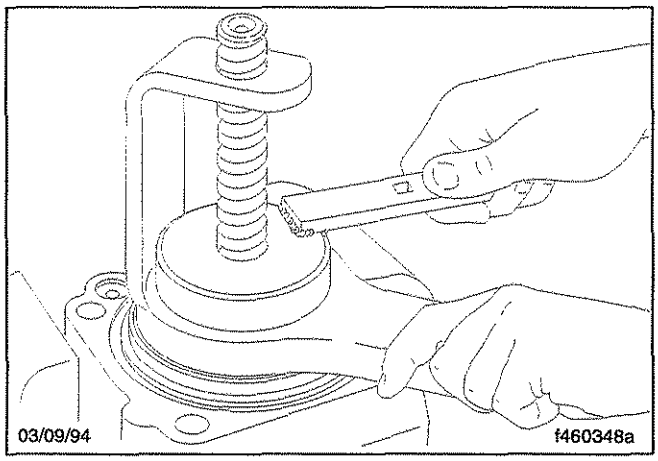


Fig. 27, Unscrew the Adjuster Locknut and Bearing Adjuster

25. Remove and discard the seal ring and the O-ring from the bearing adjuster. See **Fig. 28**.

26. Remove the thin washer, thrust bearing, input shaft, rotary valve, and worm shaft assembly from the valve housing. See **Fig. 29**.

IMPORTANT: Don't disassemble the input shaft or worm shaft assembly any further. These aren't serviceable.

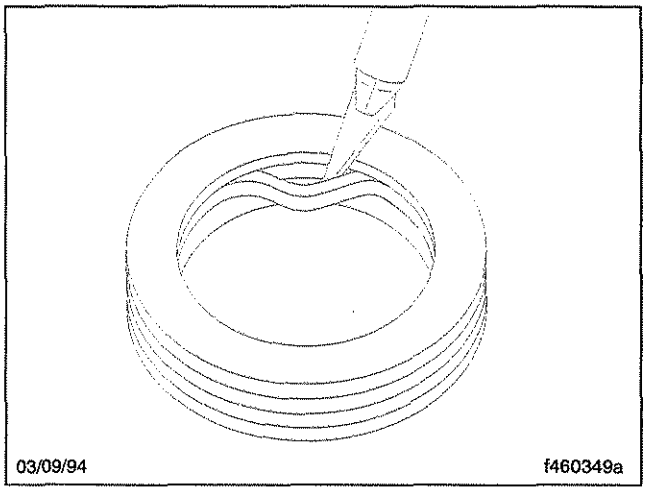


Fig. 28, Remove the Seal Ring and O-Ring

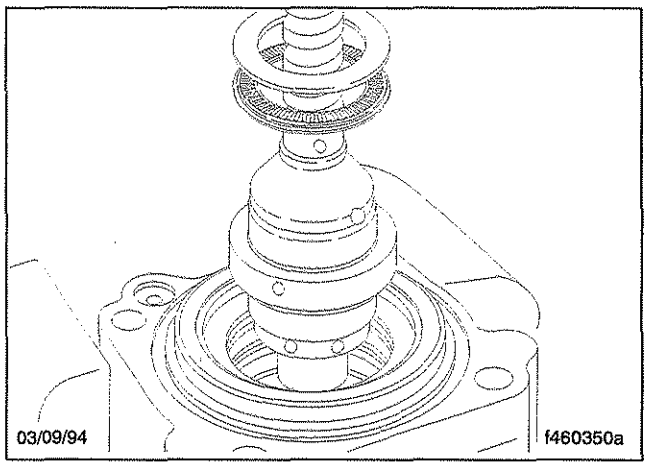


Fig. 29, Remove the Thin Washer, Thrust Bearing, Input Shaft, Rotary Valve, and Worm Shaft Assembly

Steering Gear Disassembly, Inspection, Assembly, and Final Adjustments

27. Depending on how the gear is equipped, do one of the following (a, b, or c):

    A. Remove the roller thrust bearing assembly and the thick thrustwasher from the valve housing. See **Fig. 30**.

    B. Remove the spacer sleeve, thin thrustwasher, roller thrust bearing assembly, and the thick thrustwasher from the valve housing. See **Fig. 31**.

    C. Remove the ball bearing assembly and ball race from the valve housing. See **Fig. 32**.

⚠ WARNING

If a ball bearing assembly is present, do not continue servicing the steering gear. Contact a Freightliner district service manager for instructions on returning the steering gear to the manufacturer. Under no circumstances is this steering gear to be serviced further, or installed on a vehicle. To do so could cause an accident resulting in property damage or serious personal injury.

28. Using a small knife, a probe, or a pick, remove and discard the seal rings and O-rings from the valve housing. See **Fig. 33**.

⚠ CAUTION

In the next step, be careful when removing the retaining ring and seal from the valve housing, or you may damage the seal bore. If this happens, you will have to replace the gear housing.

29. Turn the valve housing over, and remove the retaining ring. See **Fig. 34**. Using a 1-1/8 inch socket, tap out the seal from the valve housing. See **Fig. 35**. Discard the seal.

30. If replacing either of the auxiliary port plugs, remove them. Be sure to remove and discard the O-rings.

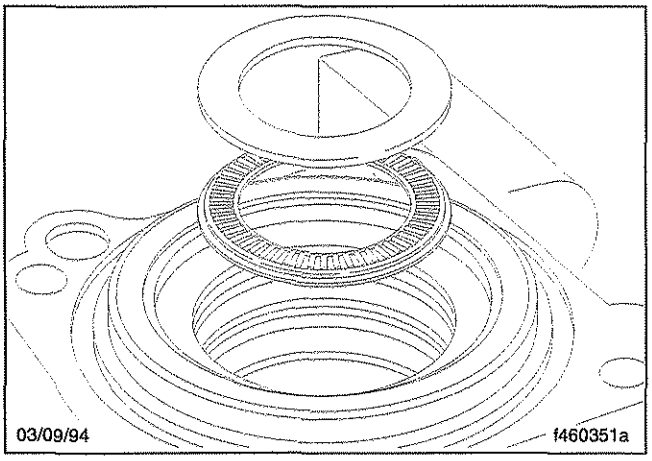


Fig. 30, Remove the Roller Thrust Bearing and Thick Thrustwasher

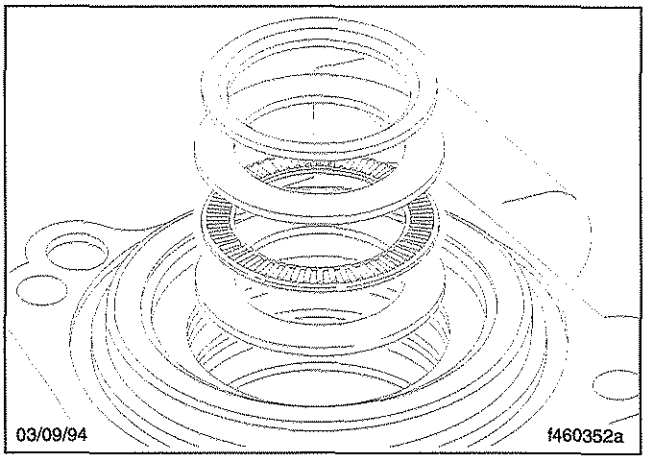


Fig. 31, Remove the Spacer Sleeve, Thin Thrustwasher, Roller Thrust Bearing Assembly, and the Thick Thrustwasher

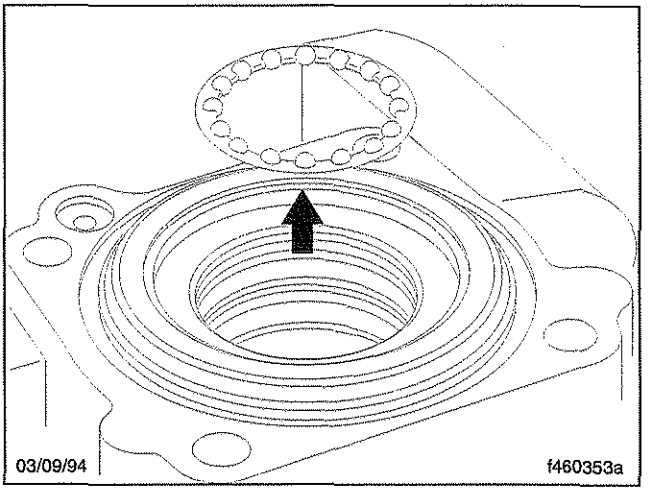


Fig. 32, Remove the Ball Bearing Assembly and the Ball Race

Steering Gear Disassembly, Inspection, Assembly, and Final Adjustments

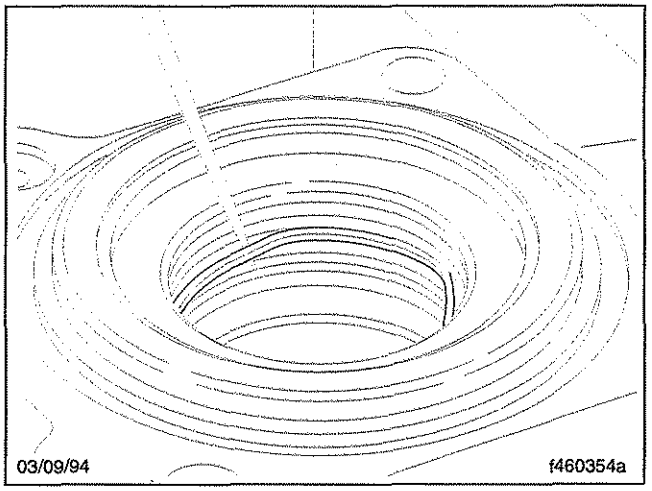


Fig. 33, Remove and Discard the Seal Rings and O-rings from the Valve Housing.

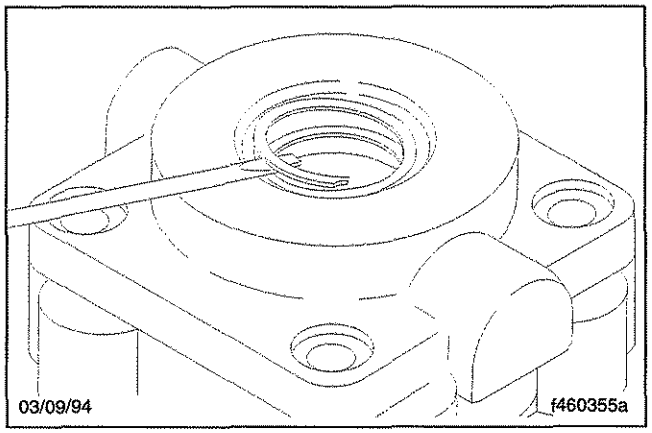


Fig. 34, Remove the Retaining Ring

31. The steering gear is equipped with either a poppet fixed stopscrew, or an adjusting screw and sealing nut (see **Fig. 36**).

    If the poppet fixed stopscrew needs replacement, remove it, using a 5/8-inch socket wrench, or an E-14 Torx® wrench.

    If the adjusting screw and sealing nut need replacement, remove them, using a 7/32-inch allen wrench and a 3/4-inch socket wrench.

32. Remove the retaining ring from the output end of the housing trunnion. See **Fig. 37**.

33. Remove and discard the dirt seal. See **Fig. 38**.

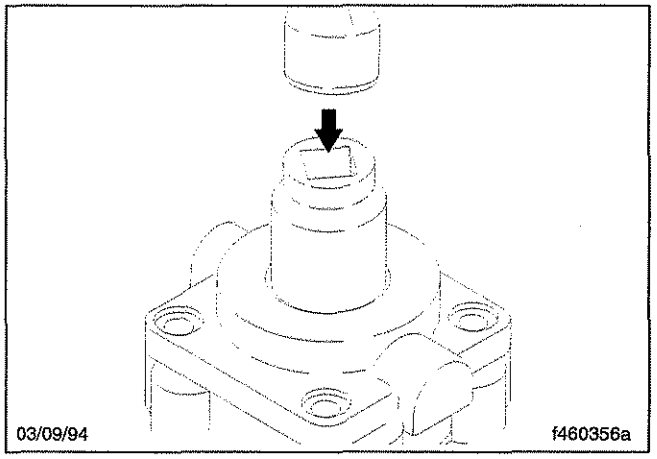


Fig. 35, Tap out the Seal from the Valve Housing

34. Insert a screwdriver into the gear housing, and carefully push the seal and the spacer washer out

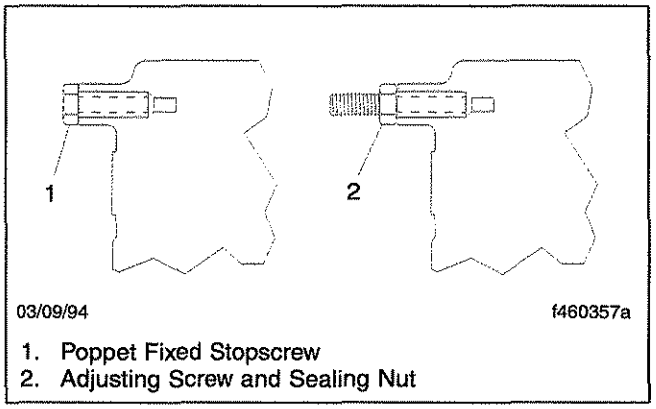


Fig. 36, Gear Equipped with a Poppet Fixed Stopscrew and Adjusting Screw and Sealing Nut

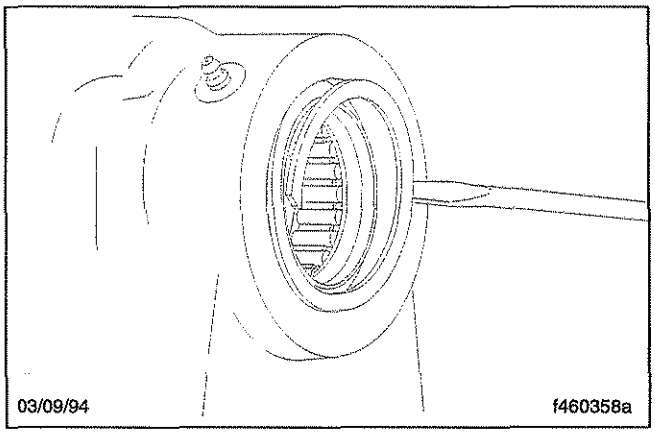


Fig. 37, Remove the Retaining Ring

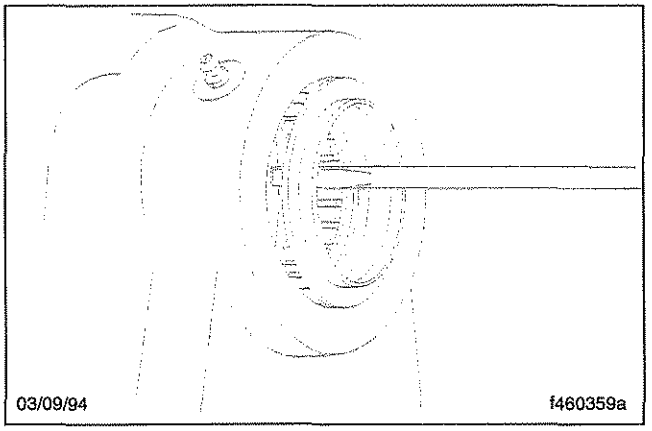


Fig. 38, Remove the Dirt Seal

of the other end of the bearing bore. See **Fig. 39**. Be careful not to damage the sealing area of the bore. Discard the seal.

35. If replacing the roller bearing in the housing, remove it, using special tool J37071. Press the roller bearing out of the trunnion end of the housing, from the side of the bore where the side cover was attached. See **Fig. 40**.

36. If replacing the retaining ring, remove it through the trunnion end, opposite the end where the side cover was attached. See **Fig. 41**. Be careful not to damage the pressure seal bore area.

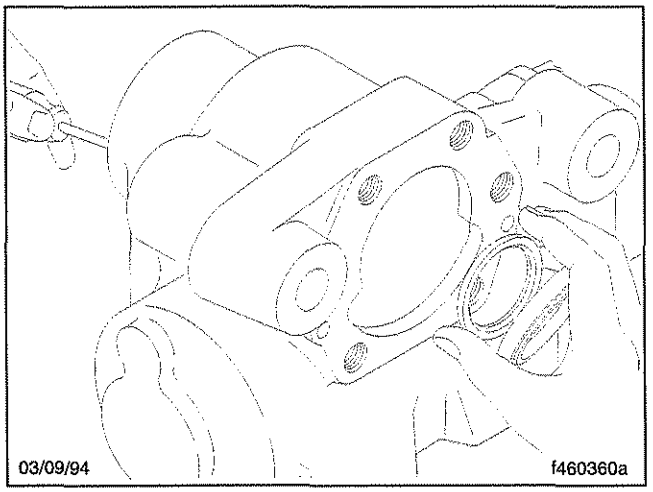


Fig. 39, Push the Seal and the Spacer Washer

Inspection

All sealing surfaces and seal cavities must be free of nicks and corrosion. If any part is nicked or corroded where sealing occurs, the part must be replaced to ensure proper sealing.

Wash all parts in a clean petroleum-based solvent. Blow them dry with air.

1. Inspect the rack piston teeth for cracks and wear. See **Fig. 42**. If a step can be detected by running your fingernail horizontally across the teeth surfaces, the rack piston, the sector shaft, and the set of 32 (TAS65), or 34 (TAS85) steel balls must be replaced.

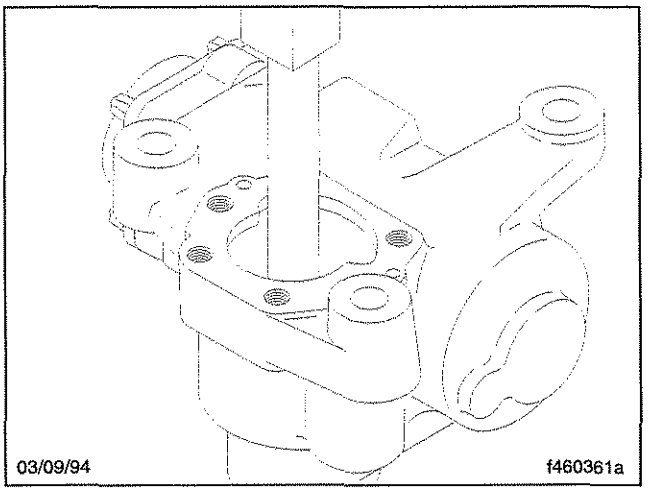


Fig. 40, Press out the Roller Bearing

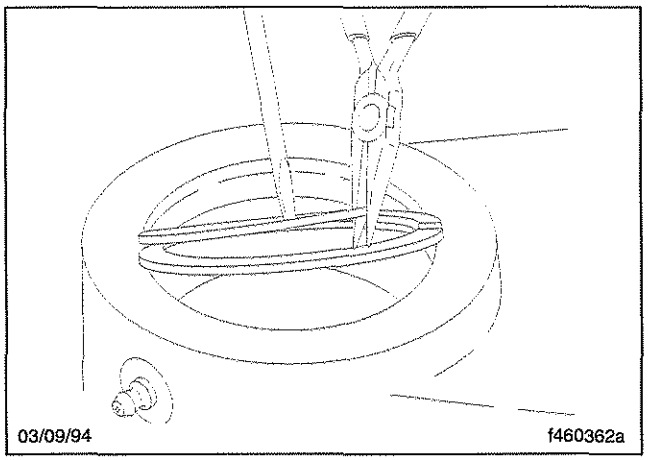


Fig. 41, Remove the Retaining Ring

Steering Gear Disassembly, Inspection, Assembly, and Final Adjustments

2. Inspect the rack piston internal ball-track grooves for brinelling (dents) or spalling (flaking). See **Fig. 43**. If either condition exists, replace the following parts: the rack piston, the valve/worm shaft assembly, and the set of steel balls.
3. Inspect the worm shaft ball-track grooves for brinelling or spalling. See **Fig. 44**. If either condition exists, replace the following parts: the worm/input shaft assembly, the rack piston, and the set of 32 steel balls. Inspect the upper shaft-seal area, near the input shaft serrations, for nicks. Run your fingernail across the sealing surface to detect steps. See **Fig. 45**.
4. Inspect the housing cylinder bore. See **Fig. 46**. Minor scoring marks running lengthwise through the bore are normal, and should not be compared to the scoring that might be found in the cylinder bores of an internal combustion engine. Replace the housing only if it has been tested for internal leakage, and it is determined that the scoring is the cause of internal leakage greater than 1 gpm (3.8 Lpm). For test procedures, refer to **Troubleshooting, 300**.

NOTE: In evaluating this test, make sure that internal leakage of more than 1 gpm (3.8 Lpm) can be attributed only to the housing, and not to the seals in the worm shaft, rack piston, and valve assembly.

5. Inspect the housing faces for nicks that would prevent proper sealing. See **Fig. 47**. Replace the gear housing if these nicks cannot be easily

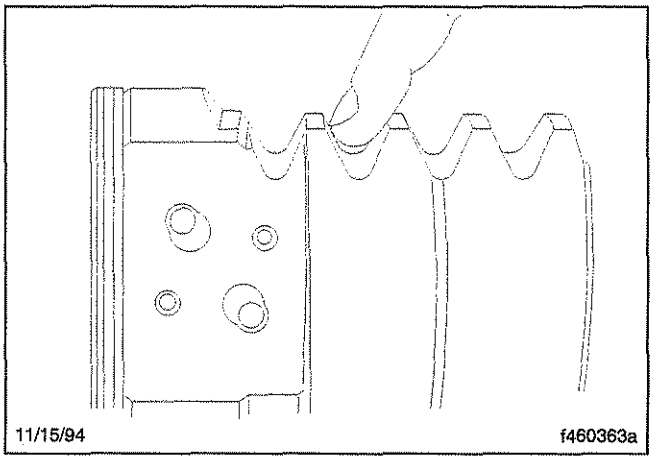


Fig. 42, Inspect the Rack Piston Teeth

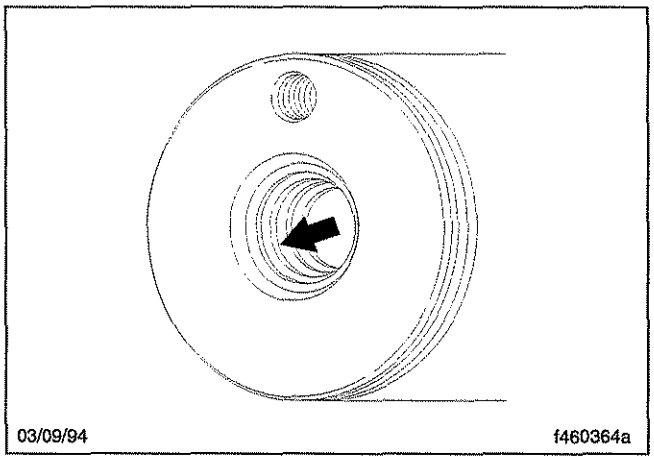


Fig. 43, Inspect the Rack Piston Internal Ball-Track Grooves

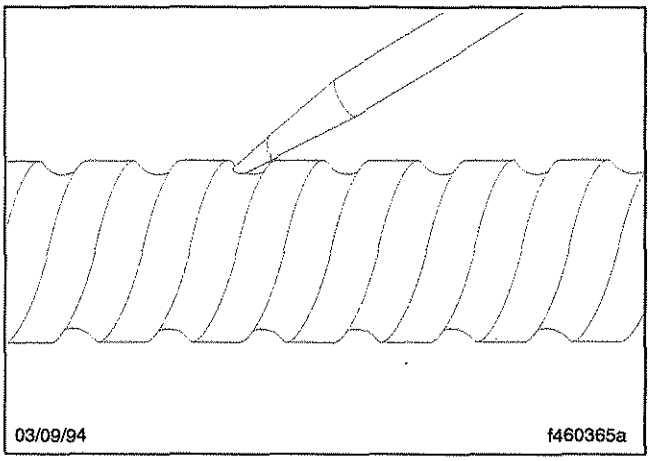


Fig. 44, Inspect the Worm Shaft Ball-Track Grooves

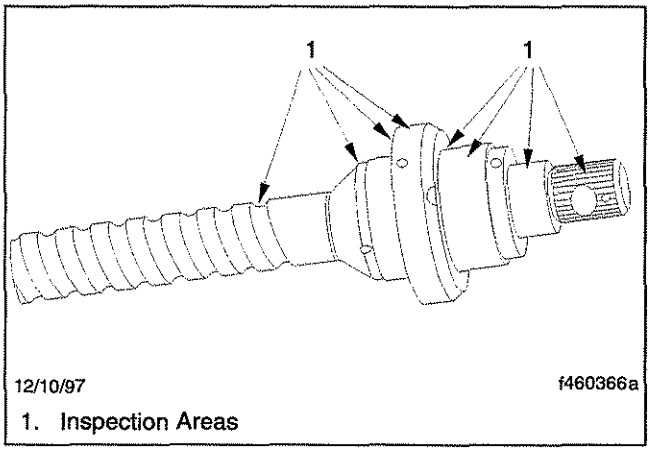


Fig. 45, Inspect the Upper Shaft-Seal Area

Steering Gear Disassembly, Inspection, Assembly, and Final Adjustments

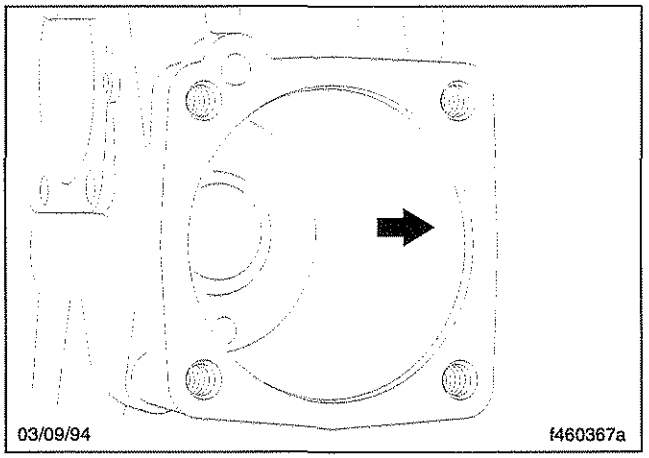


Fig. 46, Inspect the Housing Cylinder Bore

removed with a fine-toothed flat file, without changing the dimensional characteristics.

6. Inspect the housing roller bearing (**Fig. 48**) for brinelling or spalling. If either condition exists, replace the housing bearing. On TAS65 gears, inspect the side cover bushing. If the clearance between the bushing and the sector shaft is more than 0.008 inch (0.20 mm), replace the side cover and bushing assembly. See **Fig. 49**. On TAS85 gears, inspect the side cover bearing for brinelling or spalling. If the bearing is damaged, replace the side cover and bearing assembly.

7. Inspect the sector shaft bearing sealing areas for brinelling or spalling. See **Fig. 50**. Run your fingernail across these areas to detect steps. Also, inspect for cracks. If any of these conditions exist, replace the sector shaft.

8. Check the sector shaft assembly (**Fig. 1**, Ref. 52) for damaged adjusting screw threads. Make sure the staked retainer (Ref. 54) is locked in place and has no cracks. The adjusting screw must turn by hand with no end play (lash). If the adjusting screw is damaged, replace it and its retainer.

9. Inspect the thrust bearing rollers for any deterioration. Inspect the thrustwashers for brinelling, spalling, or cracks. See **Fig. 51** or **Fig. 52**. Replace any part if these conditions are detected.

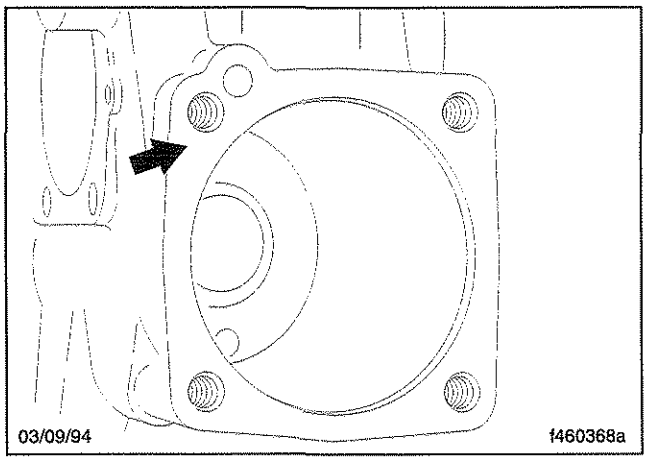


Fig. 47, Inspect the Housing Faces for Nicks

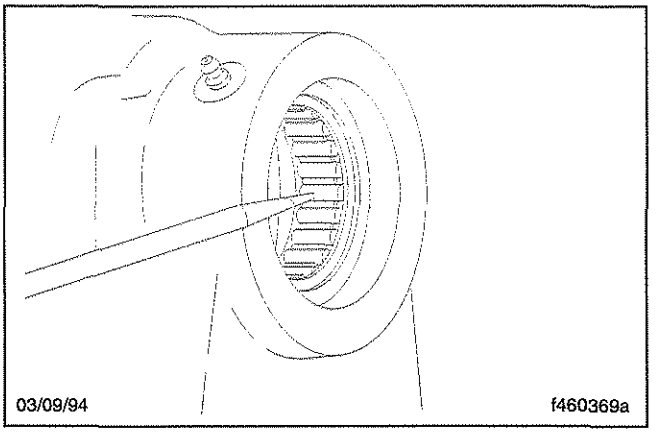


Fig. 48, Inspect the Housing Roller Bearing

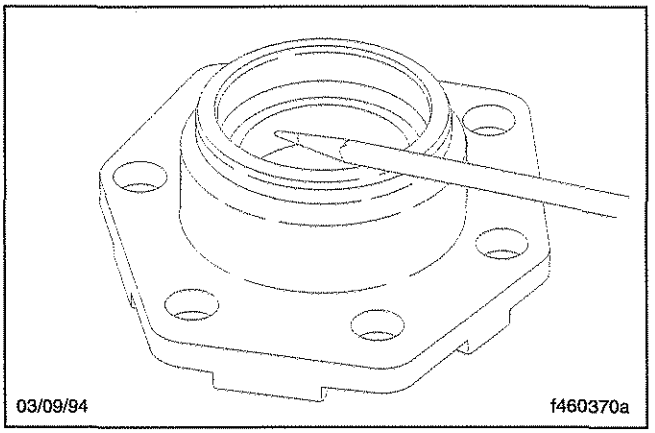
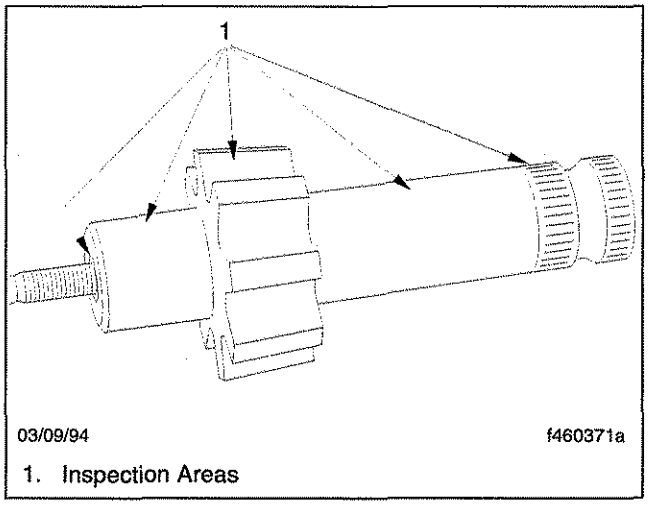


Fig. 49, Inspect the Side Cover Bushing

Steering Gear Disassembly, Inspection, Assembly, and Final Adjustments



1. Inspection Areas

Fig. 50, Inspect the Sector Shaft Bearing Sealing Areas

Assembly (See Fig. 1)

IMPORTANT: Be sure that required tools are available before beginning the service procedures described here. See the special tools table in **Specifications, 400**. The special tools required for disassembly and assembly of the steering gear components are available from the Kent-Moore Tool Division, or an affiliated dealer.

After inspection, clean all parts again in clean petroleum-based solvent, and blow them dry with air.

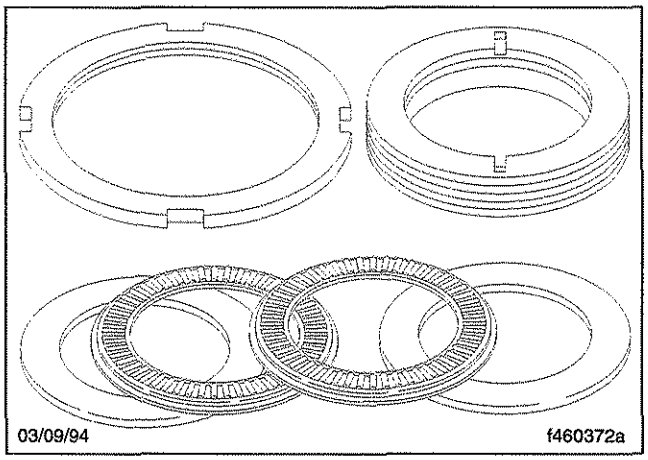


Fig. 51, Inspect the Thrust Bearing Rollers and Thrustwashers

All seals, seal rings, and gaskets, must be replaced with new ones each time the gear is disassembled. Individual seals, seal rings, and gaskets, as well as complete seal kits are available from Freightliner parts distributors.

1. If installing a new roller bearing into the gear housing:
   - 1.1 Put the gear housing on its side, with the trunnion end of the bore facing up, as shown in **Fig. 53**.
   - 1.2 Install the retaining ring in the groove closest to the side-cover end of the bore. See **Fig. 53**. Then lubricate the bore.

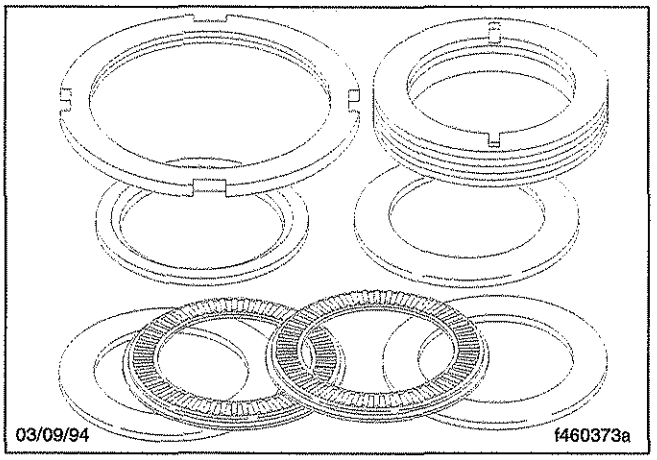


Fig. 52, Inspect the Thrust Bearing Rollers and Thrustwashers

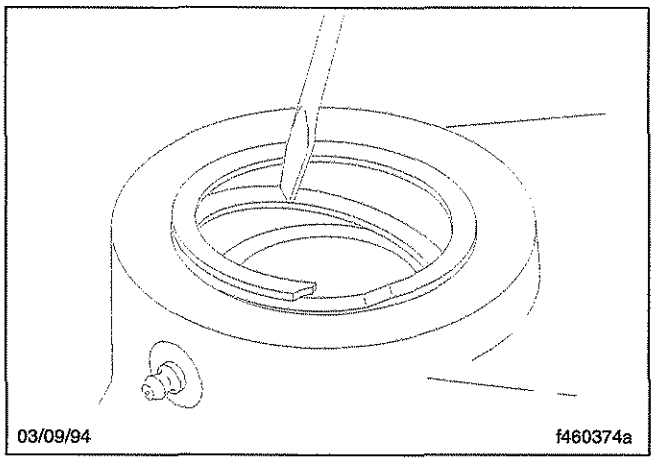


Fig. 53, Put the Gear Housing on its Side

1.3 Place the new roller bearing on the housing bore, with the lettered side of the bearing shell facing up.

⚠ CAUTION

When using special tool J37071 (TAS65), or J38779 (TAS85) to install the roller bearing, be sure to use the *installation* side of the tool, or you may damage the new roller bearing.

1.4 Using the installation end of the special tool, press the roller bearing into the housing until it seats against the retaining ring. See **Fig. 54**.

2. Put the gear housing on its side, with the side-cover end of the bore facing up, as shown in **Fig. 55**.
3. Install the washer in the bore, with the small diameter end of it facing the roller bearing retaining ring. See **Fig. 55**.
4. Put the new seal on special tool J37071 (TAS65), or J38779 (TAS85) so that the lip of the seal with the garter spring is toward the shoulder of the tool. See **Fig. 56**.
5. From the side-cover end of the bore, press the new seal onto the washer (and the roller bearing below it) with a force of 100 to 800 lbs (45 to 363 kg).
6. Turn the gear housing over so that the trunnion end of the bore is up, and install the new dirt seal against the roller bearing, with the lip facing up. See **Fig. 57**.

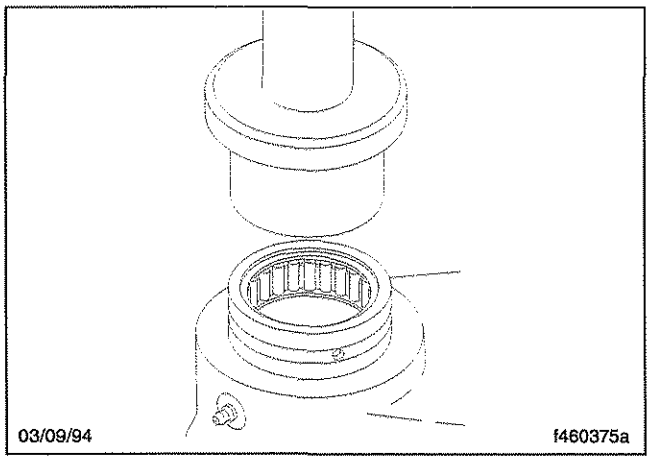


Fig. 54, Press the Roller Bearing into the Housing

7. Install the second retaining ring, seating it firmly into the groove in the bore. See **Fig. 58**.
8. Pack the area between the dirt seal and the pressure seal (including the roller bearing) with Mobil Temp® 1 grease, or equivalent. See **Fig. 59**.

⚠ CAUTION

In the next step, when putting the valve housing in a vise, be careful not to clamp against the threaded port hole or the relief-valve hole sealing faces. To do so may damage these surfaces, which would require the replacement of the valve housing.

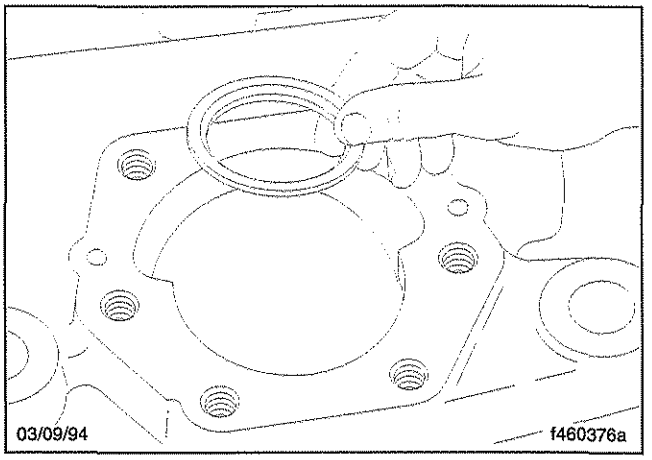


Fig. 55, Put the Gear Housing on its Side (with the side-cover end of the bore facing up)

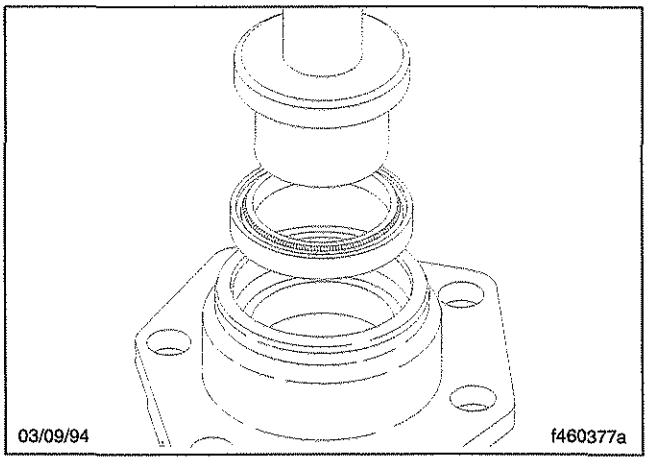


Fig. 56, Put the New Seal on Special Tool J37071 (TAS65), or J38779 (TAS85)

Steering Gear Disassembly, Inspection, Assembly, and Final Adjustments

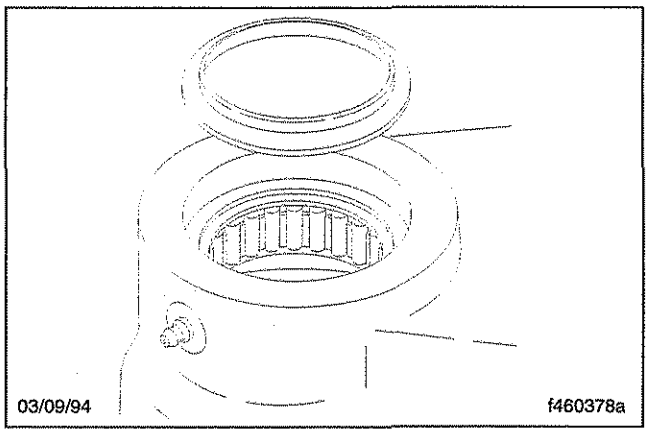


Fig. 57, Install the New Dirt Seal

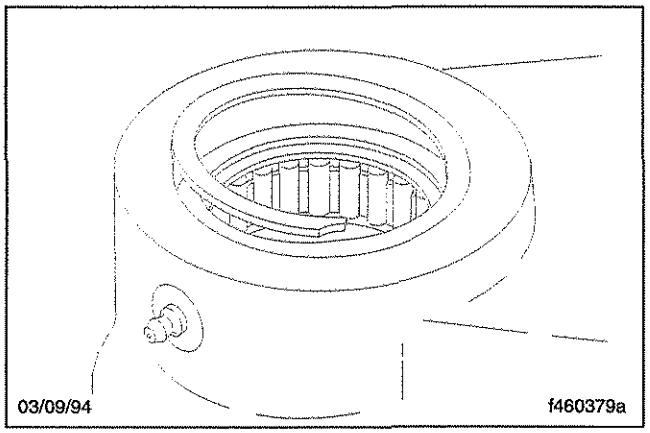


Fig. 58, Install the Second Retaining Ring

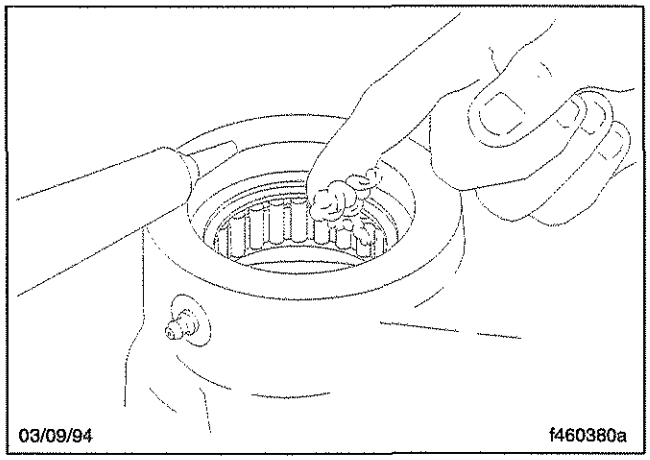


Fig. 59, Pack the Area between the Dirt Seal and the Pressure Seal with Grease

9. Put the valve housing in a vise so the input/worm shaft can be installed with the worm shaft up.
10. Lubricate and install a new O-ring in the valve housing. See **Fig. 60**.
11. Lubricate a new large diameter O-ring and a new seal ring, then install them in the valve housing. See **Fig. 61**.
12. Depending on how the steering gear is equipped (see **Fig. 1**), do one of the following (a or b):

    A. Install the roller thrust bearing and the thick thrustwasher on the input shaft thrust face. See **Fig. 62**. Then install a new seal ring (**Fig. 1**, Ref.

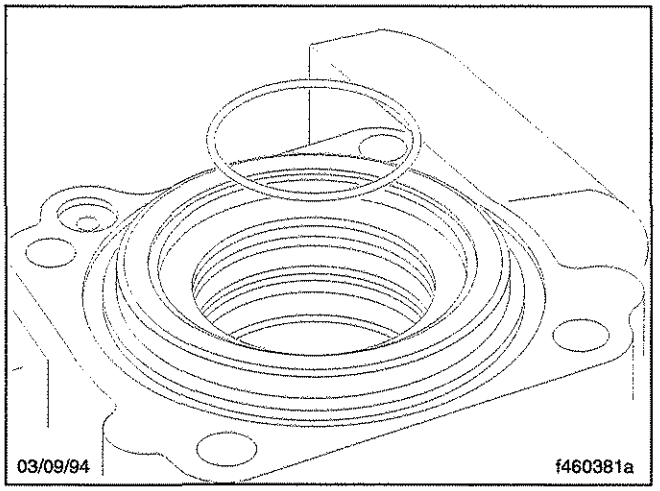


Fig. 60, Lubricate and Install a New O-Ring

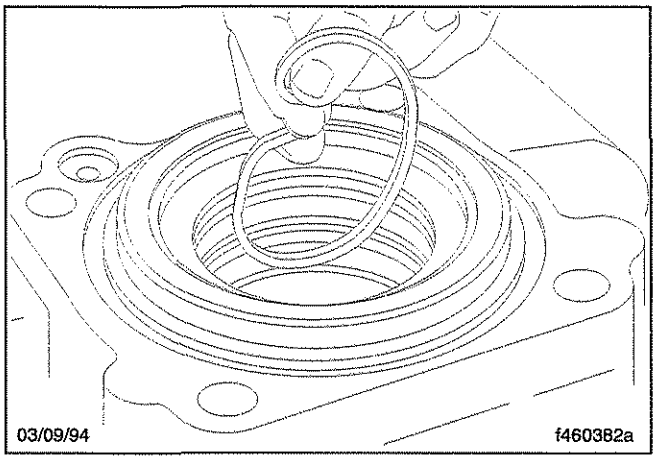


Fig. 61, Lubricate and Install a New Large Diameter O-Ring and a New Seal Ring

11) onto the input shaft, and against the thick thrustwasher.

B. Install the spacer sleeve (the side with the curved edge down), thin thrustwasher, roller thrust bearing, and thick thrustwasher (see **Fig. 1**, Refs. 21, 20, 15, and 19) on the input shaft thrust face. See **Fig. 63**. Then install a new seal ring (**Fig. 1**, Ref. 11) onto the input shaft, and against the thick thrustwasher.

IMPORTANT: If you have replaced the input shaft/valve/worm assembly with a new assembly, don't install the existing spacer sleeve or the thin washer.

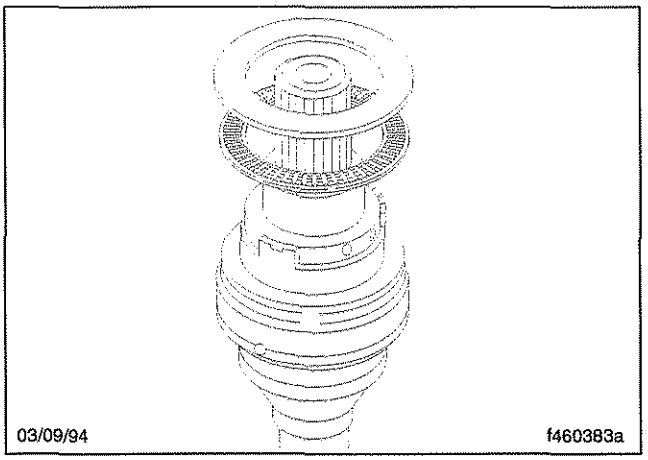


Fig. 62, Install the Roller Thrust Bearing and the Thick Thrustwasher

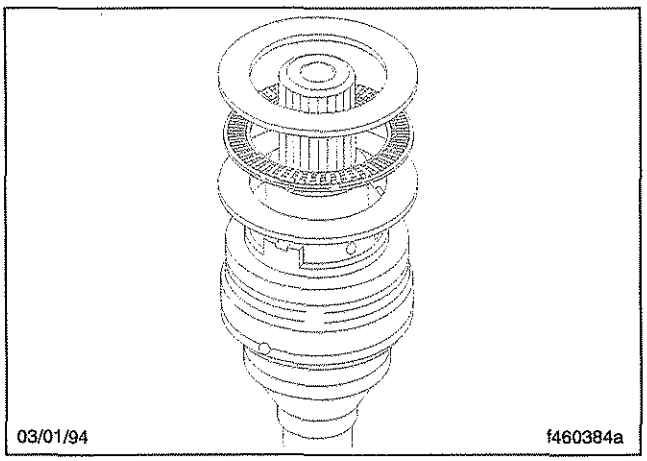


Fig. 63, Install the Spacer Sleeve, Thin Thrustwasher, Roller Thrust Bearing, and Thick Thrustwasher

They are not needed with a new input shaft/valve/worm assembly.

13. Lubricate, then install the input shaft/valve/worm assembly in the valve housing, seating it firmly. See **Fig. 64**.
14. Lubricate, then install a second thrust bearing and thin washer over the worm shaft. See **Fig. 65**.
15. Lubricate the new O-ring and seal ring (**Fig. 1**, Refs. 23 and 22). Install the O-ring, then the seal ring in the groove of the bearing adjuster. See **Fig. 66**.
16. Making sure the bearing adjuster threads are clean and free of any stake burrs, lubricate, then install

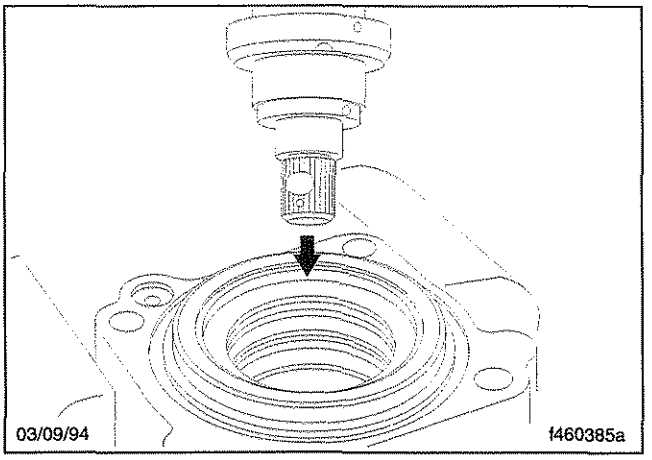


Fig. 64, Lubricate, then Install the Input Shaft/ Valve/Worm Assembly

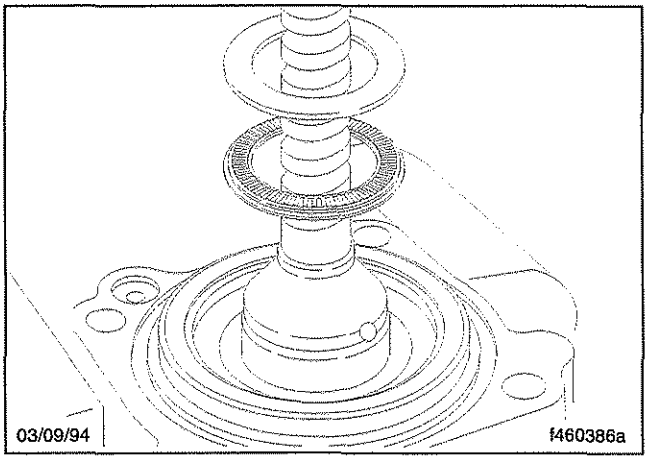


Fig. 65, Lubricate, then Install a Second Thrust Bearing and Thin Washer

Steering Gear Disassembly, Inspection, Assembly, and Final Adjustments

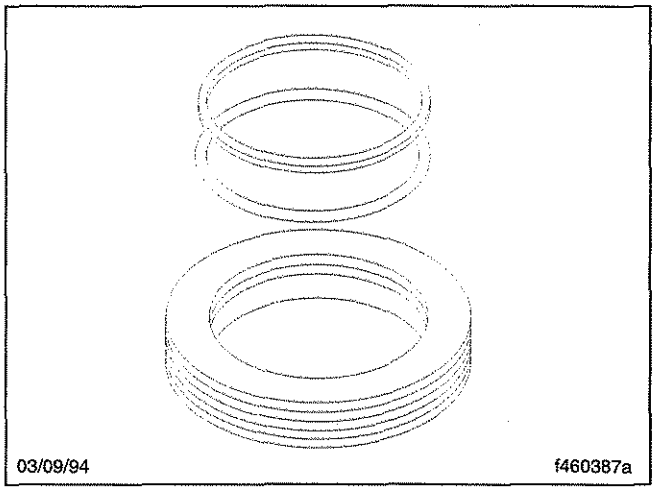


Fig. 66, Lubricate the New O-Ring and Seal Ring

the bearing adjuster over the worm shaft, and into the valve housing.

Using a torque wrench and bearing adjuster tool J37070, tighten the valve adjuster 11 to 15 lbf·ft (15 to 20 N·m), then back it off 1/4 to 1/2 turn. See **Fig. 67**.

17. Turn the valve housing over in the vise so that the worm shaft is facing down.
18. Using an inch-pound torque wrench, check the torque needed to turn the input shaft 360 degrees clockwise and counterclockwise. Tighten the bearing adjuster so that the torque needed to turn the input shaft is increased by 5 to 10 lbf·in (60 to 120 N·cm). See **Fig. 68**.

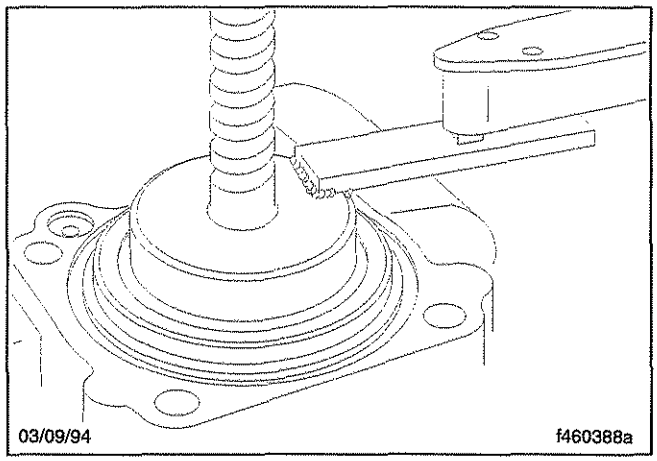


Fig. 67, Install the Bearing Adjuster over the Worm Shaft

19. Turn the valve housing over in the vise again, so that the worm shaft is facing up.
20. Oil and install the locknut on the bearing adjuster, and using special tools J37070 and J37464, tighten the locknut 101 to 122 lbf·ft (137 to 165 N·m), while holding the bearing adjuster. See **Fig. 69**.
21. Check the torque needed to turn the input shaft again. If the torque isn't the same as it was previously, remove the locknut from the bearing adjuster, and repeat the previous steps beginning with turning the valve housing over in the vise so that the worm shaft is facing down.

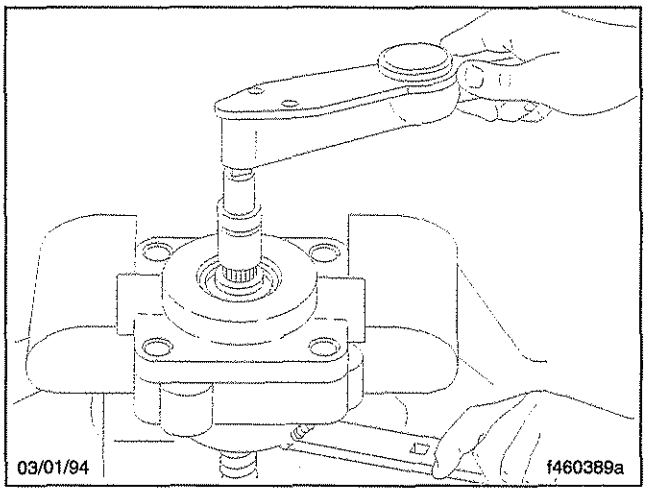


Fig. 68, Check the Torque

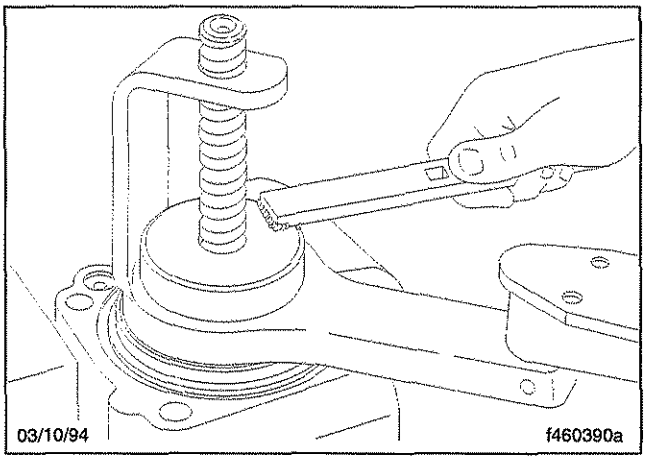


Fig. 69, Install the Locknut on the Bearing Adjuster

22. Using a punch, stake the locknut to the valve housing at two opposite slots in the locknut. Stake each slot in the most clockwise corner, as shown in **Fig. 70**.

23. Stake the locknut to the bearing adjuster at two places 180 degrees apart. See **Fig. 70**. Don't use a spot that was staked before.

24. Check the torque needed to turn the input shaft. If the torque isn't the same as it was previously, unstake the locknut and the bearing adjuster, and repeat the previous steps beginning with turning the valve housing over in the vise so that the worm shaft is facing down.

NOTE: The torque needed to turn the input shaft must not be more than 22 lbf·in (240 N·cm).

25. Oil the new grease seal rings, and install them in the valve housing. See **Fig. 71**.

26. If you are installing the removed automatic poppet adjuster seats and sleeve assemblies, reset them as follows:

    IMPORTANT: Make sure the poppet adjuster seat and sleeve assemblies and the threaded holes in the rack piston are free of Loctite®.

    26.1 Turn the poppet adjuster seat and sleeve assembly so that it is in the *opposite* direction in which it was installed, and loosely screw it into the threaded hole in the rack piston. See **Fig. 72**.

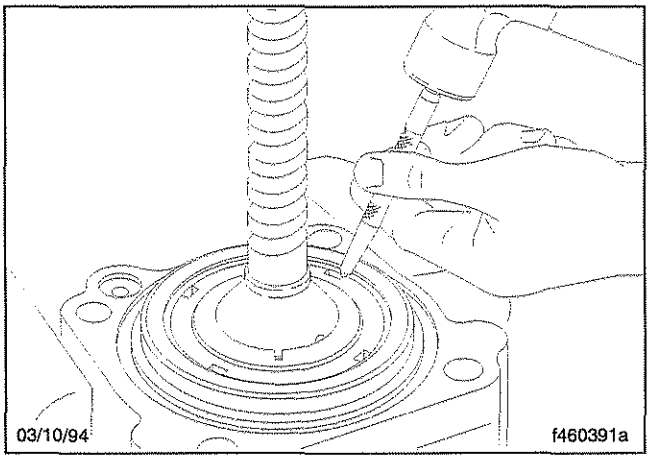


Fig. 70, Stake the Locknut to the Valve Housing and the Bearing Adjuster

    26.2 Press the adjuster seat into the adjuster sleeve with a force of 500 to 2500 lbs (227 to 1134 kg) until the shoulder on the seat bottoms on the sleeve. See **Fig. 73** and **Fig. 74**.

    26.3 Remove the adjuster seat and sleeve assembly from the rack piston.

    26.4 Repeat the previous steps as needed for the other poppet adjuster seat and sleeve assembly.

27. Install a new backup O-ring and new Teflon® seal ring on the rack piston. See **Fig. 75**. Do not stretch them any more than necessary when installing them.

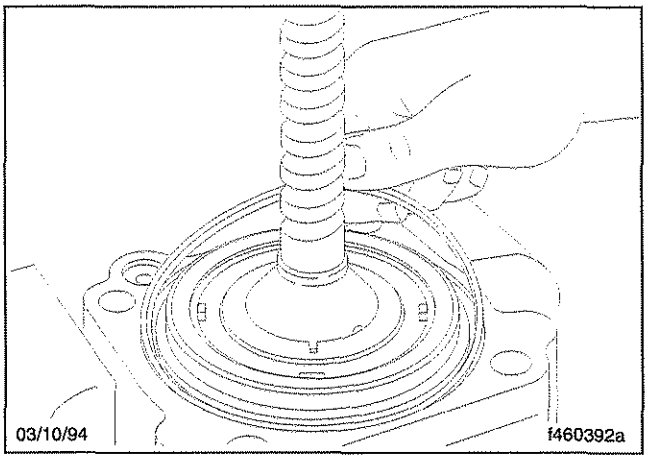


Fig. 71, Install the New Grease Seal Rings

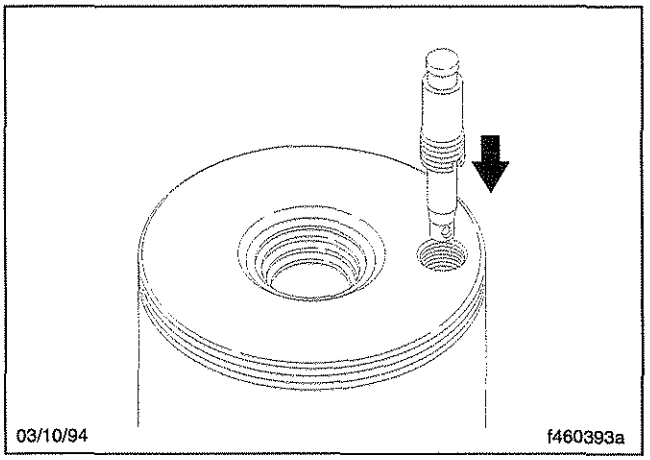


Fig. 72, Screw the Poppet Adjuster Seat and Sleeve Assembly into the Rack Piston

Steering Gear Disassembly, Inspection, Assembly, and Final Adjustments

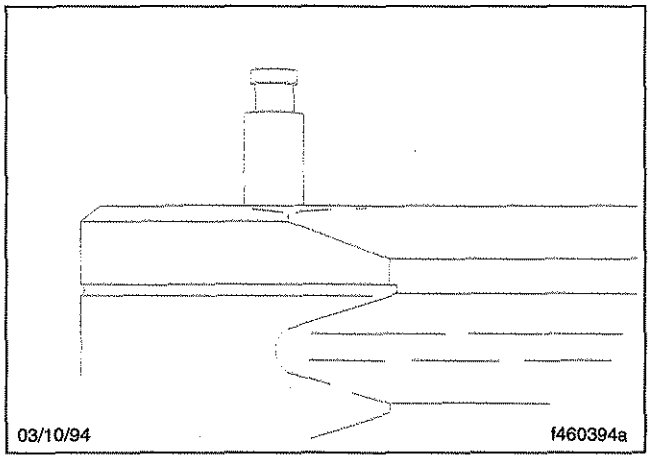


Fig. 73, Adjuster Seat/Adjuster Sleeve in the Rack Piston

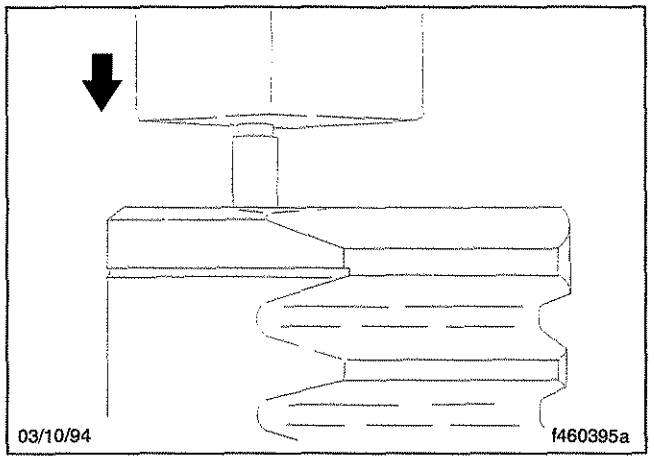


Fig. 74, Press the Adjuster Seat into the Adjuster Sleeve

⚠ CAUTION

When doing the next step, be careful not to get any Loctite® or Locquic on the adjuster seat itself. If this happens, the automatic poppets will not adjust correctly.

NOTE: If you are installing new poppet adjuster seat and sleeve assemblies, they may already have Dri-Loc® 200 on them; if so, more Loctite® isn't needed.

28. Apply Locquic primer "T" to the threaded poppet holes in the rack piston, and to the threads on the poppet adjuster seat and sleeve assemblies. Let dry for ten minutes, then apply Loctite® RC680 to the same threads. See **Fig. 76**.
29. Place the rack piston in a padded vise, and install a poppet adjuster seat and sleeve assembly, slotted end out, into the threaded hole at one end of the rack piston. See **Fig. 77**.

⚠ WARNING

Wear eye protection while assembling the poppets. The poppets are spring-loaded, and could be ejected, which could result in serious eye injury.

30. In the other end of the hole, install the poppet assembly parts in the following order (see **Fig. 78**):

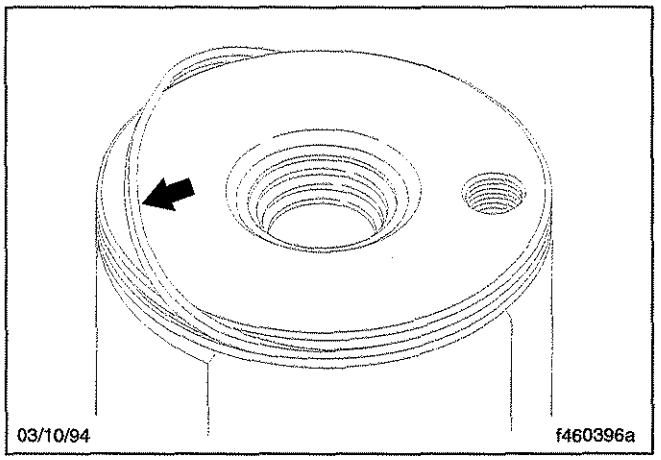


Fig. 75, Install a new Backup O-Ring and new Teflon® Seal Ring

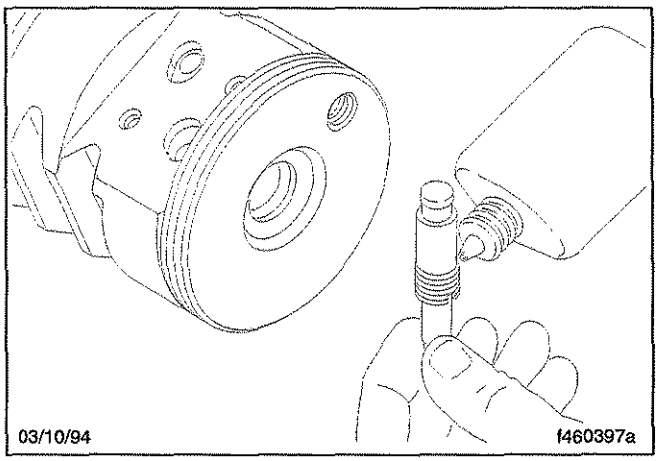


Fig. 76, Apply Locquic Primer T

Steering Gear Disassembly, Inspection, Assembly, and Final Adjustments

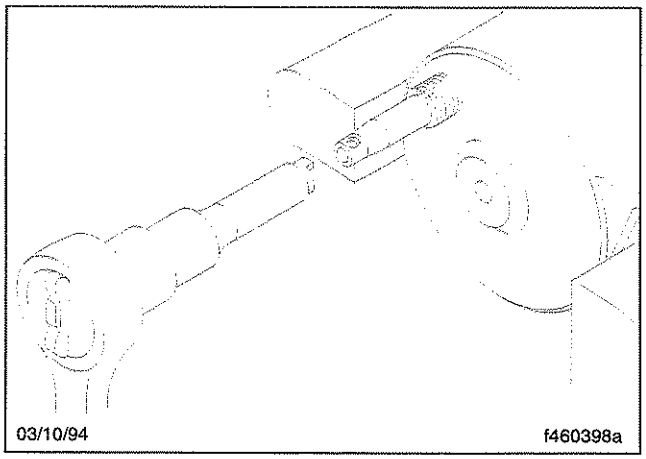


Fig. 77, Install a Poppet Adjuster Seat and Sleeve Assembly

one poppet, the poppet spring, the nylon spacer rod, the push tube, the other poppet, and the other poppet adjuster seat and sleeve assembly.

31. Using special tool J36452 or J38713, tighten both poppet adjuster seat and sleeve assemblies: on TAS65 steering gears—10 lbf·ft (14 N·m); on TAS85 steering gears—18 lbf·ft (24 N·m). See **Fig. 79**.

32. Put the rack piston on a clean, cloth-covered bench, with the worm end of the piston near the edge of the bench, and the ball guide holes facing up.

NOTE: When made to the correct dimensions to raise and support the piston, a wooden V-block will make the following steps easier.

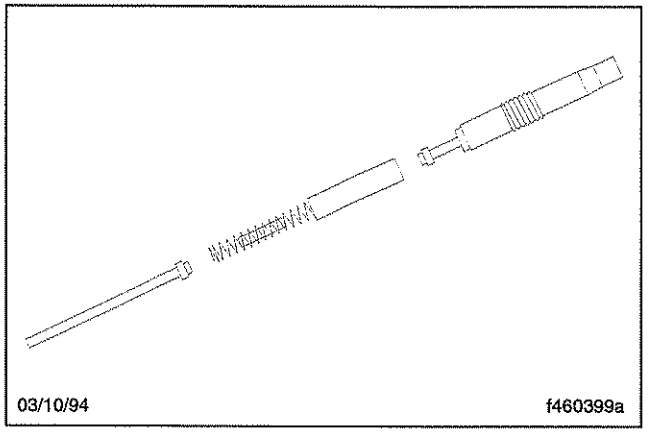


Fig. 78, Install the Poppet Assembly Parts

33. Insert the worm shaft and input shaft assembly into the worm end of the rack piston, close to the maximum depth, without the valve housing contacting the upper poppet. See **Fig. 80**.

34. Line up the grooves in the worm shaft with the ball guide holes in the rack piston.

    Make sure the valve housing extends over the edge of the bench (as shown in **Fig. 80**), or the rack piston is put on a V-block, so that the valve housing and worm shaft can turn freely.

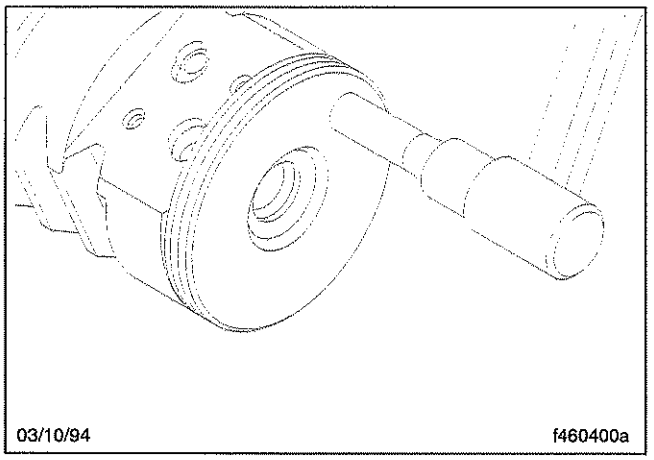


Fig. 79, Tighten both Poppet Adjuster Seat and Sleeve Assemblies

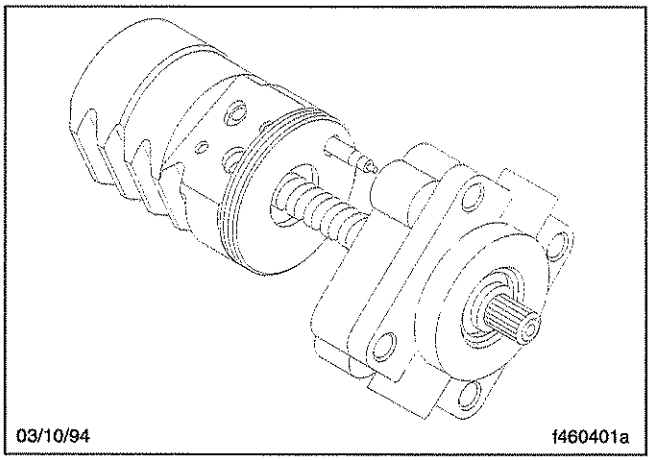


Fig. 80, Insert the Worm Shaft and Input Shaft Assembly

Steering Gear Disassembly, Inspection, Assembly, and Final Adjustments

⚠ WARNING

In the next step, do not seat the ball return guides with a hammer. This could damage them and cause steering gear lockup or loss of steering, resulting in an accident causing personal injury or property damage.

35. Install *new* ball return guide halves in the rack piston. See **Fig. 81**. Make sure they are correctly seated.

NOTE: Left-side ball return guide halves are copper-plated, and right-side ones are not. Make sure the correct new ball return guide halves are installed, by comparing them with the old ones; then discard the old ones.

⚠ CAUTION

If you are installing a new rack piston, or a new input shaft/valve/worm assembly, don't install the existing steel balls. Use a new set of steel balls, or damage to the steering gear may result.

36. Insert the 32 (TAS65), or 34 (TAS85) steel balls in the ball return guide hole, as shown in **Fig. 82**. As the balls are dropped into the guide, turn the worm shaft so that the balls are pulled down into its grooves.

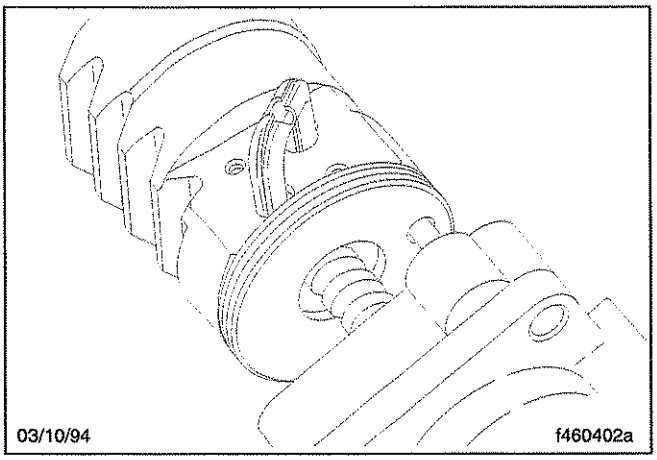


Fig. 81, Install new Ball Return Guide Halves

⚠ WARNING

Make sure the ball return guide halves stay down and in place while you are inserting the steel balls or turning the input shaft. Failure to hold the ball guide halves down may result in a ball being trapped outside the closed ball-track loop. A trapped ball could cause a steering lockup, which could result in an accident and personal injury or property damage.

37. If the ball guide halves raise up at any time during or after the installation of the steel balls, remove all of the balls, and the input shaft/valve/worm assembly from the rack piston. Repeat the previous steps as needed.

IMPORTANT: Don't let the valve housing pilot face touch the poppet adjuster, or move more than 2.7 inches (69 mm) from the upper end of the rack piston. See **Fig. 83**. If this happens, the poppet adjuster could be incorrectly preset or the worm could be backed out beyond the closed ball loop.

38. Lubricate the new seal for the ball return guide cap, and install it in the groove in the cap. See **Fig. 84**.

39. Using a 5/32-inch allen socket and two new 5/32-inch allen screws (or a T-30 Torx® wrench and two new Torx® head screws), install the ball return guide cap on the rack piston. Make sure the seal makes full contact with the rack piston surface. Tighten the fasteners alternately once or twice, to a final torque of 14 to 22 lbf·ft (19 to 30 N·m).

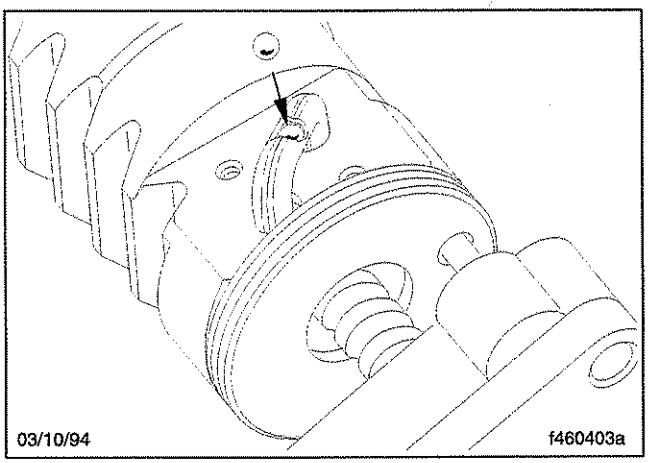
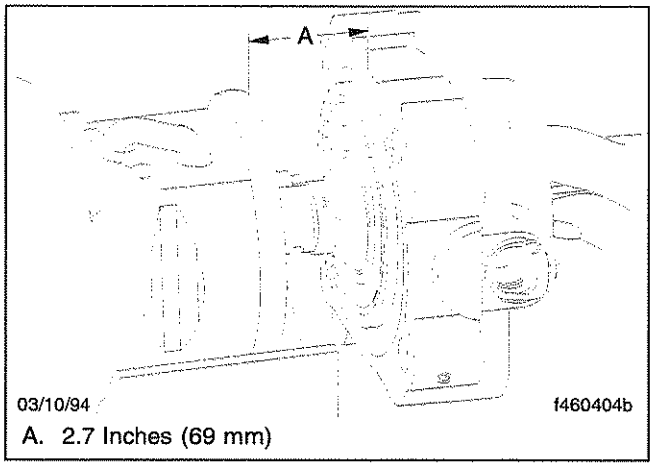


Fig. 82, Insert the Steel Balls

Steering Gear Disassembly, Inspection, Assembly, and Final Adjustments



A. 2.7 Inches (69 mm)

Fig. 83, Check the Valve Housing Pilot Face

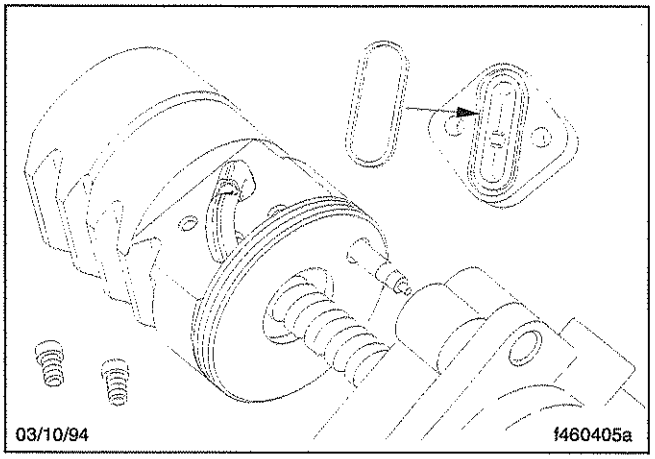


Fig. 84, Install the Seal

40. To ensure that the steel balls have been correctly installed, turn the worm shaft from one end of travel to the other, without allowing the valve housing to contact the poppet adjuster, and without moving the valve housing pilot face more than 2.7 inches (69 mm) from the input end (upper end) of the rack piston. See **Fig. 83**.

    If the worm shaft doesn't turn, remove all 32 (or 34) of the steel balls and install them again, following the instructions in the previous steps.

41. If the poppet stopscrew is being replaced, install the new one and its washer in the gear housing. See **Fig. 85**. Tighten it 38 to 42 lbf·ft (52 to 57 N·m).

    If the service poppet adjusting screw (**Fig. 1**, Ref. 42) and the service sealing jam nut (Ref. 43) are being used for automatic poppet adjustment, turn the adjusting screw into the jam nut until 1.03 to 1.09 inches (26 to 28 mm) protrudes from the bottom of the jam nut. See **Fig. 86**. Install the assembly into the gear housing. Tighten the jam nut 33 to 37 lbf·ft (45 to 50 N·m).

42. Put clean oil on the rack piston Teflon® seal ring and into the bore of the gear housing. Position the rack piston on the worm gear with a gap of 3/8 to 1/2 inch (10 to 13 mm) between the valve housing and the upper poppet adjuster seat and sleeve assembly.

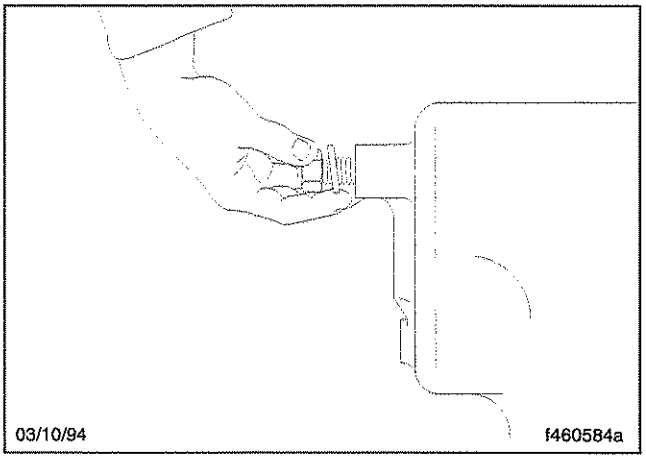
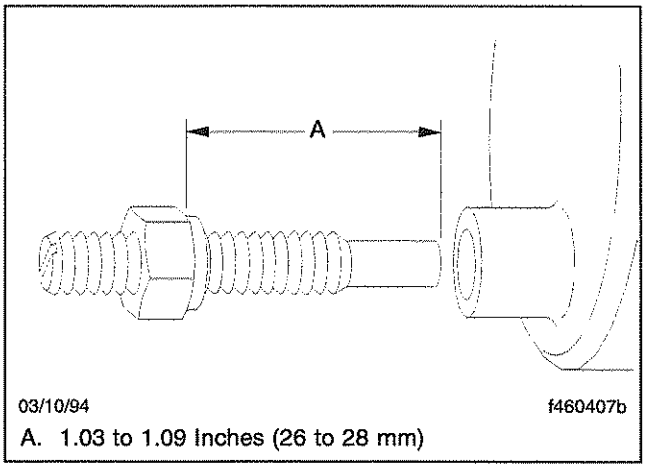


Fig. 85, Install a new Poppet Stopscrew



A. 1.03 to 1.09 Inches (26 to 28 mm)

Fig. 86, Check the Distance from the Bottom of the Jam Nut

Steering Gear Disassembly, Inspection, Assembly, and Final Adjustments

IMPORTANT: This gap is to ensure that the poppets don't make contact with anything while the steering gear is being assembled.

⚠ CAUTION

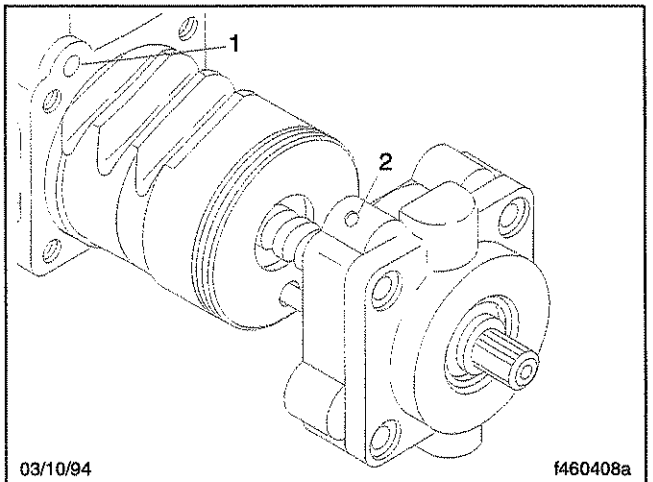
When installing the rack piston in the steering gear housing, be careful not to damage the seal ring on the rack piston, as this could seriously affect the operation of the steering gear.

Do not let the poppet adjuster seat and sleeve assemblies on the rack piston bottom out when installing the rack piston in the gear housing.

43. Install the rack piston and worm shaft assembly in the gear housing, being careful not to damage the seal ring on the rack piston. Don't let the poppet adjuster sleeve assemblies bottom out inside the gear housing. Install the piston with the rack teeth toward the sector shaft hole in the housing. See **Fig. 87**. Be sure the valve housing cylinder feed hole lines up with the gear housing feed hole.

44. Using an E-16 Torx® socket wrench, install and tighten the four valve housing bolts: on TAS65 steering gears—105 to 115 lbf·ft (142 to 156 N·m); on TAS85 steering gears—150 to 170 lbf·ft (203 to 230 N·m). See **Fig. 88**.

45. If the sector shaft adjusting screw is being replaced, do the following:



1. Gear Housing Feed Hole
2. Valve Housing Cylinder Feed-Hole Boss

Fig. 87, Install the Piston with the Rack Teeth toward the Sector Shaft Hole

45.1 Coat the end of the new adjusting screw with wheel bearing grease, and with the sector shaft in a padded vise, insert the new adjusting screw into the recess in the sector shaft end.

45.2 Install a new sector-shaft screw retainer in the sector shaft. Adjust the retainer so that the sector shaft adjusting screw can be turned freely by hand. It should have a maximum end play of 0.002 inch (0.05 mm).

⚠ WARNING

Be careful when staking the sector-shaft screw retainer. If the retainer is broken or cracked, the sector shaft could come loose, resulting in loss of manual and power steering control. This could cause an accident resulting in personal injury or property damage. Replace a broken or cracked sector-shaft screw retainer.

45.3 Stake the sector-shaft screw retainer to the slots in the sector shaft. See **Fig. 89**. Check the adjusting screw again for free movement and end play.

46. On TAS65 gears, lightly oil the side-cover "DU" bushing. Do not grease it. On a TAS85 gear, heavily grease the side-cover bearing with Mobil Temp 1 or 2 grease. Don't oil it. See **Fig. 90**.

47. Put a new seal on special tool J37071 (TAS65), or J38779 (TAS85) so that the garter spring is against the shoulder of the tool. See **Fig. 91**. Press the

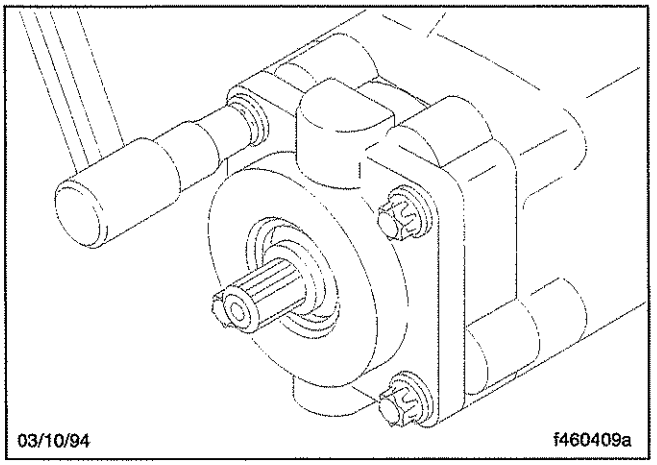


Fig. 88, Install the Valve Housing Bolts

Steering Gear Disassembly, Inspection, Assembly, and Final Adjustments

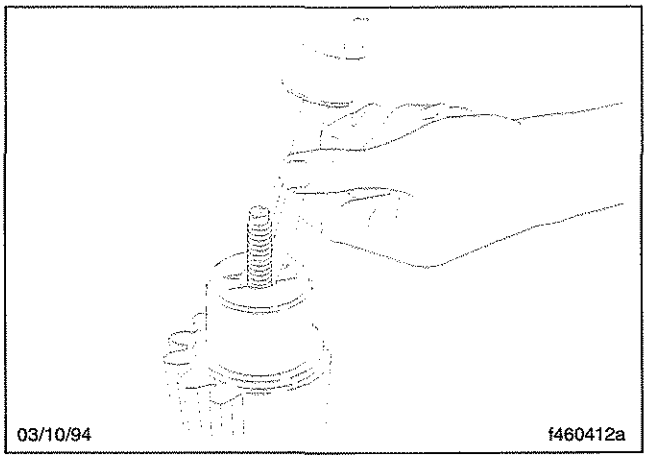


Fig. 89, Stake the Sector-Shaft Screw Retainer

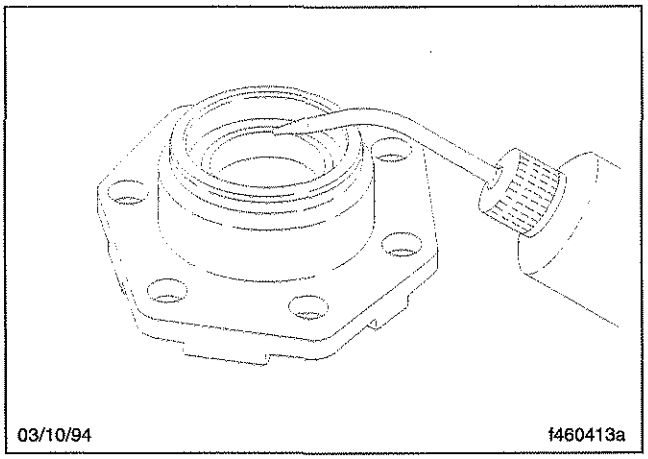


Fig. 90, Applying Oil to the DU Bushing

new seal into the side cover with a force of 100 to 800 lbs (45 to 363 kg). Make sure the seal is seated against the bottom of the counterbore.

48. On TAS65 gears, lightly oil the short bearing end of the sector shaft. On TAS85 gears, heavily grease the short bearing end of the sector shaft. Insert the sector shaft into the side cover. Screw the sector shaft adjusting screw counterclockwise into the side cover, until the screw seats. See **Fig. 92**. Then rotate the adjusting screw clockwise one turn, so that the side cover rotates freely on the sector shaft.

49. Loosely install the sector-shaft adjusting screw jam nut onto the sector-shaft adjusting screw a few threads. See **Fig. 93**. Final adjustment will be made later.

50. Press a new rubber plug into the hole provided in the side cover, until the plug is flush. See **Fig. 94**.

⚠ WARNING

Do not weld or plug this hole permanently. This is a safety vent which functions only if the side cover output shaft seal doesn't work. If the seal doesn't work and the plug cannot vent, the steering gear can lock up or otherwise malfunction. This could result in a loss of steering control, which could cause personal injury or property damage.

51. Apply clean grease to a new side cover gasket, and install it on the side cover. See **Fig. 95**. Apply enough grease to hold the gasket in place.

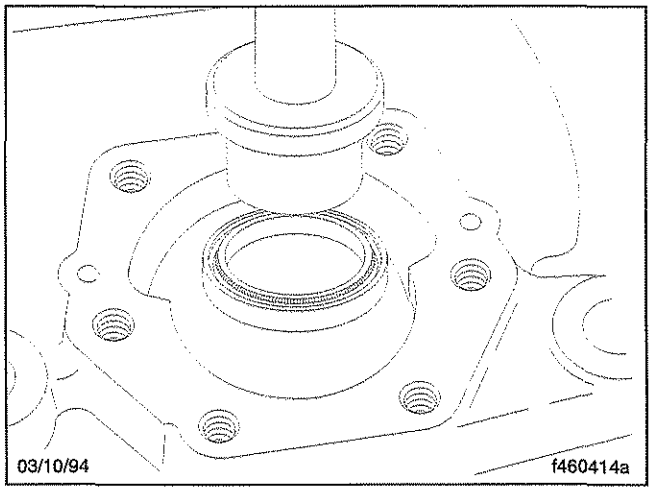


Fig. 91, Press in the New Seal

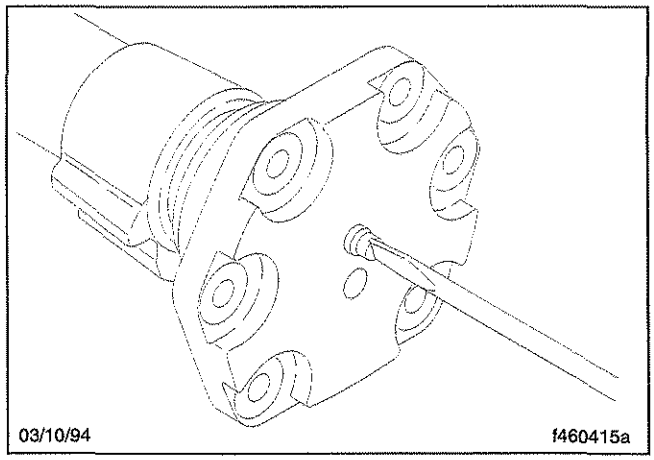


Fig. 92, Install the Sector Shaft Adjusting Screw

Steering Gear Disassembly, Inspection, Assembly, and Final Adjustments

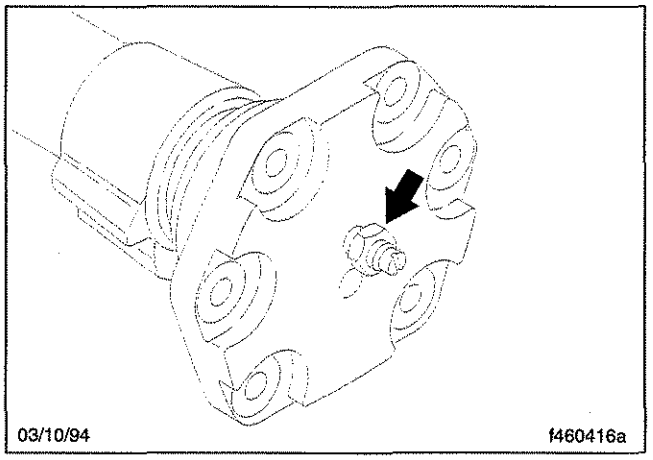


Fig. 93, Loosely Install the Sector-Shaft Adjusting Screw Jam Nut

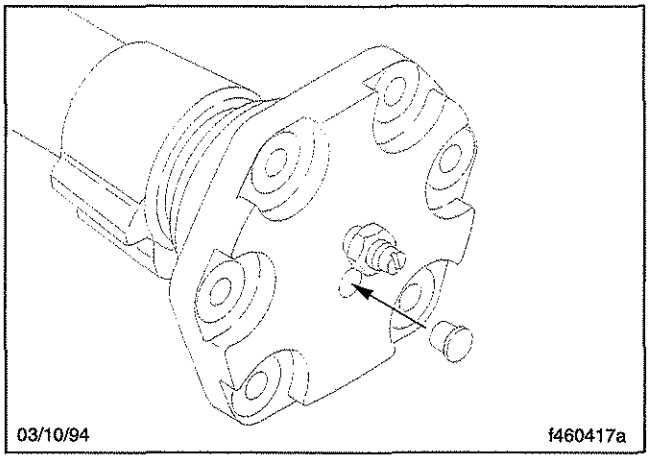


Fig. 94, Press in a New Rubber Plug

52. There are four teeth on the rack piston. Turn the input shaft as needed to position the rack piston so that the tooth space identified by the pencil in **Fig. 96** (it is the space between the second and the third tooth) is in the center of the sector shaft opening. See **Fig. 97**. This will center the rack piston in the opening.

⚠ WARNING

If the rack piston is not centered, steering gear travel will be severely limited in one direction. This could cause an accident, resulting in personal injury or property damage.

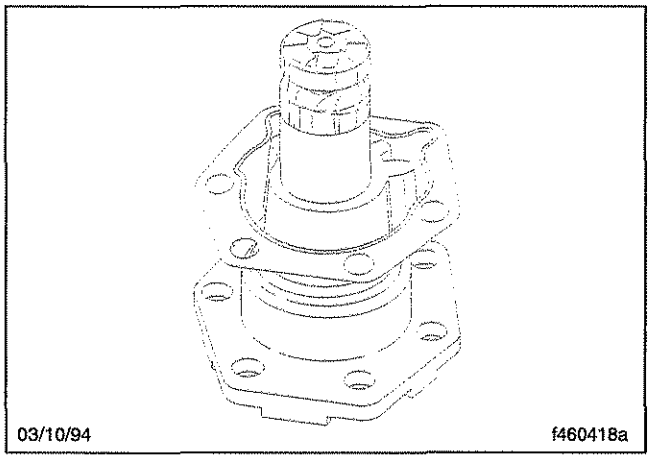


Fig. 95, Install the Side Cover Gasket

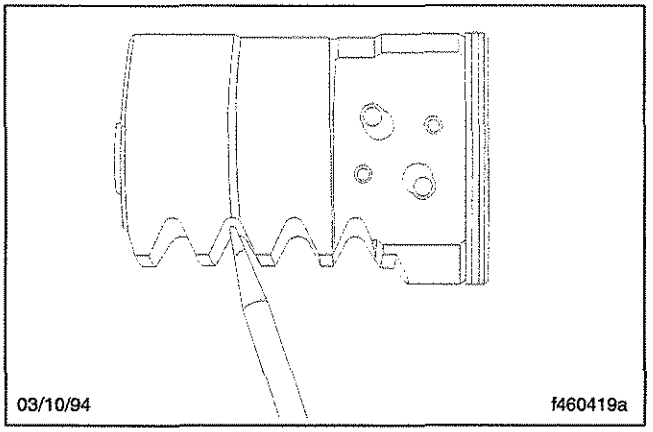


Fig. 96, Check the Tooth Space

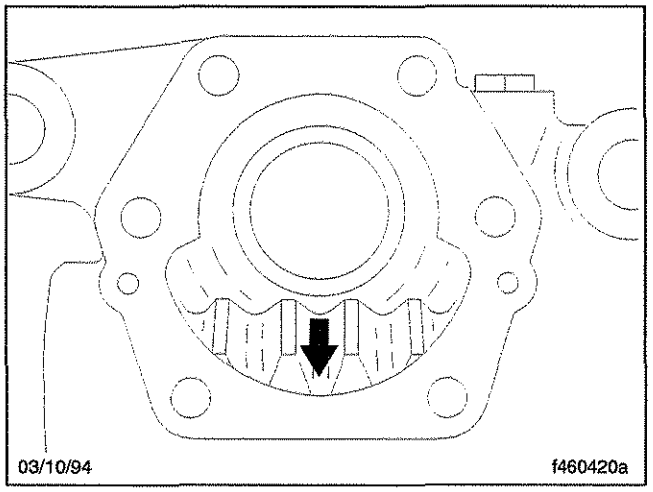


Fig. 97, Check the Tooth Position

53. Remove all tape from the sector shaft splines. Retape the splines and the bolt groove with *one layer* of masking tape.

⚠ CAUTION

If the splines on the sector shaft are not taped correctly, the splines will damage the housing seal during assembly, causing the seal to leak.

54. Install the sector shaft and side cover, as an assembly, in the gear housing. See **Fig. 98**. Make sure the center tooth of the sector shaft engages the center space (between the second and third teeth) of the rack piston.

55. Install the special side cover bolts in the side cover. Using the torque pattern shown in **Fig. 99** or **Fig. 100**, tighten dry bolts 220 to 240 lbf·ft (298 to 325 N·m), or lubricated bolts 160 to 180 lbf·ft (217 to 244 N·m). See **Fig. 101**.

56. Remove the tape from the sector shaft, and pack the end of the housing trunnion area at the sector shaft with Mobil Temp 1 or 2 grease, or equivalent. Put grease on the new trunnion dirt seal, and install it over the sector shaft and into the trunnion bore. See **Fig. 102**.

IMPORTANT: Make sure the input shaft seal is installed squarely in the seal bore.

57. Apply clean grease to the new input shaft seal. Then place it, garter spring side first, over the input shaft. Using special tool J37073 and a mallet, tap the seal into the valve housing seal bore until

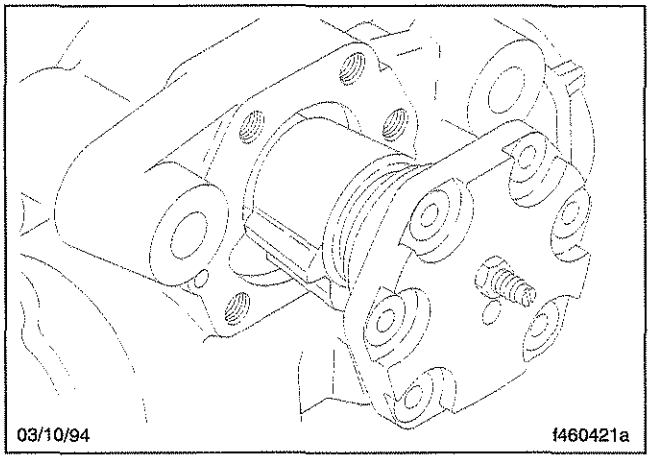


Fig. 98, Install the Sector Shaft and Side Cover

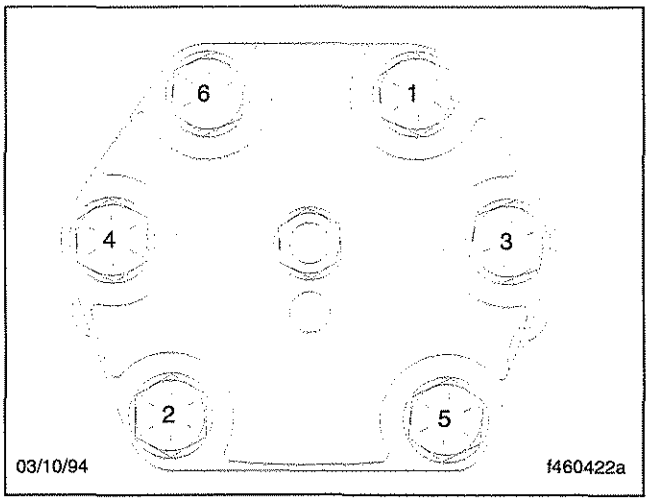


Fig. 99, Six-Bolt Tightening Sequence

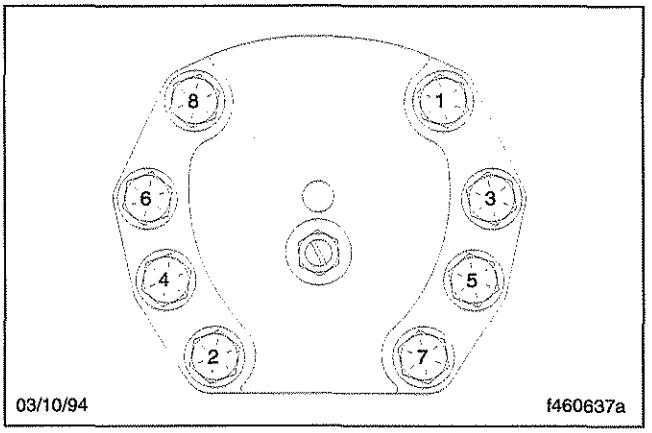


Fig. 100, Eight-Bolt Tightening Sequence

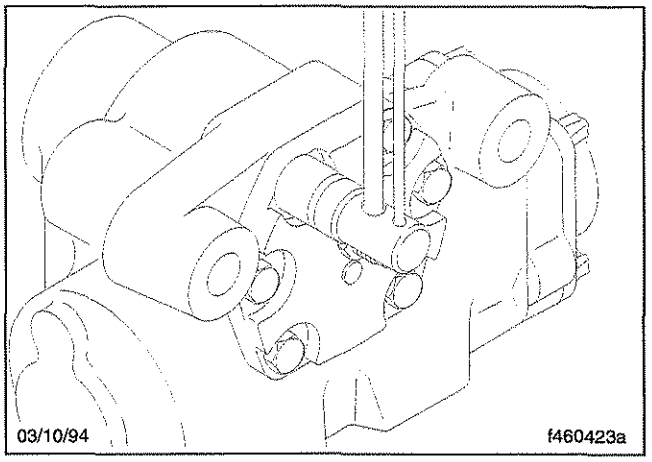


Fig. 101, Install the Special Side Cover Bolts

Steering Gear Disassembly, Inspection, Assembly, and Final Adjustments

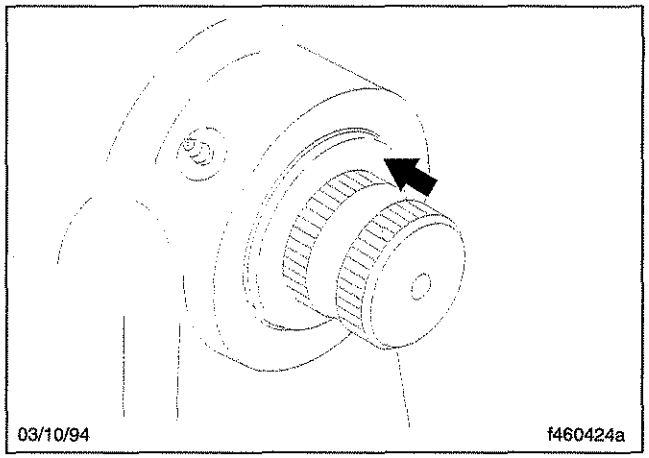


Fig. 102, Install a new Trunnion Dirt Seal

it clears the retaining ring groove. See **Fig. 103**. Remove any seal material that may have sheared off in the retaining ring groove.

58. Install a new retaining ring into its groove in the valve housing. See **Fig. 104**.

59. Pack the end of the valve housing bore (around the input shaft) with Mobil Temp 1 or 2 grease, or equivalent. Apply grease to the new dirt and water seal, and install it over the input shaft. Seat the dirt and water seal in the groove behind the serrations of the input shaft, and against the valve housing. See **Fig. 105**.

60. If the grease fitting is being replaced, install a new one in the gear housing, using a piece of metal tubing over the head of the new fitting, as shown in **Fig. 106**. Tap the new grease fitting in place.

61. If the auxiliary port plugs were removed, install new O-rings on them, and install the plugs in the gear housing. Tighten them 25 to 35 lbf·ft (34 to 47 N·m).

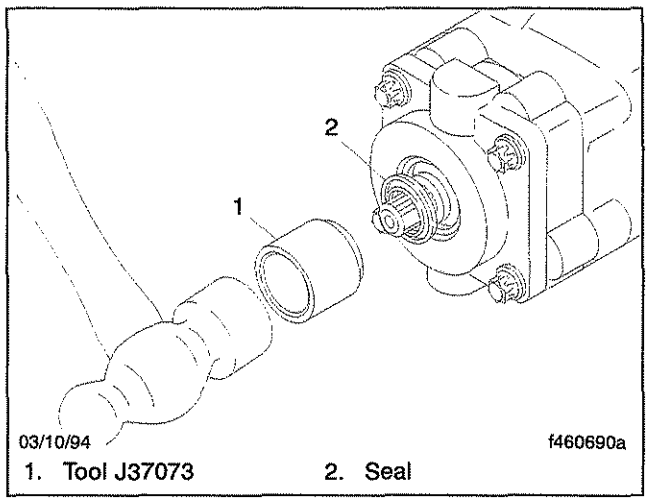


Fig. 103, Tap the Seal into the Valve Housing Bore

Final Adjustments

Before installing the steering gear on the vehicle, make these adjustments:

NOTE: Worm shaft preload adjustment was done when the input shaft was installed in the valve housing during the assembly procedure.

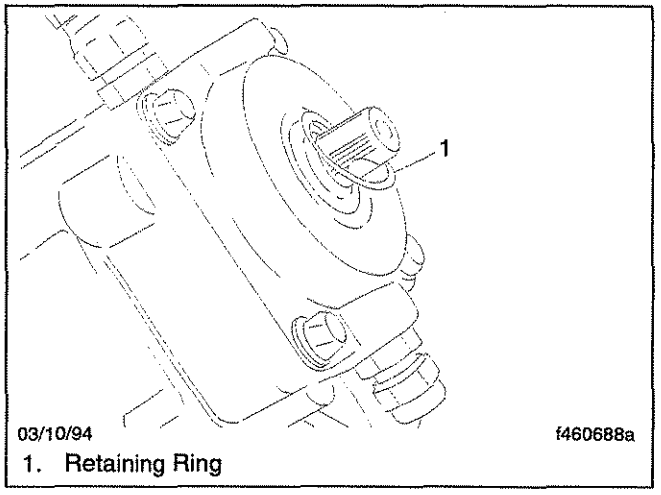


Fig. 104, Install a new Retaining Ring

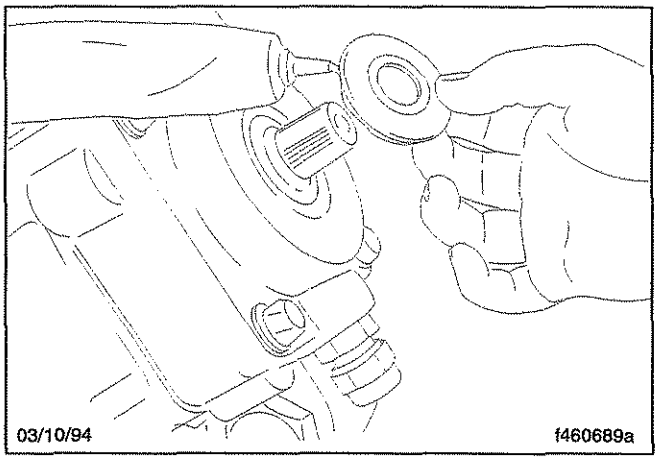


Fig. 105, Install the Dirt and Water Seal

Steering Gear Disassembly, Inspection, Assembly, and Final Adjustments

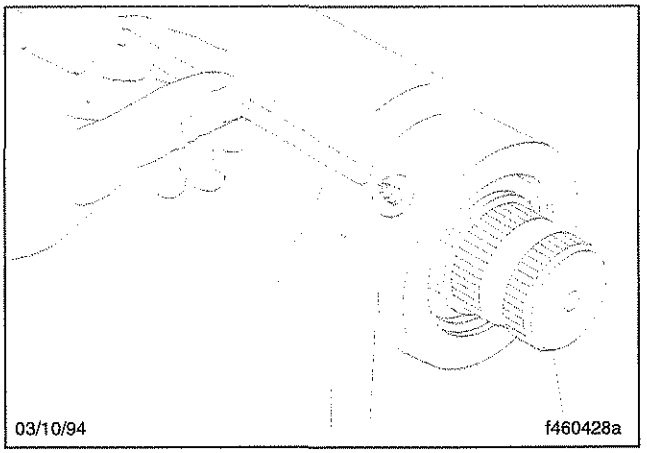


Fig. 106, Install a new Grease Fitting

⚠ CAUTION

When the steering gear is not connected to the steering system, don't turn the input shaft more than 1-1/2 turns from the center position, or the automatic poppets could become inoperative when the steering gear is installed on the vehicle. This would require either disassembling the gear to position the poppet seat and sleeve assemblies for automatic adjustment, or using the special poppet adjusting screw kit 021407-X1 for manual poppet adjustment.

1. Center the steering gear by turning the input shaft until the timing mark on the end of the sector shaft is in line with the timing mark on the end of the housing trunnion. See **Fig. 107**. Use a 12-point, 11/16- or 3/4-inch socket wrench to turn the input shaft.

   If the input shaft is turned more than 1-1/2 turns from the center position, you will have to either disassemble the gear to adjust the poppets again, or install the special poppet adjusting screw kit 021407-X1.

NOTE: If new or reset poppets are in the gear, they will be moved when the input shaft is turned less than one rotation in either direction from the center position. This will not affect the function of the poppets.

2. Adjust the sector shaft adjusting screw while turning the input shaft 180 degrees each side of center, until the input shaft reaches a torque of 30 to 35 lbf ·in (340 to 400 N·cm). See **Fig. 108**. Use a 12-point socket and an inch-pound torque wrench to turn the input shaft.
3. Back out the sector shaft adjusting screw one turn. Note the torque needed to turn the input shaft through 180 degrees each side of center.
4. Tighten the sector shaft adjusting screw so that the torque noted in the previous step is increased by 2 to 4 lbf·in (20 to 40 N·cm). Then, while holding the adjusting screw in place, tighten the sector shaft adjusting screw jam nut 40 to 45 lbf·ft (54 to 61 N·m).
5. Check the torque needed to turn the input shaft. If it is more than 35 lbf·in (400 N·cm), repeat the two previous steps to adjust the input shaft again.

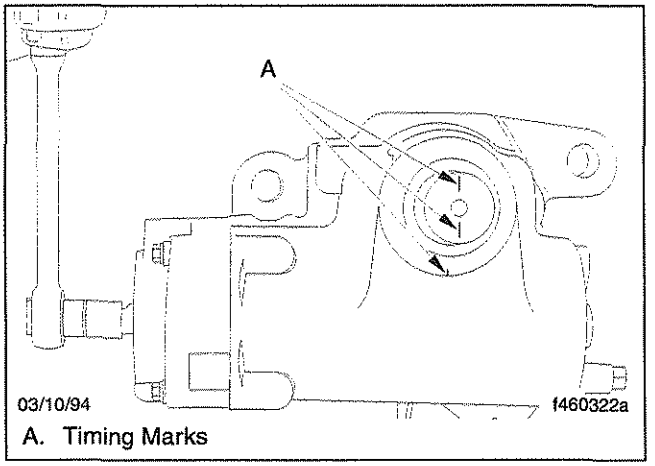


Fig. 107, Check the Timing Marks

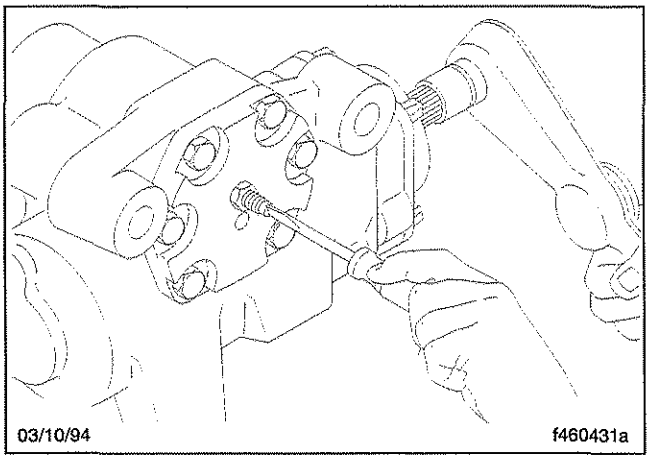


Fig. 108, Adjust the Sector Shaft Adjusting Screw

Input Shaft Seal Replacement

Replacement

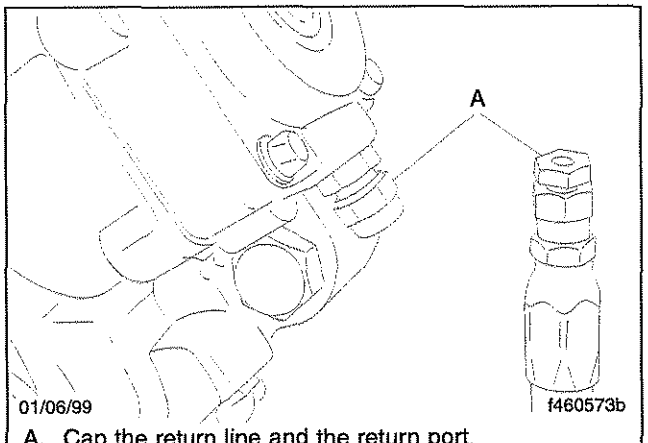
⚠ WARNING

All steering mechanisms are safety items. Because of this, follow the instructions in this subject exactly. Failure to do so may result in loss of steering, which could cause an accident resulting in personal injury or property damage.

Be sure that the required tools are available before beginning the service procedures described here. See the special tools table in **Specifications, 400**. The special tool required for replacing the seal is available from the Kent-Moore Tool Division, or an affiliated dealer.

If the input shaft seal is causing an external leak, use the following procedure to replace it. This procedure doesn't require removing and disassembling the steering gear.

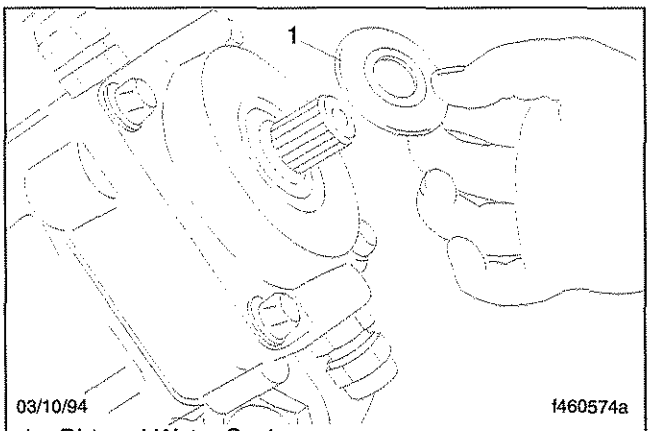
1. Apply the parking brakes, chock the tires, and tilt the hood.
2. Clean all dirt from the area around the return line fitting and input shaft.
3. Disconnect the return line from the steering gear, and cap the line. See **Fig. 1**. Also cap the return port of the gear with a 3/4–16 O-ring-type high pressure fitting.
4. Disconnect the steering driveline from the steering gear input shaft. For instructions, refer to **Subject 110**.



A. Cap the return line and the return port.

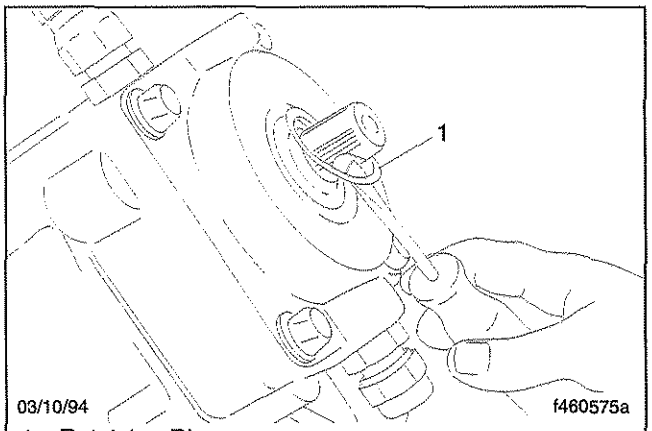
Fig. 1, Disconnect the Return Line

5. Remove the dirt and water seal (**Fig. 2**) from the input shaft.
6. Wipe off the grease from around the input shaft, and then remove the spiral retaining ring (**Fig. 3**) by inserting a screwdriver into the notch in the end of the ring.
7. Slip the input yoke back onto the input shaft. Install the pinch bolt (**Fig. 4**), but don't tighten it.
8. Tie or wrap a shop towel around the input shaft area (**Fig. 5**), and place a drip pan under the gear to catch any spilled oil.
9. If needed, fill the power steering fluid reservoir. For the correct fluid, refer to the vehicle maintenance manual.



1. Dirt and Water Seal

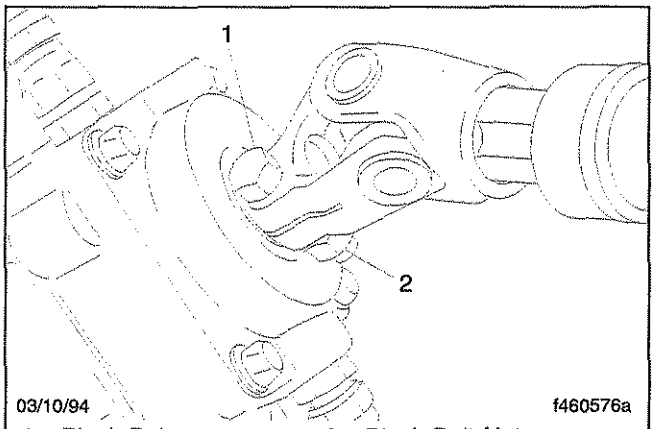
Fig. 2, Remove the Dirt and Water Seal



1. Retaining Ring

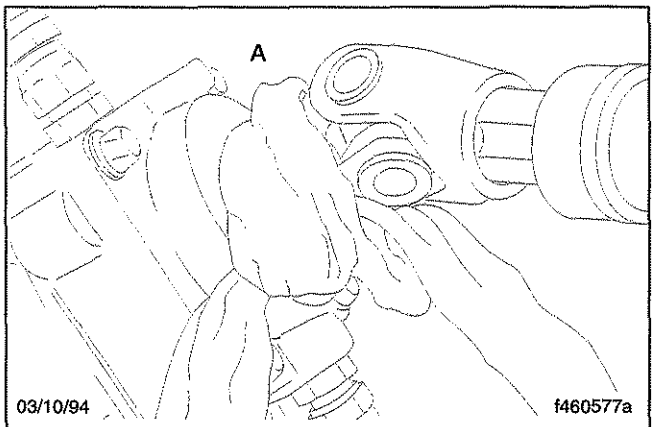
Fig. 3, Remove the Retaining Ring

Input Shaft Seal Replacement



1. Pinch Bolt 2. Pinch Bolt Nut

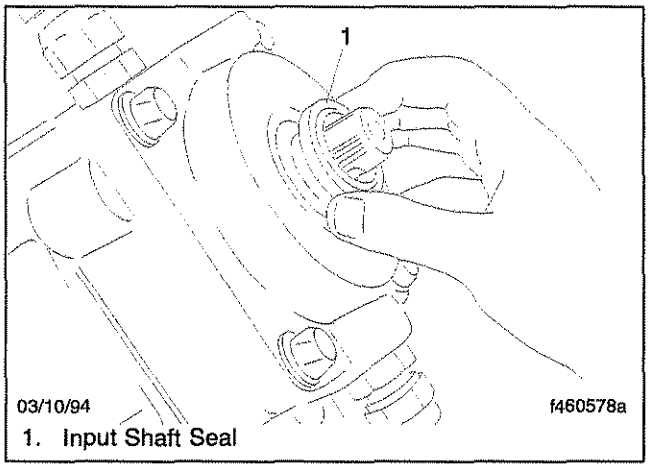
Fig. 4, Install the Pinch Bolt



A. Cover the input shaft area.

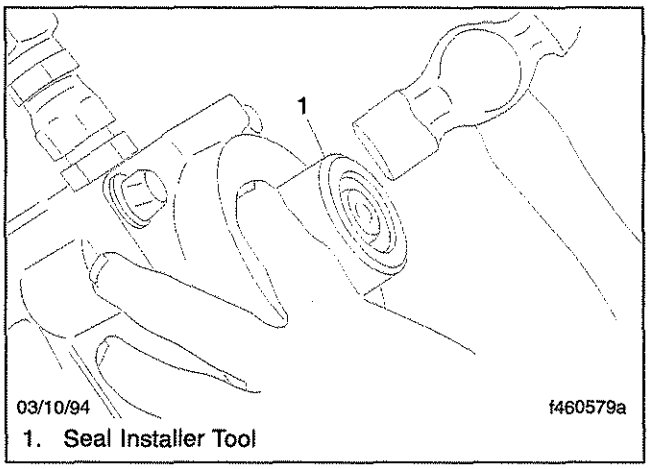
Fig. 5, Shop Towel Covering the Input Shaft

10. With the transmission in neutral, momentarily crank the starter (quickly turn off the engine if it starts).
11. Remove the shop towel and disconnect the steering driveline from the input shaft.
12. Remove the input shaft seal (**Fig. 6**).
13. Check the seal area of the valve housing for any seal fragments. Remove any that are found.
14. Check the seal for heat damage. If the seal is stiff and brittle, and not pliable like the new seal, it is probably heat damaged. Determine and fix the cause of excessive heat. For instructions, refer to **Troubleshooting, 300**.
15. Put clean grease on the new input shaft seal, and place it over the input shaft, garter spring side first (**Fig. 6**). Place the seal installer tool J37073 over the input shaft and against the seal, small diameter end first (**Fig. 7**). Tap the seal installer tool until the tool shoulder is square against the valve housing. Remove any seal material that may have sheared off in the seal bore or retaining ring groove.
16. Insert the new retaining ring into the groove.
17. Pack the end of the valve housing bore around the input shaft with clean high-temperature industrial grease (Mobil Temp 1 or 2, or equivalent). Also apply grease to a new dirt and water seal. Install the seal over the input shaft, seating it in the



1. Input Shaft Seal

Fig. 6, Install the Input Shaft Seal



1. Seal Installer Tool

Fig. 7, Position the Seal Installer Tool

groove behind the serrations and against the valve housing (**Fig. 8**).

18. Connect the steering driveline to the steering gear input shaft. For instructions, refer to **Subject 110**.
19. Connect the return line to the steering gear return port.
20. Fill and bleed the steering system.

    IMPORTANT: For the next two substeps, do not turn the steering wheel. Doing so can cause air to enter the system, which can make it more difficult and time-consuming to bleed air from the system.

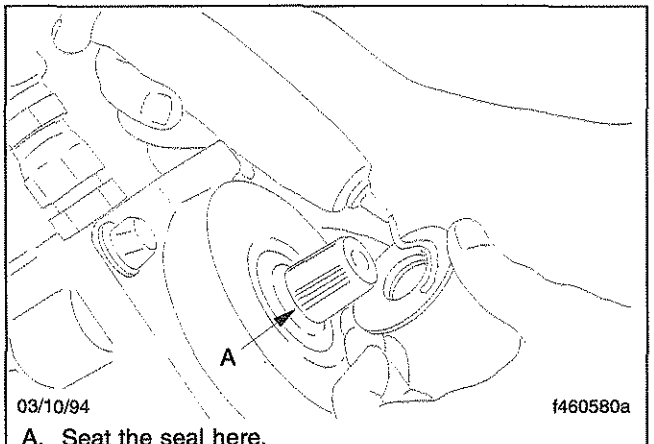
    20.1 Crank the starter for 10 seconds without allowing the engine to start. If the engine does start, shut it down immediately. Check and fill the reservoir as needed.

    Repeat this procedure three times, each time checking and filling the reservoir.

    20.2 Start the engine and let it idle for two minutes. Shut down the engine, and check the fluid level in the reservoir.

    20.3 Start the engine again. Steer the vehicle from full-left to full-right, several times. As needed, add fluid to the full line on the reservoir dipstick.

21. With the engine running, check for leaks in the steering system. Eliminate leaks as needed.
22. Lower the hood, and remove the chocks from the tires.



A. Seat the seal here.

Fig. 8, Install the Dirt and Water Seal

Post-Service Checks

After power steering components have been worked on, and before the vehicle is placed into service, the following items must be checked.

⚠ WARNING

Failure to check the following items could result in damage to the power steering system. This could cause a loss of hydraulic assist, which could cause personal injury or property damage.

1. Place a thermometer in the power steering reservoir, then warm the hydraulic system to normal operating temperature of 125° to 135°F (51° to 57°C), by operating the engine at low idle, while turning the steering wheel through several full left and right turns. With the engine running and the power steering system at operating temperature, turn the steering wheel slowly from stop to stop, while checking the power steering reservoir for frothing or a change in the fluid level (a sign that air is trapped in the system). If air is present, inspect the system for leaking hoses or loose fittings. Replace the hoses or tighten the fittings as necessary. Bleed the air from the system.
2. With the engine turned off and warm, check the power steering reservoir fluid level, using the instructions in the steering section in the vehicle maintenance manual.
3. At full-left and full-right wheel cuts, be sure the axle stops (on the rear-side of the spindle) are set so there is at least 1/2-inch (13-mm) clearance between the tires and any fixed components that are attached to the vehicle. Clearance between moving components should be 3/4 inch (19 mm). If clearance is less than the above, reset the axle stops.
4. Check that the poppet plungers are set correctly. If needed, adjust them. For instructions refer to **Subject 100**.
5. If there are still problems with the power steering system, go to **Troubleshooting, 300**, and perform the steering system hydraulic tests as instructed; otherwise, go to the next step.
6. Test drive the vehicle, or take a ride with the driver. Check the steering wheel spoke position. If during straight-ahead driving on a level road, the steering wheel spokes are not within ±10 degrees of the 9 o'clock and 3 o'clock positions, remove the steering wheel and reposition it.

Troubleshooting

If there is a complaint about the steering system, do the checks below before servicing the steering gear or pump. This procedure is intended as a general guideline for the mechanic or technician to follow when diagnosing steering complaints.

The first step is always to talk to the driver. Get a detailed explanation of what the problem is and when it happens. Ask about any repairs, modifications, or prior adjustments. Then, if the truck is roadworthy, test drive it or ride with the driver and try to duplicate the problem.

After identifying the complaint, see the appropriate box in **Table 1** that best fits the complaint. Form SD–94, "Checklist for Troubleshooting Hydraulic Power Steering System Performance," should also be used to record test information. Form SD–94 (**Fig. 10** and **Fig. 11**) can be ordered through your dealer. Dealers can order form SD–94 through the TAO electronic mail system.

- At the TAO Mail Menu, key in B for bulletin boards.
- Tab down to Pub–Forms–FTL and key in L for list.
- At Freightliner Manuals Order Form, key in U.

If you don't have access to the TAO electronic mail system, contact Publishing Distribution at (503) 735-7343.

The table on the form will refer you to a series of checks or tests to do for each type of complaint. The easiest and least costly checks are listed first. By doing the checks in order, starting with the lowest number, you can avoid unnecessary labor and expense. Instructions for doing the checks are given on the following pages. Each numbered step in the instructions corresponds with the diagnostic checks in **Table 1**. The numbers and checks in this table correspond to the numbered steps that follow.

Troubleshooting and Diagnostic Steps										
Step*	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Complaint	**Tire Press./ Vehicle Load**	**Fifth Wheel Lube**	**Vehicle Alignment**	**Loose/ Binding Components**	**Noise**	**System Operating Temp.**	**System Leaks or Restrictions**	**Pump Performance**	**Gear Poppet Adjustment**	**Gear Internal Leakage**
Hard or Heavy Steering	•	•		•		•	•	•	•	•
Low Assist										
Binding	•	•		•		•	•	•	•	•
Locking										
Occasional Loss of Assist										
Reduced Wheel Cut									•	
Vehicle Pulls to One Side	•		•					•		
Darting/ Oversteer	•	•	•	•						
Vehicle Wanders										
Noisy Steering					•		•	•		

Troubleshooting and Diagnostic Checks

Troubleshooting and Diagnostic Steps										
Step*	1	2	3	4	5	6	7	8	9	10
Complaint	Tire Press./ Vehicle Load	Fifth Wheel Lube	Vehicle Align-ment	Loose/ Binding Compo-nents	Noise	System Operat-ing Temp.	System Leaks or Restric-tions	Pump Perfor-mance	Gear Poppet Adjust-ment	Gear Internal Leakage
Steering Gear External Seal Leaks						•	•	•		
Excessive Heat										

* The numbers in this table correspond to the numbered steps in the diagnostic checks.

Table 1, Troubleshooting and Diagnostic Steps

Diagnostic Checks

1. Check tire pressure and load.

   1.1 Check the tire pressure. Low pressure causes increased steering effort due to extra friction with the road surface. Check the tires for damage or erratic wear. Make sure the tires on each side of the front and rear axles are inflated to the correct pressure. Unequal tire pressure causes unequal friction between the tire and the road. This can cause pulling to one side. Correct the pressures if needed. See **Fig. 1**.

   1.2 Check whether duplex or oversized tires have been installed, and that the tire sizes are correctly matched. Extra tire width causes increased steering effort due to extra friction with the road surface. Also, the power steering gear poppets will need to be adjusted if the axle stops were turned out to reduce wheel cut due to the change in tires. See **Subject 100** for instructions.

   1.3 Determine whether the vehicle is operated at or over the rated load. Increased load causes greater steering effort. It may be necessary to modify the power steering, wheels, tires, or springs.

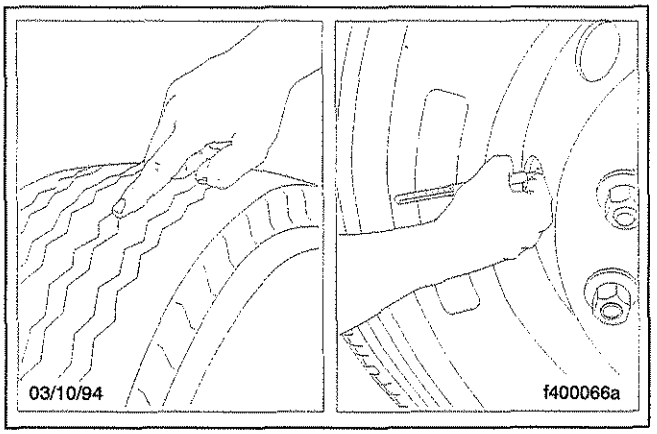


Fig. 1, Check the Tire and the Tire Pressure

2. Check the fifth wheel.

   See if the fifth wheel is adequately lubricated. A dry fifth wheel plate makes it difficult to change direction. See **Fig. 2**. Check the plate surface for burrs, gouges, or irregularities.

3. Check the wheel bearing adjustment and axle alignment.

   3.1 Check wheel bearing adjustment. See **Group 33** and **Group 35** for instructions.

   3.2 Check the front and rear axles for correct alignment. Adjust them back to specifications if necessary. See **Group 33** and **Group 35** for instructions.

4. Check for loose or binding components.

   Check whether any steering components are loose or binding, need maintenance, or need adjustment as follows:

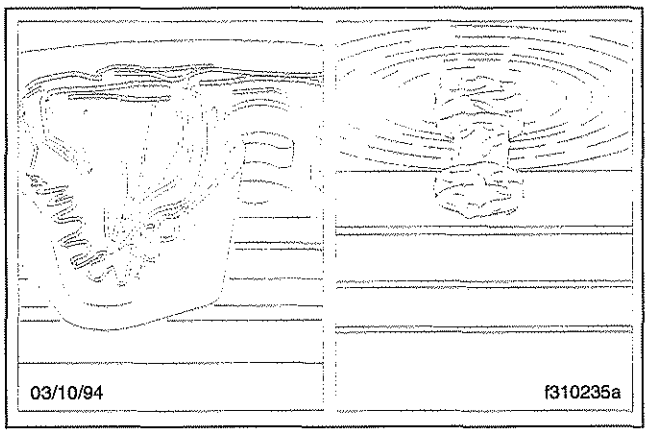


Fig. 2, Check the Fifth Wheel

4.1 Lubricate the drag link, tie rods, and knuckle pins. See the applicable groups in the *Century Class Trucks Maintenance Manual*.

4.2 Chock the rearmost tires and raise the front tires off the ground. With the engine shut down, turn the steering wheel and check for looseness or binding. Make sure all components are free to move but are not excessively loose.

4.3 Check the steering driveline U-joints for looseness or binding. Lubricate them if needed. For instructions, see **Group 46** in the *Century Class Trucks Maintenance Manual*.

4.4 Check for correct steering driveline phasing. See **Fig. 3**. Reset the phasing if needed.

4.5 Check the sector shaft adjustment. See **Subject 100** for instructions.

⚠ WARNING

Failure to connect the input yoke and the pitman arm, and to tighten all fasteners to the prescribed torque value, can cause loss of steering and vehicle control.

4.6 With the engine off, chock the rearmost tires and place the front tires on radius plates (turntables). Disconnect the drag link from the steering arm. See **Fig. 4**.

By hand, pull the tire to one axle stop and release. The tire should self-return to almost straight ahead. See **Fig. 5**. Repeat in opposite direction. If the tire does not return to near straight ahead, check for a binding or lack of lubrication problem in the steering axle kingpin bushings or tie rod linkage. Connect the drag link and tighten the castle nut and install a new cotter pin. See the drag link section in this group.

⚠ CAUTION

Do not steer the gear with the linkage removed, as misadjustment of automatic poppets may result.

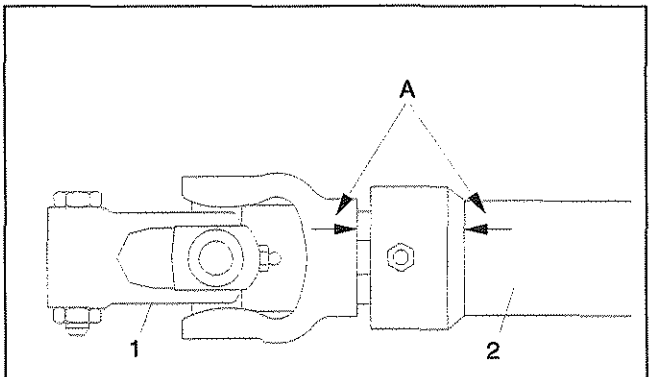
⚠ WARNING

Failure to connect the drag link and the steering arm, and to tighten all fasteners to the prescribed torque value, can cause loss of steering and vehicle control.

4.7 Visually inspect all suspension fasteners and components for wear or looseness.

5. Check for noise.

NOTE: Noises from the power steering system do not necessarily mean there is a problem. Some noises are



A. Align arrows.
1. Lower End Yoke
2. Driveline Tube and Yoke Assembly

Fig. 3, Check for Correct Steering Driveline Phasing

Troubleshooting and Diagnostic Checks

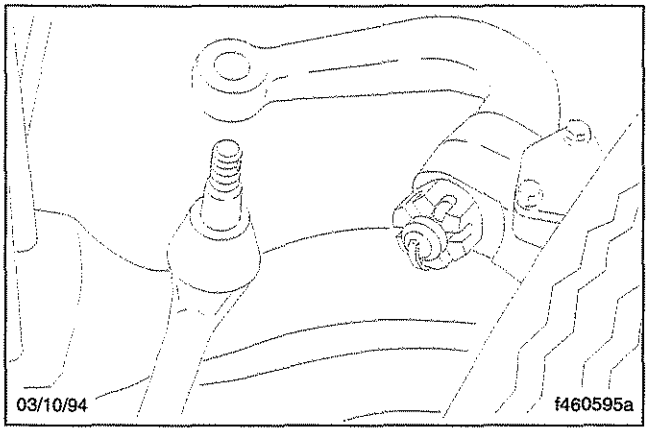


Fig. 4, Disconnect the Drag Link

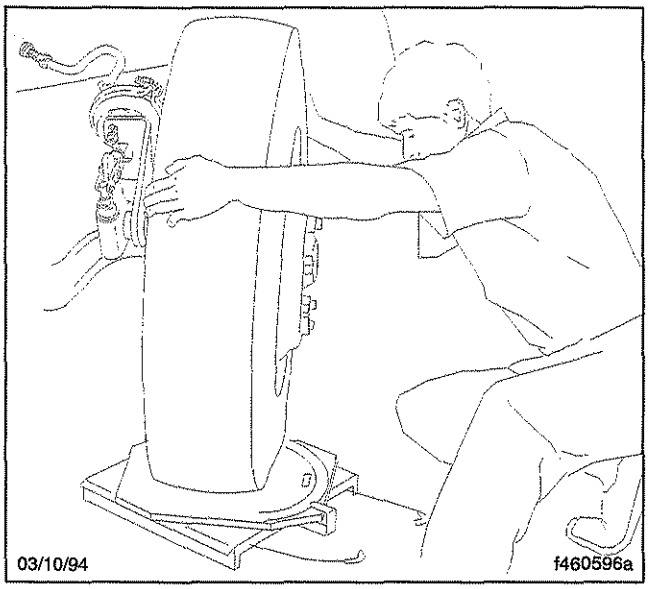


Fig. 5, Pull the Tire to One Axle Stop

normal and are the result of proper operation. See **Table 2**.

6. Test the system operating temperature.

6.1 Park the vehicle outside.

6.2 Check for correct fluid level. If required, add fluid.

6.3 Place a thermometer in the fluid reservoir to monitor fluid temperature.

6.4 Run the vehicle at governed rpm for 40 minutes to bring the fluid to an elevated temperature. Check and record fluid temperature on the check-list (form SD–94) at the start of the 40 minute test, and at 10, 20, 30, and 40 minutes.

Do not allow the temperature to exceed 150°F (66°C) above the outside temperature (ambient), or 250°F (121°C). If this temperature is exceeded, stop the 40 minute test and record the last noted temperature on the checklist.

6.5 If the temperature does not exceed 150°F (66°C) above the outside temperature (ambient), or 250°F (121°C) during the 40 minute test, excessive system heat is probably not the cause of the complaint. Go on to the next test for the complaint. See **Table 1**.

6.6 If at any time the temperature exceeded 150°F (66°C) above the outside temperature (ambient), or 250°F (121°C), the system is operating at excessive temperature levels, and steering system performance and life may be affected. Damage to hoses, seals, and other components may result if the vehicle is operated at excessive steering system temperatures.

6.7 Excessive system restrictions or excessive pump flow may be the cause of the complaint. Go on to the next test for the complaint. See **Table 1**.

Power Steering System Noises	
Symptom	**Action to Take**
Growling or Other Abnormal Steering Noise	Check the fluid level. Check for air (bubbles or foam). Check for hose and fitting leaks. Add fluid if needed. If the fluid has air, check for inlet tube/hose leaks. Correct all leaks.
A Change from the Usual Pump Sound	Check the power steering fluid reservoir. Check for air in the fluid (bubbles or foam). If the fluid has air, check for inlet tube/hose leaks. Correct all leaks.

Power Steering System Noises	
Symptom	**Action to Take**
Clicking Noise During a Turn	Check for loose steering components. Check the front suspension for insufficient spring pin shims. Tighten any loose steering components. Add front spring pin shims if needed.
Hissing When the Steering Wheel Is at or Near Full Turn	Fluid flowing past a poppet valve makes a hissing noise. This is normal. No action is needed.
Hissing at Less Than Full Turn	Do check (step) no. 9 (Steering Gear Poppet Test).

Table 2, Power Steering System Noises

7. Check for leaks, restrictions, and test system back pressure.

   7.1 Check for correct fluid level. If required, add fluid.

   7.2 The inspection and test must be done with the power steering fluid at operating temperature 150° to 160°F (66° to 71°C). With the engine at idle, monitor the fluid temperature with a thermometer in the fluid reservoir. If the fluid is too cold, raise the temperature by turning the steering wheel from stop to stop until the desired temperature is reached.

   7.3 With the engine at idle, visually inspect all hoses and fittings for signs of kinked or collapsed hoses, or leaking fittings. Visually inspect all external seals. Repair all leaking fittings, and replace parts as required. Replace any leaking seals. Inspect the seal bores and sealing surfaces for scrapes or burrs. Be sure the seals are installed correctly using the recommended tools. If the steering gear input shaft seal is excessively hard, do the check (Test System Operating Temperature), if not already done.

   7.4 Install a low pressure gauge 200 to 300 psi (1378 to 2069 kPa) maximum between the pressure line and the pump (location P2). See **Fig. 6**.

⚠ CAUTION

Don't move the steering wheel or allow the system pressure to exceed the rating of the gauge during the following procedure or damage to the gauge may result.

   7.5 Run the engine at idle and check for correct fluid level. If required, add fluid. If bubbles or foam appear in the reservoir, check the hose fittings for looseness or leaks.

   7.6 With the engine at idle, read the total system back pressure on the pressure gauge. Record the reading on the checklist (form SD–94).

   7.7 If the total system back pressure (P2) is greater than 100 psi (689 kPa), go to the next step. If the pressure at P2 is less, restriction is not a problem. Go to the next test for the complaint. See **Table 1**.

   7.8 System back pressure has been determined to be excessive and the component at fault can be pinpointed by checking pressures at key locations in the steering system. With the engine at idle, use the low pressure gauge and hose connection adapters necessary to measure pressures at all locations identified in **Fig. 6**. Each time the gauge is moved, ensure that the fluid level is correct, and air is removed from the system by running the engine at idle and checking the fluid level.

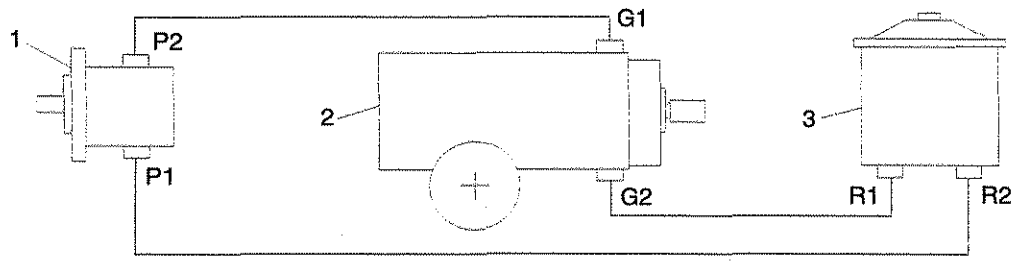
   7.9 Determine the individual component restrictions by subtracting the values shown in **Table 3**. Record the values on form SD–94.

   7.10 See the column on the right in **Table 3** for action to take if any component exceeds the maximum allowable restriction as listed for each component.

8. Test pump performance.

   8.1 Set up the system for hydraulic checks. See **Subject 305** for instructions.

Troubleshooting and Diagnostic Checks



1. Steering Pump 2. Steering Gear 3. Reservoir

Fig. 6, Plumbing Diagram

System and Component Restrictions		
Total System and Component Restrictions	**Maximum Allowable**	**Action to Take**
P2 =Total System	100 psi (689 kPa)	Check pressures at the key locations.
P2-G1 = Hose: Pump-to-Gear	12 psi (83 kPa)	Check for a kinked or plugged hose. Replace the hose if necessary.
G1-G2 = Steering Gear	55 psi (379 kPa)	The gear rotary valve is damaged. Replace the gear. See instructions in this manual.
G2-R1 = Hose: Gear-to-Reservoir	12 psi (83 kPa)	Check for a kinked or plugged hose. Replace the hose if necessary.
R1-R2 = Reservoir	2 qt: 4 psi (28 kPa) 9 qt: 8 psi (55 kPa)	Replace the filter. Check for internal blockage.
R2-P1 = Hose: Pump Supply	12 psi (83 kPa)	Check for a kinked, collapsed, or plugged hose. Replace the hose if necessary.

Table 3, System and Component Restrictions

8.2 Make sure the fluid temperature is 150° to 160°F (66° to 71°C) and the vehicle is stationary with the front wheels pointing forward and the rearmost tires chocked.

8.3 Run the engine at idle. See the engine idle table in **Subject 305** for correct engine idle speed.

8.4 Adjust idle speed, if necessary. See the engine manufacturer's instructions.

8.5 Slowly close the load valve. When the valve is completely closed, read the pressure gauge. See **Fig. 7**.

⚠ CAUTION

Don't leave the valve closed for longer than 5 seconds since this could damage the power steering system.

8.6 If the pressure rises rapidly, appears to be uncontrolled, or rises above the maximum pressure of 2275 psi (15 650 kPa), open the load valve immediately. Indicate on form SD–94 whether the pump response was erratic or not. If the response was erratic, replace the pressure relief valve in the pump. For instructions, see the pump section in this group. If the pressure was constant, go to the next step. With the fluid

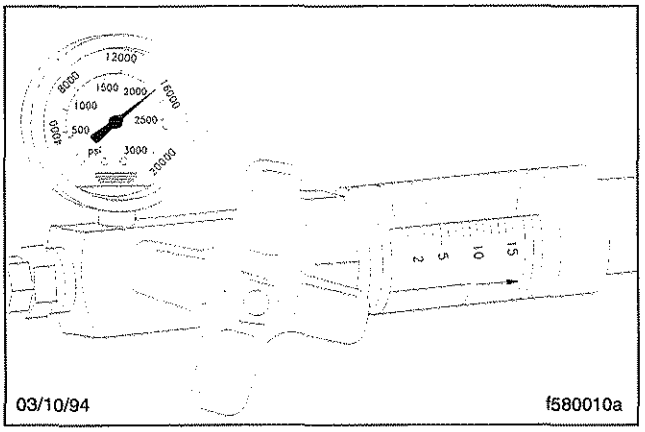


Fig. 7, Read the Pressure Gauge

temperature at 150° to 160°F (66° to 71°C) repeat the previous two steps.

8.7 If the pump pressure measures 1900 to 2275 psi (13 100 to 15 650 kPa), it is acceptable. Skip the next step and record the pressure on form SD–94. If the pressure is not within this range, replace the pressure relief valve if not done previously in this test. With the fluid temperature at 150° to 160°F (66° to 71°C) repeat the two previous steps. If the pressure relief valve has been replaced, go to the next step.

8.8 If the pressure was not within the above applicable range, and the relief valve has been previously replaced, replace the pump. For instructions, see the pump section in this group. If the pump was replaced, evaluate its performance by repeating the Test Performance check.

8.9 Record the relief pressure on form SD–94.

8.10 With the engine at idle, test the pump relief valve reaction. Note the flow rate with the load valve open.

8.11 Close the load valve until the pump relief pressure is reached (previously determined). The flow rate should drop to zero.

8.12 Immediately open the load valve and note the flow rate. It should return to the value noted previously.

8.13 If the flow rate returns immediately, the relief valve is acceptable. Go to the next step.

If the flow rate does not return immediately, the pump relief valve is not working correctly. Replace the relief valve if not previously done, following instructions in the pump section in this group.

8.14 With the engine at 1500 rpm, repeat the steps beginning with testing the pump relief valve reaction.

8.15 Record on form SD–94 whether the relief valve operated "OK" or "Not OK" at idle and 1500 rpm. Near the bottom of the form, list any pump repairs that were made.

8.16 With the engine at idle, test the pump flow. Slowly close the load valve until the pressure gauge reads 1000 psi (6895 kPa).

8.17 Read the flow gauge and record the flow rate on form SD–94.

8.18 Open the load valve.

8.19 Run the engine at 1500 rpm. Leave the load valve open, do *not* close the load valve. Read the flow gauge and record the flow rate on form SD–94.

8.20 At idle the minimum flow rate is 3.1 gpm (11.7 Lpm). The maximum flow rate at either engine speed is 6.0 gpm (22.8 Lpm). If the flow rate is below the minimum, repair or replace the pump. For instructions, see the pump section in this group. If the flow rate is above the maximum, replace the flow control and relief valve in the pump. For instructions, see the pump section in this group.

9. Check the steering gear poppet relief valve and the axle stop adjustment.

NOTE: Poppets limit the steering assist when the front wheels approach the axle stops. Improper adjustment can apply excessive force to the steering linkage or loss of assist as the steering wheel approaches either full left or full right turns.

9.1 If the turning angle is inadequate, make sure the axle stops are set to the maximum possible turn angle. Make sure the axle stop settings limit the steering travel so there is 1/2-inch (13-mm) clearance from all stationary components, and 3/4-inch (19-

Troubleshooting and Diagnostic Checks

mm) clearance from all moving components.

9.2 Make sure the pitman arm is oriented on the steering gear sector shaft correctly. See **Subject 110**.

9.3 Set up the system for hydraulic checks. See **Subject 305** for instructions.

9.4 Make sure the fluid temperature is 150° to 160°F (66° to 71°C) and the vehicle is stationary with the front wheels pointing forward.

9.5 Run the engine at idle with the load valve open. See the engine idle table in **Subject 305** for correct engine idle speed.

9.6 Turn the steering wheel to either full-lock position.

⚠ CAUTION

If power steering pump relief pressure is reached while the steering wheel is at full-lock, release the steering wheel from this position. Don't allow the pump relief pressure to be maintained for longer than five seconds, or damage to the pump may result.

9.7 Note the pressure gauge reading.

9.8 Repeat the previous three steps for the opposite turn direction, and note the pressure gauge reading.

9.9 The pressure readings at the axle stops should not exceed 1200 psi (8200 kPa). If the pressures are acceptable, record on form SD–94 and go on to the next test for the complaint. See **Table 1**. If the pressure is too high, the automatic poppet valves may have been adjusted inward too far and cannot be reset out. If not equipped, install and adjust a special poppet adjusting screw (from Ross kit number 021407-X1) following instructions in **Subject 100**. Retest the poppet relief valve and record the pressures on form SD–94.

9.10 If the pressure is relieved and assist is lost when the wheel is too far from the axle stop, adjust the automatic poppet valves as follows: (for gears equipped with a poppet adjusting screw, go to the next step) with the engine running at 1500 rpm, turn the steering to full-lock left and full-lock right so that the axle stops are contacted on both sides. This adjusts the poppets inward to the correct setting. Retest the poppet relief valve and record the pressures on form SD–94.

9.11 If the special poppet adjusting screw has been previously installed and pressure relief with loss of assist is detected too far from the axle stop, the poppets must be re-adjusted. See **Subject 100**. If the adjustable poppets have been reset properly and after subsequent vehicle operation, loss of assist continues to occur when the wheel is too far from the axle stop, the poppets have become loose due to previous incorrect poppet adjustment, and must be replaced. See **Subject 120**, for replacement instructions. After poppet replacement and adjustment, retest for correct poppet relief pressures, and record pressures on form SD–94.

10. Test for steering gear internal leakage.

10.1 Set up the system for hydraulic checks. See **Subject 305** for instructions.

10.2 Make sure the fluid temperature is 150° to 160°F (66° to 71°C) and the vehicle is stationary with the front wheels pointing forward.

10.3 Run the engine at idle with the load valve open. See the engine idle table in **Subject 305** for correct engine idle speed.

10.4 Place an unhardened steel spacer, 1-inch (2.5-cm) thick between the axle and the axle stop at one side of the axle. See **Fig. 8**. The spacer should have an extension or handle long enough to keep your fingers clear of the axle stop area. A brazing rod or welding rod works well for this purpose.

⚠ WARNING

Keep your fingers clear of the axle stops and spacer block during this test. Make sure that the spacer block contacts the axle stop squarely. Contact that is not square could break the axle stop,

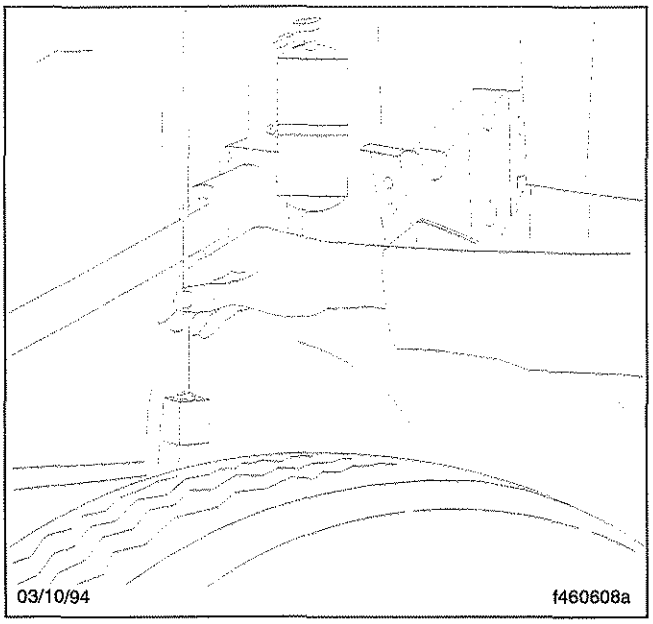


Fig. 8, Position the Steel Spacer

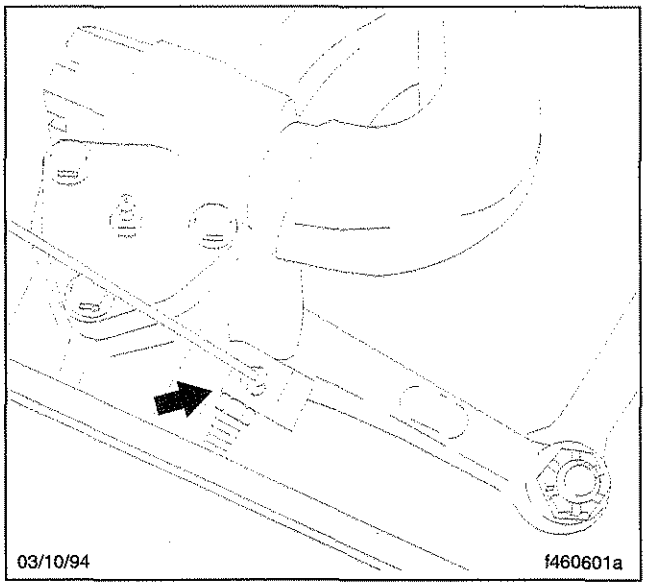


Fig. 9, Axle Stop Contacting the Steel Spacer

or dangerously eject the spacer block, causing injury.

⚠ CAUTION

While running this test, do not hold the steering wheel in the full turn position for longer than 5 seconds at a time to avoid damaging the pump.

10.5 Have someone turn the steering wheel until the axle stop contacts the spacer block. Apply 20 lbf (9 kg) to the rim of the steering wheel. See **Fig. 9**.

10.6 Read the internal leakage rate on the flow meter.

10.7 Record the reading on form SD–94.

10.8 Repeat the previous four steps (beginning with placing the spacer between the axle and the axle stop) for the opposite turn direction.

10.9 The maximum permissible internal leakage is 1.0 gpm (3.8 Lpm). If leakage is greater in either turning direction, replace the steering gear components as needed following instructions in **Subject 120**.

Troubleshooting and Diagnostic Checks

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Checklist for Troubleshooting Hydraulic Power Steering System Performance

Date _____ Work Order No. _____

Evaluation Performed By _____ ☐ Dealership ☐ Fleet ☐ Independent

Vehicle Identification

Vehicle Model _____ Chassis No. _____ Date in Service _____
Mileage _____ Mileage when steering complaint first occurred _____
Vehicle application _____ Normal steering axle load _____

Steering System Description

Steering Pump Manufacturer _____ Model No. _____
Steering Gear Manufacturer _____ Model No. _____ Date Code _____
Reservoir Capacity: ☐ 2 quart ☐ 4 quart ☐ 9 quart
Type of Fluid: ☐ ATF ☐ 10W ☐ 10W-30 ☐ 10W-40 ☐ Other _____

Steering Complaint and Appropriate Checks

LH	RH	Both	COMPLAINT	CHECKS 1 Tire Press./ Vehicle Load	2 Fifth Wheel Lube	3 Vehicle Alignment	4 Loose/ Binding Components	5 Noise	6 System Operating Temp.	7 System Leaks or Restrictions	8 Pump Performance	9 Gear Poppet Adjustment	10 Gear Internal Leakage
			Hard or Heavy Steering	•	•		•		•	•	•	•	•
			Low Assist										
			Binding	•	•		•		•	•	•	•	•
			Locking										
			Occasional Loss of Assist										
			Reduced Wheel Cut									•	
			Vehicle Pulls to One Side	•		•					•		
			Darting/ Oversteer	•	•	•	•						
			Vehicle Wanders										
			Noisy Steering					•		•	•		
			Steering Gear External Seal Leaks						•	•	•		
			Excessive Heat										
			Other (describe as completely as possible) _____										

Vehicle Checks

No. 1—Tire Pressure/Load: Front Tire Pressure Left Right
Oversized front tires? ☐ Yes ☐ No
Heavy load operation? ☐ Yes ☐ No ☐ psi ☐ kPa _____ _____
Rear tire pressure even? ☐ Yes ☐ No

No. 2—Fifth Wheel Lube and Condition: ☐ OK ☐ Not OK

No. 3—Vehicle Alignment and Wheel Bearing Adjustment: Left Right
Rear axle _____ Front axle: Caster _____ _____
Wheel bearings: ☐ OK ☐ Not OK Camber _____ _____

No. 4—Binding Components:
Lubrication of drag link, tie rod, and knuckle pins? ☐ Yes ☐ No
COE steering column bearing binds? ☐ Yes ☐ No

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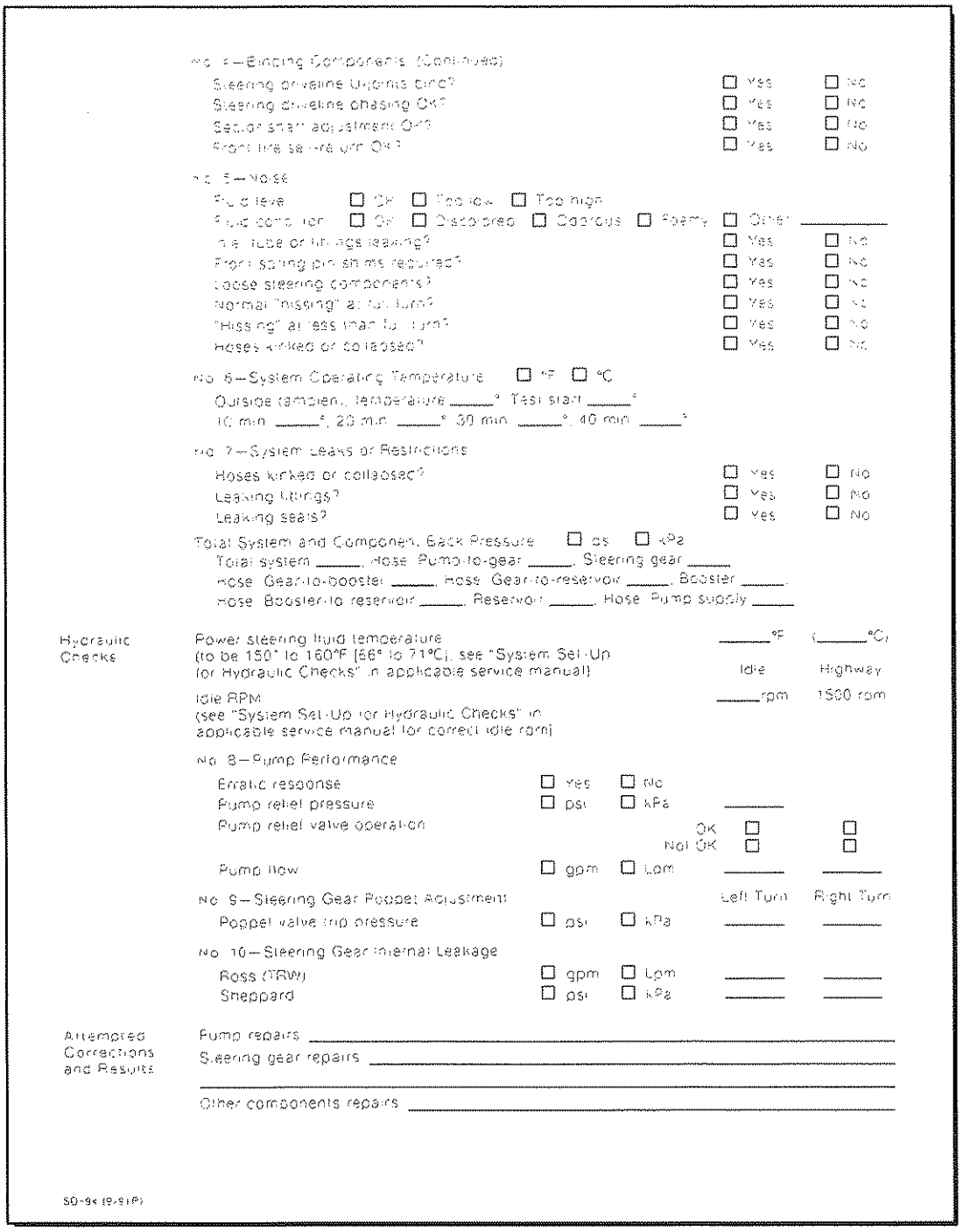
Fig. 10, Front Side, Checklist for Troubleshooting Hydraulic Power Steering System Performance



No. 4—Binding Components (Continued)

Steering driveline U-joints OK?	☐ Yes	☐ No
Steering driveline phasing OK?	☐ Yes	☐ No
Sector shaft adjustment OK?	☐ Yes	☐ No
Front axle service OK?	☐ Yes	☐ No

No. 5—Hoses

Pump relief ☐ OK ☐ Too low ☐ Too high

Fluid condition ☐ OK ☐ Discolored ☐ Odorous ☐ Foamy ☐ Other _____

Hose, tube or fittings leaking?	☐ Yes	☐ No
Front spring pin shims required?	☐ Yes	☐ No
Loose steering components?	☐ Yes	☐ No
Normal "hissing" at full turn?	☐ Yes	☐ No
"Hissing" at less than full turn?	☐ Yes	☐ No
Hoses kinked or collapsed?	☐ Yes	☐ No

No. 6—System Operating Temperature ☐ °F ☐ °C

Outside (ambient) temperature _____° Test start _____°

10 min _____°, 20 min _____°, 30 min _____°, 40 min _____°

No. 7—System Leaks or Restrictions

Hoses kinked or collapsed?	☐ Yes	☐ No
Leaking fittings?	☐ Yes	☐ No
Leaking seals?	☐ Yes	☐ No

Total System and Component Back Pressure ☐ psi ☐ kPa

Total system _____, Hose: Pump-to-gear _____, Steering gear _____

Hose: Gear-to-booster _____, Hose: Gear-to-reservoir _____, Booster _____

Hose: Booster-to-reservoir _____, Reservoir _____, Hose: Pump supply _____

Hydraulic Checks

Power steering fluid temperature (to be 150° to 160°F [66° to 71°C], see "System Set-Up for Hydraulic Checks" in applicable service manual) _____°F (_____°C)

Idle	Highway
Idle RPM (see "System Set-Up for Hydraulic Checks" in applicable service manual for correct idle rpm) _____rpm	1500 rpm

No. 8—Pump Performance

Erratic response	☐ Yes	☐ No		
Pump relief pressure	☐ psi	☐ kPa	_____	
Pump relief valve operation		OK ☐	☐	
		Not OK ☐	☐	
Pump flow	☐ gpm	☐ Lpm	_____	_____

No. 9—Steering Gear Poppet Adjustment

			Left Turn	Right Turn
Poppet valve trip pressure	☐ psi	☐ kPa	_____	_____

No. 10—Steering Gear Internal Leakage

Ross (TRW)	☐ gpm	☐ Lpm	_____	_____
Sheppard	☐ psi	☐ kPa	_____	_____

Attempted Corrections and Results

Pump repairs _____

Steering gear repairs _____

_____

Other components repairs _____

SD-94-(9-91P)

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Fig. 11, Back Side, Checklist for Troubleshooting Hydraulic Power Steering System Performance

System Setup

NOTE: Use a 1 to 10 gpm (3.8 to 38 Lpm) flow meter, a pressure gauge 0 to 2500 psi (0 to 17 225 kPa minimum), and a load valve, preferably in one test unit.

1. Install the test unit between the pump high-pressure line and the steering gear.
2. Fill and bleed the steering system. Refer to **Subject 110** for instructions.
3. Checks must be done with the power steering fluid at operating temperature 150° to 160°F (66° to 71°C). Monitor the fluid temperature with a thermometer in the fluid reservoir. If the fluid is too cold, raise the temperature as follows:

   Run the engine at idle.

   Partially close the load valve on the test unit until the pressure gauge reads 1000 psi (6895 kPa).

⚠ CAUTION

Do not leave the load valve fully closed, since this could damage the power steering system.

NOTE: When testing pump performance, poppet relief valve pressures, and internal gear leakage, refer to **Table 1** for engine idle speeds. Adjust idle speed if necessary. Refer to the engine manufacturer's instructions.

4. Open the valve when the fluid temperature reaches 150° to 160°F (66° to 71°C).

Engine Idle Speeds	
Engine Type	**Idle Speed (rpm)**
Detroit Diesel	600
Cummins NTC	600
Cummins L10, M11	700
Caterpillar 3406 and 3176	700

Table 1, Engine Idle Speeds

⚠ CAUTION

Do not allow the fluid temperature to exceed 250°F (121°C), since this could damage the power steering system.

Record all data from the hydraulic checks on form SD–94, "Checklist for Troubleshooting Hydraulic Power Steering System Performance."

Specifications

See **Fig. 1** for the steering system plumbing diagram.
See **Fig. 2** for the steering gear mounting diagram.

Kent-Moore Tools, Kent-Moore Tool Division, 29784 Little Mack, Roseville, MI 48066		
Kent-Moore Part Number		Tool
TAS65	TAS85	
J37070	J37070	Adjuster Tool
J37464	J37464	Adjuster Locknut Tool
J37071	J38779	Bearing and Seal Tool
J37073	J37073	Input Seal Installer
J38713	J38713	Poppet Adjuster Seat Tool, Heavy-Duty (preferred)
J36452	J36452	Poppet Adjuster Seat Tool
J37130	J37130	Relief Valve Plug
J8092	J8092	Tool Handle

Table 1, Kent-Moore Tools, Kent-Moore Tool Division, 29784 Little Mack, Roseville, MI 48066

Steering Gear Torque Values			
Description	Bolt or Nut Size	Grade	Torque lbf.ft (N.m)
Valve Housing Bolt:			
TAS65	1/2–13	—	105–115 (142–156)
TAS85	—	—	150–170 (203–230)
Poppet Fixed Stopscrew	—	—	38–42 (52–57)
Auxiliary Cylinder Fitting	—	—	25–35 (34–47)
Poppet Adjuster Sleeve and Seat Assembly			
TAS65	—	—	8–12 (11–16)
TAS85	—	—	16–20 (22–27)
Ball Return Guide Bolt	—	—	14–22 (19–30)
Sector Shaft Adjusting Screw Jam Nut	—	—	40–45 (54–61)
Side Cover Special Bolt	5/8–18	—	220–240 (298–325)
Steering Driveline Lower End Yoke Pinch Bolt Locknut	7/16–20	C	55 (75)
Pitman Arm Pinch Bolt Nut	3/4–16	C	230 (312)

Specifications

Steering Gear Torque Values			
Description	**Bolt or Nut Size**	**Grade**	**Torque lbf.ft (N.m)**
Steering Gear Mounting Fastener* TAS65 TAS85	7/8–9	8	427 (579)
Steering Gear Bracket-to-Frame Rail Mounting Fastener	5/8–11	8	145 (197)

* Torque values are for nuts that are wax coated and cadmium plated, or for hexbolts that have phosphate-and oil-coated threads. Both are used with hardened washers. For dry threads, refer to General Information in the Century Class Trucks Maintenance Manual.

Table 2, Steering Gear Torque Values

⚠ WARNING

Fill only with approved clean fluid. Do not mix automatic transmission fluid with engine oil; use one or the other. If you are changing from one fluid type to the other, completely flush the steering system with the fluid type being added. Any mixture or any unapproved fluid could lead to seal deterioration and leaks. Any fluid leak could eventually cause loss of power steering assist.

Approved Power Steering Fluids		
Fluid Type	**Approved Fluid**	
Automatic Transmission Fluid	Dexron® II	
	Dexron® III	
Heavy-Duty Engine Oil	Shell Rotella T	SAE 30
0 to 210°F (–18 to 99°C) *	Mobil	SAE 10W-30
IMPORTANT: Do not use heavy-duty engine oil in vehicles built from November 4, 2002.	Ashland	SAE 10W-40
	Union	SAE 10W-40
	Texaco	SAE 10W-40
	Mobil	SAE 10W-40
	Union Guardol	15W-40
	Union Guardol	SAE 30
	Imperial Essolube	15W-40
	Shell	SAE 10W-30
	Shell	SAE 10W-40
	Chevron	10W-40

* Operating temperature range: minimum (ambient start-up) to maximum.

Table 3, Approved Power Steering Fluids

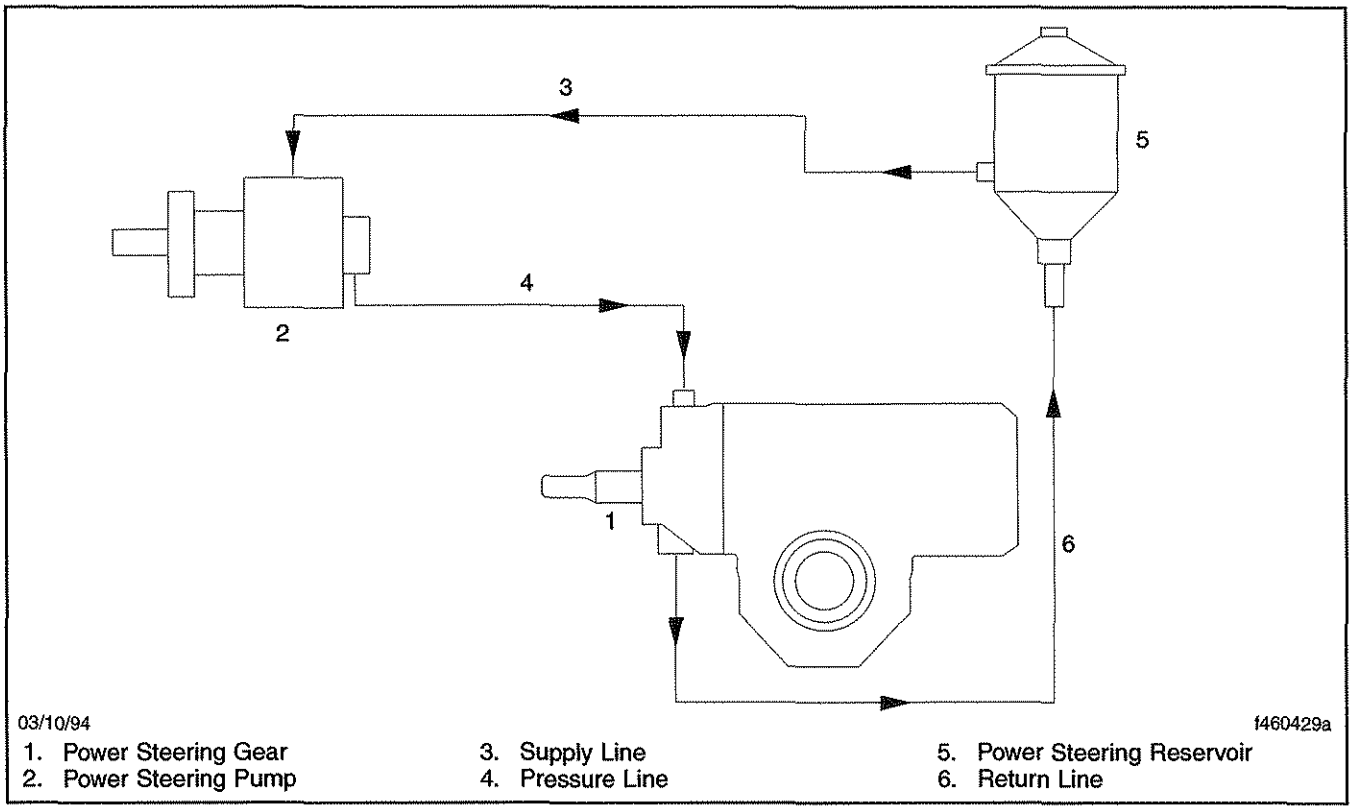
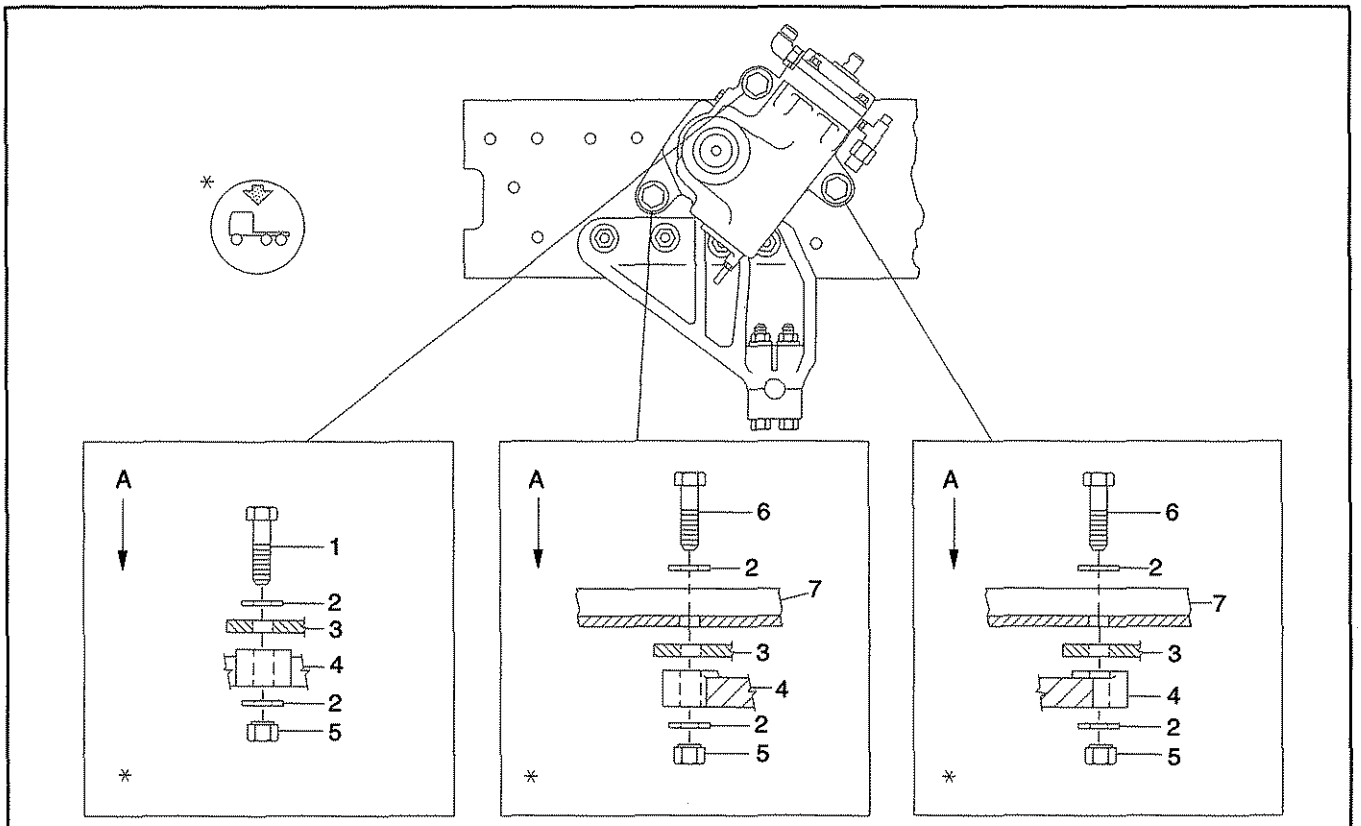


Fig. 1, Plumbing Diagram

Specifications



05/08/95 f461024

A. outboard

1. 7/8–9 x 4-1/4 Capscrew, Grade 8
2. 7/8" i.d. Hardened Washer
3. Gear Mounting Bracket
4. Steering Gear
5. 7/8–9 Hexnut
6. 7/8–9 x 4-3/4 Capscrew, Grade 8 (aluminum rails only)
7. Frame Rail

Fig. 2, Steering Gear Mounting

Contents

Subject	Subject Number
General Description and Principles of Operation	050
Service Operations	
Steering Pump Removal and Installation	100
Steering Pump Disassembly, Inspection, and Assembly	110
Troubleshooting	300
Specifications	400

General Description (See Fig. 1)

The TRW PS Series power steering pump supplies power steering fluid for the operation of the power steering gear.

The main parts of the power steering pump are the housing, input shaft, cam ring, rotor, vanes, control valve, and cover assembly.

Principles of Operation

The input shaft, powered by the adaptor gear in the engine gear case, or by the crankshaft pulley, turns the rotor, which is inside the cam ring. As the rotor turns, centrifugal force pushes the vanes out toward the surface of the cam ring. As fluid enters the cam ring through the inlet port, the rotor vanes force it out through the outlet port, and into the system. The fluid operates the steering gear. Eventually the fluid returns to the power steering reservoir, and then back to the power steering pump.

If the system pressure gets too high, a relief valve inside the control valve is forced off its seat, shunting fluid into a relief passage connected to the inlet port. The fluid then recirculates inside the pump instead of going to the outlet port. When the system pressure drops to the correct level, the relief valve seats, closing off the relief passage to the inlet port. The fluid flow returns to normal, flowing from the inlet port to the outlet port and then into the power steering system.

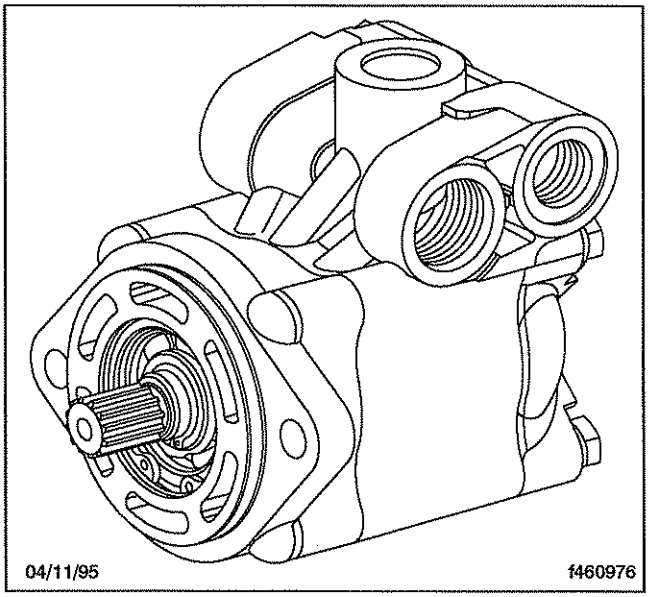
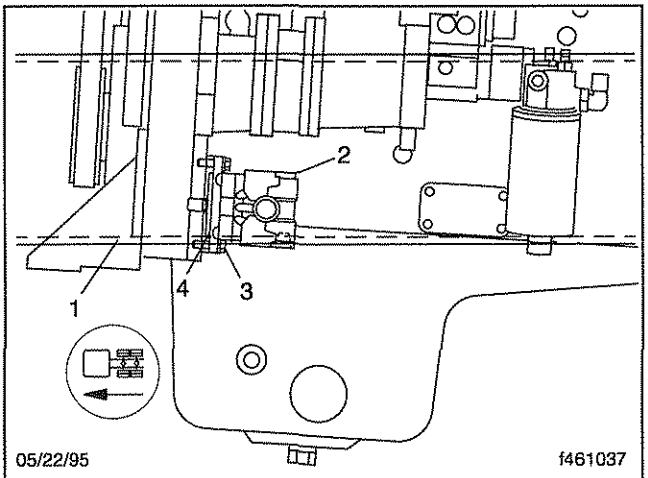


Fig. 1, TRW PS Series Power Steering Pump

Steering Pump Removal and Installation

Removal

1. Apply the parking brake, chock the tires, then tilt the hood or cab. For cab tilt instructions, see **Group 60** in this manual.
2. Clean all outside dirt from around the fittings and hose connections.
3. Put a container under the pump, then disconnect the hoses from the fittings on the pump. Plug the hoses and cap the fittings to keep out dirt and to prevent fluid from leaking.
4. Remove the pump.
   - 4.1 Remove the mounting capscrews and lockwashers that attach the pump to the engine accessory drive mounting flange. See **Fig. 1**. Hold the pump as you remove the second mounting bolt.
   - 4.2 Pull the pump straight out from the engine. Keep it level to avoid spilling fluid.
5. Turn the pump upside down over a container and let the fluid drain out.



NOTE: On Argosy COE vehicles, the pump mounts on the forward face of the engine accessory drive mounting flange.

1. Frame Rail
2. Steering Pump
3. M10 x 35 Capscrew and 7/16-inch Lockwasher
4. Gasket

Fig. 1, Steering Pump Mounting on Cummins M11 Engine, Century Class Conventional

6. Discard the gasket from the pump mounting flange.

Installation

1. Using engine oil, lightly lubricate a new gasket and the pump shaft.
2. Install the pump.
   - 2.1 Install a new gasket on the pump mounting flange, then place the pump on the engine's accessory drive mounting.
   - 2.2 Install the lockwashers and capscrews, and tighten them 35 lbf·ft (46 N·m).
3. Connect the inlet hose (from the power steering reservoir) to the inlet port. Tighten it 26 lbf·ft (35 N·m).
4. Connect the outlet hose (from the power steering gear) to the outlet port.
5. Bleed the power steering system.
   - 5.1 Check the fluid level in the power steering reservoir and if needed, fill it to the correct level.
   - 5.2 Start the engine and let it idle for several minutes.
   - 5.3 Turn the wheels to a full-left and full-right turn. Repeat about three times.
   - 5.4 Check the fluid level in the power steering reservoir. Add fluid as necessary to the full line on the reservoir dipstick.
   - 5.5 Shut down the engine.
6. Lower the hood or cab. For cab tilt instructions, see **Group 60** in this manual. Then remove the chocks.

Steering Pump Disassembly, Inspection, and Assembly

CAUTION: Be careful when working on the pump housing; it is aluminum, and can be easily damaged. When putting the pump in a vise, pad the vise jaws and clamp only the cover; tighten the vise just enough to hold the pump.

Disassembly (See Fig. 1)

WARNING: Wear safety goggles or glasses when disassembling the power steering pump. Some of the parts are held in place by springs or snap rings, which can release with considerable force, possibly causing injury.

NOTE: Prepare for fluid drainage before disassembling the pump.

1. Remove the power steering pump from the engine, following the instructions in **Subject 100.**
2. Carefully remove the end plug **(Fig. 2)** from the pump housing. Remove the spring **(Fig. 3),** if it didn't come out with the end plug.
3. Remove and discard the O-ring from the plug.

IMPORTANT: TRW does not recommend disassembly of the control valve spool assembly.

4. Remove the control valve spool assembly by hand, or by pushing it with a small rod. **See Fig. 4.** Don't push on the small screen in the relief valve seat assembly.
5. Using a solvent-proof marker, make a mark across the housing and the cover. **See Fig. 5.** Remove the four screws and washers holding the housing and the cover together. **See Fig. 6.** Using a twisting motion, separate the housing from the cover.
6. Remove the spring. **See Fig. 7.**
7. Using a solvent-proof marker, draw a line across the top plate and the bottom plate. **See Fig. 8.**
8. Holding the cam ring in place, remove the top plate. **See Fig. 9.** Remove and discard the O-ring and backup O-ring.
9. Holding the bottom plate in place, remove the cam ring. Note and record whether the dots near the locating pin holes on the cam ring are up or down. **See Fig. 10.**
10. Look for wear on the outside edge of the vanes. Note and record the direction of the wear for assembly. Carefully remove the rotor and vanes, as the vanes will slip from their slots in the rotor. **See Fig. 11.**
11. Remove the locating pins. **See Fig. 12.** Make marks on the outside of the cover (not on the sealing surface) to note from which holes the locating pins were removed.
12. Remove the bottom plate. **See Fig. 13.**
13. Turn the cover over and remove the large retaining ring. **See Fig. 14.**
14. Press out the input shaft and ball bearing assembly. **See Fig. 15.**
15. Remove the spacer from the cover. **See Fig. 16.**
16. Using care not to damage the bore, remove the shaft seal. **See Fig. 17.**

Inspection

1. Clean all the parts, using a solvent compatible with the power steering fluid. Then, using filtered compressed air, dry all the parts.

NOTE: Replace any parts that are damaged or worn.

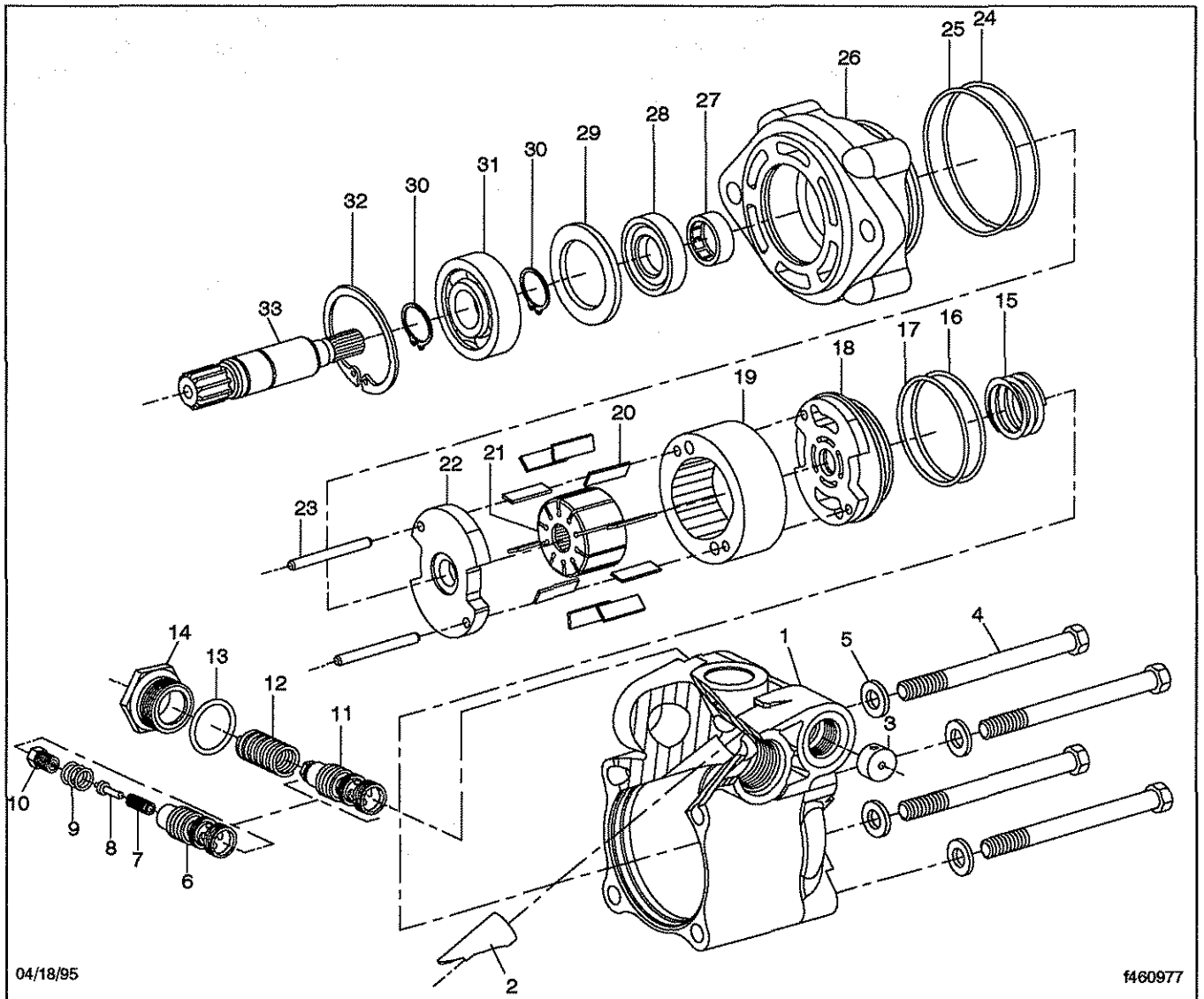
2. Inspect the housing for cracks, stripped threads, a damaged valve bore, and damaged sealing areas. **See Fig. 18.**
3. Inspect the cover for nicks in the O-ring seal grooves. Make sure that the seal drain hole is open, and that the seal bore is free of nicks and other damage. **See Fig. 19.**

   Make sure that the surface on which the bottom plate rests is flat and free of nicks and other damage.
4. Check that the needles roll freely in the needle bearing. If needed, replace the needle bearing.

   4.1 Place the cover in a press with the flange side down. Using an 11/16-inch socket, press the needle bearing out of the cover. **See Fig. 20.**

   CAUTION: Make sure that the press is clean and free of debris. Debris could damage the face of the cover, which will affect pump operation.

Steering Pump Disassembly, Inspection, and Assembly



1. Pump Housing
2. Boost Tube
3. Orifice
4. Mounting Bolt
5. Washer
6. Spool
7. Spring
8. Poppet
9. Shims
10. Relief Valve Seat Assembly
11. Control Valve Spool Assembly
12. Spring
13. O-Ring
14. Plug
15. Spring
16. O-Ring
17. Backup O-Ring
18. Top Plate
19. Cam Ring
20. Vane
21. Rotor
22. Bottom Plate
23. Locating Pin
24. Small O-Ring
25. Large O-Ring
26. Cover
27. Needle Bearing
28. Shaft Seal
29. Spacer
30. Small Retaining Ring (2 qty.)
31. Ball Bearing
32. Large Retaining Ring
33. Input Shaft

Fig. 1, Steering Pump, Exploded View

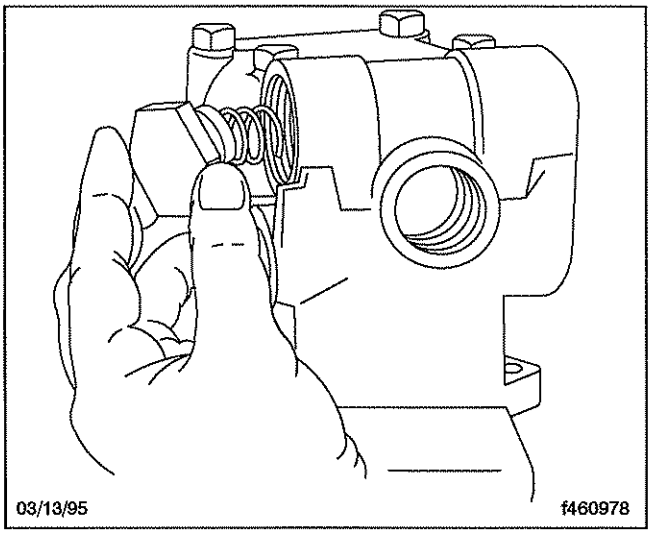


Fig. 2, Removing the End Plug

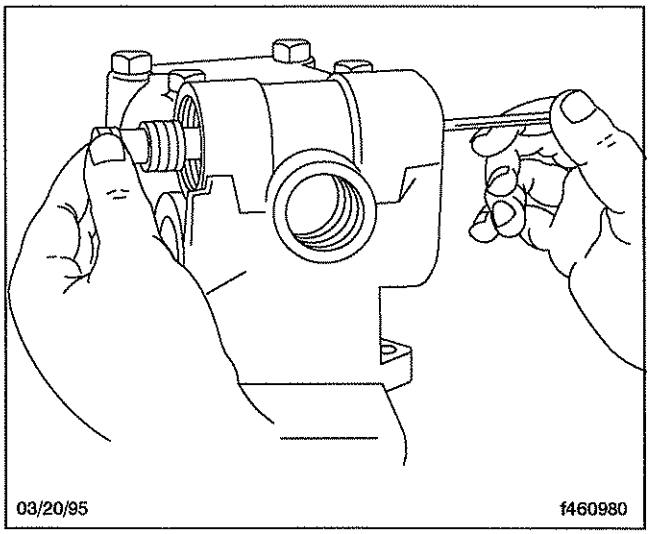


Fig. 4, Removing the Control Valve Assembly

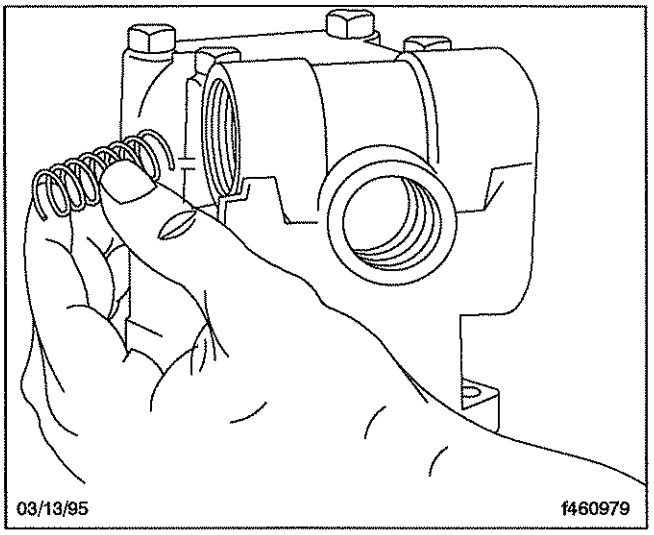


Fig. 3, Removing the Spring

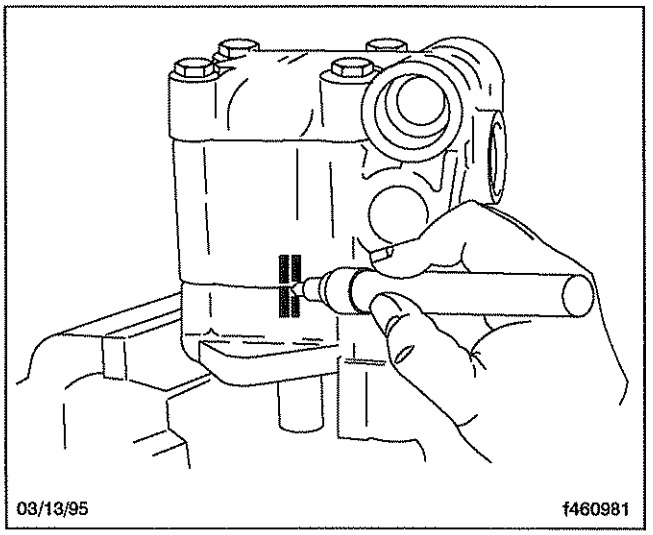


Fig. 5, Marking the Housing and the Cover

4.2 Put the cover in a clean press with the flange side up. Make sure that the lettered side of the needle bearing is facing toward the press.

4.3 Using a 7/8-inch deep socket, press the new needle bearing into the cover until it is flush with the inside surface of the cover. **See Fig. 21.**

5. Inspect the top plate for seal area nicks, and abnormal wear or erosion. A polished pattern from the rotor and vanes is normal; grooves you can feel with your fingernail are not normal.

6. Look for abnormal wear, erosion, or surface damage on the inside of the cam ring.

7. Check the vanes on the rotor for damage or too much play in the rotor slots. **See Fig. 22.** If you can move the vanes from side-to-side in the slots, replace the whole rotor assembly.

NOTE: If the vanes are removed, make sure they are installed with the rounded edge out.

Steering Pump Disassembly, Inspection, and Assembly

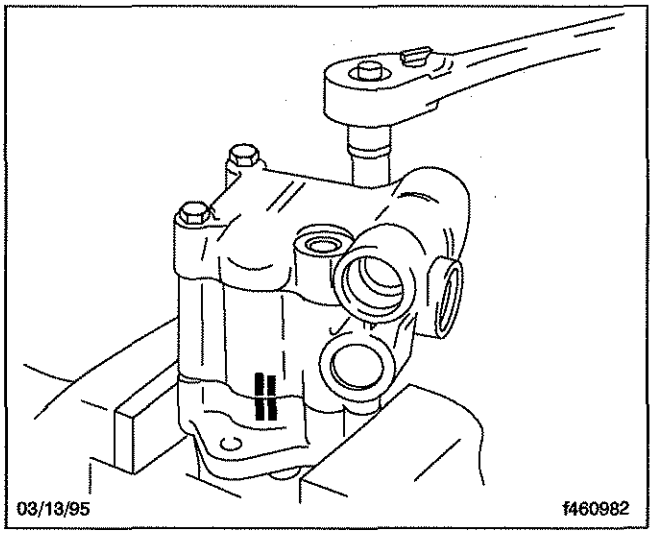


Fig. 6, Removing the Screws and Washers

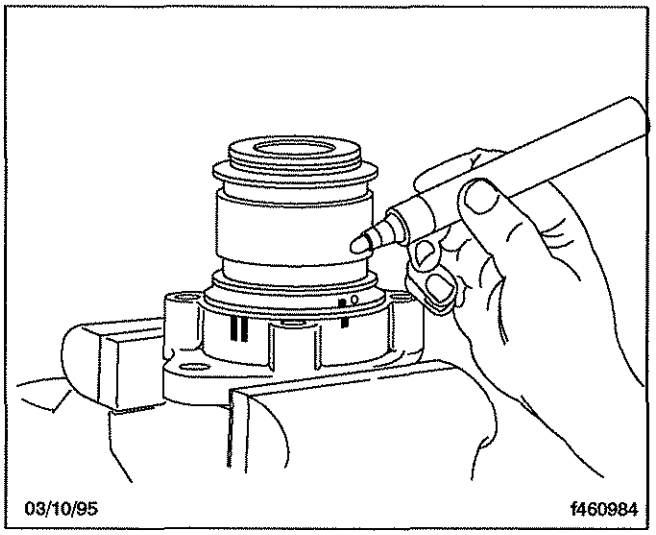


Fig. 8, Marking the Top Plate and the Bottom Plate

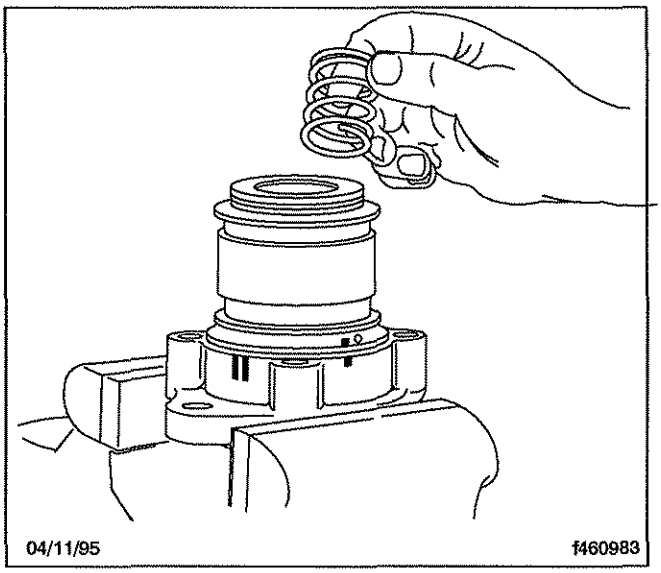


Fig. 7, Removing the Spring

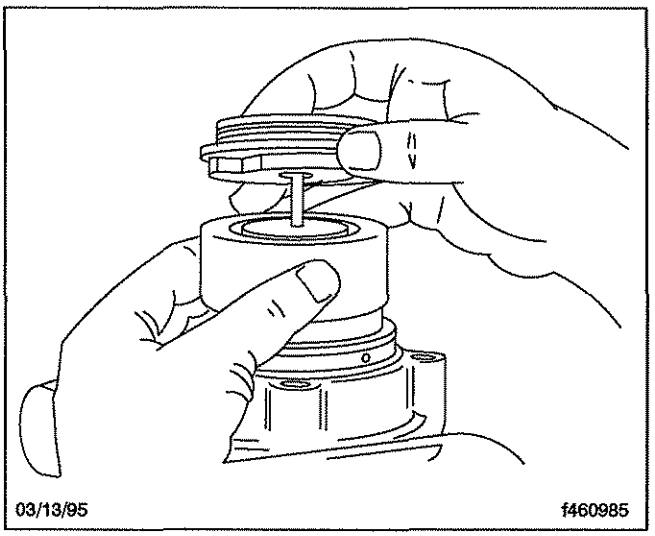


Fig. 9, Removing the Top Plate

8. Check the bottom plate for abnormal wear patterns.

9. Check the input shaft for damaged splines and abnormal wear grooves around the seal area. **See Fig. 23.** Replace the input shaft if there are grooves that can be detected with your fingernail.

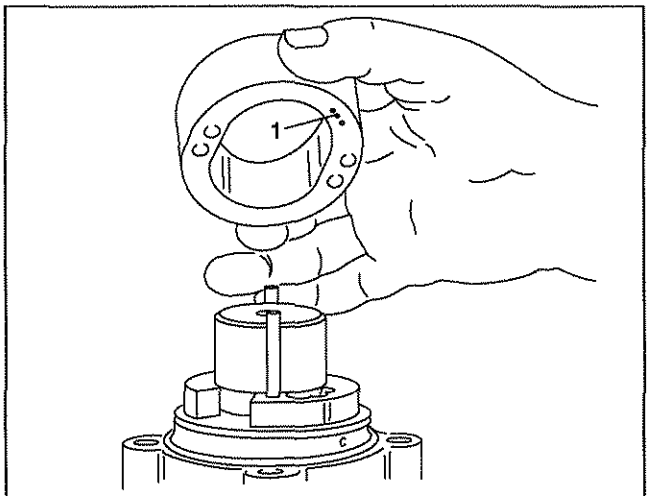
   9.1 Remove the retaining ring (engine drive end) from the shaft. **See Fig. 24.**

   Remove the woodruf key, if equipped.

   9.2 Applying pressure to the engine drive end of the input shaft, press the input shaft from the ball bearing. **See Fig. 25.**

   9.3 Press the new input shaft (from the small splined end) into the ball bearing until the shaft bottoms out on the retaining ring. **See Fig. 26.**

   9.4 Install the retaining ring on the input shaft with the sheared edge pointing away from the bearing. Make sure that the retaining ring is properly seated.



1. Dots

Fig. 10, Checking whether the Dots are Up or Down.

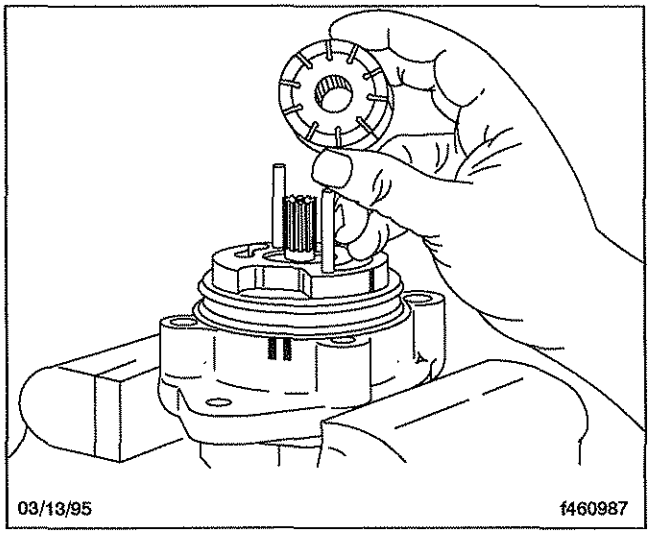


Fig. 11, Removing the Rotor and Vanes

IMPORTANT: TRW does not recommend disassembly of the control valve spool assembly.

10. Check the control valve spool assembly for wear or chipping. If needed, back-flush with air and solvent. Check the assembly for nicks or burrs.

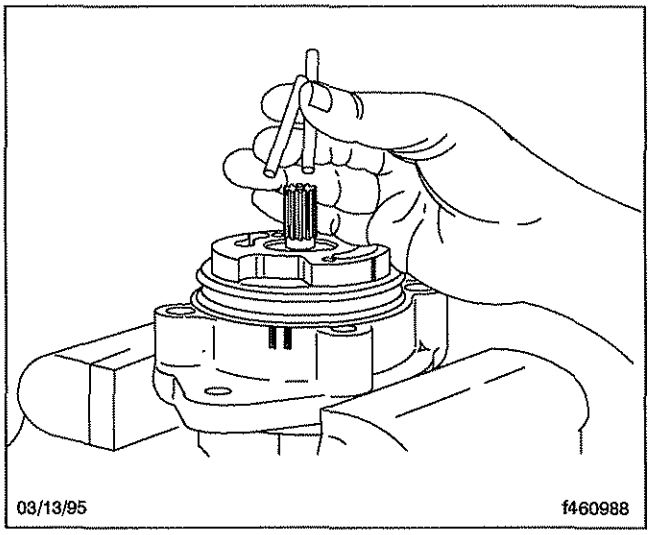


Fig. 12, Removing the Locating Pins

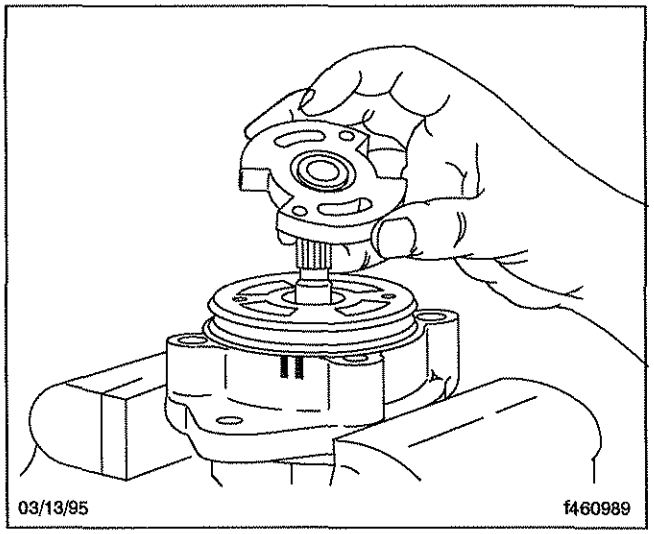


Fig. 13, Removing the Bottom Plate

Assembly

CAUTION: Make sure that the press is clean and free of debris. Debris could damage the face of the cover, which will affect pump operation.

1. Coat the outside surface of the shaft seal with a petroleum-based chassis grease. With the lettered side facing toward the needle bearing, press the seal into the cover. **See Fig. 27.** The installed seal should be flush with, or just below, the sealing surface on the cover.

Steering Pump Disassembly, Inspection, and Assembly

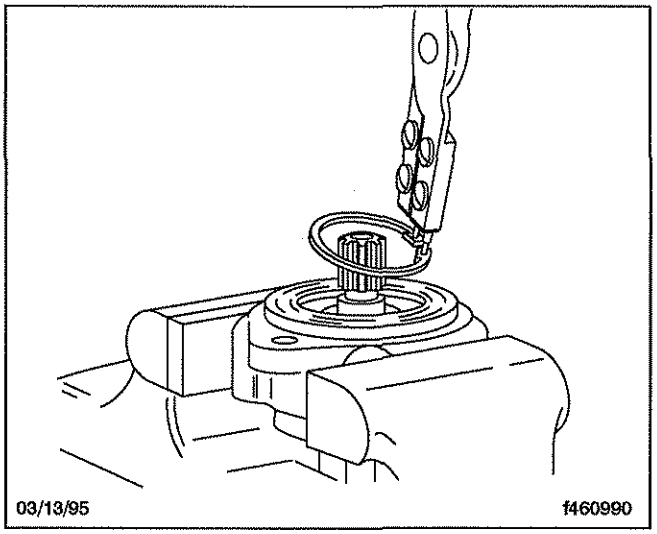


Fig. 14, Removing the Large Retaining Ring

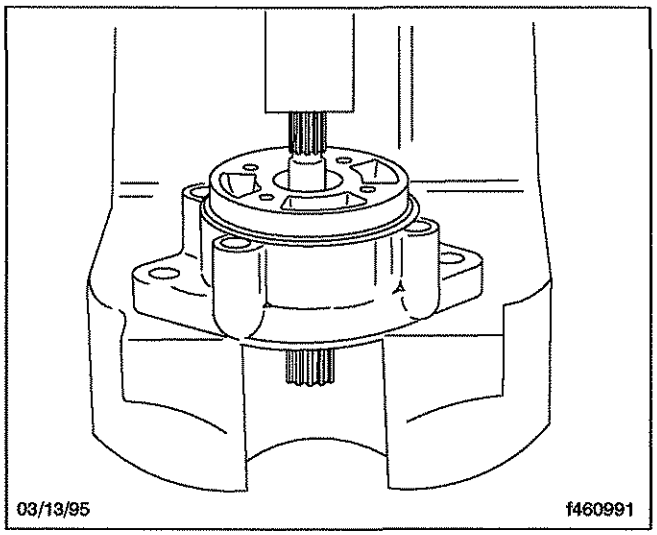


Fig. 15, Pressing out the Input Shaft and Ball Bearing Assembly

2. Grease the inside surface of the shaft seal using a petroleum-based chassis grease.
3. Install the spacer. **See Fig. 16.** Make sure that it lies flat.

CAUTION: Don't allow the splines to contact the shaft seal. The splines could damage the shaft seal.

4. Insert the input shaft (small splined end first) into the cover. Don't allow the splines to contact the shaft seal. Insert the shaft into the seal by hand until the ball bearing contacts the cover.

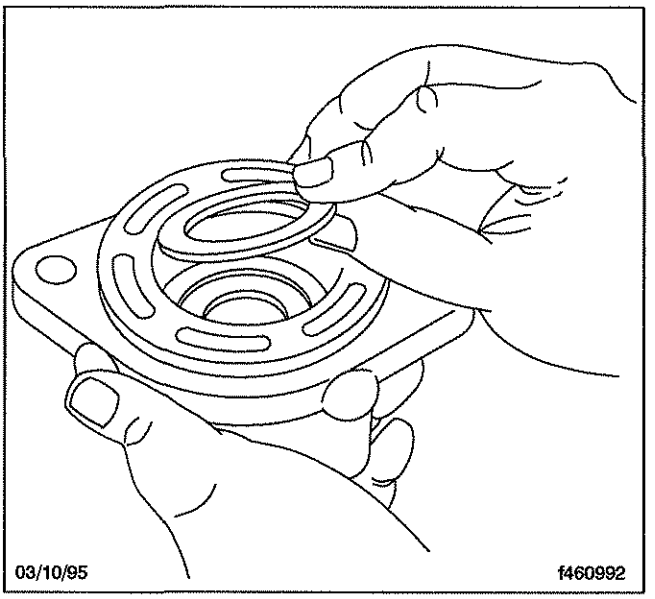


Fig. 16, Removing the Spacer

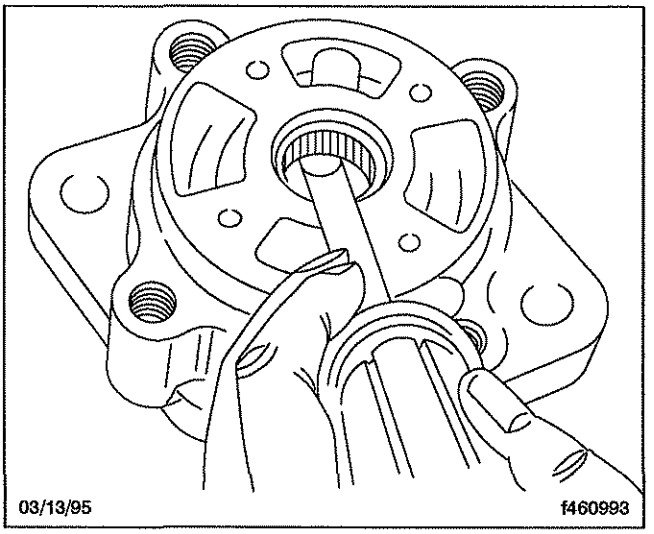
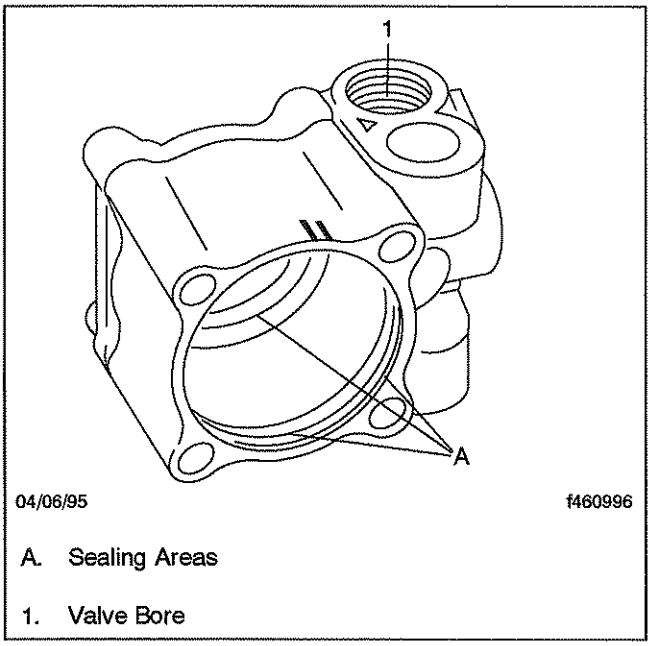


Fig. 17, Removing the Shaft Seal

Using a 7/8-inch socket, press the shaft and bearing into the cover. **See Fig. 28.**

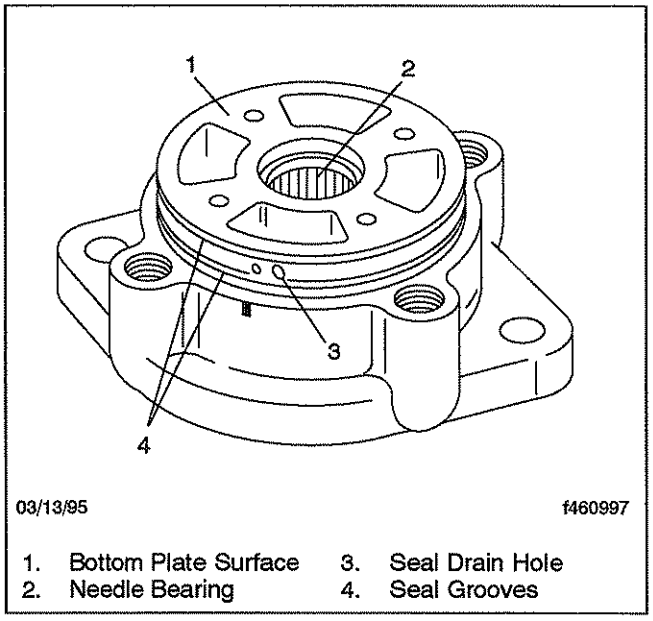
CAUTION: When placing the cover in a padded vise, don't use excessive clamping force. This could damage the cover.



A. Sealing Areas

1. Valve Bore

Fig. 18, Inspect the Housing



1. Bottom Plate Surface
2. Needle Bearing
3. Seal Drain Hole
4. Seal Grooves

Fig. 19, Inspect the Cover

5. Place the cover in a padded vise and install the large retaining ring with the sheared edge out.

   Turn the cover assembly over.

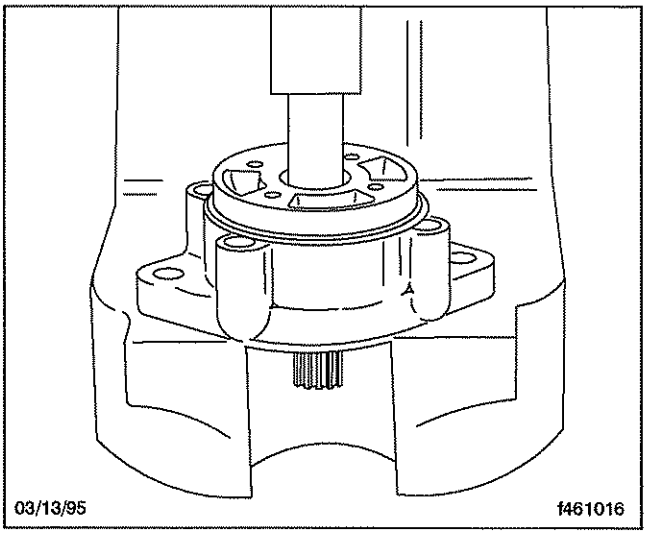


Fig. 20, Pressing the Needle Bearing out of the Cover

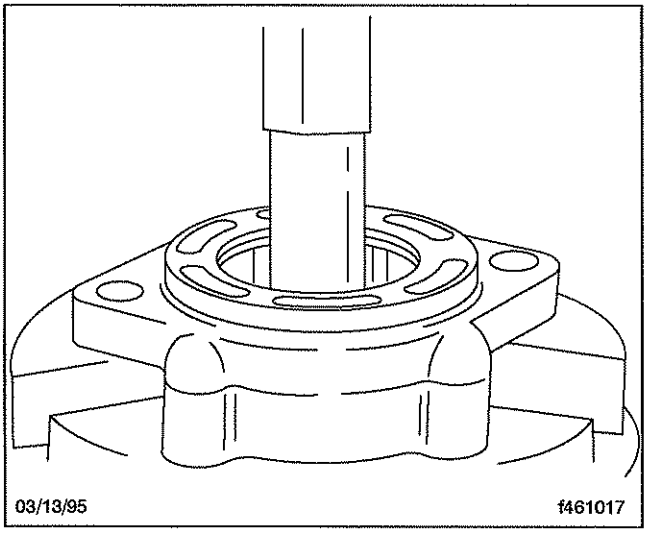


Fig. 21, Pressing a New Needle Bearing into the Cover

6. Install the new large and small O-rings in the cover. Make sure that they are seated properly. **See Fig. 29.**

7. Using the marks made during disassembly as a guide, install the locating pins.

IMPORTANT: In one of the four cutouts in the cover there is a bar. When installed, the bottom plate must cover this bar.

Steering Pump Disassembly, Inspection, and Assembly

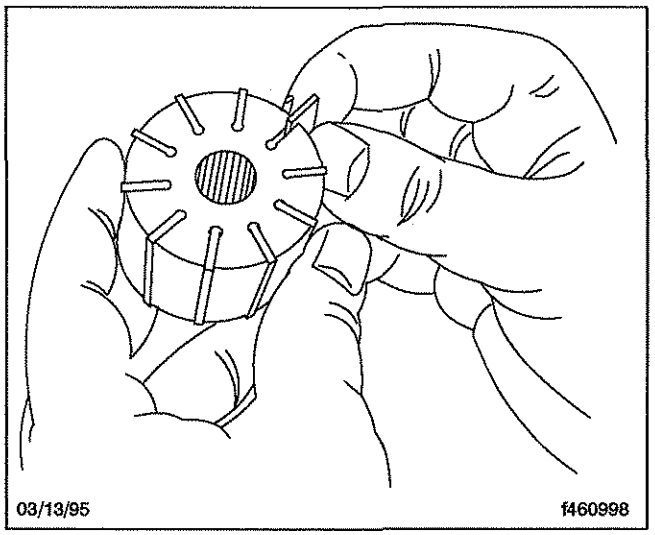
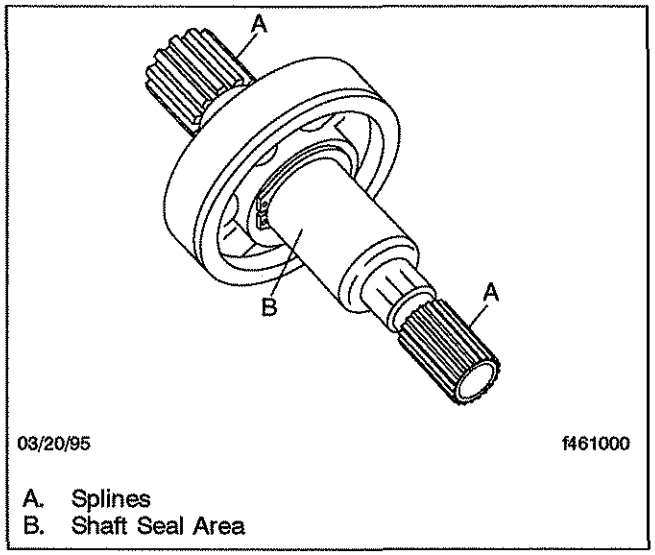


Fig. 22, Checking the Vanes



A. Splines
B. Shaft Seal Area

Fig. 23, Check the Input Shaft

8. Install the bottom plate with the pockets facing up. **See Fig. 30.** Make sure that the marks made during disassembly are aligned.

9. Install the cam ring with the dots facing up or down as noted during disassembly. Make sure that the cam ring is flush with the bottom plates large outside diameter, and that the marks made during disassembly are aligned. **See Fig. 31.**

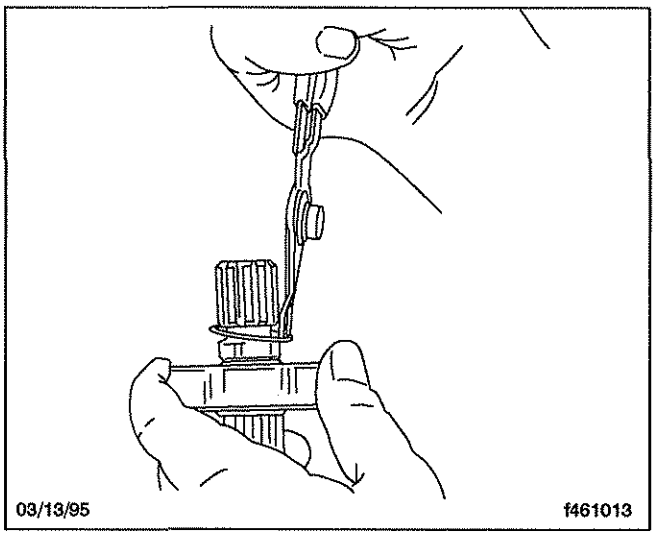


Fig. 24, Removing the Retaining Ring

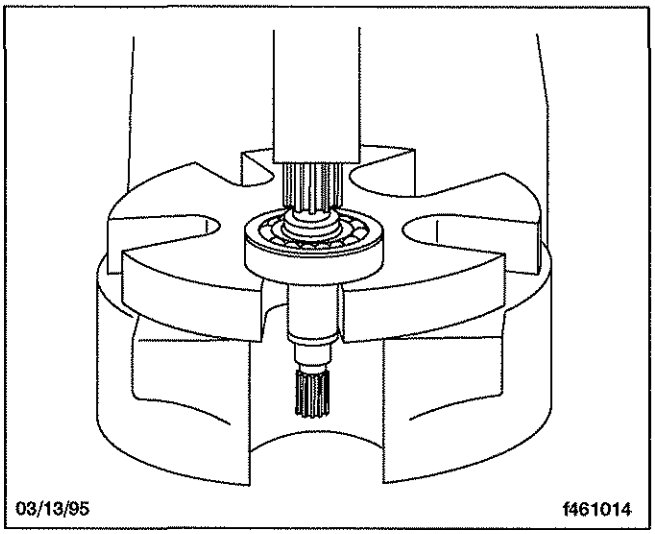


Fig. 25, Pressing the Input Shaft

10. Install the rotor and vanes. Make sure that squared edge on each vane points toward the center of the rotor. **See Fig. 32.**

11. Install the top plate with the pin holes down. Make sure that the locating pins are engaged in the pin holes, not the pockets. **See Fig. 33.**

    Make sure that the top plate is flush with the cam, and that the marks made during disassembly are aligned.

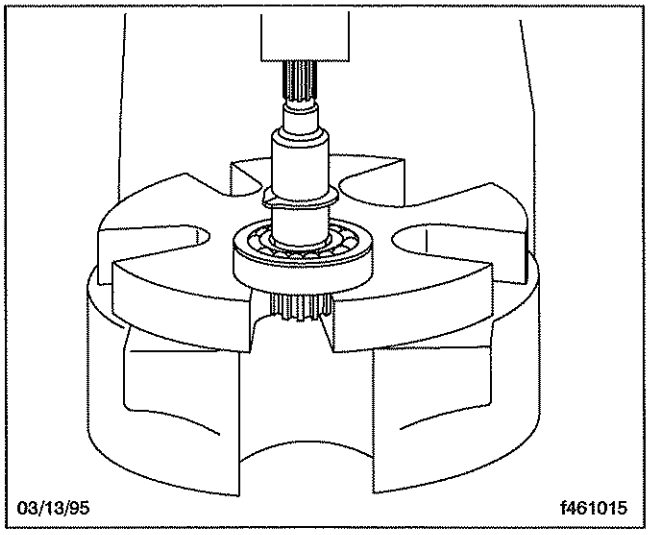


Fig. 26, Pressing the New Input Shaft

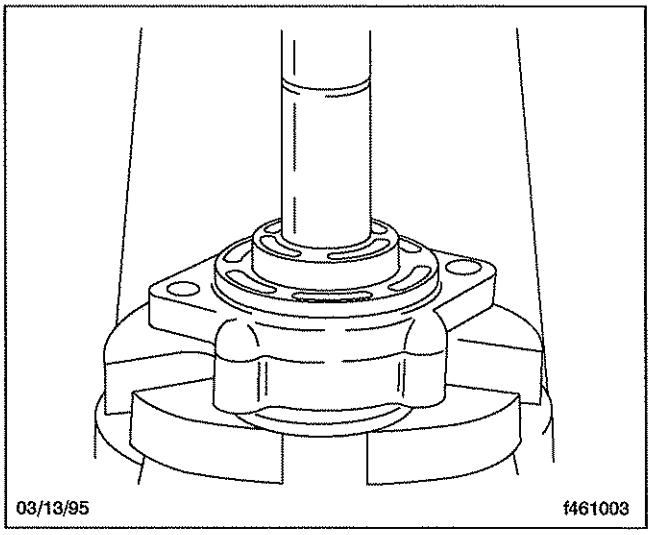


Fig. 28, Pressing the Shaft and Bearing into the Cover.

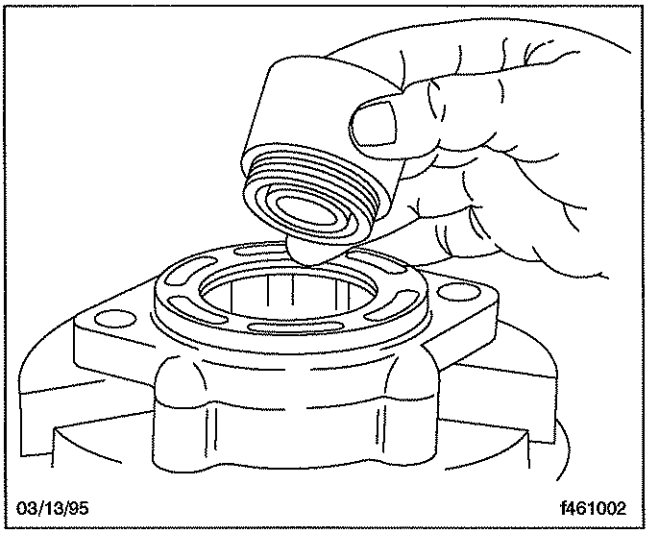
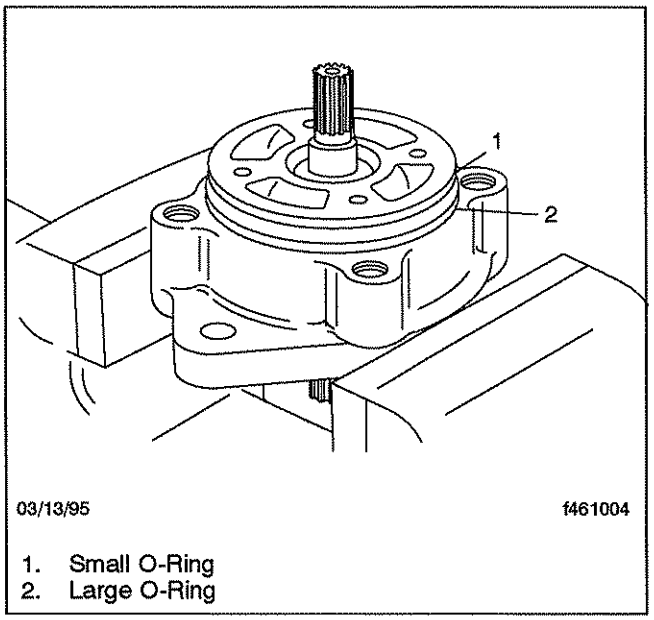


Fig. 27, Installing the Seal in the Cover

NOTE: The backup O-ring will fit tighter on the top plate after loosely wrapping (no twisting) it around two fingers, then allowing it to unwrap.

12. Install the backup O-ring on the top plate. Seat the O-ring at the bottom of the groove.
13. Install a new O-ring (without allowing it to roll) on the top plate. Seat the O-ring at the top of the groove.
14. Grease both the O-ring and the backup O-ring. **See Fig. 34.**



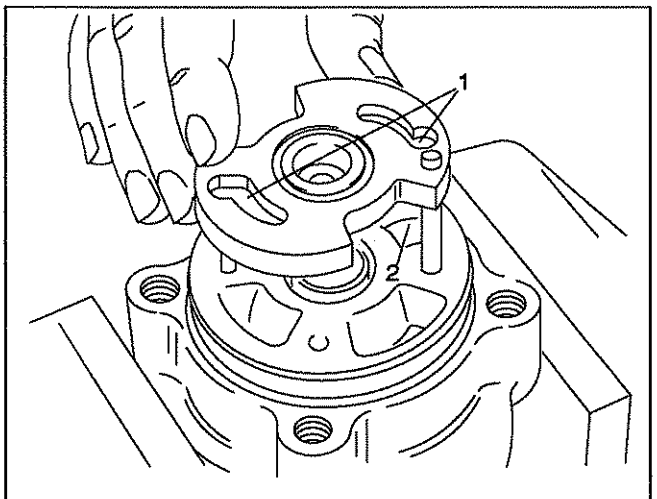
1. Small O-Ring
2. Large O-Ring

Fig. 29, Installing the O-Rings

CAUTION: The housing may have sharp edges. Use care to not cut your finger when applying grease to the housing.

15. Grease the sealing areas of the housing. **See Fig. 35.**
16. Place the spring on the top plate.

Steering Pump Disassembly, Inspection, and Assembly



1. Pockets
2. Bar

Fig. 30, Installing the Bottom Plate

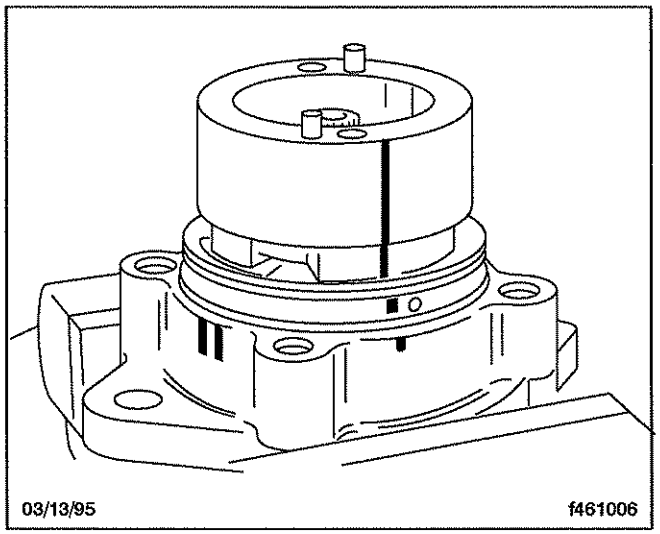
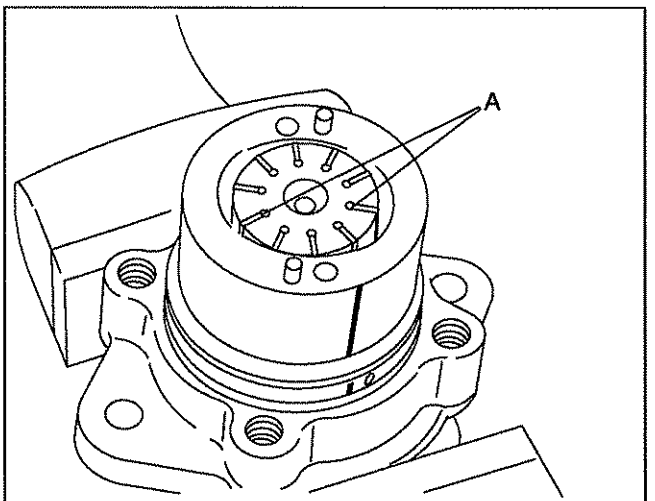


Fig. 31, Installing the Cam Ring

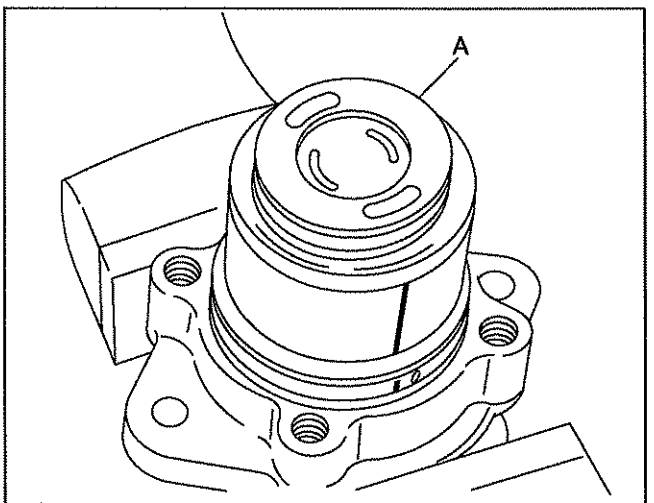
17. Place the housing over the cover assembly. Make sure that the marks made during disassembly are aligned. **See Fig. 36.**

CAUTION: Evenly thread the mounting bolts into the cover. If not evenly threaded into the cover, damage could occur to the seals, top plate, or housing.



A. Squared edge of vane pointing toward the center of the rotor.

Fig. 32, Installing the Rotor and the Vanes



A. Top plate installed with pin holes down.

Fig. 33, Installing the Top Plate

18. Install the mounting bolts and washers. Evenly thread all four bolts into the cover. Alternately tighten the bolts 30 lbf·ft (41 N·m).

19. Screw the relief valve seat assembly into the control valve spool assembly. Tighten the assembly 87 lbf·in (982 N·cm).

Steering Pump Disassembly, Inspection, and Assembly

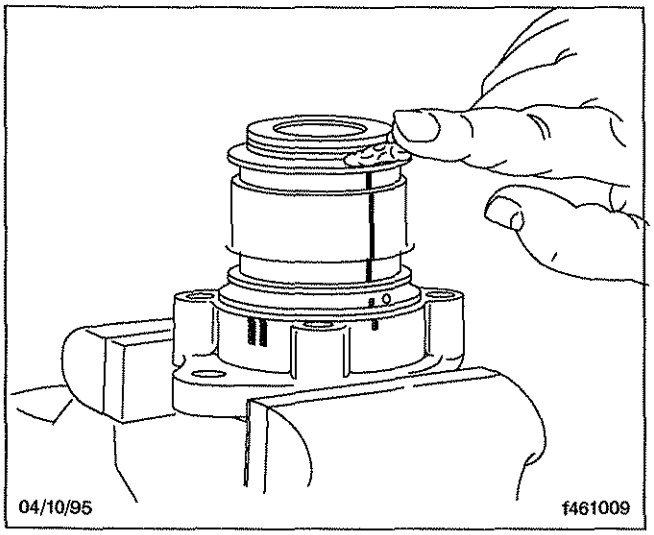


Fig. 34, Greasing the O-Rings

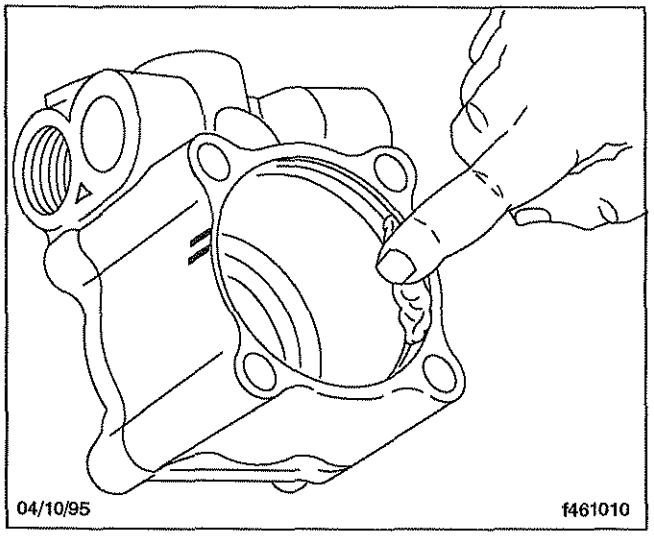


Fig. 35, Greasing the Sealing Areas

NOTE: Placing the spool assembly in a collet will assist the tightening procedure.

20. Insert the valve spool assembly (screen end last) into the housing. Make sure that the spool slides freely in the housing. **See Fig. 37.**
21. Install the spring in the housing.
22. Install a new O-ring on the end plug.

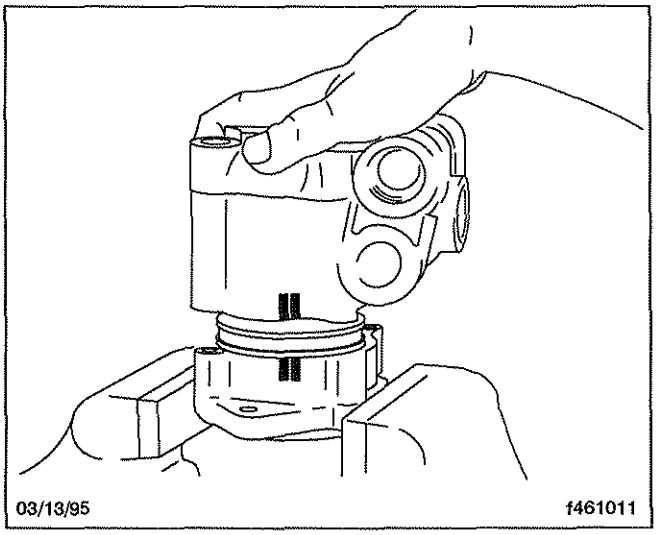


Fig. 36, Installing the Housing

23. Lightly grease the O-ring and the end plug threads. Install the end plug and tighten 30 lbf·ft (41 N·m).
24. Install the woodruf key into the new input shaft (if removed during the input shaft replacement).
25. Turn the pump by hand and make sure that it turns freely.
26. Install the power steering pump on the engine, following the instructions in **Subject 100.**

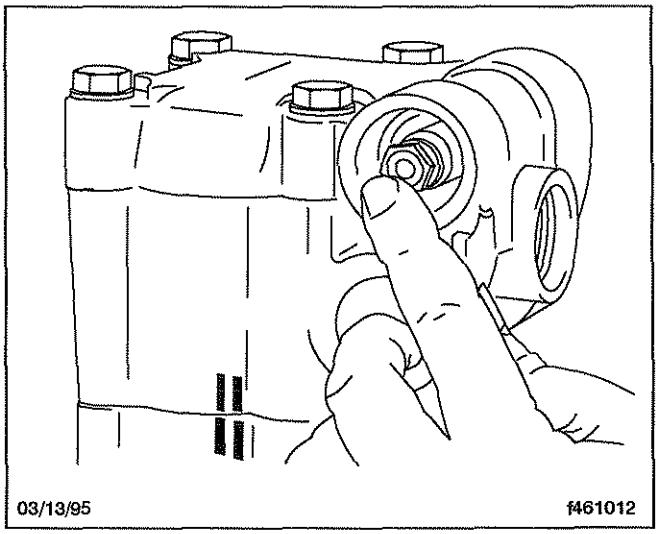


Fig. 37, Installing the Valve Spool Assembly

Problem—The Power Steering Pump Doesn't Deliver Fluid

Possible Cause	Remedy
The pump input shaft is broken, or not engaging.	Remove the pump. Repair or replace parts as needed.
The control valve is stuck open.	Remove and disassemble the pump. Clean the control valve in a solvent. Install the control valve, then check for any binding in its bore. If the control valve binds or feels gritty when you move it, replace the pump.
One or more rotor vanes is stuck.	Remove and disassemble the pump. Check the rotor and vanes for dirt or damage. If damaged, replace the rotor and vane assembly. If dirty, clean the rotor and vanes in a solvent, then assemble the parts and check for free vane movement. If the problem persists, replace the pump.
Incorrect power steering fluid is used.	Check for the type of fluid used. If it's incorrect, drain, flush, and fill the system with the correct fluid.
The pump intake port is blocked.	Drain and flush the system. Fill the system with clean fluid.
The air vent in the power steering reservoir is clogged.	Remove the filter cap from the reservoir, then clean the air slot.
A power steering inlet hose is kinked or blocked.	Repair or replace the hose.

Problem—The Power Steering Pump is Making Noise

Possible Cause	Remedy
The intake line is plugged.	Drain the system. Clear the intake line if needed. Fill the system.
There is an air leak at the pump connections, the fittings, the reservoir connections, or the shaft seal.	Check all the connections by pouring power steering fluid over them, then listen for a reduction in sound. Tighten all the connections as needed. If the problem persists, remove the pump, then disassemble it and replace the shaft seal.
The pump input shaft is misaligned.	Remove and disassemble the pump. Replace the shaft seal and bearing.

Specifications

Fastener Torques	
Description	**Torque: lbf.ft (N.m)**
Pump Mounting Hexbolts	35 (47)
Pump Housing-to-Cover Assembly Bolts	30 (41)
Pump End-Plug	30 (41)
Pump Inlet Connection	26 (35)

Table 1, Fastener Torques

Approved Power Steering Fluids		
Fluid Type	**Approved Fluid**	
Automatic Transmission Fluid*	Dexron® II	
	Dexron® III	
Heavy-Duty Engine Oil*	Union	10W–40
IMPORTANT: Do not use heavy-duty engine oil in vehicles built from November 4, 2002.	Texaco	10W–40
	Chevron	10W–40
	Mobil Super	10W–40
	Union	15W–40
	76 Lubricants	15W–40
	Shell Rotella T	30W

* Do not mix engine oil with automatic transmission fluid (ATF). Use the same lubricant for parts as is used in the power steering system.

Table 2, Approved Power Steering Fluids

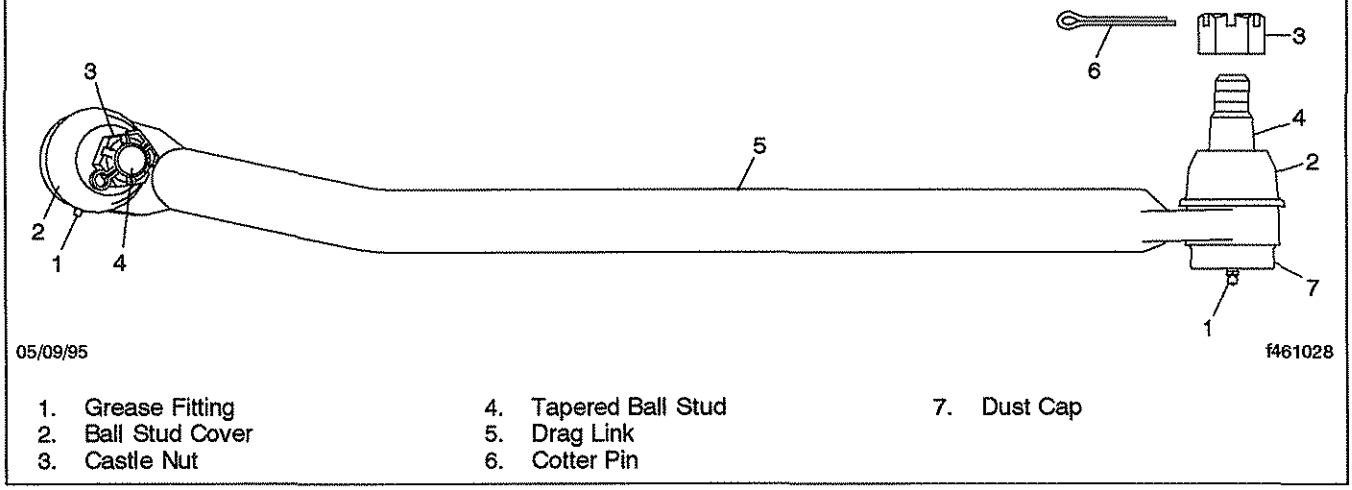
Contents

Subject	Subject Number
General Description	050
Service Operations	
Drag Link Removal and Installation	100
On-Vehicle Ball Stud Testing	110
Ball Stud Cover Replacement	120

General Description

A fixed-length drag link assembly **(Fig. 1)** connects the steering gear pitman arm to the axle steering arm. The ball stud and socket assemblies at each end of the drag link prevent binding when the relative angles of the pitman arm and steering arm change, which happens when the vehicle is steered or the front axle moves up or down.

Both ball-stud sockets of a fixed-length drag link assembly are an integral part of the drag link; they cannot be moved to change its length. **See Fig. 1.** The ball studs and sockets are a dual-seat design.



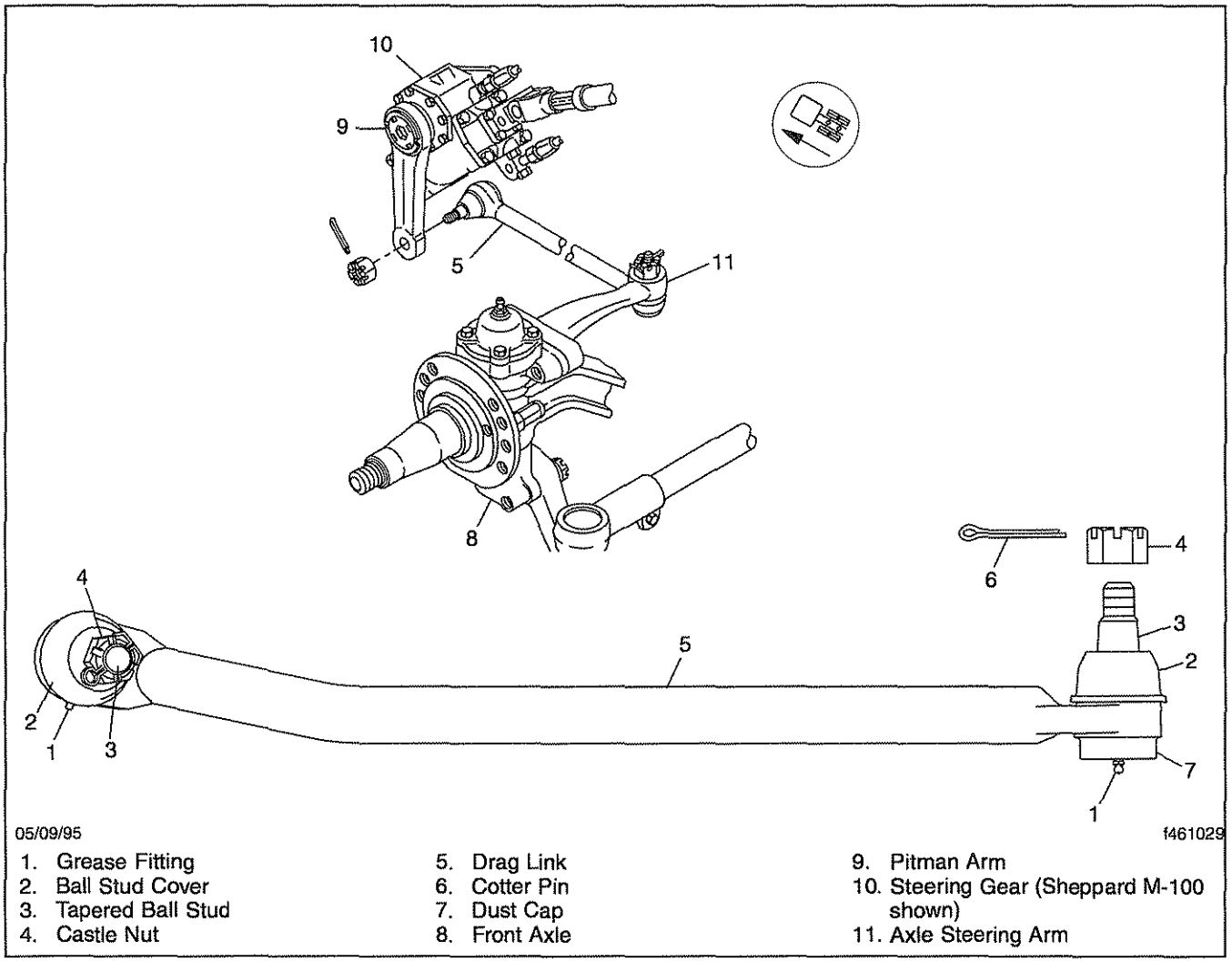
1. Grease Fitting
2. Ball Stud Cover
3. Castle Nut
4. Tapered Ball Stud
5. Drag Link
6. Cotter Pin
7. Dust Cap

Fig. 1, Fixed-Length Drag Link Assembly

Drag Link Removal and Installation

Removal

1. Position the front tires straight ahead. If possible, drive the vehicle in a straight line for a short distance, stopping at the spot where service work will be done. *Do not move the tires from the straight-ahead position during removal or at any time while the drag link is removed.*
2. Apply the parking brakes and chock the rear tires.
3. Tilt the hood or cab. For cab tilting instructions, see **Group 60** in this manual.
4. At both ends of the drag link, remove the cotter pins and castle nuts from the ball studs. See **Fig. 1**.
5. Using a ball stud removal tool, remove the ball studs from the pitman arm and the axle steering arm.
6. Check the ball stud cover for damage. If needed, replace the cover using the instructions in **Subject 120**.



1. Grease Fitting
2. Ball Stud Cover
3. Tapered Ball Stud
4. Castle Nut
5. Drag Link
6. Cotter Pin
7. Dust Cap
8. Front Axle
9. Pitman Arm
10. Steering Gear (Sheppard M-100 shown)
11. Axle Steering Arm

Fig. 1, Drag Link Installation

Drag Link Removal and Installation

Installation

1. Insert the axle-end ball stud up through the bottom of the axle steering arm, then install the castle nut, finger-tight.
2. Turn the steering wheel as needed to align the hole in the lower end of the pitman arm with the forward ball stud. Insert the ball stud in the pitman arm from the inboard side. Install the castle nut. See **Fig. 1**.
3. Tighten both of the castle nuts:
   - 3/4–16; 90 to 170 lbf·ft (122 to 230 N·m)
   - 7/8–14; 160 to 300 lbf·ft (217 to 407 N·m)

   If needed, continue tightening each nut until a slot on the nut aligns with the hole in the ball stud. *Do not back off the nut to align it with the cotter pin hole.*
4. Install and lock a new cotter pin in each of the ball studs and nuts.

⚠ WARNING

Install and lock new cotter pins in the ball studs and nuts. Failure to do so could result in disengagement of the components, causing loss of steering control, which could result in personal injury and property damage.

5. Check the vehicle maintenance manual to determine if lubrication of the drag link is required. If so, follow the instructions in the maintenance manual.
6. Check the axle stop settings, and adjust them if needed. For instructions, refer to **Group 33** in this manual.
7. Check the settings of the steering gear poppet valves (TRW) or relief valve plungers (Sheppard). Adjust them if needed. For instructions on checking and adjusting, refer to the applicable steering gear section elsewhere in this group.
8. With the front tires straight ahead, and no load on the vehicle, the steering wheel spokes should be within ±10 degrees of center as shown in **Fig. 2**. If not, remove the steering wheel and install it in the correct position.
9. Return the hood or cab to the operating position. For cab lowering instructions, see **Group 60** in this manual.

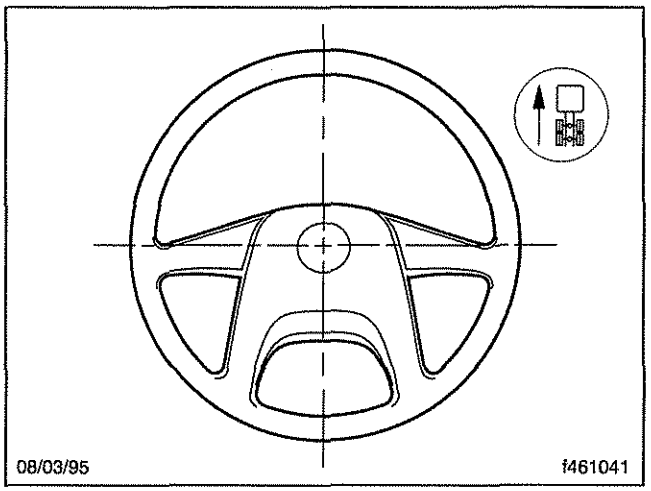


Fig. 2, Steering Wheel Centered

Testing

WARNING: All steering mechanisms are essential to the safe operation of the vehicle. Follow the instructions in this subject exactly. Failure to do so may result in loss of steering, which could cause personal injury or property damage.

Have someone gently turn the steering wheel back and forth; check for looseness between the ball stud end, and both the pitman arm and steering arm. Also check for looseness of the ball stud nut.

If the ball stud *end* is loose, replace the drag link. If the ball stud *nut* is loose, replace the nut and cotter key. Tighten the ball stud nut as follows **(see Table 1):**

Size	Torque lbf·ft (N·m)
3/4–16	90–170 (122–230)
7/8–14	160–300 (217–407)

Table 1, Torque Values

Grasp the drag link near the pitman arm end, push and pull laterally to check for axial looseness in the ball stud end. If there is looseness, replace the drag link. For instructions, refer to **Subject 100.** If there is 1/8-inch (3-mm) looseness or more, do not drive the vehicle until the drag link is replaced.

Grasp the drag link near the steering arm end. Push and pull vertically to check for axial looseness in the ball stud end. If there is looseness, replace the drag link. For instructions, refer to **Subject 100.** If there is 1/8-inch (3-mm) looseness or more, do not drive the vehicle until the drag link is replaced.

Grease the drag link until the old grease is purged.

Ball Stud Cover Replacement

Replacement (See Fig. 1)

1. Remove the drag link. For instructions, refer to **Subject 100.**

CAUTION: Use care when removing the ball stud cover with a screwdriver. Damage to the sealing surface of the socket forging could occur.

2. Using a screwdriver, press or tap on the flanged portion of the cover and remove it from the ball stud socket assembly.
3. Using a clean rag, wipe off all grease and dirt from around the ball stud and socket throat.
4. Grease the socket throat and ball stud with a multipurpose chassis grease NLGI Grade 2 (8% 12-hydroxy lithium stearate grease) or NLGI Grade 1 (6% 12-hydroxy lithium stearate grease); Grade 2 is preferred. Using the same grease, fill the new ball stud cover three-quarters full.
5. Position the socket assembly in a large vise, or on a press so that the ball stud is perpendicular to the socket stem.

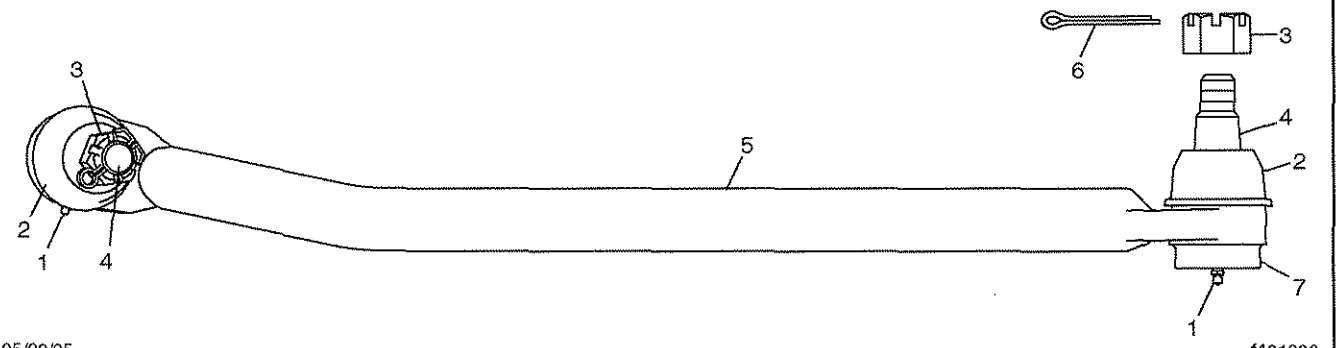
CAUTION: Do not use a screwdriver, chisel, or punch (or any other sharp-pointed tool) to install the ball stud cover. Using these types of tools could cut and damage the cover.

IMPORTANT: To install the stud cover, use a section of tubing that has an inside diameter as close as possible to the outside diameter of the stud cover. Also, make sure that the inside edge of the tube is chamfered (angled) to avoid cutting the rubber stud cover.

6. Using a section of tubing, press on the new stud cover. The cover is in place when the flanged portion of the cover is seated on the machined section (sealing face) of the socket forging.

CAUTION: Do not apply excessive pressure when pressing on the seal. Too much pressure during installation could deform the cover and result in incorrect sealing.

7. Install the drag link. For instructions, refer to **Subject 100.**



1. Grease Fitting
2. Ball Stud Cover
3. Castle Nut
4. Tapered Ball Stud
5. Drag Link
6. Cotter Pin
7. Dust Cap

Fig. 1, Drag Link Assembly

Contents

Subject	Subject Number
General Description	050
Service Operations	
Steering Driveline Removal and Installation	100
Steering Driveline Boots Replacement, Century Class Conventional	110
Steering Driveline Boot Replacement, Argosy COE	120
Specifications	400

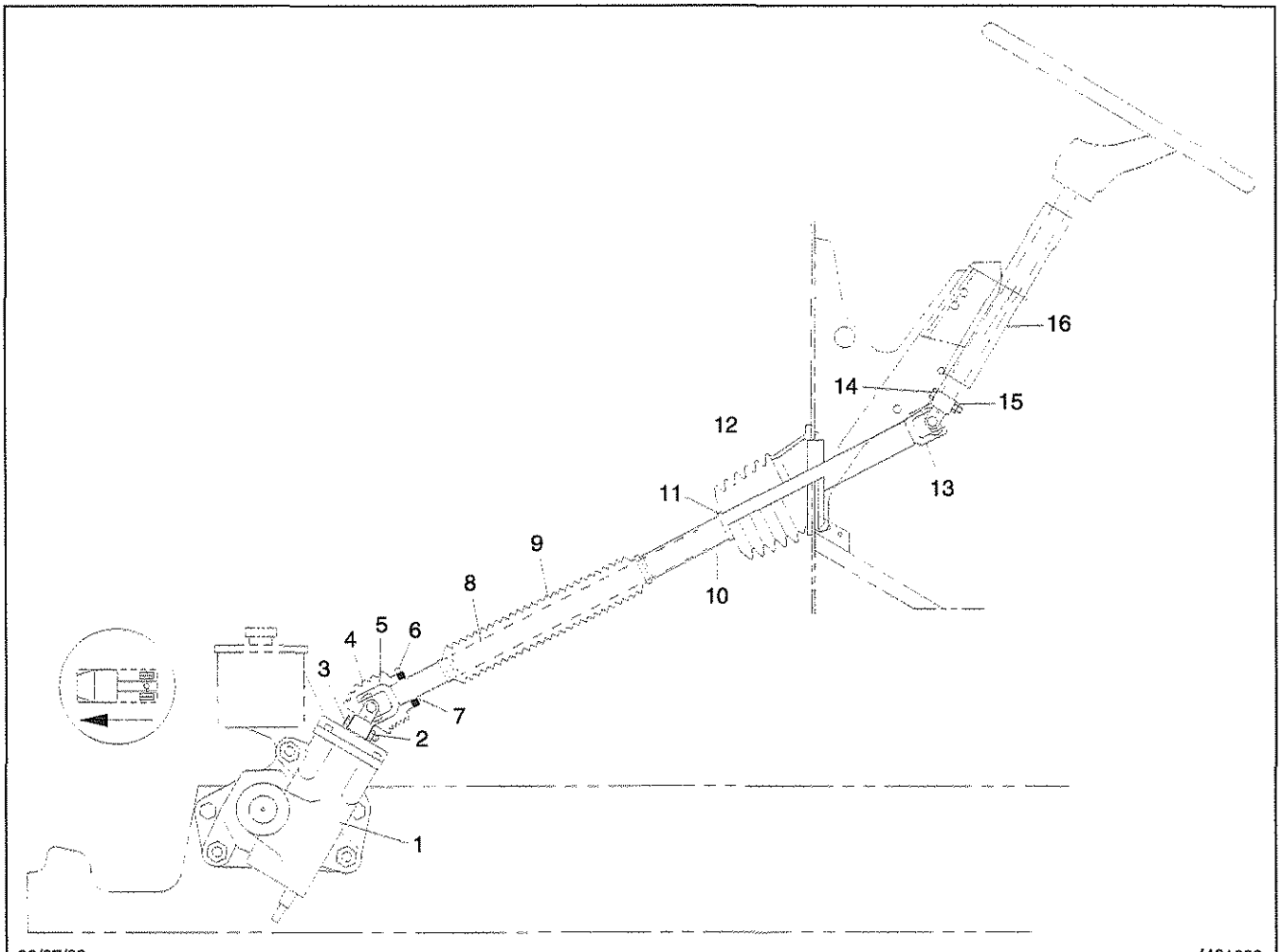
General Description

There are two types of steering drivelines available depending on your vehicle:

On Century Class conventionals, a single steering driveline connects the steering column to the steering gear by means of a telescoping shaft with integral yokes, an upper and a lower end yoke, and a pair of universal joints. See **Fig. 1**.

On Argosy COEs, there are two drivelines. The upper driveline connects to the base of the steering column. The lower driveline connects to the steering gear input shaft. The two drivelines connect to each other just below the cab floor where a bearing (the deck bearing) helps secure them.

Each driveline shaft consists of a tubular upper section, splined on the outside, which mates with an internally splined lower section. The telescoping shaft eases in-



1. Power Steering Gear
2. Pinch Bolt Nut
3. Lower End Yoke Pinch Bolt
4. Lower Boot
5. Lower End Yoke
6. Boot Clamp
7. Spacer
8. Inner Tube (male)
9. Steering Driveline Boot
10. Outer Tube (female)
11. Upper Boot Bushing
12. Upper Boot
13. Upper End Yoke
14. Upper End Yoke Pinch Bolt
15. Upper End Yoke Pinch Bolt Nut
16. Steering Column

Fig. 1, Steering Driveline Installation, Century Class Conventional (left-hand drive)

General Description

stallation and removal of the steering column, steering driveline, and steering gear. It also compensates for changes in distance between the steering column and steering gear, which occur when the relative positions of the frame rails and cab change during vehicle operation, or when a COE cab is tilted.

The upper end yoke is internally serrated to match the external serrations at the end of the steering column shaft; the lower end yoke is internally serrated to match the external serrations on the steering gear input shaft. Each end yoke is secured to its respective shaft by a pinch bolt that engages a notch in the shaft.

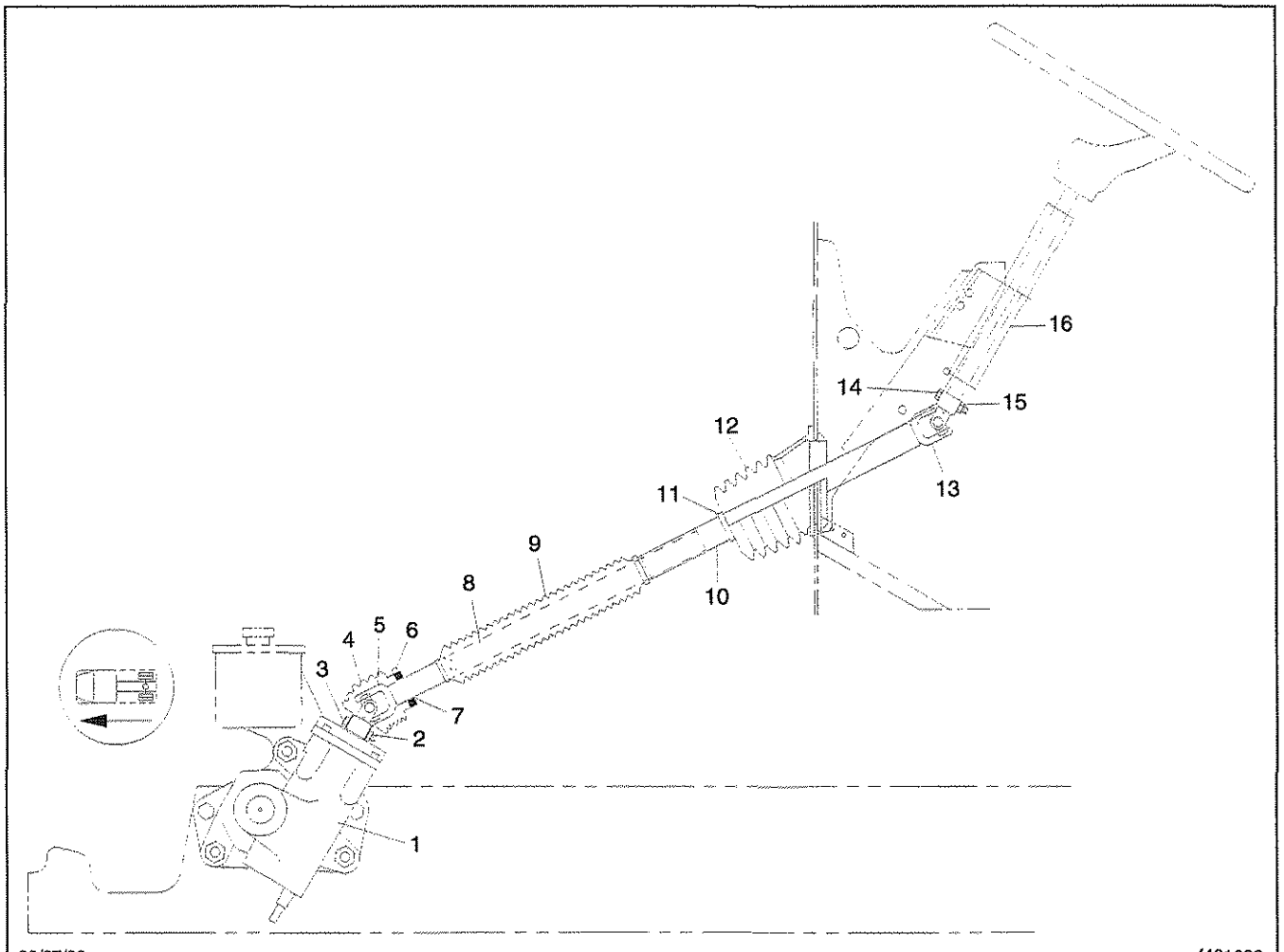
The universal joint at each end of each steering driveline allows the transfer of steering motion from the steering column shaft, to the steering driveline, and to the steering gear input shaft, even though the driveline is at an angle to both of the other shafts. Each universal joint cross rides in four needle bearing cups, two carried in the end yoke, and two carried in the steering driveline's integral yoke. The needle bearing cups are held in place in each yoke by snap rings.

Steering Driveline Removal and Installation

Removal

NOTE: It is not necessary to loosen the steering wheel and column assembly to do this procedure.

1. Position the front tires straight ahead. If possible, drive the vehicle in a straight line for a short distance, stopping at the spot where service operations will be done.
2. Apply the parking brakes, and chock the tires. Open the hood or tilt the cab. For cab tilt instructions, see **Group 60** in this manual.
3. Remove the upper boot bushing. See **Fig. 1**.
4. From inside the cab, disconnect the upper end yoke.
   4.1 Detach the lower portion of the steering column cover and remove it.



1. Power Steering Gear
2. Pinch Bolt Nut
3. Lower End Yoke Pinch Bolt
4. Lower Boot
5. Lower End Yoke
6. Boot Clamp
7. Spacer
8. Inner Tube (male)
9. Steering Driveline Boot
10. Outer Tube (female)
11. Upper Boot Bushing
12. Upper Boot
13. Upper End Yoke
14. Upper End Yoke Pinch Bolt
15. Upper End Yoke Pinch Bolt Nut
16. Steering Column

Fig. 1, Steering Driveline, Left-Hand Drive

Steering Driveline Removal and Installation

4.2 Remove the pinch bolt nut and the pinch bolt from the upper end yoke. Discard the nut and the bolt. Do not reuse the nut or the bolt.

⚠ CAUTION

Be careful when disconnecting the steering driveline from the steering column. Excessive force could damage the steering gear input valve attached to the opposite end of the steering shaft.

4.3 Remove the upper end yoke from the steering column shaft.

5. Disconnect the lower end yoke.

5.1 Remove the pinch bolt nut and the pinch bolt from the lower end yoke. See **Fig. 2**. Discard the nut and the bolt. Do not reuse the nut or the bolt.

5.2 Remove the yoke from the steering gear input shaft. Don't turn the steering gear input shaft when removing the lower end yoke.

⚠ CAUTION

Do not use a torch to break the threads loose when removing the lower end yoke. Heat will damage the seals in the power steering gear.

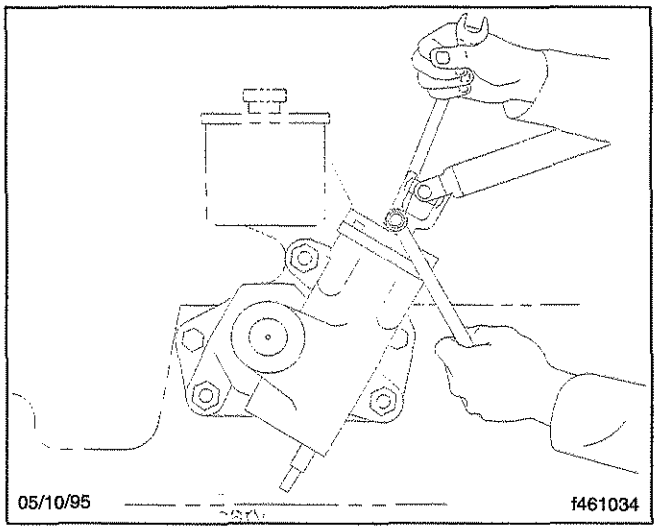


Fig. 2, Disconnect the Lower End Yoke

6. Pull the steering driveline forward through the upper boot and out of the engine compartment. Be careful not to dislodge the upper boot from its seat in the frontwall.

Installation

IMPORTANT: When installing the replacement steering driveline, be sure to connect the inner tube (male) to the steering gear and connect the outer tube (female) to the steering column. See **Fig. 1**.

1. Insert the upper end of the new steering driveline through the upper boot and partially into the cab.

⚠ CAUTION

Do not pull the driveline apart. The male and female halves are pre-oriented so that the pinch bolt slots on each end of the shaft line up with each other. Assembling the driveline with the U-joints incorrectly oriented could cause binding at the U-joints.

2. Install the lower end yoke on the steering gear input shaft. Before installing the new pinch bolt nut, make sure the new pinch bolt is centered in the steering gear input shaft notch. The pinch bolt is centered if it can slip in and out of the end yoke with ease. Install a new pinch bolt nut, and tighten it 45 to 55 lbf·ft (61 to 75 N·m).
3. Apply white Torque Seal F–900 to the exposed pinch bolt thread and to the locknut. See **Fig. 3**.
4. Before attaching the upper end yoke to the steering column, be sure the front tires are straight ahead and the steering gear is centered.
5. Slide the upper end yoke onto the steering column shaft, then install the new end yoke pinch bolt. Before installing the pinch bolt nut, make sure the pinch bolt is centered in the steering column shaft notch. The pinch bolt is centered if it can slip in and out of the end yoke with ease. Install a new pinch bolt nut, and tighten it 45 to 55 lbf·ft (61 to 75 N·m).
6. Apply white Torque Seal F–900 to the exposed pinch bolt thread and to the locknut.
7. Inside the cab, install the steering column cover.
8. Install the upper boot bushing.

Fig. 3, Apply White Torque Seal F-900

9. With the front tires pointing straight ahead, the steering wheel should be within ±10 degrees of center as shown in **Fig. 4**.

   If not, remove the steering wheel and install it in the correct position. For instructions, refer to the applicable section in this group.

10. Return the hood or cab to the operating position. For cab tilt instructions, see **Group 60**.

11. Leave the parking brakes applied and the chocks at the rear tires.

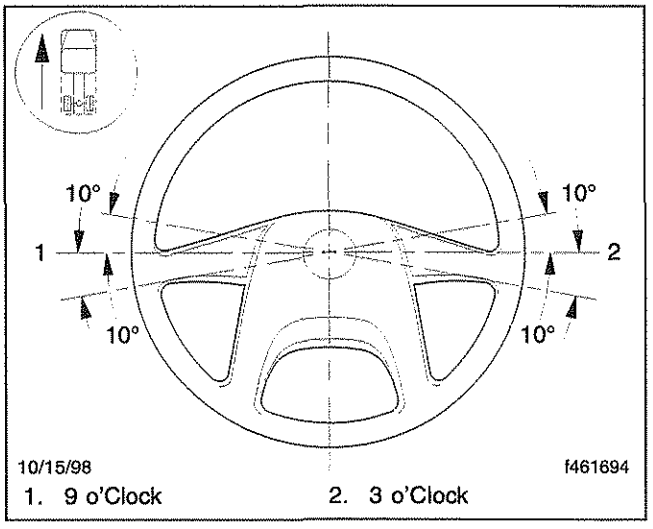


Fig. 4, Steering Wheel Centered

⚠ WARNING

Driving a vehicle with hard steering or binding in the steering system could result in partial or complete loss of steering control during vehicle operation, possibly causing personal injury and property damage.

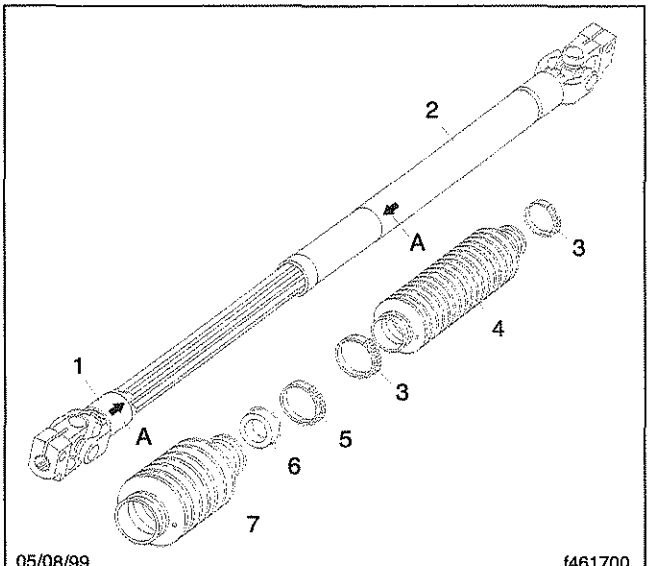
12. Start the vehicle and turn the steering wheel from side to side to check for hard steering or binding. If there is difficulty, check the assembly and installation of the driveline parts. If the cause is not the driveline, refer to the applicable steering gear section in this group.

13. Remove the chocks from the tires.

Steering Driveline Boots Replacement, Century Class Conventional

Replacement

1. Position the front tires straight ahead. If possible, drive the vehicle in a straight line for a short distance, stopping at the spot where service operations will be done.
2. Apply the parking brakes, chock the tires, and open the hood.
3. Disconnect the lower end yoke.
   - 3.1 Remove the pinch bolt nut and the pinch bolt from the lower end yoke. Discard the nut and the bolt.
   - 3.2 Remove the yoke from the steering gear input shaft. Don't turn the steering gear input shaft when removing the lower end yoke. Push the driveline inner tube into the outer tube as you remove the lower end yoke. See **Fig. 1**.
4. Remove the lower boot clamp. Then remove the lower boot and the spacer.



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A. Alignment Arrows
1. Inner Tube (to the steering gear)
2. Outer Tube (to the steering column)
3. Steering Driveline Boot Clamp
4. Steering Driveline Boot
5. Lower Boot Clamp
6. Spacer
7. Lower Boot

Fig. 1, Steering Driveline

5. Remove the steering driveline boot clamps. Slide the steering driveline boot down over the inner tube, and remove both the boot and the inner tube.
6. Using a clean, dry cloth, clean the splined section of the inner tube. Do not use cleansers.
7. Apply a thin film of TRW grease, TRW part number 406039, to the splined portion of the inner tube.

IMPORTANT: Use only TRW grease on the inner tube.

8. Place a new steering driveline boot over the inner tube.
9. Insert the inner tube in the outer tube. Make sure the arrows are aligned.

⚠ CAUTION

If the arrow on the driveline inner tube is not aligned with the arrow on the outer tube, the U-joints will not be correctly oriented. Assembling the driveline with the U-joints incorrectly oriented could cause binding at the U-joints.

10. Use clamps to attach the steering driveline boot to the outer and inner tubes.
11. Stroke the driveline several times to ensure that the boot is firmly in place, and that the driveline slides freely.
12. Place the spacer and a new lower boot on the steering driveline. Use a clamp to attach the upper end of the boot to the driveline.
13. Before attaching the lower end yoke to the steering gear input shaft, be sure the front tires are straight ahead, the steering gear is centered, the arrows on the driveline inner tube and the outer tube are aligned, and the driveline slides freely.
14. Install the lower end yoke on the steering gear input shaft. Before installing the pinch bolt nut, make sure the pinch bolt is centered in the steering gear input shaft notch. The pinch bolt is centered if it can slip in and out of the end yoke with ease. Install a *new* pinch bolt and a *new* pinch bolt nut. Tighten the nut 45 to 55 lbf·ft (61 to 75 N·m).
15. Apply white Torque Seal F-900 to the exposed pinch bolt thread and to the locknut. See **Fig. 2**.
16. Remove the chocks from the tires, and close the hood.

Steering Driveline Boots Replacement, Century Class Conventional

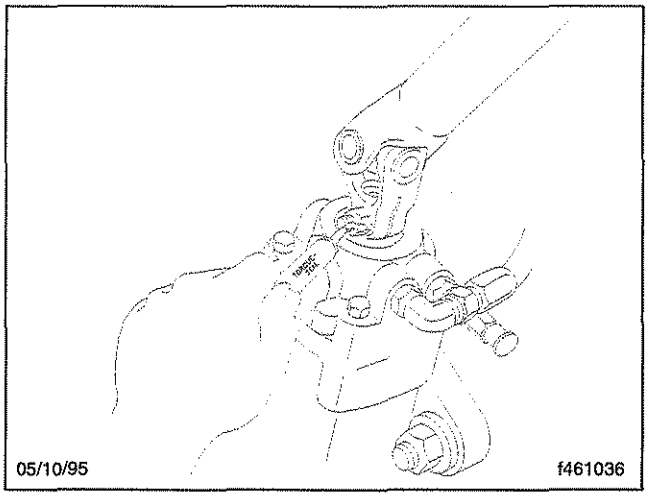


Fig. 2, Apply White Torque Seal F-900

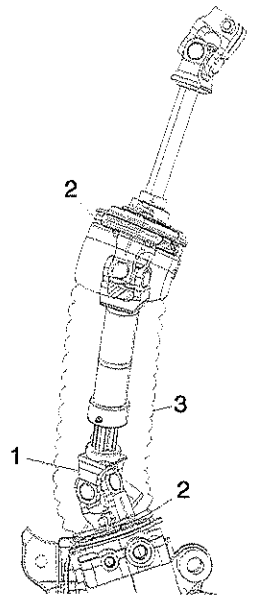
Steering Driveline Boot Replacement, Argosy COE

Replacement

1. Position the front tires straight ahead. If possible, drive the vehicle in a straight line for a short distance, stopping at the spot where service operations will be done.
2. Turn off the engine, apply the parking brakes, chock the tires, and tilt the cab. For cab tilt instructions, see **Group 60**.
3. Remove the steering driveline boot tie straps at the top and bottom of the steering driveline boot. See **Fig. 1**.
4. Disconnect the lower end yoke.
   - 4.1 Remove the pinch bolt nut, the pinch bolt, and washers from the lower end yoke. Discard the nut and the bolt.
   - 4.2 Mark the lower end yoke and the steering gear input shaft so that when the yoke is installed on the shaft, they are in the same position as when they were removed.
   - 4.3 Remove the yoke from the steering gear input shaft. Don't turn the steering gear input shaft when removing the lower end yoke. Push the driveline inner tube into the outer tube as you remove the lower end yoke. See **Fig. 2**.
5. Remove the steering driveline boot.
6. Using a clean, dry cloth, clean the splined section of the inner tube. Do not use cleansers.
7. Apply a thin film of TRW grease, TRW part number 406039, to the splined portion of the inner tube.

IMPORTANT: Use only TRW grease on the inner tube.

8. Install a new steering driveline boot to the steering shaft bracket.
   - 8.1 Align the LHD (left-hand drive) arrow or the RHD (right-hand drive) arrow on the steering driveline boot with the marker on the steering shaft bracket. See **Fig. 3**.
   - 8.2 Make sure the steering driveline boot is completely over the lip of the steering shaft bracket. See **Fig. 2**.
   - 8.3 Use a tie strap to attach the upper end of the steering driveline boot to the steering shaft bracket.
9. Make sure the arrows on the lower end yoke and the steering shaft are aligned. See **Fig. 2**.



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1. Lower End Yoke
2. Steering Driveline Boot Tie Strap
3. Steering Driveline Boot

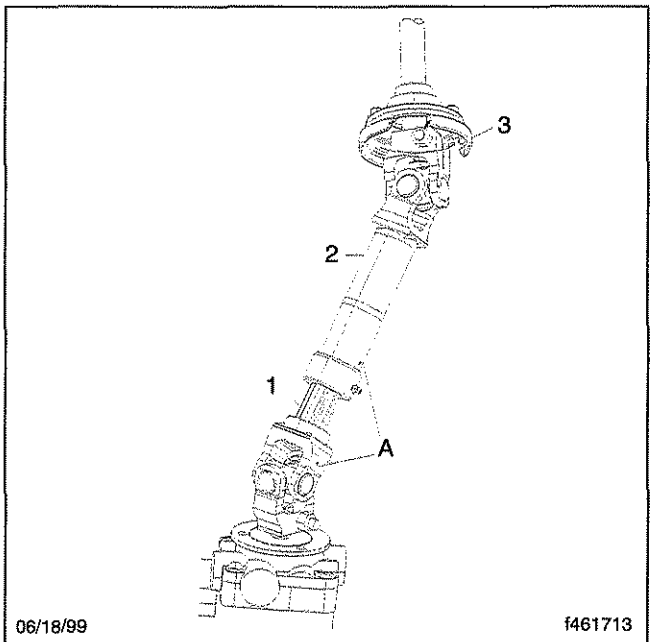
Fig. 1, Steering Driveline, Side View

⚠ CAUTION

If the arrow on the lower end yoke is not aligned with the arrow on the steering shaft, the U-joints will not be correctly oriented. Assembling the driveline with the U-joints incorrectly oriented could cause binding at the U-joints.

10. Before attaching the lower end yoke to the steering gear input shaft, be sure the front tires are straight ahead, the steering gear is centered, the arrows on the lower end yoke and the steering shaft are aligned, and the driveline slides freely.
11. Install the lower end yoke on the steering gear input shaft. Before installing a new pinch bolt nut, make sure the pinch bolt is centered in the steering gear input shaft notch. The pinch bolt is centered if it can slip in and out of the end yoke with ease. Install a *new* pinch bolt and washer, and a *new* pinch bolt nut and washer. Tighten the nut 55 to 65 lbf·ft (75 to 88 N·m).

Steering Driveline Boot Replacement, Argosy COE



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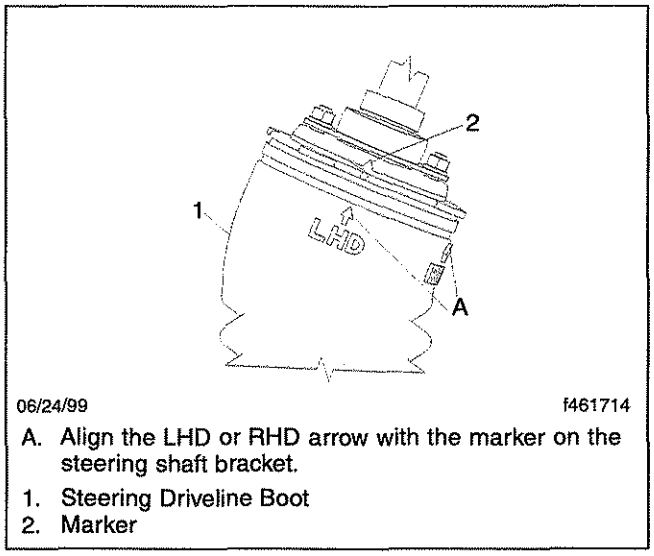
A. Align the arrows on the lower end yoke and the steering shaft.
1. Inner Tube (to the steering gear)
2. Outer Tube (to the steering column)
3. Steering Shaft Bracket

Fig. 2, Steering Driveline, Front View



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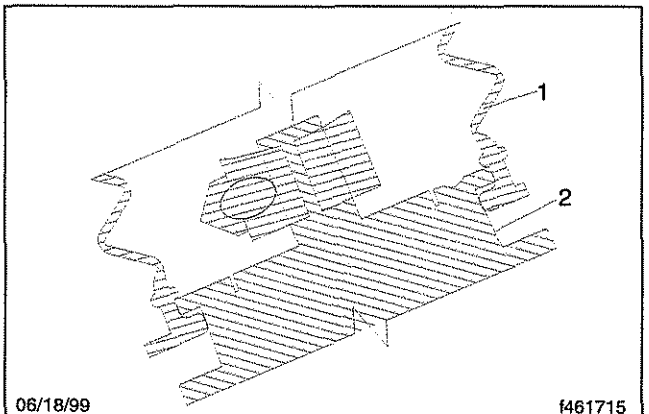
A. Align the LHD or RHD arrow with the marker on the steering shaft bracket.
1. Steering Driveline Boot
2. Marker

Fig. 3, Steering Driveline Boot

12. Attach the new steering driveline boot to the steering gear.
    12.1 Make sure the steering driveline boot is completely over the lip on the steering gear. See **Fig. 4**.
    12.2 Use a tie strap to attach the lower end of the steering driveline boot to the steering gear.
13. Apply white Torque Seal F900 to the exposed pinch bolt thread and to the locknut. See **Fig. 5**.
14. Remove the chocks from the tires, and return the cab to the operating position. For cab tilt instructions, see **Group 60**.



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1. Steering Driveline Boot
2. Steering Gear

Fig. 4, Steering Driveline Boot, Section View

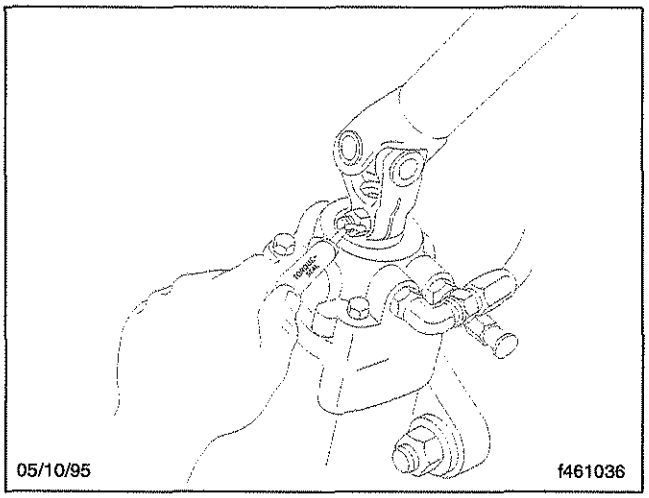

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Fig. 5, Apply White Torque Seal F900

Specifications

Torque Values			
Description	**Grade**	**Size**	**Torque lbf·ft (N·m)**
End Yoke Pinch Bolt Nut	8 or 8.2	7/16–20 UNF	45 to 55 (61 to 75)

Table 1, Torque Values

Contents

Subject	Subject Number
General Description	050
Service Operations	
Steering Gear Removal and Installation	100
Input Shaft Seal Replacement	110
Sector Shaft Replacement	120
Automatic Relief Plunger Adjustment	130
Setting the Automatic Relief Plunger	140
Automatic Relief Plunger Repair Procedure	150
Pitman Arm Removal and Installation	160
Steering Gear Post-Service Checks	170
Troubleshooting and Diagnostic Checks	300
System Setup for Hydraulic Checks	305
Specifications	400

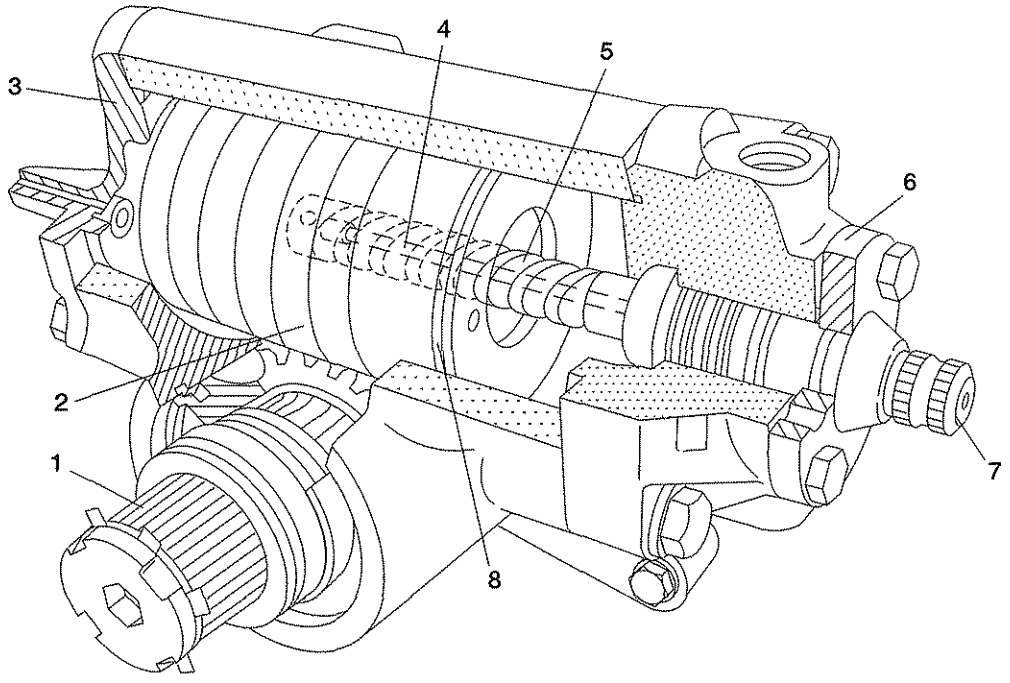
General Description

The Sheppard M100 integral power steering gear provides full-time hydraulic steering. This gear is installed as an option on vehicles with a front axle capacity of up to 14,000 pounds (6350 kg).

The steering gear is mounted on the left frame rail. It connects the steering driveline to an input shaft that is connected to a sector shaft and the pitman arm.

Principles of Operation

When the steering wheel is turned, the force is transmitted to the steering gear input (actuating) shaft (**Fig. 1**) via the steering driveline. The input shaft is connected to the rotary valve and a torsion bar. When the input shaft turns, the twisting force on the torsion bar turns the rotary valve, which causes the fluid pressure to build up at one end of the piston. The rotary valve shaft fits into one end of the piston and the fluid pressure buildup, together with the recirculating ball mechanism, forces the piston to move in one direction inside the bore of the gear housing. The rack teeth on the piston mesh with the teeth on the sector (output) shaft so that the sector shaft rotates when the piston moves. When the sector shaft turns, it moves the pitman arm. The pitman arm in turn connects to the steering linkage, which turns the wheels.



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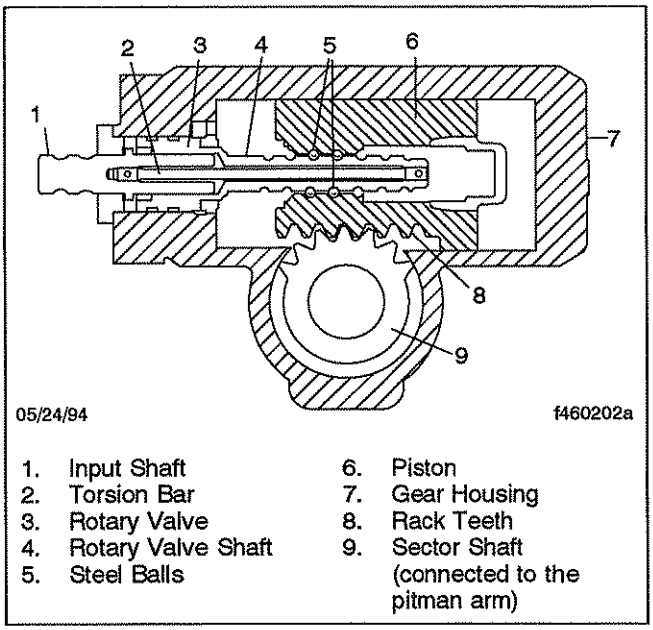
1. Sector (output) Shaft
2. Piston Rack
3. Cylinder Head
4. Torsion Bar
5. Rotary Valve Shaft Ball Thread
6. Bearing Cap Cover
7. Input (actuating) Shaft
8. Piston Ring

Fig. 1, Sheppard M100 Power Steering Gear



1. Input Shaft
2. Torsion Bar
3. Rotary Valve
4. Rotary Valve Shaft
5. Steel Balls
6. Piston
7. Gear Housing
8. Rack Teeth
9. Sector Shaft (connected to the pitman arm)

Fig. 2, Steering Gear (sectional view)

Steering Gear Removal and Installation

Removal

IMPORTANT: Before removing the steering gear, refer to **Troubleshooting 300** to identify the problem.

1. Place the front tires in the straight-ahead position. If possible, drive the vehicle in a straight line for a short distance stopping at the place where the work is to be done. Apply the vehicle parking brakes and chock the tires.

⚠ CAUTION

Do not turn the steering wheel or the steering shaft more than a half turn (except for alignment purposes) during the removal and installation procedures. Doing so may damage the clockspring in a vehicle equipped with an air bag.

2. Clean all outside dirt from around the fittings and hose connections.
3. Drain the power steering system. Disconnect all hydraulic lines from the gear, marking the lines for later reference during installation. Seal the lines and the fittings to keep dirt out.
4. Disconnect the pitman arm from the steering gear. See **Fig. 1**. For instructions, see **Subject 160**.
5. Disconnect the steering driveline from the steering gear input shaft.
   - 5.1 Remove the pinch bolt nut and the pinch bolt from the lower end of the steering driveline yoke.

⚠ CAUTION

Do not pound the U-joint or input shaft coupling on or off the input shaft. Internal damage to the steering gear can result.

   - 5.2 Remove the steering driveline yoke from the steering gear input shaft.

6. Clean the entire assembly before removing the gear.

⚠ WARNING

The steering gear is heavy. Use caution when removing, lifting, or carrying the steering gear. Failure to do so could cause personal injury.

7. Remove the fasteners attaching the steering gear to the frame rail. Remove the steering gear and place the steering gear on a clean surface.

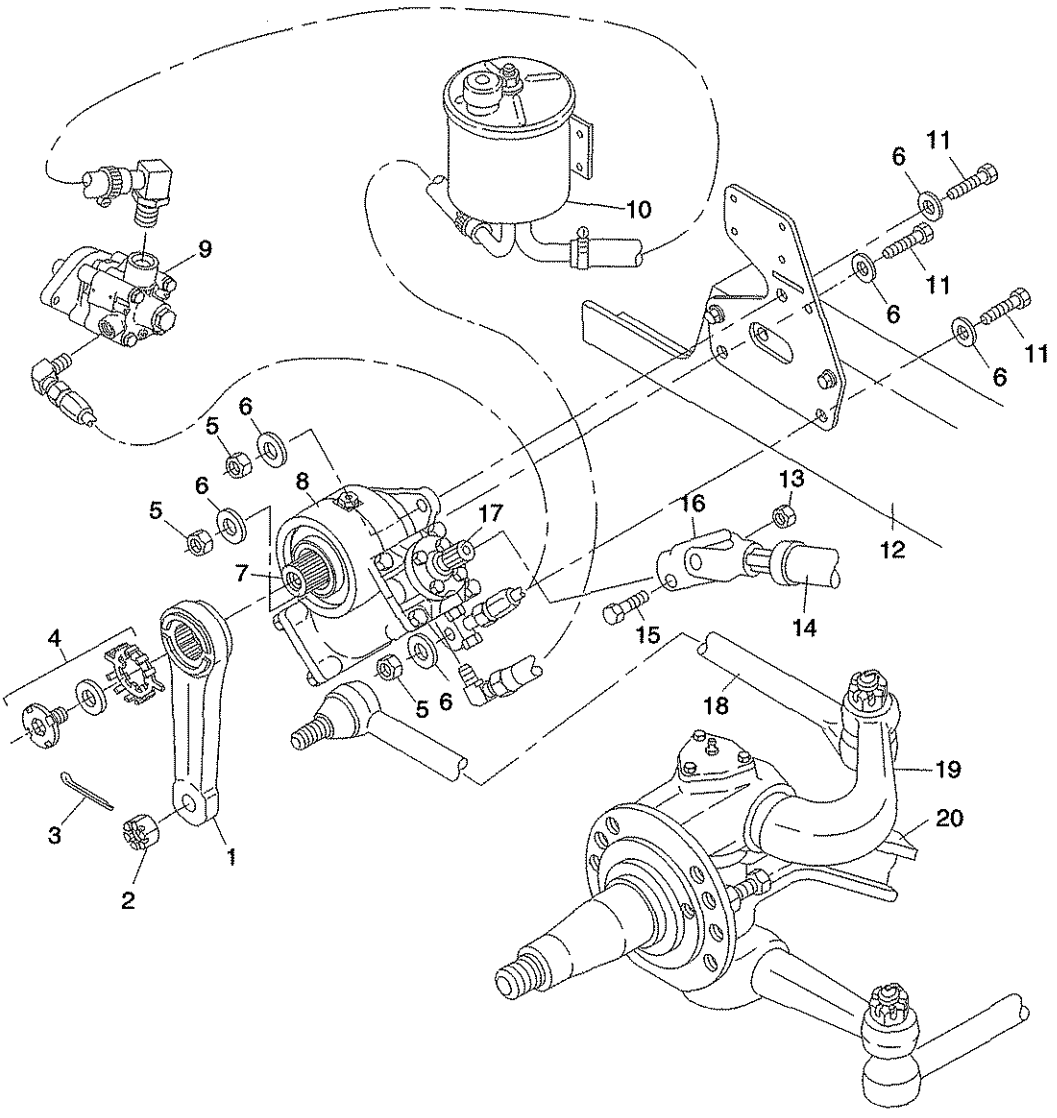
Installation

1. Align the holes in the steering gear housing with the holes in the frame rail. Place a washer over each hex bolt and install the three hex bolts. Install a washer and nut on the end of each hex bolt and tighten the nuts 388 lbf·ft (526 N·m).
2. Install the pitman arm on the steering gear. For instructions, see **Subject 160.**
3. Connect the steering driveline to the steering gear input shaft.
   - 3.1 Clean the steering gear input shaft and the inside of the steering driveline yoke.
   - 3.2 Slide the yoke on the input shaft and install the yoke pinch bolt and a new pinch bolt nut. Tighten the pinch bolt nut 60 lbf·ft (81 N·m).
   - 3.3 Apply torque seal, OGP F900WHITE, to the exposed pinch bolt threads and the locknut tips.
4. Connect the hydraulic lines to the gear as marked earlier or as shown in the plumbing diagram in **Specifications 400**. Tighten the nut on each fitting finger-tight. Then with a wrench, tighten the nut until there is firm resistance. Tighten the nut one-sixth turn more.
5. Position the steering wheel so that it is within ±10 degrees of center as shown in **Fig. 2**.

⚠ WARNING

For the first two substeps below, do not turn the steering wheel. Doing so can cause air to enter the system. This could result in an unexpected loss of power steering assist, which could cause personal injury or property damage.

Steering Gear Removal and Installation



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NOTE: Not all fasteners are shown.

1. Pitman Arm
2. Castle Nut
3. Cotter Pin
4. Pitman Arm Retainer Assembly
5. Hex Nut
6. Washer
7. Sector (output) Shaft
8. Steering Gear
9. Power Steering Pump
10. Power Steering Reservoir
11. Hex Bolt
12. Frame Rail
13. Pinch Bolt Nut
14. Steering Driveline
15. Pinch Bolt
16. Lower End Yoke
17. Input (actuating) Shaft
18. Drag Link
19. Axle Steering Arm
20. Front Axle

Fig. 1, Sheppard M100 Power Steering Gear Installation

6. Connect the pitman arm to the steering gear. For instructions, see **Subject 160**.
7. Adjust the automatic relief plunger. For instructions, see **Subject 130**.

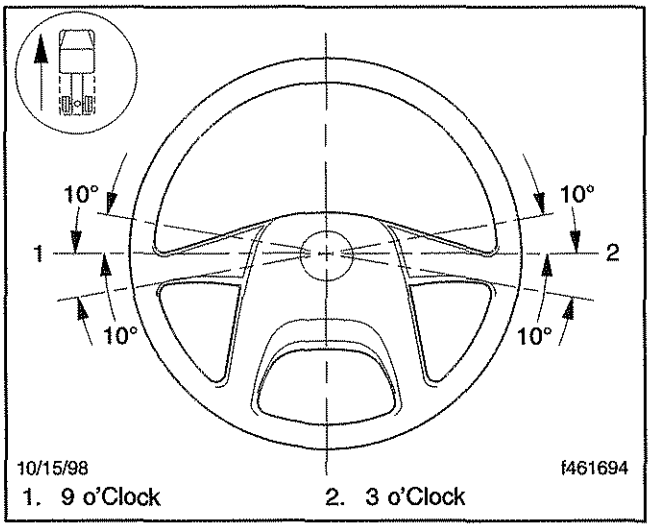


Fig. 2, Steering Wheel Centered

8. Refer to **Subject 170** and do the checks as instructed.

Input Shaft Seal Replacement

Disassembly

1. Turn off the engine, apply the parking brakes, and chock the tires.

IMPORTANT: Do not remove the steering gear for this procedure.

2. Open the hood or tilt the cab. For cab tilt instructions, see **Group 60** in this manual.
3. Remove the pinch bolt on the lower end yoke of the steering shaft.
4. Remove the lower yoke from the steering gear input shaft. If necessary, secure the shaft so it will not interfere with your work.

IMPORTANT: Do not pull the slip shaft out of the steering shaft. Installation of the slip shaft requires rephasing.

5. Place a drain pan under the power steering gear. Draining the system is not necessary, but some fluid will be lost.

⚠ CAUTION

Do not turn the input shaft during repairs. Damage to the steering gear will result.

6. Remove the rubber boot. See **Fig. 1**.
7. Remove the capscrews that attach the bearing cap cover to the bearing cap and remove the bearing cap cover.

IMPORTANT: The thrust washer will stick to the bearing cap cover. Install the thrust washer on the bearing cap before proceeding.

8. Place the bearing cap cover on a clean work surface. Pry the salt seal out of the bearing cap cover and discard the seal. See **Fig. 2**.
9. Press the oil seal out of the bearing cap cover cover using a suitable size socket or seal driver. Use of an arbor press is recommended. See **Fig. 3**. Discard the oil seal.
10. Remove the O-ring from the bearing cap cover. Discard the O-ring.
11. Clean the bearing cap cover with a suitable solvent.

Assembly

1. Place the bearing cap cover face down on a clean work surface. With the garter spring visible inside the oil seal, install the oil seal in the bearing cap cover using a suitable size driver and an arbor press. Coat the outside diameter of the oil seal with clean chassis lube. The garter spring will be visible when the oil seal is properly installed.
2. Install a new O-ring in the bearing cap cover. Make sure the oil seal is properly installed before proceeding.
3. With the lip of the salt seal facing out, press a new salt seal into the bearing cap cover until it is flush with the face of the cover. See **Fig. 4**.

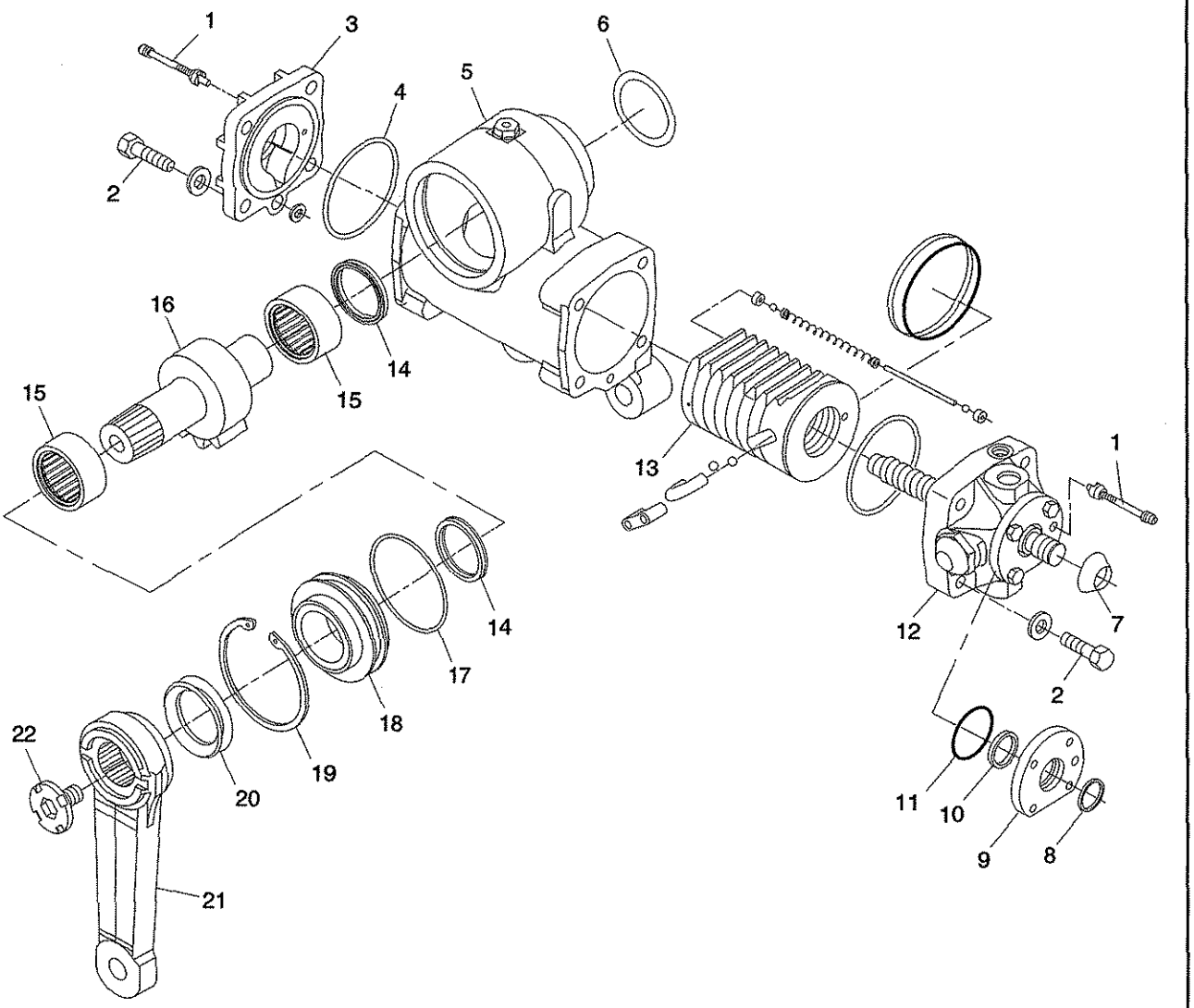
NOTE: Tape the input shaft splines before installing the bearing cap cover to prevent seal damage.

4. Using capscrews, attach the bearing cap cover to the bearing cap and torque the capscrews 53 to 64 lbf·ft (72 to 87 N·m).

NOTE: Two rubber boots are included in the replacement kit. Choose the rubber boot that will provide the tightest fit on the input shaft.

5. Install the rubber boot on the input shaft. Make sure the boot is below the spline and contacts the bearing cap cover when installed.
6. Remove the tape from the splines and install the U-joint following the instructions in **Section 46.04**, Subject 100.
7. Check the fluid level in the power steering reservoir and fill if necessary.
8. Start the vehicle and check for leaks.
9. Remove the drain pan and return the hood or cab to the operating position. For cab tilt instructions, see **Group 60** in this manual.
10. Remove the chocks from the tires.

Input Shaft Seal Replacement



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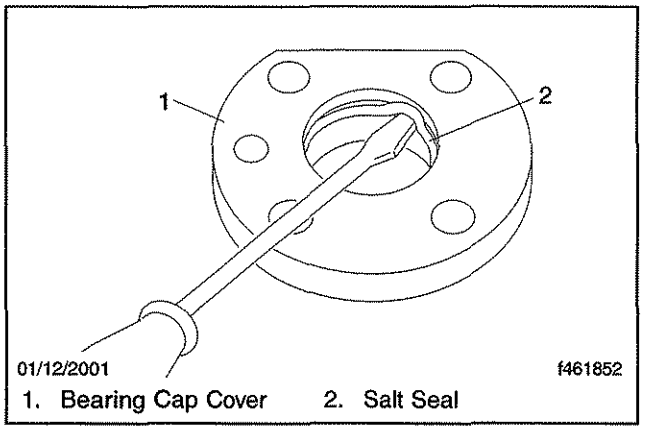
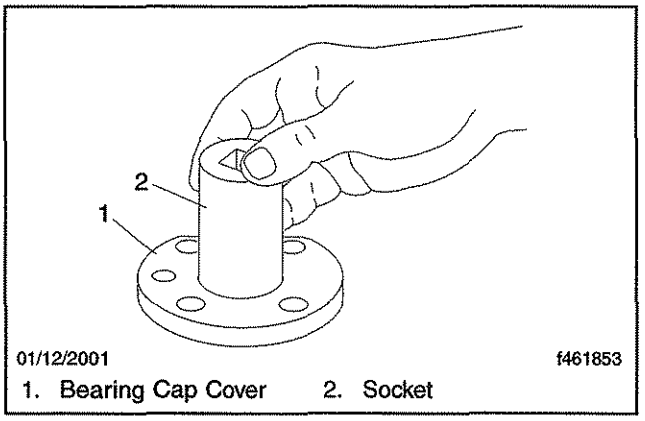
1. Automatic Relief Plunger
2. Capscrew
3. Cylinder Head
4. O-Ring
5. Steering Gear Housing
6. Frame Side Dust Cover
7. Rubber Boot
8. Salt Seal
9. Bearing Cap Cover
10. Oil Seal
11. O-Ring
12. Bearing Cap
13. Piston Rack
14. Oil Seal
15. Roller Bearing
16. Sector Shaft
17. O-Ring
18. Sector Shaft Cover
19. Snap Ring
20. Sector Shaft Boot
21. Pitman Arm
22. Pitman Arm Retainer

Fig. 1, Steering Gear Assembly



1. Bearing Cap Cover 2. Salt Seal

Fig. 2, Remove the Salt Seal



1. Bearing Cap Cover 2. Socket

Fig. 3, Remove the Oil Seal

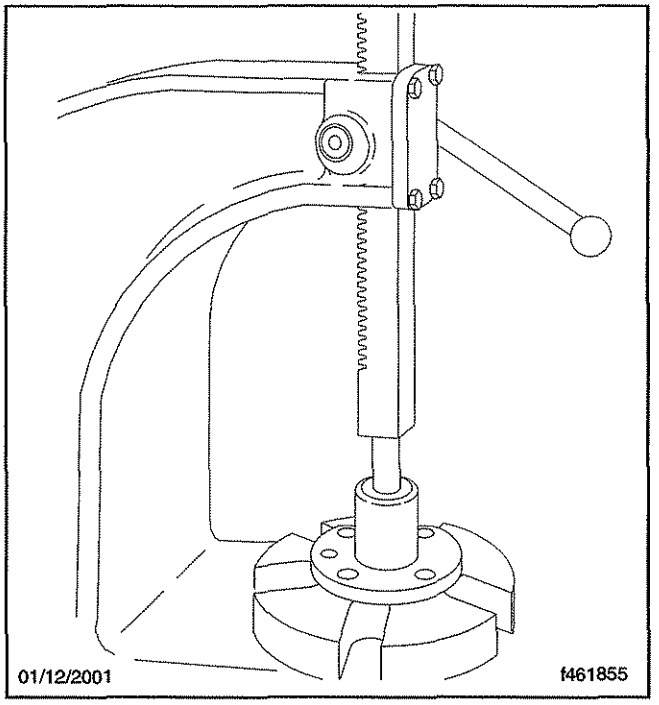


Fig. 4, Install the Salt Seal

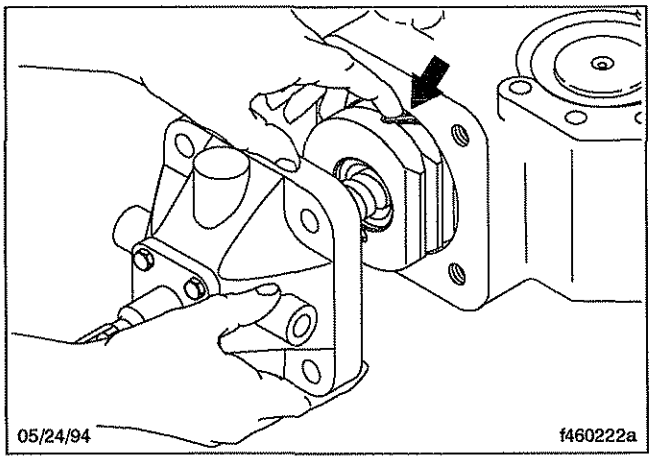


Fig. 14, Hold the Ball Guide Retainer in Place

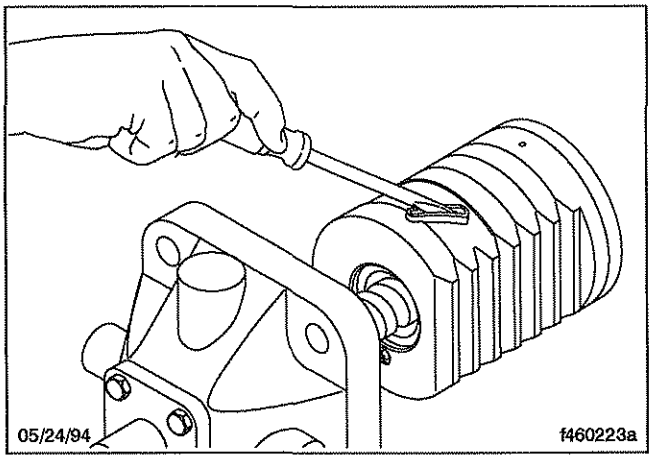


Fig. 15, Remove the Ball Guide Retainer

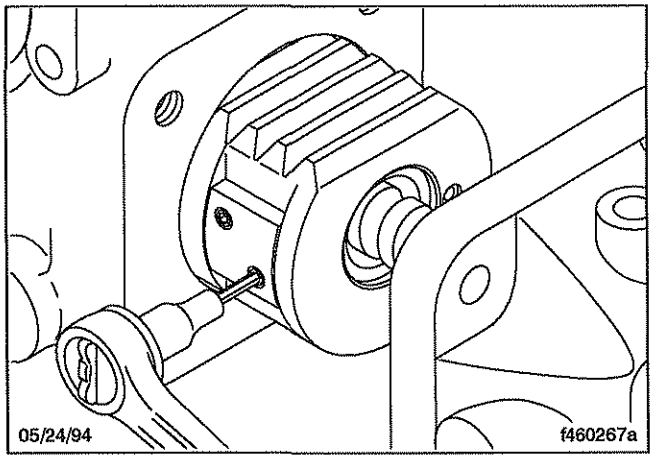


Fig. 16, Remove the Ball Guide Retainer

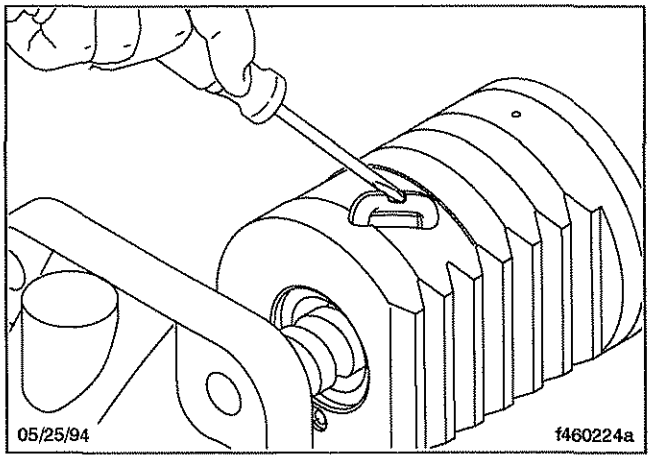


Fig. 17, Remove the Ball Return Guide Halves

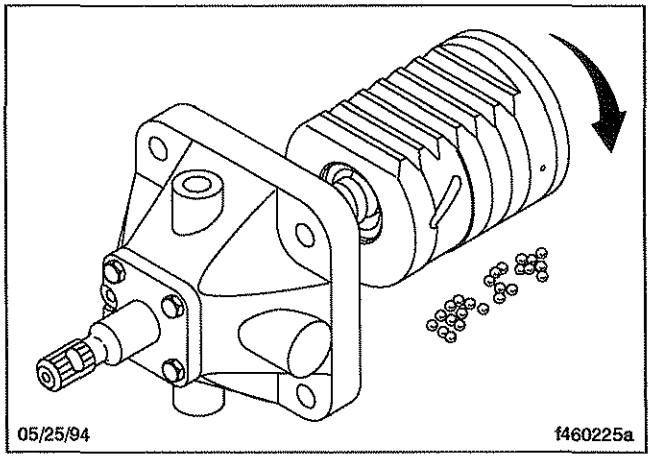


Fig. 18, Remove the Steel Balls

CAUTION: The relief ball valves inside the piston are held in place by spring tension. Be careful when removing the relief valve seats from the piston to avoid personal injury or loss of the balls.

20. Using a 3/16-inch allen wrench, remove the relief valve seat from one end of the piston, then the steel ball, spring, and plastic rod. **See Fig. 25.**
21. Remove the relief valve seat from the other end of the piston.
22. Remove the Teflon seal ring and the back-up O-ring from the piston. **See Fig. 26.**
23. If needed, remove the end plug **(Fig. 27)** from the piston, by first drilling out the locking pin **(Fig. 1,**

Steering Gear Disassembly, Inspection, and Assembly

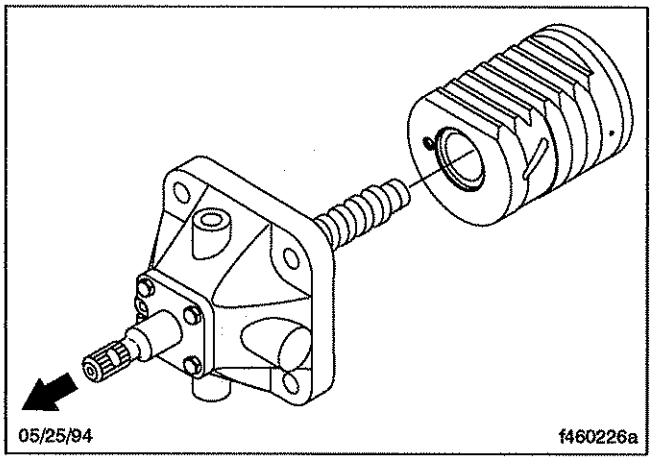
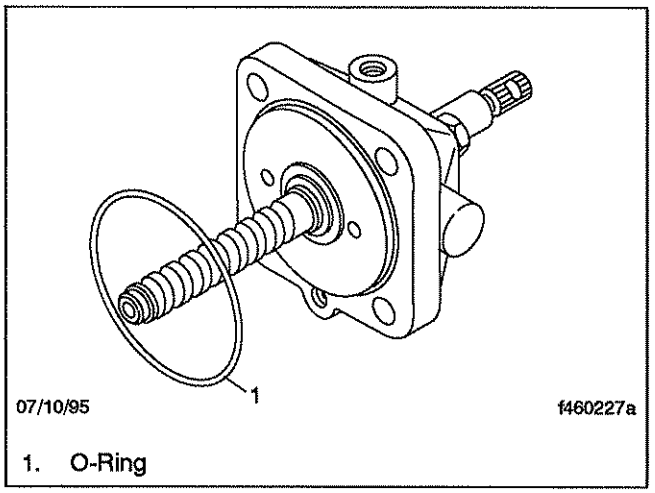


Fig. 19, Remove the Input Shaft and Bearing Cap Assembly



1. O-Ring

Fig. 20, Remove the Tetra Seal and the O-Ring

Ref. 56). Remove and discard the O-ring from the end plug.

24. Remove the roller bearing from the gear housing **(Fig. 28)**, if needed, by pressing it out of the housing.

25. Using a puller, remove the roller bearing (if needed) from the sector shaft cover. **See Fig. 29.**

Inspection

WARNING: Allow no dirt or other foreign matter to enter the steering gear. Dirt and foreign material in the steering system can cause damage and steering problems resulting in possible personal injury or property damage.

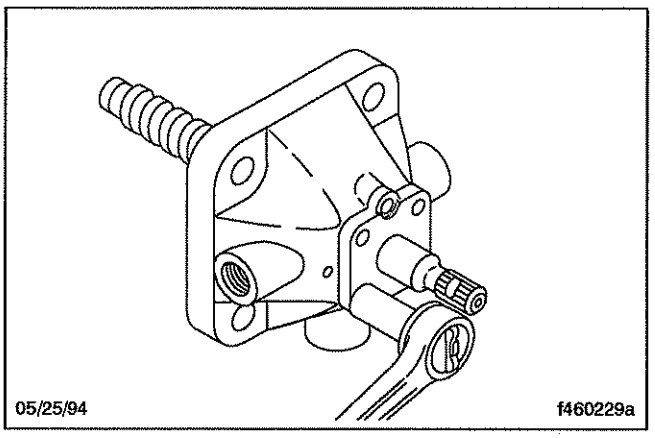


Fig. 21, Remove the Bearing Cap Attachment Bolts

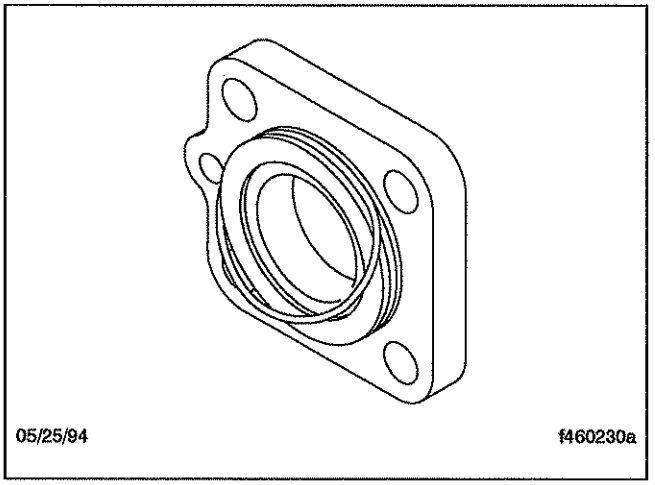


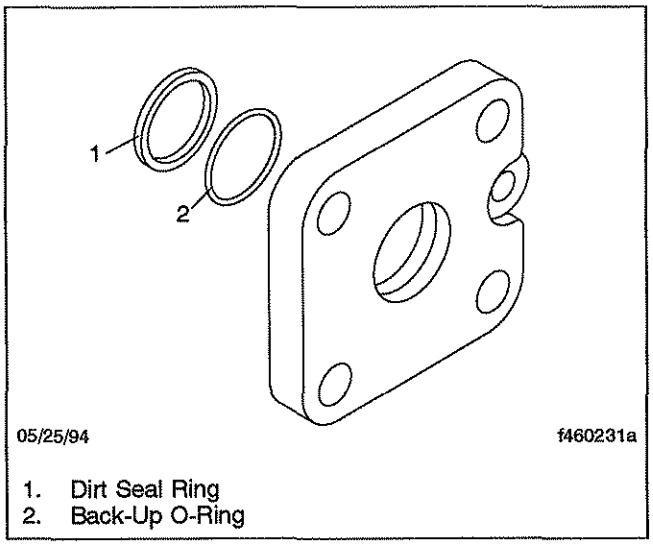
Fig. 22, Remove the O-Ring

1. Clean the machined parts one at a time, to avoid damage from bumping them together. Use a clean solvent to wash the parts, and dry them with compressed air.

2. Replace all the O-rings and seals whenever doing any kind of repair.

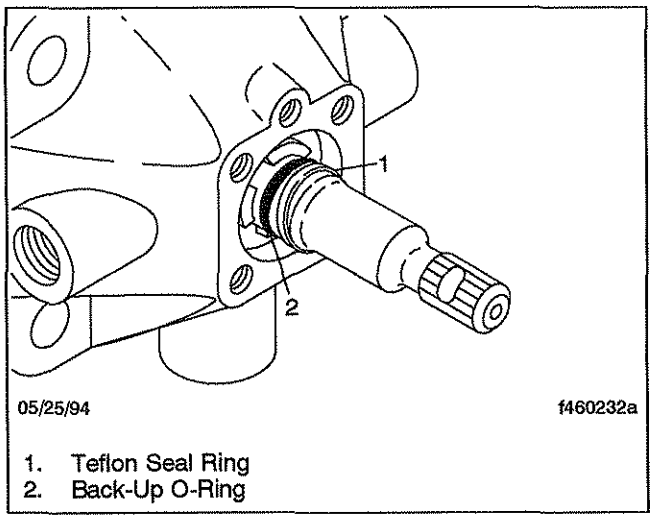
3. Carefully check all the steering gear parts. Replace worn parts, as well as any parts that show signs of stress or fatigue. Pay particular attention to the following:

   CAUTION: Do not hone or bore out the cylinder bore. This will increase internal leakage.



1. Dirt Seal Ring
2. Back-Up O-Ring

Fig. 23, Remove the Dirt Seal Assembly



1. Teflon Seal Ring
2. Back-Up O-Ring

Fig. 24, Remove the Outer Teflon Seal Ring and the Back-Up O-Ring

3.1 Check the piston and steering gear housing for scoring. Scoring may be caused by high operating temperatures, air in the hydraulic system, or incorrect or contaminated lubricant.

If parts have minor scoring, polish them with a fine handstone or crocus cloth to allow free movement of the mating parts.

Don't be alarmed over minor scoring or scuffing of the piston or the steering gear

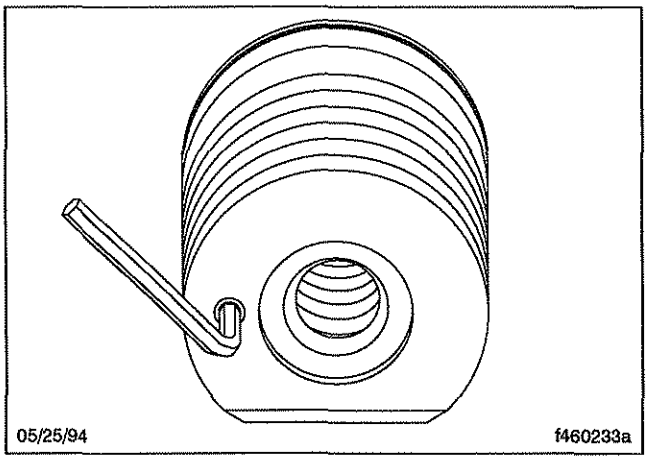


Fig. 25, Remove the Relief Valve Seat

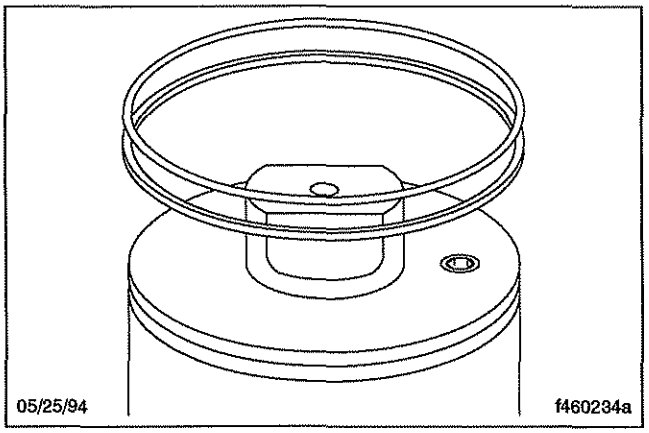
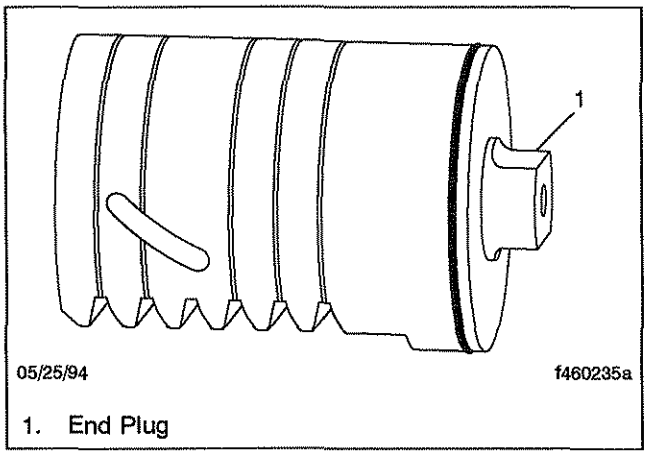


Fig. 26, Remove the Back-Up O-Ring and the Teflon Seal Ring



1. End Plug

Fig. 27, Remove the End Plug

Steering Gear Disassembly, Inspection, and Assembly

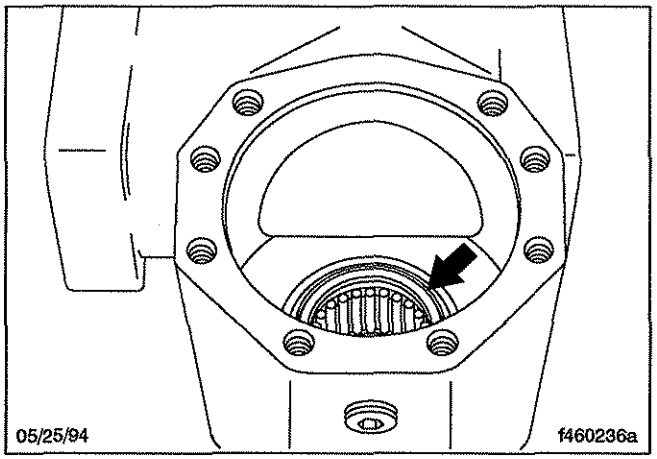


Fig. 28, Remove the Roller Bearing from the Gear Housing

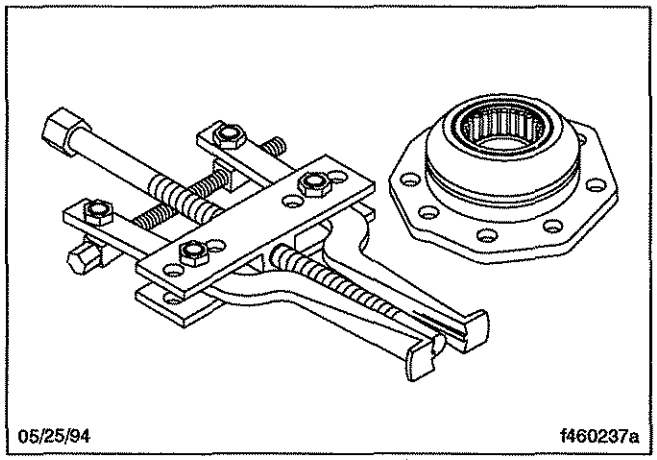


Fig. 29, Remove the Roller Bearing from the Sector Shaft Cover

housing. This will not affect the safety or operation of the steering gear.

If scoring is severe, leakage will affect steering reacting time; slow, binding, or uneven steering input will be noticeable. In this case, replace the damaged parts.

3.2 Check the ball threads on the rotary valve shaft for wear. Thread wear can be caused by the following:

- Incorrect lubricant.
- Overloading the steering gear.
- Too low operating pressure.
- Too low oil pressure.
- Constant high temperature.

3.3 Look for wear or damage along the sealing surface of the input shaft. Replace the input shaft and the bearing cup assembly if the sealing surface is worn or damaged.

3.4 Check the piston rack and the sector shaft pinion gear for cracked or broken gear teeth. Also, check the steering gear housing for cracks or breaks. Such conditions are signs of impact damage.

4. Inspection of the steering gear parts may reveal problems in other areas of the steering system. To avoid repeat problems, follow each clue to its conclusion.

4.1 Check the steering gear components for discoloration (blue color), caused by high operating temperatures. High operating temperatures are most frequently caused by too little lubricant, too high a flow rate, or too much system back-pressure. For further information, refer to **Troubleshooting, 300.**

4.2 Scoring of the steering gear housing and piston can be caused by air in the hydraulic system. Check for an air leak on the suction side of the power steering pump. Repair the leak, then bleed the air from the power steering system.

4.3 Scoring of the piston or steering gear housing, wear on the roller bearings, or on the supply and return ports can be caused by an incorrect or contaminated lubricant. If the lubricant is contaminated, check for and correct the source of contamination. If incorrect or contaminated lubricant was used, drain and flush the system. Change the filter then fill the steering system with clean lubricant of the correct type. Refer to the applicable table in **Specifications, 400** for fluid specifications.

4.4 A distorted pitman arm, a broken steering gear housing, a twisted sector shaft, and broken or cracked rack and sector shaft teeth are some signs of impact damage. Don't replace broken or damaged mount-

ing brackets without finding the cause of the damage.

Consider any steering gear that has impact damage as unsafe. Impact loads transmitted through the front axle and steering linkage into the steering gear, can stress parts to a point just short of failure. Further use is unsafe; replace the steering gear assembly and the pitman arm.

Assembly

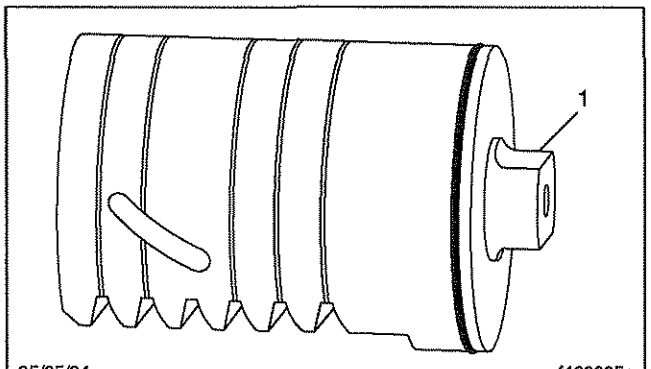
1. Assemble the piston:

   1.1 If the piston end plug **(Fig. 30)** was removed, coat its threads lightly with pipe sealer; then install it, along with a new O-ring, on the end of the piston. Using a new locking pin (**Fig. 1**, Ref. 56), pin the end plug.

   1.2 Using a 3/16-inch allen wrench, install a relief valve seat in one end of the piston. **See Fig. 31.**

   1.3 At the opposite end of the piston, install a relief valve ball. Then put the plastic tube inside the spiral spring, and install both in the same passage as the relief valve ball. **See Fig. 31.**

   1.4 Install the remaining relief valve ball, then the other relief valve seat. Push in the relief valve seat while engaging its threads. Tighten both relief valve seats firmly.



1. End Plug

Fig. 30, Coat the Threads of the End Plug

   1.5 Install the back-up O-ring in the piston groove, then install the Teflon seal on top of the back-up ring. **See Fig. 32.**

IMPORTANT: When installing square-cut Teflon seal rings, make sure they remain flat. Don't twist them.

   1.6 Set the piston assembly aside to let the Teflon seal ring contract. If desired, use a ring compressor, as shown in **Fig. 33.**

2. Install the input shaft seals **(see Fig. 34):**

   2.1 Install the back-up O-ring in the groove on the input shaft.

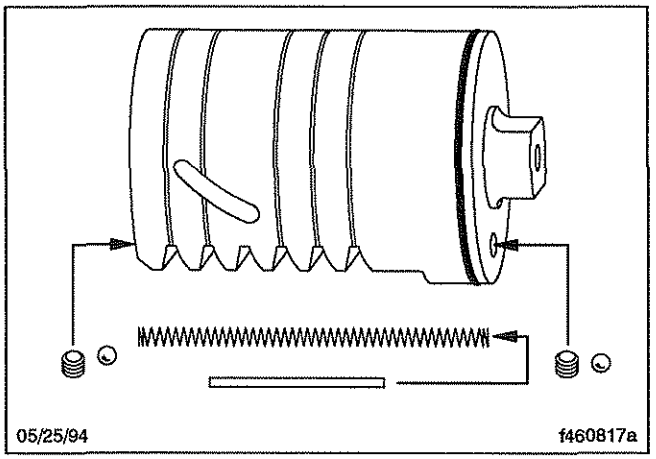
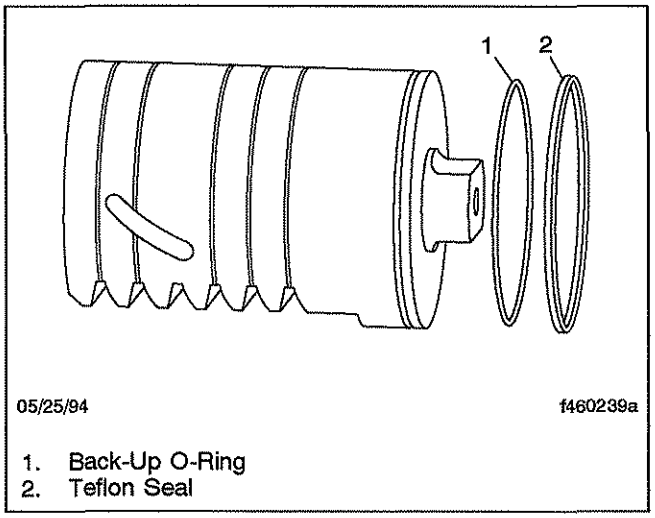


Fig. 31, Install a Relief Valve Seat



1. Back-Up O-Ring
2. Teflon Seal

Fig. 32, Install the Back-Up O-Ring and the Teflon Seal

Steering Gear Disassembly, Inspection, and Assembly

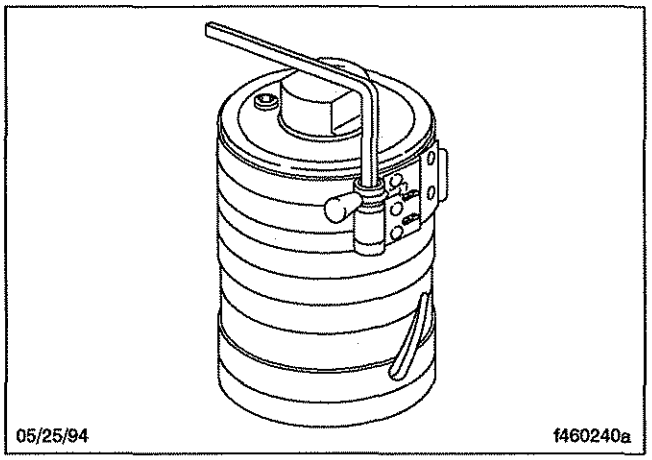


Fig. 33, Using a Ring Compressor

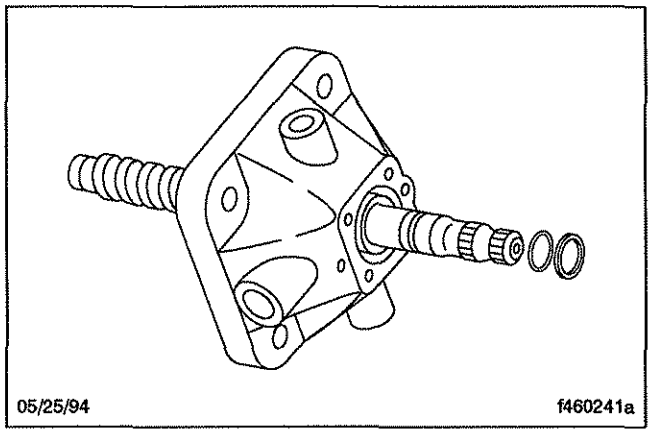


Fig. 34, Install the Input Shaft Seals

2.2 Install the Teflon seal ring over the back-up ring.

3. Check that the grooves for the dirt seal assembly in the bearing-cap cover **(Fig. 35)** are clean and free of burrs. Then install the new dirt seal assembly:

   3.1 Install the back-up O-ring in the bore of the bearing-cap cover.

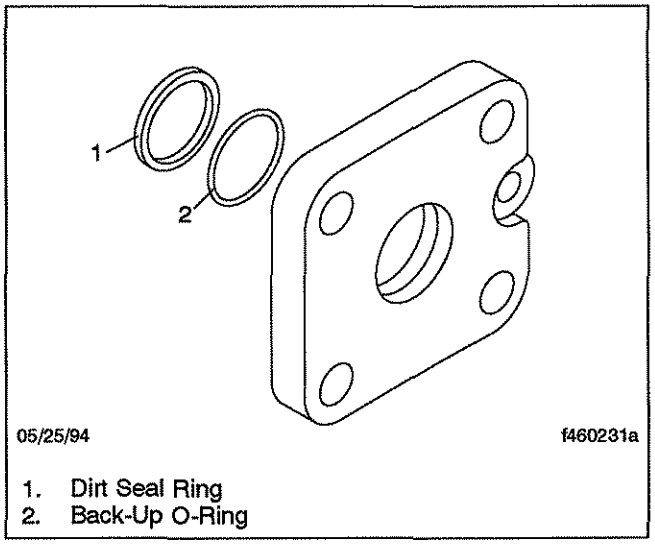
   3.2 Install the Teflon seal ring on top of the back-up O-ring.

4. Install the O-ring in the bearing-cap cover. **See Fig. 36.**

5. Align the plunger hole on the bearing-cap cover with the plunger hole on the bearing cap, as shown in **Fig. 37.** Then install the bearing-cap cover on the bearing cap. Be careful not to pinch the input shaft seals or the dirt seal assembly. Tighten the bolts to the torque values in **Specifications, 400.**

6. If the roller bearing was removed from the sector shaft cover, install a new one into the sector shaft cover **(Fig. 38)**, using a press. Press the bearing until it is flush with the face of the bearing bore.

7. Install the new three-piece high-pressure seal in the sector shaft cover **(Fig. 39):**



1. Dirt Seal Ring
2. Back-Up O-Ring

Fig. 35, Check the Dirt Seal Assembly

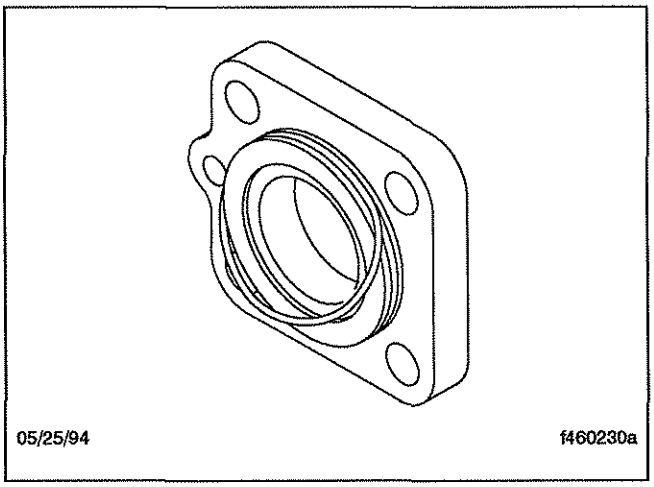


Fig. 36, Install the O-Ring

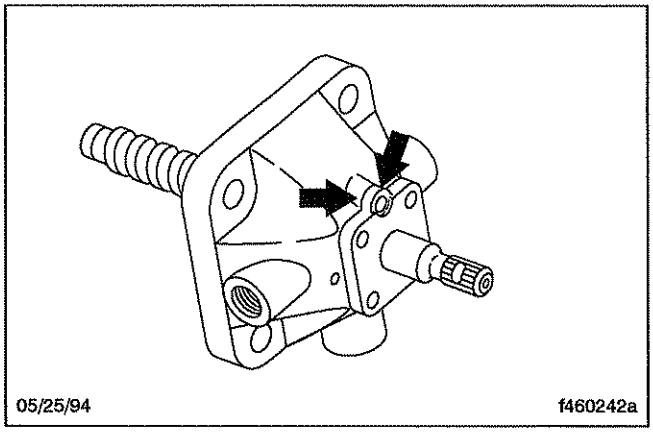


Fig. 37, Align the Plunger Holes

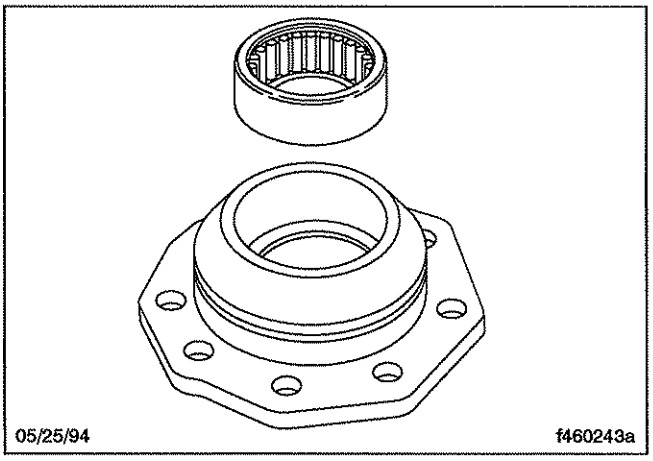


Fig. 38, Install the Roller Bearing in the Sector Shaft Cover

7.1 Install the seal back-up spacer in the sector shaft cover.

7.2 Install the seal O-ring on top of the back-up spacer.

7.3 Install the Teflon sector shaft seal on top of the seal O-ring.

8. Install the large O-ring on the sector shaft cover, and lubricate it lightly with clean engine oil.

9. Install the other three-piece high-pressure seal in the gear housing.

10. If the roller bearing was removed from the gear housing, install a new one, using a press. Install the new roller bearing so that it bottoms out on the shoulder of the sector shaft bore. **See Fig. 40.**

11. Coat the piston and the gear housing bore lightly with clean engine oil. Find the chamfer at one end of the piston bore in the gear housing, then install the piston in that end of the bore, as shown in **Fig. 41.** If necessary, tap the end of the piston lightly with a soft hammer in order to get it moving into the piston bore. Make sure the ball return guide cavity is exposed.

12. Put a light coat of grease on the new O-ring, then install it on the bearing cap assembly. **See Fig. 42.**

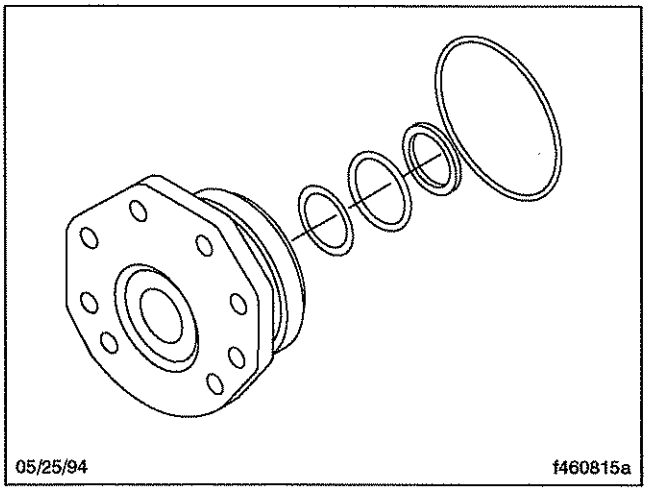


Fig. 39, Install the High-Pressure Seal

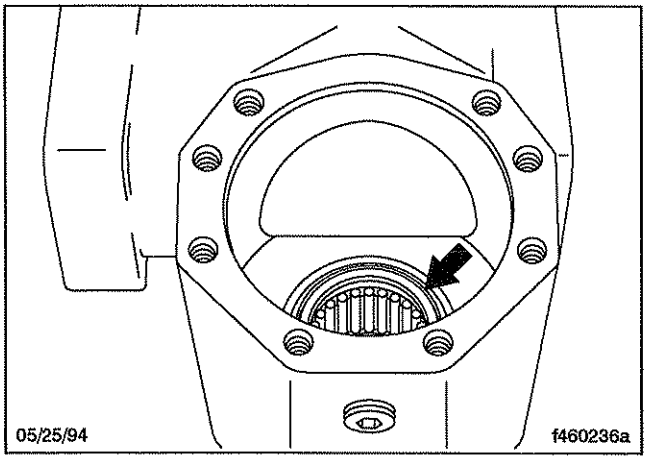


Fig. 40, Install the Roller Bearing in the Gear Housing

Steering Gear Disassembly, Inspection, and Assembly

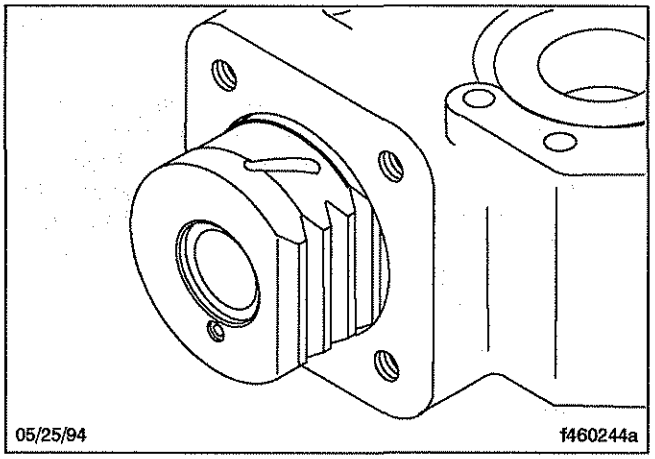


Fig. 41, Install the Piston

13. Install the bearing cap and actuating shaft assembly into the piston, as shown in **Fig. 43.**

CAUTION: When installing the ball guide halves into the piston, make sure they go all the way into the ball guide cavity; otherwise, they could be pushed out when the steel balls are installed, resulting in loss of the steel balls.

IMPORTANT: Don't insert the bearing cap assembly completely into the piston. Leave 3 inches (7.5 cm) of space between the face of the bearing cap and the end of the piston, as shown in **Fig. 43.**

14. Install both ball guide halves all the way into the ball guide cavity of the piston. **See Fig. 44.**

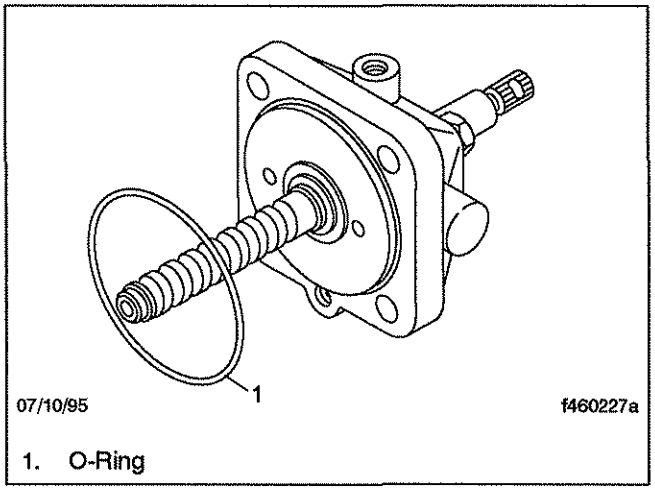


Fig. 42, Install the O-Ring

15. Support the bearing cap assembly with one hand, and with the other, load the 24 steel balls into the ball guide. **See Fig. 45.**

    Turn the bearing cap and input shaft assembly slowly inward while installing the steel balls.

CAUTION: Do not back out the input shaft from the piston while loading the steel balls. To do so will cause the shaft to bind, resulting in possible damage to it.

16. After all 24 balls have been installed, install the ball return guide retainer in the ball guide cavity. **See Fig. 46** or **Fig. 47.**

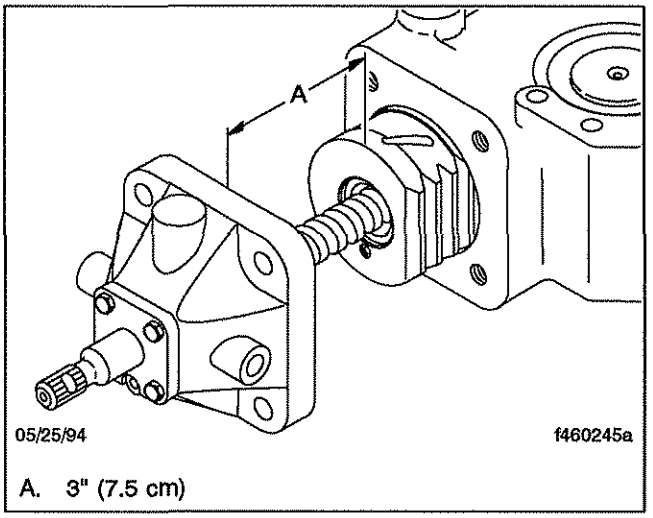


Fig. 43, Install the Bearing Cap and Actuating Shaft Assembly

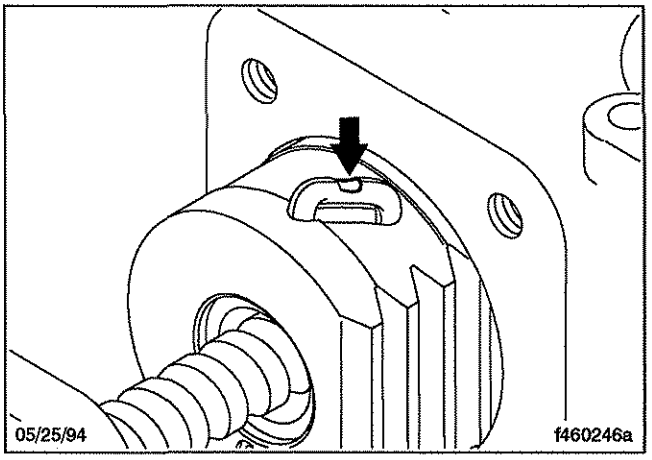


Fig. 44, Install the Ball Guide Halves

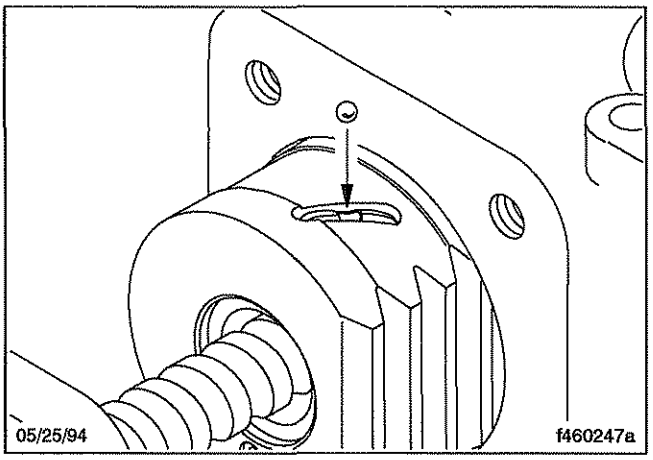


Fig. 45, Load the Steel Balls into the Ball Guide

If the retainer is the type that slips in **(Fig. 46)**, make sure it's installed flush with the surface of the piston.

If the retainer is the bolted-on type **(Fig. 46)**, be sure to replace the seal ring inside the retainer. Tighten the bolts 12 lbf·ft (16 N·m). **See Fig. 48.**

IMPORTANT: When you install the piston all the way into the housing bore, be careful not to pinch the piston seal.

17. Slide the piston all the way into the housing bore, making sure the piston rack aligns with the bore for the sector shaft as shown in **Fig. 49.** Guide the piston, as shown in **Fig. 50**, so the piston seal ring isn't pinched.

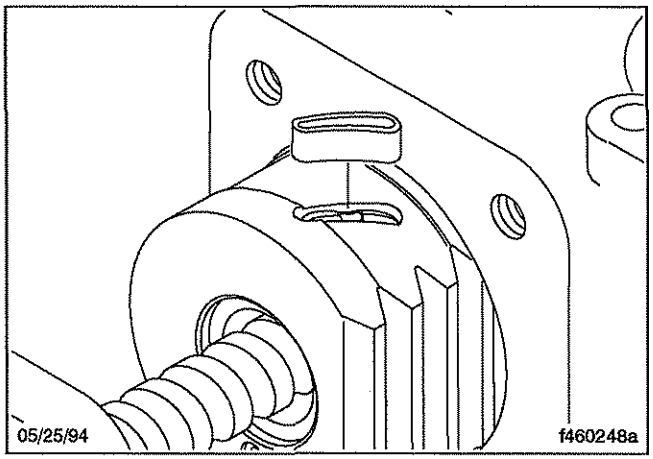


Fig. 46, Install the Ball Return Guide Retainer

18. Install the new tetra seal on the bearing cap assembly **(see Fig. 51)**, then put the bearing cap assembly on the gear housing.

NOTE: If the bearing cap assembly doesn't sit flush on the housing, check that the bearing cap O-ring and the tetra seal are in place.

19. Using the four mounting bolts, install the bearing cap assembly on the gear housing. Tighten the bolts to the torque values in **Specifications, 400. See Fig. 52.**

20. Find the timing mark on the piston rack; then, by turning the input shaft, center the timing mark in the pinion bore of the housing. **See Fig. 53.**

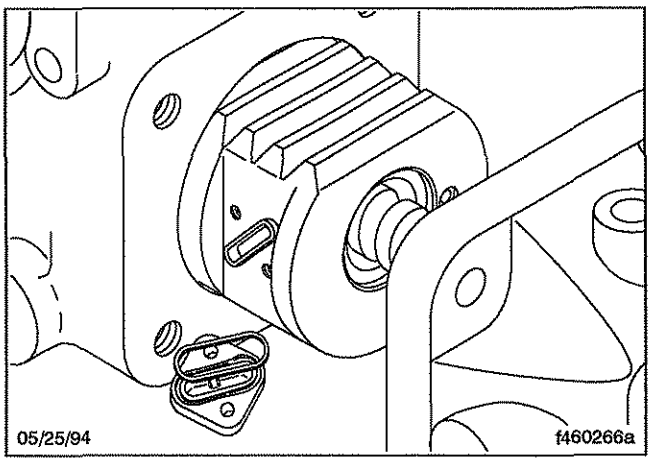


Fig. 47, Install the Ball Return Guide Retainer

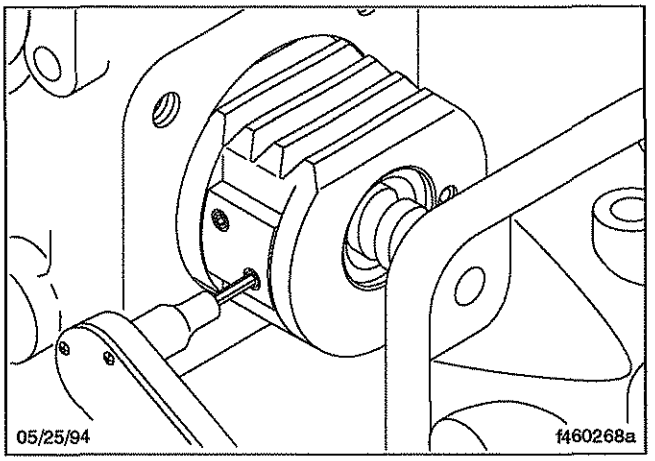


Fig. 48, Tighten the Bolts

Steering Gear Disassembly, Inspection, and Assembly

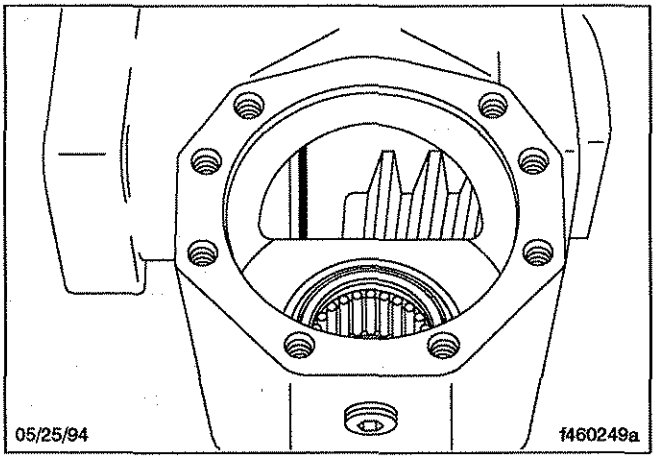


Fig. 49, Slide the Piston Into the Housing Bore

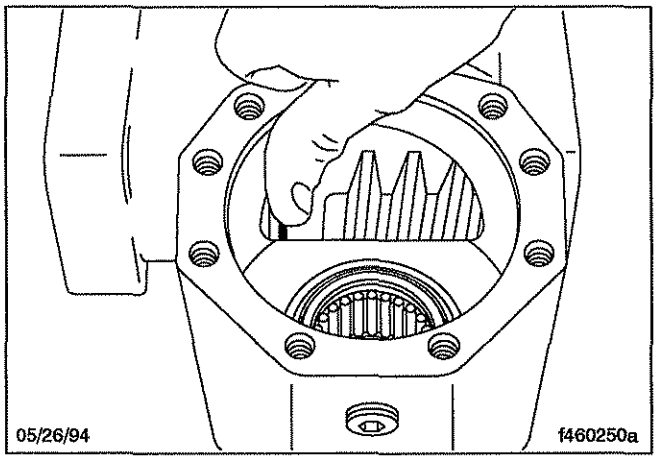
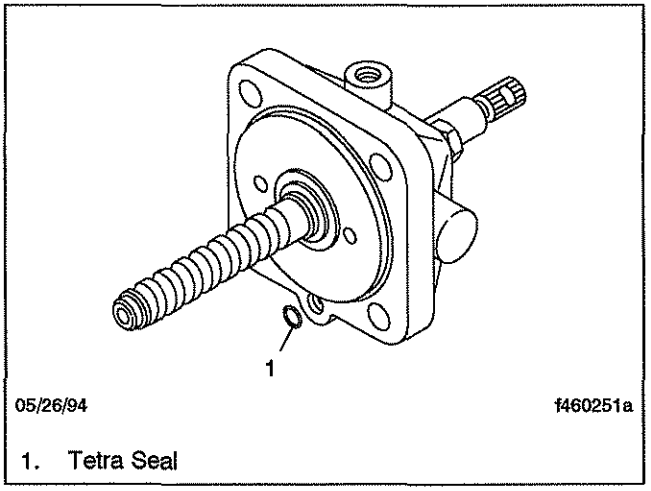


Fig. 50, Guide the Piston to Prevent Seal Ring Pinching

21. Line up the timing marks on the piston rack and the sector shaft, then install the sector shaft in the pinion bore. **See Fig. 54.**
22. Make sure the sector shaft teeth mesh with the piston rack, then tap the end of the sector shaft with a soft hammer. **See Fig. 55.**
23. Put a light coat of oil on the seal ring on the sector shaft cover, then, using the eight mounting bolts, install the sector shaft cover. **See Fig. 56.** Tighten the bolts to the torque values in **Specifications, 400.**
24. Install a new O-ring and tetra seal on the cylinder head **(Fig. 57)**, then put a light coat of grease on the ring and seal.



1. Tetra Seal

Fig. 51, Install the Tetra Seal

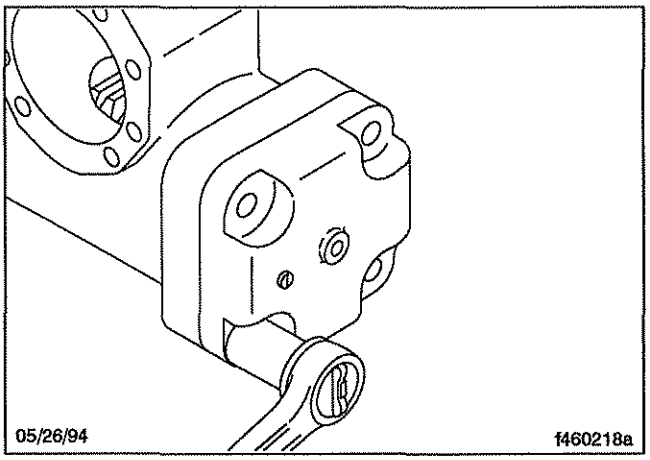


Fig. 52, Tighten the Bolts

25. Using four mounting bolts, install the cylinder head on the gear housing. **See Fig. 58.** Tighten the bolts to the torque values in **Specifications, 400.**
26. Install the relief plungers in the cylinder head and the bearing cap. Tighten the plungers until they are flush with the end caps, as shown in **Fig. 59.**
27. Install the dust cover on the end of the sector shaft, and tighten it firmly. **See Fig. 60.**
28. Install the rubber boot over the input shaft, as shown in **Fig. 61.**
29. Install the pitman arm:

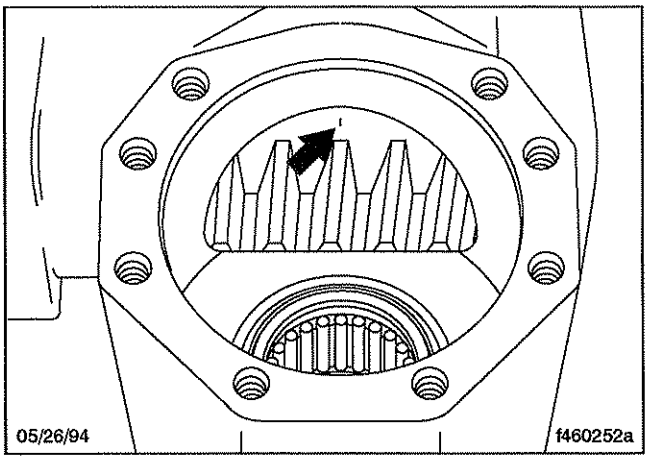
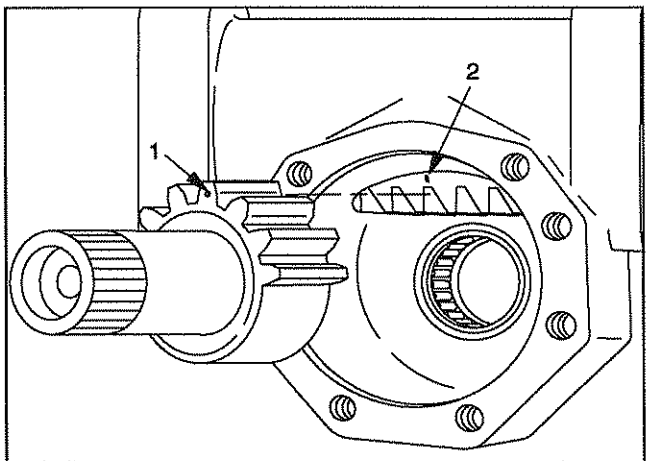


Fig. 53, Center the Timing Mark



1. Sector Shaft Timing Mark
2. Piston Rack Timing Mark

Fig. 54, Line Up the Timing Marks

WARNING: Don't pound, weld, or apply heat to the pitman arm or the sector shaft. Damage to the pitman arm or sector shaft could cause loss of steering control, resulting in possible personal injury or property damage.

29.1 Line up the timing mark on the pitman arm with the mark on the sector shaft, as shown in **Fig. 62.**

29.2 Push the pitman arm on the sector shaft as far as it will go. Do not pound on the pitman arm.

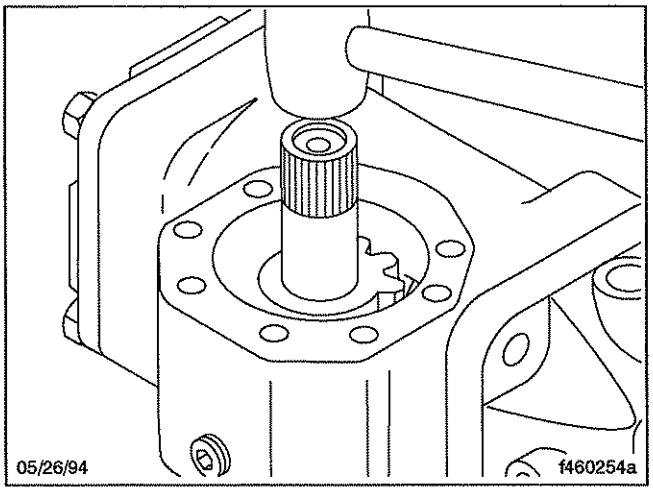


Fig. 55, Tap the end of the Sector Shaft

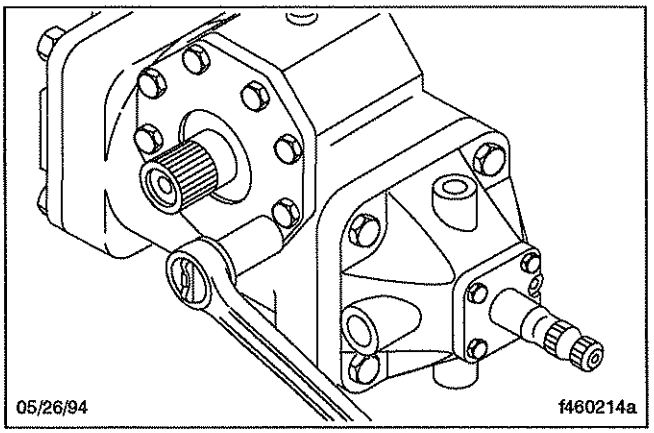


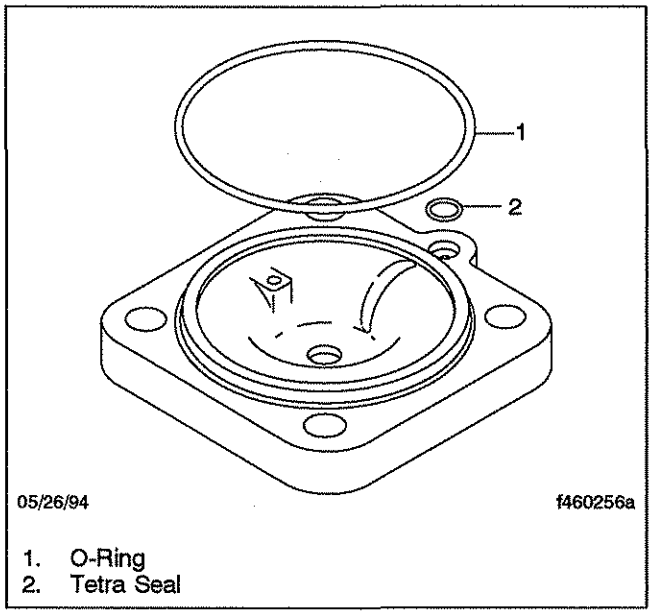
Fig. 56, Install the Sector Shaft Cover

29.3 Put Lok-Cease, Never Seez, or white lead on the threads of the retainer, and both sides of the tab washer and friction washer. Then, screw the retainer into the output shaft by hand. Make sure that the tabs of the retainer are aligned with the notches in the pitman arm.

29.4 Using a torque wrench (not an impact wrench), tighten the retainer to the value stamped on the face of the retainer. **See Fig. 63.** The retainers are stamped with one of three different torque values:

225 lbf·ft (305 N·m); 350 lbf·ft (475 N·m); or 450 lbf·ft (610 N·m).

Steering Gear Disassembly, Inspection, and Assembly



1. O-Ring
2. Tetra Seal

Fig. 57, Install the O-Ring and Tetra Seal

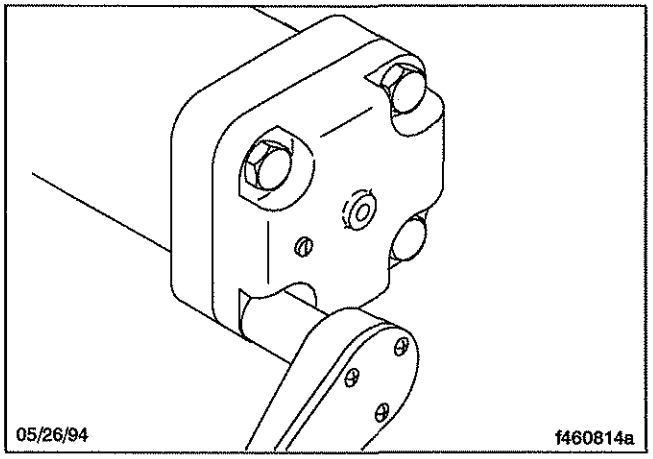


Fig. 58, Install the Cylinder Head

29.5 After tightening the retainer, remove it from the pitman arm and measure the distance between the end of the sector shaft and the end of the splined surface of the pitman arm. **See Fig. 64**, Ref. A.

Depending on which torque value is stamped on the face of the retainer, the distance must be between:

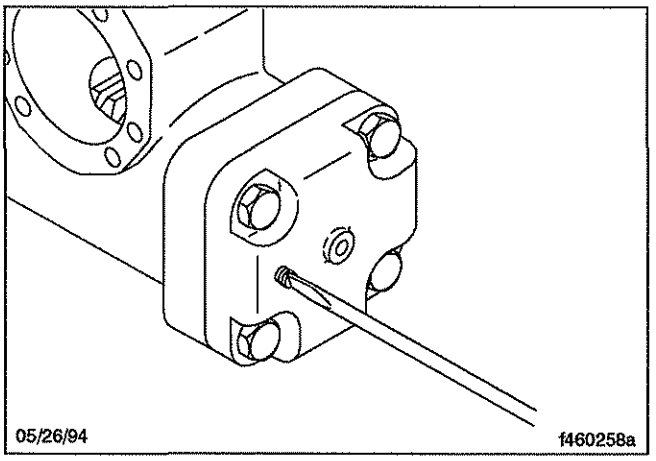


Fig. 59, Tighten the Plungers

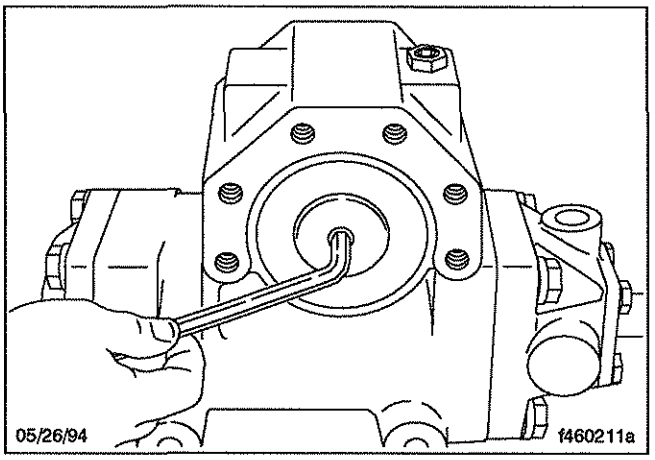


Fig. 60, Install the Dust Cover

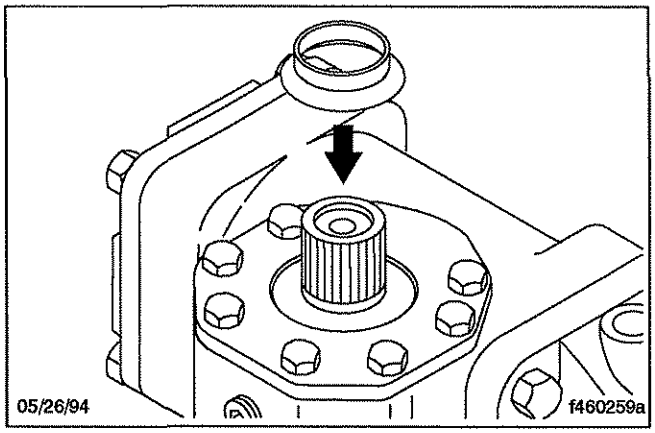


Fig. 61, Install the Rubber Boot

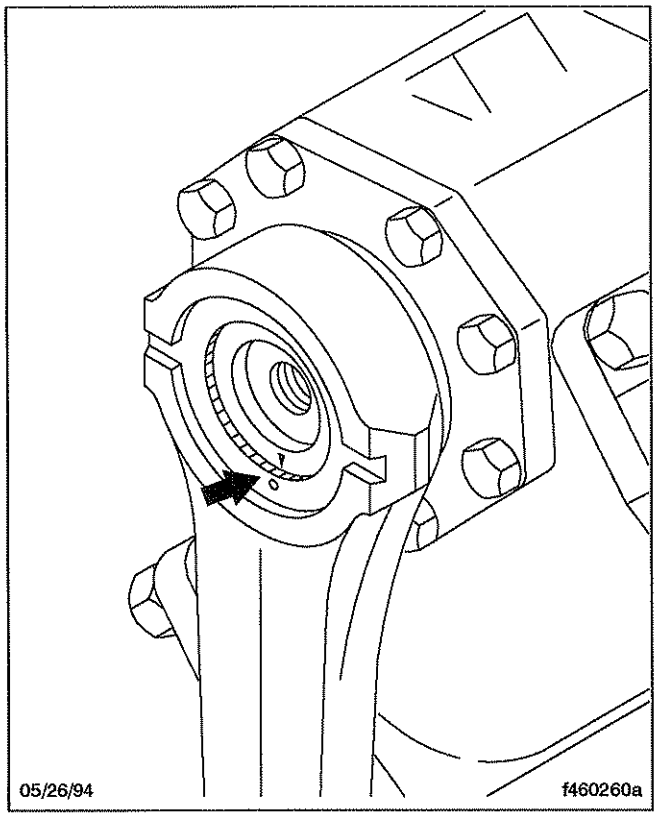


Fig. 62, Align the Timing Marks

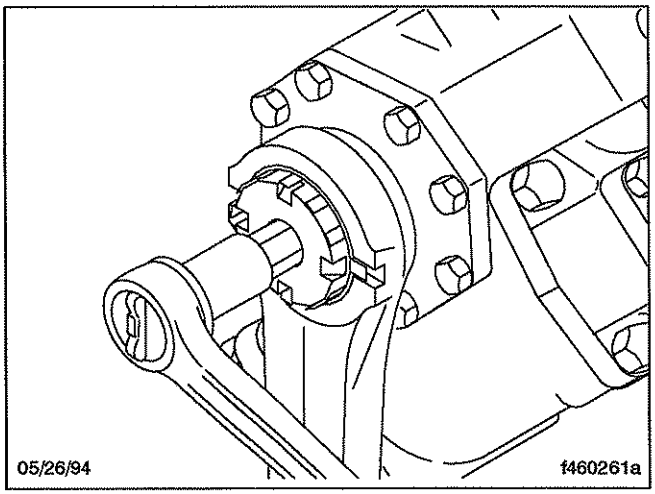


Fig. 63, Tighten the Retainer

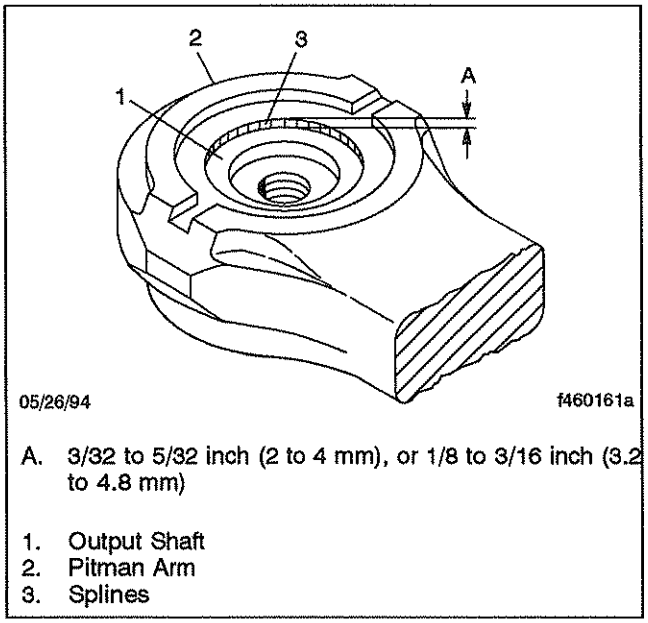
3/32 and 5/32 inch (2 to 4 mm) for retainers stamped with the 225 lbf·ft (305 N·m) and 350 lbf·ft (475 N·m) torque values;

1/8 and 3/16 inch (3.2 to 4.8 mm) for retainers stamped with the 450 lbf·ft (610 N·m) torque value.

If the measurement is not correct, replace the pitman arm and the sector shaft.

29.6 If the measurement is correct, install the retainer and tighten it to the torque value stamped on the face of the retainer. Bend the two tabs on the tab washer up into the slots on the retainer.

IMPORTANT: After the specified torque value is reached, it may be necessary to continue tightening the retainer until two of the tabs on the tab washer are aligned with the notches in the retainer. Do not back off the retainer to align the tabs.



A. 3/32 to 5/32 inch (2 to 4 mm), or 1/8 to 3/16 inch (3.2 to 4.8 mm)

1. Output Shaft
2. Pitman Arm
3. Splines

Fig. 64, Measure the Distance

Replacement

1. Turn off the engine, apply the parking brakes, and chock the tires.

NOTE: Removal of the power steering gear is not necessary to perform this procedure. Partial disassembly of the steering gear is required to replace the sector shaft seals. Be sure to time the sector shaft after replacement.

2. Open the hood or tilt the cab. For cab tilt instructions, see **Group 60** in this manual.
3. Disconnect the pitman arm from the steering gear. For instructions, see **Subject 160.**
4. Remove and discard the rubber boot on the sector shaft.
5. If the snap ring cover is equipped with a protective cap, pry the cap out of the bore.

IMPORTANT: When working with snap ring covers, you will need to remove the factory installed silicone protectant from the snap ring and carefully clean the cover area before disassembly.

6. Remove the snap ring on the sector shaft cover. See **Fig. 1.**
7. Clean the shaft before removing the sector shaft cover.

⚠ CAUTION

Do not turn the steering wheel or the steering shaft during this procedure. Turning either the steering wheel or steering shaft will result in steering gear damage.

NOTE: A slide hammer may be used to remove the sector shaft.

8. Remove the sector shaft cover and sector shaft from the housing. Separate the cover from the sector shaft. Discard the sector shaft.

NOTE: It may be necessary to remove the dust cover from the frame side of the sector shaft. Use a gasket scraper or screwdriver to remove the frame side dust cover.

9. Pry the excluder seal from the sector shaft cover. Using a seal pick, remove the oil seal from the sector shaft cover and the steering gear housing. Remove the O-ring from the cover. Discard all seals.

NOTE: Lightly coat the new seals with clean motor oil to facilitate installation of the sector shaft.

IMPORTANT: The sector shaft oil seal has a lip. Do not press on the lip of the oil seal when installing. Press only on the body of the seal. It will be necessary to bend the oil seal when installing. Once the seal is installed, you may have to work the seal into place with your fingers or a blunt seal pick to properly seat the seal.

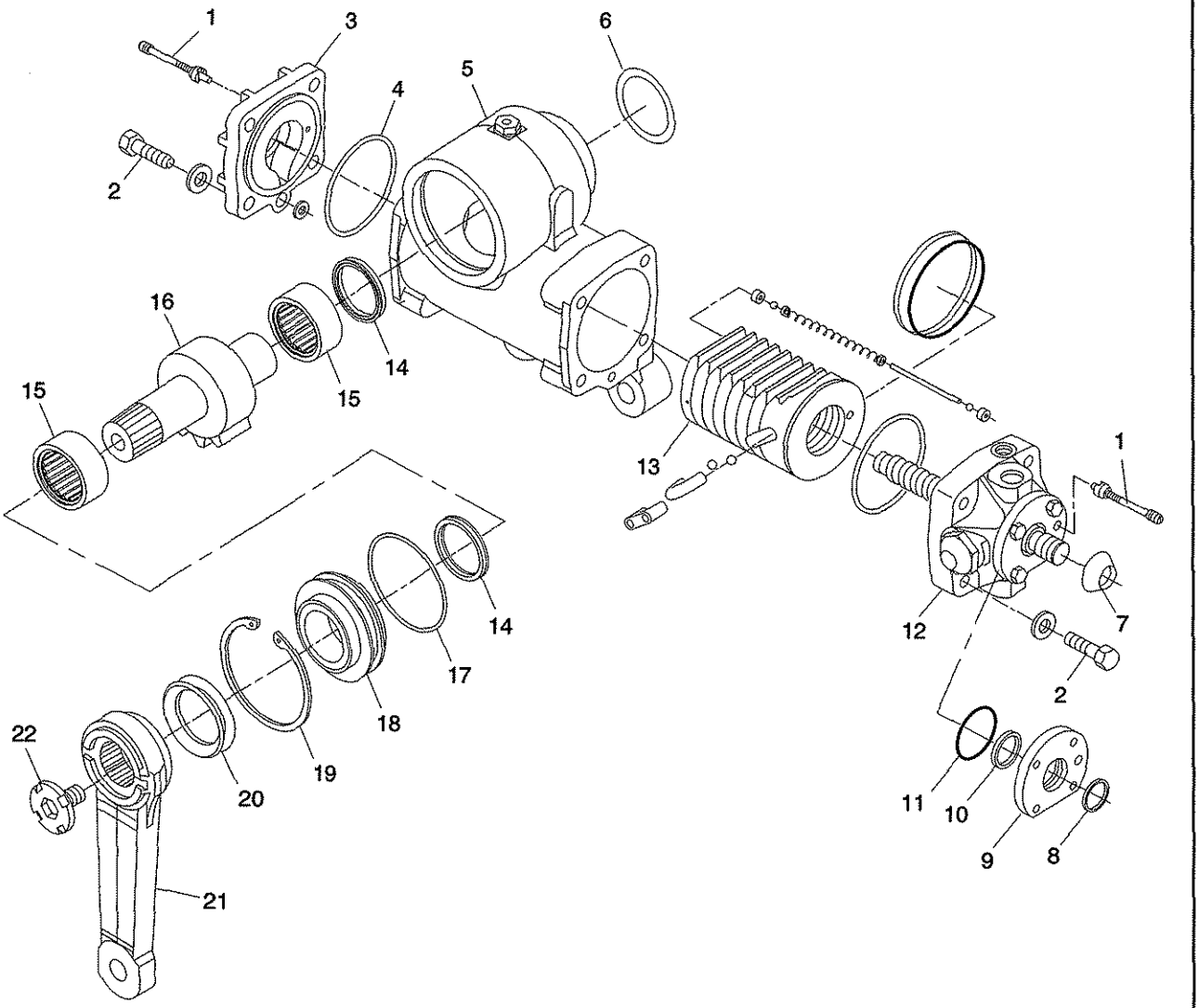
10. Install a new oil seal in the steering gear housing and the sector shaft cover. When properly fitted, the oil seal will ride between the bearing and the cover. The black lip of the seal must face the inside of the steering gear and the blue side must face the outside of the steering gear.
11. Install a new sector shaft in the housing. Make sure that the timing mark on the sector shaft is placed between the two timing marks on the piston rack. See **Fig. 2.** It may be necessary to tap on the sector shaft to properly seat it into the housing.
12. Install the sector shaft cover on the steering gear. Make sure that the cover is properly seated when installing. Snap ring covers must be flush or below the snap ring groove to be properly installed.
13. Using a snap ring, attach the sector shaft cover to the steering gear. Tighten the capscrews 72 to 81 lbf·ft (98 to 110 N·m).

⚠ WARNING

When installing a snap ring style cover, the cover must be flush or below the groove in the housing. Improper installation could result in separation of the cover, possibly resulting in personal injury.

14. Apply a coat of clean chassis lube in the lip of the excluder seal. With the lip of the excluder seal facing out and using an appropriate size seal driver, install the excluder seal in the cover. See **Fig. 3.** Apply a bead of grease over the excluder seal and slide the rubber boot over the sector shaft.
15. Install the pitman arm. For instructions, see **Subject 160.**

Sector Shaft Replacement



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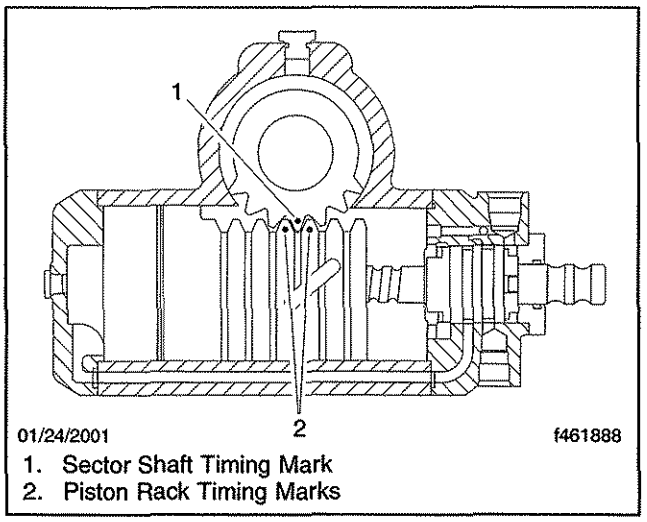
1. Automatic Relief Plunger
2. Capscrew
3. Cylinder Head
4. O-Ring
5. Steering Gear Housing
6. Frame Side Dust Cover
7. Rubber Boot
8. Salt Seal
9. Bearing Cap Cover
10. Oil Seal
11. O-Ring
12. Bearing Cap
13. Piston Rack
14. Oil Seal
15. Roller Bearing
16. Sector Shaft
17. O-Ring
18. Sector Shaft Cover
19. Snap Ring
20. Sector Shaft Boot
21. Pitman Arm
22. Pitman Arm Retainer

Fig. 1, Steering Gear Assembly

16. Fill the system with steering fluid. Start the engine. Check the fluid level in the power steering reservoir and add more fluid if necessary.
17. Return the hood or cab to the operating position. For cab tilt instructions, see **Group 60** in this manual.



1. Sector Shaft Timing Mark
2. Piston Rack Timing Marks

Fig. 2, Align the Timing Marks

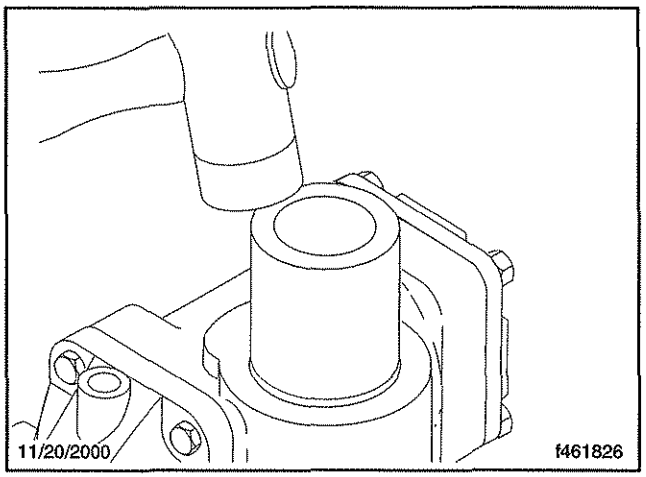


Fig. 3, Installing the Excluder Seal

18. Remove the chocks from the tires.

Adjustment

The only circumstances in which the automatic relief plungers require adjusting are when the tire size is changed, the wheel cut is reduced, or a replacement steering gear is installed. Do not adjust the automatic relief plungers under any other circumstances.

1. Turn off the engine, apply the parking brakes, and chock the tires.
2. Open the hood or tilt the cab. For cab tilt instructions, see **Group 60** in this manual.
3. Verify that the steering gear has automatic relief plungers. Steering gears with automatic relief plungers will have the word AUTO cast into the housing. See **Fig. 1**. Steering gears with automatic relief plungers also have plastic caps on the plunger bosses.
4. Remove the plastic caps from both plunger bosses.

⚠ CAUTION

Make sure there are no sharp edges on the punch that could damage the bore. Take care when using the punch to ensure that the relief plunger bore is not damaged. If the relief plunger bore is damaged, a leak may occur.

5. Using a 1/4-inch punch and ball peen hammer, carefully drive the relief plunger in until it bottoms in the bore. Repeat this procedure for the other relief plunger.
6. Replace the plastic caps.
7. Set the automatic relief plungers. For instructions, see **Subject 140.**

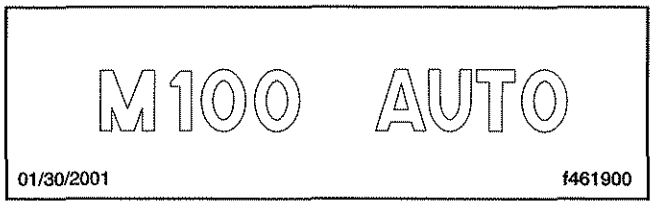


Fig. 1, Automatic Relief Plunger Identifier

Setting the Automatic Relief Plunger

The only circumstances in which the automatic relief plungers need to be set are when the tire size is changed, the wheel cut is extended, or a replacement steering gear is installed. Do not set the automatic relief plungers under any other circumstances.

1. Turn off the engine, apply the parking brakes, and chock the tires.
2. Open the hood or tilt the cab. For cab tilt instructions, see **Group 60** in this manual.
3. Verify that the steering gear has automatic relief plungers. Steering gears with automatic relief plungers will have the word AUTO cast into the housing. See **Fig. 1**. Steering gears with automatic relief plungers also have plastic caps on the plunger bosses.
4. Using a jack, raise the vehicle until the front wheels are off the ground.

NOTE: Check that the axle stops are set correctly before setting the relief plungers. For instructions on checking the axle stop adjustment, see **Troubleshooting 300**.

5. Start the engine and turn the tires to a full-lock position in both directions. With the tires off the ground, the automatic relief plungers will be set to the correct position when the spindle contacts the axle stop.

NOTE: As the tires reach the end of travel, you will feel the piston contact the relief plunger. Continue turning the tires until the spindle reaches the axle stop bolt.

6. Return the tires to the straight-ahead position.
7. Lower the vehicle until the tires contact the ground. Remove the jack
8. Shut off the engine.

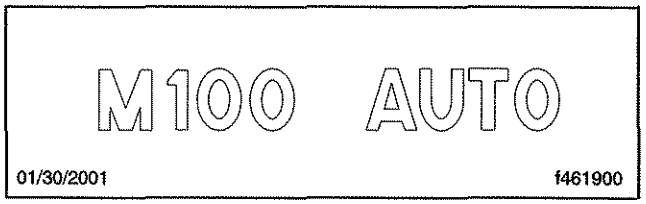


Fig. 1, Automatic Relief Plunger Identifier

9. Return the hood or cab to the operating position. For cab tilt instructions, see **Group 60** in this manual.
10. Remove the chocks from the tires.

Automatic Relief Plunger Repair Procedure

There is a relief plunger in the cylinder head and one in the bearing cap. Follow the appropriate set of procedures for the relief plunger you are repairing.

Repair Procedure for the Cylinder Head Automatic Relief Plunger

1. Turn off the engine, apply the parking brakes, and chock the tires.
2. Open the hood or tilt the cab. For cab tilt instructions, see **Group 60** in this manual.
3. Remove the steering driveline. For instructions, see **Section 46.04**, Subject 100.
4. Verify that the steering gear has automatic relief plungers. Steering gears with automatic relief plungers will have the word AUTO cast into the housing. See **Fig. 1**. Steering gears with automatic relief plungers also have plastic caps on the plunger bosses.
5. Place a drain pan under the steering gear.
6. Mark the cylinder head and the steering gear housing for later reference during installation. Remove the capscrews that attach the cylinder head to the housing. Remove the cylinder head.
7. Remove the plastic cap from the plunger boss.

⚠ CAUTION

When driving the relief plunger assembly, do not allow the 1/4-inch punch to contact the bore and do not hit the plunger with excessive force. Failure to follow these directions could result in damage to the steering gear or relief plunger assembly.

8. Place the cylinder head in a vise. Using a 1/4-inch punch and hammer, carefully drive the relief plunger assembly in until it bottoms in the bore. The spring pin, flange, and plunger body should be accessible for repair at this point.

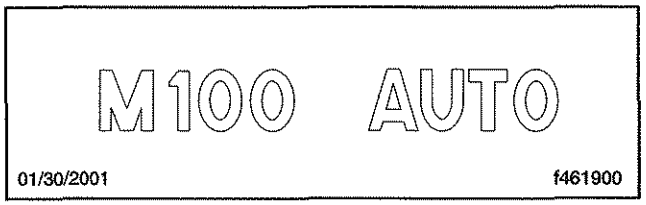


Fig. 1, Automatic Relief Plunger Identifier

⚠ CAUTION

Do not allow the screwdriver bit to slip off the plunger body. Damage to the bore could result.

NOTE: The relief plunger flange is held in place with patch lock and the threads are staked at the factory. It will require approximately 15 to 20 lbf·in (150 to 205 N·cm) to remove the flange.

9. Carefully insert a screwdriver bit into the plunger bore to hold the slotted head of the relief plunger body in place. Using an open-end wrench to hold the flange in place, carefully turn the flange to remove the flange from the plunger body. See **Fig. 2**. Discard the flange.
10. Remove the plunger body from the spring pin and discard the plunger body. It may be necessary to tap the plunger body to remove it from the spring pin. Use of a 1/8-inch pin punch is recommended.

IMPORTANT: Check the plunger bore for nicks or gouges before installing the plunger assembly. Be careful not to introduce dirt or contaminants in the plunger bore when reassembling.

11. Coat the O-ring on the new plunger assembly with a light coat of grease. Install the plunger body through the spring pin. See **Fig. 3**.

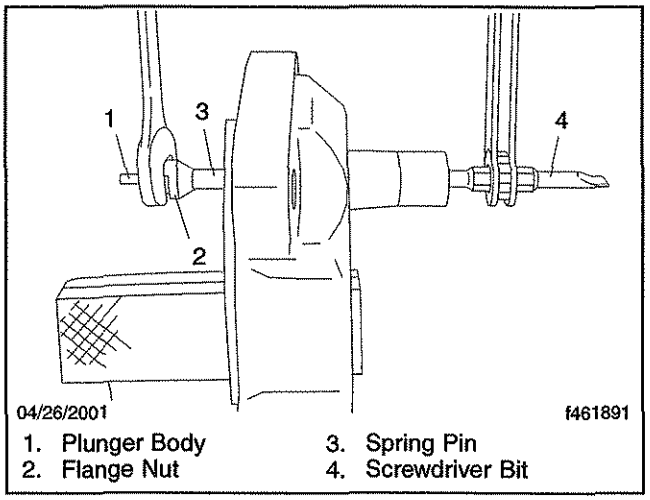


Fig. 2, Remove the Flange

Automatic Relief Plunger Repair Procedure

NOTE: The plunger body has patch lock on the threads. It will require approximately 15 to 20 lbf·in (150 to 205 N·cm) to overcome the patch lock.

12. Use a screwdriver bit and ratchet to hold the plunger body in place. Using an open-end wrench, install the flange on the plunger body until the flange contacts the spring pin.

⚠ WARNING

The flange must contact the spring pin. If it doesn't, a leak or steering gear damage may result. This could cause steering failure, possibly resulting in personal injury or property damage.

⚠ WARNING

Use extreme caution when staking the threads of the plunger body. Hitting the threads too hard could bend the plunger, which could cause steering failure, possibly resulting in personal injury or property damage.

13. With the flange against the spring pin, use a center punch to stake the threads of the plunger body. See **Fig. 4**. Be careful not to bend the plunger when staking the threads.
14. Align the marks on the cylinder head with the marks on the steering gear housing and install the cylinder head on the housing using the cylinder head capscrews. Tighten the capscrews 114 to 124 lbf·ft (154 to 168 N·m).

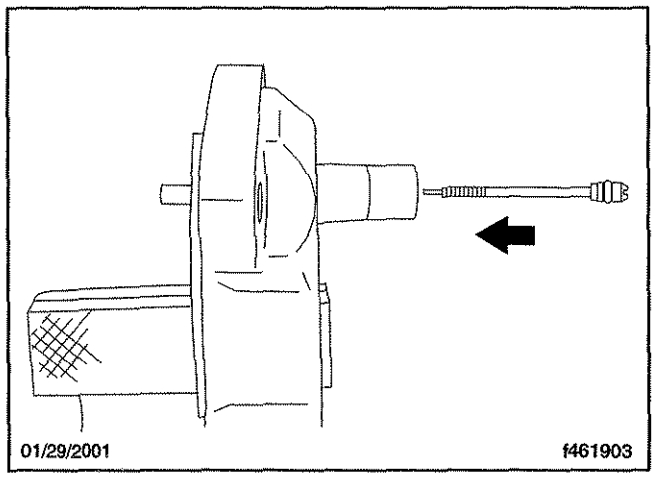


Fig. 3, Install the Plunger Body

15. Install the plastic cap on the plunger boss.
16. Install the steering driveline. For instructions, see **Section 46.04**, Subject 100.
17. Fill the power steering reservoir with an approved fluid.
18. Start the engine. Check the fluid level in the power steering reservoir and add more fluid if necessary. Check for leaks.
19. Set the automatic relief plunger. For instructions, see **Subject 140.**
20. Remove the drain pan.
21. Return the hood or cab to the operating position. For cab tilt instructions, see **Group 60** in this manual.
22. Remove the chocks from the tires.

Repair Procedure for the Bearing Cap Automatic Relief Plunger

1. Turn off the engine, apply the parking brakes, and chock the tires.

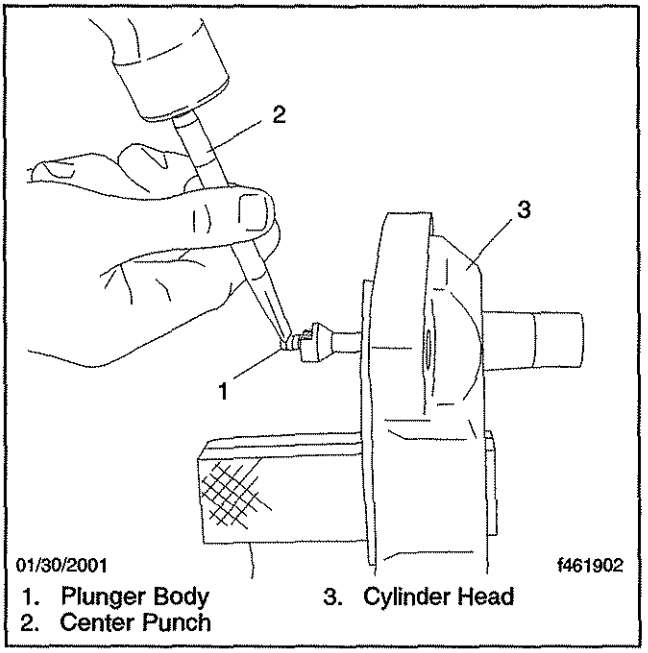


Fig. 4, Stake the Threads

Automatic Relief Plunger Repair Procedure

2. Open the hood or tilt the cab. For cab tilt instructions, see **Group 60** in this manual.
3. Verify that the steering gear has automatic relief plungers. Steering gears with automatic relief plungers will have the word AUTO cast into the housing. See **Fig. 1**. Steering gears with automatic relief plungers also have plastic caps on the plunger boss.
4. Place a drain pan under the steering gear.
5. Mark the bearing cap and steering gear housing for reassembly.
6. Disconnect the steering driveline from the steering gear input shaft. For instructions, see **Subject 100**.
7. Remove the plastic cap from the plunger boss.

⚠ CAUTION

When driving the relief plunger assembly, do not allow the 1/4-inch punch to contact the bore and do not hit the plunger with excessive force. Failure to follow these directions could result in damage to the steering gear or relief plunger assembly.

8. Using a 1/4-inch punch and hammer, carefully drive the relief plunger assembly in until it bottoms in the bore.
9. Remove the four capscrews that attach the bearing cap to the steering gear housing.

⚠ CAUTION

Do not force the input shaft when turning it out of the housing. The shaft could bind and steering gear damage could result.

10. Separate the bearing cap assembly from the housing by turning the input shaft out of the housing. Turn the shaft until it stops.

⚠ CAUTION

Do not allow the screwdriver bit to slip off the plunger body. Damage to the bore could result.

NOTE: The relief plunger flange is held in place with patch lock and the threads are staked at the factory. It will require approximately 15 to 20 lbf·in (150 to 205 N·cm) to remove the flange.

11. Carefully insert a screwdriver bit into the plunger bore to hold the slotted head of the relief plunger body in place. Using an open-end wrench to hold the flange in place, carefully turn the flange to remove the flange from the plunger body. See **Fig. 5**. Discard the flange.
12. Remove the plunger body from the spring pin and discard the plunger body. It may be necessary to tap the plunger body to remove it from the spring pin. Use of a 1/8-inch pin punch is recommended.

IMPORTANT: Check the plunger bore for nicks or gouges before installing the plunger assembly. Be careful not to introduce dirt or contaminants in the plunger bore when reassembling.

13. Coat the O-ring on the new plunger assembly with a light coat of grease. Install the plunger body through the spring pin. See **Fig. 6**.

⚠ WARNING

The flange must contact the spring pin. If it doesn't, a leak or steering gear damage may result. This could cause steering failure, possibly resulting in personal injury or property damage.

NOTE: The plunger body has patch lock on the threads. It will require approximately 15 to 20 lbf·in (150 to 205 N·cm) to overcome the patch lock.

14. Use a screwdriver bit and ratchet to hold the plunger body in place. Using an open-end wrench,

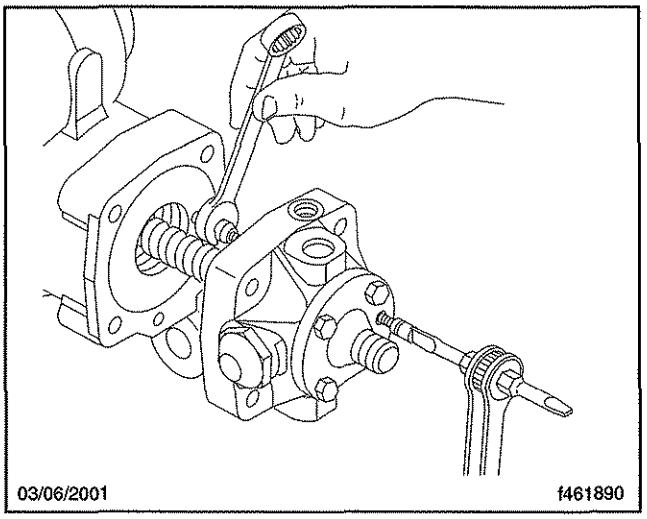
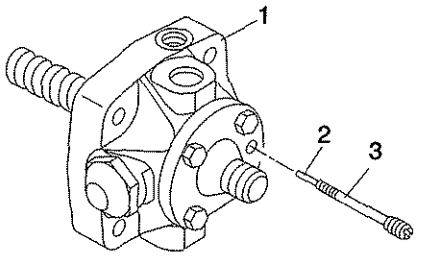


Fig. 5, Remove the Flange

Automatic Relief Plunger Repair Procedure



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1. Bearing Cap
2. Plunger Body
3. Spring Pin

Fig. 6, Install the Plunger Body

install the flange on the plunger body until the flange contacts the spring pin.

⚠ WARNING

Use extreme caution when staking the threads of the plunger body. Hitting the threads too hard could bend the plunger, which could cause steering failure, possibly resulting in personal injury or property damage.

15. With the flange against the spring pin, use a center punch to stake the threads of the plunger body. See **Fig. 4**. Be careful not to bend the plunger when staking the threads.
16. Align the marks on the bearing cap with the marks on the steering gear housing and install the bearing cap on the housing using the bearing cap capscrews. Tighten the capscrews 114 to 140 lbf·ft (154 to 190 N·m).
17. Install the plastic cap on the plunger boss.
18. Connect the steering driveline to the steering gear input shaft. For instructions, see **Subject 100**.
19. Fill the power steering reservoir with an approved fluid.
20. Start the engine. Check the fluid level in the power steering reservoir and add more fluid if necessary. Check for leaks.
21. Set the automatic relief plunger. For instructions, see **Subject 140**.
22. Remove the drain pan.
23. Return the hood or cab to the operating position. For cab tilt instructions, see **Group 60** in this manual.
24. Remove the chocks from the tires.

Pitman Arm Removal and Installation

Removal

NOTE: This procedure is for removing the pitman arm from the steering gear. If replacement of the pitman is required, the pitman arm must also be removed from the drag link.

Special Tool: A Sheppard pitman arm puller, Kent-Moore part number ZTSE4439, or a three-jaw puller will be required to remove the pitman arm.

1. Turn off the engine, apply the parking brakes, and chock the tires.
2. Open the hood or tilt the cab. For cab tilt instructions, see **Group 60** in this manual.

⚠ DANGER

Do not use a hammer or apply heat to the pitman arm to remove it. Doing so could damage the sector shaft, the pitman arm, or the seals and possibly lead to loss of vehicle control resulting in death or serious personal injury.

IMPORTANT: Do not bend the aligning tabs out of the pitman arm.

3. Using a punch, bend the retaining tabs out of the pitman arm retainer.
4. Lubricate the face of the retainer with clean chassis lube.

IMPORTANT: Failure to lubricate the face of the retainer will cause difficulty in removing the pitman arm.

5. Disconnect the pitman arm from the steering gear.
   - 5.1 Slide the pitman arm puller over the pitman arm. Align the hole in the puller with the Allen socket in the retainer.
   - 5.2 Insert the Allen drive socket through the puller and into the retainer socket. Use an impact wrench to back off the retainer. The retainer will act as a jack screw to disconnect the pitman arm from the steering gear.

Installation

Proper installation of the pitman arm is critical to the safe operation of the vehicle. Correct torque values are very important. Always follow these procedures when installing a pitman arm.

⚠ WARNING

If the pitman arm is not installed to the proper specifications, it can come loose causing an accident which could result in death or severe personal injury.

1. Align the timing marks on the pitman arm with the timing marks on the sector shaft and install the pitman arm on the sector shaft. The timing marks will appear like those in **Fig. 1** or **Fig. 2.**
2. Install the pitman arm retainer on the sector shaft. Be sure to align the tabs in the notches of the pitman arm. Coat the threads of the retainer with antiseize compound. A coating of antiseize should be applied to both sides of the friction washer if a new retainer is being used.
3. Torque the retainer 350 lbf·ft (475 N·m).

⚠ WARNING

Do not back off the torque value to align the tabs. If the pitman arm is not installed to the proper specifications, it can come loose causing an accident which could result in death or severe personal injury.

4. Continue torquing the retainer past the specified value until two of the notches in the retainer align with the tabs of the washer.

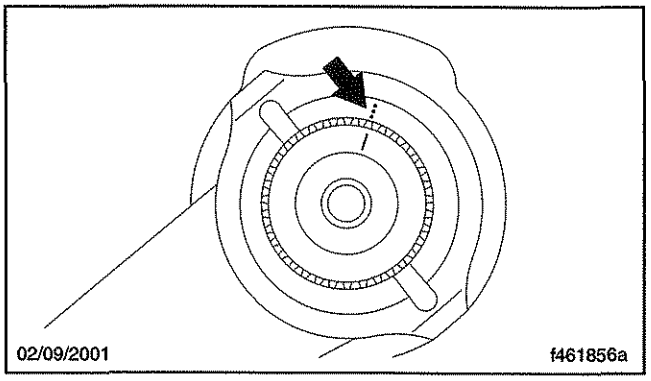


Fig. 1, Align the Timing Marks

Pitman Arm Removal and Installation

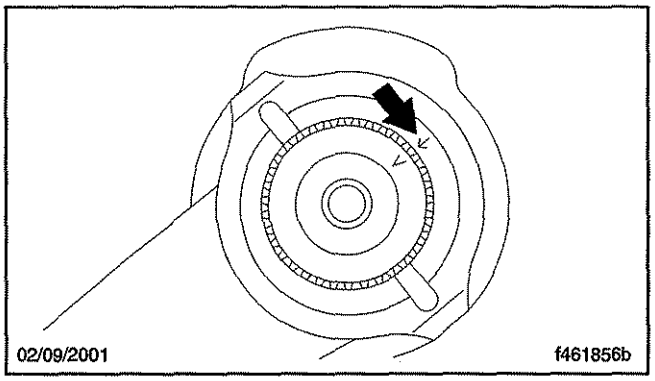


Fig. 2, Align the Timing Marks

⚠ WARNING

Once the retainer is torqued to specifications and locked in place, do not re-torque the retainer. Constant torquing of the retainer may cause the pitman arm to come loose causing an accident which could result in death or severe personal injury.

5. Using a punch and hammer, bend the retaining tabs of the washer in to the notches on the retainer. See **Fig. 3**. Apply torque seal, OGP F900WHITE, to the tabs.
6. Reset the automatic relief plungers. For instructions, see **Subject 140**.
7. Lower the hood or tilt the cab. For cab tilt instructions, see **Group 60** in this manual.
8. Remove the chocks from the tires.

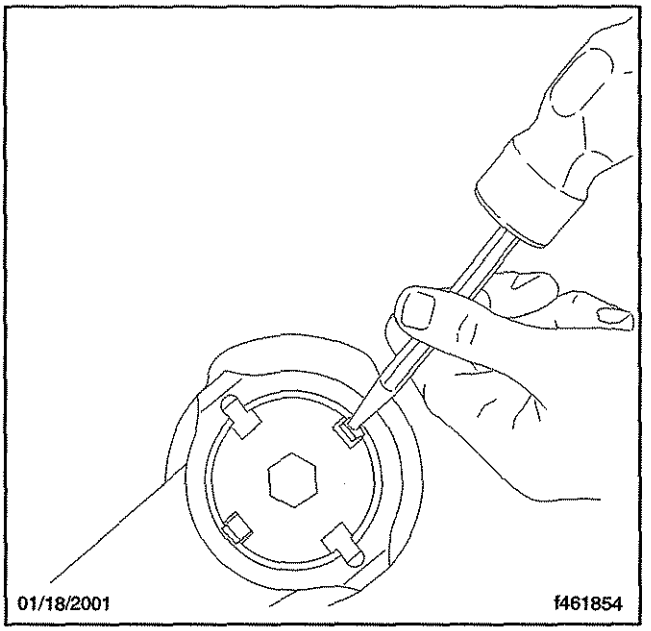


Fig. 3, Bend the Retaining Tabs

Checks

After power steering components have been worked on and before the vehicle is placed into service, the following items must be checked.

⚠ WARNING

Do the checks below. Failure to do these checks could result in damage to the power steering system and a loss of hydraulic assist. This could limit steering control, possibly resulting in personal injury or property damage.

1. Place a thermometer in the power steering reservoir. Warm the hydraulic system to a normal operating temperature of 150 to 160°F (66 to 71°C) by starting the engine and operating it at low idle while turning the steering wheel through several full left and right turns. With the engine running and the power steering system at operating temperature, turn the steering wheel slowly from stop to stop while checking the power steering reservoir for frothing or a change in the oil level (a sign that air is trapped in the system). If air is present, inspect the system for leaking hoses or loose fittings. Replace the hoses or tighten the fittings as necessary. Bleed the air from the system.
2. With the engine turned off and warm, check the power steering reservoir fluid level using the instructions in **Group 46** in the *Century Class Trucks Maintenance Manual.*
3. At full-left and full-right wheel cuts, be sure the axle stops (on the rear-side of the spindle) are set so there is at least 1/2-inch (13-mm) clearance between the tires and any fixed components that are attached to the vehicle. Clearance between moving components should be 3/4 inch (19 mm). If clearance is less than the above, reset the axle stops.
4. Check that the relief plungers are set correctly. If needed, adjust them. For instructions on adjusting the automatic relief plungers, see **Subject 130.**
5. If there are still problems with the power steering system, refer to **Troubleshooting 300** and perform the steering system hydraulic tests as instructed. Otherwise, go to the next step.
6. Test drive the vehicle or take a ride with the driver. Check the steering wheel spoke position. If during straight-ahead driving on a level road, the steering wheel spokes are not centered as shown in **Fig. 1,** remove the steering wheel and reposition it.

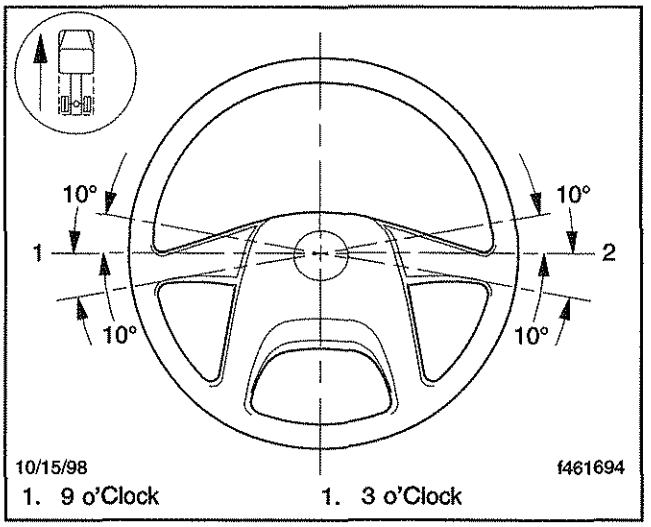


Fig. 1, Steering Wheel Centered

Troubleshooting

If there is a complaint about the steering system, do the checks below before servicing the steering gear or pump. This procedure is intended as a general guideline for the mechanic or technician to follow when diagnosing steering complaints.

The first step is always to talk to the driver. Get a detailed explanation of what the problem is and when it happens. Ask about any repairs, modifications, or prior adjustments. Then, if the truck is roadworthy, test drive it or ride with the driver and try to duplicate the problem.

After identifying the complaint, refer to the appropriate box in **Table 1** that best fits the complaint. Form SD–94, "Checklist for Troubleshooting Hydraulic Power Steering System Performance," should also be used to record test information. Form SD–94, **Fig. 7** and **Fig. 8**, is available and can be ordered through your dealer. Dealers can order this form through the TAO electronic mail system.

- At the TAO Mail Menu, key in B for bulletin boards.
- Tab down to Pub–Forms–FTL and key in L for list.
- At Freightliner Manuals Order Form, key in U.

If you don't have access to the TAO electronic mail system, contact Publishing Distribution at 503-745-7343.

The table on form SD–94 will refer you to a series of checks or tests to do for each type of complaint. The easiest and least costly checks are listed first. By doing the checks in order, starting with the lowest number, you can avoid unnecessary labor and expense. Instructions for doing the checks are given on the following pages. Each numbered step in the instructions corresponds with the diagnostic checks in **Table 1**. The numbers and checks in this table correspond to the numbered steps that follow.

Troubleshooting and Diagnostic Steps										
	1	2	3	4	5	6	7	8	9	10
Complaint	Tire Press./ Vehicle Load	Fifth Wheel Lube	Vehicle Alignment	Loose/ Binding Components	Noise	System Operating Temp.	System Leaks or Restrictions	Pump Performance	Relief Plunger Adjustment	Gear Internal Leakage
Hard or Heavy Steering	•	•		•		•	•	•	•	•
Low Assist										
Binding	•	•		•		•	•	•	•	•
Locking										
Occasional Loss of Assist										
Reduced Wheel Cut									•	
Vehicle Pulls to One Side	•		•					•		
Darting/ Oversteer	•	•	•	•						
Vehicle Wanders										

Troubleshooting and Diagnostic Checks

Troubleshooting and Diagnostic Steps										
	1	2	3	4	5	6	7	8	9	10
Complaint	Tire Press./ Vehicle Load	Fifth Wheel Lube	Vehicle Alignment	Loose/ Binding Components	Noise	System Operating Temp.	System Leaks or Restrictions	Pump Performance	Relief Plunger Adjustment	Gear Internal Leakage
Noisy Steering					•		•	•		
Steering Gear External Seal Leaks						•	•	•		
Excessive Heat										

Table 1, Troubleshooting and Diagnostic Steps

Diagnostic Checks

1. Check tire pressure and load.

   1.1 Check the tire pressure. Low pressure causes increased steering effort due to extra friction with the road surface. Check the tires for damage or erratic wear. Make sure the tires on each side of the front and rear axles are inflated to the correct pressure. Unequal tire pressure causes unequal friction between the tire and the road. This can cause pulling to one side. Correct the pressures if needed.

   1.2 Check whether duplex or oversized tires have been installed and that the tire sizes are correctly matched. Extra tire width causes increased steering effort due to extra friction with the road surface. The power steering gear relief plungers will also need to be adjusted if the axle stops were turned out to reduce wheel cut due to the change in tires. For instructions on adjusting an automatic relief plunger, see **Subject 130**.

   1.3 Determine whether the vehicle is operated at or over the rated load. Increased load causes greater steering effort. It may be necessary to modify the power steering, wheels, tires, or springs.

2. Check the fifth wheel.

   See if the fifth wheel is adequately lubricated. A dry fifth wheel plate makes it difficult to change direction. See **Fig. 1**. Check the plate surface for burrs, gouges, or irregularities.

3. Check the wheel bearing adjustment and axle alignment.

   3.1 Check the wheel bearing adjustment. Refer to **Group 33** and **Group 35** in this manual for instructions.

   3.2 Check the front and rear axles for correct alignment. Adjust them back to specifica-

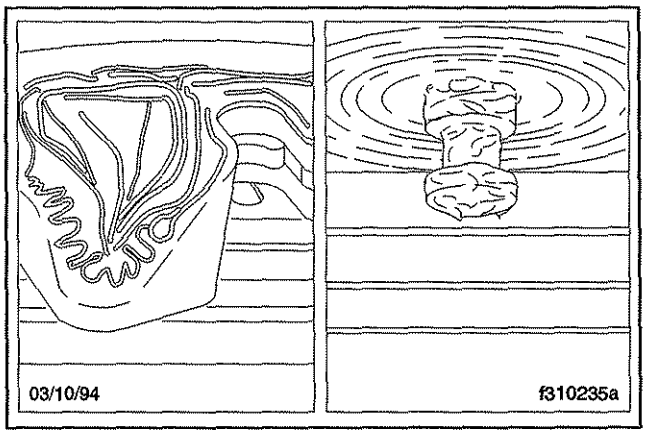


Fig. 1, Check Fifth Wheel Lubrication

tions if necessary. Refer to **Group 33** and **Group 35** in this manual for instructions.

4. Check for loose or binding components.

   Check whether any steering components are loose or binding, need maintenance, or need adjustment as follows:

   4.1 Lubricate the drag link, tie rods, and knuckle pins. Refer to **Group 46** in the *Century Class Trucks Maintenance Manual.*

   4.2 Chock the rearmost tires and raise the front tires off the ground. With the engine shut down, turn the steering wheel and check for looseness or binding. Make sure all components are free to move but are not excessively loose.

   4.3 Check the steering driveline U-joints for looseness or binding. Lubricate them if needed. For instructions, refer to **Group 46** in the *Century Class Trucks Maintenance Manual.*

   4.4 Check for correct steering driveline phasing. Reset the phasing if needed.

⚠ WARNING

Connect the input yoke and tighten all fasteners to the specified torque values. Failure to do this can cause loss of steering control, possibly resulting in personal injury and property damage.

   4.5 With the engine off, chock the rearmost tires and place the front tires on radius plates (turntables). Disconnect the drag link from the steering arm. See **Fig. 2.**

   By hand, pull the tire to one axle stop and release. The tire should self-return to almost straight ahead. See **Fig. 3.** Repeat in opposite direction. If the tire does not return to near straight ahead, check for a binding or lack of lubrication problem in the steering axle kingpin bushings or tie rod linkage. Connect the drag link and tighten the castle nut and install a new cotter pin. Refer to the drag link section in this group.

⚠ CAUTION

Do not steer the gear with the linkage removed, as misadjustment of the relief plungers may result.

⚠ WARNING

Connect the input yoke and tighten all fasteners to the specified torque values. Failure to do this can cause loss of steering control, possibly resulting in personal injury and property damage.

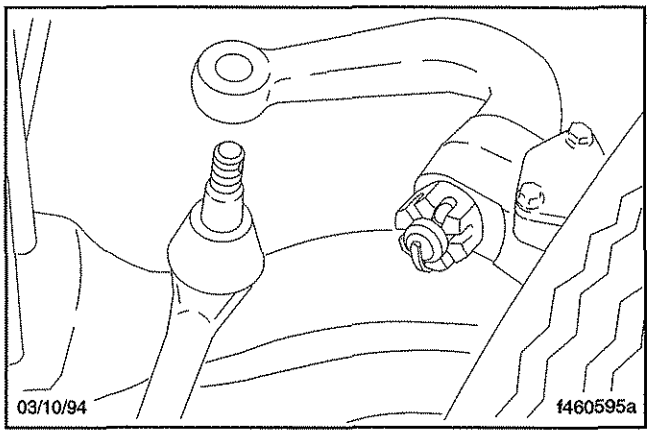


Fig. 2, Disconnect the Drag Link

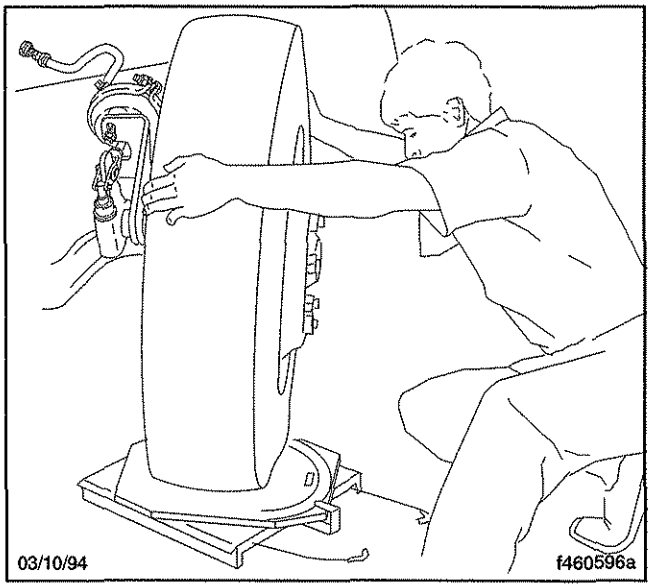


Fig. 3, Pull the Tire to One Axle Stop

Troubleshooting and Diagnostic Checks

4.6 Visually inspect all suspension fasteners and components for wear or looseness.

5. Check for noise.

NOTE: Noises from the power steering system do not necessarily mean there is a problem. Some noises are normal and are the result of proper operation. See **Table 2.**

6. Test the system operating temperature.

6.1 Park the vehicle outside.

6.2 Check for correct fluid level. If required, add fluid.

6.3 Place a thermometer in the fluid reservoir to monitor fluid temperature.

6.4 Run the vehicle at governed rpm for 40 minutes to bring the fluid to an elevated temperature. Check and record fluid temperature on the checklist (form SD–94) at the start of the 40 minute test and at 10, 20, 30, and 40 minutes.

Do not allow the temperature to exceed 150°F (66°C) above the outside (ambient) temperature or 250°F (121°C). If this temperature is exceeded, stop the 40 minute test and record the last noted temperature on the checklist.

6.5 If the temperature does not exceed 150°F (66°C) above the ambient temperature or 250°F (121°C) during the 40 minute test, excessive system heat is probably not the cause of the complaint. Go on to the next test for the complaint. See **Table 1.**

6.6 If at any time the temperature exceeded 150°F (66°C) above the ambient temperature or 250°F (121°C), the system is operating at excessive temperature levels and steering system performance and life may be affected. Damage to hoses, seals, and other components may result if the vehicle is operated at excessive steering system temperatures.

6.7 Excessive system restrictions or excessive pump flow may be the cause of the complaint. Go on to the next test for the complaint. See **Table 1.**

7. Check for leaks, restrictions, and test system back pressure.

7.1 Check for correct fluid level. If required, add fluid.

7.2 The inspection and test must be done with the power steering fluid at operating temperature of 180°F (82°C). With the engine at idle, monitor the fluid temperature with a thermometer in the fluid reservoir. If the fluid is too cold, raise the temperature by turning the steering wheel from stop to stop until the desired temperature is reached.

7.3 With the engine at idle, visually inspect all hoses and fittings for signs of kinked or collapsed hoses or leaking fittings. Visually inspect all external seals. Repair all leaking fittings and replace parts as required. Replace any leaking seals. Inspect the seal bores and sealing surfaces for scrapes or burrs. Be sure the seals are installed correctly using the recommended tools. If the steering gear input shaft oil seal is excessively hard, check the system operating temperature if not already done.

7.4 Install a low pressure gauge 200 to 300 psi (1378 to 2069 kPa) maximum between the pressure line and the pump (location P2). See **Fig. 4.**

Power Steering System Noises	
Symptom	**Action to Take**
Growling or Other Abnormal Steering Noise	Check the fluid level. Check for air bubbles or foam. Check for hose and fitting leaks. Add fluid if needed. If the fluid has air, check for inlet tube/hose leaks. Correct all leaks.
A Change from the Usual Pump Sound	Check the power steering fluid reservoir. Check for air bubbles or foam in the fluid. If the fluid has air, check for inlet tube/hose leaks. Correct all leaks.
Clicking Noise During a Turn	Check for loose steering components. Check the front suspension for insufficient spring pin shims. Tighten any loose steering components. Add front spring pin shims if needed.

Power Steering System Noises	
Symptom	**Action to Take**
Hissing When the Steering Wheel Is at or Near Full Turn	Fluid flowing past the relief plunger makes a hissing noise. This is normal. No action is needed.
Hissing at Less Than Full Turn	Check the relief plunger.

Table 2, Power Steering System Noises

⚠ CAUTION

Don't move the steering wheel or allow the system pressure to exceed the rating of the gauge during the following procedure or damage to the gauge may result.

7.5 Run the engine at idle and check for correct fluid level. If required, add fluid. If bubbles or foam appear in the reservoir, check the hose fittings for looseness or leaks.

7.6 With the engine at idle, read the total system back pressure on the pressure gauge. Record the reading on the checklist.

7.7 If the total system back pressure (P2) is greater than 100 psi (689 kPa), go to the next step. If the pressure at P2 is less, restriction is not a problem. Go to the next test for the complaint. See **Table 1**.

7.8 System back pressure has been determined to be excessive and the component at fault can be pinpointed by checking pressures at key locations in the steering system. With the engine at idle, use the low pressure gauge and hose connection adapters necessary to measure pressures at all locations identified in **Fig. 4**. Each time the gauge is moved, ensure that the fluid level is correct and that air is removed from the system by running the engine at idle and checking the fluid level.

7.9 Determine the individual component restrictions by subtracting the values shown in **Table 3**. Record the values on form SD–94.

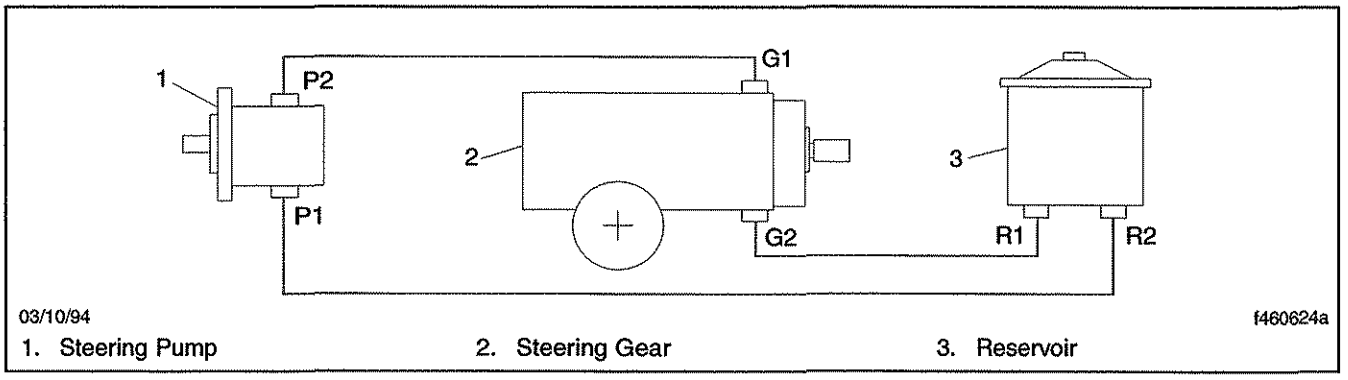
7.10 Refer to the "Action to Take" column in **Table 3** for action to take if any component exceeds the maximum allowable restriction as listed for each component.

8. Test pump performance.

8.1 Set up the system for hydraulic checks. Refer to **Subject 305** for instructions.

8.2 Make sure the fluid temperature is 180°F (82°C) and the vehicle is stationary with the front wheels pointing forward and the rearmost tires chocked.

8.3 Run the engine at idle. Refer to the engine idle table in **Subject 305** for the correct engine idle speed.



1. Steering Pump 2. Steering Gear 3. Reservoir

Fig. 4, Plumbing Diagram

Troubleshooting and Diagnostic Checks

System and Component Restrictions		
Total System and Component Restrictions	**Maximum Allowable Pressure**	**Action to Take**
P2 = Total System	100 psi (689 kPa)	Check pressures at the key locations.
P2-G1 = Hose: Pump-to-Gear	12 psi (83 kPa)	Check for a kinked or plugged hose. Replace the hose if necessary.
G1-G2 = Steering Gear	55 psi (379 kPa)	The gear rotary valve is damaged. Replace the gear. See instructions in this manual.
G2-R1 = Hose: Gear-to-Reservoir	12 psi (83 kPa)	Check for a kinked or plugged hose. Replace the hose if necessary.
R1-R2 = Reservoir	2 qt: 4 psi (28 kPa)	Replace the filter. Check for internal blockage.
R2-P1 = Hose: Pump Supply	12 psi (83 kPa)	Check for a kinked, collapsed, or plugged hose. Replace the hose if necessary.

Table 3, System and Component Restrictions

8.4 Adjust idle speed if necessary. Refer to the engine manufacturer's instructions.

8.5 Slowly close the load valve. When the valve is completely closed, read the pressure gauge.

⚠ CAUTION

Don't leave the valve closed for longer than 5 seconds since this could damage the power steering system.

8.6 If the pressure rises rapidly, appears to be uncontrolled, or rises above the maximum pressure of 2175 psi (14 996 kPa), open the load valve immediately. Indicate on form SD–94 whether the pump response was erratic or not. If the response was erratic, replace the pressure relief valve in the pump. For instructions, refer to the appropriate power steering pump section in this group. If the pressure was constant, go to the next step. With the fluid temperature at 180°F (82°C) repeat the previous two steps.

8.7 If the pump pressure measures 1900 to 2175 psi (13 100 to 14 996 kPa), it is acceptable. Skip the next step and record the pressure on form SD–94. If the pressure is not within this range, replace the pressure relief valve if not done previously in this test. With the fluid temperature at 180°F (82°C) repeat the two previous steps. If the pressure relief valve has been replaced, go to the next step.

8.8 If the pressure was not within the above applicable range and the relief valve has been previously replaced, replace the pump. For instructions, refer to the appropriate power steering pump section in this group. If the pump was replaced, evaluate its performance by repeating the test pump performance check.

8.9 Record the relief pressure on form SD–94.

8.10 With the engine at idle, test the pump relief valve reaction. Note the flow rate with the load valve open.

8.11 Close the load valve until the pump relief pressure is reached (previously determined). The flow rate should drop to zero.

8.12 Immediately open the load valve and note the flow rate. It should return to the value noted previously.

8.13 If the flow rate returns immediately, the relief valve is acceptable. Go to the next step.

If the flow rate does not return immediately, the pump relief valve is not working correctly. Replace the relief valve if not previously done, following the instructions in the appropriate power steering pump section in this group.

8.14 With the engine at 1500 rpm, repeat the steps beginning with testing the pump relief valve reaction.

8.15 Record on form SD–94 whether the relief valve operated okay or not okay at idle and at 1500 rpm. Near the bottom of the form, list any pump repairs that were made.

8.16 With the engine at idle, test the pump flow. Slowly close the load valve until the pressure gauge reads 1000 psi (6895 kPa).

8.17 Read the flow gauge and record the flow rate on form SD–94.

8.18 Open the load valve.

8.19 Run the engine at 1500 rpm. Leave the load valve open, do *not* close the load valve. Read the flow gauge and record the flow rate on form SD–94.

8.20 At idle the minimum flow rate is 3.1 gpm (11.7 Lpm). The maximum flow rate at either engine speed is 6.0 gpm (22.8 Lpm). If the flow rate is below the minimum, repair or replace the pump. For instructions, refer to the appropriate power steering pump section in this group. If the flow rate is above the maximum, replace the flow control and relief valve in the pump. For instructions, refer to the pump section in this group.

9. Check the steering gear relief plunger and the axle stop adjustment.

   NOTE: Relief plungers limit the steering assist when the front wheels approach the axle stops. Improper adjustment can apply excessive force to the steering linkage or loss of assist as the steering wheel approaches either full left or full right turns.

   9.1 If the turning angle is inadequate, make sure the axle stops are set to the maximum possible turn angle. Make sure the axle stop settings limit the steering travel so there is 1/2-inch (13-mm) clearance from all stationary components, and 3/4-inch (19-mm) clearance from all moving components.

   9.2 Make sure the pitman arm is oriented on the steering gear sector shaft correctly. Refer to **Subject 160**.

   9.3 Set up the system for hydraulic checks. Refer to **Subject 305** for instructions.

   9.4 Make sure the fluid temperature is 180°F (82°C) and the vehicle is stationary with the front wheels pointing forward.

   9.5 Run the engine at idle with the load valve open. Refer to the engine idle table in **Subject 305** for the correct engine idle speed.

   9.6 Turn the steering wheel to either full-lock position.

⚠ CAUTION

If power steering pump relief pressure is reached while the steering wheel is at full-lock, release the steering wheel from this position. Don't allow the pump relief pressure to be maintained for longer than five seconds. Doing so may damage the pump.

   9.7 Note the pressure gauge reading.

   9.8 Repeat the previous three steps for the opposite turn direction and note the pressure gauge reading.

10. Test for steering gear internal leakage.

   10.1 Set up the system for hydraulic checks. Refer to **Subject 305** for instructions.

   10.2 Make sure the fluid temperature is 180°F (82°C) and the vehicle is stationary with the front wheels pointing forward.

   10.3 Run the engine at idle with the load valve open. Refer to the engine idle table in **Subject 305** for the correct engine idle speed.

   10.4 Place an unhardened steel spacer, 1-inch (2.5-cm) thick between the axle and the axle stop at one side of the axle. See **Fig. 5.** The spacer should have an extension or handle long enough to keep your fingers clear of the axle stop area. A brazing rod or welding rod works well for this purpose.

Troubleshooting and Diagnostic Checks

⚠ WARNING

During this test, keep your fingers clear of the axle stops and spacer block and make sure that the spacer block contacts the axle stop squarely. Otherwise there is a risk of crushed fingers or personal injury from a forcibly ejected spacer block, as well as a damaged axle stop.

⚠ CAUTION

While running this test, do not hold the steering wheel in the full turn position for longer than 5 seconds at a time to avoid damaging the pump.

10.5 Have someone turn the steering wheel until the axle stop contacts the spacer block. Apply 20 lb (9 kg) to the rim of the steering wheel. See **Fig. 6**.

10.6 Read the internal leakage rate on the flow meter.

10.7 Record the reading on form SD–94.

10.8 Repeat the previous four steps (beginning with placing the spacer between the axle and the axle stop) for the opposite turn direction.

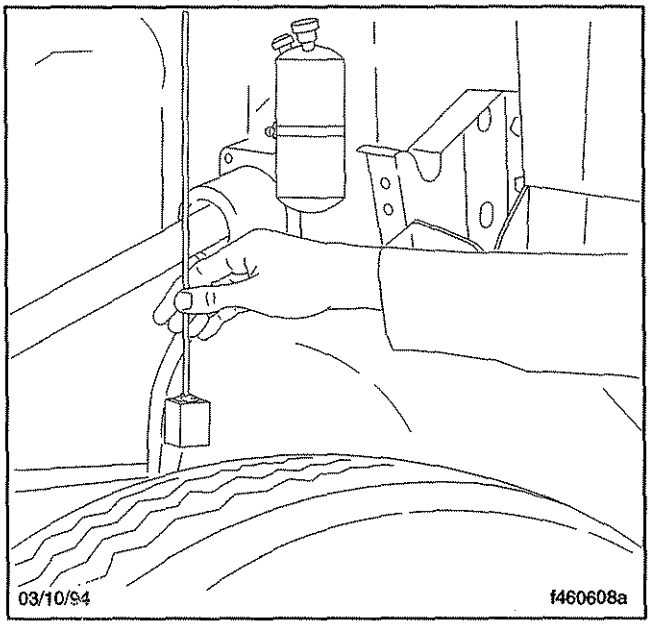


Fig. 5, Position the Steel Spacer

10.9 The maximum permissible internal leakage is 1.0 gpm (3.8 Lpm). If leakage is greater in either turning direction, replace the steering gear components.

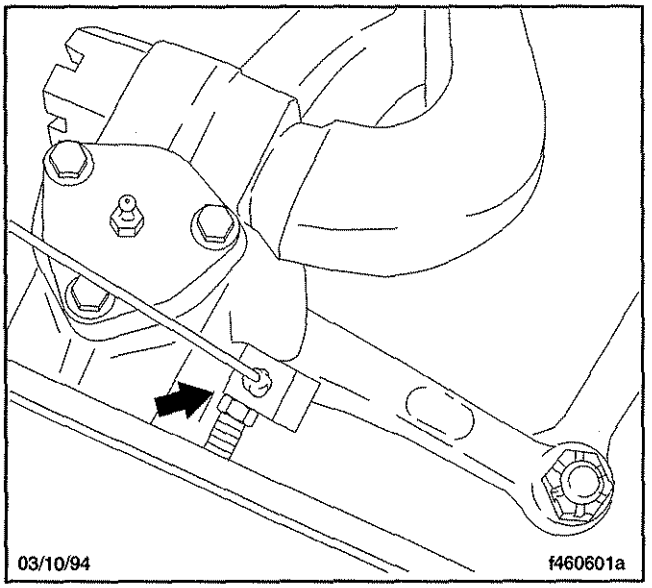


Fig. 6, Axle Stop Contacting the Steel Spacer

FREIGHTLINER
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Checklist for Troubleshooting Hydraulic Power Steering System Performance

Date _____ Work Order No. _____

Evaluation Performed By _____ ☐ Dealership ☐ Fleet ☐ Independent

Vehicle Identification

Vehicle Model _____ Chassis No. _____ Date in Service _____

Mileage _____ Mileage when steering complaint first occurred _____

Vehicle application _____ Normal steering axle load _____

Steering System Description

Steering Pump Manufacturer _____ Model No. _____

Steering Gear Manufacturer _____ Model No. _____ Date Code _____

Reservoir Capacity: ☐ 2 quart ☐ 4 quart ☐ 9 quart

Type of Fluid: ☐ ATF ☐ 10W ☐ 10W-30 ☐ 10W-40 ☐ Other _____

Steering Complaint and Appropriate Checks

				CHECKS									
				1	2	3	4	5	6	7	8	9	10
LH	RH	Both	COMPLAINT	Tire Press./ Vehicle Load	Fifth Wheel Lube	Vehicle Align-ment	Loose/ Binding Compo-nents	Noise	System Operat-ing Temp.	System Leaks or Restric-tions	Pump Perform-ance	Gear Poppet Adjust-ment	Gear Internal Leakage
			Hard or Heavy Steering	•	•		•		•	•	•	•	•
			Low Assist										
			Binding	•	•		•		•	•	•	•	•
			Locking										
			Occasional Loss of Assist										
			Reduced Wheel Cut									•	
			Vehicle Pulls to One Side	•		•					•		
			Darting/ Oversteer	•	•	•	•						
			Vehicle Wanders										
			Noisy Steering					•		•	•		
			Steering Gear External Seal Leaks						•	•	•		
			Excessive Heat										
			Other (describe as completely as possible) _____										

Vehicle Checks

No. 1—Tire Pressure/Load:

Front Tire Pressure

Left Right

Oversized front tires? ☐ Yes ☐ No

Heavy load operation? ☐ Yes ☐ No ☐ psi ☐ kPa _____ _____

Rear tire pressure even? ☐ Yes ☐ No

No. 2—Fifth Wheel Lube and Condition: ☐ OK ☐ Not OK

No. 3—Vehicle Alignment and Wheel Bearing Adjustment:

Left Right

Rear axle _____ Front axle: Caster _____ _____

Wheel bearings: ☐ OK ☐ Not OK Camber _____ _____

No. 4—Binding Components:

Lubrication of drag link, tie rod, and knuckle pins? ☐ Yes ☐ No

COE steering column bearing binds? ☐ Yes ☐ No

SD-94 (9/91P)

01/16/98 f460206

Fig. 7, Front Side, Checklist for Troubleshooting Hydraulic Power Steering System Performance

Troubleshooting and Diagnostic Checks

No 4—Binding Components (Continued)

Steering driveline U-joints bind?	☐ Yes	☐ No
Steering driveline phasing OK?	☐ Yes	☐ No
Sector shaft adjustment OK?	☐ Yes	☐ No
Front tire self-return OK?	☐ Yes	☐ No

No 5—Noise

Fluid level ☐ OK ☐ Too low ☐ Too high

Fluid condition ☐ OK ☐ Discolored ☐ Odorous ☐ Foamy ☐ Other _____

Inlet tube or fittings leaking?	☐ Yes	☐ No
Front spring pin shims required?	☐ Yes	☐ No
Loose steering components?	☐ Yes	☐ No
Normal "hissing" at full turn?	☐ Yes	☐ No
"Hissing" at less than full turn?	☐ Yes	☐ No
Hoses kinked or collapsed?	☐ Yes	☐ No

No 6—System Operating Temperature ☐ °F ☐ °C

Outside (ambient) temperature _____°, Test start _____°

10 min _____°, 20 min _____°, 30 min _____°, 40 min _____°

No 7—System Leaks or Restrictions

Hoses kinked or collapsed?	☐ Yes	☐ No
Leaking fittings?	☐ Yes	☐ No
Leaking seals?	☐ Yes	☐ No

Total System and Component Back Pressure ☐ psi ☐ kPa

Total system _____, Hose Pump-to-gear _____, Steering gear _____,

Hose Gear-to-booster _____, Hose Gear-to-reservoir _____, Booster _____,

Hose Booster-to-reservoir _____, Reservoir _____, Hose Pump supply _____

Hydraulic Checks

Power steering fluid temperature (to be 150° to 160°F [66° to 71°C], see "System Set-Up for Hydraulic Checks" in applicable service manual) _____°F (_____°C)

Idle RPM (see "System Set-Up for Hydraulic Checks" in applicable service manual for correct idle rpm)

		Idle	Highway
		_____rpm	1500 rpm

No 8—Pump Performance

Erratic response	☐ Yes ☐ No		
Pump relief pressure	☐ psi ☐ kPa	_____	
Pump relief valve operation		OK ☐ / Not OK ☐	☐ / ☐
Pump flow	☐ gpm ☐ Lpm	_____	_____

No 9—Steering Gear Poppet Adjustment		Left Turn	Right Turn
Poppet valve trip pressure	☐ psi ☐ kPa	_____	_____

No 10—Steering Gear Internal Leakage

Ross (TRW)	☐ gpm ☐ Lpm	_____	_____
Sheppard	☐ psi ☐ kPa	_____	_____

Attempted Corrections and Results

Pump repairs _____

Steering gear repairs _____

_____

Other components repairs _____

SD-91 (9-91P)

01/16/98 f460207

Fig. 8, Back Side, Checklist for Troubleshooting Hydraulic Power Steering System Performance

System Setup

NOTE: Use a 1 to 10 gpm (3.8 to 38 L/min) flow meter, a pressure gauge 0 to 2500 psi (0 to 17 225 kPa) minimum, and a load valve, preferably in one test unit.

1. Install the test unit between the pump high-pressure line and the steering gear.
2. Fill the steering system.
3. Place a thermometer in the power steering fluid reservoir.
4. Checks must be done with the power steering fluid at the operating temperature 180°F (82°C). Monitor the fluid temperature with the thermometer. If the fluid is too cold, raise the temperature as follows:

   Run the engine at idle.

   Partially close the load valve on the test unit until the pressure gauge reads 1000 psi (6895 kPa).

⚠ CAUTION

Do not leave the load valve fully closed since this could damage the power steering system.

5. Open the valve when the fluid temperature reaches 180°F (82°C).

⚠ CAUTION

Do not allow the fluid temperature to exceed 250°F (121°C) since this could damage the power steering system.

6. When doing steps 8, 9, and 10 in **Troubleshooting 300**, see **Table 1** for engine idle speed. If adjustment of the idle speed is necessary, see the engine manufacturer's instructions.

Engine Idle Speeds	
Engine Type	**Idle Speed (rpm)**
Caterpillar C–10, C–12, C–15, C–16	700
Cummins ISM	700
Cummins N14 (330 to 370 hp)	600
Cummins N14 (410 to 525 hp)	650
Cummins ISX and Signature 600	600
Detroit Diesel Series 60	600

Table 1, Engine Idle Speeds

NOTE: Record all data from the hydraulic checks on form SD–94, "Checklist for Troubleshooting Hydraulic Power Steering System Performance."

See **Fig. 1** for a plumbing diagram of the power steering system.

Steering Gear Torque Values			
Description	**Size**	**Grade**	**Torque lbf·ft (N·m)**
Bearing Cap Cover Capscrews	M10 x 1.5	10.9	53 to 64 (72 to 87)
Bearing Cap Capscrews	M14 x 2	8.8	114 to 140 (154 to 190)
Cylinder Head Capscrews	M14 x 2	8.8	114 to 124 (154 to 168)
Sector Shaft Cover Capscrews	M12 x 1.75	8.8	72 to 81 (98 to 110)
Pitman Arm Retainer	—	—	350 (475)
Steering Gear Mounting Fasteners	7/8–9	8	388 (526)

Table 1, Steering Gear Torque Values

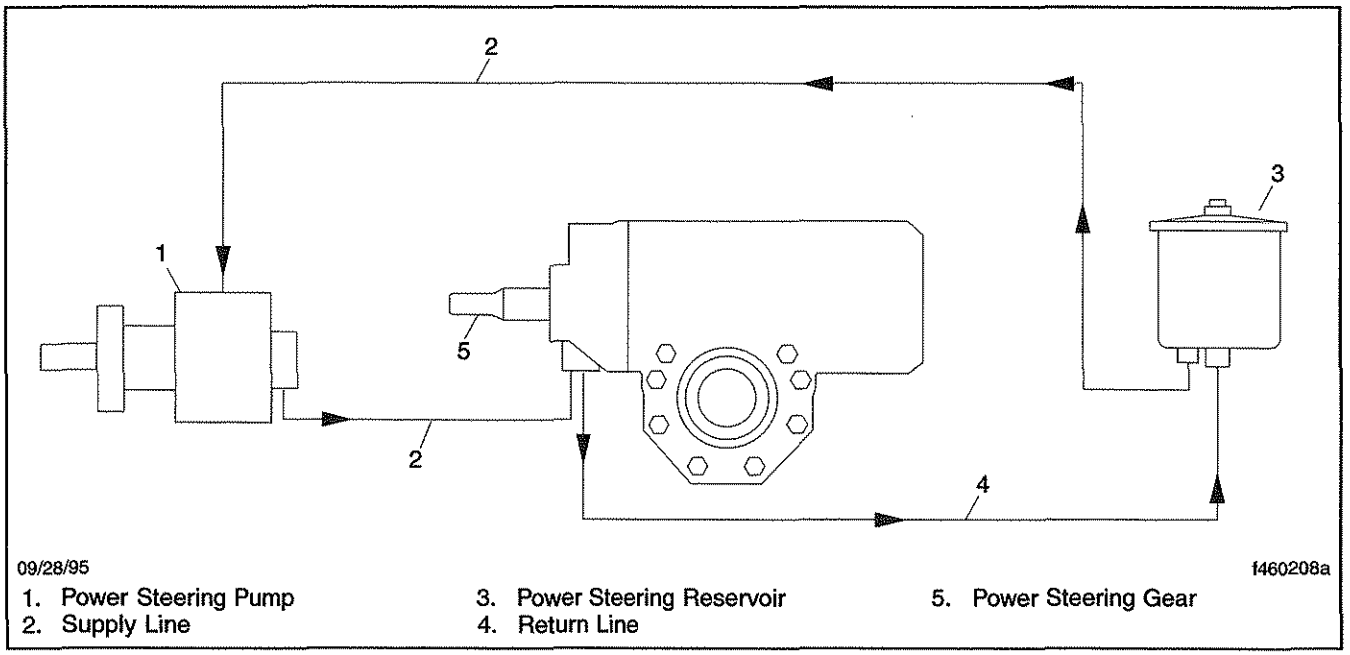


Fig. 1, Plumbing Diagram of the Power Steering System

Tilt Steering Column Assembly 46.06

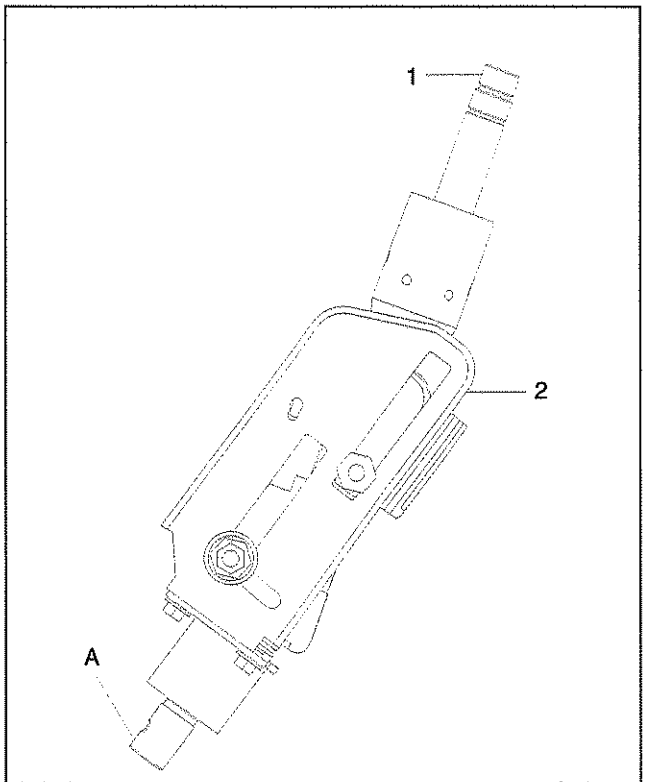
Contents

Subject	Subject Number
General Information	050
Service Operations	
Steering Wheel Removal and Installation	100
Tilt Column Removal and Installation	110
Specifications	400

General Information (See Fig. 1)

The tilt function of the tilt steering column is controlled by a foot-operated release valve. See **Fig. 2**. For operating instructions, refer to the vehicle driver's manual.

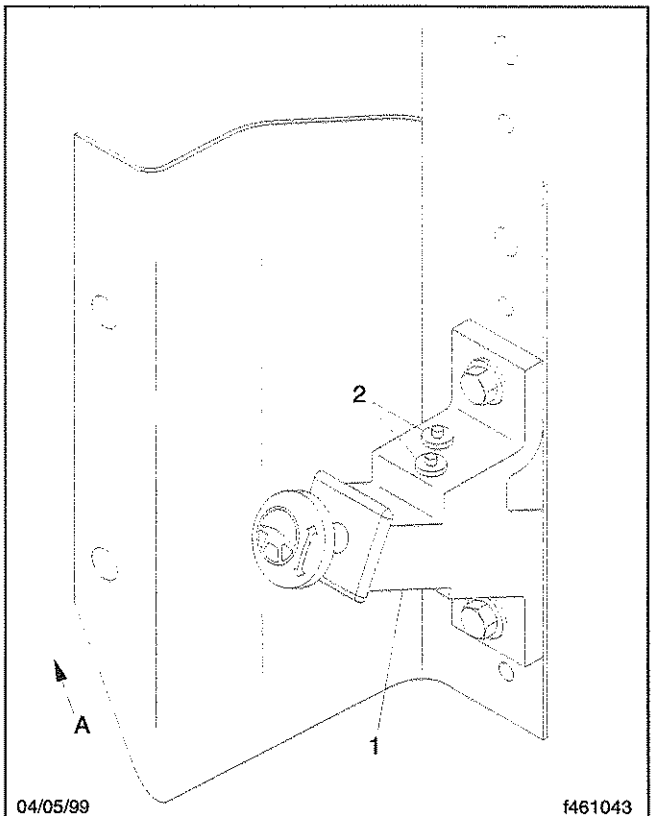
At the upper end of the tilt steering column assembly are threads to accept a wheel nut, and tapered external serrations to match the internal serrations of the steering wheel hub. At the lower end, the shaft is serrated to connect with the steering driveline upper end yoke.



08/11/95 f461044

A. Steering driveline upper end yoke attaches here.
1. Tilt Steering Column Shaft
2. Tilt Column Assembly

Fig. 1, Tilt Steering Column Assembly



04/05/99 f461043

A. Driver's door opening
1. Column Release Valve
2. Air Line Connections

Fig. 2, Tilt Column Release Valve, Left-Hand Drive Shown

Removal of Steering Wheel Without an Air Bag

NOTE: Remove the steering wheel only if the steering wheel or steering column is being replaced. If the wheel or column is being removed to allow servicing of the dash, remove the steering wheel and column as an assembly. For instructions, refer to **Subject 110**.

1. Position the front tires straight ahead. If possible, drive the vehicle in a straight line for a short distance stopping at the spot where service operations will be performed.

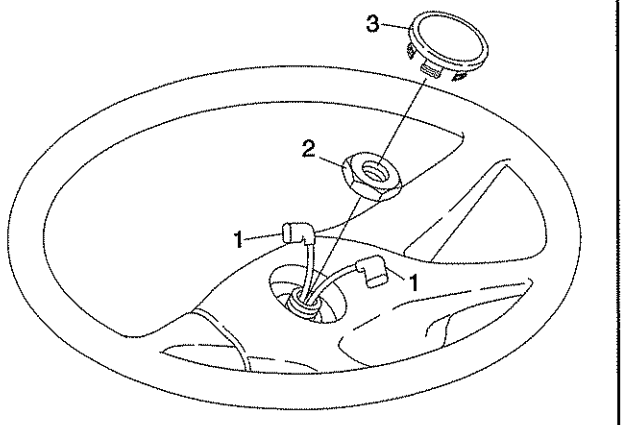
   Apply the parking brakes and chock the tires.

2. Using a small screwdriver, pry under the outermost ring of the steering wheel horn button cover. Lift the horn button cover from the steering wheel hub, then disconnect the wire terminals at the horn button. See **Fig. 1**.

IMPORTANT: The steering wheel has an alignment mark within the hub. After removing the wheel nut, mark the column shaft at the wheel alignment mark to ensure proper installation of the wheel.

3. Without turning the steering wheel, remove the wheel nut (**Fig. 1**). Using a steering wheel puller, remove the steering wheel from the shaft.

IMPORTANT: Be careful when you are removing the steering wheel, or you could damage the horn wires.



08/23/95 f461054

1. Horn Cable Assembly
2. Wheel Nut
3. Horn Button Cover

Fig. 1, Steering Wheel Removal

A steel block measuring 1-5/8 x 5/8 x 1/4 inch (41 x 16 x 6.4 mm) can be used with the puller to protect the wires during steering wheel removal.

Removal of Steering Wheel With an Air Bag

IMPORTANT: To determine which type of supplemental protection system is installed in the vehicle, look at the module under the driver's seat. The air bag/SPACE system and the air bag only system installed prior to May 12, 2000 have a SPACE module. If the vehicle has a SPACE system, gas cylinders are also located under the driver's seat. See **Fig. 2**. The air bag only system that became available on May 12, 2000 has an air bag sensor module located under the driver's seat. See **Fig. 3**.

NOTE: Remove the steering wheel only if the steering wheel or steering column is being replaced. If the wheel or column is being removed to allow servicing of the dash, remove the steering wheel and column as an assembly. For instructions, refer to **Subject 110**.

1. Position the front tires straight ahead. If possible, drive the vehicle in a straight line for a short distance stopping at the spot where service operations will be performed.

   Apply the parking brakes and chock the tires.

⚠ CAUTION

Do not turn the steering wheel or the steering shaft at any time during this procedure. Doing so may damage the clockspring.

2. Disconnect the batteries by removing the negative terminal first, then the positive terminal.

⚠ WARNING

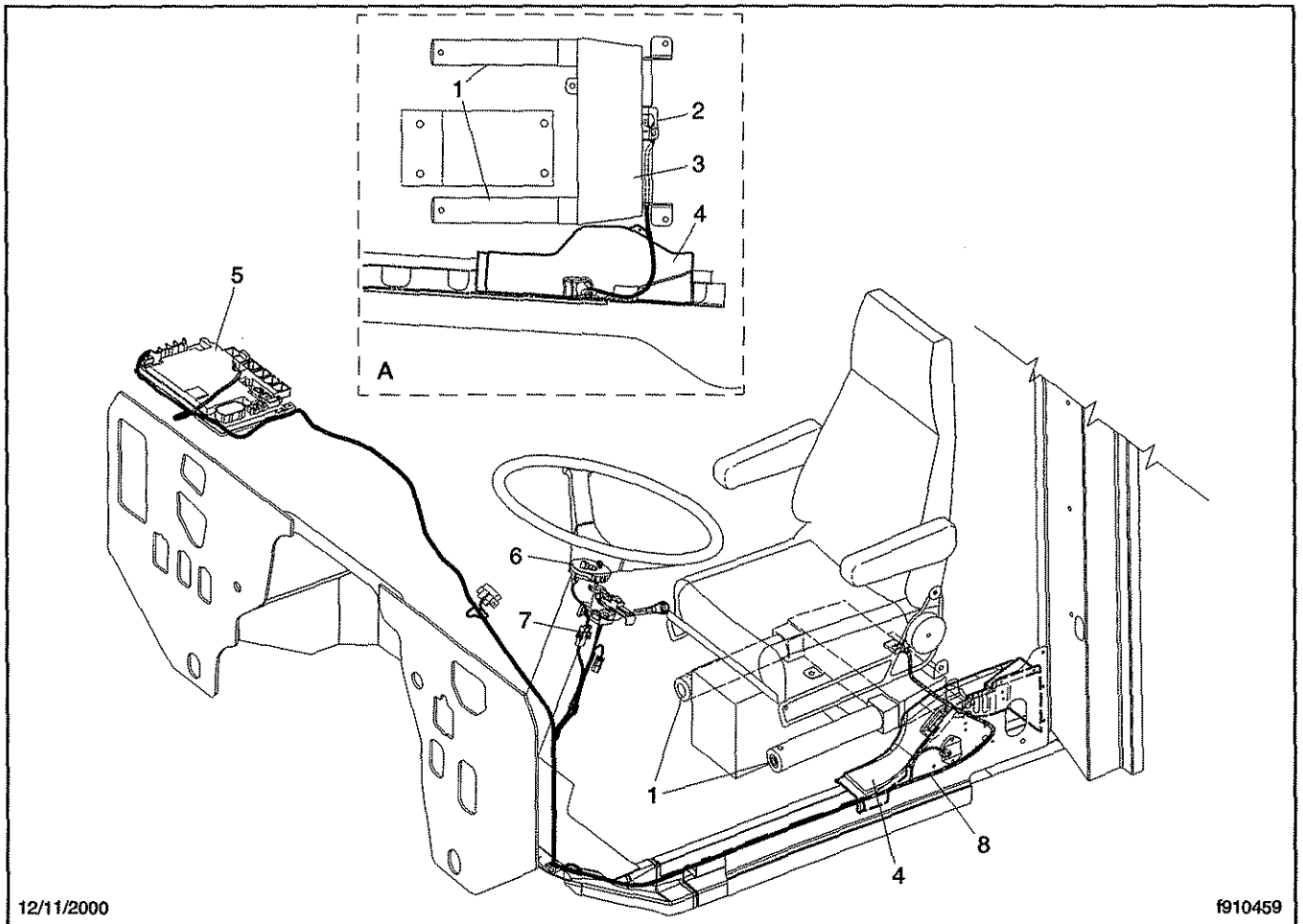
Wait two minutes after disconnecting the batteries to allow the internal components to discharge. Failure to allow the components to discharge could cause the air bag to deploy, resulting in severe bodily injury or death.

Consider undeployed air bags to be dangerous and capable of deploying at any time. Follow the safety guidelines and handling instructions

Steering Wheel Removal and Installation

in Section 46.09, Subject 110. Failure to observe safety and handling information could cause the unintentional deployment of the air bag, which could result in severe injury or death.

3. Disconnect the air bag circuit from the air bag sensor module or the SPACE module.
   - 3.1 On vehicles with an air bag/SPACE system, disconnect the DSS connector at the back of the SPACE module. See **Fig. 2.**
   - 3.2 On vehicles with an air bag only system installed from May 12, 2000, disconnect the AS2 connector under the B pillar cover. See **Fig. 3.**
4. Pull the lower steering column cover off of the dash.
5. Remove the fastener cover plugs from the steering column cover.
6. Remove the T25 Torx®-head fasteners and the steering column cover. See **Fig. 4.**
7. Remove the T30 Torx-head fasteners underneath the steering wheel. See **Fig. 5.**



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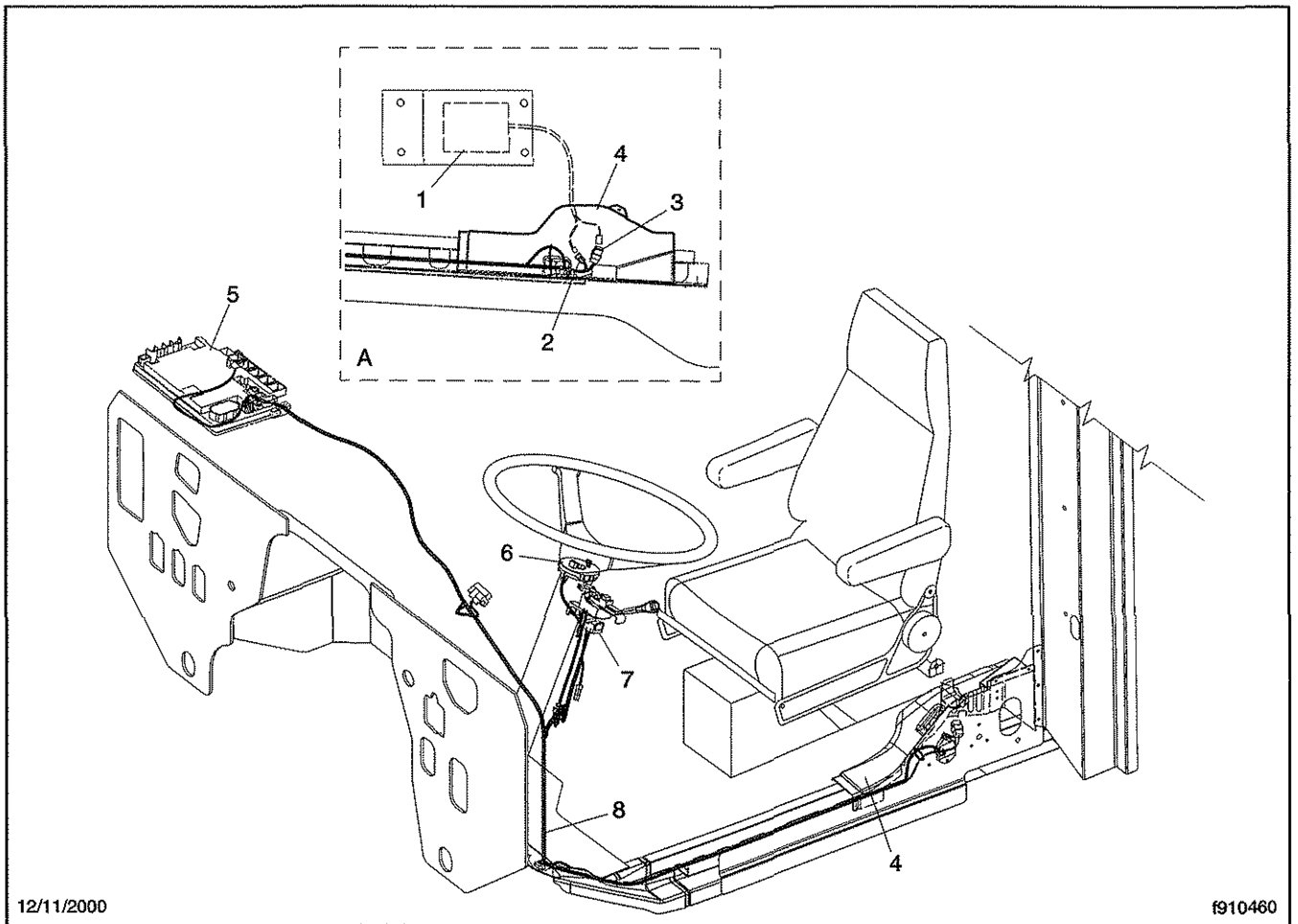
A. Top view of Air Bag/SPACE System
1. Gas Cylinder (SPACE system only)
2. DSS (Driver-Side SPACE) Connector
3. Driver-Side SPACE Module
4. B Pillar Cover
5. Power Distribution Module
6. Clockspring
7. SRS (Supplemental Restraint System) Connector
8. Air Bag Wiring Harness

Fig. 2, Air Bag Harness Routing on Air Bag/SPACE Systems Installed Prior to May 12, 2000



A. Top view of Air Bag Sensor Module

1. Air Bag Sensor Module
2. AS2 Connector
3. AS1 Connector
4. B Pillar Cover
5. Power Distribution Module
6. Clockspring
7. SRS1 (Supplemental Restraint System) Connector
8. Air Bag Wiring Harness

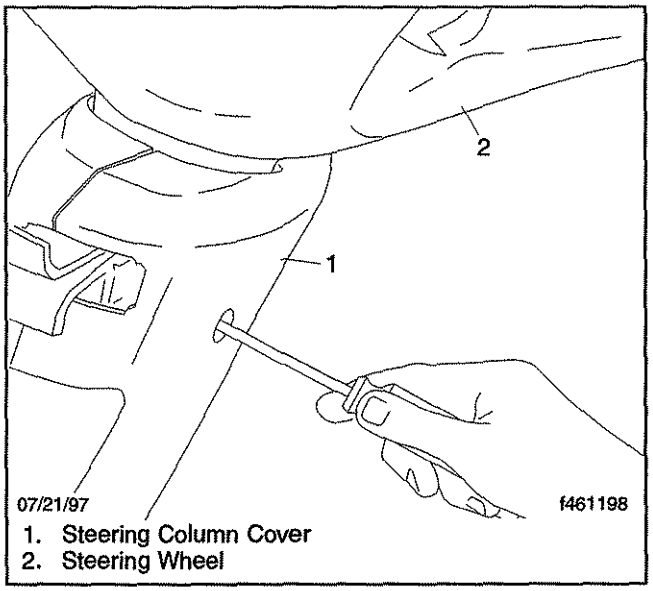
Fig. 3, Air Bag Harness Routing on Air Bag Only Systems Installed From May 12, 2000

8. Carefully lift the air bag module from the steering wheel and disconnect the air bag connector (and the horn switch connector if equipped) from the air bag. See **Fig. 6.**
9. Remove the air bag module.
10. Without turning the steering wheel, remove the wheel nut (**Fig. 6**). Using a steering wheel puller, remove the wheel from the shaft.
11. Tape the upper and lower portions of the clockspring (**Fig. 7**) together to prevent the clockspring from turning.
12. Inspect the clockspring and clockspring connector. Replace the clockspring if there is any melting or damage. For clockspring replacement instructions, see **Section 46.09**, Subject 120.

Installation of Steering Wheel Without an Air Bag

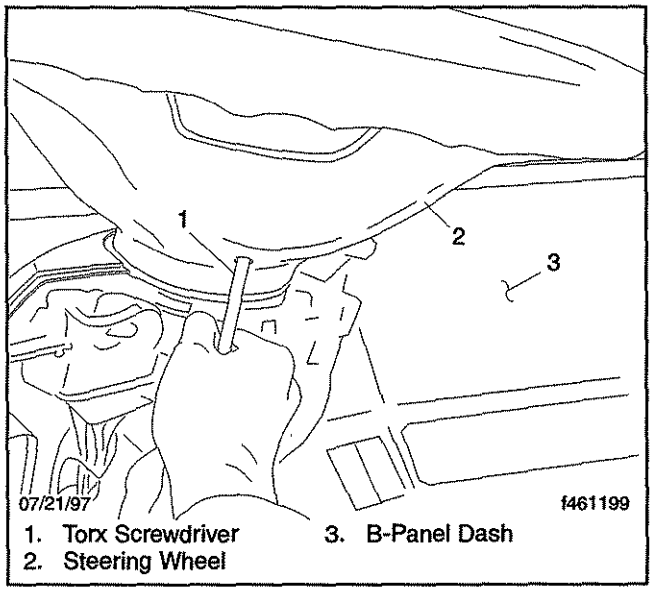
NOTE: Before installing the steering wheel, make sure the front tires are pointed straight ahead, and the steering gear is centered.

Steering Wheel Removal and Installation



1. Steering Column Cover
2. Steering Wheel

Fig. 4, Remove the Steering Column Cover

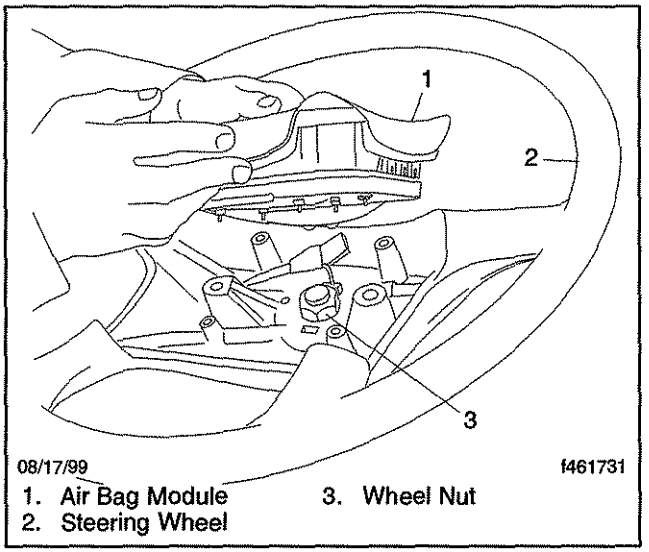


1. Torx Screwdriver
2. Steering Wheel
3. B-Panel Dash

Fig. 5, Remove the Fasteners

1. With the marks on the column and steering wheel aligned, place the steering wheel on the steering column. Make sure that the steering wheel is within ±10 degrees of center as shown in **Fig. 8.**

   Insert the horn ground wires (from the center of the steering column shaft) through the center of the wheel nut. Install the wheel nut and tighten 55 to 65 lbf·ft (75 to 88 N·m).



1. Air Bag Module
2. Steering Wheel
3. Wheel Nut

Fig. 6, Lift Off the Air Bag Module

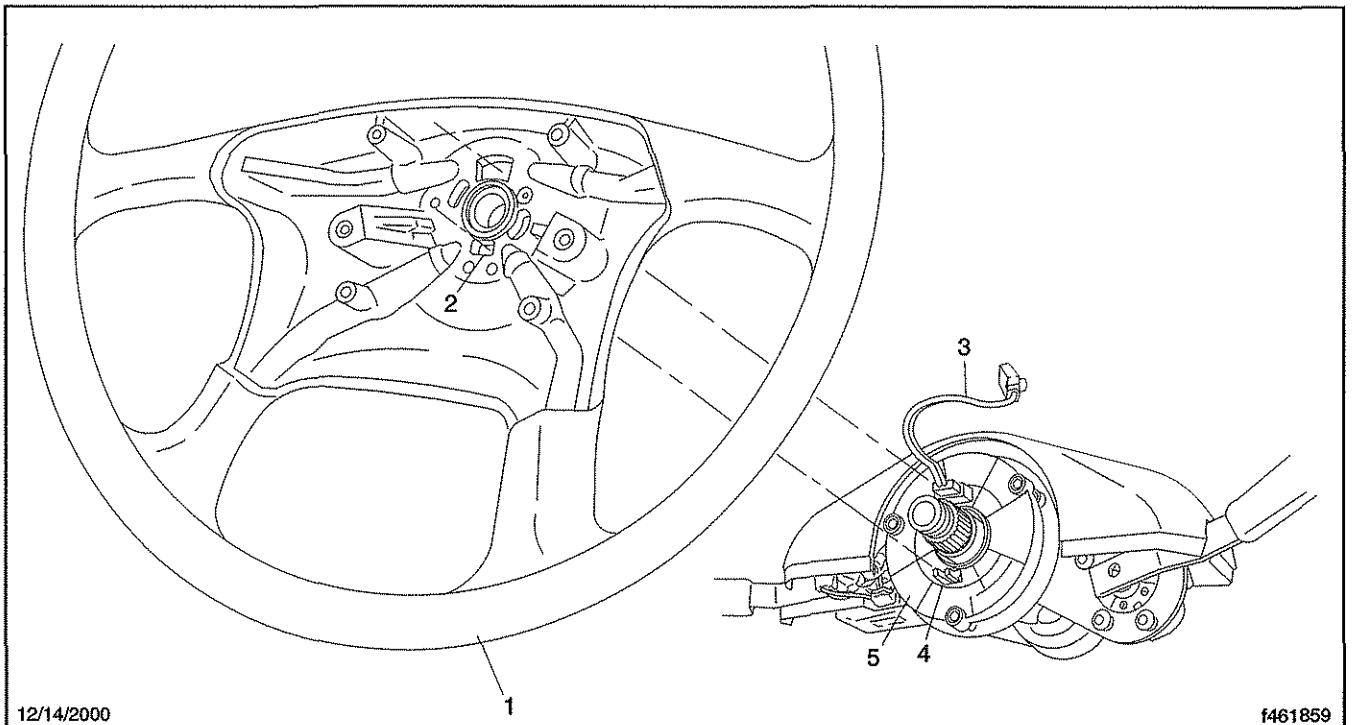
2. Connect the ground wire terminals to the horn button. With the steering wheel in the straight-ahead position, push the horn button cover into place on the steering wheel hub.
3. Remove the chocks from the tires.

Installation of Steering Wheel With an Air Bag

NOTE: Before installing the steering wheel, make sure the front tires are pointed straight ahead and the steering gear is centered.

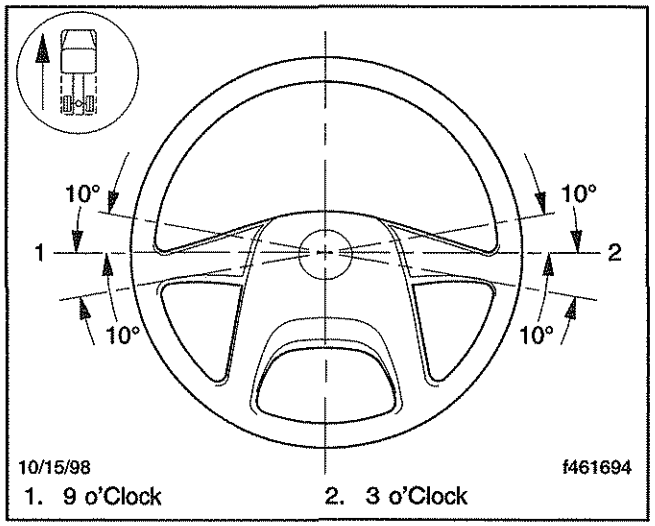
1. Pull the air bag connector from the steering column through the cutout above the center hole on the steering wheel. See **Fig. 7.**
2. Remove the tape from the clockspring.
3. Align the tab on the clockspring with the cutout below the center hole on the steering wheel, and place the steering wheel on the steering column. See **Fig. 7.** Make sure that the steering wheel is within ±10 degrees of center as shown in **Fig. 8.** Install the wheel nut and tighten 55 to 65 lbf·ft (75 to 88 N·m).
4. Connect the air bag connector to the air bag module and carefully set the air bag module on the steering wheel.

Steering Wheel Removal and Installation



1. Steering Wheel
2. Cutout
3. Air Bag Cable Assembly
4. Tab
5. Clockspring

Fig. 7, Installation of Steering Wheel With an Air Bag



1. 9 o'Clock
2. 3 o'Clock

Fig. 8, Steering Wheel Centered

5. Attach the air bag module to the steering wheel using T30 Torx-head fasteners.
6. Attach the steering column cover to the steering column using T25 Torx-head fasteners.
7. Attach the fastener cover plugs to the steering column cover.
8. Attach the lower steering column cover to the dash.
9. Reactivate the air bag by connecting the DSS connector on air bag/SPACE systems or by connecting the AS2 connector on air bag only systems built from May 12, 2000.
10. Connect the batteries.
11. Remove the chocks from the tires.

Tilt Column Removal and Installation

Removal

NOTE: If the steering wheel is not being replaced, see **Subject 100** for steering wheel removal and installation instructions.

1. Position the front tires straight ahead. If possible, drive the vehicle in a straight line for a short distance stopping at the spot where service operations will be performed.

   Apply the parking brakes and chock the tires.

⚠ CAUTION

Do not turn the steering wheel or the steering shaft at any time during this procedure. Doing so may damage the clockspring.

2. Depress the column adjustment knob and tilt the column until it is as far away from the dash as possible.
3. If the steering wheel is equipped with an air bag, disconnect the batteries and wait two minutes before proceeding.

⚠ WARNING

Wait two minutes after disconnecting the batteries to allow the internal components to discharge. Failure to allow the components to discharge could cause the air bag to deploy, resulting in severe bodily injury or death.

Undeployed air bags can be dangerous and are capable of deploying at any time. Follow the safety guidelines and handling instructions in Section 46.09, Subject 110. Failure to observe safety and handling information could cause the unintentional deployment of the air bag, which could result in severe injury or death.

IMPORTANT: To determine which type of supplemental protection system is installed in the vehicle, look at the module under the driver's seat. The air bag/SPACE system and the air bag only system installed prior to May 12, 2000 have a SPACE module. If the vehicle has a SPACE system, gas cylinders are also located under the driver's seat. See **Fig. 1**. The air bag only system that became available on May 12, 2000 has an air bag sensor module located under the driver's seat. See **Fig. 2**.

4. If the steering wheel is equipped with an air bag, deactivate the air bag by disconnecting the DSS connector (**Fig. 1**) on air bag/SPACE systems installed prior to May 12, 2000, or by disconnecting the AS2 connector (**Fig. 2**) on air bag only systems installed from May 12, 2000.
5. Using a T25 Torx®-driver, remove the lower steering column cover seal. See **Fig. 3**.

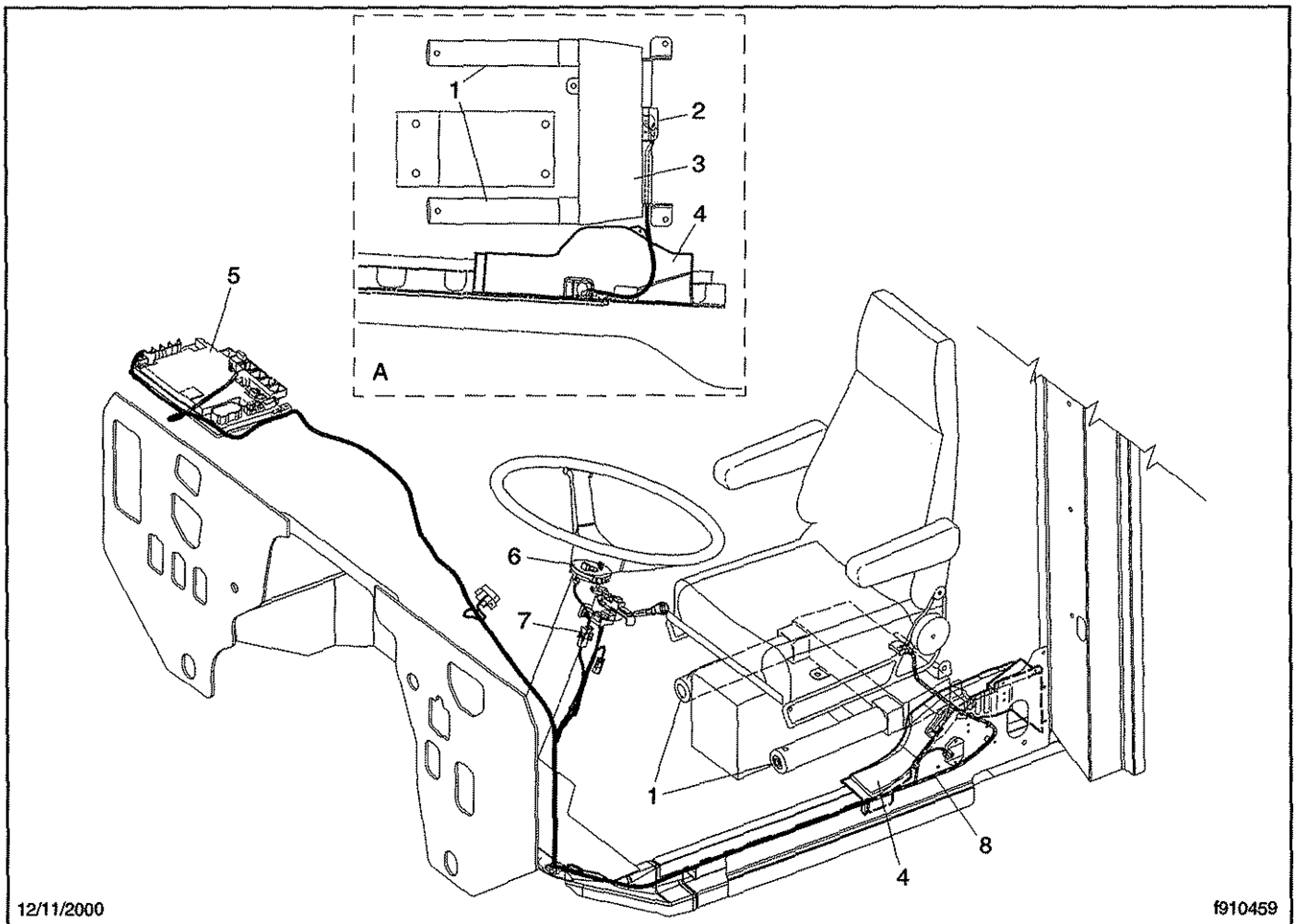
   Remove the steering column cover panels from the front and back of the column.
6. Remove the pinch bolt nut and pinch bolt from the upper end yoke. Discard the nut and the bolt.
7. Remove the two screws that attach the trailer brake control valve mounting bracket to the steering column. Remove the control valve (and the horn ground wire) from the steering column.
8. Remove the two screws that attach the turn-signal switch mounting bracket. Remove the turn-signal switch assembly from the steering column. Disconnect the wiring connector from the turn-signal switch.
9. Disconnect the air line that is attached to the foot-operated release valve.
10. Remove the upper end yoke from the steering column shaft.
11. Remove the nuts and washers that attach the steering column to the mounting bracket.

    Remove the steering column assembly from the vehicle. See **Fig. 4**.

Installation

1. Position the steering column on the steering column mounting bracket. See **Fig. 4**. Tighten the nuts 26 lbf·ft (35 N·m).
2. Connect the air line to the foot-operated release valve.
3. Clean the end of the column shaft with a clean dry cloth.
4. Slide the upper end yoke onto the column shaft, then install a new end yoke pinch bolt. Before installing the pinch bolt nut, make sure the pinch bolt is centered in the steering column shaft notch. The pinch bolt is centered if it can slip in and out

Tilt Column Removal and Installation



A. Top view of Air Bag/SPACE System
1. Gas Cylinder (SPACE system only)
2. DSS (Driver-Side SPACE) Connector
3. Driver-Side SPACE Module
4. B Pillar Cover
5. Power Distribution Module
6. Clockspring
7. SRS (Supplemental Restraint System) Connector
8. Air Bag Wiring Harness

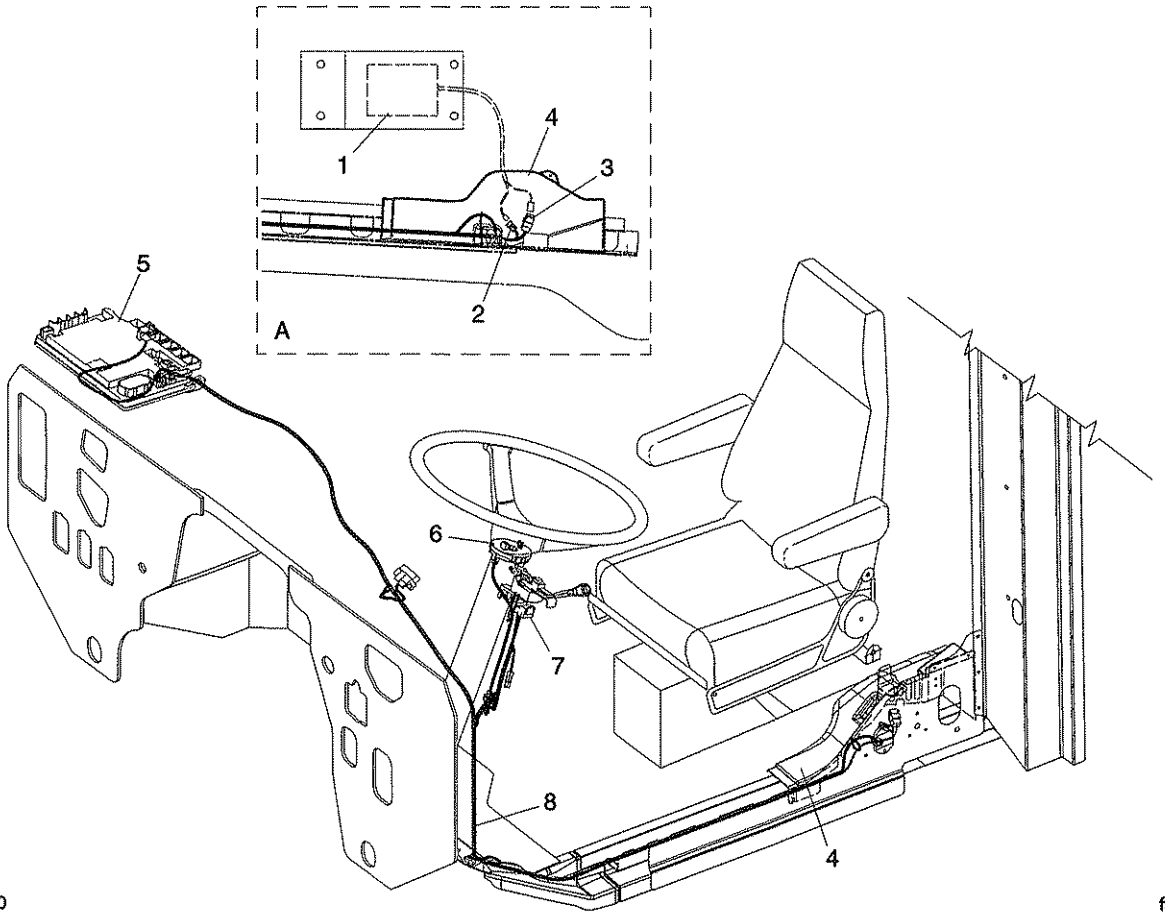
Fig. 1, Air Bag Harness Routing on Air Bag/SPACE Systems Installed Prior to May 12, 2000

of the end yoke with ease. Install a new pinch bolt nut and tighten:

- 3/18–16 37 lbf·ft (50 N·m)
- 3/18–24 44 lbf·ft (60 N·m)
- 7/16–20 55 lbf·ft (75 N·m)

5. Apply white Torque Seal OGP F900WHITE to the exposed pinch bolt threads and to the locknut.
6. Place the turn-signal switch assembly on the steering column. If the turn signal assembly is on the left side of the steering column, align the switch so that it is pointed directly to the left. If the turn signal assembly is on the right side of the steering column, align the turn-signal switch so that it is pointed directly to the right. Install and firmly tighten the mounting screws. Connect the turn signal harness connector.

NOTE: Make sure there is slack in the turn signal harness. This will allow the turn signal switch assembly to move with the tilt column assembly.



A. Top view of Air Bag Sensor Module

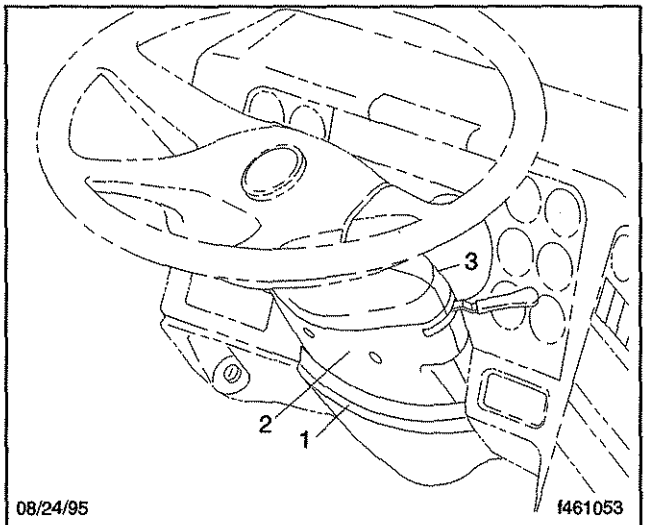
1. Air Bag Sensor Module
2. AS2 Connector
3. AS1 Connector
4. B Pillar Cover
5. Power Distribution Module
6. Clockspring
7. SRS1 (Supplemental Restraint System) Connector
8. Air Bag Wiring Harness

Fig. 2, Air Bag Harness Routing on Air Bag Only Systems Installed From May 12, 2000

7. Position the trailer brake control valve mounting bracket on the steering column. Insert the horn ground wire through the bracket. Install and firmly tighten the mounting screws.
8. Install the lower steering column cover seal.

   Position the steering column cover panels on the front and back of the column. Both panels have fittings that should snap into the column. Install two fasteners and attach the two panels together. See **Fig. 3.**
9. If the steering wheel is equipped with an air bag, reactivate the air bag by connecting the DSS connector on air bag/SPACE systems built prior to May 12, 2000, or by connecting the AS2 connector on air bag only systems built from May 12, 2000.
10. If the steering wheel is equipped with an air bag, connect the batteries.
11. Check the position of the steering wheel when the front tires are straight ahead. The steering wheel should be within ±10 degrees of center as shown in **Fig. 5.**

Tilt Column Removal and Installation

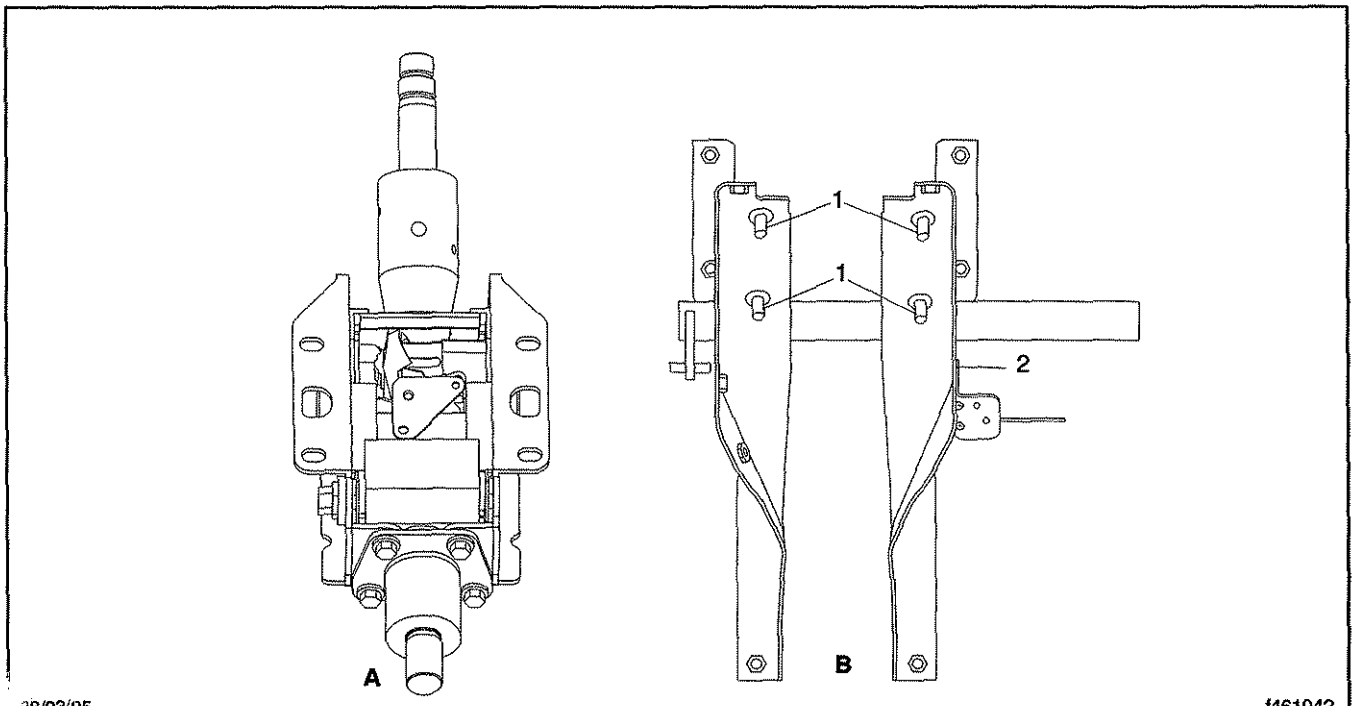


1. Lower Steering Column Cover Seal
2. Lower Steering Column Cover
3. Upper Steering Column Cover

Fig. 3, Tilt Steering Column, Left-Hand Drive Shown

If necessary, remove the steering wheel and reposition it. Refer to **Subject 100** for instructions.

12. Remove the chocks from the tires.
13. Test drive the vehicle and make sure that the steering column assembly operates smoothly. If it is not, repeat the service operations.



A. Tilt column viewed from the rear
1. Tilt Column Mounting Studs
B. Mounting bracket viewed from the front
2. Steering Column Mounting Bracket

Fig. 4, Tilt Steering Column Mounting

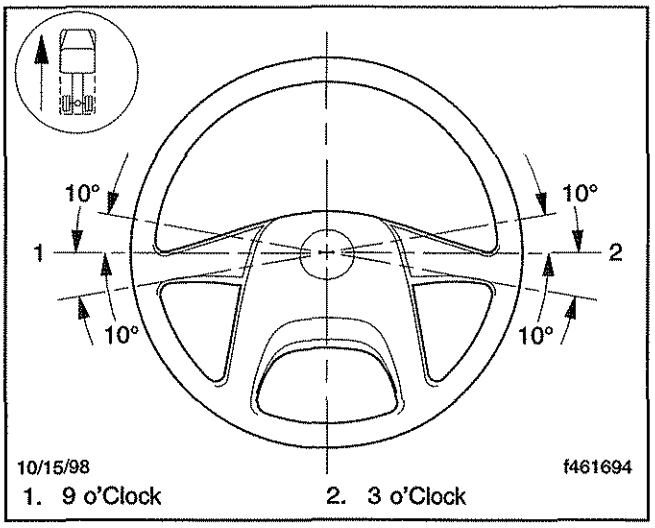


Fig. 5, Steering Wheel Centered

Specifications

Torque Values		
Description	**Size**	**Torque lbf·ft (N·m)**
Steering Wheel Retaining Nut	—	55–65 (75–88)
Steering Column Mounting Bracket Nuts	—	26 (35)
Steering Driveline Upper End Yoke Pinch Bolt	3/18–16	37 (50)
	3/18–24	44 (60)
	7/16–20	55 (75)

Table 1, Torque Values

Steering Wheel and Column Assembly 46.07

Contents

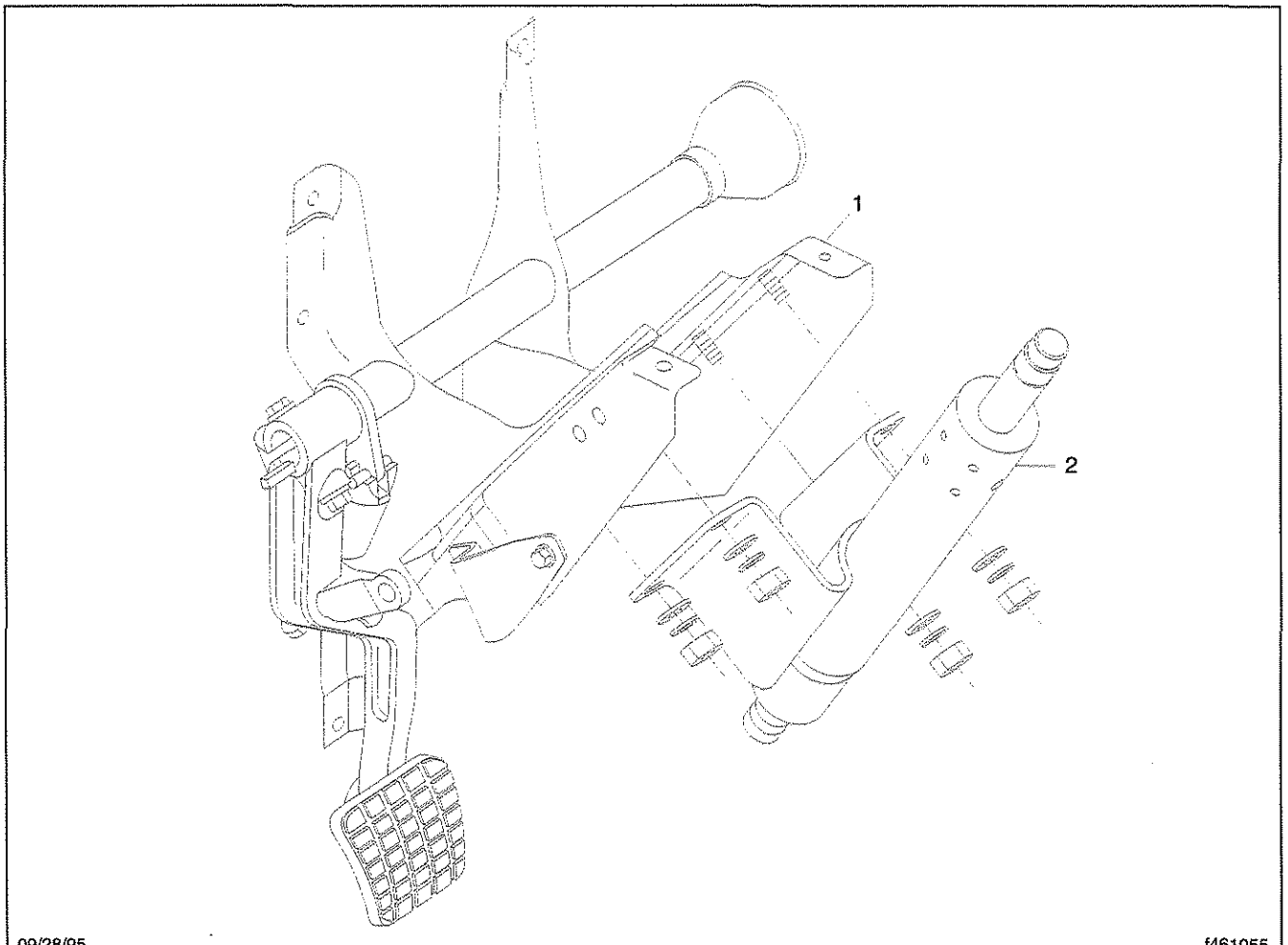
Subject	Subject Number
General Information	050
Service Operations	
Steering Wheel Removal and Installation	100
Steering Column Assembly Removal and Installation	110
Specifications	400

General Information (See Fig. 1)

The steering wheel is cushion-rimmed, with a button for the electric horn mounted in the center of the wheel hub.

A turn signal switch attaches to the steering column just below the steering wheel. If the vehicle is equipped with a trailer brake control valve, it is attached to the right side of the steering column on left-hand-drive (LH DR) vehicles, and on the left side of the steering column on right-hand-drive (RH DR) vehicles.

Major parts of the steering column assembly are a jacket (tube), bearing assemblies (staked in place in the top and bottom of the jacket), a steering column shaft, and wiring and contact assemblies for the electric horn. At the upper end of the steering column shaft are threads to accept a wheel nut, and straight external serrations to match the internal serrations of the steering wheel hub. The lower end has straight external serrations to match the internal serrations of the steering driveline upper end-yoke. The steering column assembly is attached to the dash steering column bracket with four fasteners that are hidden by the steering column cover. A lower steering column cover extends from the under-dash cover to the floor. The steering column assembly is not repairable; if



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1. Steering Column Bracket Assembly
2. Fixed Steering Column

Fig. 1, Steering Column Assembly Installation

General Information

any steering column parts are damaged or badly worn, the steering column assembly must be replaced.

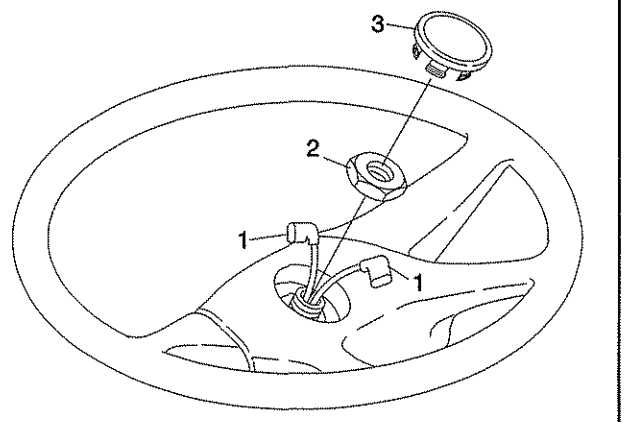
Removal of Steering Wheel

NOTE: Remove the steering wheel only if the steering wheel or steering column is being replaced. If the wheel or column is being removed to allow servicing of the dash, remove the steering wheel and column as an assembly. For instructions, refer to **Subject 110**.

1. Position the front tires straight ahead. If possible, drive the vehicle in a straight line for a short distance stopping at the spot where service operations will be performed. Do not turn the steering wheel at any time during this procedure.

   Apply the parking brakes and chock the tires.

2. Using a small screwdriver, pry under the outermost ring of the steering wheel horn button cover. Lift the horn button cover from the steering wheel hub, then disconnect the wire terminals at the horn button. See **Fig. 1**.



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1. Horn Cable Assembly
2. Wheel Nut
3. Horn Button Cover

Fig. 1, Steering Wheel Removal

IMPORTANT: The steering wheel has an alignment mark within the hub. After removing the wheel nut, mark the column shaft at the wheel alignment mark to ensure proper installation of the wheel.

3. Without turning the steering wheel, remove the wheel nut (**Fig. 1**). Using a steering wheel puller, remove the steering wheel from the shaft.

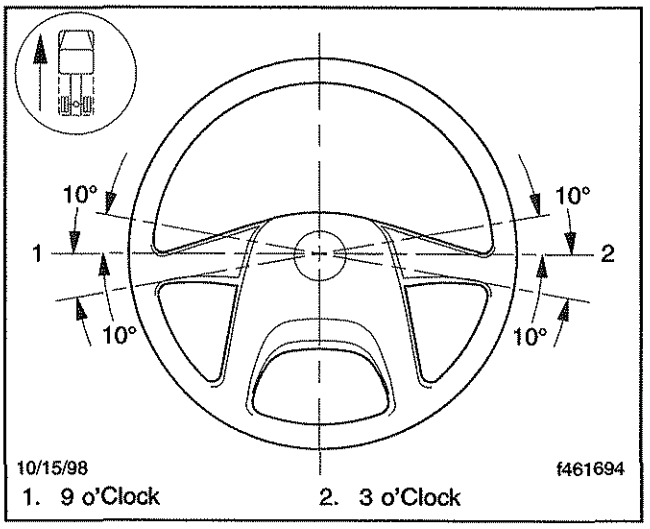
IMPORTANT: Be careful when you are removing the steering wheel, or you could damage the horn wires. A steel block measuring 1-5/8 x 5/8 x 1/4 inch (41 x 16 x 6.4 mm) can be used with the puller to protect the wires during steering wheel removal.

Installation of Steering Wheel

NOTE: Before installing the steering wheel, make sure the front tires are pointed straight ahead and the steering gear is centered.

1. With the marks on the column and steering wheel aligned, place the steering wheel on the steering column. Make sure that the steering wheel is within ±10 degrees of center as shown in **Fig. 2**.

   Insert the horn ground wires (from the center of the steering column shaft) through the center of the wheel nut. Install the wheel nut and tighten 55 to 65 lbf·ft (75 to 88 N·m).



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1. 9 o'Clock 2. 3 o'Clock

Fig. 2, Steering Wheel Centered

2. Connect the ground wire terminals to the horn button. With the steering wheel in the straight-ahead position, push the horn button cover into place on the steering wheel hub.

Steering Wheel Removal and Installation

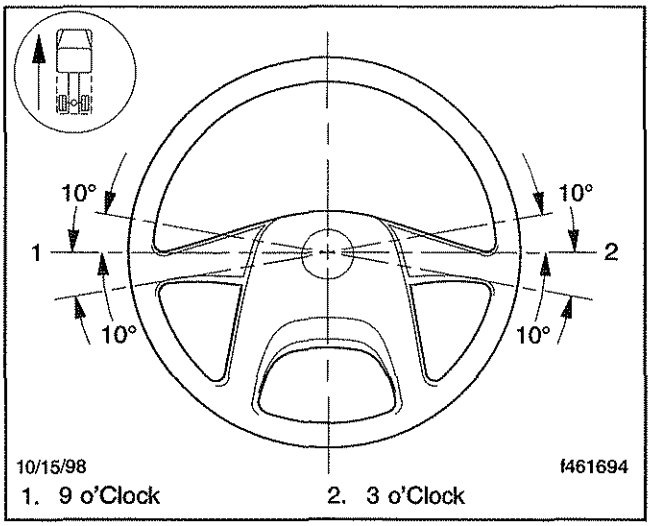


Fig. 5, Steering Wheel Centered

1. Pull the air bag cable assembly from the steering column through the cutout above the center hole on the steering wheel. See **Fig. 6**.
2. Align the tab on the clockspring with the cutout below the center hole on the steering wheel, and place the steering wheel on the steering column. See **Fig. 6**. Make sure that the steering wheel is within ±10 degrees of center as shown in **Fig. 5**. Install the wheel nut and tighten 55 to 65 lbf·ft (75 to 88 N·m).
3. Connect the air bag cable assembly to the air bag module and carefully set the air bag module on the steering wheel.
4. Attach the air bag module to the steering wheel using T30 Torx-head fasteners.
5. Attach the steering column cover to the steering column using T25 Torx-head fasteners.
6. Attach the fastener cover plugs to the steering column cover.
7. Attach the lower steering column cover to the dash.
8. Connect the batteries.

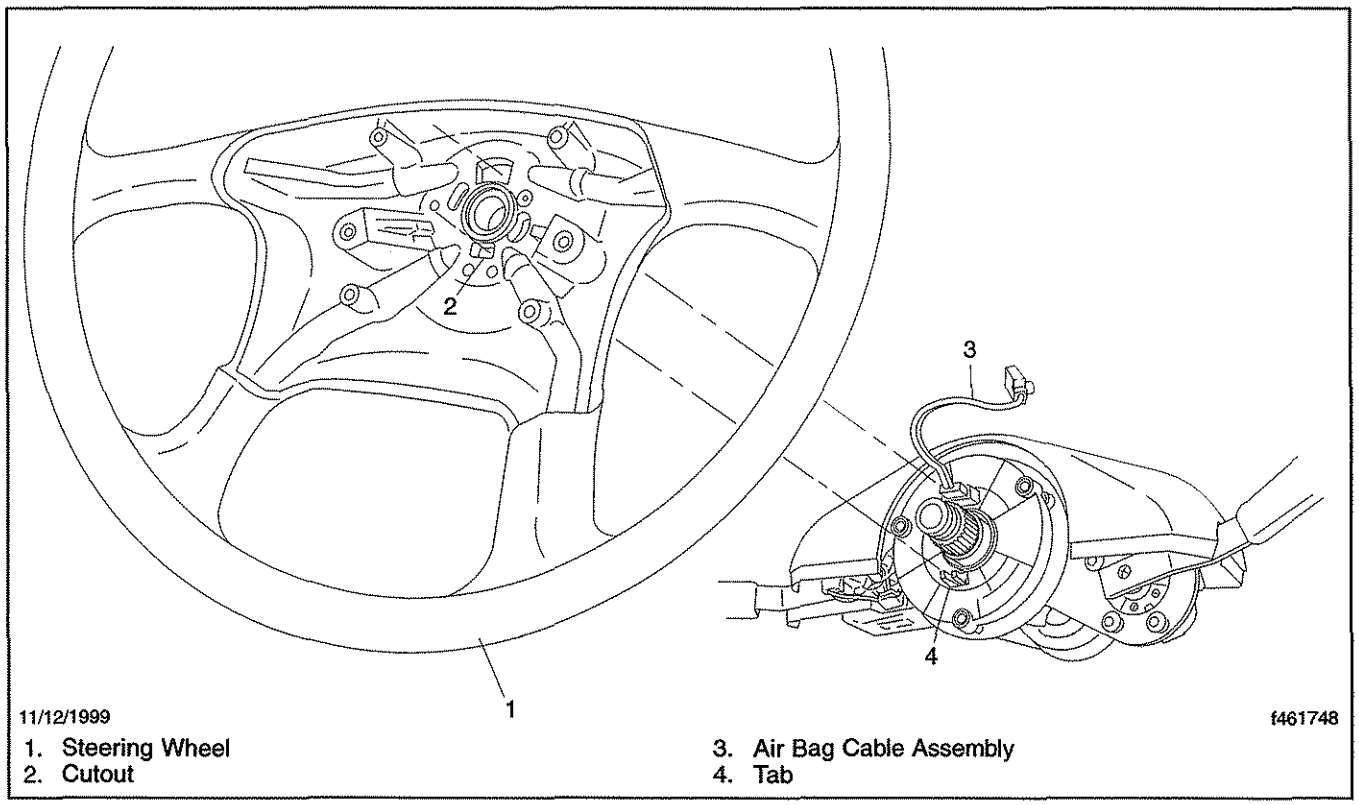


Fig. 6, Installation of Steering Wheel Equipped With an Air Bag

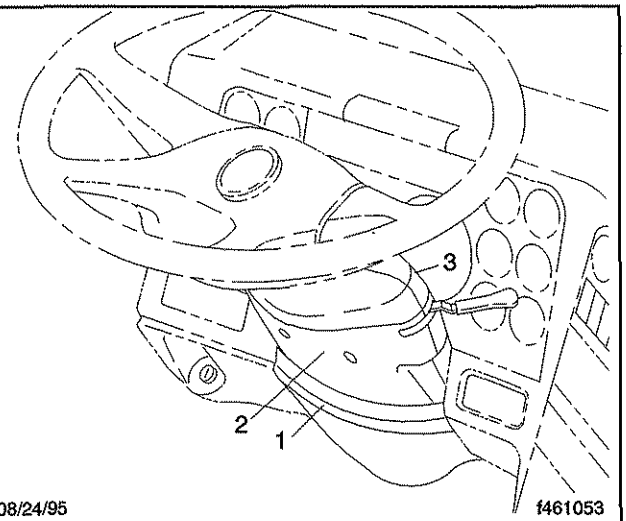
Steering Column Assembly Removal and Installation

Removal (See Fig. 1)

1. Park the vehicle on a level surface. Make sure the front tires are pointing forward. Apply the parking brakes. Shut down the engine. Chock the tires.

IMPORTANT: Once the vehicle is parked, do not turn the steering wheel at any time during the following procedures.

2. Disconnect the batteries.
3. Remove the lower steering column cover seal.
4. Remove the steering column cover panels from the front and back of the column.
5. Remove the pinch-bolt nut and pinch bolt from the upper end yoke. Discard the nut and the bolt.
6. Remove the two screws that attach the trailer brake control valve mounting bracket to the steering column. Remove the control valve (and the horn ground wire) from the steering column.
7. Remove the two screws that attach the turn signal switch mounting bracket. Remove the turn signal switch mounting assembly from the steering column. Disconnect the wiring connector from the turn signal switch.



1. Lower Steering Column Cover Seal
2. Lower Steering Column Cover
3. Upper Steering Column Cover

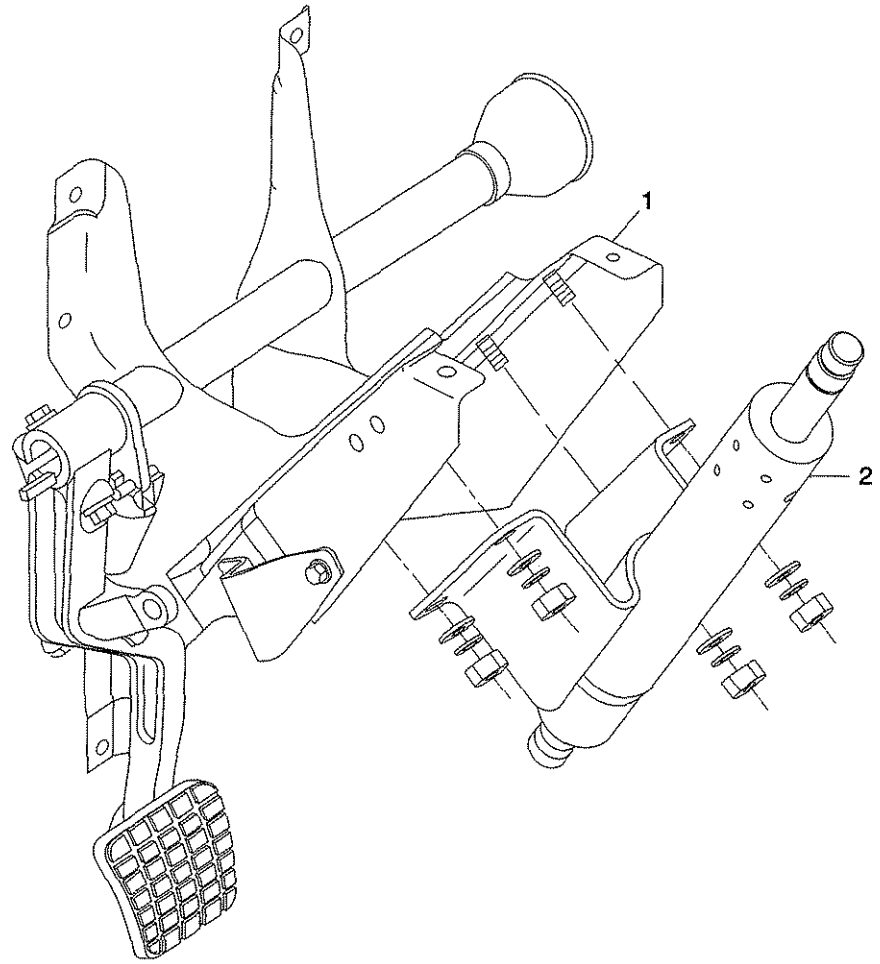
Fig. 1, Steering Column Covers, Left-Hand Drive Shown

8. Remove the upper end yoke from the steering column shaft.
9. Remove the nuts and washers that attach the steering column to the mounting bracket.
10. Remove the steering column assembly from the vehicle. See **Fig. 2.**

Installation

1. Position the steering column on the steering column mounting bracket. See **Fig. 2.** Tighten the nuts 26 lbf·ft (35 N·m).
2. Wipe the end of the column shaft with a clean, dry cloth.
3. Slide the upper end yoke onto the column shaft. Install a new end yoke pinch bolt. Before installing the pinch-bolt nut, make sure the pinch bolt is centered in the steering column shaft notch. The pinch bolt is centered if it can slip in and out of the end yoke with ease. Install and tighten a new pinch-bolt nut. For the proper torque, see **Specifications, 400.**
4. Apply torque seal OGP F900WHITE to the exposed pinch-bolt threads and to the locknut.
5. Place the turn signal switch mounting assembly on the steering column. On left-hand-drive (LH DR) vehicles, align the switch so that it is pointed directly to the left toward the driver's door. On right-hand-drive (RH DR) vehicles, align the switch so that it is pointed directly to the right toward the driver's door. Install and firmly tighten the mounting screws. Connect the turn signal harness connector.
6. Insert the horn ground wire through the bracket. Position the trailer brake control valve mounting bracket on the steering column. Install and firmly tighten the mounting screws.
7. Install the lower steering column cover seal.
8. Position the steering column cover panels on the front and back of the column. Both panels have fittings that should snap into the column. Install two fasteners and attach the two panels together. See **Fig. 1.**
9. Check the position of the steering wheel when the front tires are pointing forward. The steering wheel

Steering Column Assembly Removal and Installation



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1. Steering Column Bracket Assembly
2. Fixed Steering Column

Fig. 2, Steering Column Assembly Installation

should be within ±10 degrees of center as shown in **Fig. 3.**

If necessary, remove the steering wheel and reposition it. See **Subject 100** for instructions.

10. Connect the batteries.
11. Remove the chocks from the tires.
12. Test drive the vehicle and make sure the steering column assembly operates smoothly. If it does not operate smoothly, repeat the service operations.

Steering Column Assembly Removal and Installation

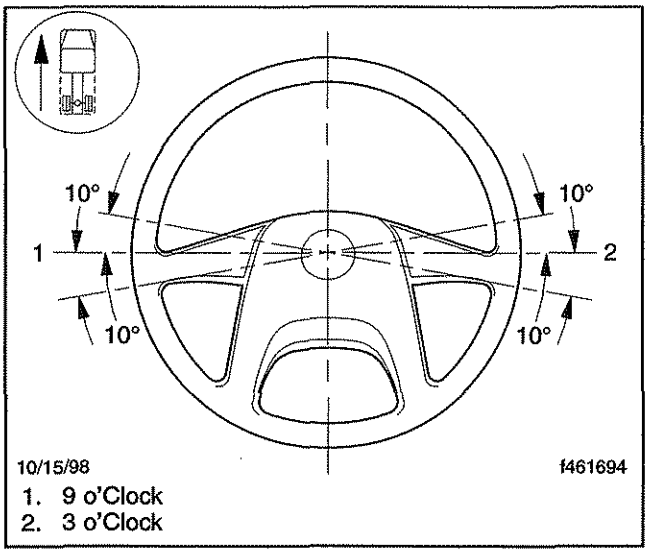


Fig. 3, Steering Wheel Centered

Specifications

Torque Values		
Description	**Size**	**Torque lbf·ft (N·m)**
Steering Wheel Retaining Nut	—	55–65 (75–88)
Steering Column Mounting Bracket Nuts	—	26 (35)
Steering Driveline Upper End Yoke Pinch Bolt	3/18–16	37 (50)
	3/18–24	44 (60)
	7/16–20	55 (75)

Table 1, Torque Values

Power Steering Pump, Vickers V20F 46.08

Contents

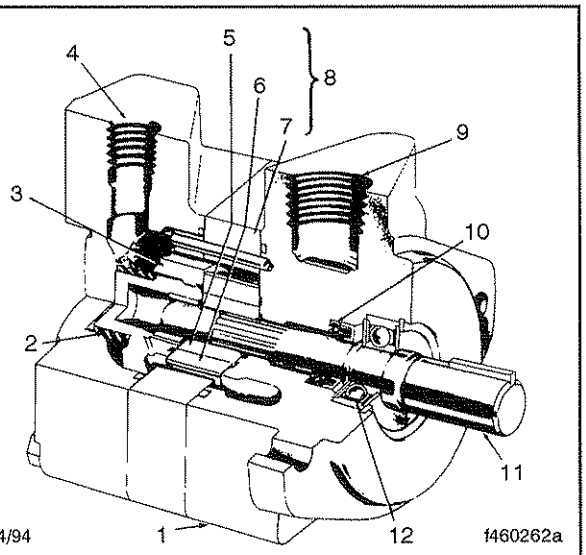
Subject	Subject Number
General Information	050
Service Operations	
Steering Pump Removal and Installation	100
Steering Pump Disassembly, Inspection, and Assembly	110
Troubleshooting	300
Specifications	400

General Information

The Vickers V20F power steering pump, used with Caterpillar C10/C12 engines, supplies the hydraulic fluid needed to operate the power steering system. See **Fig. 1.**

Primary parts of the pump include a ported body, a cover, and a pumping cartridge. Fluid from the power steering reservoir enters the pumping cartridge through the inlet port in the body. A rotor inside the pumping cartridge is driven by the pump's driveshaft and the engine's accessory drive. When the rotor turns, vanes move along the surface of a cam ring. Hydraulic fluid is circulated under pressure and forced between the vanes creating sealed chambers that carry and discharge the fluid through a pressure plate to the outlet port in the pump cover.

The cover's integral flow control and relief valve limits the fluid flow and the system pressure to preset values. Fluid that is not used to operate the system is recirculated to the power steering reservoir.



1. Body
2. Spring
3. Pressure Plate
4. Outlet Port
5. Rotor
6. Vane
7. Cam Ring
8. Pumping Cartridge
9. Inlet Port
10. Shaft Seal
11. Driveshaft
12. Bearing

Fig. 1, Vickers V20F Series Power Steering Pump

Steering Pump Removal and Installation

Removal

1. Clean all outside dirt from around the fittings and hose connections. See **Fig. 1**.
2. Disconnect the hydraulic pressure line (between the power steering gear and the pump) from the elbow fitting on the pump. Plug the line, and cap the fitting. If the pump is being replaced, remove the elbow and plug the port in the pump.
3. At the power steering pump, disconnect the reservoir supply line from the pump. Drain the power steering fluid from the line. Plug the supply line and cap the fitting on the pump. If the pump is being replaced, remove the elbow and plug the port in the pump.
4. Remove the mounting bolts that attach the pump to the engine accessory drive mounting flange. See **Fig. 2**. Slide the pump out of the sleeve, and remove the pump from the engine.

Installation

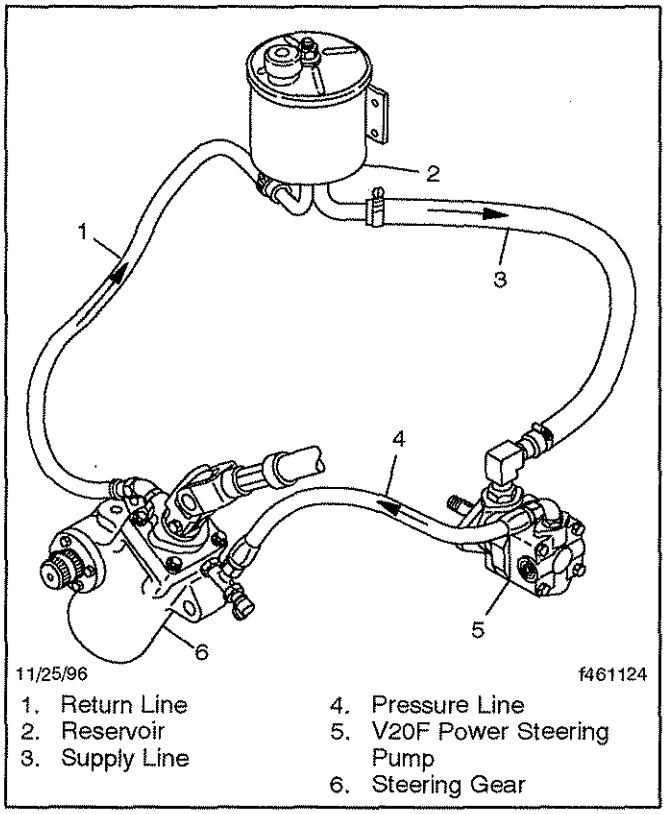
1. Using engine oil, lightly lubricate a new gasket and the pump shaft.
2. Install the new gasket on the pump mounting flange, then place the pump on the engine's accessory drive mounting. See **Fig. 2**. Turn the pump or shaft as needed to mesh the shaft with the sleeve. Seat the pilot of the pump mounting flange in the accessory drive mounting, without applying unnecessary force. Install the lockwashers and mounting bolts, and tighten them 32 lbf·ft (43 N·m).
3. Connect the hydraulic pressure and pump supply lines. See **Fig. 1**.
   - 3.1 Connect the pressure line to the elbow fitting at the pump's pressure line port. If a new pump is installed, first install the elbow fitting.
   - 3.2 Connect the supply line to the elbow fitting at the pump's supply line port. If a new pump is installed, first install the elbow fitting.
   - 3.3 Tighten the elbow fitting nuts finger-tight. Use a wrench to tighten the nuts until there is resistance; then tighten them one-sixth turn more.
4. Check the fluid level of the power steering reservoir and add fluid if necessary. Start the engine and let it idle for two minutes. Do not turn the steering wheel; doing so can cause air to enter the system.

   Turn off the engine, and check the fluid level in the reservoir.
5. Start the engine again. To remove air from the system, steer the vehicle from full-left to full-right, several times. Adjust the steering gear poppet or pressure-relief valves. For instructions, see the appropriate section in this manual.

   Add fluid, as necessary, to the full line on the reservoir dipstick.
6. If the steering gear doesn't have a manual bleed screw, turn the steering wheel from full lock to full lock two or three times with the engine running at idle. Repeat this step, and add fluid as necessary until there are no bubbles in the reservoir.

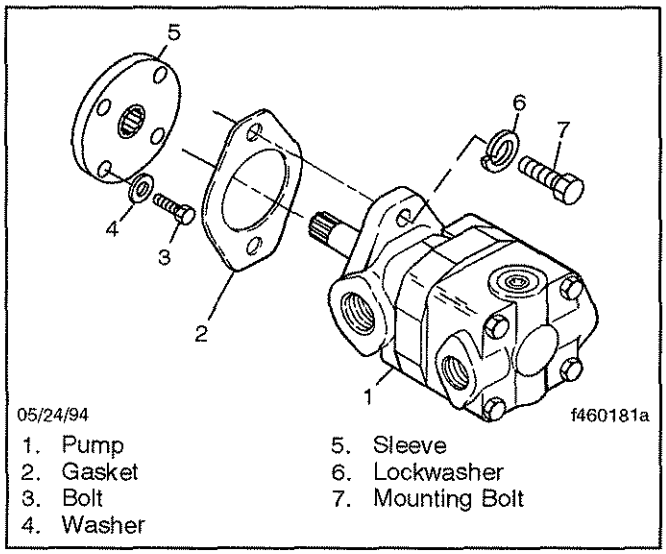
   If the steering gear is equipped with a manual bleed screw, turn the steering wheel from full lock to full lock two or three times with the engine running at idle. Then loosen the manual bleed screw about one turn and look for clear fluid or fluid mixed with bubbles at the threaded area of the bleed screw. Repeat this step and add fluid, as necessary, until only clear fluid discharges. Tighten the manual bleed screw 27 to 33 lbf·in (300 to 360 N·cm). Refill the reservoir, if necessary, to the full line on the reservoir dipstick.

Steering Pump Removal and Installation



1. Return Line
2. Reservoir
3. Supply Line
4. Pressure Line
5. V20F Power Steering Pump
6. Steering Gear

Fig. 1, Steering Pump Fittings and Hose Connections (two-line pump shown)



1. Pump
2. Gasket
3. Bolt
4. Washer
5. Sleeve
6. Lockwasher
7. Mounting Bolt

Fig. 2, Caterpillar N10 and N12 Pump Mounting

Steering Pump Disassembly, Inspection, and Assembly

Disassembly (See Fig. 1)

1. Remove the power steering pump. See **Subject 100** .
2. Clamp the pump body in a vise with the cover facing up.

⚠ CAUTION

CAUTION: Don't use excessive pressure to clamp the pump body. Applying excessive pressure could damage the pump body.

3. Remove the four capscrews from the cover, and remove the cover and O-ring.
4. Remove the relief valve plugs from the pump cover.
5. Insert a suitable tool through the snap ring end of the cover and carefully push out the relief valve and spring.

⚠ CAUTION

CAUTION: Do not disassemble the relief valve. Valve specifications are set by the manufacturer. The valve may not work properly if disassembled, and damage to the pump could occur.

6. Remove the pressure plate and spring.
7. Note the position of the cam ring, then remove the guide pins and cam ring.
8. Remove the vanes from the rotor, then remove the rotor from the shaft.
9. Turn the pump body over. If applicable, remove the shaft key and the snap ring that holds the bearing in place.
10. Using a soft hammer, tap on the splined end of the shaft to remove the shaft from the pump body.
11. Remove the snap ring from the shaft.
12. Support the bearing inner race on a press, and press the shaft out of the bearing.
13. Using a suitable hooked tool, pull the shaft seal out of the pump body.

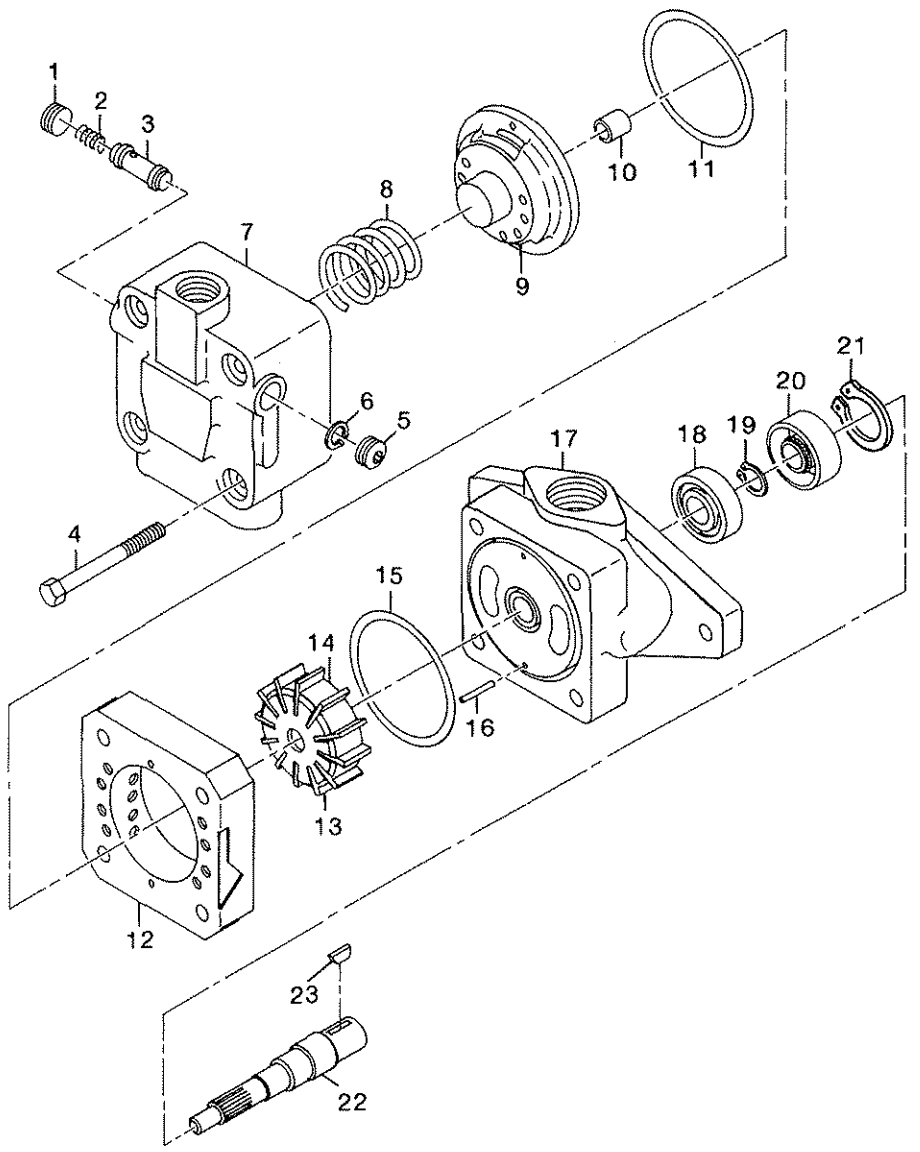
Inspection

1. Clean all parts in an approved cleaning solvent.
2. Check the body, pressure plate, cam ring, and rotor for scoring or wear. Replace parts if necessary.
3. Check the vanes for burrs. Check the rotor slots for wear. Replace parts if necessary.
4. Check the bearings for wear and looseness. Applying pressure, turn the bearings and check for pitted or cracked bearing races. Replace the bearings if necessary.
5. Check the oil seal sealing surface on the shaft for wear. If wear marks on the shaft can't be removed by light polishing, replace the shaft.
6. Check that the relief valve moves easily within the cover bore. If the cover bore is worn or pitted, replace the cover.
7. Check the relief valve for burrs. Remove burrs by polishing, but take care not to round off the corners of the valve ends.

Assembly (See Fig. 1)

1. Coat all parts with hydraulic fluid. If using a new assembly part, remove any burrs from the sharp edges of the part.
2. Insert the small end of the relief valve in the bore of the pump cover. On one side of the cover, install the spring and relief valve plug. Install the snap ring and the other relief valve plug on the opposite side.
3. Support the bearing inner race, and press the shaft through the bearing. Install the small snap ring on the shaft.
4. Lubricate the sealing lip of the shaft seal with chassis grease. Check that the shaft seal garter spring is facing toward the cover end of the pump. See **Fig. 2**. Press the seal in place.
5. Slide the driveshaft into the pump body until the bearing is seated. If necessary, use a soft hammer and lightly tap the end of the shaft.
6. Install new O-rings in the pump body and cover.

Steering Pump Disassembly, Inspection, and Assembly



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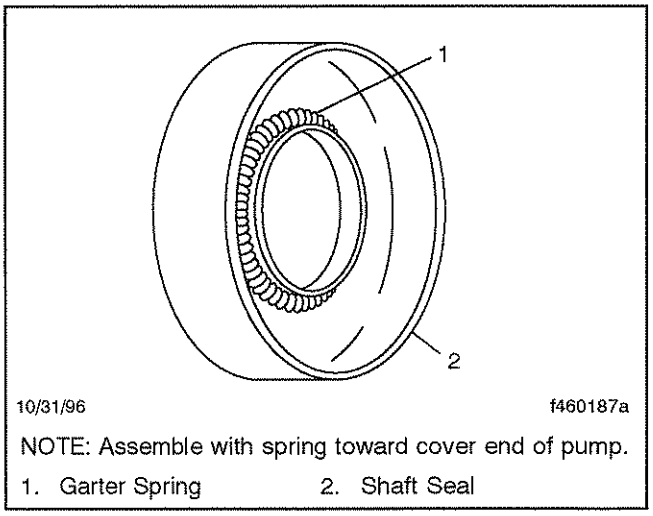
1. Relief Valve Plug
2. Spring
3. Relief Valve
4. Capscrew
5. Relief Valve Plug
6. Snap Ring
7. Cover
8. Spring
9. Pressure Plate
10. Bushing
11. O-ring
12. Cam Ring
13. Roll Vane
14. Rotor
15. O-ring
16. Guide Pin
17. Body
18. Shaft Seal
19. Snap Ring
20. Bearing
21. Snap Ring
22. Driveshaft
23. Key (if applicable)

Fig. 1, Hydraulic Power Steering Pump Assembly

7. Insert the cam ring guide pins in the pump body. Make sure that the arrow on the perimeter of the ring points in the direction of rotation, then install the cam ring. See **Fig. 3**.

Steering Pump Disassembly, Inspection, and Assembly

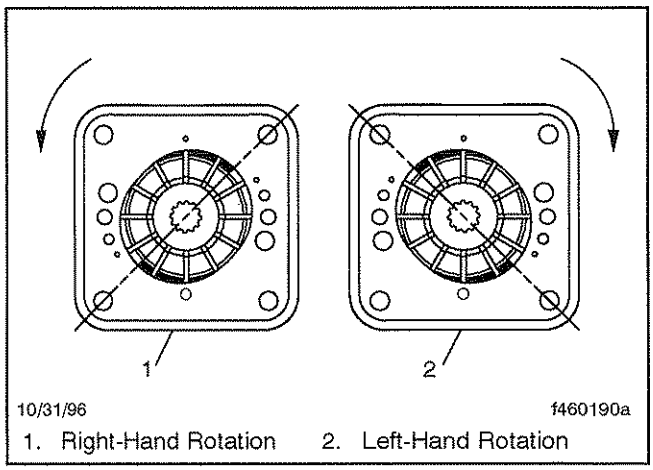


NOTE: Assemble with spring toward cover end of pump.

1. Garter Spring 2. Shaft Seal

Fig. 2, Shaft Seal

8. Install the rotor on the driveshaft. Insert the vanes in the rotor slots. Make sure that the radius edges of the vanes are positioned toward the cam ring.
9. Place the pressure plate on the guide pins.
10. Position the spring on the pressure plate, then install the pump cover. Tighten the capscrews 80 lbf·ft (108 N·m).
11. Turn the driveshaft to ensure that there is no internal binding.



1. Right-Hand Rotation 2. Left-Hand Rotation

Fig. 3, Cam Ring Positions (view from cover end)

⚠ WARNING

WARNING: Be sure to correct any binding of the steering pump. This could cause damage to the pump, an unexpected loss of power steering assist, and possible personal injury or property damage.

12. Install the shaft key (if applicable).
13. Install the pump; see **Subject 100**.

Troubleshooting Charts

For further troubleshooting information, see the applicable power steering gear section in this Manual.

Problem—Pump Not Delivering Fluid or Insufficient Pump Pressure

Problem—Pump Not Delivering Fluid or Insufficient Pump Pressure	
Possible Cause	**Remedy**
The pump cam ring is installed wrong.	Remove the pump cam ring. See **Fig. 1** for proper installation.
The shaft is damaged or disengaged.	Disassemble the pump and check the shaft. Replace parts as needed.
There is a restriction in the reservoir supply line.	Check all filters for dirt and sludge. Clean as needed.
An unapproved hydraulic oil was used.	Drain, flush and refill the system, using the proper oil. Refer to the vehicle maintenance manual for lubricant specifications.
Air leaks at the intake. The pump is not priming	Tighten loose fittings, and replace damaged hoses and fittings. Make sure that the minimum drive speed is 600 rpm.
Rotor vane(s) damaged.	Disassemble the pump and check for dirt or metal chips. Clean all parts and replace as needed. Drain, flush, and refill the system, using the proper oil. Refer to the vehicle maintenance manual for lubricant specifications.

Problem—Abnormal or Excessive Noise

Problem—Abnormal or Excessive Noise	
Possible Cause	**Remedy**
The pump intake port is blocked.	Clean the intake port filters. Check fluid condition and, if necessary, drain, flush, and refill the system, using the proper oil. Refer to the vehicle maintenance manual for lubricant specifications.
Air leaks at the intake port on the shaft seal (oil is probably foaming in the power steering reservoir).	Check the inlet connections and shaft seal. Tighten any loose hose connections and replace the seal if needed.

Troubleshooting

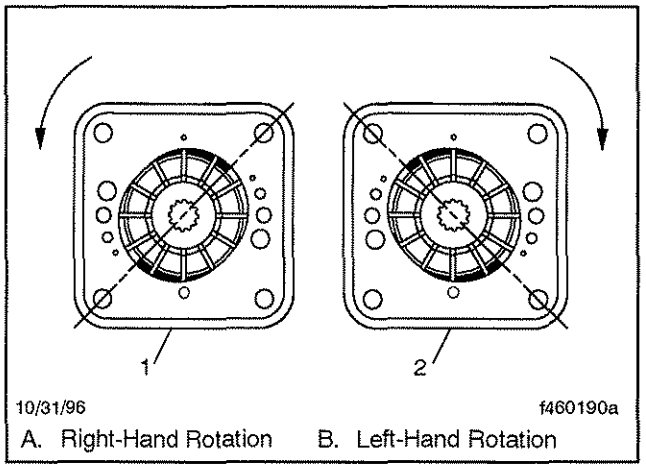
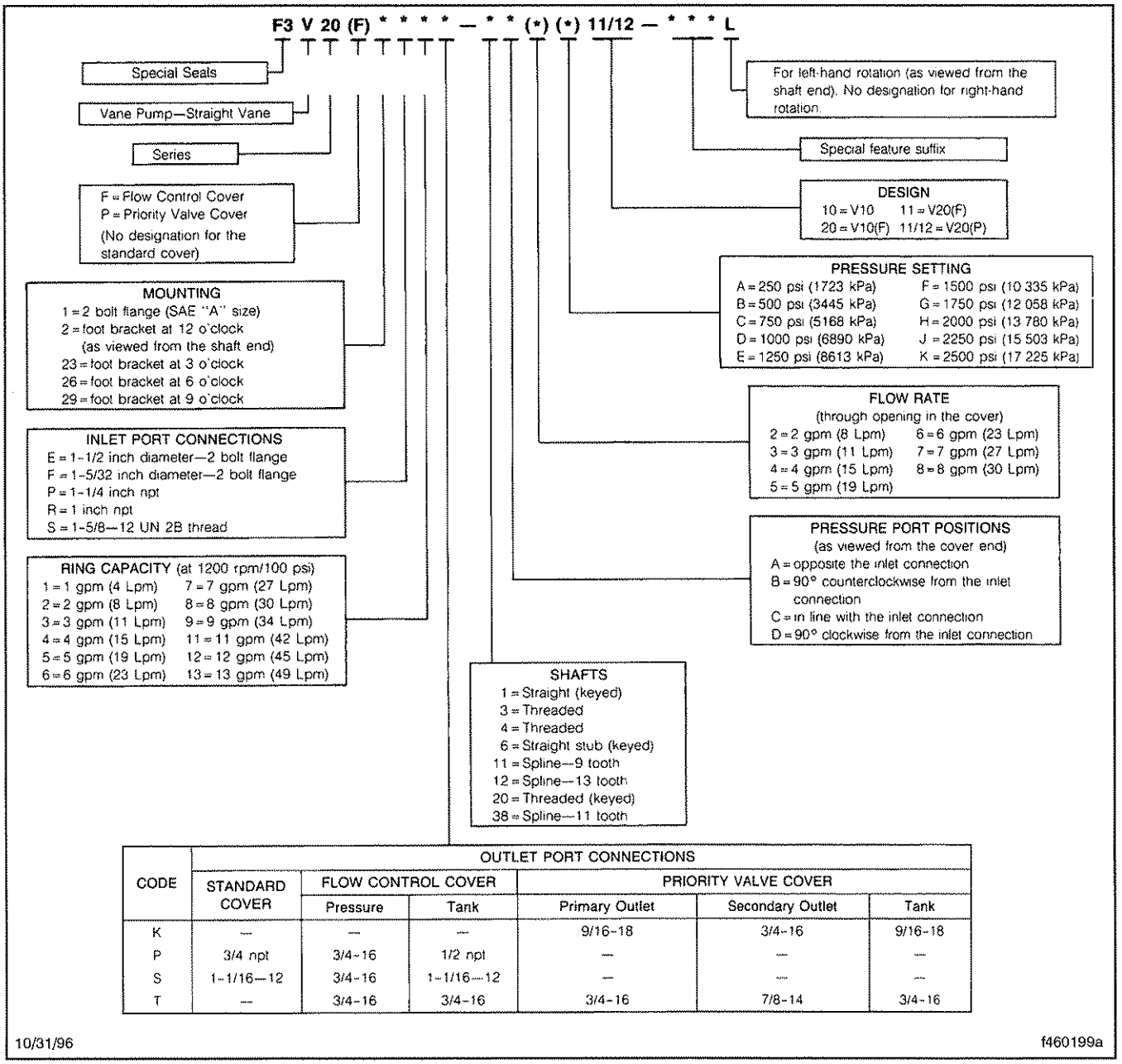


Fig. 1, Cam Ring Positions (view from end cover)

See **Fig. 1** for model number breakdown.



CODE	OUTLET PORT CONNECTIONS					
	STANDARD COVER	FLOW CONTROL COVER		PRIORITY VALVE COVER		
		Pressure	Tank	Primary Outlet	Secondary Outlet	Tank
K	—	—	—	9/16-18	3/4-16	9/16-18
P	3/4 npt	3/4-16	1/2 npt	—	—	—
S	1-1/16—12	3/4-16	1-1/16—12	—	—	—
T	—	3/4-16	3/4-16	3/4-16	7/8-14	3/4-16

Fig. 1, Model Number Breakdown

Contents

Subject	Subject Number
General Information	050
Service Operations	
Air Bag Replacement	100
Safety Guidelines	110
Clockspring Replacement	120
Air Bag Disposal Procedure	130
Air Bag Sensor Module Replacement	140

General Information

A new air bag only system became available on May 12, 2000. This system is different from the air bag only system installed prior to May 12, 2000. In this section, only the newer air bag only system installed from May 12, 2000 will be covered.

IMPORTANT: To determine which type of supplemental protection system is installed in the vehicle, look at the module under the driver's seat. The air bag/SPACE system and the air bag only system installed prior to May 12, 2000 have a SPACE module. If the vehicle has a SPACE system, gas cylinders are also located under the driver's seat. See **Fig. 1**. The air bag only system that became available on May 12, 2000 has an air bag sensor module located under the driver's seat. See **Fig. 2**.

For information on the air bag only system installed prior to May 12, 2000 or the air bag/SPACE system, see **Section 91.05** of the *Century Class Trucks Workshop Manual.*

The troubleshooting procedures and the wiring diagrams for both air bag systems can be found in **Section 91.05** of the *Century Class Trucks Workshop Manual.*

The air bag only system, when used with seat belts, provides additional protection to the driver in severe frontal collisions. The air bag is located in the steering wheel hub.

⚠ WARNING

Damaged seat belts or seat belts that were worn in an accident must be replaced and their anchoring points must be checked. Failure to do so may result in personal injury or death.

The operational readiness of the air bag only system is indicated by a supplemental restraint system (SRS) indicator on the dash. The SRS indicator comes on when starting the engine and then goes off. The indicator will remain on if there is a problem with the system. The vehicle should be serviced if the indicator does not come on or if it remains on.

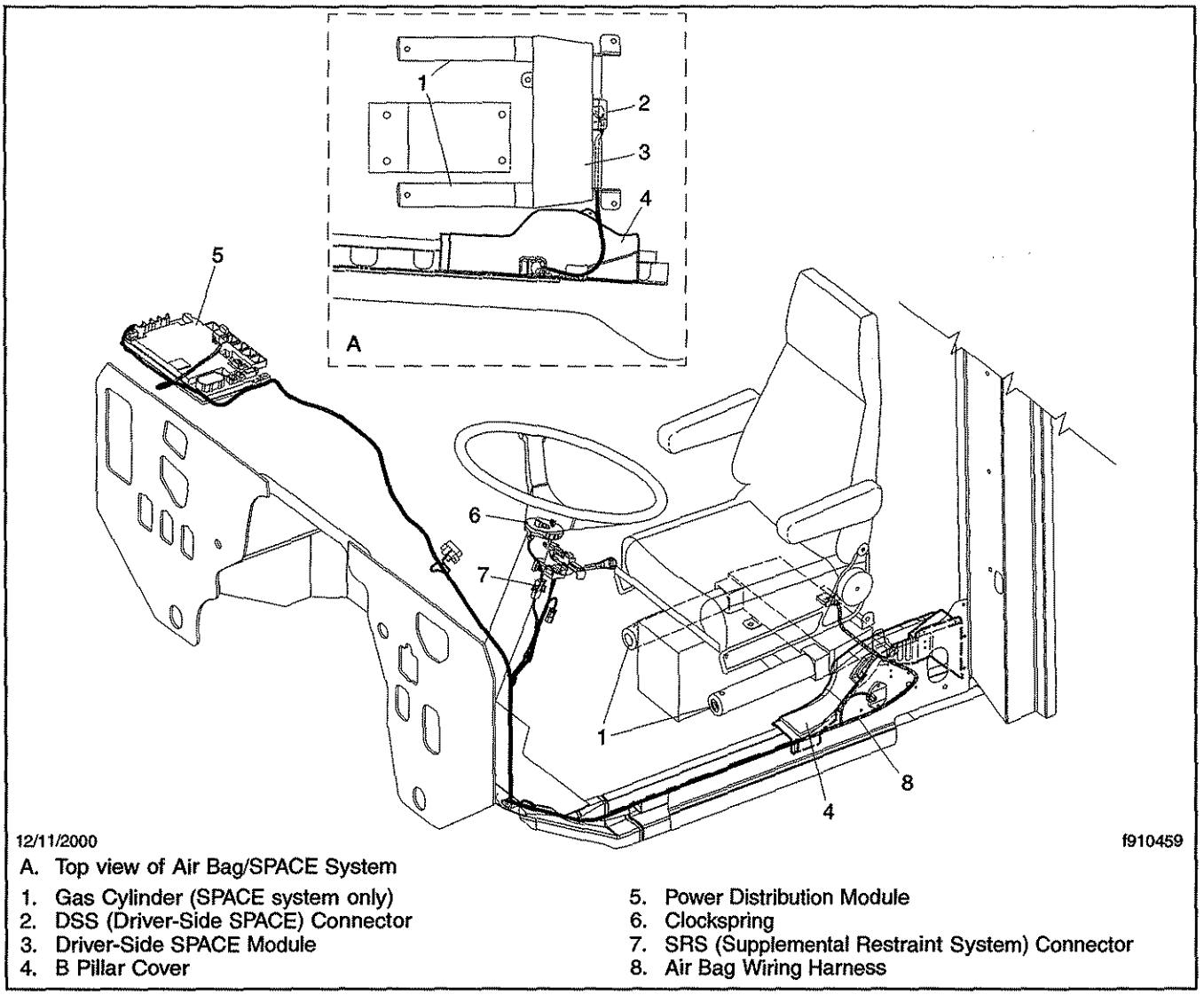
⚠ WARNING

The air bag system is designed to activate only in severe frontal collisions. Only in these situations will they provide supplemental protection. The driver and the passenger should always wear seat belts. For maximum protection in the event of a collision or rollover, the driver's back must be against the seat back in a normal seated position and the driver's head must be upright. The seat belts must be fastened and properly positioned on the body. Because the air bag inflates with considerable speed and force, it is important that the driver maintain a proper seat position to stay a safe distance from the inflating air bag.

Do not place objects on the steering wheel or between you and the steering wheel. Keep your hands on the sides and lower portion of the steering wheel. Any objects may cause harm during an accident.

Failure to follow these instructions may result in death or personal injury.

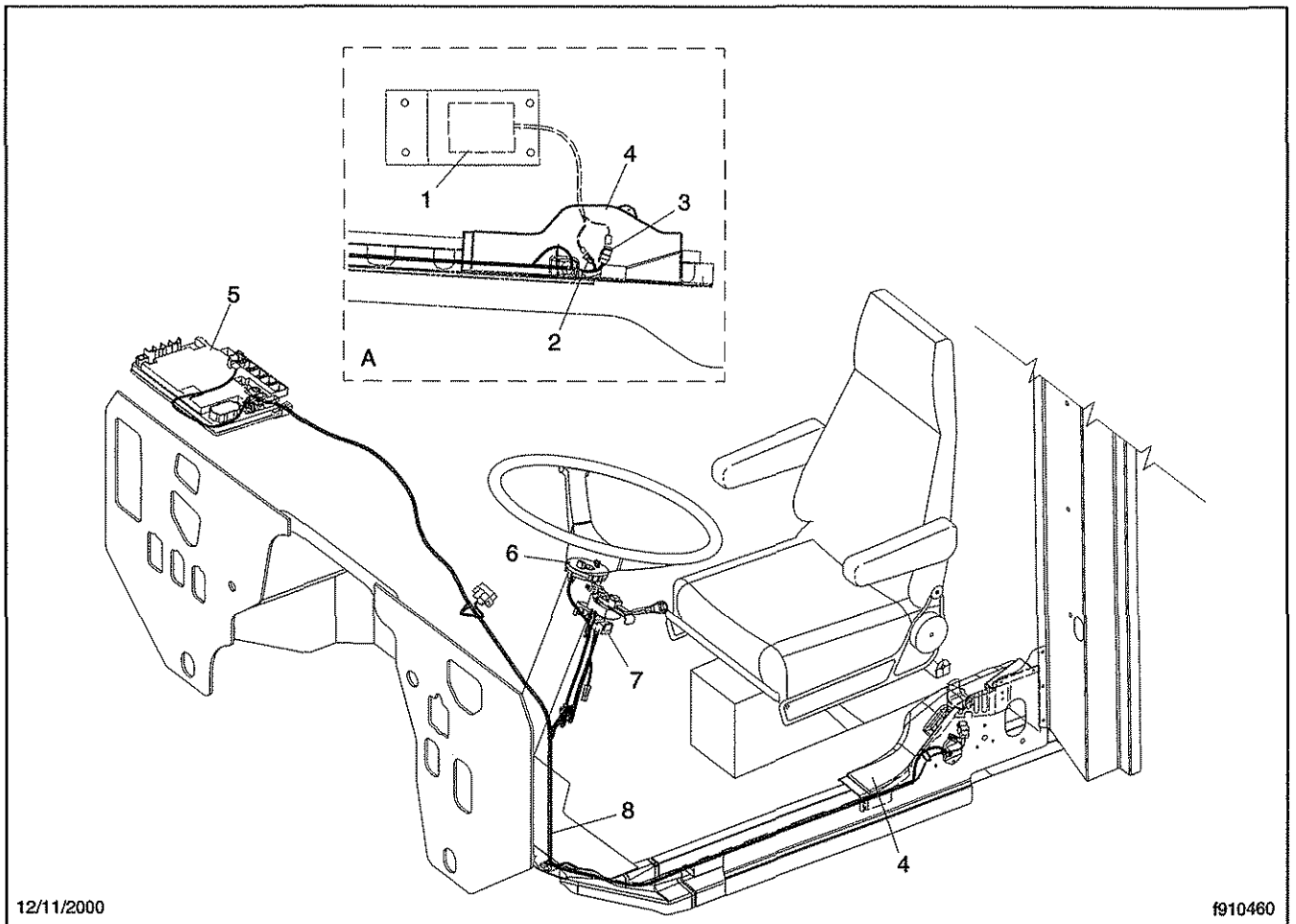
General Information



A. Top view of Air Bag/SPACE System

1. Gas Cylinder (SPACE system only)
2. DSS (Driver-Side SPACE) Connector
3. Driver-Side SPACE Module
4. B Pillar Cover
5. Power Distribution Module
6. Clockspring
7. SRS (Supplemental Restraint System) Connector
8. Air Bag Wiring Harness

Fig. 1, Air Bag Harness Routing on Air Bag/SPACE Systems Installed Prior to May 12, 2000



A. Top view of Air Bag Sensor Module

1. Air Bag Sensor Module
2. AS2 Connector
3. AS1 Connector
4. B Pillar Cover
5. Power Distribution Module
6. Clockspring
7. SRS1 (Supplemental Restraint System) Connector
8. Air Bag Wiring Harness

Fig. 2, Air Bag Harness Routing on Air Bag Only Systems Installed From May 12, 2000

Replacement

NOTE: The following air bag replacement procedure is for the air bag only system that became available on May 12, 2000. For information on the air bag only system installed prior to May 12, 2000, see **Section 91.05** of the *Century Class Trucks Workshop Manual.*

IMPORTANT: To determine which type of supplemental protection system is installed in the vehicle, look at the module under the driver's seat. The air bag/SPACE system and the air bag only system installed prior to May 12, 2000 have a SPACE module. If the vehicle has a SPACE system, gas cylinders are also located under the driver's seat. See **Fig. 1**. The air bag only system that became available on May 12, 2000 has an air bag sensor module located under the driver's seat. See **Fig. 2**.

⚠ WARNING

Do not attempt to service the air bag system on damaged vehicles unless trained to do so. Damaged air bag systems should be examined by qualified personnel before any attempt is made to remove or to deploy the air bag. All intentional deployments should be performed by trained personnel. Unintentional or improper initiation of an air bag deployment could cause severe bodily injury or death.

1. Turn off the engine, apply the parking brakes, and chock the rear tires.
2. Disconnect the batteries and wait two minutes before proceeding.

⚠ WARNING

Wait two minutes after disconnecting the batteries to allow the internal components to discharge. Failure to allow the components to discharge could cause the air bag to deploy, resulting in severe bodily injury or death.

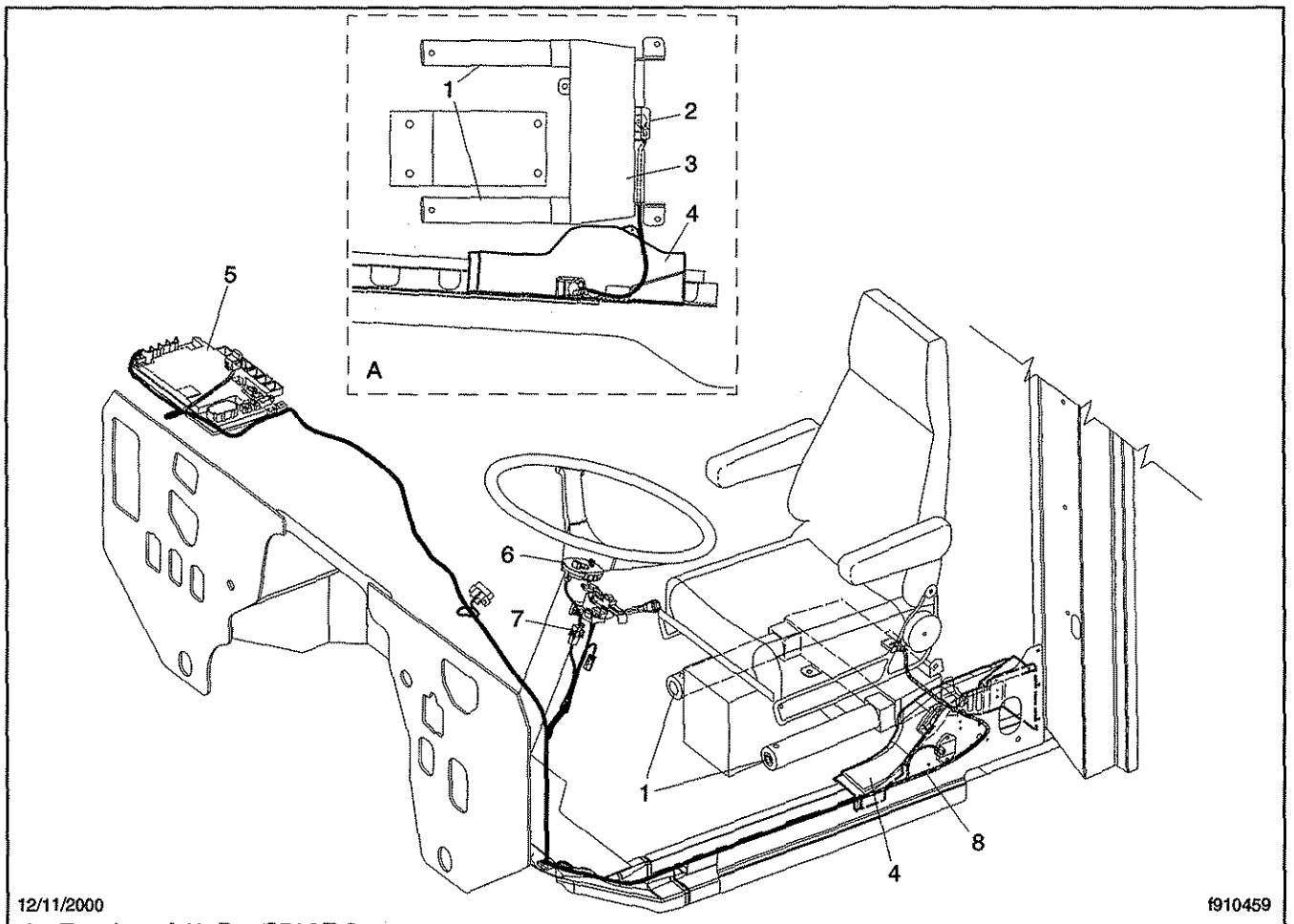
3. Disconnect the AS2 connector under the B pillar cover. See **Fig. 2**.
4. Remove the fastener cover plugs from the steering wheel lower column cover. See **Fig. 3**.
5. Using a T25 Torx®-driver, remove the fasteners and the column cover.
6. Using a T30 Torx®-driver, loosen the retainer screws underneath the steering wheel. See **Fig. 4**.

⚠ WARNING

Consider undeployed air bags to be dangerous and capable of deploying at any time. Follow the safety guidelines in Subject 110. Failure to observe safety guidelines could cause the unintentional deployment of the air bag, which could result in severe injury or death.

7. Carefully lift the air bag from the steering wheel and disconnect the air bag connector from the air bag. See **Fig. 5**, **Fig. 6**, and **Fig. 7**.
8. Remove the air bag.
9. Inspect the clockspring and clockspring connector. Replace the clockspring if there is any melting or damage. For clockspring replacement instructions, see **Subject 120**.
10. Connect the electrical wiring from the clockspring (and from the horn switch connector if equipped) to the new the air bag module, then position the air bag module on the steering wheel.
11. Tighten the air bag retaining screws at the bottom of the steering wheel.
12. Using the fasteners, attach the steering wheel lower column cover to the dash.
13. Replace the fastener plugs.
14. Connect the AS2 connector.
15. Connect the batteries.
16. While standing outside the cab and away from the front of the air bag, turn the ignition on. Check to make sure that after the ignition is turned on, the Supplemental Restraint System (SRS) indicator comes on for several seconds and then goes out. Make sure there are no active fault codes. If the SRS indicator remains on or if there are active fault codes, follow the appropriate troubleshooting procedure in **Section 91.05** of the *Century Class Trucks Workshop Manual.*
17. If the SRS indicator goes out and there are no active fault codes, the system is functioning properly.

Air Bag Replacement

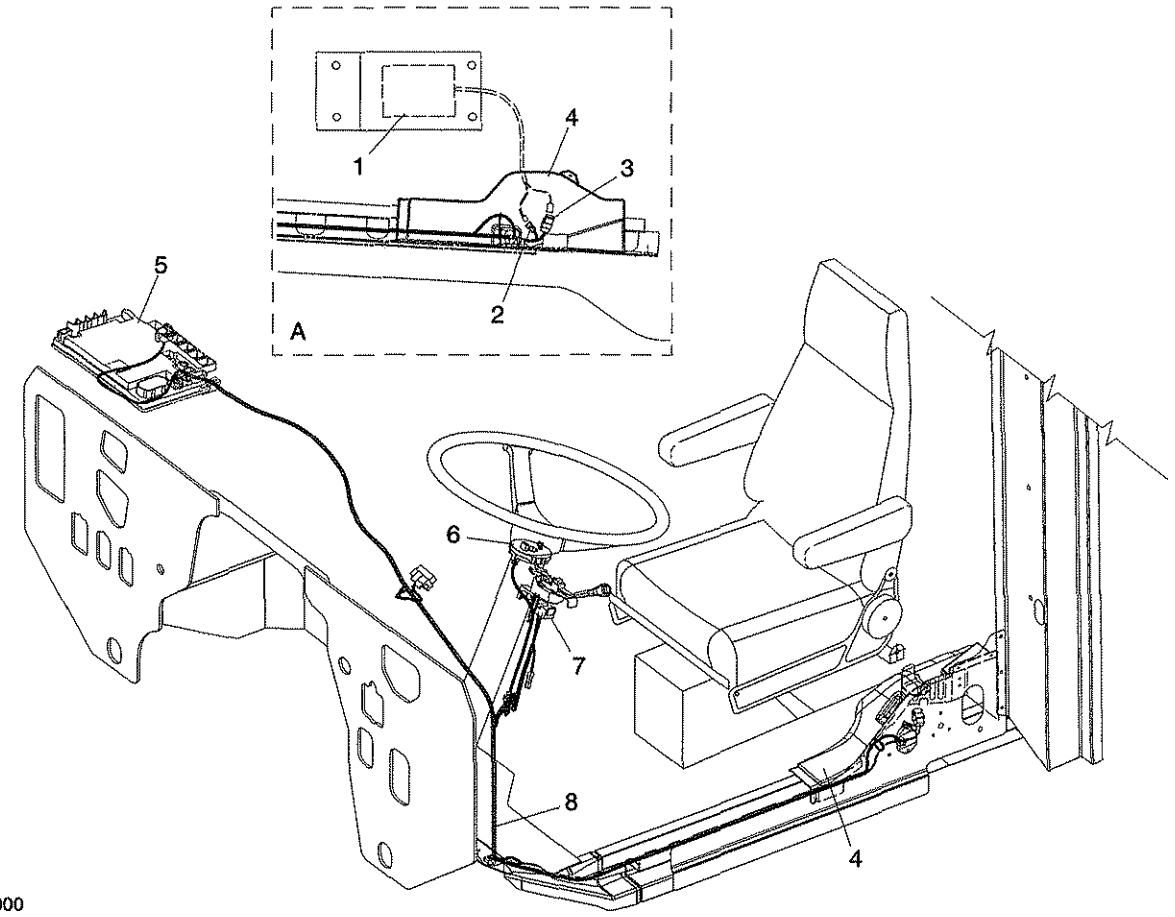


A. Top view of Air Bag/SPACE System

1. Gas Cylinder (SPACE system only)
2. DSS (Driver-Side SPACE) Connector
3. Driver-Side SPACE Module
4. B Pillar Cover
5. Power Distribution Module
6. Clockspring
7. SRS (Supplemental Restraint System) Connector
8. Air Bag Wiring Harness

Fig. 1, Air Bag Harness Routing on Air Bag/SPACE Systems Installed Prior to May 12, 2000

18. Remove the chocks from the tires.



A. Top view of Air Bag Sensor Module.

1. Air Bag Sensor Module
2. AS2 Connector
3. AS1 Connector
4. B Pillar Cover
5. Power Distribution Module
6. Clockspring
7. SRS1 (Supplemental Restraint System) Connector
8. Air Bag Wiring Harness

Fig. 2, Air Bag Harness Routing on Air Bag Only Systems Installed From May 12, 2000

Air Bag Replacement

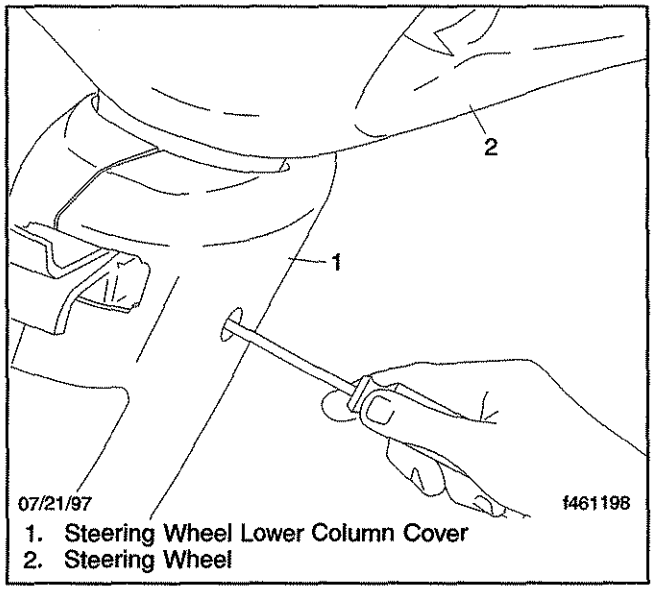


Fig. 3, Remove the Fastener Cover Plugs

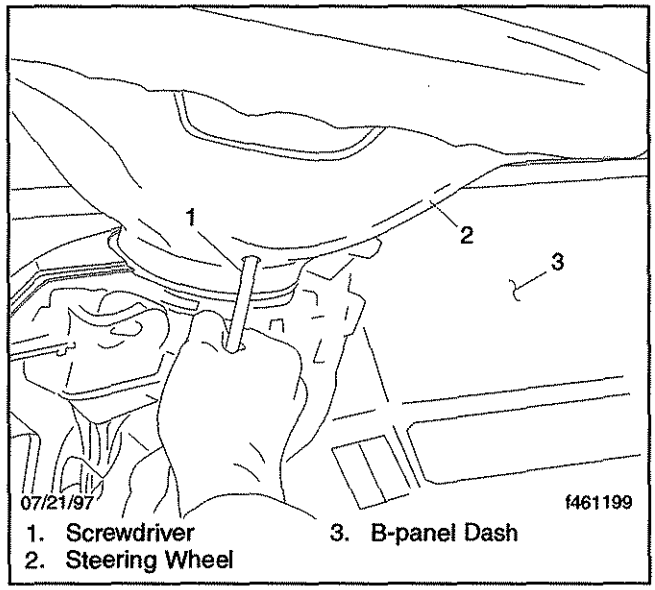


Fig. 4, Loosening the Air Bag Retainer Screws

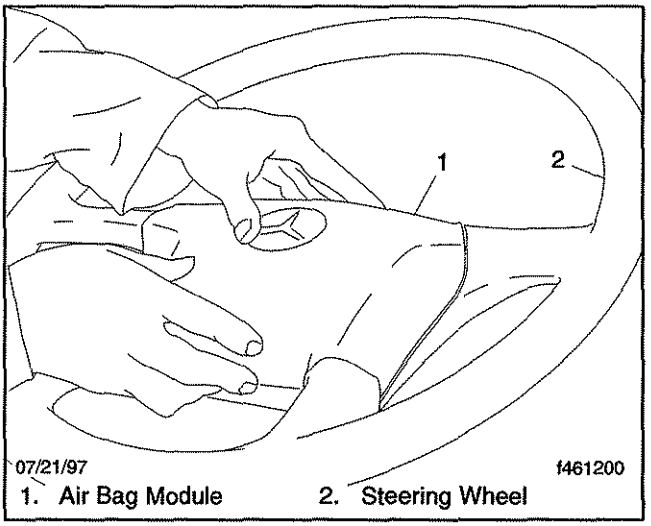


Fig. 5, Air Bag Module Installed

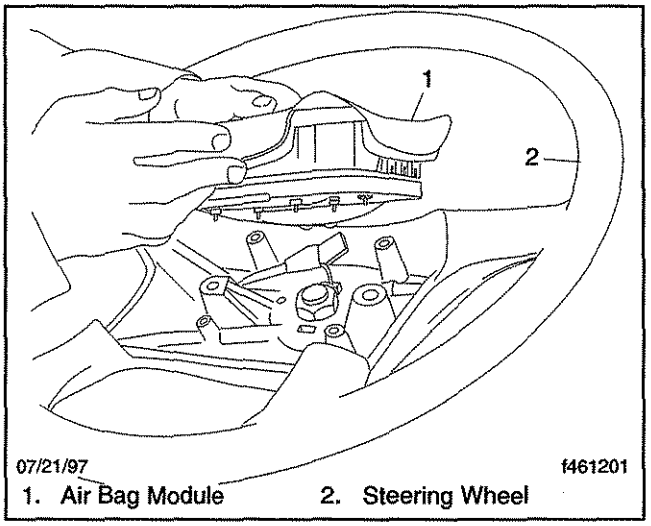
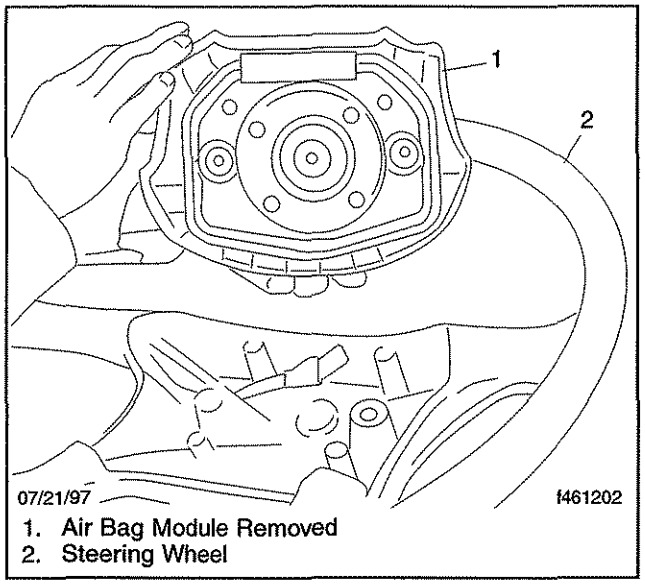


Fig. 6, Lift the Air Bag Module



1. Air Bag Module Removed
2. Steering Wheel

Fig. 7, Air Bag Removed

Safety Guidelines for the Air Bag System

⚠ WARNING

Do not attempt to service the air bag only system unless trained to do so. Damaged air bag systems should be examined by qualified personnel before any attempt is made to remove or to deploy the air bag. All intentional deployments should be performed by trained personnel. Unintentional air bag deployment could cause severe bodily injury or death.

Do not attempt to disassemble the air bag inflator unit or breach the integrity of the sealed metallic inflator case. Doing so could cause severe bodily injury or death.

Do not allow system chemicals to contact other liquids, combustibles, and flammable materials. Doing so could cause chemical burns or personal injury.

The surface of the deployed air bag may contain small amounts of sodium hydroxide (which is a by-product of the gas generant combustion) and metallic sodium. Sodium hydroxide may be irritating to the skin and eyes. Always wear rubber gloves and safety glasses when handling a deployed air bag. Immediately wash your hands and exposed skin areas with a mild soap and water. Flush your eyes immediately if exposed to sodium hydroxide.

Consider undeployed air bags to be dangerous and capable of deploying at any time. When it is necessary to work with air bag only systems, review the following list of correct handling procedures and warnings. Failure to do so could result in severe injury or death.

- **Carry undeployed air bags with the bag and the trim cover pointed away from your body.**
- **Place undeployed air bags face up on a surface in an enclosed area.**
- **Do not place objects near or on top of an undeployed air bag.**
- **Store undeployed and undamaged air bag modules in a cool, dry, enclosed area.**
- **Keep all liquids, acids, halogens, heavy metals, and heavy salts away from the air bag system.**
- **Do not cut, drill, braze, solder, weld, strike, or probe any part of the air bag system.**
- **Do not expose the air bag module to electricity. Never probe a circuit on the air bag side of a connector unless the harness or air bag is disconnected between the test point and the air bag.**
- **Do not attempt to adapt, reuse, or install an air bag system in any vehicle other than the specific vehicle for which it is designed.**
- **Do not cut wires or tamper with the connector between the vehicle wiring harness and the air bag module unless the troubleshooting diagnostics specifically directs you to do so. Cutting or removing the connector from the system will disable the safety shunt and could cause unintentional deployment.**
- **Allow deployed air bag systems to cool after deployment.**
- **Air bag systems should be deployed in an open area or outdoors to prevent accidental fires.**
- **Wear rubber gloves and safety glasses when handling a deployed air bag.**
- **Wash your hands and exposed skin surface areas immediately after handling a deployed system.**
- **Store, transport, dispose, and recycle air bag system components in accordance with all applicable federal, state and local regulations.**
- **When reactivating the system for the first time after repairs have been made, stand outside of the cab and away from the front of the air bag while turning on the ignition. Check that the SRS indicator comes on for a few seconds and then goes out. Make sure there are no active fault codes.**
- **Keep all heavy objects in the cab secured.**

Clockspring Replacement

IMPORTANT: To determine which type of supplemental protection system is installed in the vehicle, look at the module under the driver's seat. The air bag/SPACE system and the air bag only system installed prior to May 12, 2000 have a SPACE module. If the vehicle has a SPACE system, gas cylinders are also located under the driver's seat. See **Fig. 1**. The air bag only system that became available on May 12, 2000 has an air bag sensor module located under the driver's seat. See **Fig. 2**.

NOTE: The following clockspring replacement procedure is for the air bag only system that became available May 12, 2000. For information on the air bag only system installed prior to May 12, 2000, see **Section 91.05** of the *Century Class Trucks Workshop Manual*.

⚠ CAUTION

Do not turn the steering wheel or the steering shaft at any time during this procedure. Doing so may damage the clockspring.

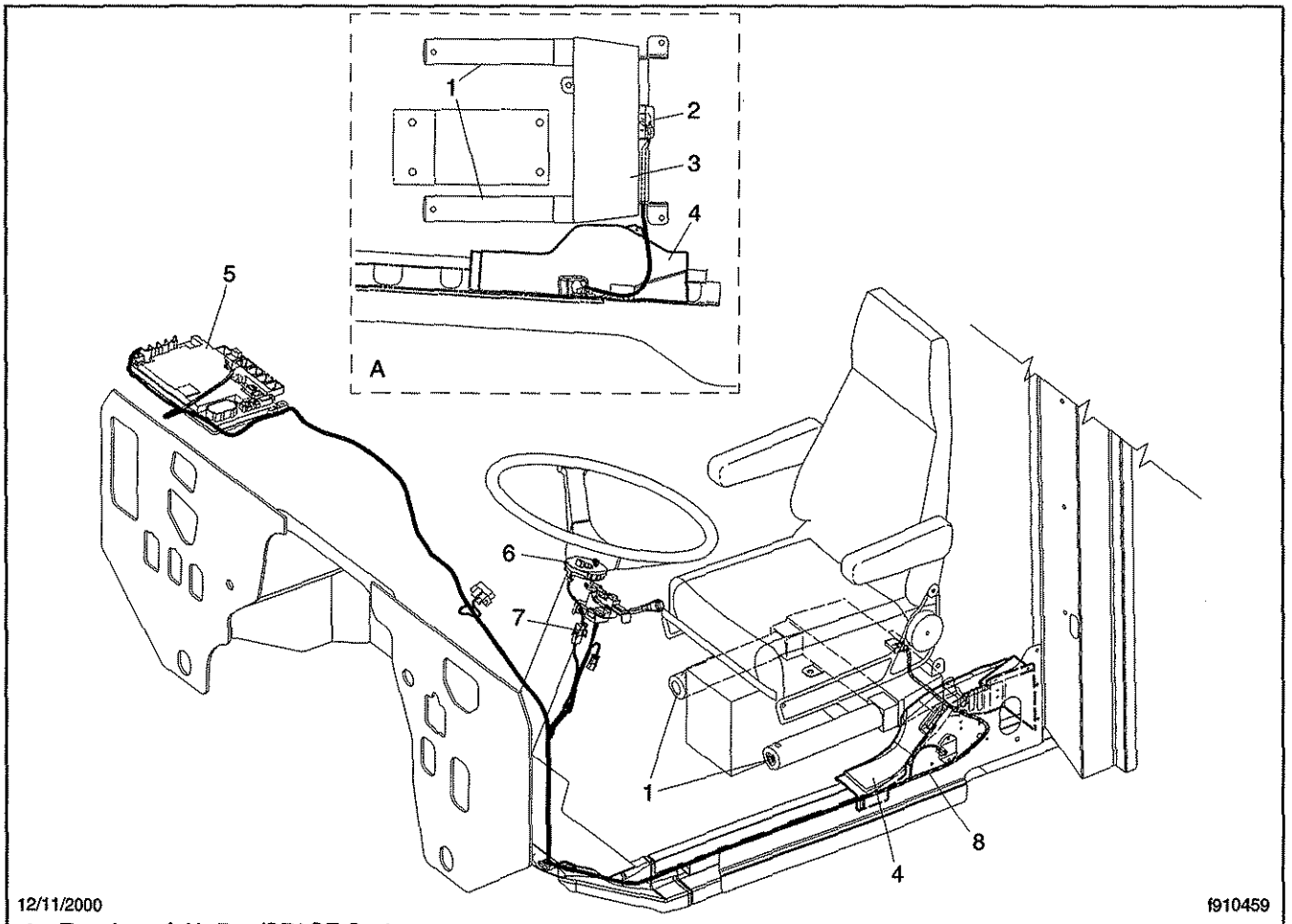
1. Park the vehicle on a level surface with the wheels straight ahead. Turn off the engine, apply the parking brakes, and chock the rear tires.
2. Disconnect the batteries and wait two minutes before proceeding.

⚠ WARNING

Wait two minutes after disconnecting the batteries to allow the internal components to discharge. Failure to allow the components to discharge could cause the air bag to deploy, resulting in severe bodily injury or death.

3. Disconnect the AS2 connector. See **Fig. 2**.
4. Remove the air bag. For instructions, see **Section 46.06**, Subject 100 of the *Century Class Trucks Workshop Manual*.
5. Remove the steering wheel. For instructions, see **Section 46.06**, Subject 100 of the *Century Class Trucks Workshop Manual*.
6. Tape the upper and lower portions of the clockspring together to prevent it from turning.
7. Disconnect the connector located under the clockspring mounting plate on top of the steering column.
8. Loosen the screws that attach the clockspring to the clockspring bracket. It is not necessary to remove the screws in order to remove the clockspring.
9. Remove the clockspring.
10. If the steering column shaft has been allowed to rotate independently of the front wheels since the clockspring replacement procedure began, recenter the clockspring.
    - 10.1 While holding the lower portion of the clockspring stationary, rotate the upper portion counterclockwise until resistance is felt. Stop rotation as soon as some resistance is felt or the clockspring may become damaged.
    - 10.2 While holding the lower portion of the clockspring stationary, rotate the upper portion clockwise four full turns.
    - 10.3 Turn the upper portion of the clockspring clockwise until the the mounting holes in the upper portion of the clockspring are aligned with the screws in the lower portion of the clockspring. Tape the upper and lower portions together until the steering wheel is installed.
11. Using screws, attach the clockspring to the clockspring bracket.
12. Reconnect the connector from the clockspring to the air bag wiring harness. If the clockspring is taped together, remove the tape.
13. Install the steering wheel. For instructions, see **Section 46.06**, Subject 100 of the *Century Class Trucks Workshop Manual*.
14. Install the air bag. For instructions, see **Section 46.06**, Subject 100 of the *Century Class Trucks Workshop Manual*.
15. Reconnect the AS2 connector. See **Fig. 2**.
16. Reconnect the batteries.
17. While standing outside the cab and away from the front of the air bag,turn the ignition on. Check to make sure that after the ignition is turned on, the

Clockspring Replacement

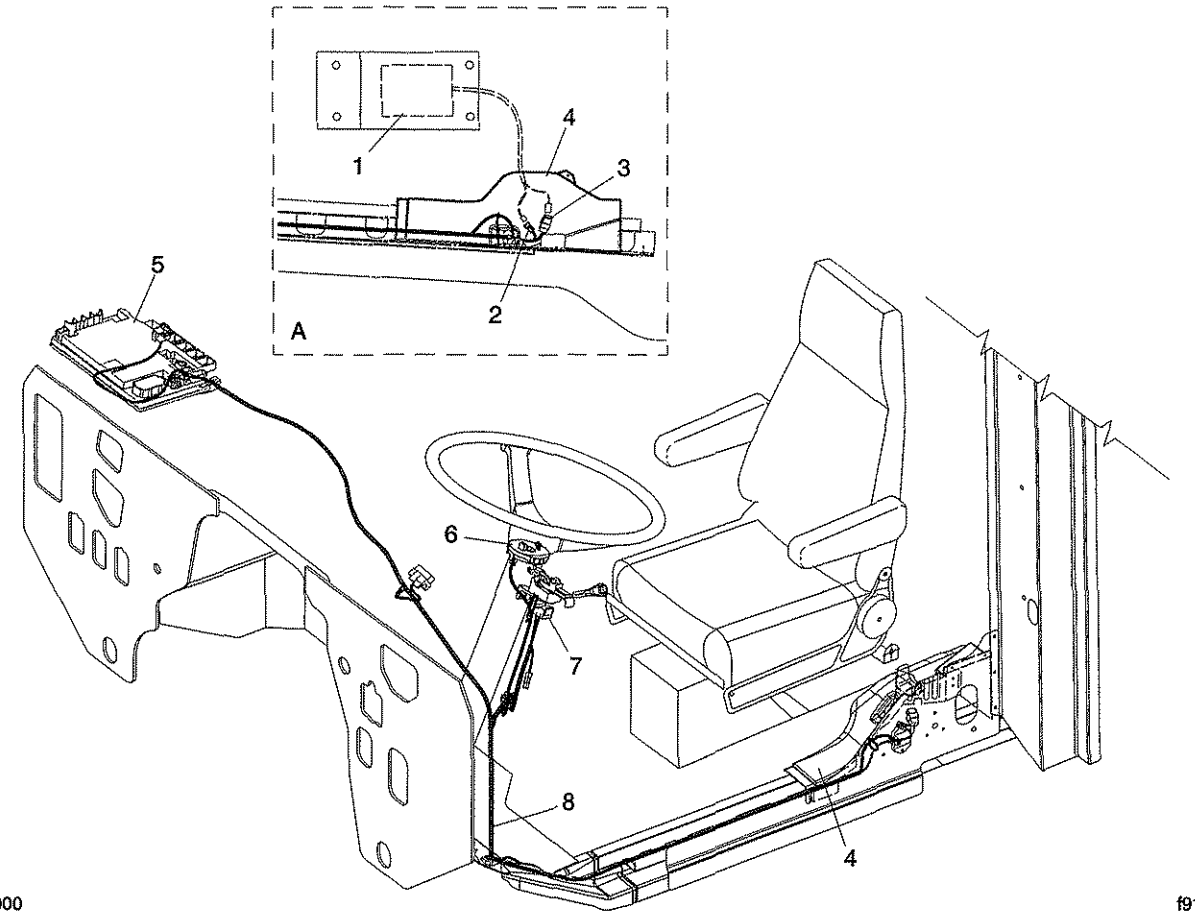


A. Top view of Air Bag/SPACE System
1. Gas Cylinder (SPACE system only)
2. DSS (Driver-Side SPACE) Connector
3. Driver-Side SPACE Module
4. B Pillar Cover
5. Power Distribution Module
6. Clockspring
7. SRS (Supplemental Restraint System) Connector
8. Air Bag Wiring Harness

Fig. 1, Air Bag Harness Routing on Air Bag/SPACE Systems Installed Prior to May 12, 2000

Supplemental Restraint System (SRS) indicator comes on for several seconds and then goes out. Make sure there are no active fault codes. If the SRS indicator remains on or if there are active fault codes, follow the appropriate troubleshooting procedure. The air bag system may need to be deactivated again.

18. If the SRS indicator goes out and there are no active fault codes, the system is functioning properly.
19. Remove the chocks from the tires.



A. Top view of Air Bag Sensor Module.

1. Air Bag Sensor Module
2. AS2 Connector
3. AS1 Connector
4. B Pillar Cover
5. Power Distribution Module
6. Clockspring
7. SRS1 (Supplemental Restraint System) Connector
8. Air Bag Wiring Harness

Fig. 2, Air Bag Harness Routing on Air Bag Only Systems Installed From May 12, 2000

Air Bag Disposal Procedure

⚠ WARNING

Air bags are designed to work in specific vehicle makes and models. Air bag modules and components can not be adapted, reused, or installed in any vehicle other than the vehicle they are designed and manufactured for. Any attempt to adapt, reuse, or install an air bag module or component in any other vehicle can result in death or severe injury to vehicle occupants in the event of an accident.

IMPORTANT: The storage, transportation, disposal, or recycling of air bag modules or components must be performed in accordance with all applicable federal, state, and local regulations including, but not limited to, those governing building and fire codes, environmental protection, occupational health and safety, and transportation.

NOTE: If a vehicle is going to be scrapped and the air bag or SPACE system has not been deployed, contact your District Service Manager for instructions on how to proceed.

1. Remove the inflator from a deployed air bag module. Send the inflator to a recycler for reclamation of the steel and aluminum components.
2. Separate the air bag from the recyclable steel and aluminum components.
3. The plastic materials may be recycled or disposed of in common trash.

Air Bag Sensor Module Replacement

Replacement

1. Turn off the engine, apply the parking brakes, and chock the rear tires.

⚠ WARNING

Before removing the mounting capscrews from the sensor module, be sure to disconnect the batteries and disconnect the wiring from the sensor module. Failure to follow these precautions may result in the air bag being unintentionally deployed, which could cause severe bodily injury or death.

2. Disconnect the batteries and wait two minutes before proceeding.

⚠ WARNING

Wait two minutes after disconnecting the batteries to allow the internal components to discharge. Failure to allow the components to discharge could cause the air bag to deploy, resulting in severe bodily injury or death.

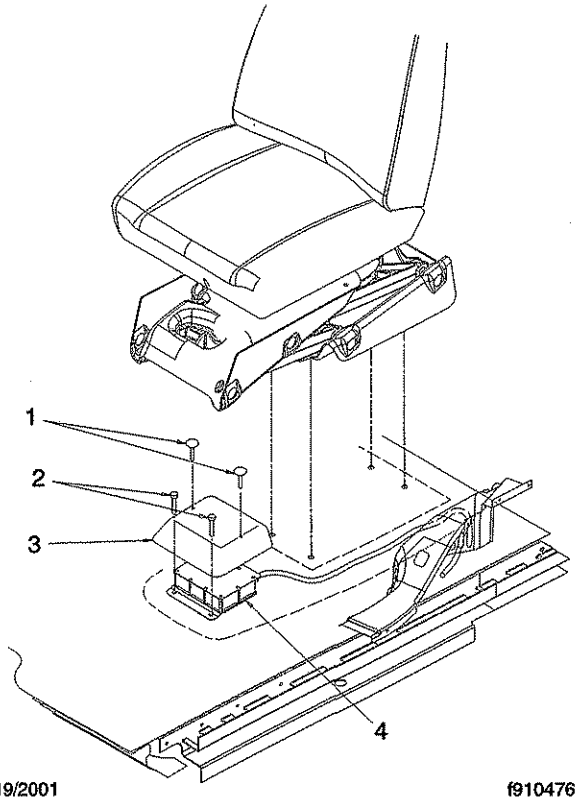
3. Raise the seat to its maximum position. If the seat is equipped with a seat shroud, lift the shroud to access the air bag sensor module.
4. Remove the plastic retainers that attach the sensor module cover to the sensor module and remove the cover. See **Fig. 1** or **Fig. 2**.
5. Disconnect the wiring from the sensor module at the AS2 connector under the B pillar cover.
6. Remove the sensor module.
   - On vehicles with an EzyRider seat, remove the capscrews that attach the sensor module to the cab floor. See **Fig. 1**.
   - On vehicles with a nonproprietary seat, remove the capscrews that attach both the sensor module and the seat to the cab floor. The front mounting capscrews for the seat may need to be loosened to remove the sensor module. See **Fig. 2**.
7. Install the new sensor module.
   - On vehicles with an EzyRider seat, use two capscrews to attach the sensor module to the cab floor. Torque the capscrews 25 to 29 lbf·ft (34 to 39 N·m).
   - On vehicles with a nonproprietary seat, use two capscrews to attach both the sensor module and the seat to the cab floor. If the front mounting capscrews for the seat were loosened, tighten the capscrews. Torque the capscrews 35 to 40 lbf·ft (47 to 54 N·m).

⚠ WARNING

Before attaching the wiring to the sensor module and before connecting the batteries, be sure to attach and tighten the mounting capscrews to the sensor module. Failure to follow these precautions may result in the air bag being unintentionally deployed, which could cause personal injury or property damage.

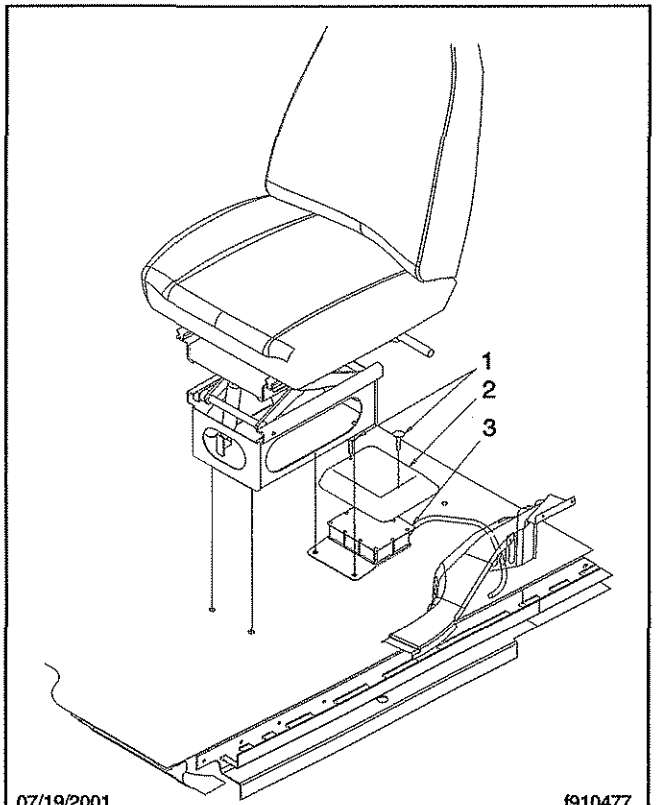
8. Attach the wiring to the sensor module.
9. Using two plastic retainers, attach the sensor module cover to the sensor module.
10. Lower the seat. If the seat is equipped with a seat shroud, lower the shroud around the base of the seat.
11. Connect the batteries and remove the chocks from the tires.

Air Bag Sensor Module Replacement



1. Sensor Module Cover Plastic Retainer
2. Sensor Module Capscrew
3. Sensor Module Cover
4. Sensor Module

Fig. 1, EzyRider Seat With Air Bag Sensor Module



1. Sensor Module Cover Plastic Retainer
2. Sensor Module Cover
3. Sensor Module

Fig. 2, Nonproprietary Seat With Air Bag Sensor Module

Contents

Subject	Subject Number
General Information	050
Service Operations	
Steering Pump Replacement	100
Troubleshooting	300
Specifications	400

General Information

The LuK Automotive Hydraulics LF 80 power steering pump supplies power steering fluid for the operation of the power steering gear.

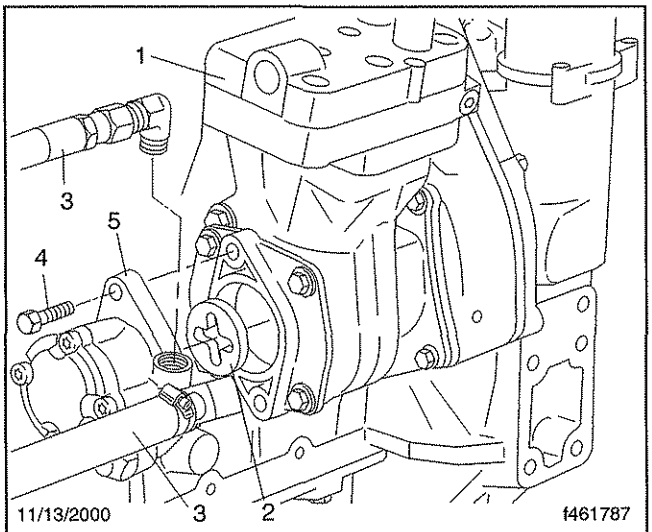
The power steering pump, used only on the MBE4000 engine with air brakes, is mounted on the air compressor. See **Fig. 1**. The power steering pump is driven by the air compressor through the cross plate.

The main parts of the power steering pump are the housing, driveshaft, cam ring, rotor, vanes, and control valve.

Principles of Operation

The power steering pump driveshaft is driven by the air compressor, which is powered by an adaptor gear connected to the engine crankshaft.

As the pump driveshaft turns the pump rotor, centrifugal force throws the vanes out against the surface of the cam ring. When fluid enters the cam ring through the inlet port, the rotor vanes force it out through the outlet port and into the system.



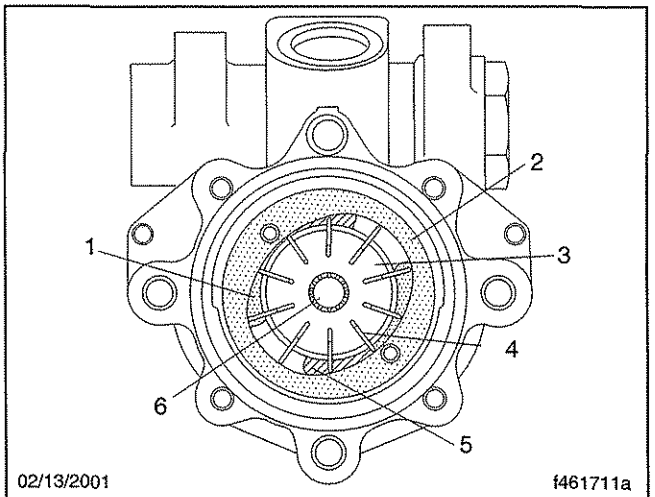
1. Air Compressor
2. Cross Plate
3. Hydraulic Line
4. Mounting Capscrew (2 qty.)
5. Power Steering Pump

Fig. 1, Power Steering Pump Mounting

The fluid enters the steering gear, providing the gear with enough fluid to steer the vehicle. Eventually the fluid returns to the power steering reservoir and then back to the power steering pump. See **Fig. 2**.

If the system pressure gets too high, a poppet inside the control valve is forced off its seat, shunting fluid into a relief passage connected to the inlet port. The fluid then recirculates inside the pump, instead of going to the outlet port.

When the system pressure drops to the correct level, the poppet seats and closes off the relief passage to the inlet port. The fluid flow returns to normal, flowing from the inlet port to the outlet port, and then into the power steering system.

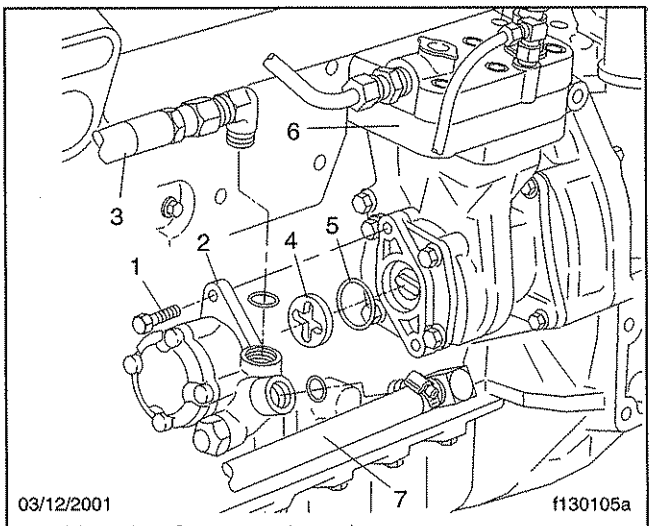


1. Low Pressure Area
2. Cam Ring Contour
3. Rotor
4. Vane
5. High Pressure Area
6. Driveshaft

Fig. 2, Power Steering Pump, Sectional View

Replacement

1. Turn off the engine, apply the parking brakes, chock the tires, and open the hood.
2. Clean the dirt from around the inlet and outlet ports and from the hydraulic filtings.
3. Drain the power steering fluid and remove the hydraulic lines. See **Fig. 1**.
   - 3.1 Put a suitable container under the power steering pump.
   - 3.2 Disconnect the inlet line and fitting from the inlet port.
   - 3.3 Disconnect the outlet line and fitting from the outlet port.
   - 3.4 Remove the O-rings from both fittings. Inspect the O-rings for wear and replace them if necessary.
   - 3.5 Drain the fluid into the container.
   - 3.6 Plug the lines to keep out dirt.



1. Mounting Capscrew (2 qty.)
2. Power Steering Pump
3. Outlet (pressure) Line
4. Cross Plate
5. O-Ring, Power Steering
6. Air Compressor
7. Inlet Line

Fig. 1, Power Steering Pump Removal

4. Remove the capscrews and washers that attach the power steering pump to the air compressor. Remove the steering pump from the air compressor.
5. Remove the cross plate and inspect it for excessive wear. Replace it if necessary. Discard the O-ring.
6. Lubricate the new O-ring with a light coating of power steering fluid, and install it in the pilot diameter of the power steering pump. See **Fig. 2**.

IMPORTANT: Some power steering gears use automatic transmission fluid. Others use heavy-duty engine oil. Do not mix power steering fluids. Lubricate parts with the same fluid used in the power steering system.

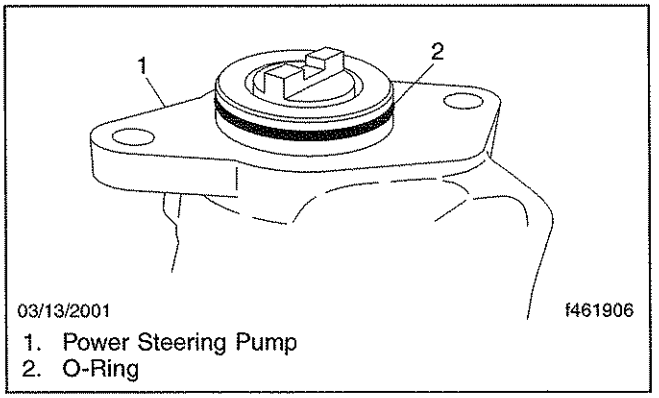
7. Install the cross plate. Use grease to hold it in place while installing the pump.

IMPORTANT: Before installing a new steering pump, make sure the cross plate aligns with the air compressor shaft.

8. Attach the power steering pump to the air compressor using the mounting capscrews and washers. Tighten the capscrews 32 to 37 lbf·ft (43 to 50 N·m).
9. Lubricate the O-rings with a light coating of power steering fluid, and install them in the fittings of the two hydraulic lines.

IMPORTANT: Lubricate parts with the same fluid used in the power steering system.

10. Connect the inlet line, O-ring, and fitting to the steering pump inlet port. Tighten the fitting 26 lbf·ft (35 N·m).



1. Power Steering Pump
2. O-Ring

Fig. 2, O-Ring Installation

Steering Pump Replacement

11. Connect the outlet line, O-ring, and fitting to the steering pump outlet port. Tighten the fitting 22 lbf·ft (30 N·m).
12. Add fluid to the power steering reservoir, using an approved type from the power steering fluid table in **Specifications, 400**.
    - 12.1 Start the engine and let it idle for two minutes. Do not turn the steering wheel during this time, since this can cause air to enter the system.
    - 12.2 Turn off the engine and check the fluid level in the reservoir.
13. Bleed the air from the power steering system. See **Section 46.01**, Subject 110, for TRW steering gears and **Section 46.05**, Subject 100, for Sheppard steering gears.
14. Close the hood and remove the chocks from the tires.

Troubleshooting Tables

Problem—The Power Steering Pump Doesn't Deliver Fluid

Possible Cause	Remedy
The pump driveshaft is broken, or is not engaging.	Replace the pump.
The incorrect type of power steering fluid is being used.	Check the type of fluid used. If it's incorrect, drain, flush, and fill the system with the correct type of clean power steering fluid. See the power steering fluid table in **Specifications 400**.
The pump inlet port is blocked.	Drain and flush the system. Fill the system with the correct type of clean power steering fluid. See the power steering fluid table in **Specifications 400**.
The air vent in the power steering reservoir is clogged, or the filter is dirty.	Remove the filter cap from the reservoir, then clean the air slot. Check the filter and replace it if needed.
A power steering line is kinked or blocked.	Repair or replace the line.

Problem—The Power Steering Pump Is Making Noise

Possible Cause	Remedy
The inlet line or filter is plugged.	Drain the system. Clear the inlet line if needed, then check the filter. Replace it if needed. Fill the system with the correct type of clean power steering fluid. See the power steering fluid table in **Specifications 400**.
There is an air leak at the pump connections, the fittings, the reservoir connections, or the shaft seal.	Check the fluid level in the reservoir. Check all the connections by pouring power steering fluid over them, then listen for a reduction in sound. Tighten all the connections as needed. If the problem persists, replace the pump.

Model Code Description*	
Model Code	**Description**
LF8	Power Steering Pump Series
0	Flange Type
25	Displacement (cubic cm/rev)
16	Control Flow (L/min)
150	Pressure Relief Valve Setting (bar)
L	Direction of Rotation
P	Inlet Port Size
U	Outlet (pressure) Port Size
MK1	Compressor Driven, Direct Drive
10	Design Number

* Model codes contain specifications in metric units.

Table 1, Model Code Description

Pump Port Specifications						
Code	**Size**	**Shaft Minor Diameter Inches (mm)**	**Minimum Seal Diameter Inches (mm)**	**Piping Inside Diameter Inches (mm)**	**Piping Outside Diameter Inches (mm)**	**O-Ring Chamfer**
Inlet Port						
M	M26 x 1.5	0.67 (17)	1.30 (33)	0.75 (19)	0.87 (22)	—
P	1-1/16–12		—			SAE J514
Outlet Port						
M	M16 x 1.5	0.55 (14)	0.98 (25)	0.39 (10)	0.47 (12)	—
N	M18 x 1.5			0.47 (12)	0.59 (15)	—
U	3/4–16		—			SAE J514

Table 2, Pump Port Specifications

Pump Specifications			
LuK Model Code	**Pump Displacement: cubic inch/rev (cubic cm/rev)**	**Control Flow gpm (L/min)**	**Maximum Pressure: psi (kPa)**
LF80-25-16-150-L-P-U-MK1-10	1.53 (25)	4.2 (16)	2205 (15 203)
LF80-25-16-163-L-P-U-MK1-10			2396 (16 520)
LF80-25-16-185-L-P-U-MK1-10			2683 (18 500)
LF80-21-16-150-L-P-U-MK1-10	1.28 (21)		2205 (15 203)
LF80-17-16-185-L-P-U-MK1-10	1.04 (17)		2683 (18 500)

Table 3, Pump Specifications

Specifications

Fastener Torques		
Description	Torque: lbf.ft (N.m)	Torque: lbf.in (N.cm)
Pump Mounting Bolts	32–37 (43–50)	—
Pump Inlet Fitting	26 (35)	—
Pump Outlet Fitting	22 (30)	—
Steering Gear Manual Bleed Screw (if installed)	—	27–33 (300–360)

Table 4, Fastener Torques

Approved Power Steering Fluids	
Fluid Type	Approved Fluid
Automatic Transmission Fluid*	Dexron® II Dexron® III
Heavy-Duty Engine Oil* IMPORTANT: Do not use heavy-duty engine oil in vehicles built from November 4, 2002.	15W–40

* Do not mix engine oil with automatic transmission fluid (ATF). Use the same lubricant for parts as is in the power steering system.

Table 5, Approved Power Steering Fluids

Pressure Settings		
Code	Pressure: psi (kPa)	Tolerance: psi (kPa)
81	1174.5 (8100)	58 (400)
90	1305 (9000)	
100	1450 (10 000)	
105	1522.5 (10 500)	
110	1595 (11 000)	
120	1740 (12 000)	
125	1812.5 (12 500)	
130	1885 (13 000)	
135	1957.5 (13 500)	
140	2030 (14 000)	
145	2102.5 (14 500)	
150	2175 (15 000)	
155	2247.5 (15 500)	
165	2392.5 (16 500)	
000	—	—

Table 6, Pressure Settings

Contents

Subject	Subject Number
General Information	050
Service Operations	
Steering Gear Removal and Installation	100
Filling and Air Bleeding the System	110
Input Shaft Seal Replacement	120
Sector Shaft Adjustment	130
Poppet Adjustment on a Single Gear	140
Disassembly, Inspection, Assembly, and Final Adjustments	150
Poppet Component Replacement	160
Valve Housing/Input Shaft Disassembly, Inspection, and Assembly	170
Roller Bearing Replacement	180
Housing Port Plugs, Screws, and Fittings Replacement	190
Post-Service Checks	200
Troubleshooting and Diagnostic Checks	300
System Setup for Hydraulic Checks	310
Specifications	400

General Information[1]

NOTE: Procedures contained in this section have been slightly modified from the original component manufacturer's service manual. If you are not clear on how to perform an operation, consult the component manufacturer's service literature before continuing a specific procedure.

The TRW PCF60 power steering gear is an integral hydraulic power steering gear. Integral hydraulic power steering gears contain a manual steering mechanism, a hydraulic control valve, and a hydraulic power cylinder.

The rotary control valve controls the flow of hydraulic fluid through the steering gear. The speed at which the driver can turn the steering wheel with power assist is dependent on the pump flow directed to a cylinder cavity.

The pressure required for the steering gear to steer the vehicle is created by the power steering pump to overcome resistance at the steered wheels. The control valve senses these requirements and directs fluid to the appropriate cylinder cavity in the steering gear (and in the auxiliary cylinder if it is a dual steering system) at the proper flow rate and pressure.

The higher pressure a steering gear can withstand, the more work it can perform. The maximum operating pressure for the PCF steering gear is 2685 psi (18 512 kPa). The maximum flow rate is 8 gpm (30.3 L/min).

The PCF steering gears can steer a vehicle within its front axle weight rating through a turn at low speed and engine idle. As the steering wheel is turned faster or slower, more or less fluid will be required by the gear.

The PCF power steering gear is used for front axle capacities up to 14,300 lb (6500 kg).

The recommended minimum flow at 1.5 steering wheel turns per second is 2.6 gpm (9.8 L/min).

If the rotary control valve is controlling an auxiliary cylinder, increased minimum flow is required (generally at least 75 percent) based on the size of the auxiliary cylinder and the steering geometry of the vehicle.

Maximum internal leakage for the PCF steering gear is 1.2 gpm (4.5 L/min).

Principles of Operation

When the steering wheel is turned, force is transmitted from the steering wheel to the steering gear input shaft. A torsion bar, pinned at one end to the input shaft and at the other end to the worm shaft, turns with the input shaft and exerts a rotational force on the worm shaft. In response, the worm shaft, acting through the recirculating ball mechanism, tries to move the rack piston on or along the axis through the gear housing cylinder bore.

The rack piston's axial movement is resisted by its engagement to the sector shaft, which is connected by linkage to the steered wheels. Because of this resistance, the torsion bar is twisted by the input shaft, thereby actuating the control valve. Pressurized fluid, directed by the control valve, assists in moving the rack piston on or along the axis through the cylinder bore. The rack piston then turns the sector shaft to steer the vehicle.

If the steered wheels receive a shock load, the shock forces are transmitted through the sector shaft to the rack piston and on to the worm shaft. The internal construction of the steering gear causes the control valve to send high-pressure fluid to the correct cylinder cavity to resist the shock forces. By absorbing the shock forces hydraulically, the steering gear prevents kickback at the steering wheel.

Most PCF steering gears are equipped with two poppet (unloading) valves, one at each end of the rack piston. One valve or the other, depending on the direction of the turn, will trip as the steered wheels approach the axle stops, which must be set to the manufacturer's specifications. The tripped valve reduces pressure in the gear and helps to reduce heat generated by the pump. At the same time, the valves also reduce forces on the steering linkage. These valves are automatically set to axle stops after installation in the vehicle at first full right and first full left turns.

Some PCF steering gears with or without poppets are supplied with a relief valve. The relief valve limits maximum supply pressure to protect the power steering gear, but it does not reduce pressure as the steered wheels approach the axle stops.

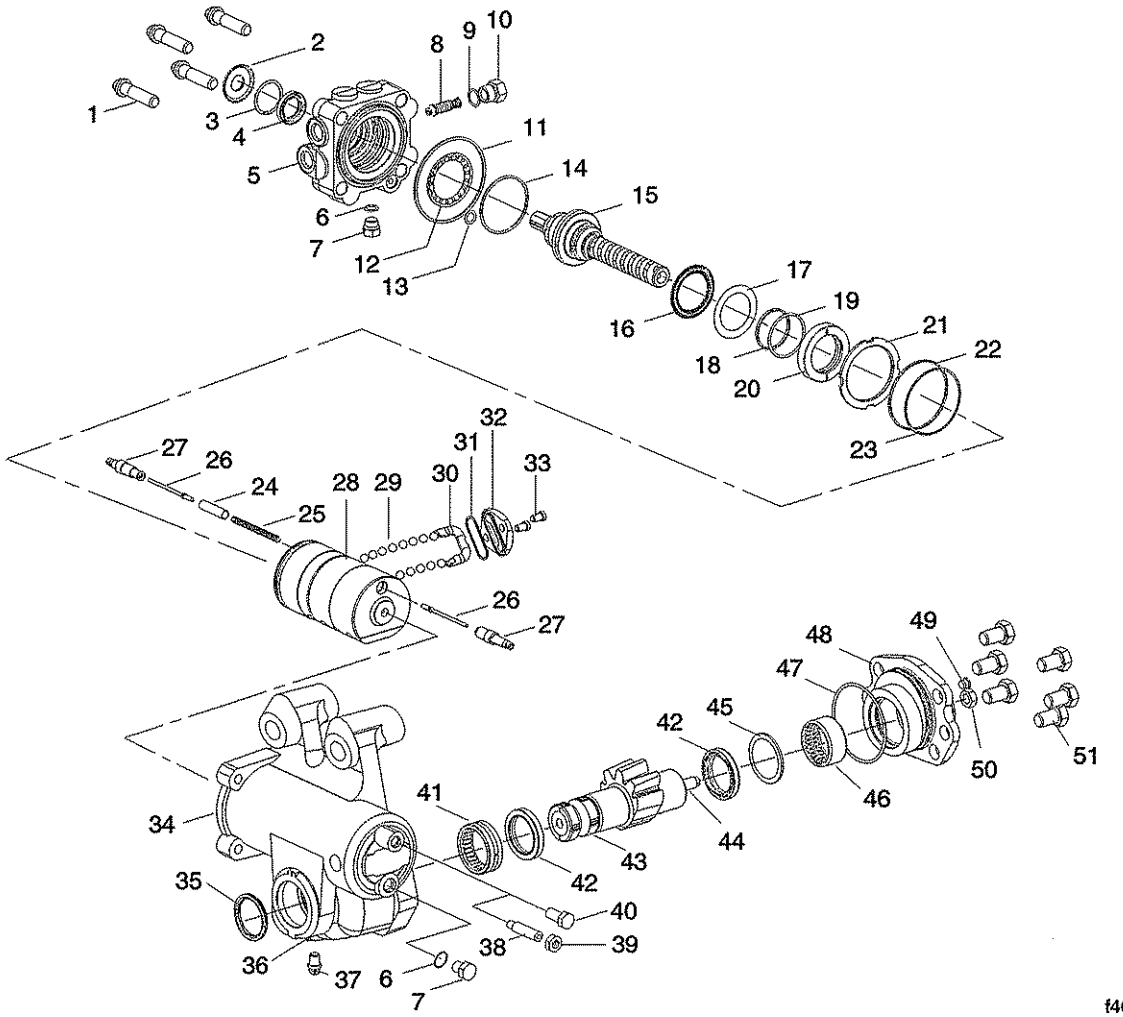
Some PCF steering gears that are mounted with the output shaft above the rack piston bore are equipped

[1] The illustrations in this section are provided by TRW Commercial Steering Systems and are used with permission.

General Information

with either an automatic bleed system or a manual bleed screw.

See **Fig. 1** for an exploded view of the PCF steering gear.



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1. Valve Housing Capscrew
2. Dirt and Water Seal
3. Retaining Ring
4. Input Shaft Seal
5. Valve Housing
6. Auxiliary Port O-Ring (2)
7. Auxiliary Port Plug (2)
8. Relief Valve
9. O-Ring
10. Relief Valve Cap
11. Valve Housing O-Ring
12. Bearing Assembly
13. O-Ring
14. Seal Ring
15. Input Shaft Assembly
16. Thrust Bearing
17. Thrust Washer
18. Seal Ring
19. O-Ring
20. Bearing Adjuster
21. Adjuster Locknut
22. O-Ring
23. Seal Ring
24. Push Tube
25. Poppet Spring
26. Poppet
27. Poppet Seat and Sleeve Assembly
28. Rack Piston
29. Ball
30. Ball Return Guide
31. Cap Seal
32. Ball Return Guide Cap
33. Torx® Capscrew
34. Gear Housing
35. Dirt and Water Seal
36. Grease Fitting
37. Automatic Bleed Plug
38. Poppet Adjusting Screw
39. Poppet Adjusting Screw Nut
40. Poppet Fixed Stop Screw
41. Roller Bearing
42. Output Seal
43. Sector Shaft Assembly
44. Sector Shaft Adjusting Screw
45. Washer
46. Roller Bearing
47. Side Cover O-Ring
48. Side Cover Assembly
49. Vent Plug, Side Cover
50. Adjusting Screw Jam Nut
51. Capscrew

Fig. 1, PCF Steering Gear

Steering Gear Removal and Installation

Removal

1. Verify that the axle stops are adjusted to the specifications in **Section 33.00**, Subject 110. Ensuring correct axle stop adjustment now will eliminate the possibility of resetting steering gear poppet valves after the gear is installed.
2. Place the front tires in the straight-ahead position. If possible, drive the vehicle in a straight line for a short distance, stopping at the spot where the work is to be done.

⚠ CAUTION

Do not turn the steering wheel or the steering shaft more than a half turn (except for alignment purposes) during the removal and installation procedures. Doing so may damage the clockspring in a vehicle equipped with an air bag.

3. Turn off the engine, apply the parking brakes, chock the tires, disconnect the batteries, and open the hood.
4. Clean all the fittings and hose connections on the steering gear until they are free of dirt.
5. Drain the fluid from the power steering system. Disconnect the hydraulic lines from the steering gear, marking the lines for later reference. Plug the lines and the fittings to keep out dirt.
6. Remove the drag link.
7. Disconnect the steering driveline from the steering gear input shaft.

   7.1 Remove the pinch bolt from the steering driveline lower end yoke.

⚠ CAUTION

Do not pound the U-joint or lower end yoke on or off the input shaft. Internal damage to the steering gear can result.

   7.2 Remove the end yoke from the input shaft.

8. Clean the entire steering gear before removing it.

⚠ WARNING

Use caution when removing, lifting, and carrying the steering gear to avoid injury.

9. Remove the fasteners that attach the steering gear to the frame rail. Remove the steering gear.

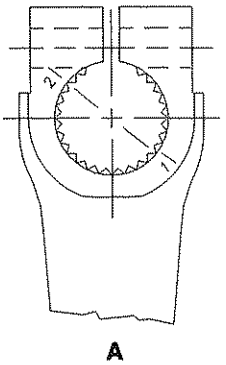
Installation

⚠ WARNING

Use caution when removing, lifting, and carrying the steering gear to avoid injury.

1. Using fasteners, install the steering gear on the frame rail. Torque the fasteners 342 to 434 lbf·ft (464 to 588 N·m).
2. If not previously done, center the steering gear. The sector (output) shaft alignment mark must be at a right angle to the steering gear input shaft center line. Make sure the steering gear remains centered as the service work continues.
3. If the pitman arm was removed, install the pitman arm on the steering gear aligning the timing marks as shown in **Fig. 1**.

NOTE: The pitman arm may not fit over the splines on the sector shaft without spreading the slot in the arm. To wedge the slot open, clamp the pitman arm in a vise with the slot at the top. Use a ball peen hammer to drive a chisel into the slot. Hold the chisel in place, remove the pitman arm from the vise, and install the



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A. Timing Mark No. 2 Aligned

Fig. 1, Typical Pitman Arm and Timing

Steering Gear Removal and Installation

pitman arm on the sector shaft. Remove the chisel from the slot.

⚠ WARNING

Never leave a chisel wedged in the pitman arm slot. When using a chisel to spread the slot in the pitman arm, maintain a firm grip on the chisel at all times. Otherwise the chisel may fly loose, which could cause an injury.

4. Install a new pitman arm pinch bolt, washer (if applicable), and a new nut. Tighten the nut 230 lbf·ft (312 N·m).
5. Connect the steering driveline to the steering gear input shaft.
   - 5.1 Clean the input shaft and the inside of the driveline yoke.
   - 5.2 Position the steering wheel so that it is within ±10 degrees of center as shown in **Fig. 2**.
   - 5.3 Slide the yoke on the input shaft and install a new pinch bolt and pinch bolt nut. Tighten the pinch bolt nut 45 to 55 lbf·ft (60 to 75 N·m).
6. Connect the drag link to the pitman arm.
   - 6.1 Connect the pitman arm end of the drag link to the pitman arm and install the castle nut.
   - 6.2 Torque the castle nut 160 to 300 lbf·ft (220 to 400 N·m). If necessary, continue tightening the castle nut until a slot on the nut aligns with a hole in the ball stud. Do not back off the nut.
   - 6.3 Install a new cotter pin through the ball stud and the castle nut, then lock the cotter pin in place.
   - 6.4 Wipe the grease fittings clean at both ball stud sockets, then fill the sockets with chassis grease using a pressure gun.
7. If the hydraulic line elbow fittings were removed, attach them to the steering gear. Torque the fittings 37 lbf·ft (51 N·m). Torque the pressure-line fitting jam nut to a maximum of 41 lbf·ft (56 N·m).
8. Remove the plugs from the hydraulic lines. Connect the hydraulic lines to the steering gear. Tighten the nut on each fitting finger tight. Then use a wrench to tighten the nut until there is firm resistance. Tighten one-sixth turn more.
9. Connect the batteries.
10. Fill and bleed the steering system. For instructions, see **Subject 110**.
11. Remove the chocks from the tires and close the hood.
12. Test drive the vehicle.
    - 12.1 With the front tires pointing straight ahead, check the position of the steering wheel spokes. If the steering wheel is not in the correct position, remove the steering wheel and install it in the correct position. For instructions, refer to the applicable section in this group.
    - 12.2 The center spokes on a four-spoke steering wheel should be ±10 degrees of the 3 o'clock and 9 o'clock positions. See **Fig. 2**.

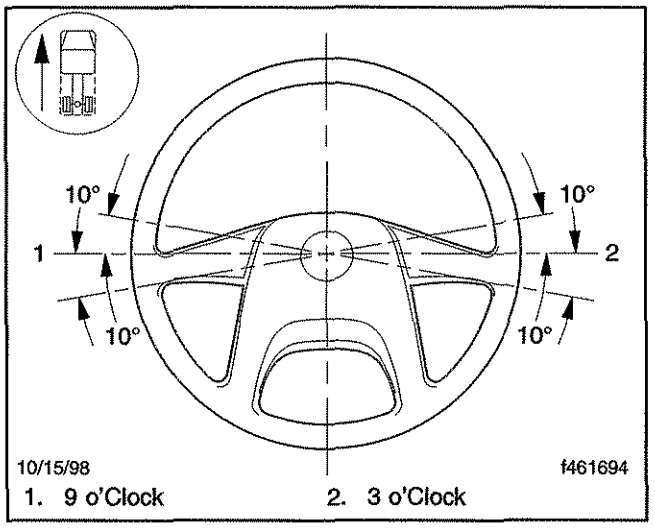


Fig. 2, Steering Wheel Centered

Filling and Air Bleeding the System

IMPORTANT: Make sure the poppets are set correctly before beginning this procedure. If the poppets are not set correctly, see **Subject 160**.

1. Fill the power steering reservoir nearly full. Do not steer.
2. Start the engine and run it for 10 seconds, then shut it off. Check and fill the reservoir. Repeat this step at least three times checking the fluid level in the reservoir each time.

IMPORTANT: Do not let the fluid level drop significantly or allow the reservoir to empty. Doing so may introduce air into the system.

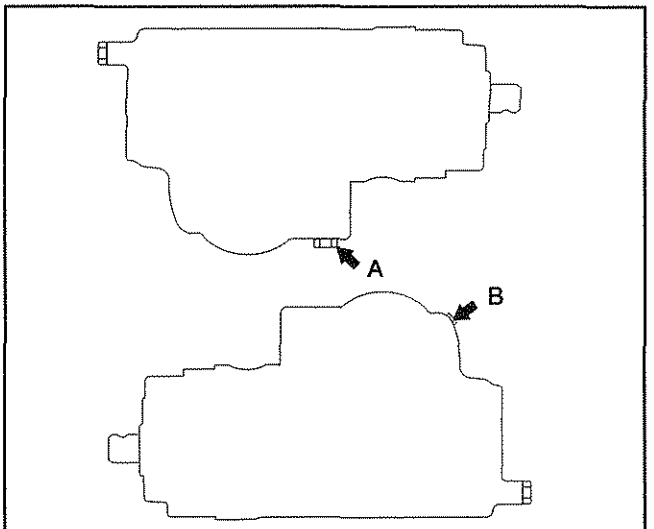
3. Start the engine and let it idle for two minutes. Do not steer. Shut off the engine and check the fluid level in the reservoir. If needed, add more fluid.
4. Start the engine again. Turn the steering wheel from full left to full right several times. If needed, add fluid to the reservoir.

   Automatic bleed systems should now be free of trapped air. If the vehicle has a manual bleed system, proceed to the next step. See **Fig. 1**.

IMPORTANT: Do not turn the steering wheel while the bleed screw is loosened.

5. With the engine idling, turn the steering wheel from full left to full right several times. Stop steering and loosen the manual bleed screw about one turn. Allow air and aerated fluid to bleed out until only clear fluid is seen. Close the bleed screw and add fluid to the reservoir if needed.

   Repeat this step until all the air is out of the system. Torque the bleed screw 40 to 50 lbf·in (450 to 560 N·cm).



A. Steering gear with automatic bleed plug. Do not remove the bleed plug.
B. Steering gear with manual bleed plug.

Fig. 1, Steering Gears With Bleed Systems

Input Shaft Seal Replacement

Replacement

The power steering pump is used in this procedure to force out the input shaft seal. To use this procedure, the power steering pump should have a minimum of 1500 psi (10 342 kPa) available.

1. Turn off the engine, apply the parking brakes, and chock the tires.
2. Disconnect the return line from the steering gear and plug the line. Cap the return port of the steering gear with a high pressure fitting.
3. Remove the steering driveline from the steering gear input shaft.
4. Remove the dirt and water seal, item 2 in **Fig. 1**, from the steering gear. Save this seal to determine the correct size of the new seal.
5. Using a clean cloth, remove the grease from around the input shaft.
6. Using a screwdriver inserted into the notch formed in the end of the retaining ring, item 3 in **Fig. 1**, remove the retaining ring. Be careful not to scratch the bore with the screwdriver.
7. Using a pinch bolt and nut, attach the steering driveline to the input shaft but do not tighten the nut.
8. Tie or wrap a shop towel around the input shaft and place a drain pan under the steering gear to catch the oil.

⚠ WARNING

Do not mix hydraulic fluid types or use unapproved fluids. Doing so could cause seal deterioration, leaks, and a loss of steering assist, which could result in serious personal injury or death.

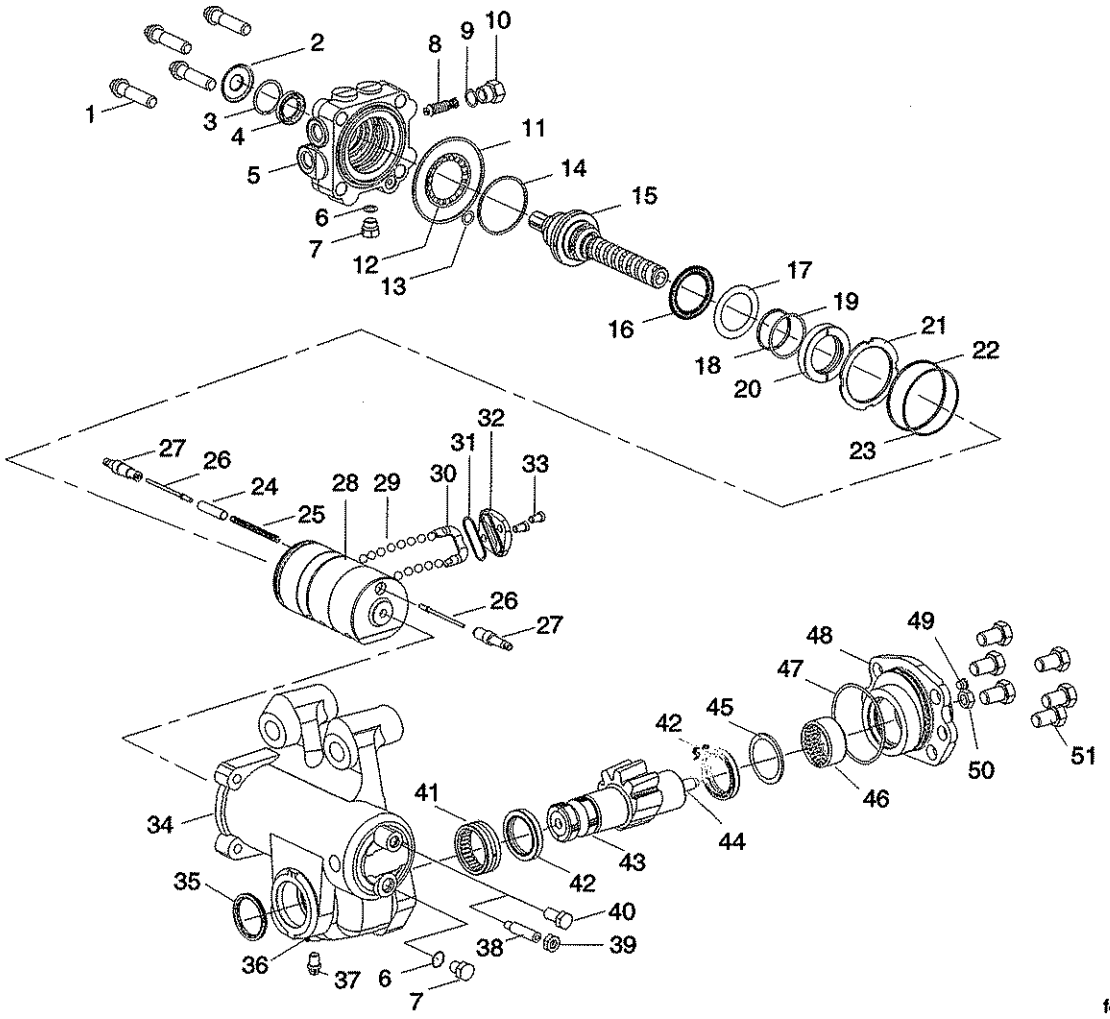
9. If needed, add hydraulic fluid to the power steering reservoir. Do not mix fluid types. See **Specifications 400** for a list of approved hydraulic fluids.
10. With the vehicle in neutral, momentarily turn the starter; if the engine starts, quickly turn it off. This should force out the input shaft seal.
11. Remove the shop towel. Disconnect the steering driveline from the steering gear and remove the input shaft seal, item 4 in **Fig. 1**.
12. Inspect the seal area of the valve housing for seal fragments. Remove all seal fragments.
13. Check the input shaft seal for heat damage. If the seal is stiff and brittle, it is probably heat damaged. Determine and fix the cause of excessive heat in the vehicle.

⚠ WARNING

Do not use a socket to install the input shaft seal. You will not be able to control the seal installation depth with a socket and this could lead to leaks. Leaks could result in loss of steering assist which could result in serious personal injury or death.

14. Install a new input shaft seal.
    - 14.1 Using Exxon Polyrex® EP2 grease (PN 045422), lubricate the inside diameter of the new input shaft seal and install it on the input shaft.
    - 14.2 Using a hammer and seal driver (PN J37073), tap the driver until the shoulder of the driver is square against the valve housing. Remove any seal material that may have sheared off in the seal bore or retaining ring groove.
15. Install a new retaining ring in the groove.
16. Using Exxon Polyrex EP2 grease (PN 045422), pack the end of the valve housing bore.
17. Install a new dirt and water seal.
    - 17.1 Choose the correct size dirt and water seal by comparing the replacement seals to the old seal, or by measuring the major diameter of the input shaft serrations. See **Table 1** for the major serration diameter and the corresponding seal part number.
    - 17.2 Apply Exxon Polyrex EP2 grease (PN 045422) to the new dirt and water seal and install it on the input shaft. Seat it in the groove behind the serrations and against the valve housing.
18. Using a new pinch bolt and nut, attach the steering driveline to the input shaft. Tighten the nut 35 to 40 lbf·ft (47 to 54 N·m).
19. Attach the return line to the steering gear return port.

Input Shaft Seal Replacement



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1. Valve Housing Capscrew
2. Dirt and Water Seal
3. Retaining Ring
4. Input Shaft Seal
5. Valve Housing
6. Auxiliary Port O-Ring (2)
7. Auxiliary Port Plug (2)
8. Relief Valve
9. O-Ring
10. Relief Valve Cap
11. Valve Housing O-Ring
12. Bearing Assembly
13. O-Ring
14. Seal Ring
15. Input Shaft Assembly
16. Thrust Bearing
17. Thrust Washer
18. Seal Ring
19. O-Ring
20. Bearing Adjuster
21. Adjuster Locknut
22. O-Ring
23. Seal Ring
24. Push Tube
25. Poppet Spring
26. Poppet
27. Poppet Seat and Sleeve Assembly
28. Rack Piston
29. Ball
30. Ball Return Guide
31. Cap Seal
32. Ball Return Guide Cap
33. Torx® Capscrew
34. Gear Housing
35. Dirt and Water Seal
36. Grease Fitting
37. Automatic Bleed Plug
38. Poppet Adjusting Screw
39. Poppet Adjusting Screw Nut
40. Poppet Fixed Stop Screw
41. Roller Bearing
42. Output Seal
43. Sector Shaft
44. Sector Shaft Adjusting Screw
45. Washer
46. Roller Bearing
47. Side Cover O-Ring
48. Side Cover
49. Vent Plug, Side Cover
50. Adjusting Screw Jam Nut
51. Capscrew

Fig. 1, PCF Steering Gear

Major Serration Diameters and Corresponding Seal Part Numbers		
Major Serration Diameter inch (mm)	**Serration Size**	**Part Number**
0.807/0.799 (20)	13/16 inch (21 mm) x 36	478044
0.866/0.857 (22)	7/8 inch (22 mm) x 36	478060
0.987/0.977 (25)	1 inch (25 mm) x 36	478050
1.008/1.000 (25)	1 inch (25 mm) x 79	478050

Table 1, Major Serration Diameters and Corresponding Seal Part Numbers

20. Bleed the air from the system. For instructions, see **Subject 110.**
21. Remove the chocks from the tires.

Sector Shaft Adjustment

The sector shaft adjustment can only be completed if the adjusting screw jam nut is accessible when the steering gear is attached to the frame rail. The jam nut is located on the side cover. If the jam nut is not accessible, the adjustment can be made by removing the steering gear and placing it in a vise. See **Subject 100** for removal instructions.

1. Apply the parking brakes and chock the rear tires.
2. With the engine on, turn the steering wheel until the timing mark on the sector shaft lines up with the timing mark on the housing. The line on the sector shaft should be at a 90-degree angle from the input shaft. The sector shaft is now on its center of travel. Turn the engine off.
3. Remove the cotter pin and castle nut that attach the drag link to the pitman arm. Remove the drag link from the pitman arm.

IMPORTANT: To avoid resetting the poppets, do not turn the input shaft more than 1-1/2 turns from the center-of-travel position while the drag link is disconnected.

4. From the center-of-travel position, grasp the pitman arm at the lower end of the arm and gently try to move the arm back and forth. If the pitman arm is loose or lash (free play) is detected, the sector shaft is out of adjustment.
5. Loosen the adjusting screw jam nut.

NOTE: If the steering gear is removed from the frame rail to correct the lash, leave the pitman arm attached to the steering gear and follow the instructions under the "Final Adjustments" heading in **Subject 150**.

6. If no lash is detected, use a screwdriver to turn the shaft adjusting screw counterclockwise until you feel lash at the sector shaft.
7. Slowly turn the shaft adjusting screw clockwise until you feel no lash at the sector shaft without using more than 10 lbf·ft (14 N·m) of torque. See **Fig. 1**. From this position, turn the screw clockwise 1/8 to 3/16 of a turn more. Hold the adjusting screw in place and tighten the jam nut 43 lbf·ft (58 N·m).
8. Turn the steering wheel one-quarter turn each side of center then back to center and check the pitman arm for lash. There should be no lash. If lash is detected, loosen the jam nut and repeat the previous step as well as this step.
9. If the steering gear was removed from the frame rail, install the steering gear on the frame rail. For instructions, see **Subject 100**.
10. Using a castle nut, attach the drag link to the pitman arm. Torque the castle nut using the appropriate torque value.
    - 3/4–16: 90 to 170 lbf·ft (122 to 230 N·m)
    - 7/8–14: 160 to 300 lbf·ft (217 to 407 N·m)
11. If required, continue to tighten the castle nut until a slot on the nut aligns with the hole in the ball stud. Do **not** back off the nut when locating the cotter pin hole. Install a new cotter pin in the ball stud and nut and lock the cotter pin in place.

⚠ WARNING

Failure to install or lock a new cotter pin in the ball stud and nut could result in disengagement of the parts and loss of steering control.

⚠ CAUTION

Do not use a power grease gun to add grease to the sector shaft bearing. Doing so could damage the high pressure seal and contaminate the hydraulic fluid.

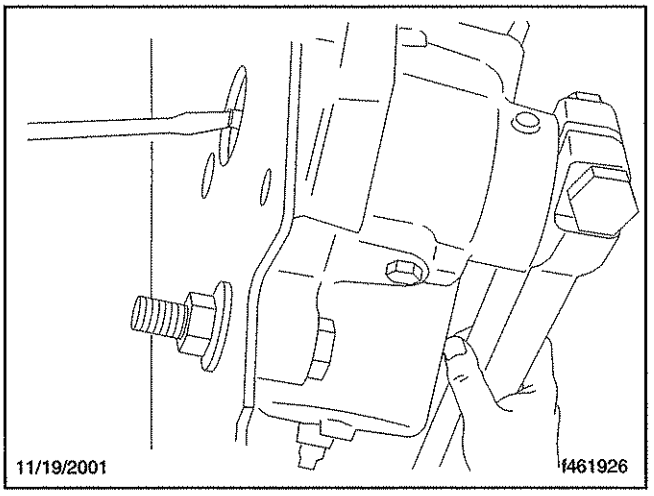


Fig. 1, Adjusting the Sector Shaft

Sector Shaft Adjustment

12. Using only a hand-operated grease gun, add grease to the sector shaft bearing through the grease fitting in the housing until grease begins to extrude past the dirt and water seal.
13. Remove the chocks from the tires.

Poppet Adjustment

The poppet adjustment will work in most cases with at least 1-3/4 turns of the steering wheel from each side of center. If a large reduction in wheel cut is being made and this procedure does not work, you may have to replace or reset the poppets using the "Poppet Component Replacement" procedure in **Subject 160.**

1. Check that the axle stops are adjusted to the specifications in **Section 33.00**, Subject 110.
2. Start the engine and allow the vehicle to idle for five to 10 minutes to warm the hydraulic fluid.
3. Shut down the engine, apply the parking brakes, and chock the rear tires.
4. If a new poppet adjusting screw and nut, items 38 and 39 in **Fig. 1**, are being used, turn the screw into the nonsealing end of the nut until the drive end of the screw is flush with the nut.

NOTE: The steering gear will have either a poppet fixed stop screw or a poppet adjusting screw. See **Fig. 1**. If the adjusting screw is already part of the steering gear, back the nut off of the adjusting screw until it is flush with the end of the adjusting screw.

5. Make sure that the engine is off and the wheels are in the straight-ahead position.
6. If equipped with a poppet fixed stop screw and washer, remove and discard both items from the lower end of the housing.

   If equipped with a poppet adjusting screw and nut that need to be replaced, remove and discard both items.
7. Using a 7/32-inch allen wrench, turn the adjusting screw and nut assembly (without turning the nut on the screw) into the housing until the nut is firmly against the housing. Tighten the nut against the housing.

⚠ CAUTION

Make sure the drive end of the adjusting screw is not below the face of the nut. If the drive end of the adjusting screw is below the face of the nut, the poppet seat flange will break when the upper poppet is prepared for setting.

⚠ WARNING

Fill the power steering reservoir with approved, clean fluid only. Do not mix automatic transmission fluid types; use one or the other. If you are changing fluid types, completely flush the steering system with the fluid type being added. Any mixture or any unapproved fluid could lead to seal deterioration and leaks. Any fluid leak could eventually cause loss of power steering assist, which could cause personal injury and property damage.

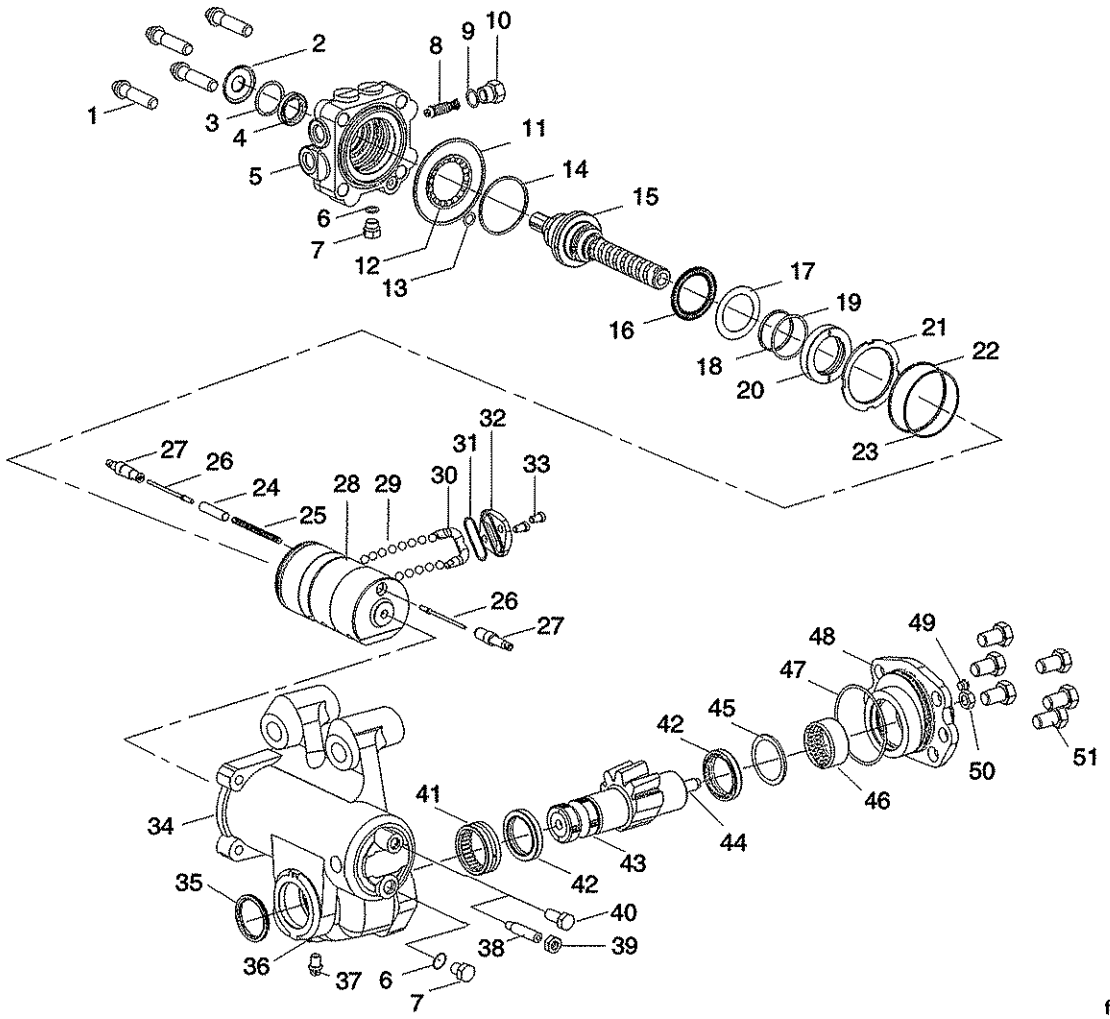
8. Add hydraulic fluid to the power steering reservoir as needed. For approved hydraulic fluids, see **Specifications 400.**
9. Place a jack under the center of the front axle and jack up the front of the vehicle so the steer axle tires are off the ground.

⚠ CAUTION

Do not hold the steering wheel at full turn for more than 10 seconds at a time. The heat buildup at pump relief pressure may damage components.

10. Push the upper poppet out to prepare it for setting.
    - 10.1 Start the engine and let it run at idle speed.
    - 10.2 Note which sector shaft timing mark is nearest the housing piston bore.
    - 10.3 Turn the steering wheel in the direction that makes this timing mark move toward the adjusting screw just installed. Turn the steering wheel in this direction until axle stop contact is made.
    - 10.4 Pull hard on the steering wheel. Put up to 40 lbf (178 N) pull on a 20-inch diameter steering wheel after the axle stop is contacted.
11. Set the upper poppet.
    - 11.1 Turn the steering wheel in the opposite direction (the end of the timing mark away from the adjusting screw) until the other axle stop is contacted.
    - 11.2 Pull hard on the steering wheel. Put up to 40 lbf (178 N) pull on a 20-inch diameter steering wheel.

Poppet Adjustment on a Single Gear



04/19/2002 f461925

1. Valve Housing Capscrew
2. Dirt and Water Seal
3. Retaining Ring
4. Input Shaft Seal
5. Valve Housing
6. Auxiliary Port O-Ring (2)
7. Auxiliary Port Plug (2)
8. Relief Valve
9. O-Ring
10. Relief Valve Cap
11. Valve Housing O-Ring
12. Bearing Assembly
13. O-Ring
14. Seal Ring
15. Input Shaft Assembly
16. Thrust Bearing
17. Thrust Washer
18. Seal Ring
19. O-Ring
20. Bearing Adjuster
21. Adjuster Locknut
22. O-Ring
23. Seal Ring
24. Push Tube
25. Poppet Spring
26. Poppet
27. Poppet Seat and Sleeve Assembly
28. Rack Piston
29. Ball
30. Ball Return Guide
31. Cap Seal
32. Ball Return Guide Cap
33. Torx® Capscrew
34. Gear Housing
35. Dirt and Water Seal
36. Grease Fitting
37. Automatic Bleed Plug
38. Poppet Adjusting Screw
39. Poppet Adjusting Screw Nut
40. Poppet Fixed Stop Screw
41. Roller Bearing
42. Output Seal
43. Sector Shaft Assembly
44. Sector Shaft Adjusting Screw
45. Washer
46. Roller Bearing
47. Side Cover O-Ring
48. Side Cover Assembly
49. Vent Plug, Side Cover
50. Adjusting Screw Jam Nut
51. Capscrew

Fig. 1, PCF Steering Gear

11.3 Release the steering wheel and shut off the engine.

12. Loosen the nut and back out the adjusting screw until the adjusting screw is one inch (2.5 cm) past the nut. Tighten the nut against the housing.

⚠ CAUTION

Do not use a power grease gun to add grease to the sector shaft bearing. Doing so could damage the high pressure seal and contaminate the hydraulic fluid.

13. Set the lower poppet.

13.1 Start the engine and let it idle.

13.2 Turn the steering wheel in the original direction (the end of the timing mark is toward the adjusting screw) until axle stop contact is made.

13.3 Hold the steering wheel in this position with up to 40 lbf (178 N) pull for 10 seconds, then release. Repeat this hold-and-release process as many times as necessary while completing the next step.

14. Position the adjusting screw.

14.1 With the steering wheel held tightly at full turn, loosen the nut and hold it in place with a wrench.

14.2 Using an allen wrench and finger pressure only, turn the adjusting screw clockwise until the allen wrench stops. Do not attempt to turn the adjusting screw in any farther. Pause the turning-in process each time the driver releases the steering wheel. Continue turning only while the steering wheel is held at full turn.

IMPORTANT: The length of the adjusting screw beyond the nut must not be more than 1-1/16 inch (27 mm) for proper thread engagement.

NOTE: The length of the adjusting screw beyond the nut may be different for each vehicle.

14.3 Back off the adjusting screw 3-1/4 turns and tighten the nut 35 lbf·ft (47 N·m).

15. The poppets have now been completely reset. Check the power steering reservoir and fill if necessary.

16. Lower the vehicle and remove the chocks from the tires.

Disassembly, Inspection, Assembly, and Final Adjustments

Disassembly

NOTE: Replace all seals, seal rings, and gaskets each time the gear is disassembled.

1. Place the front tires in the straight ahead position. If possible, drive the vehicle in a straight line for a short distance stopping at the spot where the work is to be done. Apply the parking brakes, chock the tires, disconnect the batteries, and open the hood.
2. Remove all dirt from around the fittings and hose connections before removing the steering gear.

IMPORTANT: To avoid resetting the poppets, do not turn the input shaft more than 1-1/2 turns from the center-of-travel position while the drag link is disconnected.

3. Remove the power steering gear. For instructions, see **Subject 100.**

⚠ CAUTION

Never steam clean or high-pressure wash hydraulic steering components. Do not force or abuse closely fitted parts. Use care that the bearing and sealing surfaces are not damaged by the disassembly and assembly procedures. Failure to follow these precautions could result in damage to the components.

4. Clean and dry the steering gear before beginning to disassemble it.
5. As you disassemble the gear, clean all parts in clean, OSHA-approved solvent and use only air to blow dry the parts.
6. With the input shaft horizontal and the side cover and valve housing accessible, put the steering gear in a vise with the clamps firmly against the housing mounting flange or boss.

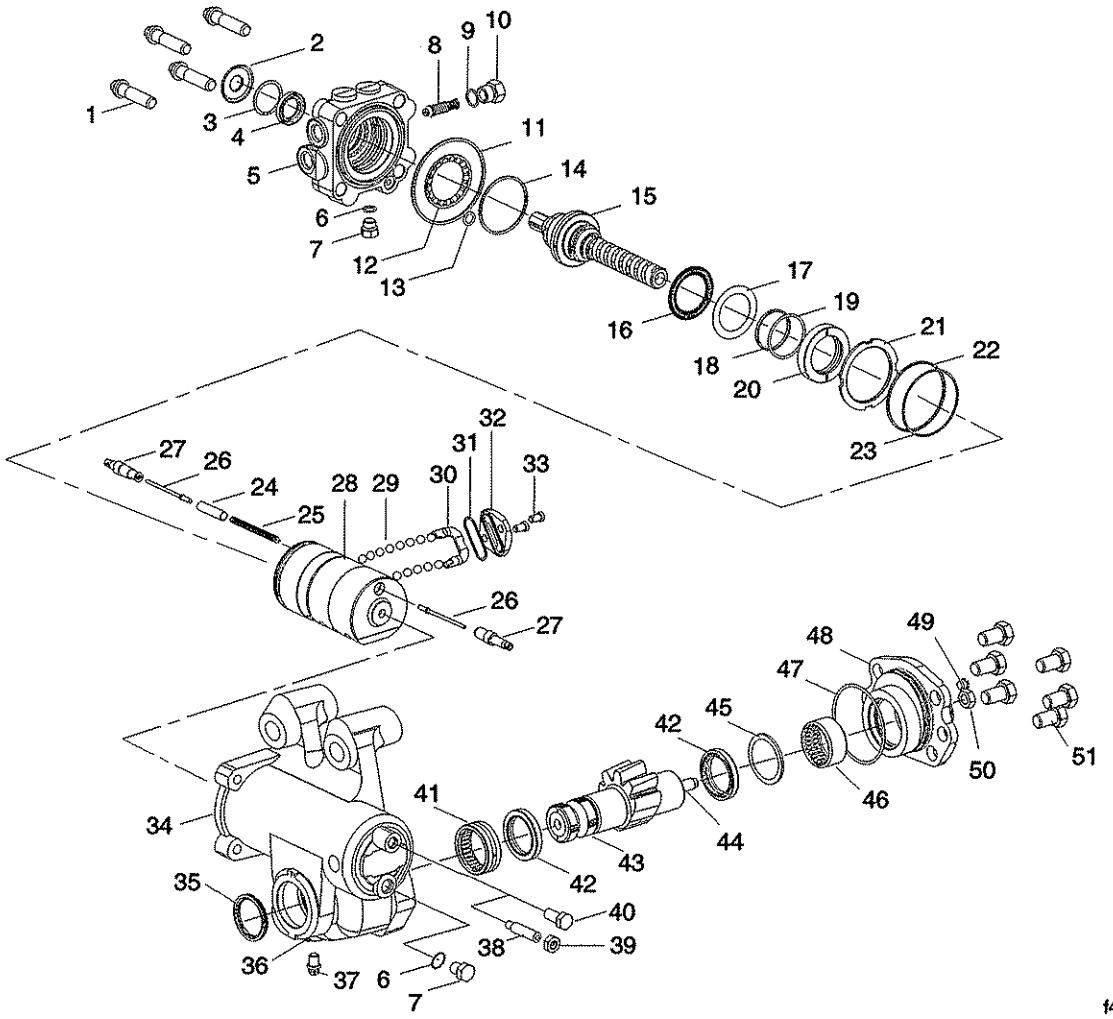
IMPORTANT: Do not clamp against the body of the housing. If the mounting boss or flange is not accessible, fabricate and attach a mounting plate to the housing mounting bosses.

7. Place a drain pan under the gear and remove the plugs from the hydraulic ports.
8. Rotate the input shaft until the timing mark on the end of the sector shaft is in line with the timing mark on the end of the housing. The sector shaft is now positioned for removal.
9. Remove any paint or corrosion from the exposed area of the sector shaft.
10. Tape the serrations and bolt groove of the sector shaft with one layer of masking tape. The tape should not extend on to the sector shaft bearing diameter.
11. Remove the adjusting screw jam nut, item 50 in **Fig. 1.**
12. Remove the capscrews that attach the side cover to the housing.
13. Remove the side cover and sector shaft assembly from the gear. Start the cover and sector shaft assembly removal by lightly tapping the end of the shaft with a soft mallet.
14. Remove and discard the vent plug, item 49 in **Fig. 1.**
15. Remove and discard the side cover O-ring, item 47 in **Fig. 1.**
16. Turn the sector shaft adjusting screw, item 44 in **Fig. 1**, clockwise through the side cover and pull the sector shaft out of the side cover.

IMPORTANT: Take care not to damage the bore or bearing when removing the output seal.

17. Clamp the side cover in a vise. Place a 3/8-inch drive socket in the center of the side cover. Using the socket for support, pry out the output seal with a rolling head pry bar. Discard the seal and remove the socket. Remove the washer.
18. Inspect the sector shaft assembly for damaged adjusting screw threads. The retainer must be securely staked in place. The adjusting screw must rotate by hand with no perceptible end play.
19. If equipped with a relief valve, remove the relief valve cap, the O-ring, and the relief valve from the valve housing. Discard the O-ring.
20. Remove the dirt and water seal, item 2 in **Fig. 1**, from the input shaft assembly. Save this seal to determine the correct size of the new seal.
21. Clean any paint or corrosion from the exposed area of the input shaft

Disassembly, Inspection, Assembly, and Final Adjustments



04/19/2002 f461925

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2. Dirt and Water Seal
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6. Auxiliary Port O-Ring (2)
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9. O-Ring
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11. Valve Housing O-Ring
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13. O-Ring
14. Seal Ring
15. Input Shaft Assembly
16. Thrust Bearing
17. Thrust Washer
18. Seal Ring
19. O-Ring
20. Bearing Adjuster
21. Adjuster Locknut
22. O-Ring
23. Seal Ring
24. Push Tube
25. Poppet Spring
26. Poppet
27. Poppet Seat and Sleeve Assembly
28. Rack Piston
29. Ball
30. Ball Return Guide
31. Cap Seal
32. Ball Return Guide Cap
33. Torx® Capscrew
34. Gear Housing
35. Dirt and Water Seal
36. Grease Fitting
37. Automatic Bleed Plug
38. Poppet Adjusting Screw
39. Poppet Adjusting Screw Nut
40. Poppet Fixed Stop Screw
41. Roller Bearing
42. Output Seal
43. Sector Shaft
44. Sector Shaft Adjusting Screw
45. Washer
46. Roller Bearing
47. Side Cover O-Ring
48. Side Cover
49. Vent Plug, Side Cover
50. Adjusting Screw Jam Nut
51. Capscrew

Fig. 1, PCF Steering Gear

22. Remove the four valve housing capscrews and remove the rack piston. Place the rack piston on a clean cloth.

IMPORTANT: The set position of the poppet seat and sleeve assembly must not be disturbed if the poppets are not going to be replaced or reset during disassembly.

23. Remove and discard the O-ring and the valve housing O-ring, items 13 and 11 in **Fig. 1**.

⚠ CAUTION

Do not remove the input shaft assembly or the balls from the rack piston until the ball return guides are removed. If this precaution is not followed, the ball return guides will be damaged.

24. Remove and discard the two Torx® capscrews, item 33 in **Fig. 1**. Remove the ball return guide cap and the cap seal. Discard the cap seal.

25. Remove the ball return guide by carefully inserting a screwdriver between the rack piston and guide.

NOTE: Left-hand ball return guide halves are plated with copper or zinc chromate for identification. Right-hand guide halves are not plated.

26. Remove the balls from the rack piston by rotating the input shaft assembly until the balls fall out. Place the balls and return guide in a container. Count the balls and make sure all have been removed. There are 31 balls in the rack piston.

IMPORTANT: The balls are a matched set. If any are lost, the set must be replaced.

27. Remove the valve housing and input shaft assembly from the rack piston.

28. Cut and remove the seal ring and O-ring, items 23 and 22 in **Fig. 1**, from the rack piston.

29. Inspect the poppet seat and sleeve assembly.

    29.1 Push on the poppet stem; it should spring back.

    29.2 Push on the poppet seat; it should not move by hand.

    29.3 If the components are bent or broken, if the poppet stems don't spring back, or if the poppet seat moves by hand, replace the poppet seat and sleeve assembly. For instructions, see **Subject 160**.

NOTE: TRW recommends that the poppet seat and sleeve assemblies not be removed unless replacement of the poppet is required.

30. Inspect the valve housing and input shaft assembly for heat damage or bearing roughness. If these conditions are present, if there is excessive internal leakage, or if preload adjustment is required, see the instructions in **Subject 170**.

31. Remove and discard the dirt and water seal, item 35 in **Fig. 1**.

32. Insert a screwdriver through the trunnion opening and carefully push the output seal out without damaging the sealing area of the bore. Discard the output seal.

NOTE: A special hook groove has been machined into the bore to hold the seal in position. Clean out the rubber from the groove prior to installing a new seal.

33. Inspect the roller bearing for brinelling or spalling. If the roller bearing needs to be replaced, see the instructions in **Subject 180**.

34. Inspect the following components for damage. If they are damaged, see the instructions in **Subject 190**.

    - poppet fixed stop screw
    - poppet adjusting screw and nut
    - automatic bleed plug
    - manual bleed screw
    - auxiliary port plug and O-ring

Inspection

⚠ WARNING

If one of the conditions in Table 1 is found in one component of the steering gear, inspect all components carefully for signs of impact damage. Replace the components if you suspect impact damage. Failure to replace all damaged components could result in a serious vehicle accident.

Disassembly, Inspection, Assembly, and Final Adjustments

Conditions in the Steering Gear That Indicate Impact Damage	
Condition	**Area**
Brinelling	Ball track grooves of rack piston
	Ball track grooves of worm screw
	Bearing area of sector shaft
	Thrust washer and bearing in valve housing
	Ball cup and bearing in valve housing
Cracks or Breaks	Bearing area of sector shaft
	Sector shaft teeth
	Rack piston teeth
	Housing
	Thrust washer and bearing in valve housing
	Worm screw
	Ball cup and bearing in valve housing
Twisted Serrations	Output shaft serrations

Table 1, Conditions in the Steering Gear That Indicate Impact Damage

1. Make sure all sealing surfaces and seal cavities are free of nicks and corrosion. Any nicked or corroded surface requires part replacement to ensure proper sealing.
2. Inspect the rack piston teeth for cracks or damage. If teeth are damaged, replace the rack piston, the sector shaft, and the set of balls.
3. Inspect the rack piston ball track grooves for brinelling or spalling. If either condition exists, replace the input shaft assembly, the valve housing, the rack piston, and the balls.
4. Inspect the sealing area of the input shaft assembly for nicks and damage. Inspect for discoloration from excess heat. Inspect the input shaft ball track grooves for brinelling or spalling. If any of these conditions exist, replace the:
   - input shaft
   - worm/valve assembly
   - valve housing
   - balls
   - rack piston
5. Inspect the gear housing cylinder bore. Some scoring marks are normal. If there was internal leakage greater than 1.2 gpm (4.5 L/min), make sure there are no damaged seals before replacing the housing.
6. Inspect the valve housing mating surface for nicks that would prevent proper sealing. Replace the gear housing if these nicks are present and cannot be easily removed with a fine-tooth flat file without changing the dimensional characteristics.
7. Inspect the roller bearing in the side cover assembly for brinelling or spalling. If either condition exists, replace the side cover assembly.
8. Inspect the sector shaft bearing and sealing areas and sector teeth contact surfaces for brinelling, spalling, or cracks. Run the end of you fingernail across these areas to detect steps. Remove the masking tape from the shaft and inspect the shaft for twisted or damaged serrations. If any of these conditions exist, replace the sector shaft.

NOTE: A replacement sector shaft comes with the adjusting screw and retainer.

Assembly

NOTE: Use the bearing and seal tool, PN J37071, in the following two steps.

1. Install a new output seal on the short end of the bearing and seal tool so that the lip with the garter spring is toward the shoulder of the tool. Working from the side cover side of the housing, pilot the bearing and seal tool into the washer and bearing and press with 100 to 800 lb (445 to 3560 N) until the seal is seated firmly.
2. Using the long end of the bearing and seal tool, install the dirt and water seal, item 35 in **Fig. 1**, making sure it is not distorted or twisted.

IMPORTANT: Press the seal only until it seats against the bearing; do not press it in farther.

3. Pack the roller bearing seal, the output seal, and the dirt and water seal liberally with clean, high temperature industrial grease, Exxon Polyrex® EP2 grease (PN 045422).

4. Lightly oil the valve housing O-ring, item 11 in **Fig. 1**, and install the O-ring in the mounting face groove of the valve housing.
5. Lightly oil a new seal ring, item 14 in **Fig. 1**, and install the seal ring in the valve housing mounting face groove.
6. Install a new O-ring, item 22 in **Fig. 1**, and then a seal ring, item 23, on the rack piston. Do not overstretch the rings as they're being installed. Do not allow the seal ring to become twisted.
7. Apply clean oil to the gear housing cylinder bore. Place the rack piston in the housing with the ball return guide holes up.
8. Install the input shaft assembly in the rack piston close to maximum depth without the valve housing making contact with the poppet stem. Insert two 14 mm x 2.0 mm All Threads through the lower valve housing mounting holes and tighten them to support the worm and valve assembly. Line up the rack piston ball guide holes with the worm ball track grooves by rotating the input shaft.
9. Install the ball return guide in the rack piston until seated. Rotate the input shaft slightly if necessary.

⚠ WARNING

Do not seat the ball return guide with a hammer. Damage to the guide can result in subsequent lockup or loss of steering, resulting in personal injury or property damage.

IMPORTANT: If a new rack piston, input shaft, or input shaft assembly is being installed, the balls must be replaced. The balls in a service ball kit are sized to function in the ball track guide path as altered by component replacement.

When using a service ball kit, use the correct quantity of balls. There are 31 balls in the PCF60 steering gear.

NOTE: Hold the ball return guide firmly in place while performing the following step.

10. Insert as many balls as you can through the hole in the top of the ball return guide. Rotate the input shaft to pull the balls down and around the ball track guide path. Continue until the correct number of balls is in the ball track guide path.

    If the ball guide becomes unseated (raised) at any time, start the procedure again beginning with the previous step.

⚠ WARNING

Hold down the ball return guide until the ball return guide cap is installed. Failure to hold the guide will result in a trapped ball or balls, which could cause a vehicle accident resulting in personal injury or property damage.

⚠ CAUTION

Do not allow the valve housing to contact the poppet stem or move more than 2.5 inches (64 mm) from the upper end of the rack piston during these procedures. This could incorrectly reset the poppet or back out the input shaft assembly beyond the closed ball loop, trapping the balls.

⚠ CAUTION

Remove any fluid present in the two screw holes. Fluid in these holes could cause improper clamp load when torquing the ball return guide cap.

11. Install a new cap seal in the groove of the ball return guide cap. Make sure the seal makes full contact with the rack piston surface. Install two new Torx capscrews and torque each capscrew alternately until a final torque of 18 lbf·ft (24 N·m) is reached.

IMPORTANT: The cap seal is greased to hold the seal in the groove while it is assembled. Be sure not to trap the seal outside of the groove during assembly.

12. Rotate the input shaft from one end of travel to the other without contacting the poppet stem to the valve housing and without moving the valve housing face more than 2.5 inches (64 mm) from the input end (upper end) of the rack piston. If you cannot rotate the input shaft, remove the balls and install them again.

⚠ WARNING

If a gear is installed on a vehicle when the input shaft is not able to be rotated, the gear will not function correctly. Steering and gear failure may

Disassembly, Inspection, Assembly, and Final Adjustments

result, possibly causing personal injury or property damage.

13. Apply clean oil to the seal ring, item 23 in **Fig. 1**, on the rack piston. Make sure there is a space of 3/8 to 1/2 inch (10 to 13 mm) between the valve housing and the poppet stem to prevent poppet contact at either end. Remove the All Threads and push the rack piston into the housing with the rack piston teeth toward the sector shaft cavity. Line up the valve housing cylinder feed hole with the gear housing feed hole. Make sure both O-rings in the valve housing remain in position.

IMPORTANT: Do not damage the seal ring while installing the rack piston in the housing.

IMPORTANT: The poppet seat and sleeve assembly must not bottom against the internal poppet stops in the steering gear until the gear is installed on the vehicle and the poppet adjustment procedures are performed.

14. Lubricate and install the four valve housing capscrews in the housing. Torque the capscrews 118 to 138 lbf·ft (160 to 187 N·m).

15. If the gear is equipped with a relief valve, install a new O-ring on the relief valve cap. Install the small end of the tapered spring on the pin on the relief valve cartridge and install the relief valve with the large end of the tapered spring end first in the relief valve cap cavity. Turn the relief valve cap into the valve housing and torque 30 lbf·ft (41 N·m).

⚠ CAUTION

The caged bearing assembly is sealed and will not receive lubrication from the hydraulic fluid in the gear. Failure to use the proper grease could result in premature bearing wear.

16. Apply a generous amount of Exxon Polyrex EP2 grease (PN 045422), and **only** this type of grease, to the caged bearing assembly in the side cover. Then install the washer, item 45 in **Fig. 1**, on top of the bearing.

NOTE: Use bearing and seal tool PN J37071.

17. Grease and install a new output seal on the installation tool so that the side with the garter spring is against the shoulder of the tool. Pilot the tool into the side cover with a force of 100 to 800 lb (445 to 3560 N) until it is seated against the bearing or bushing.

IMPORTANT: Make sure the outside diameter of the seal and the inside diameter of the bore are free from grease and dust for proper engagement of the seal.

18. Apply a generous amount of Exxon Polyrex EP2 grease (PN 045422) to the short bearing area of the sector shaft.

19. Install the sector shaft in the side cover and turn the sector shaft adjusting screw counterclockwise until the screw reaches solid height.

    Rotate the adjusting screw clockwise one-half turn so that the side cover will rotate freely on the sector shaft.

20. Install the sector shaft adjusting screw jam nut, item 50 in **Fig. 1**, on the sector shaft adjusting screw a few threads. Final adjustment will be made later.

21. Press the new vent plug into the hole provided in the side cover until the plug has bottomed.

⚠ WARNING

Do not weld or otherwise plug this hole in a permanent manner. This is a safety vent that functions only if the side cover fails. If the seal fails and the plug cannot vent, the steering gear may lockup or malfunction possibly resulting in personal injury or property damage.

22. Apply clean oil to the new side cover O-ring, item 47 in **Fig. 1**, and install it on the side cover.

⚠ WARNING

If the rack piston is not centered when the sector shaft is installed, gear travel will be severely limited in one direction. This could cause an accident possibly resulting in personal injury or property damage.

23. There are four teeth on the rack piston. Rotate the input shaft to position the rack piston so that the space between the second and third tooth is in the center of the sector shaft opening. This will center the rack piston for installation of the sector shaft.

⚠ CAUTION

If the serrations are not properly taped, they will damage the output seal in the housing and cause the seal to leak.

24. Remove all tape on the serrations. Apply one layer of masking tape on the serrations and bolt groove of the sector shaft. Install the sector shaft in the housing. The center tooth of the sector shaft must engage the center space (between the second and third tooth) of the rack piston. Lightly tap on the side cover with a rubber mallet to seat the cover against the housing face.
25. Install the capscrews in positions 3 and 4 on the side cover by hand. Then install the remaining capscrews in the side cover and tighten them in the sequence shown in **Fig. 2**. Lubricate the capscrews and torque 180 to 220 lbf·ft (244 to 298 N·m).

IMPORTANT: If the capscrews must be replaced, use capscrews of the same design, type, and length as those removed.

26. Remove the tape from the sector shaft.
27. Pack the end of the valve housing bore with Exxon Polyrex EP2 grease (PN 045422). Apply more grease to the inside of a new dirt and water seal and install it on the input shaft. Seat the seal in the groove behind the serrations and against the valve housing.

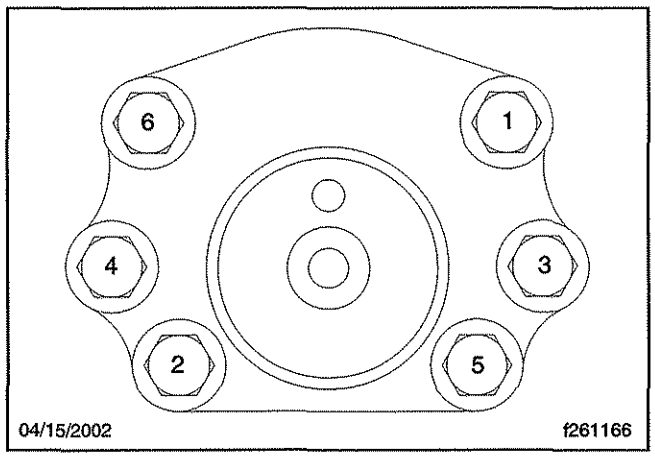


Fig. 2, Capscrew Tightening Sequence

NOTE: This step may have already been completed if the valve housing and input shaft assembly were disassembled for repair.

Final Adjustments

Before installing the steering gear on the vehicle, make the following adjustments.

NOTE: Worm shaft preload adjustment was done when the input shaft was installed in the valve housing during the assembly procedure.

IMPORTANT: When the steering gear is not connected to the steering system, don't turn the input shaft more than 1-1/2 turns from the center position or the automatic poppets could become inoperative when the steering gear is installed on the vehicle. This would require disassembling the gear to position the poppet seat and sleeve assemblies.

1. Using a 3/4- or 11/16-inch socket or box end wrench, center the steering gear by rotating the input shaft until the timing mark on the end of the sector shaft is in line with the timing mark on the end of the housing trunnion.

NOTE: If new or reset poppets are in the gear, they will be moved when the input shaft is turned less than one rotation in either direction from the center position. This will not affect the function of the poppets.

2. With the adjusting screw jam nut loose, turn the sector shaft adjusting screw clockwise to provide 45 to 50 lbf·in (450 to 560 N·cm) of torque to rotate the input shaft through one-half turn each side of center.

NOTE: This step will properly mesh and seat the rack piston and sector shaft for final adjustments.

3. Turn the sector shaft adjusting screw counterclockwise one-half turn and note the maximum torque required to rotate the input shaft through one-half turn each side of center.
4. Turn the sector shaft adjusting screw clockwise to increase the maximum torque noted in the previous step by 7 lbf·in (79 N·cm). Tighten the jam nut firmly against the side cover while holding the adjusting screw in position.
5. Torque the jam nut 43 lbf·ft (58 N·m) and check the input shaft torque again. Adjust the sector shaft

Disassembly, Inspection, Assembly, and Final Adjustments

adjusting screw if the input shaft torque exceeds 40 lbf·in (452 N·cm).

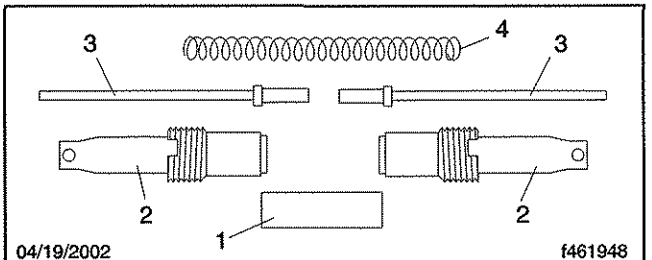
6. Install the steering gear on the vehicle. For instructions, see **Subject 100**.
7. Remove the chocks from the tires.

Replacement

1. Remove the rack piston from the steering gear. For instructions, see **Subject 150.**
2. Place the rack piston in a soft-jawed vise.
3. Place special tool, PN J36452-A, over the seat of the poppet seat and sleeve assembly and engage the special tool in the slots of the threaded sleeve. Hit the end of the tool firmly four or five times with a two-pound sledge hammer to loosen the Loctite®.
4. Place a ratchet on the special tool and remove the seat and sleeve assembly from the rack piston. If the ratchet does not turn easily, strike the special tool again with a hammer. If the engaging tangs won't stay in place while torquing, it may be necessary to hold the tool in place with an arbor press while applying loosening torque.
5. Discard the poppet seat and sleeve assembly. See **Fig. 1.**
6. Remove the two poppets, the spring, and the push tube. See **Fig. 1.**
7. If necessary, remove and discard the second poppet seat and valve assembly.

NOTE: It is possible to reset one poppet seat and sleeve assembly for automatic poppet adjustment while it is in the rack piston if one poppet seat and sleeve assembly and the poppets, spring, spacer rod, and push tube are removed.

8. To reset the automatic poppet adjustment when one poppet seat and sleeve assembly has been left in the rack piston, insert a 3/8-inch (9.5-mm) diameter x 6-inch (152-mm) drill rod down through the poppet seat hole at the opposite end of the rack piston and against the adjuster seat to press the seat in until it bottoms against the adjuster sleeve.



1. Push Tube
2. Poppet Seat and Sleeve Assembly
3. Poppet
4. Spring

Fig. 1, Poppets Components

⚠ CAUTION

Do not allow Loctite or Locquic to get on the adjuster seat component of the poppet seat and sleeve assembly. Failure to follow this precaution, will prevent the poppets from functioning properly.

9. Carefully apply Locquic® T primer to the threads in the poppet holes and to the threads on the new seat and sleeve assemblies. Allow the primer to dry for ten minutes, then carefully apply Loctite RC680 to the same threads.

⚠ WARNING

Wear eye protection when assembling the poppets since the spring loaded poppets could eject and cause personal injury.

10. Place the rack piston in a soft-jawed vise. If the second poppet seat and valve assembly was removed, install a new poppet seat and sleeve assembly, with the slotted end out, into the poppet hole in one end of the rack piston.
11. From the other end of the poppet hole in the rack piston, install one poppet, the poppet spring, push tube, the other poppet, and a new poppet seat and valve assembly. The new components will stack up as shown in **Fig. 2.**

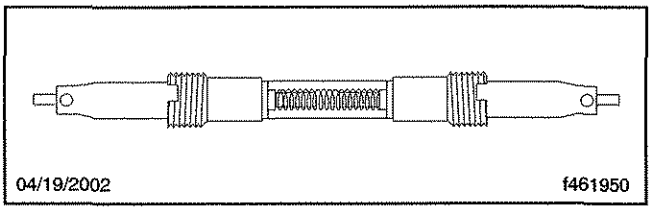


Fig. 2, Poppet Components Assembled

12. Torque the poppet seat and valve assemblies 18 lbf·ft (24 N·m).
13. Install the rack piston in the steering gear. For instructions, see **Subject 150.**

Valve Housing/Input Shaft Disassembly, Inspection, and Assembly

Disassembly

1. Remove the valve housing and the input shaft assembly from the steering gear. For instructions, see **Subject 150**.
2. Place the valve housing, with the input shaft in the upright position, in a soft-jawed vise.
3. Unstake the valve housing where the material was moved into the adjuster locknut slot.
4. Using a roll pin punch and hammer, unstake the adjuster locknut from the bearing adjuster. See **Fig. 1**.
5. Using the adjuster locknut tool (PN J37464), remove the adjuster locknut from the valve housing.
6. Using the bearing adjuster tool (PN J37070), remove the bearing adjuster from the valve housing.
7. Remove and discard the seal ring and O-ring, items 18 and 19 in **Fig. 1**, from the bearing adjuster.
8. Remove the input shaft from the valve housing.
9. Remove the thrust washer and thrust bearing, items 17 and 16 in **Fig. 1**, from the input shaft.

⚠ CAUTION

The input shaft assembly must not be disassembled any further. The components are a select fit at assembly and are available only as part of this subassembly. If disassembled further, the subassembly must be replaced.

10. Remove the bearing assembly, item 12 in **Fig. 1**, from the valve housing.

IMPORTANT: Do not remove the ball cup that the bearing assembly rides on. Do not remove the special spacer seal behind the ball cup.

11. Remove and discard the seal ring, item 14 in **Fig. 1**, from the valve housing.
12. Remove the valve housing from the vise. Turn the valve housing over and remove the retaining ring, item 3 in **Fig. 1**.

⚠ CAUTION

Be careful when removing the input shaft seal to prevent damage to the valve housing seal bore.

13. Using a 1-1/8-inch socket and hammer, remove the input shaft seal, item 4 in **Fig. 1**, from the valve housing. Discard the input shaft seal.

NOTE: The valve housing also utilizes a ball plug for manufacturing purposes that must not be removed.

Inspection

1. Inspect the sealing areas of the input shaft and valve housing for nicks. Run the edge of your fingernail over the sealing surfaces to detect steps. Inspect for discoloration from excess heat. Inspect the input shaft ball track grooves for brinelling or spalling. If any of these conditions exist, the input shaft assembly, valve housing, and balls must be replaced. Replace the rack piston if brinelling or spalling is found.
2. Inspect the rollers in the thrust bearing and the bearing assembly for deterioration. Inspect the thrust washer and ball bearing race in the valve housing for brinelling, spalling, or cracks. Replace all parts that exhibit these conditions.

Assembly

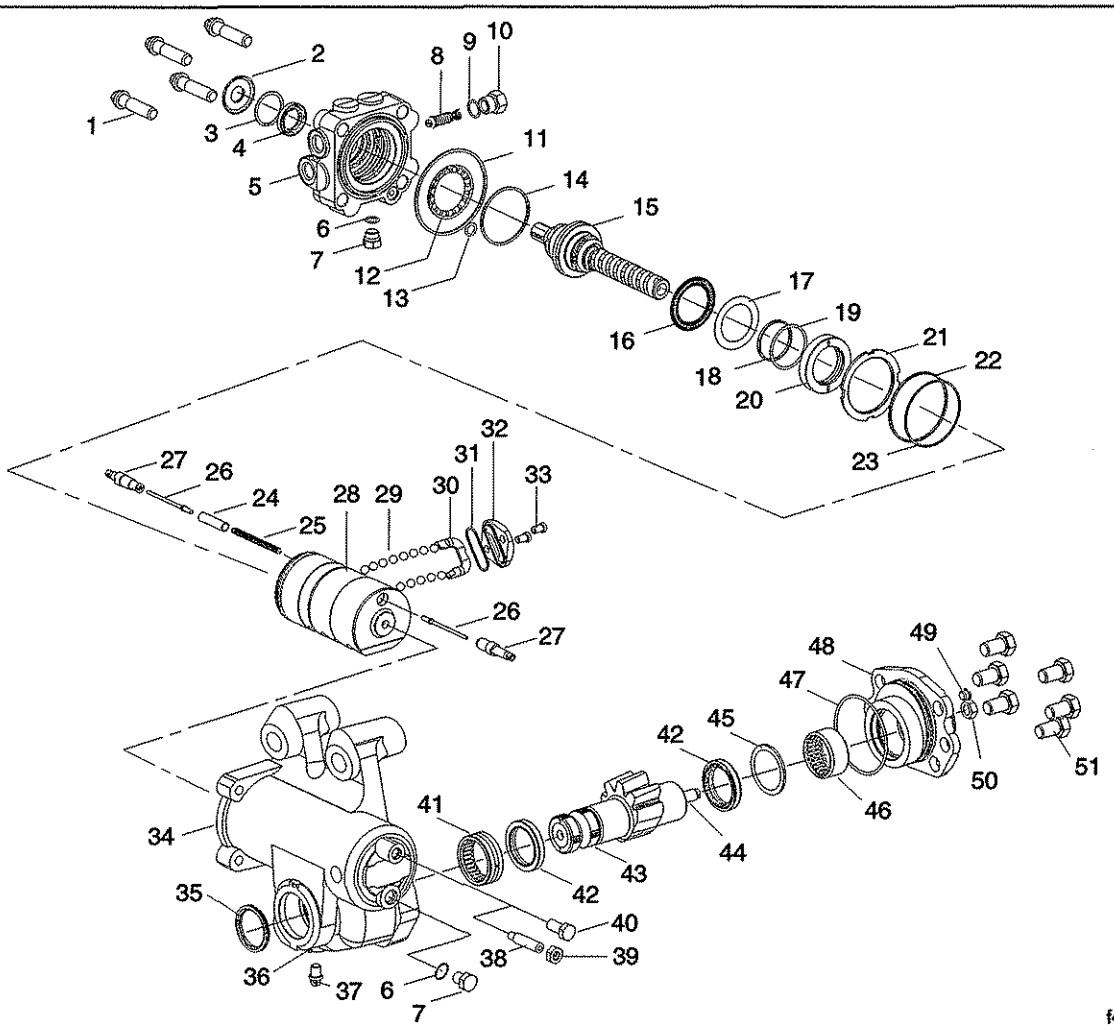
IMPORTANT: Do not clamp the valve housing against the threaded port hole or relief valve hole sealing faces when placing the valve in the vise.

1. Place the valve housing in a vise so the input shaft can be assembled with the worm screw up.
2. Lightly oil a new seal ring and install the seal ring in the large diameter groove in the valve housing. It may be necessary to bend and work the seal ring into the groove. Smooth out the seal ring.

IMPORTANT: The seal ring must be smoothed out to prevent it from damage when the worm screw is installed.

3. Install the bearing assembly in the valve housing. See **Fig. 2** for correct orientation of the bearing assembly.

Valve Housing/Input Shaft Disassembly, Inspection, and Assembly



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1. Valve Housing Capscrew
2. Dirt and Water Seal
3. Retaining Ring
4. Input Shaft Seal
5. Valve Housing
6. Auxiliary Port O-Ring (2)
7. Auxiliary Port Plug (2)
8. Relief Valve
9. O-Ring
10. Relief Valve Cap
11. Valve Housing O-Ring
12. Bearing Assembly
13. O-Ring
14. Seal Ring
15. Input Shaft Assembly
16. Thrust Bearing
17. Thrust Washer
18. Seal Ring
19. O-Ring
20. Bearing Adjuster
21. Adjuster Locknut
22. O-Ring
23. Seal Ring
24. Push Tube
25. Poppet Spring
26. Poppet
27. Poppet Seat and Sleeve Assembly
28. Rack Piston
29. Ball
30. Ball Return Guide
31. Cap Seal
32. Ball Return Guide Cap
33. Torx® Capscrew
34. Gear Housing
35. Dirt and Water Seal
36. Grease Fitting
37. Automatic Bleed Plug
38. Poppet Adjusting Screw
39. Poppet Adjusting Screw Nut
40. Poppet Fixed Stop Screw
41. Roller Bearing
42. Output Seal
43. Sector Shaft Assembly
44. Sector Shaft Adjusting Screw
45. Washer
46. Roller Bearing
47. Side Cover O-Ring
48. Side Cover Assembly
49. Vent Plug, Side Cover
50. Adjusting Screw Jam Nut
51. Capscrew

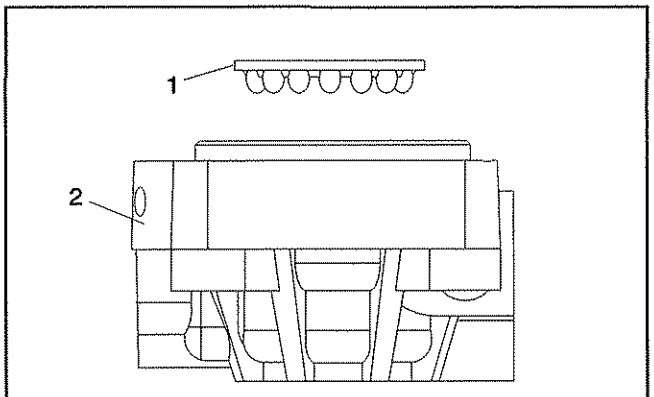
Fig. 1, PCF Steering Gear

Valve Housing/Input Shaft Disassembly, Inspection, and Assembly

4. Dip the input end of the input shaft assembly in oil up to the worm lead. Install the input shaft end of the assembly in the valve housing until it is firmly seated.
5. Apply oil to the thrust bearing and thrust washer, then install the bearing and washer over the ball groove end of the worm screw and seat them against the shoulder of the input shaft assembly.
6. Lightly oil a new O-ring and install it in the bearing adjuster seal groove. Lightly oil a new seal ring and install it in the same bearing adjuster seal groove. Smooth out the seal ring.

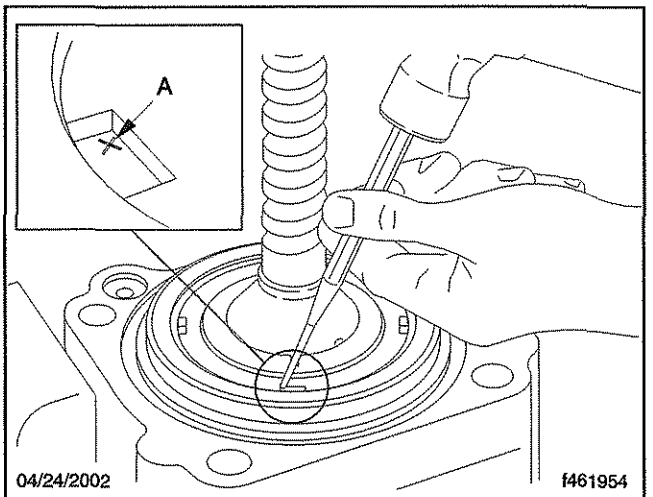
NOTE: Be sure the valve housing, the adjuster locknut, and the bearing adjuster threads are clean and free of any staking burrs that would impede the locknut from turning freely in the valve housing.

7. Lightly oil a new bearing adjuster and install it in the valve housing. Using a torque wrench inserted in the bearing adjuster tool (PN J37070), torque the bearing adjuster 13 lbf·ft (18 N·m). This will seat the components. Back off the adjuster one-quarter to one-half of a turn.
8. Lightly oil a new adjuster locknut and install it on the bearing adjuster with the slightly rounded side down. Tighten slightly to keep the bearing adjuster in place.
9. Reverse the valve housing in the vise so that the worm screw is down. With a pound-force-per-inch torque wrench on the input shaft, note the torque required to rotate the input shaft 360 degrees in each direction. Tighten the bearing adjuster to increase the maximum torque at the input shaft 5 to 10 lbf·in (50 to 110 N·cm) over that which was previously noted.
10. Reverse the valve housing in the vise so that the worm screw is up. Torque the adjuster locknut while holding the bearing adjuster in the position established in the previous step with the adjuster locknut tool (PN J37464). When using a torque wrench in the adjuster locknut tool, the torque wrench reading should be 112 lbf·ft (152 N·m).
11. Check the input shaft torque. It should match the torque measured previously. If the torque specs do not match, repeat the previous two steps.
12. Stake the valve housing in the clockwise-most corner of two opposing slots in the adjuster locknut. See **Fig. 3**. Stake the locknut into the bearing adjuster in two places, 180 degrees apart, at the threaded area. Choose areas that have not been previously staked.
13. After staking, the torque required to rotate the input shaft must be between 5 to 10 lbf·in (56 to 113 N·cm) greater than the torque noted previously. The torque value must not exceed 22 lbf·in (249 N·cm). If necessary, unstake and readjust.
14. Place the valve housing/worm screw assembly in the vise so that the worm screw is down.



1. Bearing Assembly 2. Valve Housing

Fig. 2, Correct Orientation of Bearing Assembly



A. Stake the valve housing in the clockwise-most corner of the slot in the adjuster locknut.

Fig. 3, Stake the Valve Housing

Valve Housing/Input Shaft Disassembly, Inspection, and Assembly

IMPORTANT: Remove any seal material that may have sheared off and is in the seal bore and retaining groove ring.

15. Apply Exxon Polyrex® EP2 grease (PN 045422) to the outside and inside diameters (fill cavity between the lips) of the new input shaft seal and install it, garter spring side first, on the input shaft. Align the seal in the valve housing seal bore.

IMPORTANT: The input shaft seal must be square in the seal bore and installed to the correct depth.

16. Place the seal driver tool (PN J37073) with the smaller end first, on the input shaft and against the seal. Tap the seal installer tool until the tool shoulder is squarely against the valve housing. This will correctly position the seal in the housing bore just beyond the retaining ring groove.

17. Insert the new retaining ring, item 3 in **Fig. 1**, into the retaining ring groove in the valve housing.

18. Pack the end of the valve housing bore around the input shaft with Exxon Polyrex EP2 grease (PN 045422). Apply more of the grease to the inside of a new dirt and water seal and install it on the input shaft. Seat the seal in the groove behind the serrations and against the valve housing.

19. Install the valve housing/input shaft assembly in the steering gear. For instructions, see **Subject 150**.

Replacement

1. Remove the roller bearing, item 41 in **Fig. 1**, from the gear housing. For instructions, see **Subject 150.**
2. Place the long end of the bearing and seal tool, PN J37071–A, against the trunnion end of the bearing and press it out of the side-cover end of the bearing bore. Discard the roller bearing.

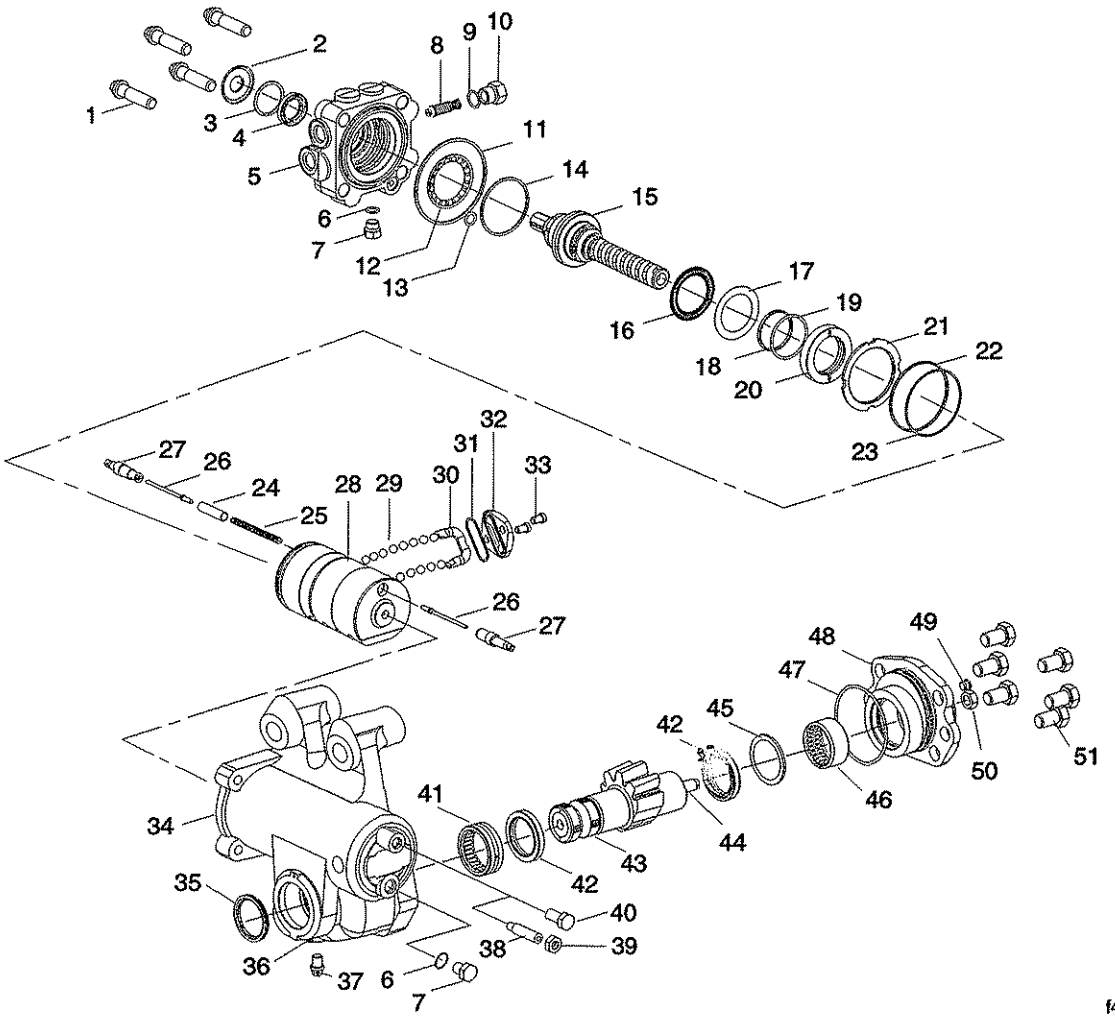
⚠ CAUTION

Use the short end of the bearing and seal tool to press in the roller bearing. If the long end of the bearing and seal tool is used to press in the bearing, the cage on the roller bearing may be damaged.

NOTE: If the unmachined trunnion face is not square, use shims to square it before pressing in the bearing.

3. Using the short end of the bearing and seal tool, press the new roller bearing into the gear housing from the side-cover end of the bearing bore until it is seated against the step bore. Be sure the housing is square with the press base and the bearing is not cocked.
4. Install the side cover on the gear housing. For instructions, see **Subject 150.**

Roller Bearing Replacement



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1. Valve Housing Capscrew
2. Dirt and Water Seal
3. Retaining Ring
4. Input Shaft Seal
5. Valve Housing
6. Auxiliary Port O-Ring (2)
7. Auxiliary Port Plug (2)
8. Relief Valve
9. O-Ring
10. Relief Valve Cap
11. Valve Housing O-Ring
12. Bearing Assembly
13. O-Ring
14. Seal Ring
15. Input Shaft Assembly
16. Thrust Bearing
17. Thrust Washer
18. Seal Ring
19. O-Ring
20. Bearing Adjuster
21. Adjuster Locknut
22. O-Ring
23. Seal Ring
24. Push Tube
25. Poppet Spring
26. Poppet
27. Poppet Seat and Sleeve Assembly
28. Rack Piston
29. Ball
30. Ball Return Guide
31. Cap Seal
32. Ball Return Guide Cap
33. Torx® Capscrew
34. Gear Housing
35. Dirt and Water Seal
36. Grease Fitting
37. Automatic Bleed Plug
38. Poppet Adjusting Screw
39. Poppet Adjusting Screw Nut
40. Poppet Fixed Stop Screw
41. Roller Bearing
42. Output Seal
43. Sector Shaft Assembly
44. Sector Shaft Adjusting Screw
45. Washer
46. Roller Bearing
47. Side Cover O-Ring
48. Side Cover Assembly
49. Vent Plug, Side Cover
50. Adjusting Screw Jam Nut
51. Capscrew

Fig. 1, PCF Steering Gear

Housing Port Plugs, Screws, and Fittings Replacement

Poppet Fixed Stop Screw Replacement

1. If damaged, remove the poppet fixed stop screw, item 40 in **Fig. 1**, and the washer. Discard the washer.
2. Install a new poppet fixed stop screw and torque 48 lbf·ft (65 N·m).

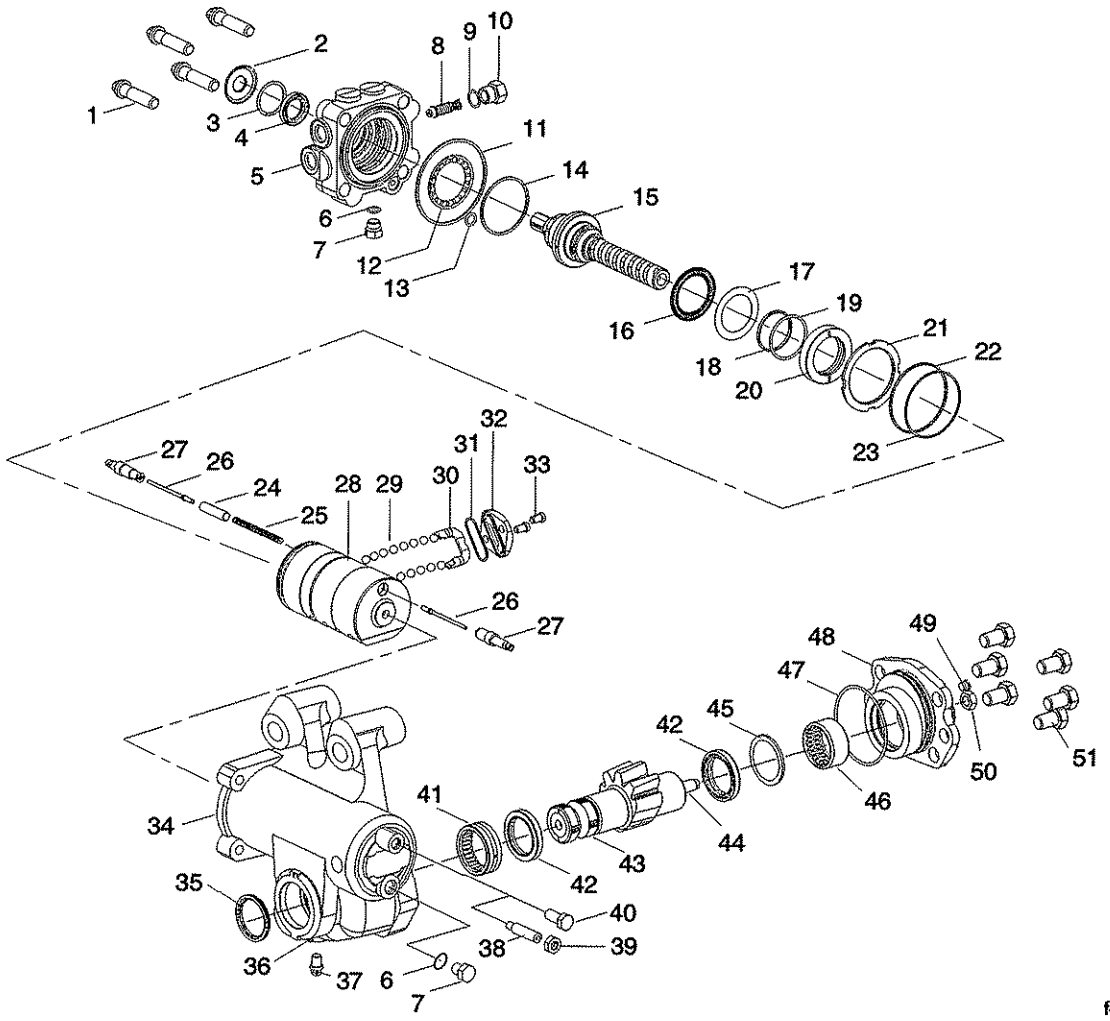
Poppet Adjusting Screw Replacement

1. If damaged, remove the poppet adjusting screw and poppet adjusting screw nut, items 38 and 39 in **Fig. 1**, without allowing the nut to change its position on the screw.
2. Install a new nut on the new poppet adjusting screw matching its position to the nut and screw removed. Torque the nut 35 lbf·ft (48 N·m).

Automatic Bleed Plug and Auxiliary Port Plug Replacement

1. If damaged, remove the automatic bleed plug, item 37 in **Fig. 1**.
2. Install a new automatic bleed plug and torque the plug 48 lbf·ft (65 N·m).
3. If damaged, remove the auxiliary port plug and the auxiliary port O-ring, items 7 and 6 in **Fig. 1**.
4. Install a new auxiliary port plug and auxiliary port O-ring in the gear housing or valve housing and torque the plug 30 lbf·ft (41 N·m).

Housing Port Plugs, Screws, and Fittings Replacement



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1. Valve Housing Capscrew
2. Dirt and Water Seal
3. Retaining Ring
4. Input Shaft Seal
5. Valve Housing
6. Auxiliary Port O-Ring (2)
7. Auxiliary Port Plug (2)
8. Relief Valve
9. O-Ring
10. Relief Valve Cap
11. Valve Housing O-Ring
12. Bearing Assembly
13. O-Ring
14. Seal Ring
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46. Roller Bearing
47. Side Cover O-Ring
48. Side Cover Assembly
49. Vent Plug, Side Cover
50. Adjusting Screw Jam Nut
51. Capscrew

Fig. 1, PCF Steering Gear

Post-Service Checks

After power steering components have been worked on and before the vehicle is placed into service, the following items must be checked.

⚠ WARNING

Failure to check the following items could result in damage to the power steering system. This could cause a loss of hydraulic assist, which could cause personal injury or property damage.

1. Operate the engine at low idle while turning the steering wheel through several full left and right turns. With the engine running and the power steering system at operating temperature, turn the steering wheel slowly from stop to stop while checking the power steering reservoir for frothing or a change in the fluid level, a sign that air is trapped in the system. If air is present, inspect the system for leaking hoses or loose fittings. Replace the hoses or tighten the fittings as necessary. Bleed the air from the system.
2. With the engine turned off and warm, check the power steering reservoir fluid level using the instructions in **Group 46** of the *Century Class Trucks Maintenance Manual.*
3. At full-left and full-right wheel cuts, be sure the axle stops on the rear-side of the spindle are set so there is at least 1/2-inch (13-mm) clearance between the tires and any fixed components that are attached to the vehicle. Clearance between moving components should be 3/4 inch (19 mm). If clearance is less than the above, reset the axle stops.
4. Check that the poppets are set correctly. If needed, adjust them. For instructions refer to **Subject 140.**
5. If there are still problems with the power steering system, see **Troubleshooting 300** and perform the steering system hydraulic tests as instructed; otherwise, go to the next step.
6. Test drive the vehicle or take a ride with the driver. Check the steering wheel spoke position. If during straight-ahead driving on a level road the steering wheel spokes are not within ±10 degrees of the 9 o'clock and 3 o'clock positions, remove the steering wheel and reposition it.

Troubleshooting

If there is a complaint about the steering system, do the checks below before servicing the steering gear or pump. This procedure is intended as a general guideline for the mechanic or technician to follow when diagnosing steering complaints.

The first step is always to talk to the driver. Get a detailed explanation of what the problem is and when it happens. Ask about any repairs, modifications, or prior adjustments. Then, if the truck is roadworthy, test drive it or ride with the driver and try to duplicate the problem.

After identifying the complaint, see the appropriate box in **Table 1** that best fits the complaint. Form SD–94, "Checklist for Troubleshooting Hydraulic Power Steering System Performance," should also be used to record test information. Form SD–94 can be ordered through your dealer. See **Fig. 9** and **Fig. 10**. Dealers can order form SD–94 through the TAO electronic mail system.

- At the TAO Mail Menu, key in B for bulletin boards.
- Tab down to Pub–Forms–FTL and key in L for list.
- At Freightliner Manuals Order Form, key in U.

If you don't have access to the TAO electronic mail system, contact Publishing Distribution at (503) 745-7343.

The table on the form will refer you to a series of checks or tests to do for each type of complaint. The easiest and least costly checks are listed first. By doing the checks in order, starting with the lowest number, you can avoid unnecessary labor and expense. Instructions for doing the checks are given on the following pages. Each numbered step in the instructions corresponds with the diagnostic checks in **Table 1**. The numbers and checks in this table correspond to the numbered steps that follow.

Troubleshooting and Diagnostic Steps										
Step*	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Complaint	**Tire Press./ Vehicle Load**	**Fifth Wheel Lube**	**Vehicle Align-ment**	**Loose/ Binding Compo-nents**	**Noise**	**System Operat-ing Temp.**	**System Leaks or Restric-tions**	**Pump Perfor-mance**	**Gear Poppet Adjust-ment**	**Gear Internal Leakage**
Hard or Heavy Steering	•	•		•		•	•	•	•	•
Low Assist										
Binding	•	•		•		•	•	•	•	•
Locking										
Occasion-al Loss of Assist										
Reduced Wheel Cut									•	
Vehicle Pulls to One Side	•		•					•		
Darting/ Oversteer	•	•	•	•						
Vehicle Wanders										
Noisy Steering					•		•	•		

Troubleshooting and Diagnostic Checks

Troubleshooting and Diagnostic Steps										
Step*	1	2	3	4	5	6	7	8	9	10
Complaint	Tire Press./ Vehicle Load	Fifth Wheel Lube	Vehicle Align-ment	Loose/ Binding Compo-nents	Noise	System Operat-ing Temp.	System Leaks or Restric-tions	Pump Perfor-mance	Gear Poppet Adjust-ment	Gear Internal Leakage
Steering Gear External Seal Leaks						•	•	•		
Excessive Heat										

* The numbers in this table correspond to the numbered steps in the diagnostic checks.

Table 1, Troubleshooting and Diagnostic Steps

Diagnostic Checks

1. Check tire pressure and load.

   1.1 Check the tire pressure. Low pressure causes increased steering effort due to extra friction with the road surface. Check the tires for damage or erratic wear. Make sure the tires on each side of the front and rear axles are inflated to the correct pressure. Unequal tire pressure causes unequal friction between the tire and the road. This can cause pulling to one side. Correct the pressures if needed. See **Fig. 1**.

   1.2 Check whether duplex or oversized tires have been installed and that the tire sizes are correctly matched. Extra tire width causes increased steering effort due to extra friction with the road surface. Also, the power steering gear poppets will need to be adjusted if the axle stops were turned out to reduce wheel cut due to the change in tires. See **Subject 140** for instructions.

   1.3 Determine whether the vehicle is operated at or over the rated load. Increased load causes greater steering effort. It may be necessary to modify the power steering, wheels, tires, or springs.

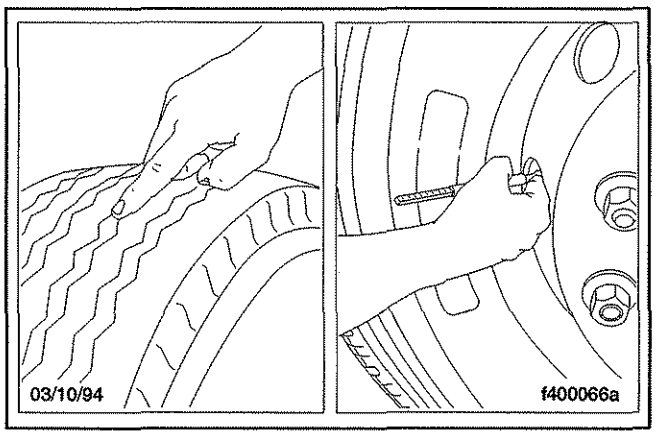


Fig. 1, Check the Tire and the Tire Pressure

2. Check the fifth wheel.

   See if the fifth wheel is adequately lubricated. A dry fifth wheel plate makes it difficult to change direction. See **Fig. 2**. Check the plate surface for burrs, gouges, or irregularities.

3. Check the wheel bearing adjustment and axle alignment.

   3.1 Check wheel bearing adjustment. See **Group 33** and **Group 35** for instructions.

   3.2 Check the front and rear axles for correct alignment. Adjust them back to specifications if necessary. See **Group 33** and **Group 35** for instructions.

4. Check for loose or binding components.

   Check whether any steering components are loose or binding, need maintenance, or need adjustment as follows:

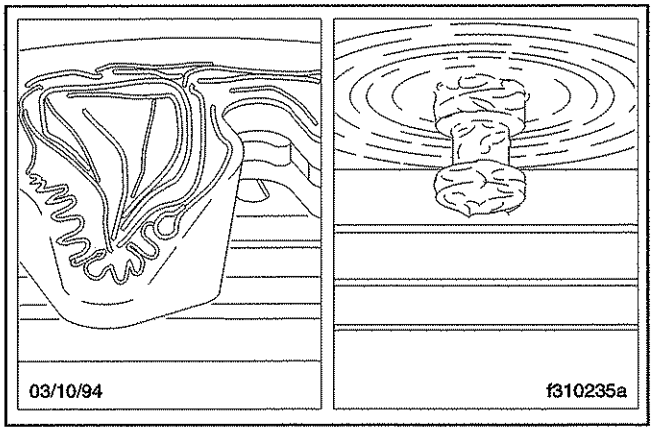


Fig. 2, Check the Fifth Wheel

4.1 Lubricate the drag link, tie rods, and knuckle pins. See the applicable groups in the *Century Class Trucks Maintenance Manual.*

4.2 Chock the rearmost tires and raise the front tires off the ground. With the engine shut down, turn the steering wheel and check for looseness or binding. Make sure all components are free to move but are not excessively loose.

4.3 Check the steering driveline U-joints for looseness or binding. For instructions, see **Group 46** in the *Century Class Trucks Maintenance Manual.*

4.4 Check for correct steering driveline phasing. See **Fig. 3**. Reset the phasing if needed.

4.5 Check the sector shaft adjustment. See **Subject 130** for instructions.

⚠ WARNING

Failure to connect the input yoke and the pitman arm and to tighten all fasteners to the prescribed torque value can cause loss of steering and vehicle control.

4.6 With the engine off, chock the rearmost tires and place the front tires on radius plates (turntables). Disconnect the drag link from the steering arm.

By hand, pull the tire to one axle stop and release. The tire should self-return to almost straight ahead. See **Fig. 4**. Repeat in the opposite direction. If the tire does not return to near straight ahead, check for a binding or lack of lubrication problem in the steering axle kingpin bushings or tie rod linkage. Connect the drag link and tighten the castle nut and install a new cotter pin. See the drag link section in this group.

⚠ CAUTION

Do not steer the gear with the linkage removed, as maladjustment of automatic poppets may result.

⚠ WARNING

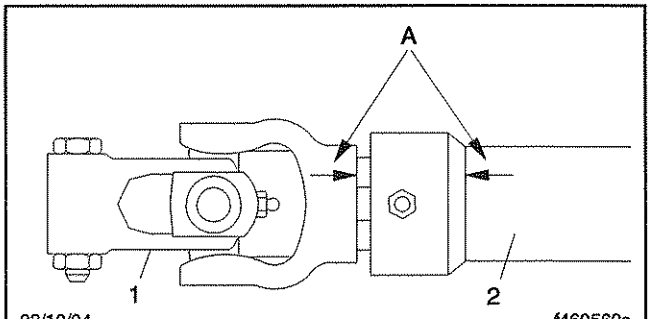
Failure to connect the drag link and the steering arm and to tighten all fasteners to the prescribed torque value can cause loss of steering and vehicle control, which can cause personal injury and property damage.

4.7 Visually inspect all suspension fasteners and components for wear or looseness.

5. Check for noise.

NOTE: Noises from the power steering system do not necessarily mean there is a problem. Some noises are normal and are the result of proper operation. See **Table 2.**

6. Test the system operating temperature.



A. Align arrows.
1. Lower End Yoke
2. Driveline Tube and Yoke Assembly

Fig. 3, Check for Correct Steering Driveline Phasing

Troubleshooting and Diagnostic Checks

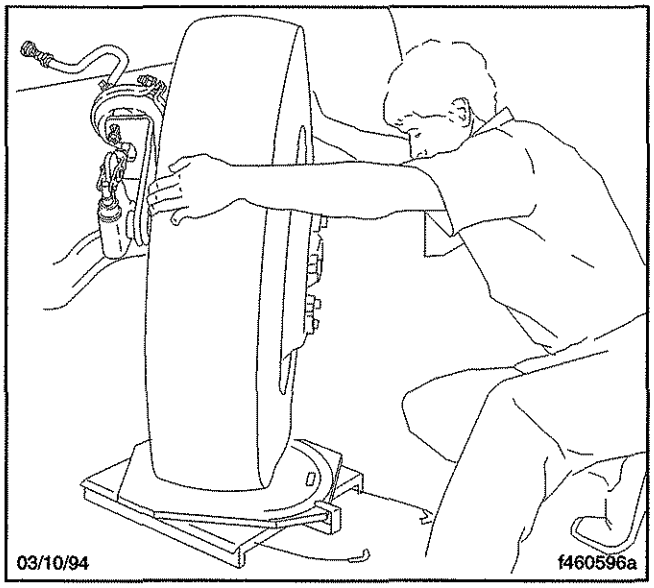


Fig. 4, Pull the Tire to One Axle Stop

6.1 Park the vehicle outside.

6.2 Check for correct fluid level. If required, add fluid.

6.3 Place a thermometer in the fluid reservoir to monitor fluid temperature.

6.4 Run the vehicle at governed rpm for 40 minutes to bring the fluid to an elevated temperature. Check and record fluid temperature on the checklist (form SD–94) at the start of the 40 minute test and at 10, 20, 30, and 40 minutes.

Do not allow the temperature to exceed 250°F (121°C). If this temperature is exceeded, stop the 40 minute test and record the last noted temperature on the checklist.

6.5 If the temperature does not exceed 250°F (121°C) during the 40 minute test, excessive system heat is probably not the cause of the complaint. Go on to the next test for the complaint. See **Table 1.**

6.6 If at any time the temperature exceeded 250°F (121°C), the system is operating at excessive temperature levels and steering system performance and life may be affected. Damage to hoses, seals, and other components may result if the vehicle is operated at excessive steering system temperatures.

6.7 Excessive system restrictions or excessive pump flow may be the cause of the complaint. Go on to the next test for the complaint. See **Table 1.**

Power Steering System Noises	
Symptom	**Action to Take**
Growling or Other Abnormal Steering Noise	Check the fluid level. Check for air bubbles and foam. Check for hose and fitting leaks. Add fluid if needed. If the fluid has air, check for inlet tube/hose leaks. Correct all leaks.
A Change from the Usual Pump Sound	Check the power steering fluid reservoir. Check for air bubbles and foam in the fluid. If the fluid has air, check for inlet tube/hose leaks. Correct all leaks.
Clicking Noise During a Turn	Check for loose steering components. Check the front suspension for insufficient spring pin shims. Tighten any loose steering components. Add front spring pin shims if needed.

Power Steering System Noises	
Symptom	**Action to Take**
Hissing When the Steering Wheel Is at or Near Full Turn	Fluid flowing past a poppet valve makes a hissing noise. This is normal. No action is needed.
Hissing at Less Than Full Turn	Perform step 9, steering gear poppet relief valve and axle stop adjustment.

Table 2, Power Steering System Noises

7. Check for leaks, restrictions, and test system back pressure.

   7.1 Check for correct fluid level. If required, add fluid.

   7.2 The inspection and test must be done with the power steering fluid at an operating temperature of 150 to 160°F (66 to 71°C). With the engine at idle, monitor the fluid temperature with a thermometer in the fluid reservoir. If the fluid is too cold, raise the temperature by turning the steering wheel from stop to stop until the desired temperature is reached.

   7.3 With the engine at idle, visually inspect all hoses and fittings for signs of kinked or collapsed hoses or leaking fittings. Visually inspect all external seals. Repair all leaking fittings and replace parts as required. Replace any leaking seals. Inspect the seal bores and sealing surfaces for scrapes or burrs. Be sure the seals are installed correctly using the recommended tools. If the steering gear input shaft seal is excessively hard, perform step 6, test the system operating temperature, if not already done.

   7.4 Install a low pressure gauge 200 to 300 psi (1378 to 2069 kPa) maximum between the pressure line and the pump (location P2). See **Fig. 5**.

⚠ CAUTION

Don't move the steering wheel or allow the system pressure to exceed the rating of the gauge during the following procedure or damage to the gauge may result.

   7.5 Run the engine at idle and check for correct fluid level. If required, add fluid. If bubbles or foam appear in the reservoir, check the hose fittings for looseness or leaks.

   7.6 With the engine at idle, read the total system back pressure on the pressure gauge. Record the reading on the checklist (form SD–94).

   7.7 If the total system back pressure (P2) is greater than 100 psi (689 kPa), go to the next step. If the pressure at P2 is less, restriction is not a problem. Go to the next test for the complaint. See **Table 1**.

   7.8 System back pressure has been determined to be excessive and the component at fault can be pinpointed by checking pressures at key locations in the steering system. With the engine at idle, use the low pressure gauge and hose connection adapters necessary to measure pressures at all locations identified in **Fig. 5**. Each time the gauge is moved, ensure that the fluid level is correct and air is removed from the system by running the engine at idle and checking the fluid level.

   7.9 Determine the individual component restrictions by subtracting the values shown in **Table 3**. Record the values on form SD–94.

   7.10 See the column on the right in **Table 3** for action to take if any component exceeds the maximum allowable restriction as listed for each component.

8. Test pump performance.

   8.1 Set up the system for hydraulic checks. See **Subject 310** for instructions.

   8.2 Make sure the fluid temperature is 150 to 160°F (66 to 71°C) and the vehicle is stationary with the front wheels pointing forward and the rearmost tires chocked.

Troubleshooting and Diagnostic Checks

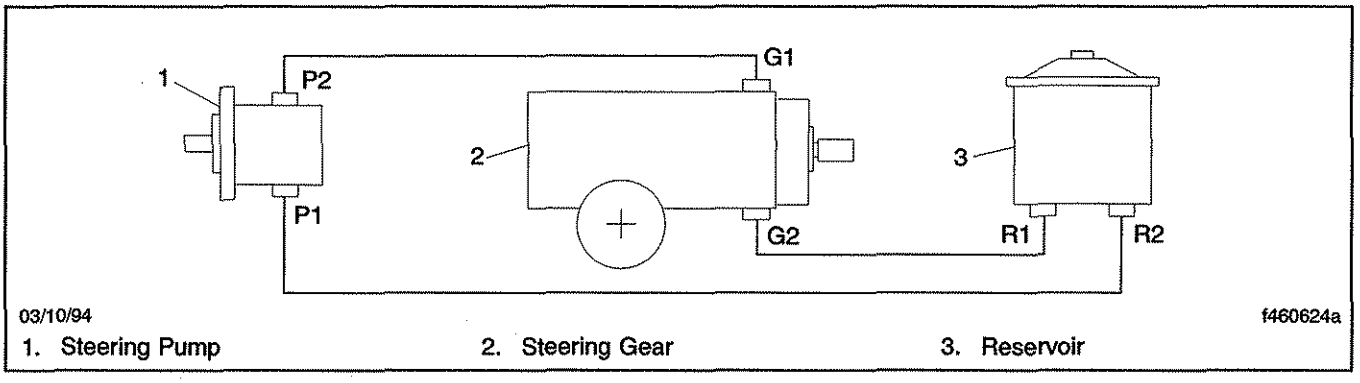


Fig. 5, Plumbing Diagram

8.3 Run the engine at idle. See the engine idle table in **Subject 310** for correct engine idle speed.

8.4 Adjust idle speed, if necessary. See the engine manufacturer's instructions.

8.5 Slowly close the load valve. When the valve is completely closed, read the pressure gauge. See **Fig. 6.**

⚠ CAUTION

Don't leave the valve closed for longer than 5 seconds since this could damage the power steering system.

8.6 If the pressure rises rapidly, appears to be uncontrolled, or rises above the maximum pressure of 2685 psi (18 512 kPa), open the load valve immediately. Indicate on form SD–94 whether the pump response was erratic or not. If the response was erratic, replace the pressure relief valve in the pump. For instructions, see the pump section in this group. If the pressure was constant, go to the next step. With the fluid temperature at 150 to 160°F (66 to 71°C) repeat the previous two steps.

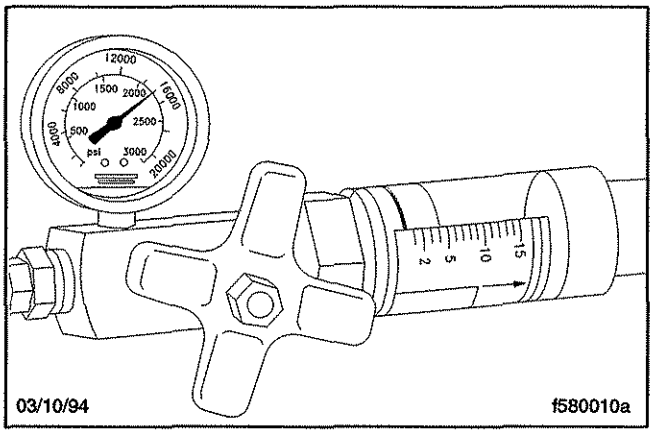


Fig. 6, Read the Pressure Gauge

System and Component Restrictions		
Total System and Component Restrictions	**Maximum Allowable**	**Action to Take**
P2 =Total System	100 psi (689 kPa)	Check pressures at the key locations.
P2-G1 = Hose: Pump-to-Gear	12 psi (83 kPa)	Check for a kinked or plugged hose. Replace the hose if necessary.
G1-G2 = Steering Gear	55 psi (379 kPa)	The gear rotary valve is damaged. Replace the gear. See instructions in this manual.
G2-R1 = Hose: Gear-to-Reservoir	12 psi (83 kPa)	Check for a kinked or plugged hose. Replace the hose if necessary.

System and Component Restrictions		
Total System and Component Restrictions	**Maximum Allowable**	**Action to Take**
R1-R2 = Reservoir	2 qt: 4 psi (28 kPa) 9 qt: 8 psi (55 kPa)	Replace the filter. Check for internal blockage.
R2-P1 = Hose: Pump Supply	12 psi (83 kPa)	Check for a kinked, collapsed, or plugged hose. Replace the hose if necessary.

Table 3, System and Component Restrictions

8.7 If the pump pressure measures 2410 to 2685 psi (16 616 to 18 512 kPa), it is acceptable. Skip the next step and record the pressure on form SD–94. If the pressure is not within this range, replace the pressure relief valve if not done previously in this test. With the fluid temperature at 150 to 160°F (66 to 71°C) repeat the two previous steps. If the pressure relief valve has been replaced, go to the next step.

8.8 If the pressure was not within the above applicable range and the relief valve has been previously replaced, replace the pump. For instructions, see the pump section in this group. If the pump was replaced, evaluate its performance by repeating the Test Performance check.

8.9 Record the relief pressure on form SD–94.

8.10 With the engine at idle, test the pump relief valve reaction. Note the flow rate with the load valve open.

8.11 Close the load valve until the pump relief pressure is reached (previously determined). The flow rate should drop to zero.

8.12 Immediately open the load valve and note the flow rate. It should return to the value noted previously.

8.13 If the flow rate returns immediately, the relief valve is acceptable. Go to the next step.

If the flow rate does not return immediately, the pump relief valve is not working correctly. Replace the relief valve if not previously done, following instructions in the pump section in this group.

8.14 With the engine at 1500 rpm, repeat the steps beginning with testing the pump relief valve reaction.

8.15 Record on form SD–94 whether the relief valve operated "OK" or "Not OK" at idle and 1500 rpm. Near the bottom of the form, list any pump repairs that were made.

8.16 With the engine at idle, test the pump flow. Slowly close the load valve until the pressure gauge reads 1000 psi (6895 kPa).

8.17 Read the flow gauge and record the flow rate on form SD–94.

8.18 Open the load valve.

8.19 Run the engine at 1500 rpm. Leave the load valve open, **do not** close the load valve. Read the flow gauge and record the flow rate on form SD–94.

8.20 At idle the minimum flow rate is 3.1 gpm (11.7 L/min). The maximum flow rate at either engine speed is 4.2 gpm (15.9 L/min). If the flow rate is below the minimum, repair or replace the pump. For instructions, see the pump section in this group. If the flow rate is above the maximum, replace the flow control and relief valve in the pump. For instructions, see the pump section in this group.

9. Check the steering gear poppet relief valve and the axle stop adjustment.

NOTE: Poppets limit the steering assist when the front wheels approach the axle stops. Improper adjustment can apply excessive force to the steering linkage or loss of assist as the steering wheel approaches either full left or full right turns.

Troubleshooting and Diagnostic Checks

9.1 If the turning angle is inadequate, make sure the axle stops are set to the maximum possible turn angle. Make sure the axle stop settings limit the steering travel so there is 1/2-inch (13-mm) clearance from all stationary components, and 3/4-inch (19-mm) clearance from all moving components.

9.2 Make sure the pitman arm is oriented on the steering gear sector shaft correctly. See **Subject 100.**

9.3 Set up the system for hydraulic checks. See **Subject 310** for instructions.

9.4 Make sure the fluid temperature is 150 to 160°F (66 to 71°C) and the vehicle is stationary with the front wheels pointing forward.

9.5 Run the engine at idle with the load valve open. See the engine idle table in **Subject 310** for correct engine idle speed.

9.6 Turn the steering wheel to either full-lock position.

⚠ CAUTION

If power steering pump relief pressure is reached while the steering wheel is at full-lock, release the steering wheel from this position. Don't allow the pump relief pressure to be maintained for longer than five seconds or damage to the pump may result.

9.7 Note the pressure gauge reading.

9.8 Repeat the previous three steps for the opposite turn direction and note the pressure gauge reading.

9.9 The pressure readings at the axle stops should not exceed 1200 psi (8200 kPa). If the pressures are acceptable, record on form SD–94 and go on to the next test for the complaint. See **Table 1.** If the pressure is too high, the automatic poppet valves may have been adjusted inward too far and cannot be reset out. Retest the poppet relief valve and record the pressures on form SD–94.

9.10 If the pressure is relieved and assist is lost when the wheel is too far from the axle stop, adjust the automatic poppet valves as follows: (for gears equipped with a poppet adjusting screw, go to the next step) with the engine running at 1500 rpm, turn the steering to full-lock left and full-lock right so that the axle stops are contacted on both sides. This adjusts the poppets inward to the correct setting. Retest the poppet relief valve and record the pressures on form SD–94.

9.11 If the special poppet adjusting screw has been previously installed and pressure relief with loss of assist is detected too far from the axle stop, the poppets must be readjusted. See **Subject 100.** If the adjustable poppets have been reset properly and after subsequent vehicle operation loss of assist continues to occur when the wheel is too far from the axle stop, the poppets have become loose due to previous incorrect poppet adjustment and must be replaced. See **Subject 160,** for replacement instructions. After poppet replacement and adjustment, retest for correct poppet relief pressures and record pressures on form SD–94.

10. Test for steering gear internal leakage.

10.1 Set up the system for hydraulic checks. See **Subject 310** for instructions.

10.2 Make sure the fluid temperature is 150 to 160°F (66 to 71°C) and the vehicle is stationary with the front wheels pointing forward.

10.3 Run the engine at idle with the load valve open. See the engine idle table in **Subject 310** for correct engine idle speed.

10.4 Place an unhardened steel spacer, 1-inch (2.5-cm) thick, between the axle and the axle stop at one side of the axle. See **Fig. 7.** The spacer should have an extension or handle long enough to keep your fingers clear of the axle stop area. A brazing rod or welding rod works well for this purpose.

⚠ WARNING

Keep your fingers clear of the axle stops and spacer block during this test. Make sure that the spacer block contacts the axle stop squarely. Contact that is not square could break the axle stop or dangerously eject the spacer block, causing injury.

⚠ CAUTION

While running this test, do not hold the steering wheel in the full turn position for longer than 5 seconds at a time to avoid damaging the pump.

10.5 Have someone turn the steering wheel until the axle stop contacts the spacer block. See **Fig. 8**. Apply 20 lbf (89 N) to the rim of the steering wheel.

10.6 Read the internal leakage rate on the flow meter.

10.7 Record the reading on form SD–94.

10.8 Repeat the previous four steps (beginning with placing the spacer between the axle and the axle stop) for the opposite turn direction.

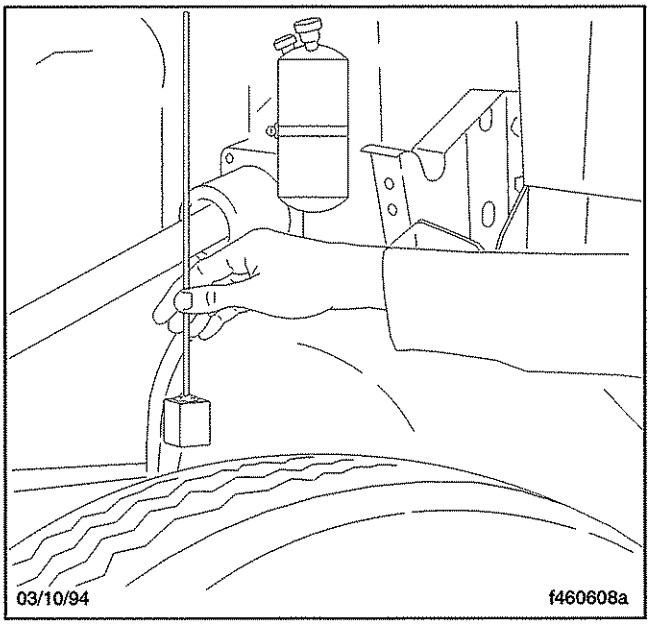


Fig. 7, Position the Steel Spacer

10.9 The maximum permissible internal leakage is 1.0 gpm (3.8 L/min). If leakage is greater in either turning direction, replace the steering gear components as needed following instructions in **Subject 150.**

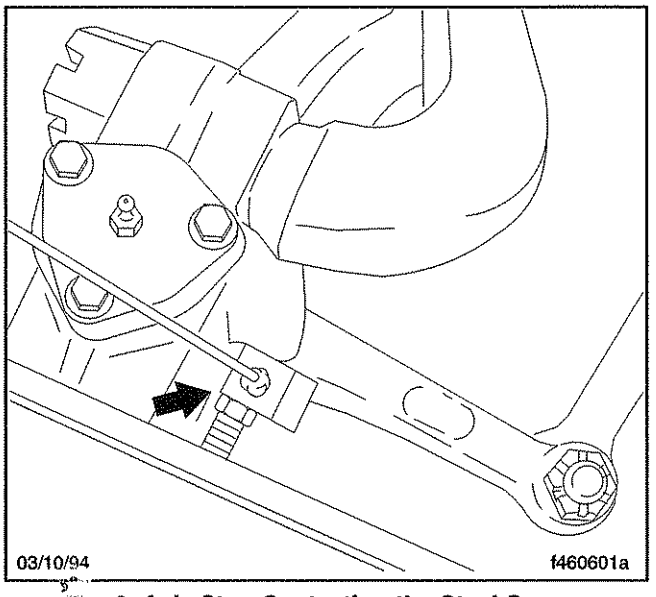


Fig. 8, Axle Stop Contacting the Steel Spacer

Troubleshooting and Diagnostic Checks

FREIGHTLINER
FREIGHTLINER CORPORATION

Checklist for Troubleshooting Hydraulic Power Steering System Performance

Date _____ Work Order No. _____

Evaluation Performed By _____ ☐ Dealership ☐ Fleet ☐ Independent

Vehicle Identification

Vehicle Model _____ Chassis No. _____ Date in Service _____

Mileage _____ Mileage when steering complaint first occurred _____

Vehicle application _____ Normal steering axle load _____

Steering System Description

Steering Pump Manufacturer _____ Model No. _____

Steering Gear Manufacturer _____ Model No. _____ Date Code _____

Reservoir Capacity: ☐ 2 quart ☐ 4 quart ☐ 9 quart

Type of Fluid: ☐ ATF ☐ 10W ☐ 10W-30 ☐ 10W-40 ☐ Other _____

Steering Complaint and Appropriate Checks

				CHECKS									
LH	RH	Both	COMPLAINT	1 Tire Press./ Vehicle Load	2 Fifth Wheel Lube	3 Vehicle Align-ment	4 Loose/ Binding Compo-nents	5 Noise	6 System Operat-ing Temp.	7 System Leaks or Restric-tions	8 Pump Perform-ance	9 Gear Poppet Adjust-ment	10 Gear Internal Leakage
			Hard or Heavy Steering	•	•		•		•	•	•	•	•
			Low Assist										
			Binding	•	•		•		•	•	•	•	•
			Locking										
			Occasionnl Loss of Assist										
			Reduced Wheel Cut									•	
			Vehicle Pulls to One Side	•		•					•		
			Darting/ Oversteer	•	•	•	•						
			Vehicle Wanders										
			Noisy Steering					•		•	•		
			Steering Gear External Seal Leaks						•	•	•		
			Excessive Heat										
			Other (describe as completely as possible) _____										

Vehicle Checks

No. 1—Tire Pressure/Load:

Oversized front tires? ☐ Yes ☐ No

Heavy load operation? ☐ Yes ☐ No ☐ psi ☐ kPa

Rear tire pressure even? ☐ Yes ☐ No

Front Tire Pressure: Left _____ Right _____

No. 2—Fifth Wheel Lube and Condition: ☐ OK ☐ Not OK

No. 3—Vehicle Alignment and Wheel Bearing Adjustment:

Rear axle _____ Front axle: Caster Left _____ Right _____

Wheel bearings: ☐ OK ☐ Not OK Camber Left _____ Right _____

No. 4—Binding Components:

Lubrication of drag link, tie rod, and knuckle pins? ☐ Yes ☐ No

COE steering column bearing binds? ☐ Yes ☐ No

SD-94 (9/91P)

01/16/98 f460206

Fig. 9, Front Side, Checklist for Troubleshooting Hydraulic Power Steering System Performance

No 4—Binding Components (Continued)

Steering driveline U-joints bind?	☐ Yes	☐ No
Steering driveline phasing OK?	☐ Yes	☐ No
Sector shaft adjustment OK?	☐ Yes	☐ No
Front tire self-return OK?	☐ Yes	☐ No

No 5—Noise

Fluid level ☐ OK ☐ Too low ☐ Too high

Fluid condition ☐ OK ☐ Discolored ☐ Odorous ☐ Foamy ☐ Other _____

Inlet tube or fittings leaking?	☐ Yes	☐ No
Front spring pin shims required?	☐ Yes	☐ No
Loose steering components?	☐ Yes	☐ No
Normal "hissing" at full turn?	☐ Yes	☐ No
"Hissing" at less than full turn?	☐ Yes	☐ No
Hoses kinked or collapsed?	☐ Yes	☐ No

No 6—System Operating Temperature ☐ °F ☐ °C

Outside (ambient) temperature _____°. Test start _____°

10 min _____°, 20 min _____°, 30 min _____°, 40 min _____°

No 7—System Leaks or Restrictions

Hoses kinked or collapsed?	☐ Yes	☐ No
Leaking fittings?	☐ Yes	☐ No
Leaking seals?	☐ Yes	☐ No

Total System and Component Back Pressure ☐ psi ☐ kPa

Total system _____, Hose Pump-to-gear _____, Steering gear _____,

Hose Gear-to-booster _____, Hose Gear-to-reservoir _____, Booster _____,

Hose Booster-to-reservoir _____, Reservoir _____, Hose Pump supply _____

Hydraulic Checks

Power steering fluid temperature (to be 150° to 160°F [66° to 71°C], see "System Set-Up for Hydraulic Checks" in applicable service manual) _____°F (_____°C)

Idle RPM (see "System Set-Up for Hydraulic Checks" in applicable service manual for correct idle rpm) _____rpm

No 8—Pump Performance

			Idle	Highway
Erratic response	☐ Yes	☐ No		
Pump relief pressure	☐ psi	☐ kPa	_____	
Pump relief valve operation		OK ☐ / Not OK ☐	☐ / ☐	
Pump flow	☐ gpm	☐ Lpm	_____	_____

No 9—Steering Gear Poppet Adjustment

			Left Turn	Right Turn
Poppet valve trip pressure	☐ psi	☐ kPa	_____	_____

No 10—Steering Gear Internal Leakage

Ross (TRW)	☐ gpm	☐ Lpm	_____	_____
Sheppard	☐ psi	☐ kPa	_____	_____

Attempted Corrections and Results

Pump repairs _____

Steering gear repairs _____

_____

Other components repairs _____

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Fig. 10, Back Side, Checklist for Troubleshooting Hydraulic Power Steering System Performance

System Setup

NOTE: Use a 1 to 10 gpm (3.8 to 38 L/min) flow meter, a pressure gauge 0 to 2500 psi (0 to 17 225 kPa) minimum, and a load valve, preferably in one test unit.

1. Install the test unit between the pump high-pressure line and the steering gear.
2. Fill and bleed the steering system. Refer to **Subject 110** for instructions.
3. Checks must be done with the power steering fluid at an operating temperature of 150 to 160°F (66 to 71°C). Monitor the fluid temperature with a thermometer in the fluid reservoir. If the fluid is too cold, raise the temperature as follows:

   Run the engine at idle.

   Partially close the load valve on the test unit until the pressure gauge reads 1000 psi (6895 kPa).

⚠ CAUTION

Do not leave the load valve fully closed, since this could damage the power steering system.

NOTE: When testing pump performance, poppet relief valve pressures, and internal gear leakage, refer to **Table 1** for engine idle speeds. Adjust idle speed if necessary. Refer to the engine manufacturer's instructions.

4. Open the valve when the fluid temperature reaches 150 to 160°F (66 to 71°C).

⚠ CAUTION

Do not allow the fluid temperature to exceed 250°F (121°C) since this could damage the power steering system.

Record all data from the hydraulic checks on form SD–94, "Checklist for Troubleshooting Hydraulic Power Steering System Performance."

Engine Idle Speeds		
Engine Manufacturer	**Engine Model**	**Idle Speed (rpm)**
Mercedes-Benz	MBE4000	600 to 850
Caterpillar	C10/C12	700
	C15/C16	700
Cummins	ISM	700
	ISX	700
	Signature	600
	N14 (300–370 hp)	600
	N14 (371–525 hp)	650
Detroit Diesel	Series 60	600

Table 1, Engine Idle Speeds

Specifications

⚠ WARNING

Fill the power steering reservoir only with approved clean fluid. Do not mix automatic transmission fluid types; use one or the other. If you are changing from one fluid type to the other, completely flush the steering system with the fluid type being added. Any mixture or any unapproved fluid could lead to seal deterioration and leaks. Any fluid leak could eventually cause loss of power steering assist.

The following hydraulic fluids are approved for use in the steering system:

- Automatic Transmission Fluid (ATF), Dexron® II
- Automatic Transmission Fluid (ATF), Dexron® III

The following type of grease is approved for use on the steering gear components:

- Exxon Polyrex® EP2 (PN 045422)

Special tools can be ordered from:

SPX Corporation, Kent-Moore Tool Group
28635 Mound Road
Warren, Michigan 48092
1-800-328-6657

Kent-Moore Tools	
Kent-Moore Part Number	**Description**
J37071 and J37071–A	Bearing and Seal Tool
J36452–A	Special Tool
J37070	Bearing Adjuster Tool
J37073	Seal Driver Tool
J37464	Adjuster Locknut Tool

Table 1, Kent-Moore Tools

Contents

Subject	Subject Number
General Information	050
Service Operations	
Steering Driveline Removal and Installation	100

General Information

The ZF steering driveline is a ball-splined telescopic shaft that consists of a cardan shaft with internal splines and a special-pattern shaft with external splines. Two rows of ball bearings run in these splines and form a positive rotating link that does not transmit noise. This design ensures freedom from radial play but light-action axial displacement with an effective stroke of ±1.18 inches (±30 mm). The ball-splined telescopic shaft has a low rate of wear and needs no maintenance.

Steering Driveline Removal and Installation

Removal

1. Position the front tires straight ahead. If possible, drive the vehicle in a straight line for a short distance, stopping at the spot where service operations will be done.
2. Shut down the engine, apply the parking brakes, chock the tires, and open the hood.
3. Remove the driver's knee bolster below the steering column. See **Fig. 1**.
   - 3.1 Pull out on the bottom of the bolster.
   - 3.2 Push up on the bolster and pull it off.
4. Make a timing mark on the upper end yoke and the lower spline of the steering column. See **Fig. 2**.
5. Remove and discard the pinch bolt and nut on the lower end of the steering driveline.
6. Remove and discard the pinch bolt and nut on the upper end of the steering driveline.
7. Remove the steering driveline.
8. If the steering driveline is being replaced, remove the steering boot bushing from the steering driveline. See **Fig. 3**.

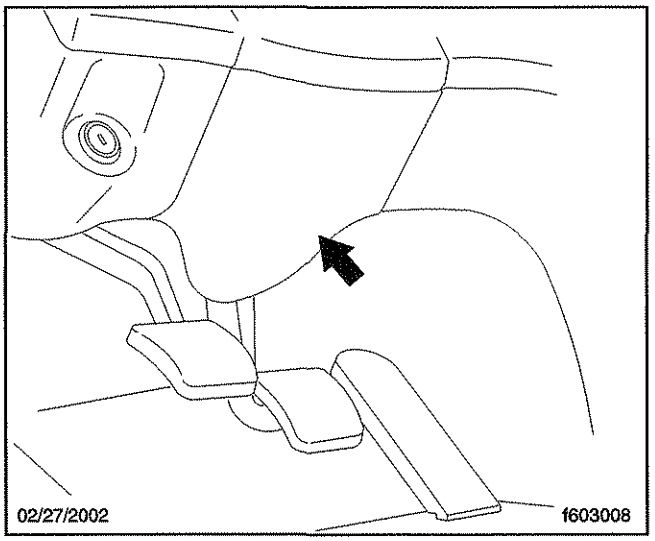
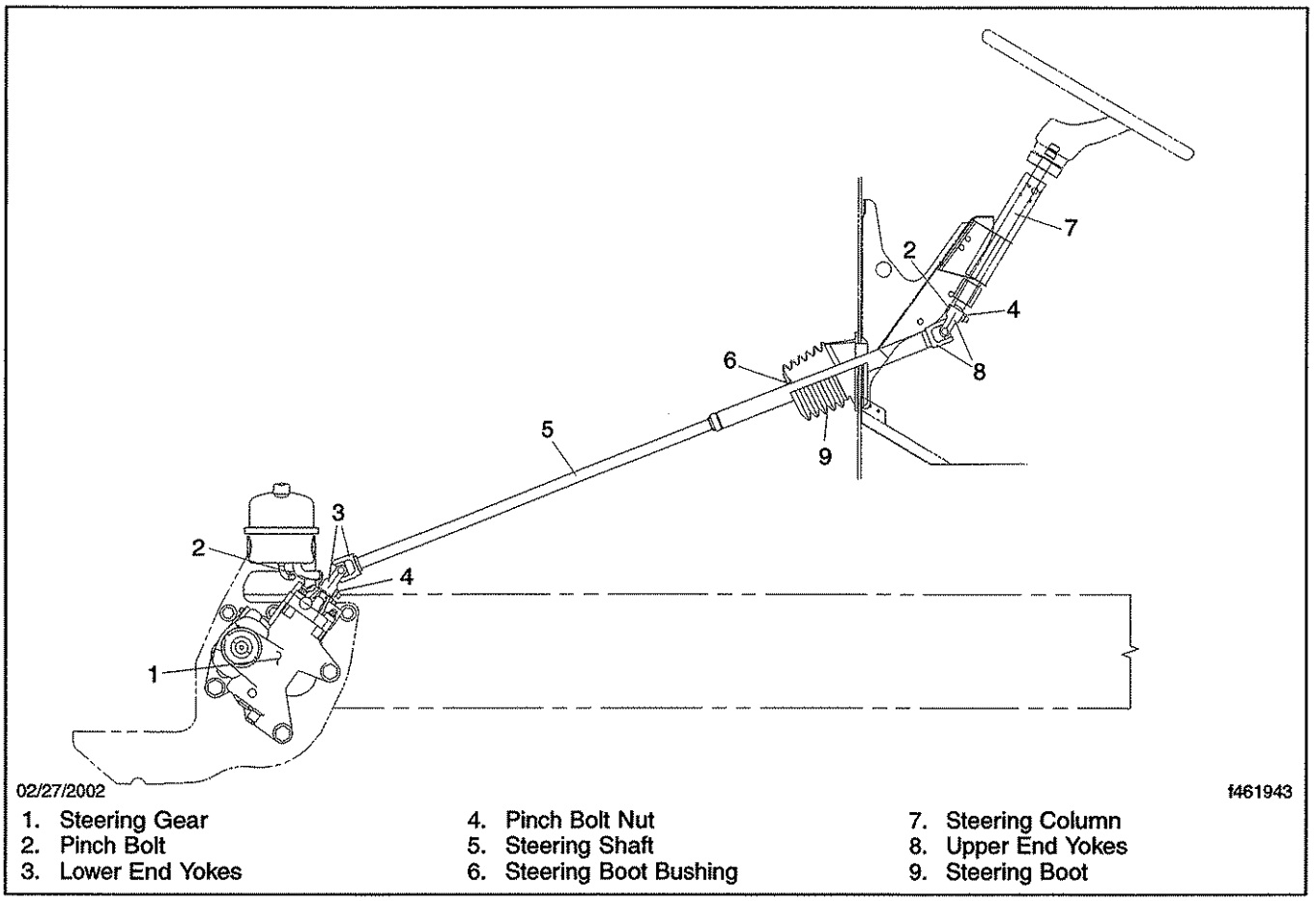


Fig. 1, Driver's Knee Bolster

Installation

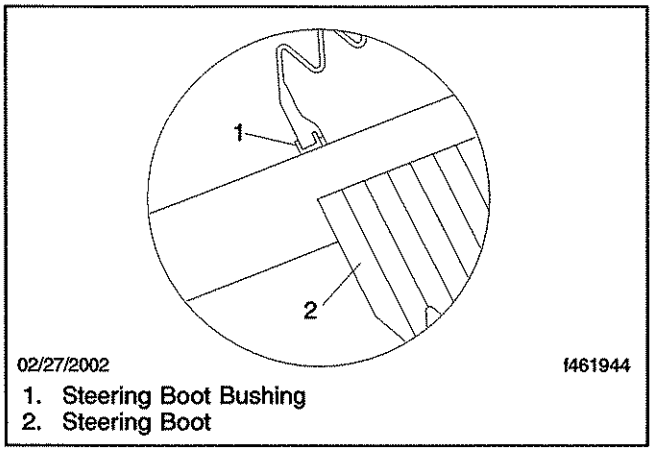
1. If the steering driveline is being replaced, install the steering boot bushing on the upper end of the new driveline.
2. Insert the upper end of the steering driveline through the steering boot and partially into the cab.
3. Align the timing mark on the upper end yoke to the timing mark on the lower spline on the steering column. Using a new 10 mm-pinch bolt and nut, attach the upper end yoke to the steering column. Torque the bolt 35 to 40 lbf·ft (47 to 54 N·m).
4. Using a new 10 mm-pinch bolt and nut, attach the steering driveline to the steering gear input shaft. Torque the bolt 35 to 40 lbf·ft (47 to 54 N·m).
5. Place the lower edge of the steering boot in the groove of the steering boot bushing. See **Fig. 3**.
6. Install the driver's knee bolster.
   - 6.1 Put the tabs in the upper slots.
   - 6.2 Push the lower portion of the bolster in place.
7. Return the hood to the operating position.
8. Remove the chocks from the tires.

Steering Driveline Removal and Installation



1. Steering Gear
2. Pinch Bolt
3. Lower End Yokes
4. Pinch Bolt Nut
5. Steering Shaft
6. Steering Boot Bushing
7. Steering Column
8. Upper End Yokes
9. Steering Boot

Fig. 2, Steering Driveline



1. Steering Boot Bushing
2. Steering Boot

Fig. 3, Steering Boot

Group Index, Alphabetical

Section	Section Number
Fuel Cooler, Hayden	47.05
Fuel Heater, Arctic Fox	47.03
Fuel Heater, Webb	47.04
Fuel Tanks and Fuel Lines	47.00
Fuel/Water Separator, Con Met	47.01
Fuel/Water Separator, Racor	47.02

Fuel Tanks and Fuel Lines 47.00

Contents

Subject	Subject Number
General Description and Principles of Operation	050
Service Operations	
Fuel Tank Replacement	100
Fuel Tank Band Replacement	110
Fuel Tank Bracket Replacement	120

General Description and Principles of Operation

The fuel system delivers fuel to the engine. It consists of the engine fuel system components, the fuel tanks and tank mounting components, and the fuel lines and shut-off valves.

The engine fuel system components include fuel filters, injectors, fuel transfer pumps, and a fuel governor. For service and maintenance procedures, refer to the applicable engine manufacturer's service and maintenance manuals.

The fuel tanks, which provide a clean storage area for fuel, are held in place by metal straps and brackets that transfer the load to the vehicle frame. A cab access step assembly or an air fairing attaches to the fuel tank straps and brackets.

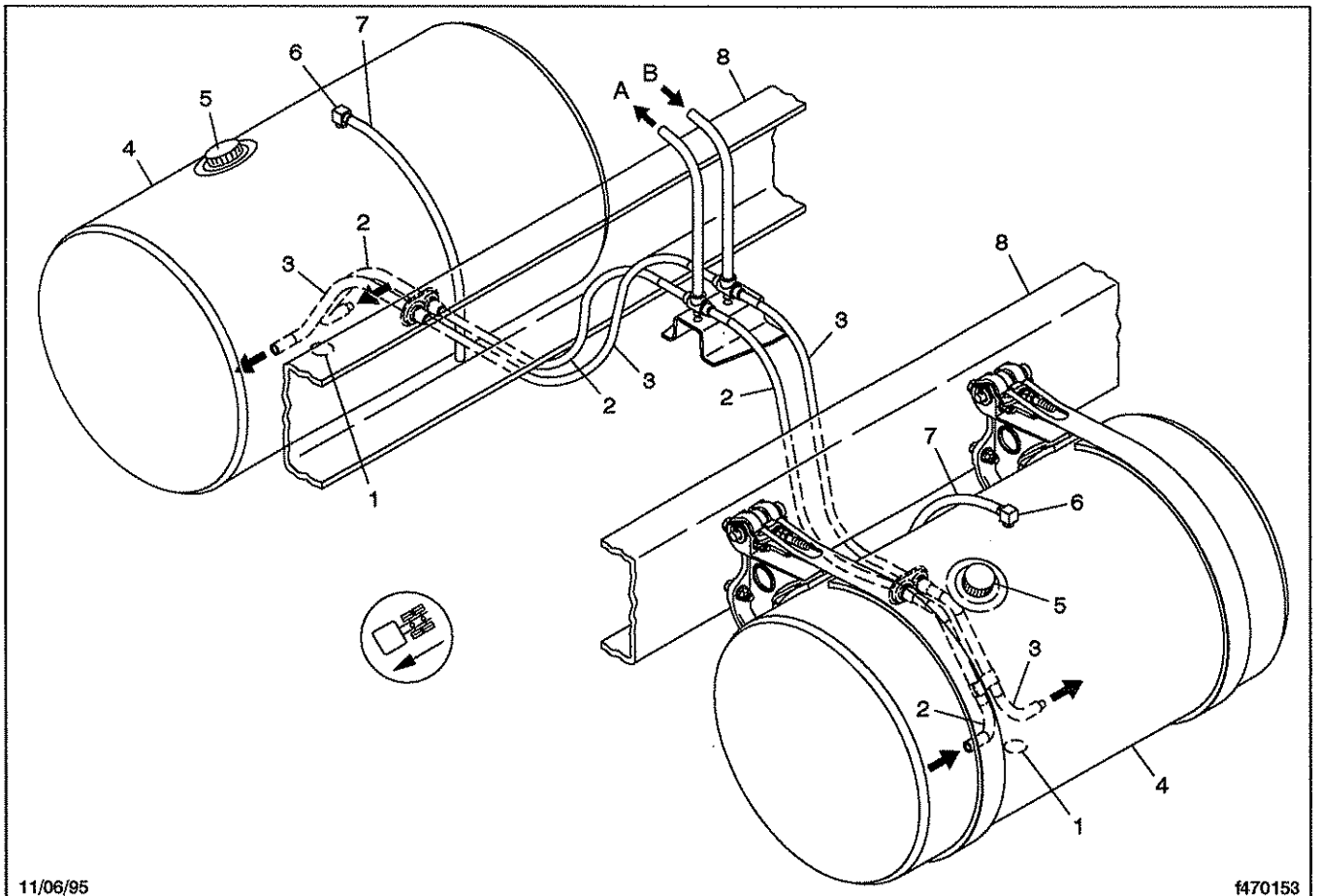
Flexible, reinforced wire-braid hoses (fuel lines) bring fuel from the tank to the engine, and return surplus fuel from the engine to the tank.

The EquiFlo® Inboard Fuel System is standard on all single-tank vehicles and recommended for all dual-tank systems. This system consists of inboard-routed fuel lines, with the suction and return lines installed in a common opening of the fuel tank(s); a new quarter-turn, non-vented fuel cap, and shut-off valves (when so equipped) located on top of the transmission. The fuel tank vent and line are located on the top of the tank. **See Fig. 1.**

The fuel lines are routed inboard of the frame rails and upward to a point on the transmission, where the shut-off valves (if so equipped) are located.

Fuel is drawn equally from and returned to each tank, so that their levels stay equal. The suction and return fuel lines, although entering the fuel tank via the same opening, are designed to direct the fuel flow to the bottom of the tank. **See Fig. 1.** This ensures thorough mixing of the fuel before it is drawn up by the suction line, so that vapor can disperse, and (electronic engines only) warm fuel is not recirculated.

General Description and Principles of Operation



NOTE: Arrows indicate direction of flow.

A. To fuel pump
B. From engine

1. Drain
2. Supply (Suction) Line
3. Return Line
4. Fuel Tank
5. Fuel Cap
6. Vent
7. Vent Line
8. Frame Rail

Fig. 1, EquiFlo Inboard Fuel System

Replacement

If there is any damage to the fuel tank, replace it.

IMPORTANT: Fuel tanks made after January 1, 1973, are subject to U.S. Federal Motor Carrier Safety Regulation 393.67. This law calls for certain standards relating to strength, leakage, and venting. These standards are achieved through the use of specific materials and construction methods. *These standards also apply to replacement fuel tanks.*

WARNING: Do not expose the fuel to, or work with the fuel system near, open flame or intense heat. To do so could cause fire, possibly resulting in serious personal injury or property damage.

1. Remove the chassis fairings. For instructions, refer to **Section 60.05**.

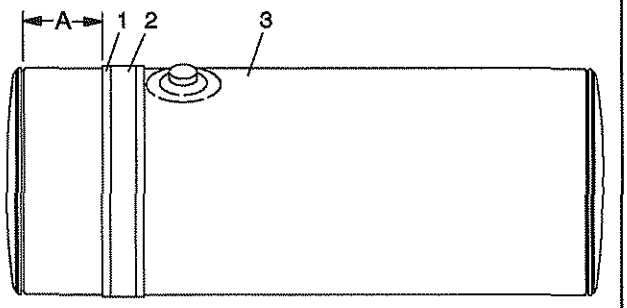
IMPORTANT: On dual tank installations, close the fuel shutoff valve(s) before draining the tank.

2. Drain the fuel from the tank.
   - 2.1 Remove the drain plug from the fuel tank that is to be replaced.
   - 2.2 Drain the fuel into a suitable container of sufficient volume to hold the amount of fuel in the tank.
   - 2.3 If the fuel is to be re-used, store it in a clean container, and keep it free from contaminants.
3. Disconnect the fuel suction line and return line from the tank, and cap the lines.
4. Remove and clean all of the pipe plugs, and save them for installation on the new tank.
5. Before removing the fuel tank bands, measure the distance from the forward edge of the fuel tank to the edge of the fuel tank band. **See Fig. 1.**
6. To prevent the fuel tank from rolling during and after removal, nail several 2 x 4 or 4 x 4 wooden blocks to the top of a pallet, then place the pallet on the forks of a fork lift. **See Fig. 2.**

   Move the fork lift and pallet into place to support the fuel tank as the tank bands are being removed.
7. Using a 15/16-inch socket with extender bar, loosen the jam nut on each tank band eye bolt. Remove the jam nut, inner hexnut, and washer. **See Fig. 3.**

   Drop the tank bands and isolators. Leave the tensioner lug inside the band.
8. Remove the fuel tank from the fuel tank bracket.
9. After removing the tank, inspect the tank bands, isolators, and brackets for damage. Replace worn or damaged parts with new parts. Refer to **Subject 120** for bracket replacement procedures; refer to **Subject 110** for band replacement procedures.
10. Using the fork lift and pallet, place the fuel tank in its approximate installed position. Make sure the fuel filler neck is rotated 25±5 degrees outboard of vertical. **See Fig. 2.**

    Install the forward tank band and band isolator loosely.
    - 10.1 Holding the tank on the forklift, attach the band and isolator to the eye bolt.
    - 10.2 Install a hardened flatwasher and the inner 5/8–11 hexnut, but do not tighten it yet.
11. Move the new tank fore or aft until the distance between the forward edge of the tank and the tank band is equal to the distance measured **in Fig. 1.**



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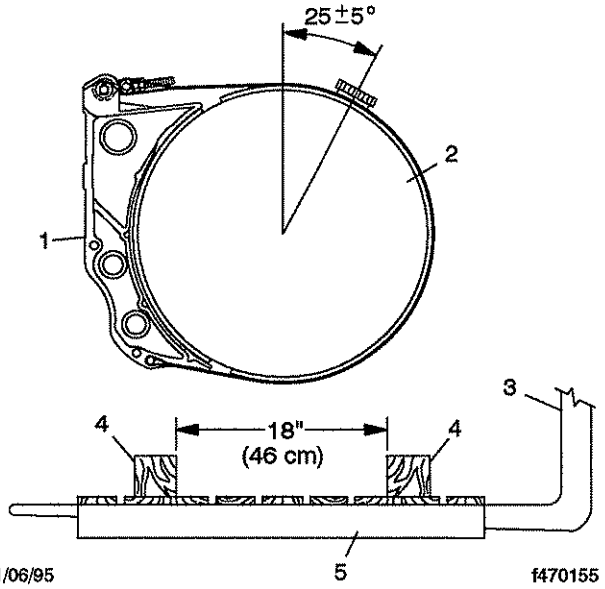
A. Measure the distance from the end of the tank to the edge of the band isolator.

1. Band Isolator
2. Fuel Tank Band
3. Fuel Tank

Fig. 1, Measuring the Band Installation Distance

Fuel Tank Replacement



Make sure the fuel filler neck is rotated 25±5 degrees outboard of vertical.

1. Fuel Tank Bracket
2. Fuel Tank
3. Lift-Truck Fork
4. 4 x 4 Wooden Block
5. Wooden Pallet

Fig. 2, Preventing the Fuel Tank From Rolling

NOTE: On vehicles equipped with side fairings, the fuel tank filler neck does not have to be centered in the fill door opening of the side fairing. The centerline of the fuel tank cap is to be within 1 inch (25 mm) of either side of the centerline of the fill door opening. **See Fig. 4.** Don't move the fuel tanks to center the fuel tank filler neck in the fill door opening.

12. Install the other tank band around the tank; then insert the isolators under the brackets so that the relief in each isolator aligns with the tank longitudinal weld seam. **See Fig. 3.**

CAUTION: Fuel tanks can be damaged by direct isolator pressure on the tank weld seam, and by overtightening the fuel tank bands. Be sure the weld seam aligns with reliefs in the isolators and that the bands are tightened to specification.

13. Tighten the inner hexnuts alternately in stages until each is tightened 30 to 35 lbf·ft (41 to 47 N·m). When both hexnuts have been tightened, install a jam nut on each hexnut. Hold each hexnut with a 15/16-inch wrench while tightening its jam nut 30 lbf·ft (41 N·m).

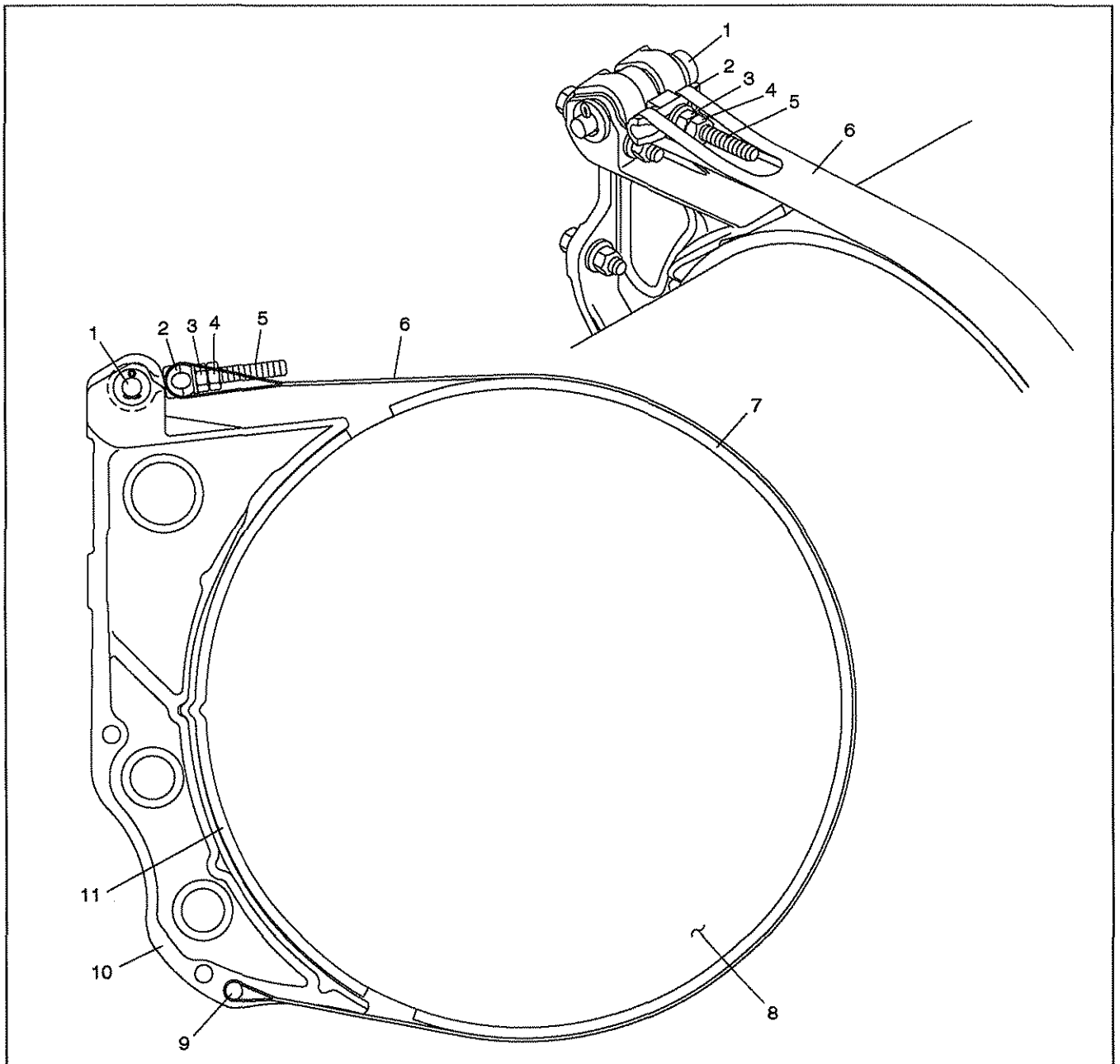
14. Make certain the fuel lines are clean, then install them on their fittings on the fuel tank.

    Coat the pipe plug threads with Loctite® 592, or an equivalent. Install pipe plugs in any remaining open threaded holes.

15. Install the chassis fairings. For instructions, refer to **Section 60.05.**

16. Fill the fuel tank with clean fuel. Prime the engine fuel pump; refer to the engine manufacturer's operation and maintenance manual.

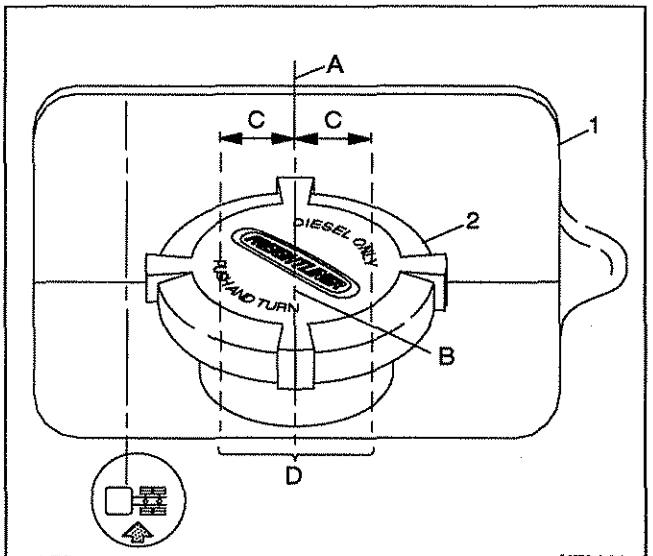
    On dual tank installations, open the fuel shutoff valve(s).



1. Large Clevis Pin
2. Tensioner Lug
3. 5/8–11 Hexnut
4. 5/8–11 Jam Nut
5. Eye Bolt
6. Fuel Tank Band
7. Band Isolator
8. Fuel Tank
9. Small Clevis Pin
10. Fuel Tank Bracket
11. Bracket Isolator

Fig. 3, Fuel Tank Band Assembly

Fuel Tank Replacement



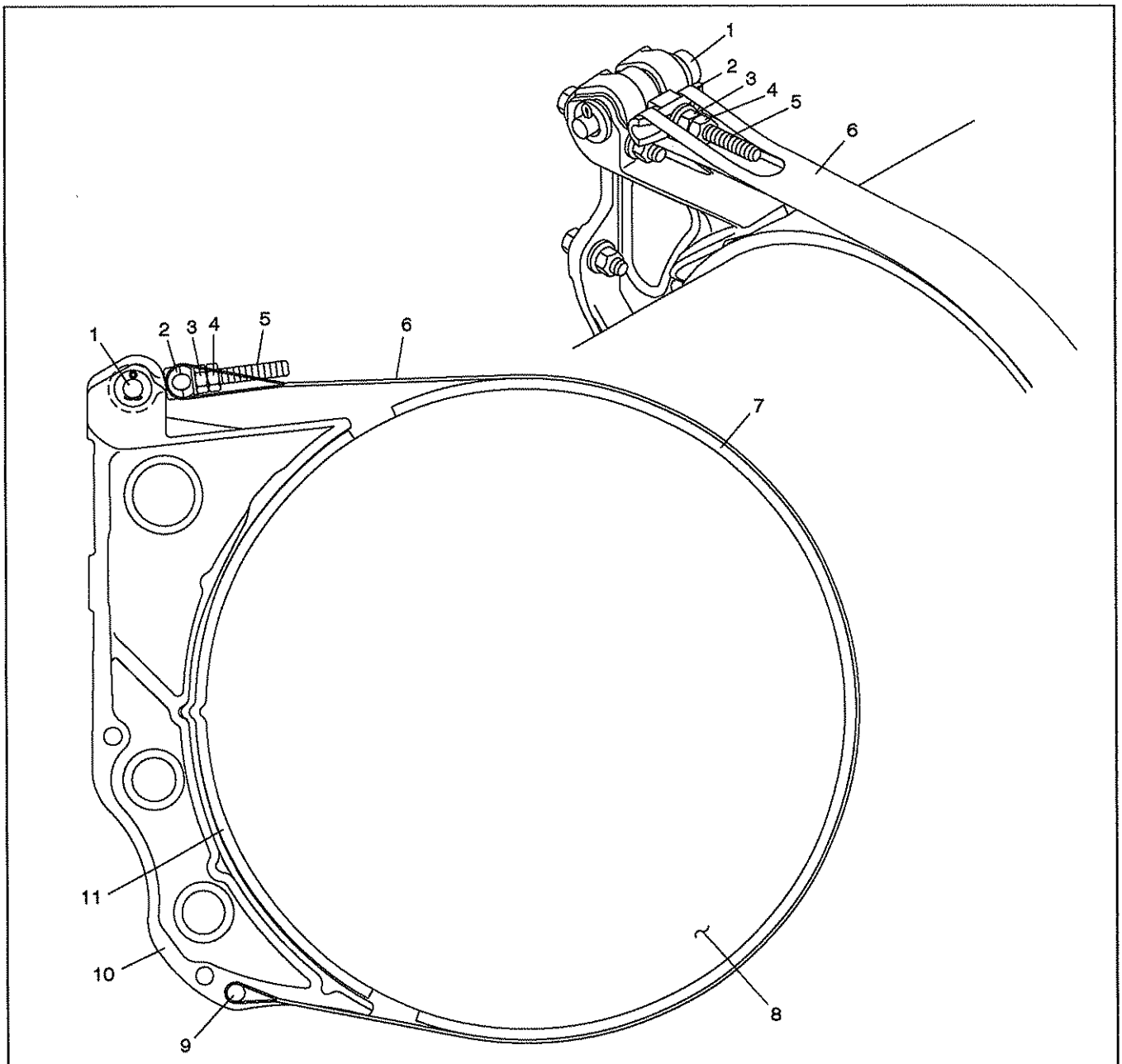
A. Centerline of fill door opening
B. Centerline of fuel cap
C. 1 inch (25 mm)
D. Fuel cap centerline to be within this area.

1. Fill Door Opening 2. Fuel Cap

Fig. 4, Fuel Cap Installation

Fuel Tank Band Replacement

Replacement (See Fig. 1)



1. Large Clevis Pin
2. Tensioner Lug
3. 5/8–11 Hexnut
4. 5/8–11 Jam Nut
5. Eye Bolt
6. Fuel Tank Band
7. Band Isolator
8. Fuel Tank
9. Small Clevis Pin
10. Fuel Tank Bracket
11. Bracket Isolator

Fig. 1, Fuel Tank Band Assembly

Fuel Tank Band Replacement

1. Remove the chassis fairings. For instructions, refer to **Section 60.05**.
2. Support the fuel tank, using a floor jack or fork lift, and padding to protect the tank.
3. Remove the nuts and washer from the tank band eye bolt at the outboard end of the tank bracket.
4. Drop the tank band. Inspect both the band and bracket isolators for wear or damage, and replace if needed.
5. Remove the band.
   - 5.1 Remove the small clevis pin from the bottom end of the fuel tank bracket, freeing the band.
   - 5.2 Remove the band from the fuel tank.
6. Install the band.
   - 6.1 Position the small end of the new band in place on the bottom edge of the fuel tank bracket.
   - 6.2 Install the small clevis pin and two hardened flatwashers onto the fuel tank bracket and band, and fasten it in place, using a cotter pin.
7. Apply Alumilastic® compound or equivalent to the bracket where it contacts the band.

CAUTION: Failure to apply Alumilastic compound, or an equivalent, to areas where aluminum and steel parts contact each other, could lead to corrosion of the metals, resulting in damage to the components or parts.

8. Position the new tank band, with band isolator, around the tank; then insert the bracket isolator under the bracket so that a relief in the isolator aligns with the tank longitudinal weld seam. **See Fig. 1.**

CAUTION: Fuel tanks can be damaged by direct isolator pressure on the tank weld seam, and by overtightening the fuel tank bands. Be sure the weld seam aligns with reliefs in the isolators and that the bands are tightened to specification.

9. Attach the upper end of the band and tighten the band nuts.
   - 9.1 Position the large end of the band, with tensioner lug in place, on the end of the eye bolt.
   - 9.2 Install a hardened flatwasher and the inner hexnut. Tighten the inner hexnut 30 to 35 lbf·ft (41 to 47 N·m).
   - 9.3 Install a jam nut on the hexnut. Hold the hexnut with a 15/16-inch wrench while tightening its jam nut 30 lbf·ft (41 N·m).
10. Repeat this procedure to replace the other band. When both bands have been replaced, check both inner hexnuts and both jam nuts for tightness.
11. Install the chassis fairings. For instructions, refer to **Section 60.05**.

Fuel Tank Bracket Replacement

Replacement (See Fig. 1)

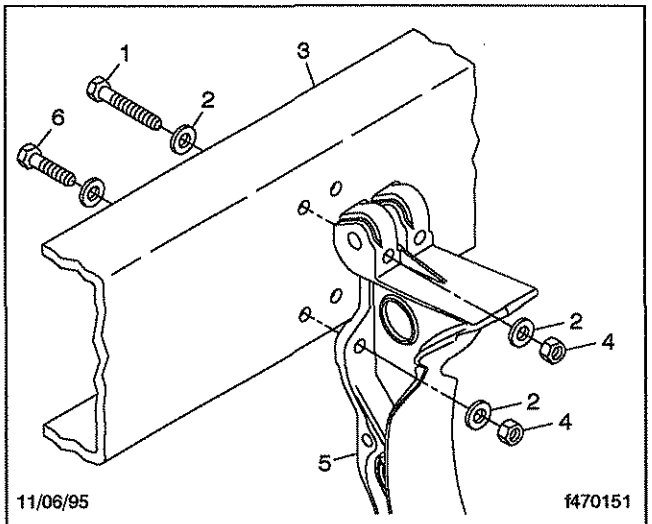
1. Support the tank and remove the fuel tank band from the bracket that is being replaced; refer to **Subject 110**.
2. Remove the fasteners that attach the bracket to the frame rail; then remove the bracket.
3. Install the bracket.

   3.1 Apply Alumilastic® compound, or equivalent, between the fuel tank bracket and the frame rail.

   CAUTION: Failure to apply Alumilastic compound, or an equivalent, to areas where aluminum and steel parts contact each other, could lead to corrosion of the metals, resulting in damage to the components or parts.

   3.2 Position the new tank bracket against the frame rail. From inside the frame rail, install the 5/8–11 grade 8 bolts and washers. On the other side of the frame rail, install hardened washers and hexnuts. The 4-inch capscrews go in the top holes; the 2-1/4 inch capscrews in the bottom holes. Tighten the hexnuts 160 lbf·ft (217 N·m).

   3.3 Install the fuel tank band; refer to **Subject 110**.



1. Large Mounting Capscrew (4 in.)
2. Hardened Flatwasher
3. Frame Rail
4. 5/8–11 Grade 8 Hexnut
5. Fuel Tank Bracket
6. Small Mounting Capscrew (2-1/4 in.)

Fig. 1, Fuel Tank Bracket Installation

Contents

Subject	Subject Number
General Information	050
Service Operations	
Con Met Fuel/Water Separator Removal and Installation	100
Con Met Fuel/Water Separator Heater and Thermostat Replacement	110
Troubleshooting	300
Specifications	400

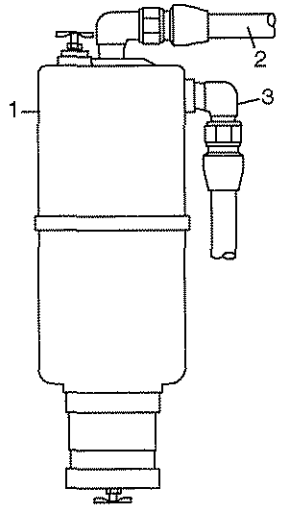
General Description

The Con Met fuel/water separator (**see Fig. 1**) removes water and solid contaminants from diesel fuel. Installed on the left frame rail between the fuel tank and the fuel transfer pump, the separator has no moving parts and contains no filters.

It is available in a basic model, or with a sight bowl, and/or a heater activated by a mechanical thermostat. All fuel and coolant line fittings are 1/2-inch NPT.

Principles of Operation

Diesel fuel enters at the top of the separator (**see Fig. 2**) and flows down through a specially-designed baffle, causing the water in the fuel to coalesce in large droplets which then accumulate in the bottom of the unit and can be drained by opening a valve.



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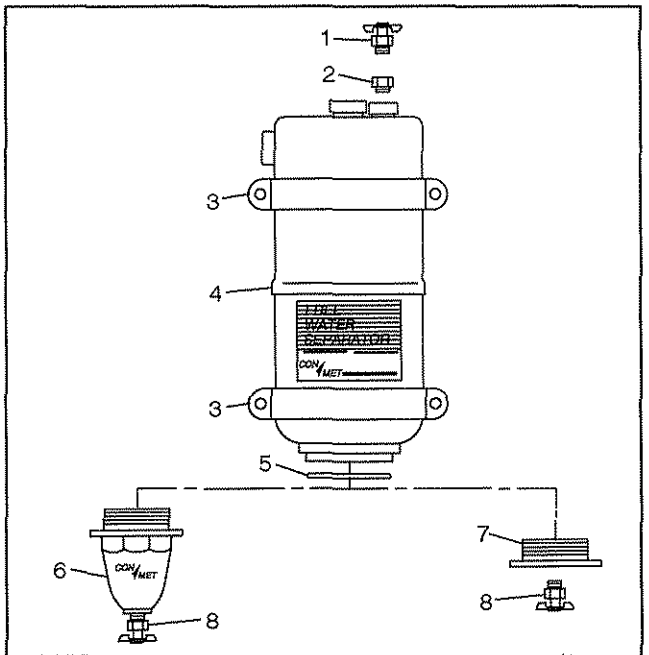
1. Fuel/Water Separator
2. Intake Line
3. Exhaust Line

Fig. 1, Con Met Fuel/Water Separator, Basic Model



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NOTE: Either bottom closure or sight bowl is installed, not both.

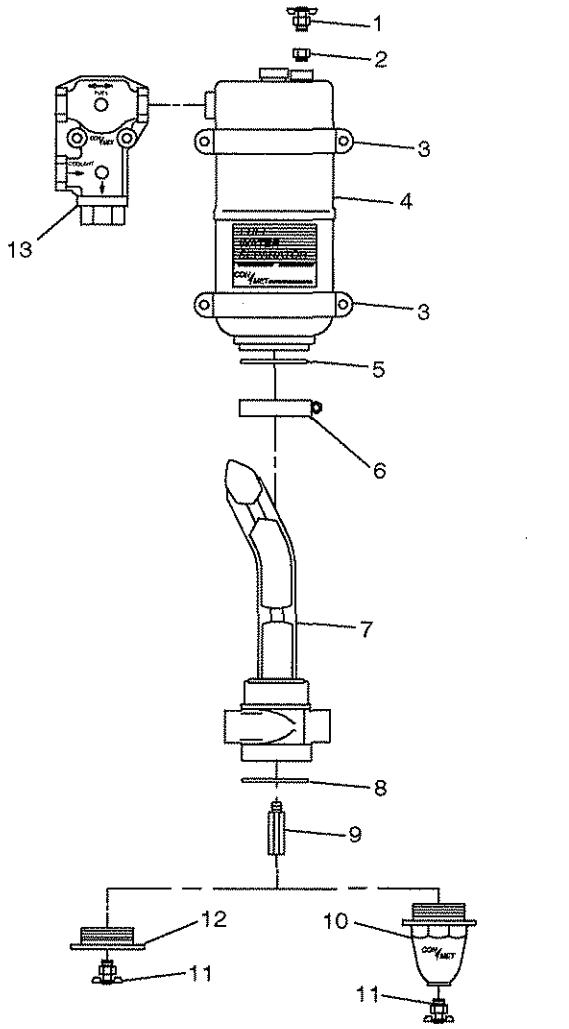
1. Vacuum Breaker Valve
2. Reducer Bushing
3. Mounting Band
4. Separator Body
5. Gasket
6. Sight Bowl
7. Bottom Closure
8. Drain Valve

Fig. 2, Separator Model with Sight Bowl Option

The heater, if installed (**see Fig. 3**), routes engine coolant through a tube to heat the fuel as it trickles down through the baffle. If a sight bowl is also installed, a heater rod warms the water in the sight bowl.

Fuel passing through the thermostat activates a valve that controls coolant flow and regulates fuel temperature. To prevent mixing, fuel and coolant are completely separated.

General Information



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NOTE: Either bottom closure or sight bowl is installed, not both.

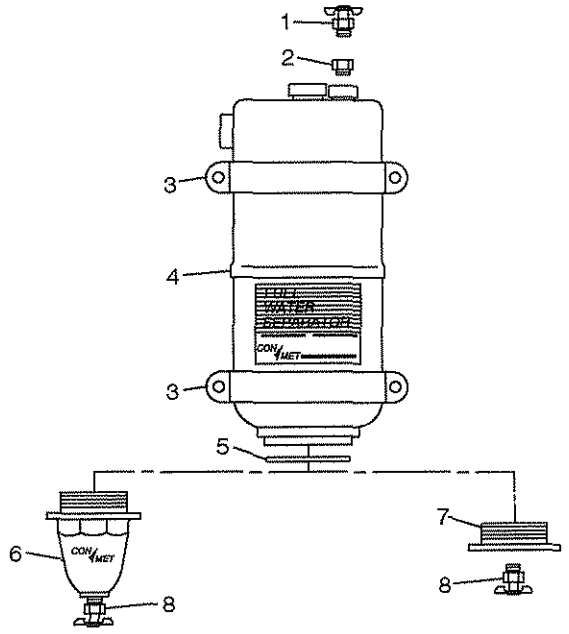
1. Vacuum Breaker Valve
2. Reducer Bushing
3. Mounting Band
4. Separator Body
5. O-Ring
6. V-Clamp
7. Heater Tube
8. Gasket
9. Sight Bowl Heater Rod
10. Sight Bowl
11. Drain Valve
12. Bottom Closure
13. Thermostat

Fig. 3, Separator Model with Heater Option

Con Met Fuel/Water Separator Removal and Installation

Removal

1. Apply the parking brakes, shut down the engine, chock the tires, and tilt the hood.
2. Drain the fuel/water separator. **See Fig. 1.**
   - 2.1 Place a suitable container under the separator body.
   - 2.2 With the engine shut down, open the drain valve (Ref. 8) on the bottom of the separator body (Ref. 4).
   - 2.3 If the accumulated water does not drain immediately, open the vacuum breaker valve (Ref. 1) on the top of the separator body.
   - 2.4 When the unit is completely drained, close the drain valve.



NOTE: Either bottom closure or sight bowl is installed, not both.

1. Vacuum Breaker Valve
2. Reducer Bushing
3. Mounting Band
4. Separator Body
5. Gasket
6. Sight Bowl
7. Bottom Closure
8. Drain Valve

Fig. 1, Con Met Fuel/Water Separator

   - 2.5 If opened, close the vacuum breaker valve.

WARNING: Drain the coolant only when the coolant and engine are cool. Draining it when these are hot could cause severe personal injury due to scalding.

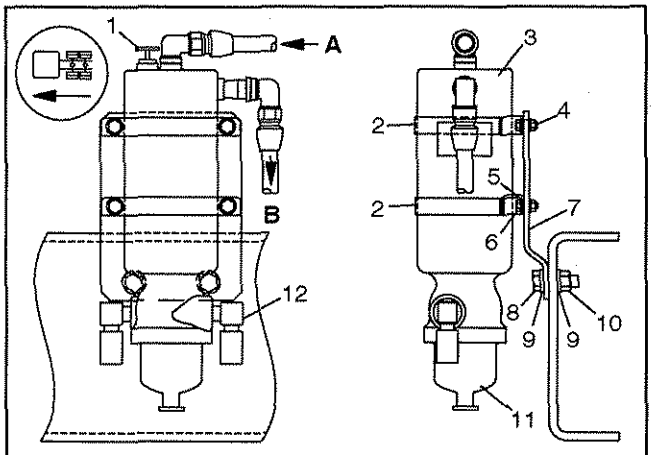
3. If a heater is installed, drain the coolant. Refer to **Section 20.01** for instructions.
4. Disconnect the 1/2-inch NPT fuel line fittings to the intake and exhaust lines on the separator body.

   If a heater is installed, disconnect the 1/2-inch NPT coolant line fittings to the heater body. Also, disconnect the 1/2-inch NPT fuel line and coolant line fittings to the thermostat.

NOTE: If installed, remove the thermostat. For instructions, refer to **Subject 110**.

5. Remove the mounting capscrews, lockwashers and hexnuts that secure the mounting bands to the mounting bracket. **See Fig. 2.** Remove the fuel/water separator from the vehicle.
6. If installed, remove the sight bowl and clean it. **See Fig. 3.**
   - 6.1 Unscrew the sight bowl from the separator body.
   - 6.2 Wipe the sight bowl clean using a soft cloth.
   - 6.3 Inspect the gasket for damage and install a new one if necessary. Lubricate the gasket with a thin film of engine oil and install it on the sight bowl.
   - 6.4 Lubricate the threads on the sight bowl with a thin film of engine oil.
   - 6.5 Hand tighten the sight bowl until the gasket has fully contacted the separator body, and then tighten 1/4 to 1/3 turn more.
   - 6.6 Make sure the drain valve is tightened and closed.

Con Met Fuel/Water Separator Removal and Installation



A. From Fuel Tanks B. To Engine

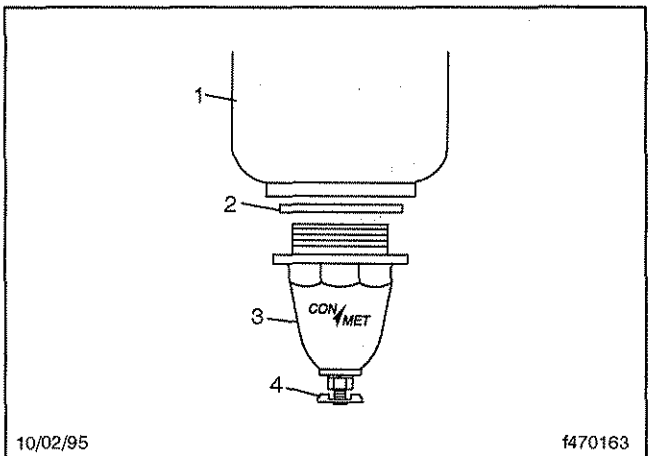
1. Vacuum Breaker Valve
2. Mounting Band
3. Separator Body
4. 5/16–18 Mounting Band Capscrew
5. Lockwasher
6. 5/16–18 Hexnut
7. Mounting Bracket
8. 5/8–11 Mounting Bracket Capscrew
9. Hardened Flatwasher
10. 5/8–11 Locknut
11. Sight Bowl (if installed)
12. Coolant Line (if installed)

Fig. 2, Con Met Fuel/Water Separator Mounting

Installation

1. Check the mounting bracket locknuts for tightness. If necessary, tighten the locknuts 113 lbf·ft (153 N·m).
2. Mount the new fuel/water separator vertically on the mounting bracket. Install the mounting bands, and secure them with the 5/16–18 mounting capscrews, lockwashers, and hexnuts. Tighten the hexnuts 15 lbf·ft (20 N·m). **See Fig. 2.**
3. Attach the 1/2-inch NPT fuel line fittings to the inlet and outlet ports on the separator body.

   If removed, attach the 1/2-inch NPT coolant line fittings to the heater body. Also, attach the 1/2-inch NPT fuel and coolant line fittings to the thermostat.



1. Separator Body
2. Gasket
3. Sight Bowl
4. Drain Valve

Fig. 3, Sight Bowl

4. Apply Loctite® 271 (or equivalent) to all fitting threads. Tighten all fittings until they are airtight.
5. Prime the fuel/water separator with clean diesel fuel.

   5.1 Open the vacuum breaker valve.

   5.2 Fill the unit with clean diesel fuel.

   5.3 Close the vacuum breaker valve and be sure it is airtight.

IMPORTANT: To prevent fuel leaks, be sure the vacuum breaker valve is closed airtight.

6. Start the engine and check for leakage. With the engine shut down, repair any leaks.
7. Lower the hood, and remove the chocks from the tires.

Con Met Fuel/Water Separator Heater and Thermostat Replacement

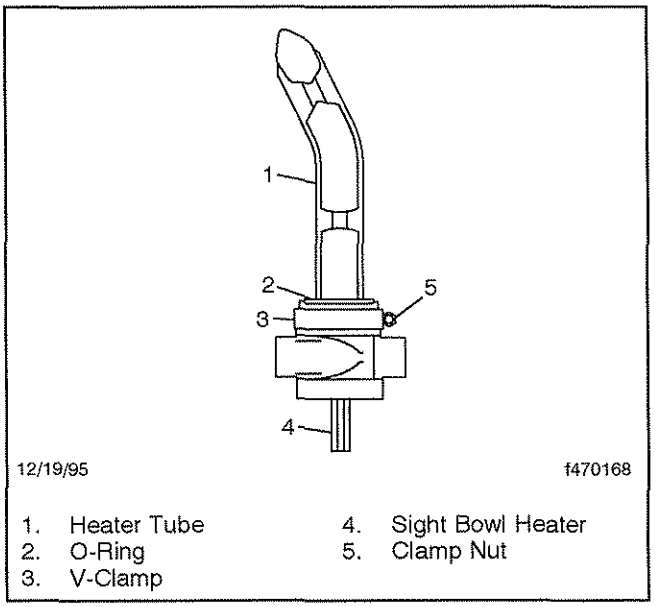
Heater Replacement

1. Apply the parking brakes, shut down the engine, chock the tires, and tilt the hood.
2. Drain the fuel/water separator. For detailed instructions, refer to **Subject 100**.

WARNING: Drain the coolant only when the coolant and engine are cool. Draining it when these are hot could cause severe personal injury due to scalding.

3. Drain the coolant. Refer to **Section 20.01** for instructions.
4. Disconnect the 1/2-inch NPT coolant line fittings from the heater tube body.
5. Loosen the clamp nut and slowly, then carefully lower the heater tube out of the separator body. **See Fig. 1.** Remove the V-clamp and O-ring with the heater.
6. Attach the 1/2-inch NPT coolant line fittings to the new heater. Apply Loctite® 271 (or equivalent) to all fitting threads. Tighten all fittings until they are airtight.

CAUTION: To prevent fuel leaks, rotate the heater so that it does not contact any internal components of the separator body.



1. Heater Tube
2. O-Ring
3. V-Clamp
4. Sight Bowl Heater
5. Clamp Nut

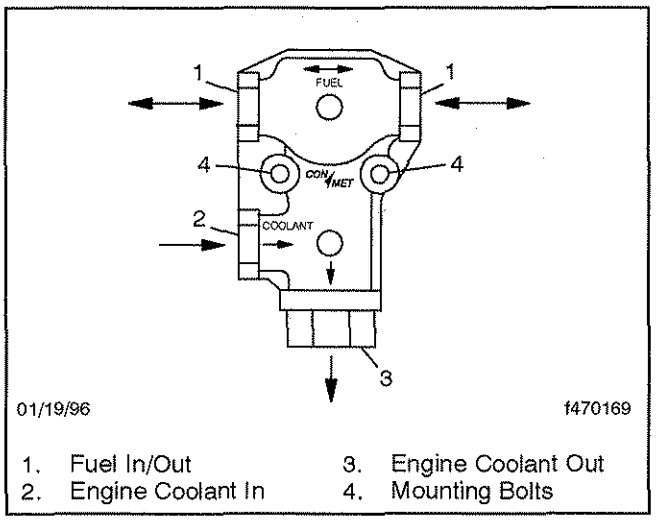
Fig. 1, Fuel Heater Assembly

7. With the V-clamp and O-ring already in place, carefully insert the new heater tube into the separator body.
8. When the O-ring is firmly seated, tighten the clamp nut 30 to 40 lbf·in (340 to 460 N·cm)
9. Lower the hood, and remove the chocks from the tires.

Thermostat Replacement

1. Apply the parking brakes, chock the tires, and tilt the hood.
2. Disconnect the 1/2-inch NPT fuel line fittings from the thermostat.
3. Mark and disconnect the 1/2-inch NPT coolant line fittings from the thermostat.
4. Remove the thermostat mounting bolts. **See Fig. 2.** Remove the thermostat from the vehicle.
5. Install the 5/16-inch thermostat mounting bolts. **See Fig. 2.** Install the new thermostat on the vehicle.
6. Attach the 1/2-inch NPT fuel line fittings to the new thermostat. Apply Loctite® 271 (or equivalent) to all fitting threads. Tighten all fittings until they are airtight.
7. Attach the 1/2-inch NPT coolant line fittings to the new thermostat as marked. Apply Loctite® 271 (or equivalent) to all fitting threads. Tighten all fittings until they are airtight.
8. Lower the hood, and remove the chocks from the tires.

Con Met Fuel/Water Separator Heater and Thermostat Replacement



1. Fuel In/Out
2. Engine Coolant In
3. Engine Coolant Out
4. Mounting Bolts

Fig. 2, Thermostat

Troubleshooting

Problem—Leaking Air in the Fuel System

Problem—Leaking Air in the Fuel System	
Possible Cause	**Remedy**
The vacuum breaker valve is loose.	Tighten the vacuum breaker valve. Make sure it is airtight.
There are loose or broken fuel fittings, valves, or filters.	Tighten or repair the fuel fittings, valves, or filters as needed.

Problem—Leaking Fuel

Problem—Leaking Fuel	
Possible Cause	**Remedy**
The sight bowl is loose.	Tighten the sight bowl. For instructions, refer to **Subject 100.**
The sight bowl is cracked or broken.	Replace the sight bowl. For instructions, refer to **Subject 100.**
The fuel heater is loose.	Tighten the fuel heater V-clamp. For instructions, refer to **Subject 110.**
The fuel heater is incorrectly installed.	Install the fuel heater correctly, so that it is not touching any components in the separator body. For instructions, refer to **Subject 110.**
There are loose or broken fittings somewhere within the fuel system, including in the return lines.	Tighten or repair the fuel fittings as needed.

Specifications

Fastener Torques			
Description	Size	Torque	
		lbf·ft (N·m)	lbf·in (N·cm)
Mounting Band Hexnuts	5/16–18	15 (20)	—
Mounting Bracket Locknuts	5/8–11	113 (153)	—
Heater Element V-Clamp	—	—	30-40 (340-460)

Table 1, Fastener Torques

Fuel/Water Separator, Racor

47.02

Contents

Subject	Subject Number
General Information	050
Service Operations	
Fuel/Water Separator Removal and Installation	100
Heater Replacement	110
Filter Element Replacement	120
Water Sensor Probe Replacement	130
Troubleshooting	300

General Description

The fuel/water separator (**Fig. 1** or **Fig. 2**) removes water and solid contaminants from diesel fuel. Installed on the left frame rail between the fuel tank and the fuel transfer pump, the separator comes with a spin-on filter element and reusable sight bowl.

It is available in two basic models. Model 490R has an in-head fuel priming pump and four fuel ports. Model 690R has no priming pump and seven fuel ports in its head. Both models can be fitted with a 200-watt heater and/or a water sensor probe installed in the sight bowl. All fuel and coolant line ports are 3/8-inch NPT.

NOTE: Models with no priming pumps are not self-priming. To prime, fill the filter element and sight bowl with clean fuel and crank the engine until it starts.

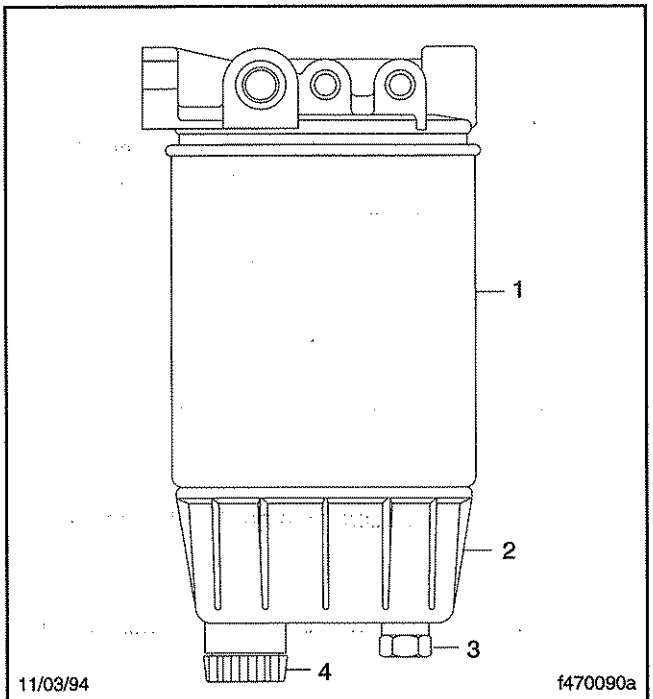
Principles of Operation

Diesel fuel enters at the top of the separator and flows on into the top of the filter element. As the fuel flows down the sides of the element, the heavier contaminants and some water fall directly to the collection bowl (sight bowl) below the element.

The filter element itself contains a resin that repels water, forcing any remaining water to bead up in tiny droplets on the sides of the container. The droplets gradually grow heavier and fall to the collection bowl. As the fuel passes from the outside to the inside of the filter element, the last traces of emulsified water, rust, dirt, and algae collect on the outer surface of the element and fall to the collection bowl.

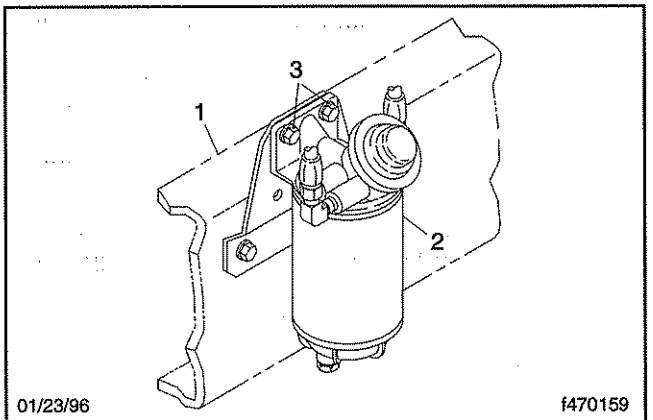
The filtered fuel is drawn out through the top of the separator, and the water and solid contaminants remain in the collection bowl. As the water collects, it completes the circuit between the two prongs of the water sensor probe. If so equipped, a warning light in the cab alerts the operator to drain the bowl.

The heater is operated by turning on the ignition keyswitch for five minutes before starting the engine.



1. Fuel Filter
2. Collection Bowl
3. Water Sensor Probe
4. Drain

Fig. 1, Model 690R Fuel/Water Separator



1. Frame Rail
2. Fuel /Water Separator
3. Mounting Capscrews

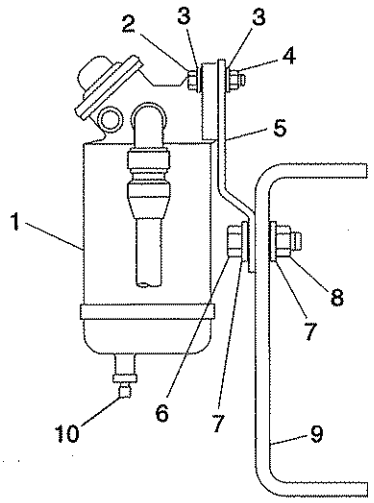
Fig. 2, Model 490R Fuel/Water Separator

Fuel/Water Separator Removal and Installation

Removal

1. Apply the parking brakes, shut down the engine, chock the tires, and tilt the cab or open the hood.
2. Drain the fuel/water separator. See **Fig. 1.**
   - 2.1 Place a suitable container under the separator.
   - 2.2 Turn the drain counterclockwise to open it. If installed, operate the pump.
   - 2.3 When finished, turn the drain clockwise to close it.

   IMPORTANT: When draining fluid from a fuel/water separator, drain the fluid into an appropriate container, and dispose of it properly. Many states now issue fines for draining fuel/water separators onto the ground. On all types of separators, stop draining fluid when you see fuel come out of the separator drain valve.



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1. Spin-On Filter Element
2. 3/8–16 Mounting Capscrew
3. 3/8–16 Washer
4. 3/8–16 Locknut
5. Mounting Bracket
6. 5/8–11 Mounting Bracket Capscrew
7. Hardened Flatwasher
8. 5/8–11 Hexnut
9. Frame Rail
10. Drain Plug

Fig. 1, Fuel/Water Separator Mounting

⚠ WARNING

Do not expose the fuel to, or work with the fuel system near, open flame or intense heat. To do so could cause fire, possibly resulting in serious personal injury or property damage.

3. Disconnect the fuel lines from the separator, and mark the lines for later assembly.
4. If installed, remove the wiring connectors from the water sensor probe and the heater element.
5. Remove the fuel/water separator mounting bolts, and remove the separator from its mounting bracket.

Installation

1. Place the separator against the mounting bracket, and secure it with the mounting bolts. Tighten the bolts 40 lbf·ft (55 N·m).
2. Remove the bowl and the filter element, as a unit, from the new separator.
3. Using clean motor oil or diesel fuel, lubricate the gasket in the top of the filter element.
4. Make sure the drain in the bowl is closed, then fill the filter element and bowl assembly with clean fuel.
5. Install the element on the mounting head and tighten by hand until snug. *Do not use tools to tighten.*
6. If removed, connect the wiring connectors to the water sensor probe and the heater.
7. Connect the fuel lines to the separator, as marked. Apply Loctite® 271 (or equivalent) to all fitting threads. Tighten all fittings until they are airtight.
8. If a primer pump is installed, prime the fuel/water separator.
   - 8.1 Loosen the vent plug.
   - 8.2 Operate the primer pump until fuel comes out at the vent plug.

NOTE: If no vent plug is installed, it may be necessary to remove the filter element and bowl from the head again to make certain they are filled with clean diesel fuel. Hand tighten them only. Do not use tools.

Fuel/Water Separator Removal and Installation

9. Start the engine and check for leaks. With the engine shut down, repair any leaks.
10. Close the hood or lower the cab, and remove the chocks from the tires.

Replacement

1. Apply the parking brakes, shut down the engine, chock the tires, and tilt the cab or open the hood.
2. Drain the fuel/water separator. For detailed instructions, refer to **Subject 100**.
3. Disconnect the heater wiring connector. See **Fig. 1**.
4. If installed, disconnect the water sensor wiring connector from the water sensor probe. See **Fig. 2**.
5. Remove the sight bowl and the filter element.

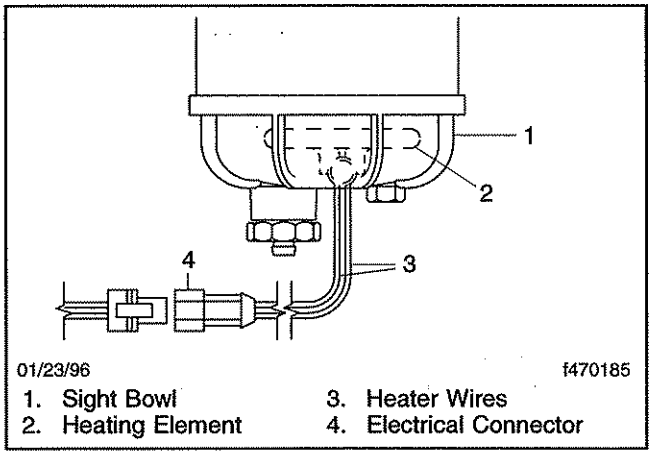


Fig. 1, In-Bowl Heater

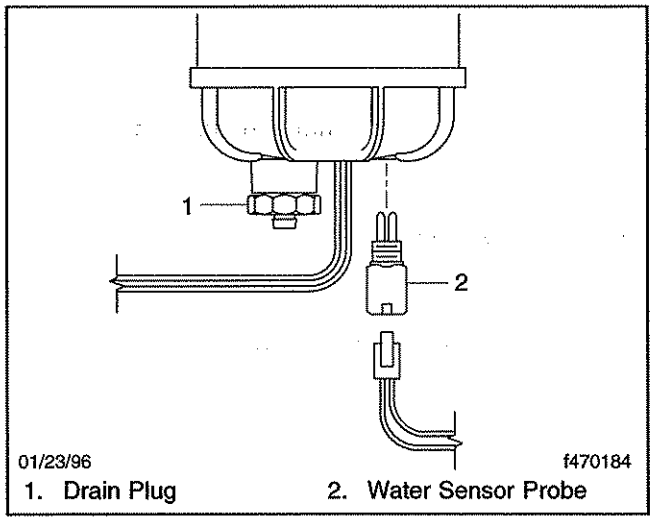
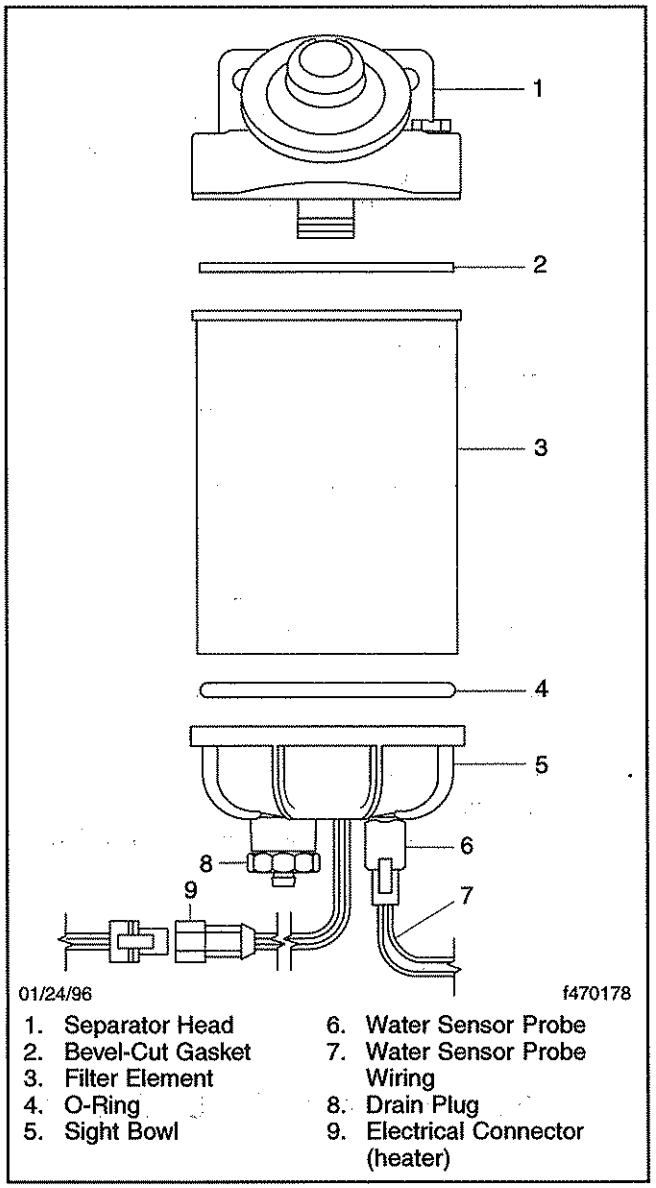


Fig. 2, Water Sensor Probe

6. Remove the sight bowl from the filter element.
7. Install a new sight bowl with heater.
   - 7.1 Remove the O-ring from the lip of the sight bowl. Lubricate the O-ring with a thin film of clean engine oil or diesel fuel and put it back in the sight bowl.
   - 7.2 Install the sight bowl on the bottom of the filter element and tighten until snug.
8. Make sure the drain plug in the base of the sight bowl is tight.
9. Connect the heater wiring connector. If installed, connect the water sensor wiring connector to the water sensor probe.
10. Fill the filter element and sight bowl assembly with clean diesel fuel.
11. If a priming pump is installed, prime the fuel water separator. For detailed instructions, refer to **Subject 100**.
12. Start the engine and check for leaks. With the engine shut down, repair any leaks.
13. Close the hood or lower the cab, and remove the chocks from the tires.

Replacement

1. Apply the parking brakes, shut down the engine, chock the tires, and tilt the cab or open the hood.
2. Drain the fuel/water separator. For detailed instructions, refer to **Subject 100.**
3. If installed, disconnect the electrical connectors from the water sensor probe and the heater wiring. See **Fig. 1.**
4. Spin off the sight bowl and the filter element together. Remove the bevel-cut gasket from the top of the filter element.
5. Remove the sight bowl from the filter element. Clean the O-ring seating surface.
6. Apply a thin coating of clean diesel fuel or engine oil to the O-ring and the new gasket.
7. Spin the sight bowl onto the new filter element and then fill the filter element and sight bowl assembly with clean diesel fuel.
8. Spin the entire assembly onto the separator head and tighten by hand until snug. *Do not use tools to tighten.*
9. If disconnected, connect the heater and water sensor wiring connectors.
10. If a priming pump is installed, prime the fuel water separator. For detailed instructions, refer to **Subject 100.**
11. Start the engine and check for leaks. With the engine shut down, repair any leaks.
12. Close the hood or lower the cab, and remove the chocks from the tires.



1. Separator Head
2. Bevel-Cut Gasket
3. Filter Element
4. O-Ring
5. Sight Bowl
6. Water Sensor Probe
7. Water Sensor Probe Wiring
8. Drain Plug
9. Electrical Connector (heater)

Fig. 1, Filter Element

Replacement

1. Apply the parking brakes, shut down the engine, chock the tires, and tilt the cab or open the hood.
2. Drain the fuel/water separator. For detailed instructions, refer to **Subject 100**.
3. Disconnect the water sensor wiring connector from the water sensor probe. See **Fig. 1**.
4. Remove the filter and the bowl.
5. Unscrew the 9/16-inch diameter water sensor probe from the base of the sight bowl.
6. Install a new probe in the base of the sight bowl.
7. Make sure the drain plug in the base of the sight bowl is tight.
8. Fill the filter element and sight bowl assembly with clean diesel fuel.
9. Install the filter and the bowl.
10. Connect the water sensor wiring connector to the water sensor probe.
11. If a priming pump is installed, prime the fuel water separator. For detailed instructions, refer to **Subject 100**.
12. Start the engine and check for leaks. With the engine shut down, repair any leaks.

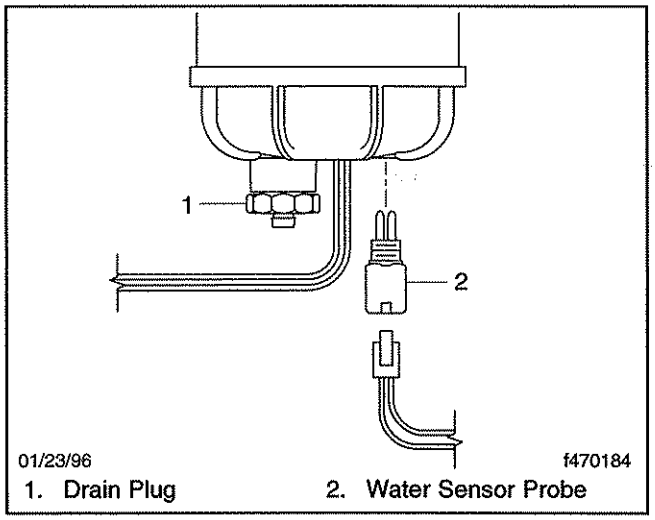


Fig. 1, Water Sensor Probe

13. Close the hood or lower the hood, and remove the chocks from the tires.

Troubleshooting

Problem—Leaking Air in the Fuel System

Problem—Leaking Air in the Fuel System	
Possible Cause	**Remedy**
The drain is not closed.	Tighten the drain valve.
The sight bowl or filter element is loose.	Tighten the sight bowl or filter element until snug, using hand pressure only.
There are loose, broken, or clogged fuel fittings, valves, or filters.	Tighten, clean, or repair the fuel fittings, valves, or filters as needed.

Fuel Heater, Arctic Fox 47.03

Contents

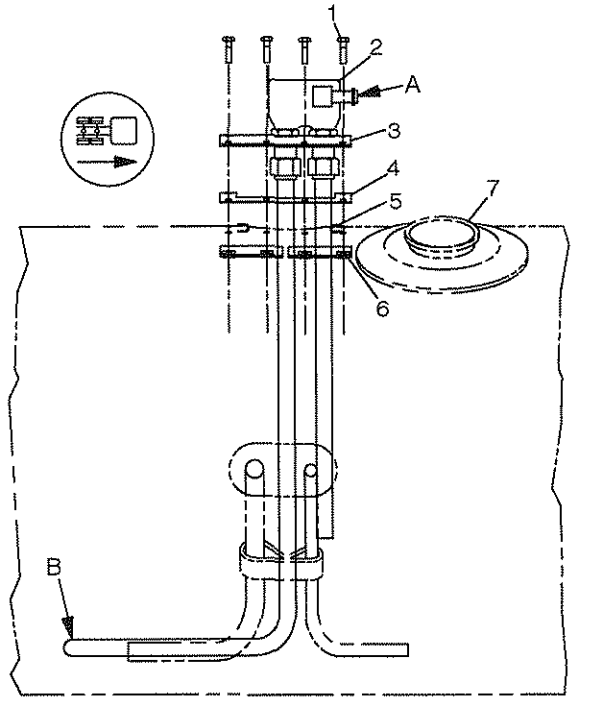
Subject	Subject Number
General Information	050
Service Operations	
Arctic Fox Fuel Heater Replacement	100

General Description

The Arctic Fox fuel heater Model C406 (**see Fig. 1**) is installed in the fuel tank facing the fuel filler neck. It comes in two different lengths to accomodate 23- and 27-inch cylindrical tanks.

Twelve 1/4-inch capscrews bolt the heater to the tank, attaching to a mounting flange that is an integral part of the heater head. A heating coil, consisting of a coolant tube in the form of a closed loop, extends down into the tank.

To prevent overheating, the unit is equipped with a temperature probe that monitors fuel temperature. It is connected to a bypass thermostat that controls an automatic coolant shut-off valve.



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NOTE: Right-hand tank shown

A. Orient coolant fittings toward the fuel filler neck.
B. Install fuel heater with lower loop pointing aft.

1. Mounting Capscrew
2. Fuel Heater
3. Mounting Flange
4. Gasket
5. Mounting Clip
6. Backing Plate
7. Fuel Filler Neck

Fig. 1, Arctic Fox Fuel Heater

Principles of Operation

Hot engine coolant is routed through the heating coil, warming the fuel as it passes. A bypass thermostat shuts off the coolant flow when the fuel in the tank reaches a temperature of approximately 80°F (27°C).

The hot coolant is then directed through a bypass circuit within the thermostat head, which sends it straight back to the engine. For this reason, the head of the fuel heater stays hot even when the heating circuit has been bypassed.

Arctic Fox Fuel Heater Replacement

Replacement

IMPORTANT: When installed in the fuel tank, the clearance between the bottom of the fuel heater and the inside of the tank wall must be at least 1 inch (25 mm) and no more than 2 inches (51 mm).

1. Apply the parking brakes, shut down the engine, and chock the tires.

WARNING: Drain the coolant only when the coolant and engine are cool. Draining it when these are hot could cause severe personal injury due to scalding.

2. Drain the coolant. Refer to **Section 20.01** for instructions.

3. Mark the coolant fittings and lines. Disconnect the coolant lines from the fittings on the fuel heater.

WARNING: Do not expose the fuel to, or work with the fuel system near, open flame or intense heat. To do so could cause fire, possibly resulting in serious personal injury or property damage.

4. Remove the twelve 1/4-inch capscrews attaching the fuel heater mounting flange to the fuel tank. **See Fig. 1.**

5. Remove the fuel heater from the fuel tank.

   5.1 Carefully work the fuel heater coil out of the fuel tank around the backing plate.

   5.2 Remove the fuel heater gasket.

6. Install the new fuel heater in the fuel tank.

   6.1 Position a new gasket on the hole in the fuel tank. Align the holes in the gasket with those in the tank.

   6.2 Insert the heater coil into the tank, making sure that it does not contact anything inside the tank, such as the tank wall, the fuel gauge, the standpipe, or tank baffles.

   6.3 Line up the heater mounting flange with the gasket and the holes in the tank, and insert the twelve 1/4-inch mounting capscrews. Tighten the capscrews 40 to 60 lbf·in (460 to 680 N·cm).

   NOTE: Be sure the heads of the capscrews are snug to the top of the mounting flange.

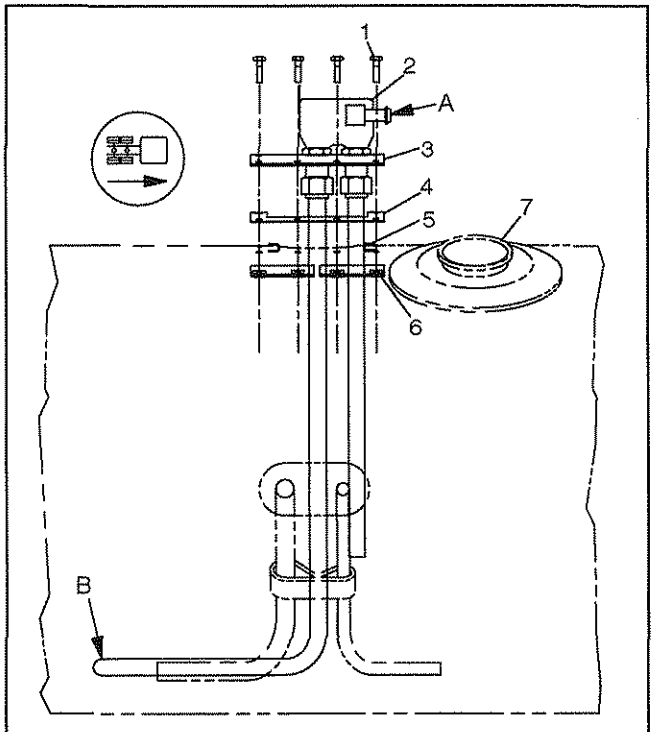
   6.4 Now tighten each capscrew 78 to 95 lbf·in (880 to 1080 N·cm).

7. Using the sequence shown **in Fig. 2**, recheck each capscrew for 78 to 95 lbf·in (880 to 1080 N·cm).

IMPORTANT: To ensure that the gasket seals properly, follow the tightening sequence exactly.

8. Connect the coolant lines to the heater, as marked. Apply Loctite® 271 (or equivalent) to all fitting threads. Tighten all fittings until they are airtight.

IMPORTANT: Keep all lines as straight and short as possible.



NOTE: Right-hand tank shown

A. Orient coolant fittings toward the fuel filler neck.
B. Install fuel heater with lower loop pointing aft.

1. Mounting Capscrew
2. Fuel Heater
3. Mounting Flange
4. Gasket
5. Mounting Clip
6. Backing Plate
7. Fuel Filler Neck

Fig. 1, Arctic Fox Fuel Heater Installation

Arctic Fox Fuel Heater Replacement

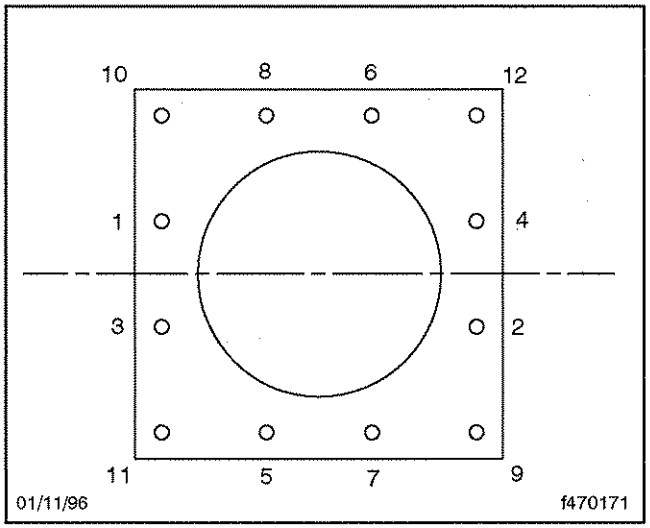


Fig. 2, Fastener Tightening Order

9. Fill the cooling system with clean coolant. Refer to **Section 20.01** for instructions.
10. Start the engine and check for coolant leaks. With the engine shut down, repair any leaks.
11. Lower the hood, and remove the chocks from the tires.

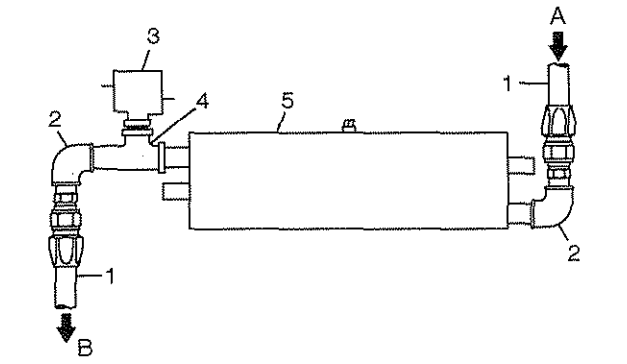
Contents

Subject	Subject Number
General Information	050
Service Operations	
Webb In-Line Fuel Heater Replacement	100

General Information

The Webb in-line fuel heater (**see Fig. 1**) is clamped to a mounting bracket, which in turn is bolted to the frame rail. Hot engine coolant circulates through the heater, heating the fuel in the supply line.

To prevent overheating, the heater is equipped with an automatic coolant shut-off valve.



A. From fuel tanks
B. To engine or fuel/water separator

1. Fuel Line
2. 90° Elbow
3. Thermostat
4. Tee
5. Fuel Heater

Fig. 1, Webb In-Line Fuel Heater

Webb In-Line Fuel Heater Replacement

Replacement

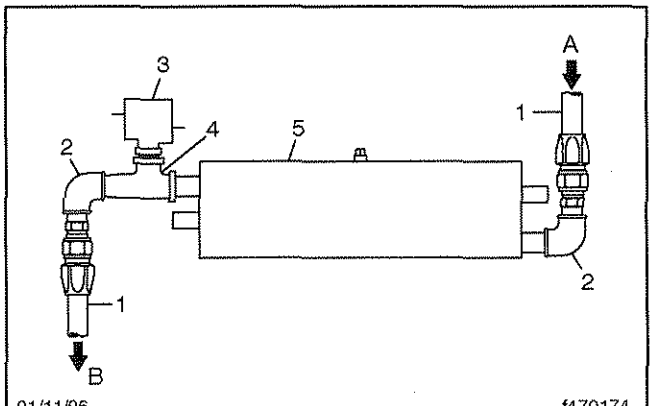
1. Apply the parking brakes, shut down the engine, and chock the tires.

WARNING: Drain the coolant only when the coolant and engine are cool. Draining it when these are hot could cause severe personal injury due to scalding.

2. Drain the coolant. Refer to **Section 20.01** for instructions.
3. On dual tank installations, close the fuel shut-off valves. Open the fuel filler cap to relieve pressure in the fuel system.

WARNING: Do not expose the fuel to, or work with the fuel system near, open flame or intense heat. To do so could cause fire, possibly resulting in serious personal injury or property damage.

4. Remove the fuel line fittings (large fittings). **See Fig. 1.** Remove the coolant line fittings (small fittings).
5. Remove the fuel heater from the fuel line. **See Fig. 2.**
   - 5.1 Remove the 1/2–13 hexnuts, washers, and capscrews attaching the two heater clamps to the mounting bracket.
   - 5.2 Remove the fuel heater from the mounting bracket.
6. Install the new fuel heater on the fuel supply line.
   - 6.1 Position the heater clamps on the mounting bracket and install the mounting capscrews, washers, and nuts.
   - 6.2 Tighten each mounting capscrew 67 lbf·ft (84 N·m).
7. Connect the coolant lines to the heater, as marked. Apply Loctite® 271 (or equivalent) to all fitting threads. Tighten all fittings until they are airtight.
8. On dual tank installations, open the fuel shut-off valves. Check the fuel filler cap to make sure it is tight.
9. Fill the cooling system with clean coolant. Refer to **Section 20.01** for instructions.
10. Start the engine and check for coolant leaks. With the engine shut down, repair any leaks.

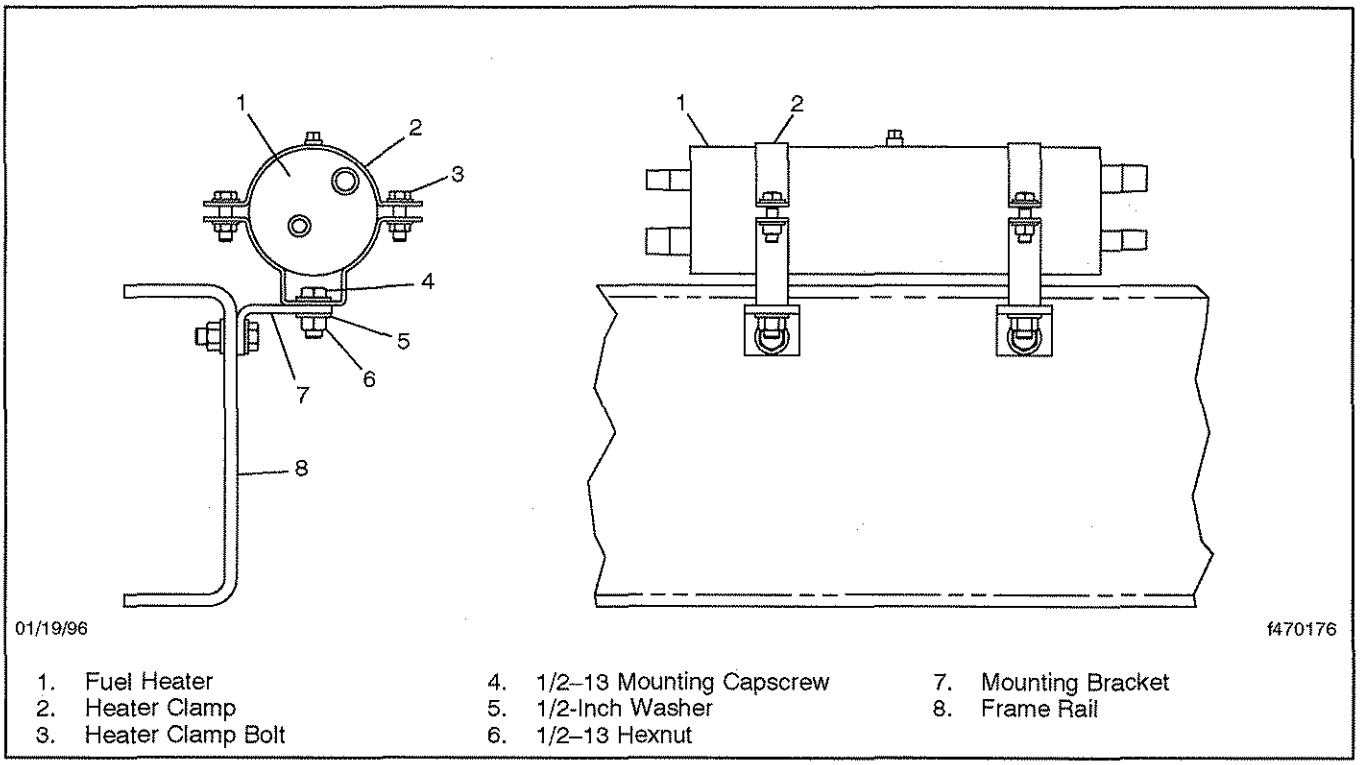


A. From fuel tanks
B. To engine or fuel/water separator

1. Fuel Line
2. 90° Elbow
3. Thermostat
4. Tee
5. Fuel Heater

Fig. 1, Webb In-Line Fuel Heater

Webb In-Line Fuel Heater Replacement



1. Fuel Heater
2. Heater Clamp
3. Heater Clamp Bolt
4. 1/2–13 Mounting Capscrew
5. 1/2-Inch Washer
6. 1/2–13 Hexnut
7. Mounting Bracket
8. Frame Rail

Fig. 2, Webb In-Line Fuel Heater Mounting

11. Lower the hood, and remove the chocks from the tires.

Fuel Cooler, Hayden

47.05

Contents

Subject	Subject Number
General Information	050
Service Operations	
Hayden Fuel Cooler Removal and Installation	100
Troubleshooting	300
Specifications	400

General Information

The Hayden fuel cooler (**see Fig. 1**) consists of a heat exchanger, fuel tubing, and a rubber mounting block.

The heat exchanger bolts to a mounting bracket which attaches to the frame rail. A retaining plate and biscuits protect the exposed side of the installation.

Fuel in the return line flows through the cooler and exchanges heat with the air flowing underneath the vehicle during operation. The cooled fuel then returns to the fuel tanks.

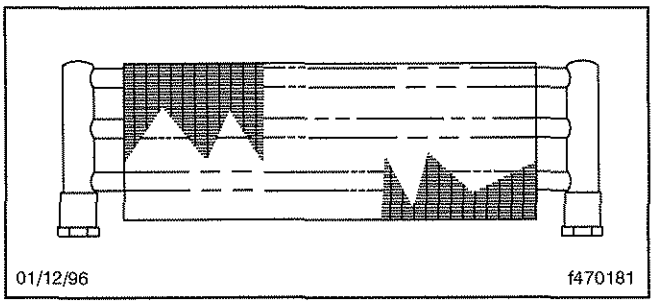


Fig. 1, Hayden Fuel Cooler

Hayden Fuel Cooler Removal and Installation

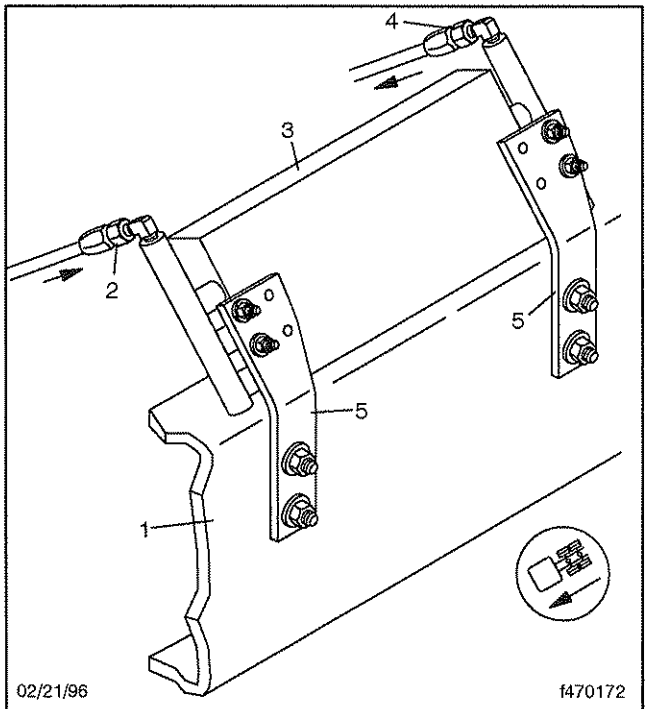
Removal

1. Apply the parking brakes, shut down the engine, and chock the tires.

WARNING: Do not expose the fuel to, or work with the fuel system near, open flame or intense heat. To do so could cause fire, possibly resulting in serious personal injury or property damage.

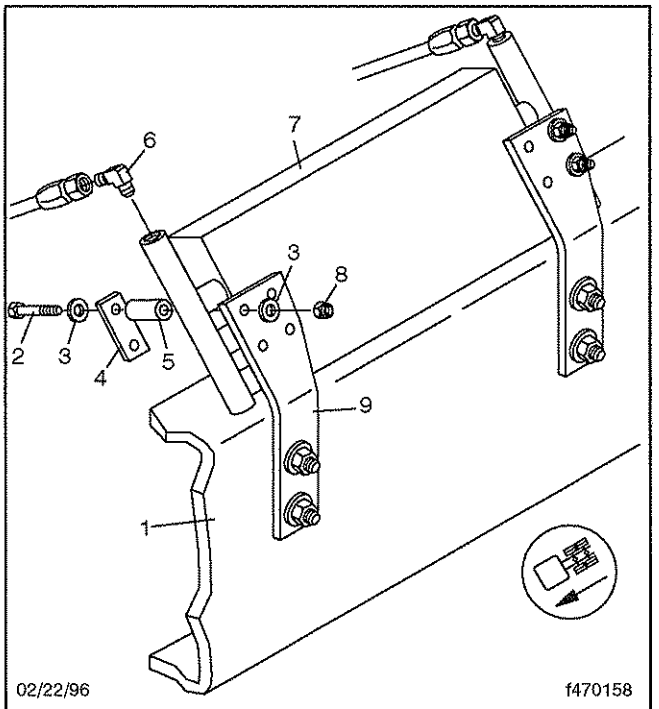
2. Mark the fuel fittings and lines. Disconnect the fuel lines from the fittings on the fuel cooler. **See Fig. 1.** Have a basin ready to catch the fuel that comes out of the lines. Tie up the fuel lines to prevent dripping.

3. Remove the fuel cooler from its mounting bracket. **See Fig. 2.**



1. Frame Rail
2. Fuel Fittings (from engine)
3. Heat Exchanger
4. Fuel Fittings (to fuel tank)
5. Mounting Bracket

Fig. 1, Fuel Cooler Fittings



1. Frame Rail
2. 5/16–18 Mounting Capscrew
3. Washer
4. Retaining Plate
5. Biscuit
6. 90° Elbow
7. Heat Exchanger
8. 5/16–18 Locknut
9. Mounting Bracket

Fig. 2, Fuel Cooler Mounting

3.1 Remove the four 5/16–18 locknuts and rear washers from the mounting bracket.

3.2 Remove the capscrews, front washers, biscuits, and retaining plates.

3.3 Drain the fuel in the fuel cooler into a basin.

Installation

1. Install the fuel cooler on its mounting bracket.

1.1 Position the retaining plates, biscuits, front washers, and 5/16–18 capscrews on the fuel cooler and mounting bracket.

Hayden Fuel Cooler Removal and Installation

1.2 Install the 5/16–18 locknut and rear washer. Tighten the locknuts 25-30 lbf·in (280-340 N·cm).

2. Connect the fuel lines to the fuel cooler.

2.1 Apply Loctite® 271 (or equivalent) to all fitting threads.

CAUTION: To avoid damaging the connections, use a back-up wrench on the heat exchanger fittings when tightening the fuel line fittings.

2.2 Connect the fuel lines and tighten the fittings 15 lbf·ft (20 N·m).

3. Prime the engine fuel pump; refer to the engine manufacturer's operation and maintenance manual.

4. Start the engine and check for fuel leaks. With the engine shut down, repair any leaks.

5. Lower the hood, and remove the chocks from the tires.

Troubleshooting

Problem—The Heat Exchanger Is Not Cooling the Fuel

Problem—The Heat Exchanger Is Not Cooling the Fuel	
Possible Cause	**Remedy**
The cooling fins are dirty.	Wearing eye protection, clean the heat exchanger fins carefully. If necessary, use water flowing at low pressure to remove debris lodged in the fins. **CAUTION:** Do not direct a high-pressure stream of water at the fuel cooler. This will damage the fins.
The cooling fins are bent.	Using a 12 fin/inch fin comb, straighten any bent fins.
The heat exchanger is clogged with contaminated fuel.	Using a compatible fuel system fluid, flush out the heat exchanger in both directions (through both fittings).
There are hairline cracks in the heat exchanger.	Replace the fuel cooler.
The heat exchanger's fuel tubing is dented badly enough to restrict fuel flow past the heat exchanger.	Replace the fuel cooler.

Problem—The Fuel Cooler Is Leaking

Problem—The Fuel Cooler Is Leaking	
Possible Cause	**Remedy**
The fuel line connections are loose.	Tighten the connections until the leaks disappear. Do not tighten more than 15 lbf·ft (20 N·m) and use a back-up wrench on the heat exchanger fitting. Start the engine and make sure there are no more leaks.
The sealant on the fittings is not adequate.	Remove the fittings, clean off any dried or cracked sealant, and apply Loctite® 271 (or equivalent) to all fitting threads.
The fitting(s) are cracked or stripped.	Replace the fitting(s).

Specifications

Fastener Torque Values			
Fastener Description	Size	Torque Value	
		lbf·ft (N·m)	lbf·in (N·cm)
Mounting Locknuts	5/16–18	—	25-30 (280-340)
Fuel Line Fittings	—	15 (20)	—

Table 1, Fastener Torque Values

Group Index, Alphabetical

Section	Section Number
Exhaust System	49.00

Exhaust System 49.00

Contents

Subject	Subject Number
General Information	050
Service Operations	
Exhaust Ducting, Frame Rail-Mounted, Removal and Installation	100
Exhaust Stack, Removal and Installation	110
Exhaust Stack, Removal and Installation, Coronado	120
Heat Shield, Removal and Installation	130
Heat Shield, Removal and Installation, Coronado	140
Muffler Replacement	150
Wide-Band Exhaust Clamp Replacement	160
Muffler Elbow, Removal and Installation	170

General Information

The exhaust system routes hot exhaust gas away from the cab, and reduces engine exhaust noise. Vehicles can have either a horizontally mounted or a vertically mounted exhaust system. Vehicles are available either with or without a vertical exhaust stack.

System components include the engine outlet exhaust pipe, muffler, muffler mounting components, saddle clamps, wide-band exhaust clamps, flex pipe, exhaust stack, and exhaust system heat shields.

A vehicle can have single or dual mufflers.

The muffler can be mounted horizontally (**Fig. 1**) where it is supported by brackets which are bolted to inside of the frame rails.

The muffler can be mounted outboard (**Fig. 2**, **Fig. 3**, or **Fig. 4**) where it is supported by uprights which are bolted to the outside of the frame rails.

On Century Class Conventionals, the muffler can be mounted on the cab (**Fig. 5**) where it is supported by a bracket bolted to the corner of the cab. This installation uses isolators between the muffler and the cab.

Or, the muffler can be cab *and* frame-rail mounted (**Fig. 6**) where it is supported by a frame rail bracket and a bracket bolted to the back of the cab. This installation uses isolators between the muffler and the cab, and between the muffler and the frame rail bracket.

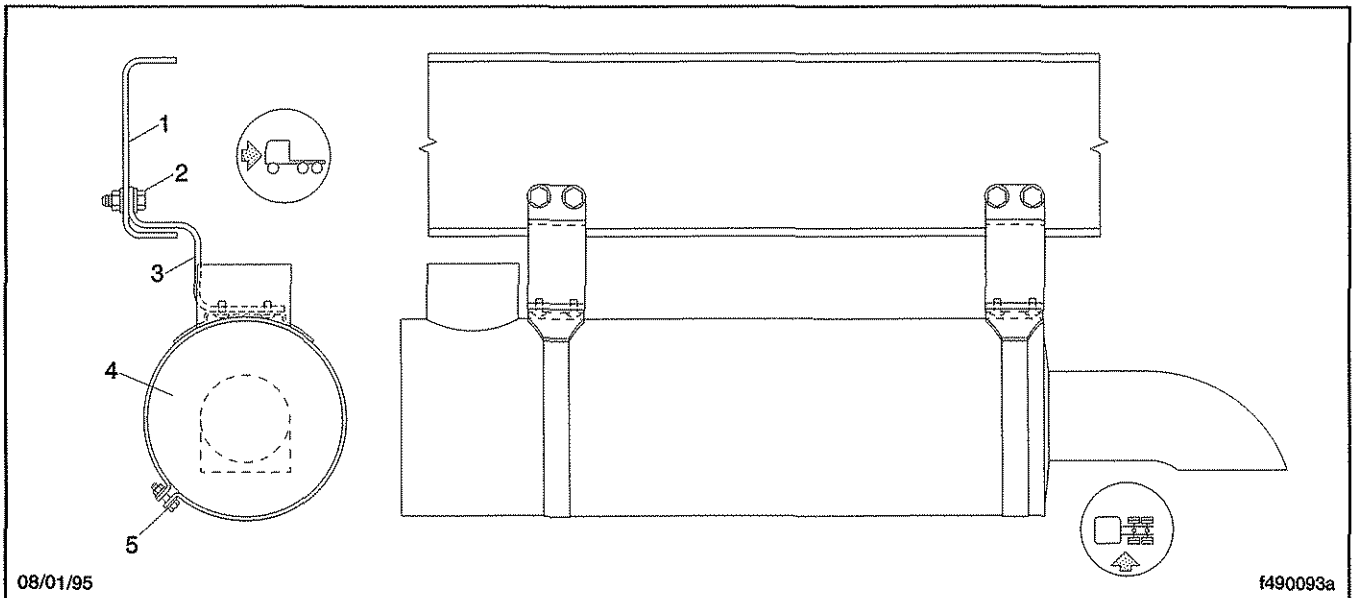
On Argosy COEs, the muffler is always frame-mounted. See **Fig. 3**.

On the Coronado, the muffler is mounted under the cab, between the frame rails. See **Fig. 7**.

Most exhaust installations consist of an engine exhaust pipe, sometimes called the turbo pipe, mounted to the rear of the turbocharger and secured with a V-clamp. From there, flex pipe and exhaust piping route the exhaust to the muffler. A bracket attached to the frame rail or the cab uses a clamp to hold and support the engine exhaust piping as it runs to the muffler. Band clamps connect all piping joints between the turbocharger and the muffler, and hold the exhaust piping to the muffler.

The exhaust piping can be mounted to the frame rail (**Fig. 8**, **Fig. 9**, or **Fig. 10**).

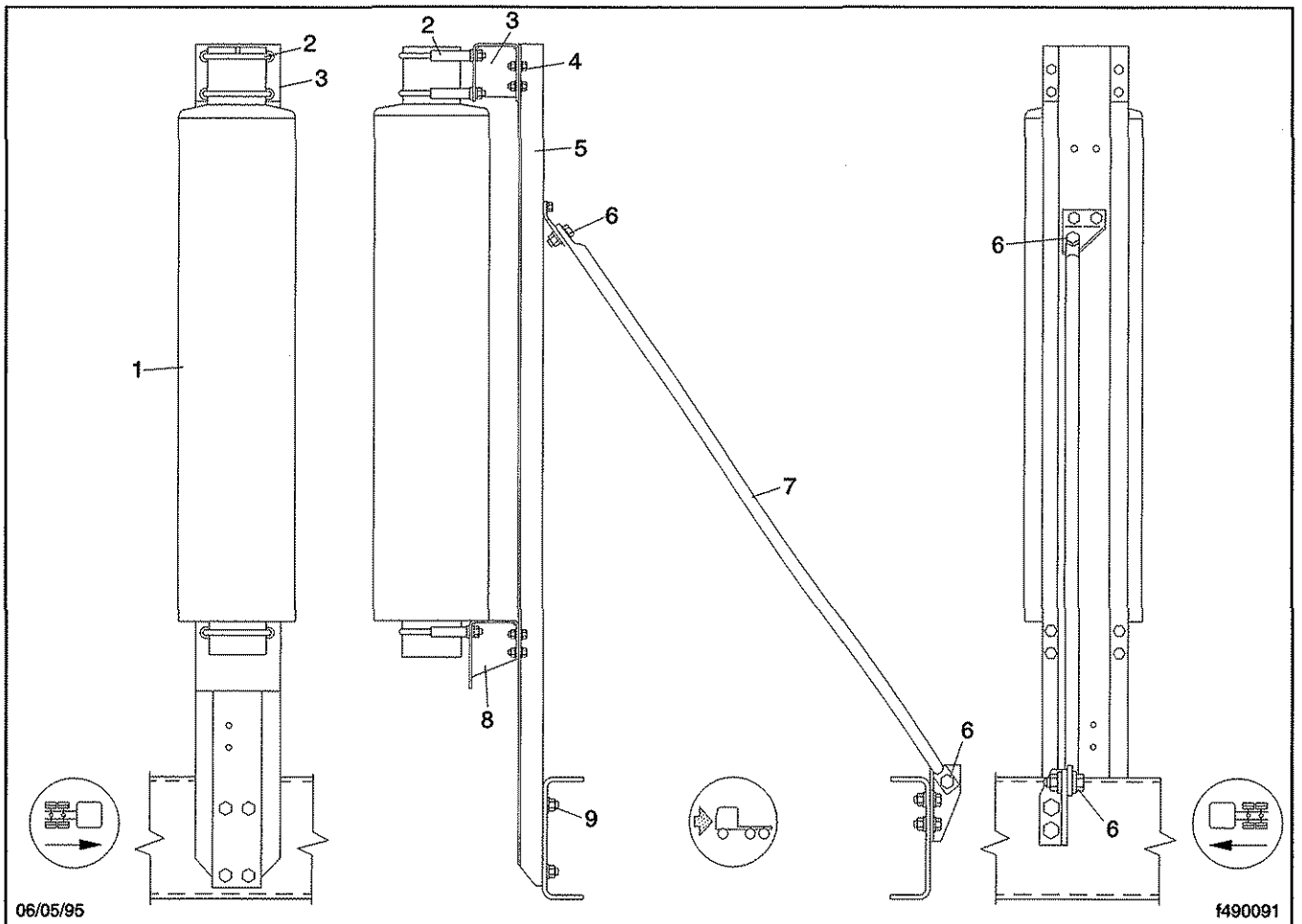
Or, the exhaust piping can be mounted to the cab (**Fig. 11**).



1. Frame Rail
2. Capscrew, 5/8–11 x 1.75, grade 8; Nut; Washer
3. Muffler Mounting Bracket
4. Muffler
5. Capscrew, 5/16–18 x 1.75, grade 8; Nut; Washer

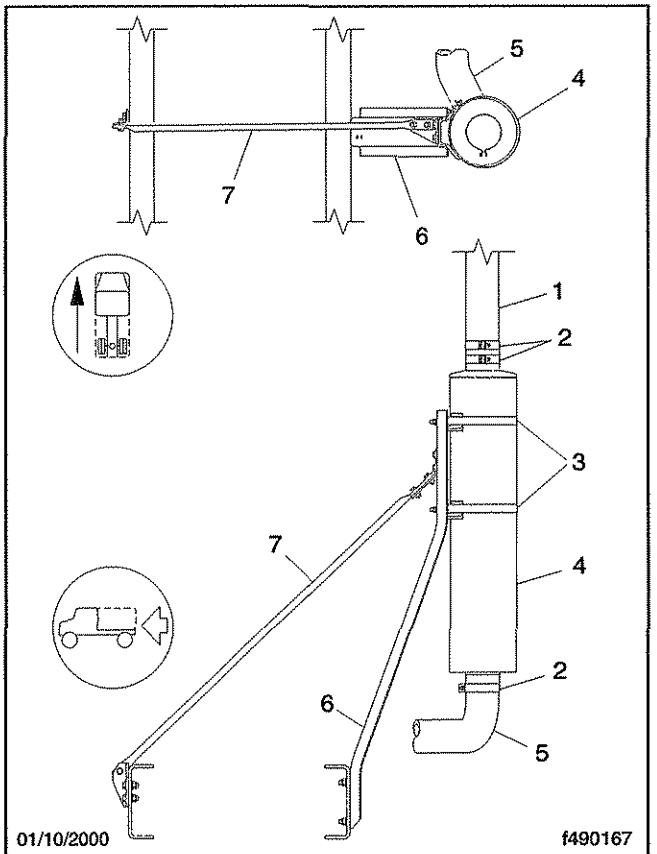
Fig. 1, Horizontal Muffler Mounting

General Information



1. Muffler
2. Saddle Clamp, 5-Inch
3. Upper Muffler Mounting Bracket
4. Capscrew, 3/8–16 x 1.25, grade 8; Nut; Washer
5. Muffler Mounting Upright
6. Capscrew, 5/8–11 x 1.25, grade 8; Nut; Washer
7. Muffler Mounting Brace
8. Lower Muffler Mounting Bracket
9. Capscrew, 5/8–11 x 1.75, grade 8; Nut; Washer

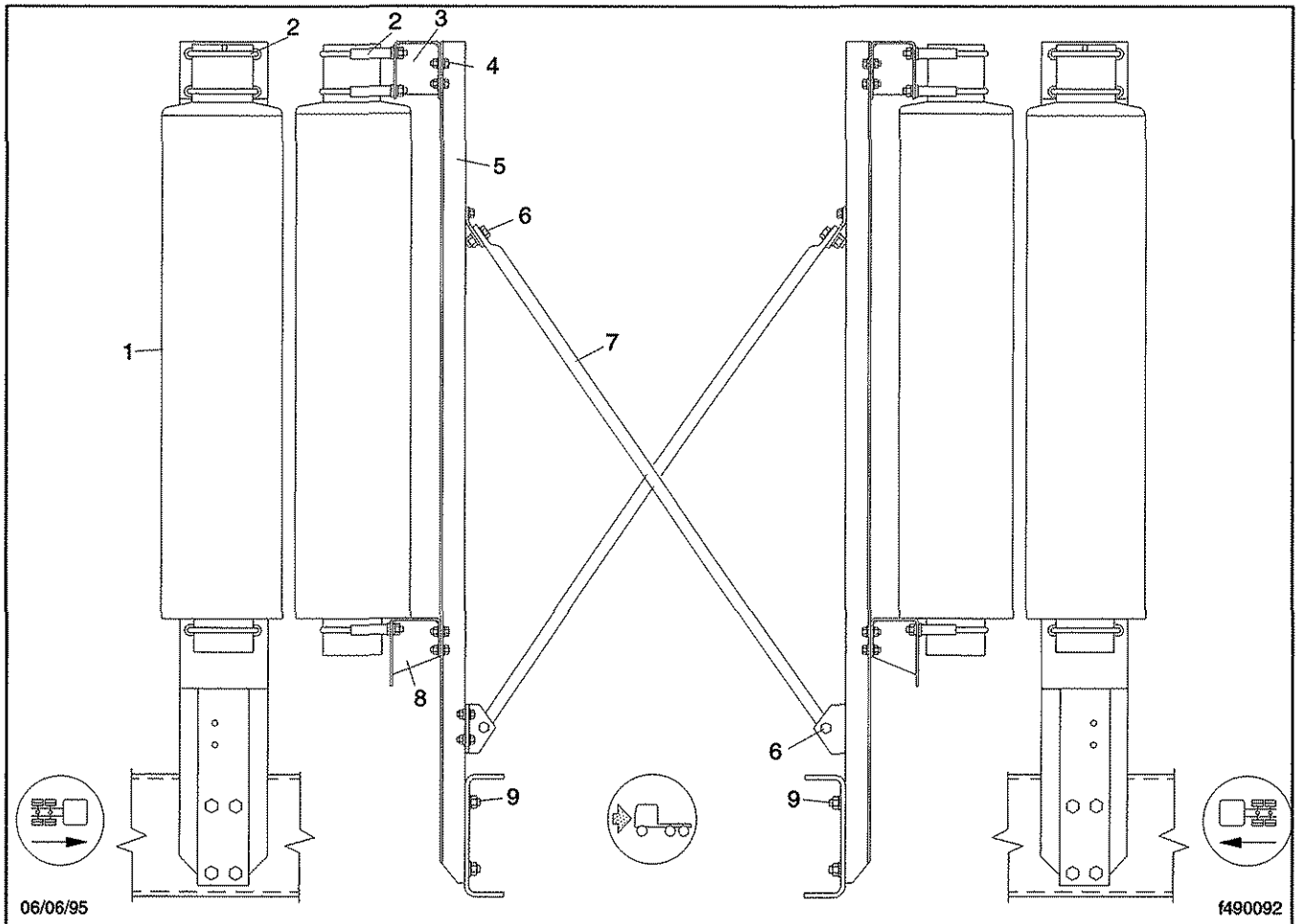
Fig. 2, Single Stationary Outboard Muffler Mounting, Century Class Conventional



1. Top Stack
2. Accuseal® Clamp, 5-Inch
3. Muffler Band
4. Muffler
5. Exhaust Pipe from Engine
6. Muffler Mounting Upright
7. Muffler Mounting Brace

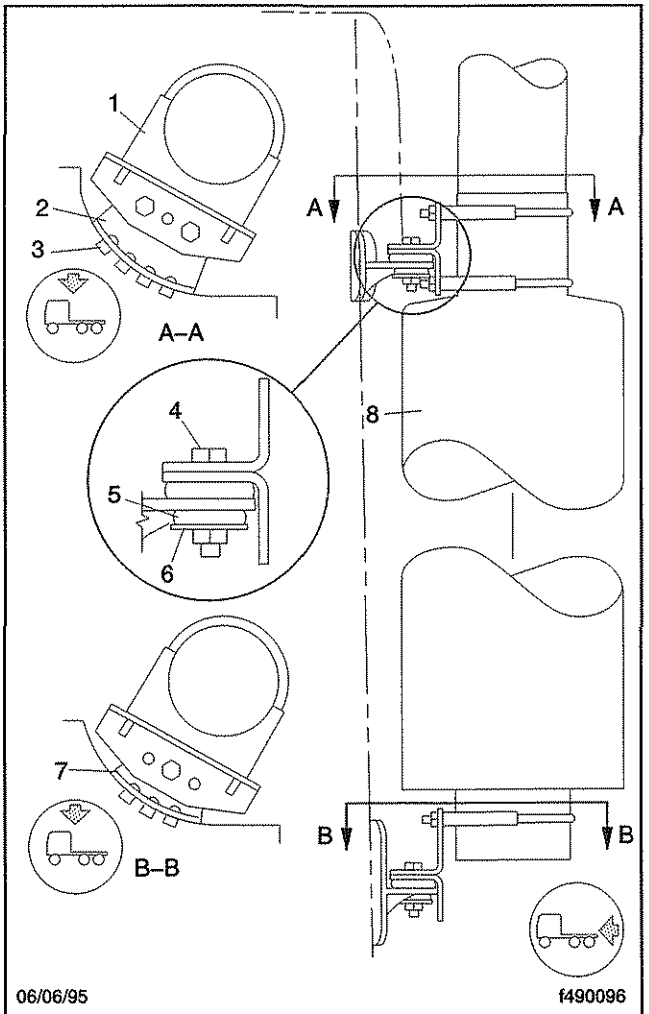
Fig. 3, Single Stationary Outboard Muffler Mounting, Argosy COE

General Information



1. Muffler
2. Saddle Clamp, 5-inch
3. Upper Muffler Mounting Bracket
4. Capscrew, 3/8–16 x 1.25, grade 8; Nut; Washer
5. Muffler Mounting Upright
6. Capscrew, 5/8–11 x 1.25, grade 8; Nut; Washer
7. Muffler Mounting Brace
8. Lower Muffler Mounting Bracket
9. Capscrew, 5/8–11 x 1.75, grade 8; Nut; Washer

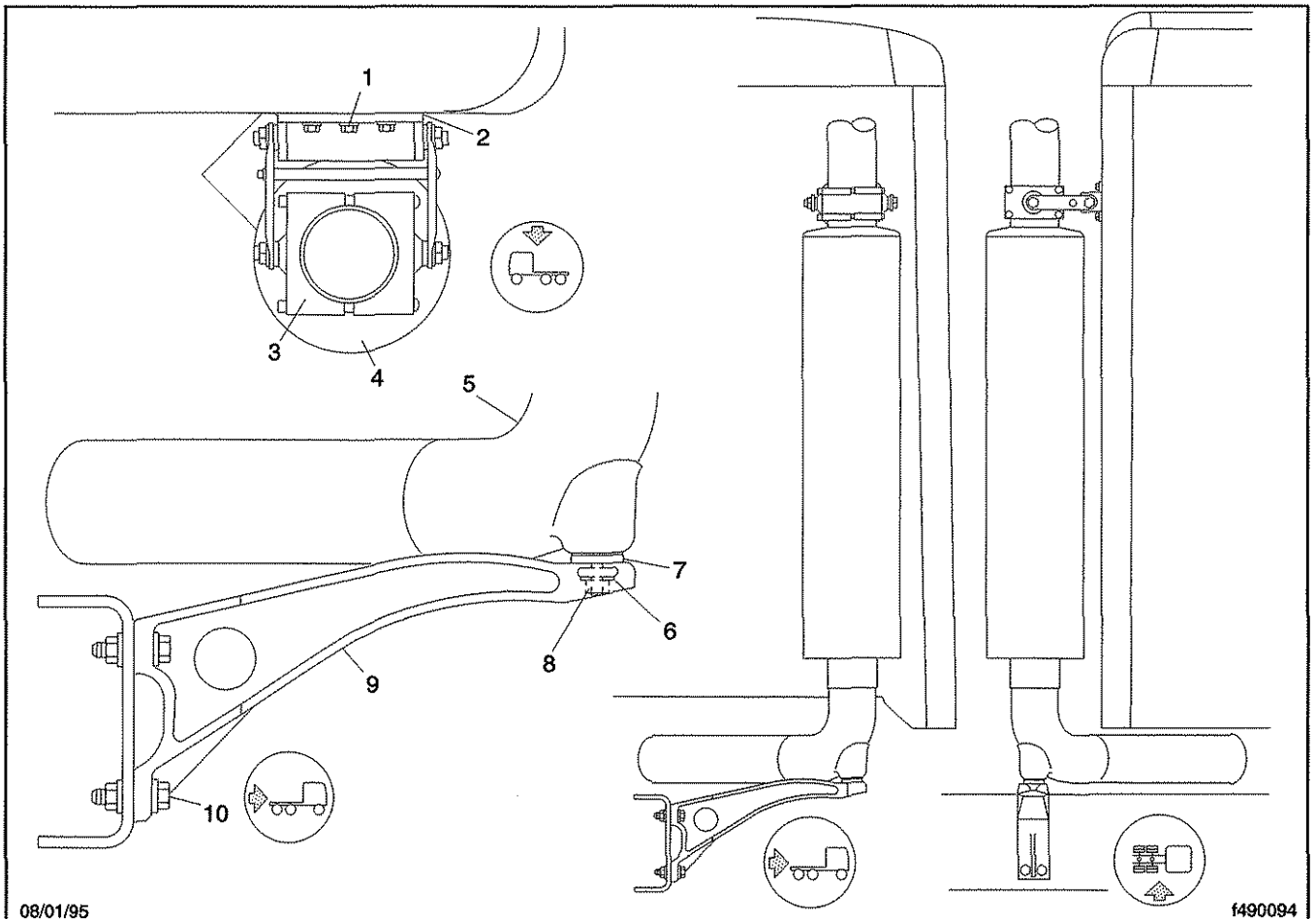
Fig. 4, Dual Stationary Outboard Muffler Mounting (Century Class Conventional shown)



1. Saddle Clamp, 5-inch
2. Upper Muffler Mounting Bracket and Gasket
3. Lockbolt and Collar
4. Capscrew, 1/2–13 x 2.25, grade 5; Nut; Washers
5. Isolator
6. Flatwasher
7. Lower Muffler Mounting Bracket
8. Muffler

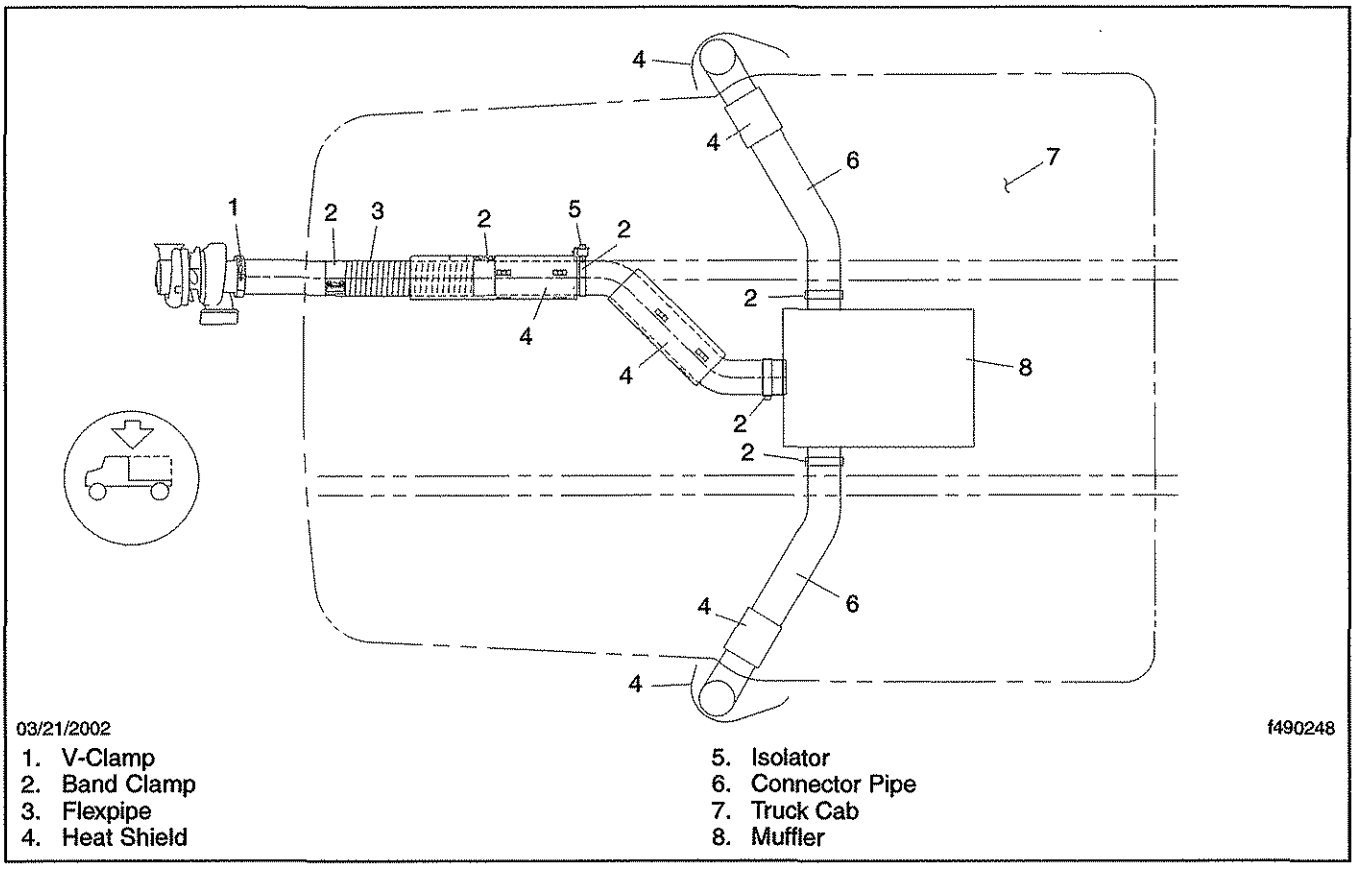
Fig. 5, Cab-Mounted Muffler, Century Class Conventional

General Information



1. Capscrew, 5/16–18, Stainless Steel; Washer
2. Gasket
3. Upper Muffler Mounting Bracket (Shackle Assembly)
4. Muffler
5. Muffler Pipe Elbow
6. Flatwasher
7. Isolator
8. Nut, 1/2–13, grade C
9. Lower Muffler Mounting Bracket
10. Capscrew, 5/8–11 x 1.75, grade 8; Nut; Washers

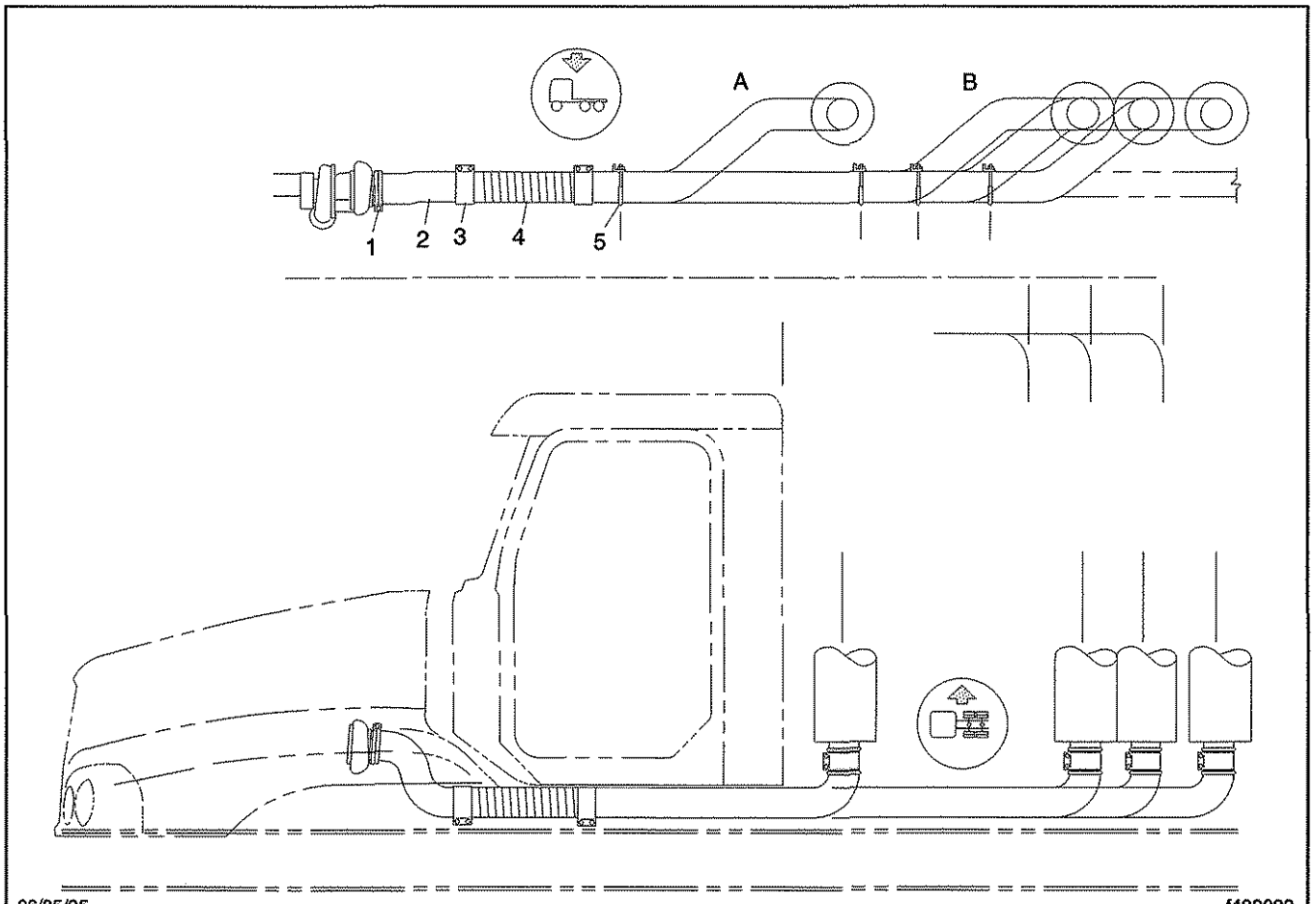
Fig. 6, Cab and Frame-Rail Mounted Muffler, Century Class Conventional



1. V-Clamp
2. Band Clamp
3. Flexpipe
4. Heat Shield
5. Isolator
6. Connector Pipe
7. Truck Cab
8. Muffler

Fig. 7, Exhaust System, Coronado

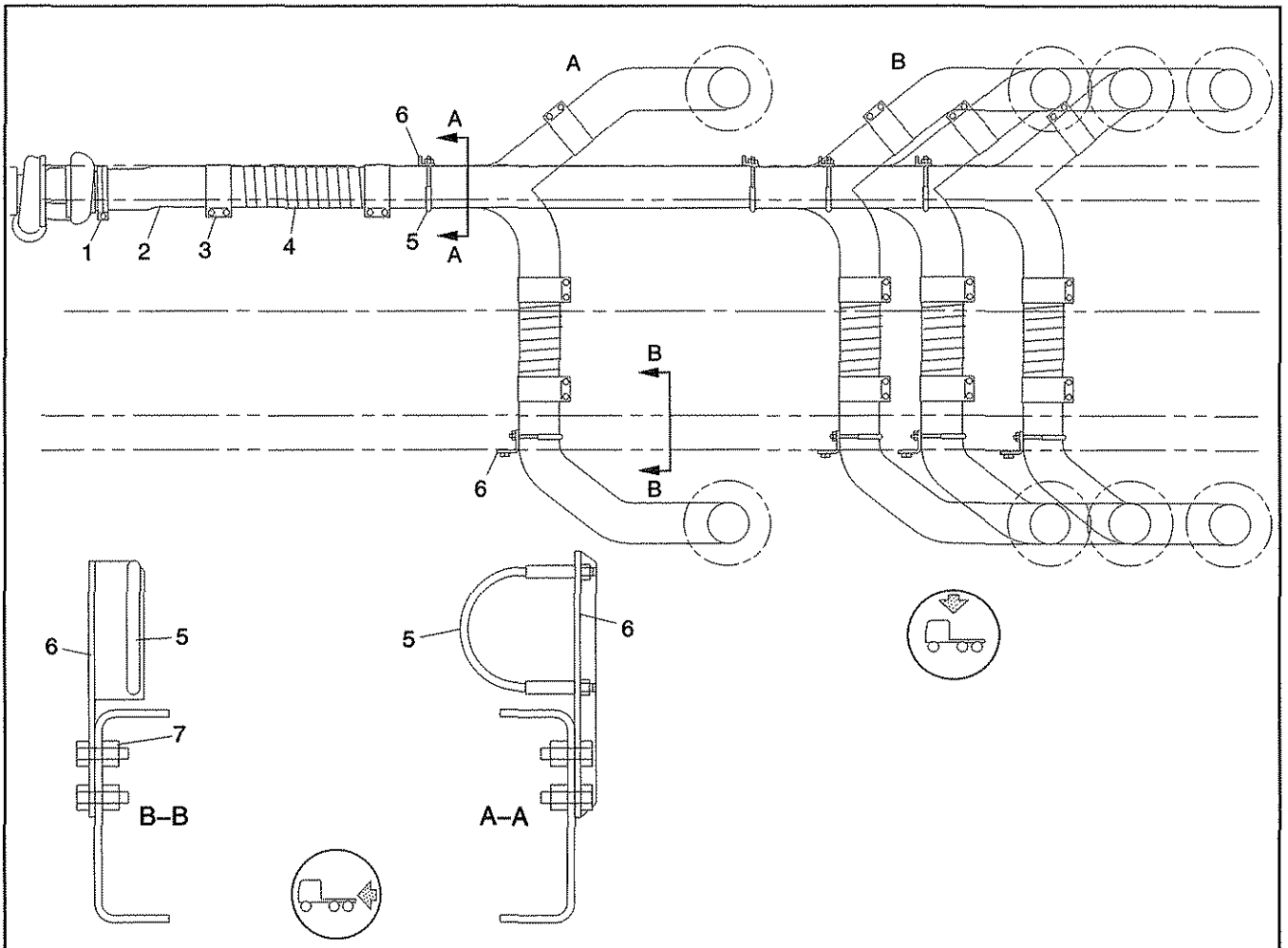
General Information



A. Muffler Location Day Cab
B. Muffler Location With Sleeper Cab

1. V-Clamp, 5-Inch
2. Engine Turbo Pipe
3. Wide-Band Clamp, 5-Inch
4. Flexpipe, 5-Inch
5. Tube Support Bracket and Clamp, 5-Inch

Fig. 8, Exhaust Piping for Single Stationary Outboard-Mounted Muffler (Century Class Conventional shown)

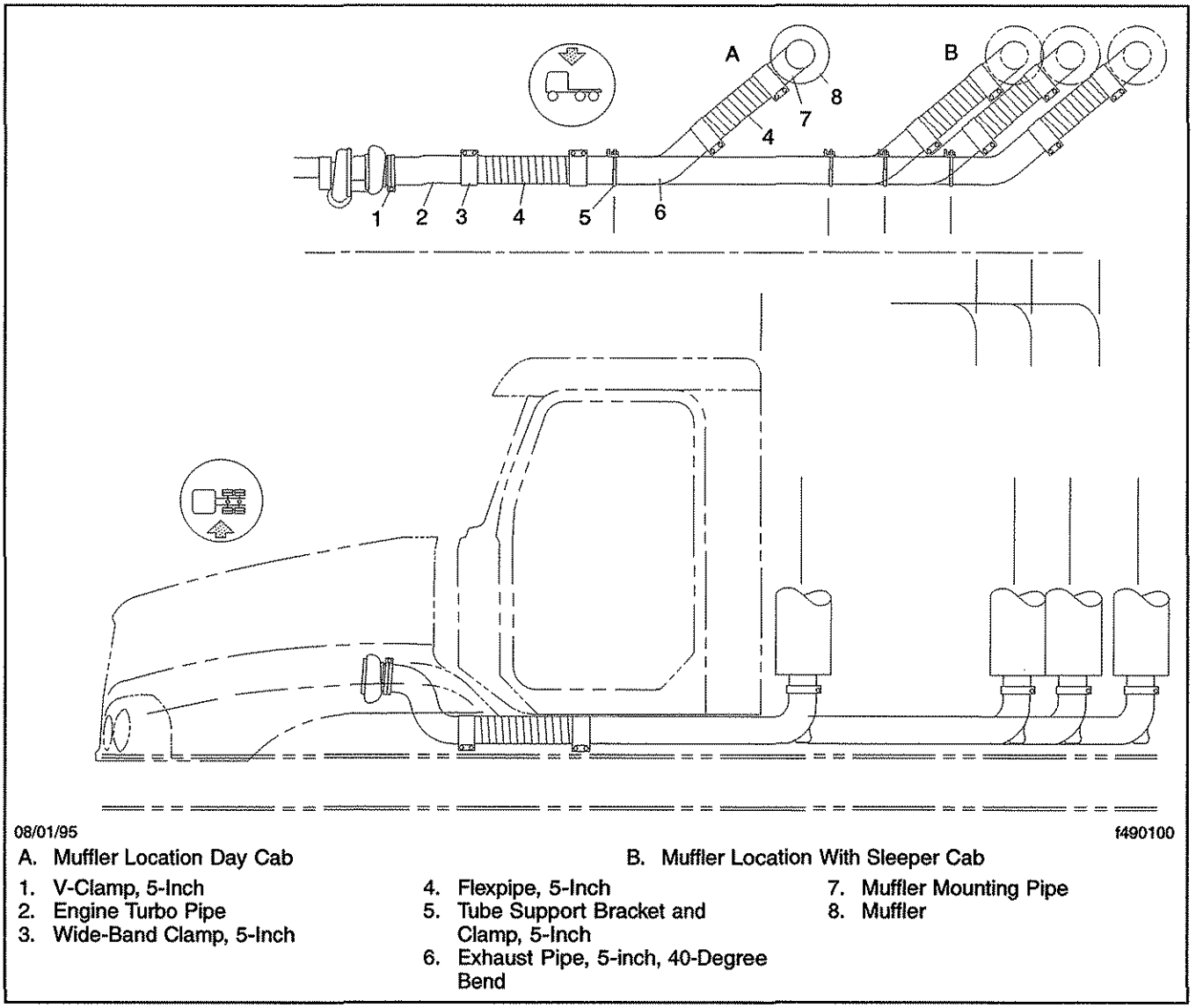


A. Muffler Location Day Cab
B. Muffler Location With Sleeper Cab

1. V-Clamp, 5-Inch
2. Engine Turbo Pipe
3. Wide-Band Clamp, 5-Inch
4. Flexpipe, 5-Inch
5. U-Bolt Tube Clamp, 5-Inch
6. Exhaust Piping Bracket
7. Capscrew, 5/8–11 x 1.75, grade 5; Nut; Washers

Fig. 9, Exhaust Piping for Dual Stationary Outboard-Mounted Mufflers (Century Class Conventional shown)

General Information



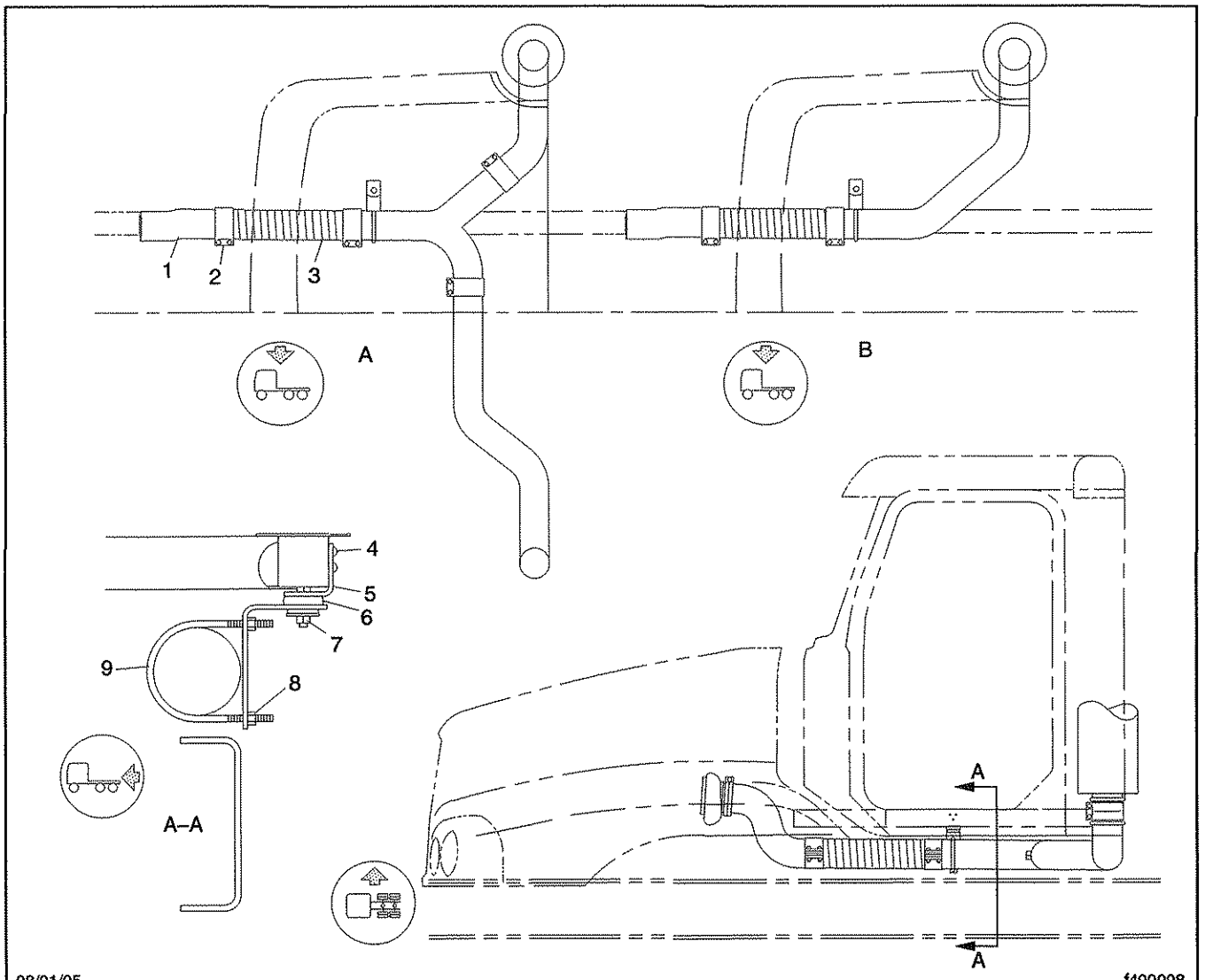
A. Muffler Location Day Cab

1. V-Clamp, 5-Inch
2. Engine Turbo Pipe
3. Wide-Band Clamp, 5-Inch
4. Flexpipe, 5-Inch
5. Tube Support Bracket and Clamp, 5-Inch
6. Exhaust Pipe, 5-inch, 40-Degree Bend

B. Muffler Location With Sleeper Cab

7. Muffler Mounting Pipe
8. Muffler

Fig. 10, Exhaust Piping for Cab and Frame-Rail Mounted Muffler, Century Class Conventional



A. Exhaust Piping for Dual Cab-Mounted Mufflers
B. Exhaust Piping for Single Cab-Mounted Muffler

1. Engine Turbo Pipe
2. Wide-Band Clamp, 5-Inch
3. Flexpipe, 5-Inch
4. Blind Rivet
5. Exhaust Mounting Bracket
6. Isolator
7. Nut, 1/2–13, Grade C
8. Nut, 3/8–16
9. U-Bolt Tube Clamp, 5-Inch

Fig. 11, Exhaust Piping for Cab-Mounted Muffler, Century Class Conventional

Exhaust Stack, Removal and Installation

Removal

1. Park the vehicle, shut down the engine, apply the parking brakes, and chock the tires.
2. *If working with a cab and frame rail-mounted muffler,* loosen the five nuts that clamp the cab-mounted muffler bracket around the top of the muffler and the stack.

   If working with any other vertical muffler, loosen the saddle clamps at the top of the muffler.
3. Lift the stack out of the muffler.

Installation

1. Insert the stack into the top of the muffler.
2. Secure the stack to the muffler.

   If working with a cab and frame rail-mounted muffler, tighten the four large nuts in the cab-mounted muffler bracket 74 lbf·ft (100 N·m) and the small nut 24 lbf·ft (33 N·m).

   If working with any other vertical muffler, tighten the saddle clamps at the top of the muffler 24 lbf·ft (33 N·m).
3. Remove the chocks from the tires.

Exhaust Stack Removal and Installation, Coronado

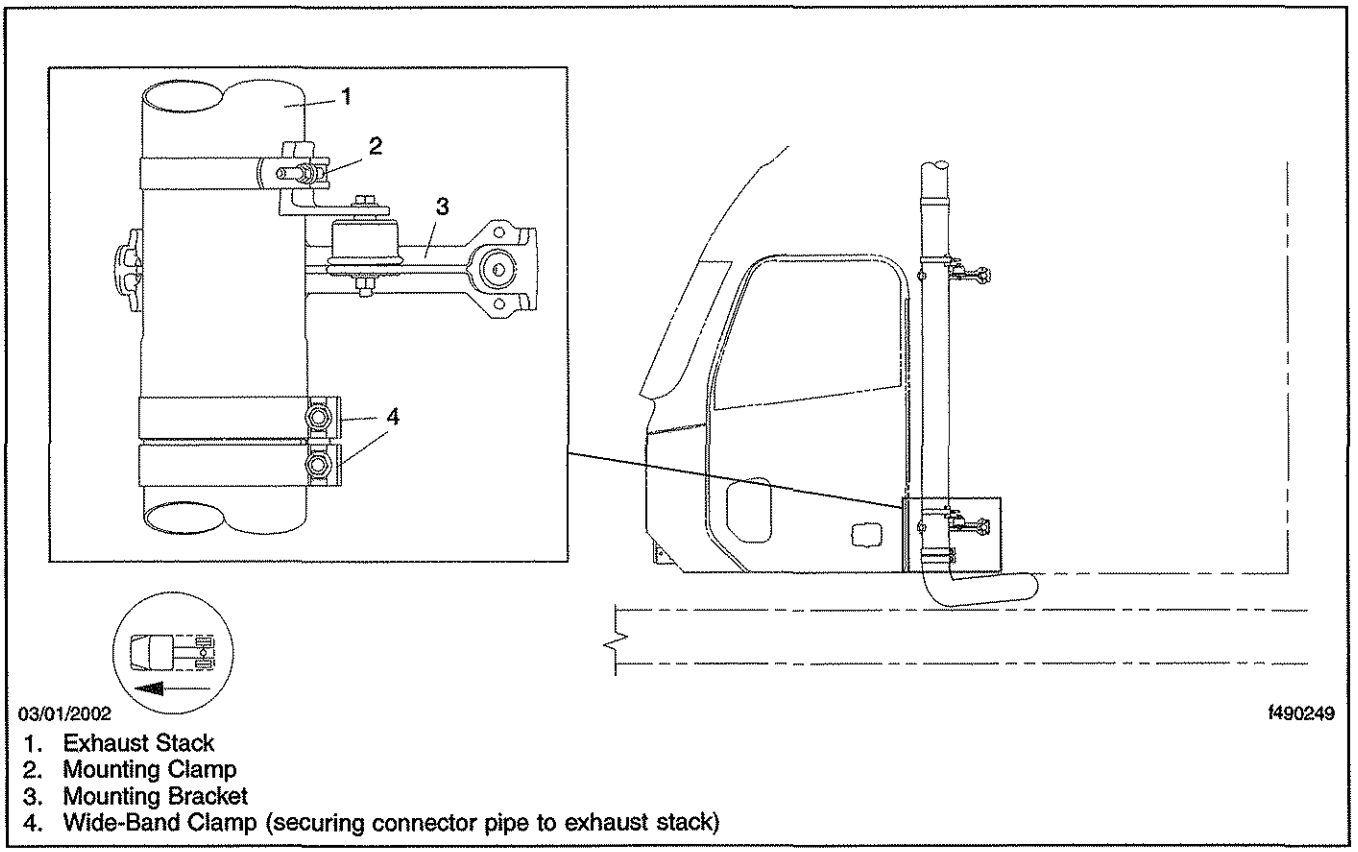
Refer to **Fig. 1** when performing the following procedures.

Removal

1. Park the vehicle, shut down the engine, apply the parking brakes, and chock the tires.
2. Remove the heat shield. For instructions, see **Subject 140.**
3. Loosen the wide-band clamp securing the stack to the muffler connector tube.
4. Loosen the nuts on the upper and lower bands that secure the stack to the mounting brackets on the cab.
5. Slide the clamps from the bracket, lift and remove the stack.

Installation

1. Insert the stack into the top of the connector tube. Make sure the clamps are around the stack for mounting in the next step.
2. Place the clamps around the mounting brackets on the cab and tighten the nuts 22 lbf·ft (30 N·m).
3. Using a level, make sure the exhaust stack is verticle. If not rotate the stack at the mounting backets.
4. Tighten the wide-band clamp at the connector tube 50 lbf·ft (68 N·m).
5. Install the heat shield. For instructions, see **Subject 140.**
6. Remove the chocks from the tires.



1. Exhaust Stack
2. Mounting Clamp
3. Mounting Bracket
4. Wide-Band Clamp (securing connector pipe to exhaust stack)

Fig. 1, Exhaust Stack, Coronado

Heat Shield Removal and Installation, Argosy and S/T

Removal

1. Park the vehicle, shut down the engine, apply the parking brakes, and chock the tires.
2. Note the position of the heat shield and heat shield mounting bands.
3. Remove the bolts that hold the ends of the shield mounting bands together.
4. Remove the heat shield and mounting bands from the muffler

Installation

1. Position the heat shield and heat shield mounting bands on the muffler.
2. Use the bolts and nuts to connect the ends of the bands, and tighten the bolts until the mounting bands are tight around the muffler.
3. Remove the chocks from the tires.

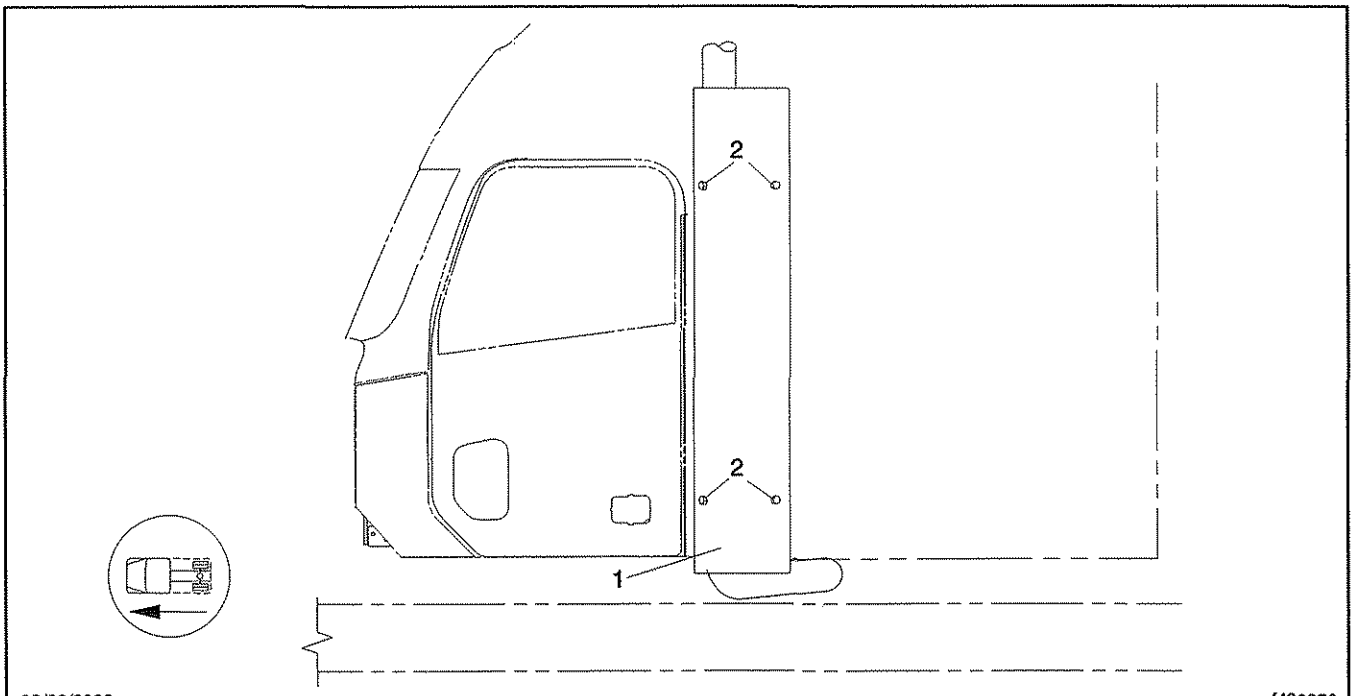
Heat Shield Removal and Installation, Coronado

Removal

1. Park the vehicle, shut down the engine, apply the parking brakes, and chock the tires.
2. Remove the four capscrews that secure the exhaust stack shield to the mounting brackets on the cab. Remove the lower bolts first. See **Fig. 1**.
3. Remove the shield.

Installation

1. Position the heat shield over the mounting brackets.
2. Install the four capscrews that secure the shield to the mounting brackets. See **Fig. 1**.
3. Remove the chocks from the tires.



1. Heat Shield
2. Mounting Bolts

Fig. 1, Exhaust Stack Heat Shield

Muffler Replacement

Cab and Frame-Rail Mounted Muffler

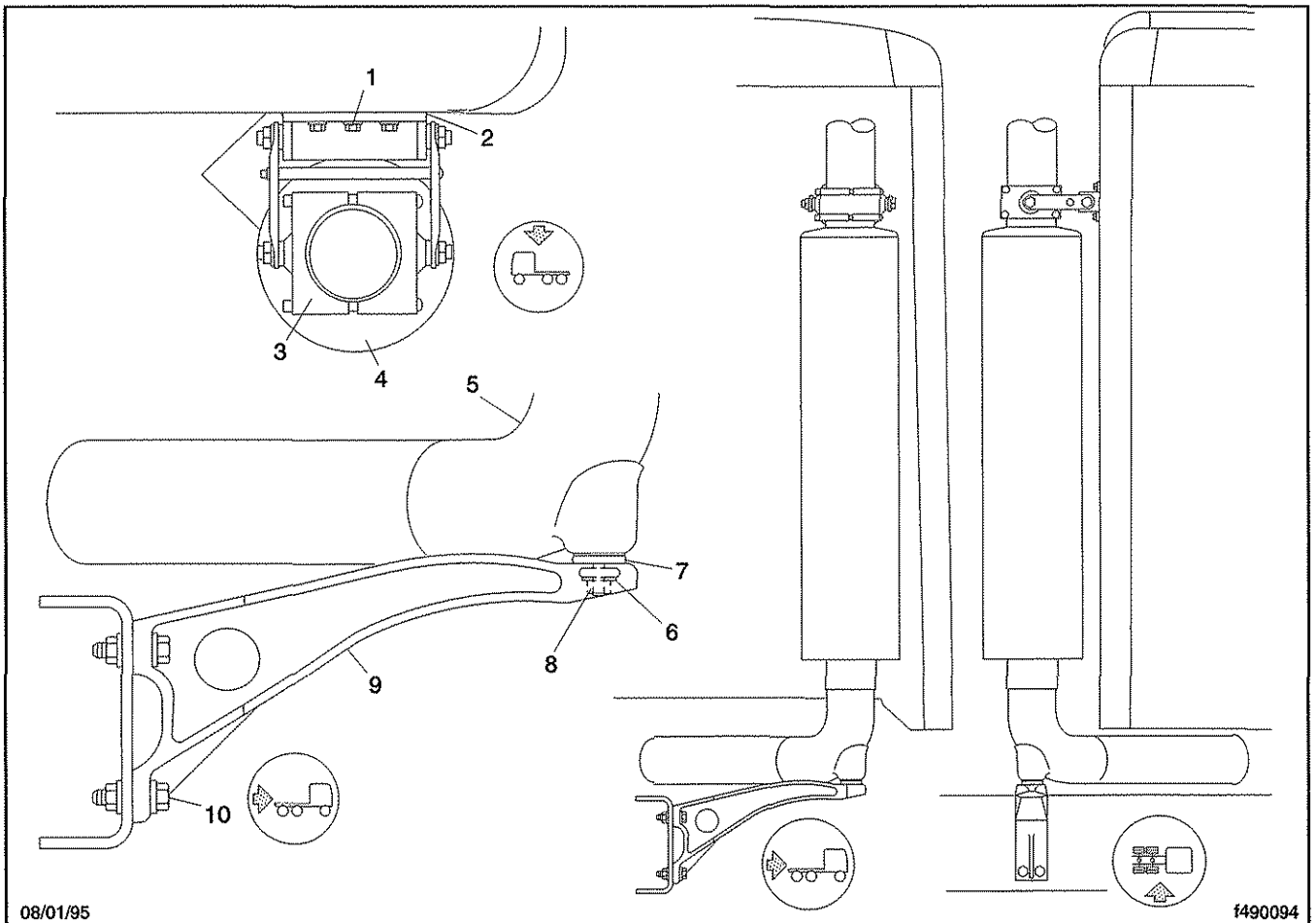
See **Fig. 1** for an overview of the cab and frame-rail mounted muffler.

Removal

1. Park the vehicle, shut down the engine, apply the parking brakes, and chock the tires.
2. Remove the top stack. For instructions, refer to **Subject 110.**
3. Loosen the band at the bottom of the muffler.
4. Remove the five nuts, one bolt, and two shackle brackets on the upper muffler mounting bracket as shown in **Fig. 2.**
5. Lift the muffler from the muffler pipe elbow, and remove the muffler from the vehicle.

Installation

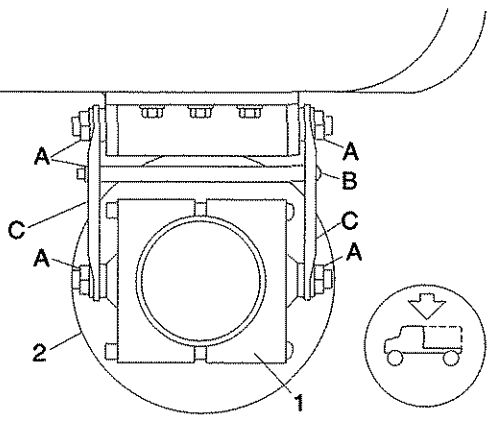
1. Position the muffler on the muffler pipe elbow. The elbow should slip up, inside the muffler inlet pipe. The distance from the bottom edge of the muffler



1. Capscrew 5/16–18, Stainless Steel; Washer
2. Gasket
3. Upper Muffler Mounting Bracket (Shackle Assembly)
4. Muffler
5. Muffler Pipe Elbow
6. Flatwasher
7. Isolator
8. Nut, 1/2–13, Grade C
9. Lower Muffler Mounting Bracket
10. Capscrew, 5/8–11 x 1.75, Grade 8; Nut; Washers

Fig. 1, Cab and Frame-Rail Mounted Muffler, Century Class Conventional

Muffler Replacement



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A. Remove these nuts.
B. Remove this bolt.
C. Remove these shackle brackets.

1. Upper Muffler Mounting Bracket (Shackle Assembly)
2. Muffler

Fig. 2, Removing the Muffler, Century Class Conventional

to the mounting point on the top of the chassis-mounted lower bracket should be 13 to 13-1/2 inches (330 to 343 mm). See **Fig. 3.**

If the installation is correct, the upper shackle assembly arms should be horizontal within ±5 degrees.

2. Position the clamp around the muffler and muffler pipe elbow, and tighten the clamp 50 lbf·ft (68 N·m).
3. Position the top of the muffler in the upper muffler mounting bracket.
4. Install the shackle brackets on the upper muffler mounting bracket. One end of each shackle bracket is keyed. Position the keyed end of the shackle bracket on the stud closest to the cab.

⚠ CAUTION

Be sure that the keyed end of the shackle bracket is aligned with the mating shoulder. If the keyed shackle bracket is not aligned with the mating shoulder, damage to the shoulder may occur.

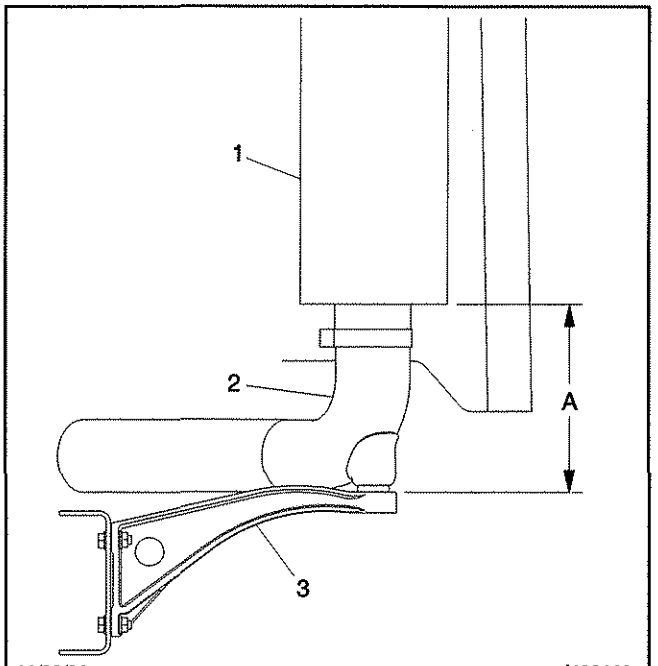
5. Install the bolt and nuts, and tighten the large nuts 64 lbf·ft (87 N·m). Tighten the small nut 24 lbf·ft (33 N·m).
6. Install the top stack. For instructions, refer to **Subject 110.**
7. Remove the chocks from the tires.

Frame-Rail Mounted Muffler

See **Fig. 4** for an overview of the frame-rail mounted muffler.

Removal

1. Park the vehicle, shut down the engine, apply the parking brakes, and chock the tires.
2. Remove the top stack. For instructions, refer to **Subject 110.**
3. Remove the heat shield from the muffler. See **Subject 130** for instructions.
4. Loosen the clamp at the bottom of the muffler.



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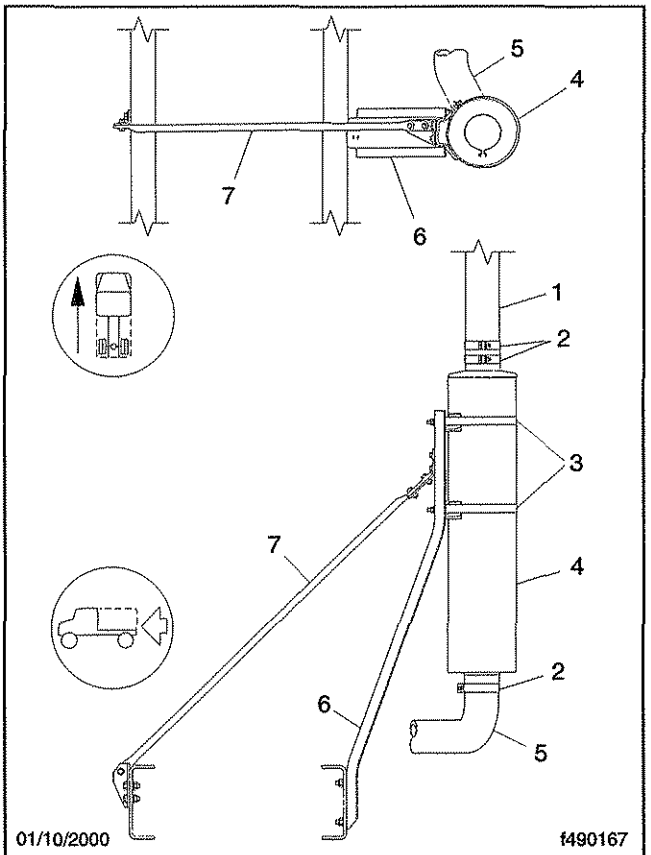
A. Measurement from muffler to top mounting on bracket: 13 to 13-1/2 inches (330 to 343 mm).

1. Muffler
2. Muffler Pipe Elbow
3. Lower Muffler Mounting Bracket

Fig. 3, Muffler-to-Bracket Measurement



1. Top Stack
2. Accuseal® Clamp, 5-Inch
3. Muffler Band
4. Muffler
5. Muffler Clamp
6. Exhaust Pipe from Engine
7. Muffler Mounting Upright
8. Muffler Mounting Brace

Fig. 4, Frame-Rail Mounted Muffler, Argosy COE

5. Loosen the two muffler bands that hold the muffler to the muffler mounting upright.
6. Lift the muffler straight up and remove it from the vehicle.

Installation

1. Put the muffler in place against the mounting upright.
2. Install the muffler bands onto the muffler and the muffler mounting brackets. Tighten the bands 22 lbf·ft (30 N·m).
3. Install the heat shield. See **Subject 130** for instructions
4. Install the top stack. See **Subject 110** for instructions.
5. Connect the exhaust pipe from the engine to the bottom of the muffler. Tighten the band 50 lbf·ft (68 N·m).
6. Remove the chocks from the tires.

Coronado Muffler

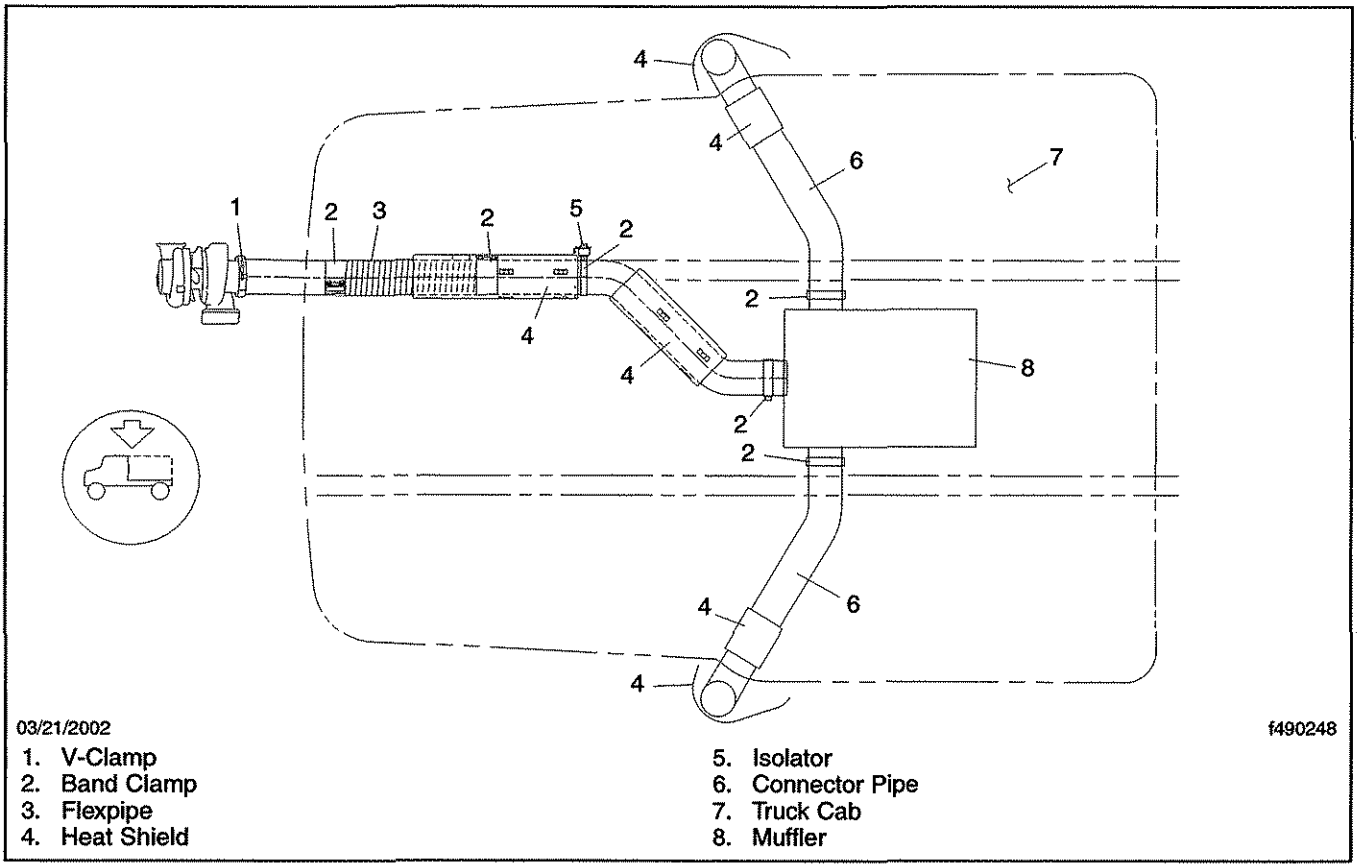
See **Fig. 5** of for an overview of the Coronado exhaust system.

Removal

1. Park the vehicle, shut down the engine, apply the parking brakes, and chock the tires.
2. Remove the exhaust stacks on each side of the vehicle. For instructions, see **Subject 120.**
3. Remove the two connector pipes from the muffler to the exhaust stacks.
   - 3.1 Loosen the clamps that secure the connector pipes to the muffler.
   - 3.2 Remove the pipes from the sides of the vehicle carefully. Avoid damaging the ends of the pipes.
4. Remove the muffler.

   NOTE: Perform these steps from underneath the vehicle.
   - 4.1 Loosen the clamp at the front of the muffler, where the connecting pipe from the engine meets the muffler.
   - 4.2 Loosen the two straps that support the muffler, allowing the muffler to slide forward and backward.
   - 4.3 Slide the muffler from the connecting pipe.
   - 4.4 While supporting the muffler, remove the nuts and bolts from the straps that secure the muffler to the bottom of the cab.
   - 4.5 Rotate and remove the muffler downward, between the frame rail and driveshaft and away from the vehicle.

Muffler Replacement



1. V-Clamp
2. Band Clamp
3. Flexpipe
4. Heat Shield
5. Isolator
6. Connector Pipe
7. Truck Cab
8. Muffler

Fig. 5, Exhaust System, Coronado

Installation

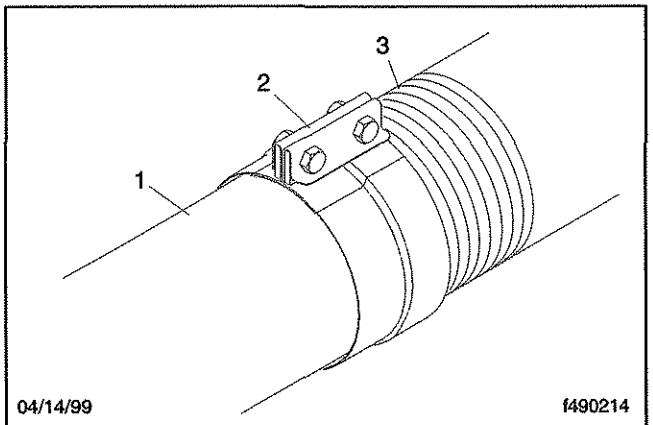
1. From underneath the vehicle, position the muffler over the driveline, behind the connecting pipe.
2. Install the nuts and bolts on the straps to secure the muffler under the vehicle. Leave the straps loose to allow the muffler to move forward and backward.
3. Install the engine connecting pipe on the muffler, position the clamp and tighten the nuts 50 lbf·ft (68 N·m).
4. Tighten the nuts on the straps that secure the muffler to the vehicle.
5. Install the connector pipes on the side of the muffler. Position and tighten the clamps at the muffler 50 lbf·ft (68 N·m).
6. Install the exhaust stack. For instructions, see **Subject 120**.
7. Install the heat shield. For instructions, see **Subject 140**.
8. Remove the chocks from the tires.

Wide-Band Exhaust Clamp Replacement

Replacement

Refer to **Fig. 1** while performing the following procedure.

1. Remove and discard the leaking or damaged wide-band exhaust clamp.
2. Insert one end of the flexpipe into the large-diameter side of the exhaust clamp until it contacts the step in the center of the clamp.
3. Insert about 3 inches (76 mm) of the exhaust piping into the small-diameter side of the exhaust clamp.
4. Make sure again that the end of the flexpipe is up against the step at the middle of the exhaust clamp.
5. Tighten snugly the hexbolt on the large-diameter (flexpipe) side of the clamp.
6. Tighten the hexbolt on the small-diameter side of the clamp 45 lbf·ft (61 N·m).
7. Tighten the hexbolt on the large-diameter side of the clamp 45 lbf·ft (61 N·m).
8. Check the hexbolt on the small-diameter side of the clamp. If needed, tighten 45 lbf·ft (61 N·m).
9. If a new flexpipe was installed, remove the flow-direction indicators from it.



1. Exhaust Tubing
2. Exhaust Clamp
3. Flexpipe

Fig. 1, Wide-Band Exhaust Clamp

10. Run the engine, and check for leaks. If needed, remove and install the exhaust clamp again.

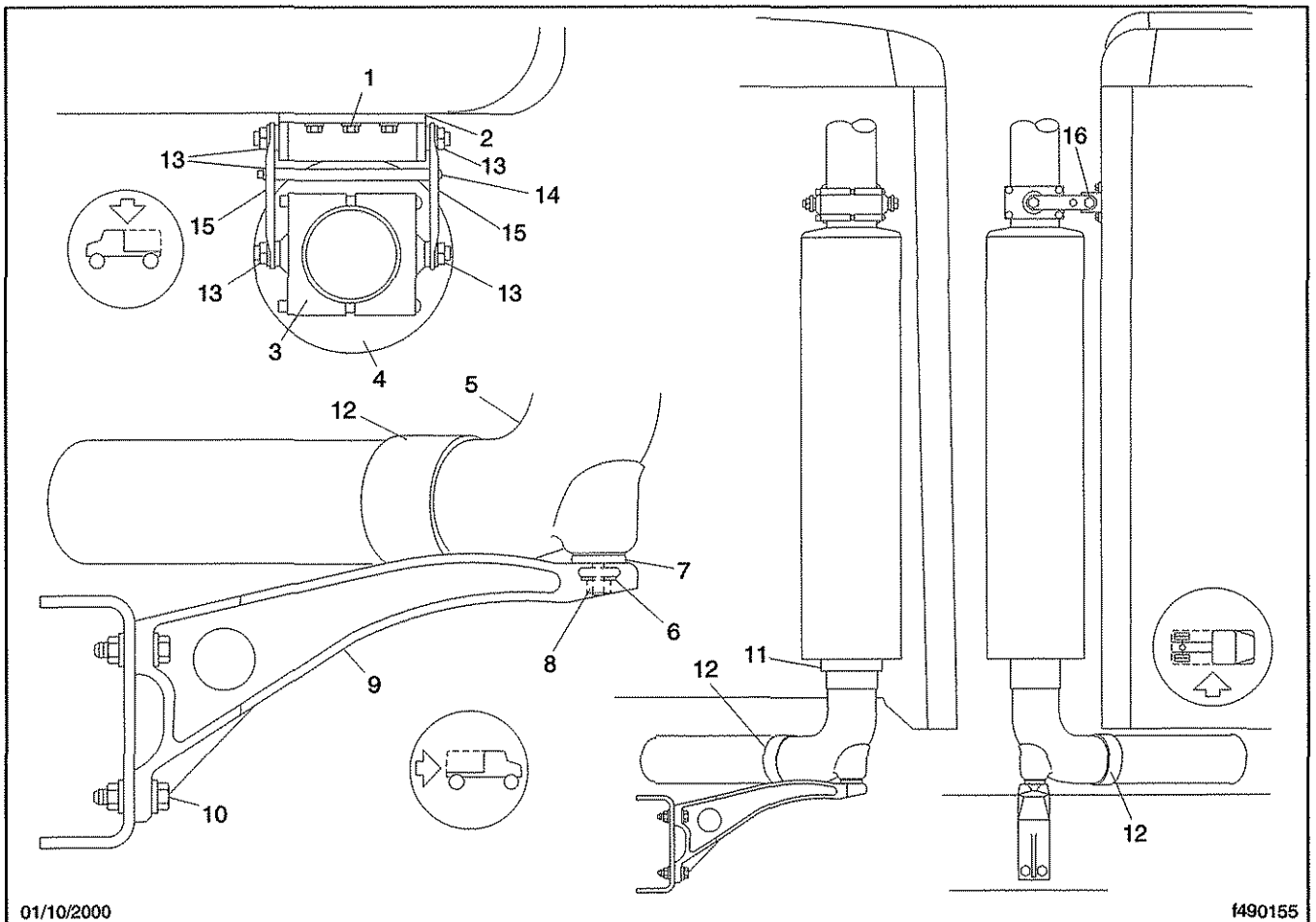
Muffler Elbow, Removal and Installation

Removal

1. Park the vehicle, shut down the engine, apply the parking brakes, and chock the tires.
2. Remove the muffler. For instructions, refer to **Subject 150**.
3. Remove the nut, flatwasher, and isolator located underneath the muffler elbow. Remove the muffler elbow. See **Fig. 1**.

Installation

1. Attach a new wide-band clamp to the horizontal flex pipe, but do not tighten.
2. Place the isolator on the muffler elbow stud.
3. Place the muffler elbow on the lower muffler mounting bracket.



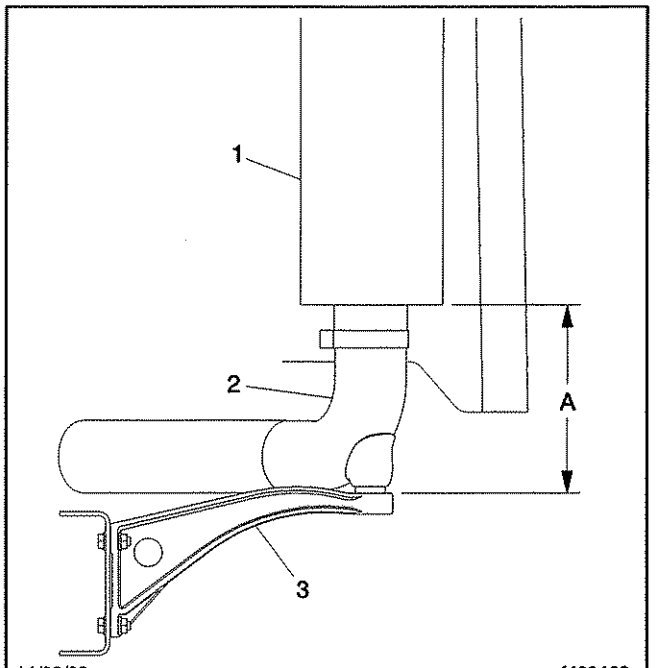
1. Capscrew 5/16–18, Stainless Steel; Washer
2. Gasket
3. Upper Muffler Mounting Bracket (Shackle Assembly)
4. Muffler
5. Muffler Elbow
6. Flatwasher
7. Isolator
8. Nut, 1/2–13, Grade C
9. Lower Muffler Mounting Bracket
10. Capscrew, 5/8–11 x 1.75, Grade 8; Nut; Washers
11. Band Clamp
12. Wide-Band Clamp
13. Nut
14. Bolt
15. Shackle Bracket
16. Keyed End of Shackle Bracket

Fig. 1, Cab and Frame Rail-Mounted Muffler

Muffler Elbow, Removal and Installation

4. Attach the muffler elbow to the horizontal flex pipe by placing the horizontal flex pipe over the muffler elbow.
5. Place the flatwasher and nut on the muffler elbow stud. Tighten the nut to 68 ± 8 lbf·ft (92 ± 11 N·m).
6. Place the band clamp over the muffler elbow, but do not tighten.
7. Position the muffler on the muffler elbow. The elbow should slip up, inside the muffler inlet pipe. The distance from the bottom edge of the muffler to the mounting point on the top of the chassis-mounted lower bracket should be 13 to 13-1/2 inches (330 to 343 mm). See **Fig. 2.**

   If the installation is correct, the upper shackle assembly arms should be horizontal within ±5 degrees.
8. Position the band clamp around the muffler and muffler elbow, and tighten the band clamp 50 lbf·ft (68 N·m).
9. Install the shackle brackets on the upper muffler mounting bracket. One end of each shackle bracket is keyed. Position the keyed end of the shackle bracket on the stud closest to the cab. See **Fig. 1.**



A. Measurement from muffler to top mounting on bracket: 13 to 13-1/2 inches (330 to 343 mm).
1. Muffler
2. Muffler Pipe Elbow
3. Lower Muffler Mounting Bracket

Fig. 2, Muffler-to-Bracket Measurement

⚠ CAUTION

Be sure that the keyed end of the shackle bracket is aligned with the mating shoulder. If the keyed shackle bracket is not aligned with the mating shoulder, damage to the shoulder may occur.

10. Position the top of the muffler in the upper muffler mounting bracket.
11. Install the bolt and nuts on the upper muffler mounting bracket, and tighten the large nuts 64 lbf·ft (87 N·m). Tighten the small nut 24 lbf·ft (33 N·m).
12. Tighten the wide-band clamp. For instructions, refer to **Subject 120.**
13. Remove the chocks from the tires.

Group Index, Alphabetical

Section	Section Number
Air Restriction Indicator/Gauge	54.07
Batteries, Maintenance-Free	54.02
Collision Warning System, Eaton® VORAD® EVT–200	54.15
Collision Warning System, Eaton® VORAD® EVT–300	54.22
Communications System, Highway Master®	54.13
Data Logging Unit	54.06
Engine Wiring, Caterpillar	54.10
Engine Wiring, Cummins CELECT Plus™	54.11
Engine Wiring, DDEC III®	54.12
Instrumentation Control Unit	54.03
Instrumentation Control Unit, Level I	54.20
Instrumentation Control Unit, Level II	54.14
Instrumentation Control Unit, Level III	54.19
Keyless Security System	54.08
Lighting System	54.01
Low Coolant Level Probe and Module	54.16
Low Voltage Disconnect, Sure Power	54.18
Magnetic Switch	54.04
Power Distribution Module	54.05
Speakers	54.09
Speedometer and Tachometer Troubleshooting	54.17
Wiring	54.0

Contents

Subject	Subject Number
General Information	050
Service Operations	
Wiring Repair and Replacement	100
Specifications	400

General Information

This section contains a general wiring schematic applying to all the engine manufacturers: Caterpillar, Cummins, and Detroit Diesel.

Separate wiring diagrams are included for the wiring behind the chassis, frontwall, engine, and sleeper cab connectors.

Harness diagrams are included for the main cab harness, frontwall harness, and trailer ABS overlay.

For electronic engine wiring and harness diagrams, see **Section 54.10** for Caterpillar engines, **Section 54.11** for Cummins engines, and **Section 54.12** for Detroit Diesel engines.

A wiring list, including optional wiring, is also included in this section.

Repair and Replacement

IMPORTANT: Before you repair or replace any damaged electrical system parts, find and correct the cause of the damage; otherwise it could occur again.

Wiring insulation can be damaged by heat (internal or external), chafing, kinking, breaking, cracking, or saturation with oil or grease.

Discolored wire insulation (brown) is caused by long-term overheating of the wire itself. Melted insulation is usually caused by an external heat source.

Repair or replace damaged wiring. The choice depends on the type of damage. See **Table 1**.

Type of Damage	Remedy
Broken wire	Repair or replace*
Kinked wire	Replace
Oil-soaked insulation	Replace
Cracked insulation	Repair if minor, otherwise replace
Melted insulation	Replace
Worn or missing insulation	Repair
Discolored insulation	Replace

* Repair the break by soldering the two broken ends together, if there is enough slack in the wire; otherwise solder in a new section of wire. See "Repairing Broken Wire" for instructions.

Table 1, Wiring Damage

REPAIRING DAMAGED WIRE INSULATION

1. Using shrink tubing, cover the damaged area. Overlap the damaged area at least 3/4 inch (20 mm) on both sides.

IMPORTANT: Don't repair the insulation if the wire underneath is also damaged. Remove and replace the damaged section.

2. If the insulation is chafed, find the source of chafing, and reroute the wiring away from it. If this isn't possible, either cover the sharp edge with protective vinyl trim 48–02188–001, or use convoluted tubing to protect the insulation.
3. Cover the repaired section of wiring with plastic convoluted tubing.

REPLACING DAMAGED WIRE

⚠ CAUTION

Never replace a wire with a smaller gauge wire. Wire gauge is selected by electrical load and current capabilities, and overheating may occur if a wrong gauge wire is used.

1. Replace damaged wire using a solder splice. See "Repairing Broken Wire" for instructions. Use only solder splices.

IMPORTANT: If the damaged wire is 12 gauge or larger, don't replace a section of it; replace the entire wire.

2. If the insulation has been discolored, find out what is causing the wire to overheat, and correct it.
3. If the insulation has been melted, check the routing of the wiring and find the problem. Reroute the wiring if possible, and secure it with clamps. If rerouting is not possible, use a heat shield to protect the wire.

REPAIRING ELECTRICAL CONNECTIONS

1. Find the cause of the damage or corrosion, and correct the problem.
2. Clean corroded connectors with a wire brush, using a solution of baking soda and water, and then dry the area. Replace any damaged connectors.
3. Spray any exposed connectors (such as ground terminals) with dielectric red enamel. See **Table 2**.

Protectant Material	Approved Brand
Dielectric Red Enamel Spray	MMM 1602 IVI–Spray Sealer, Red Electric Grade (Spray-On B–6–665)

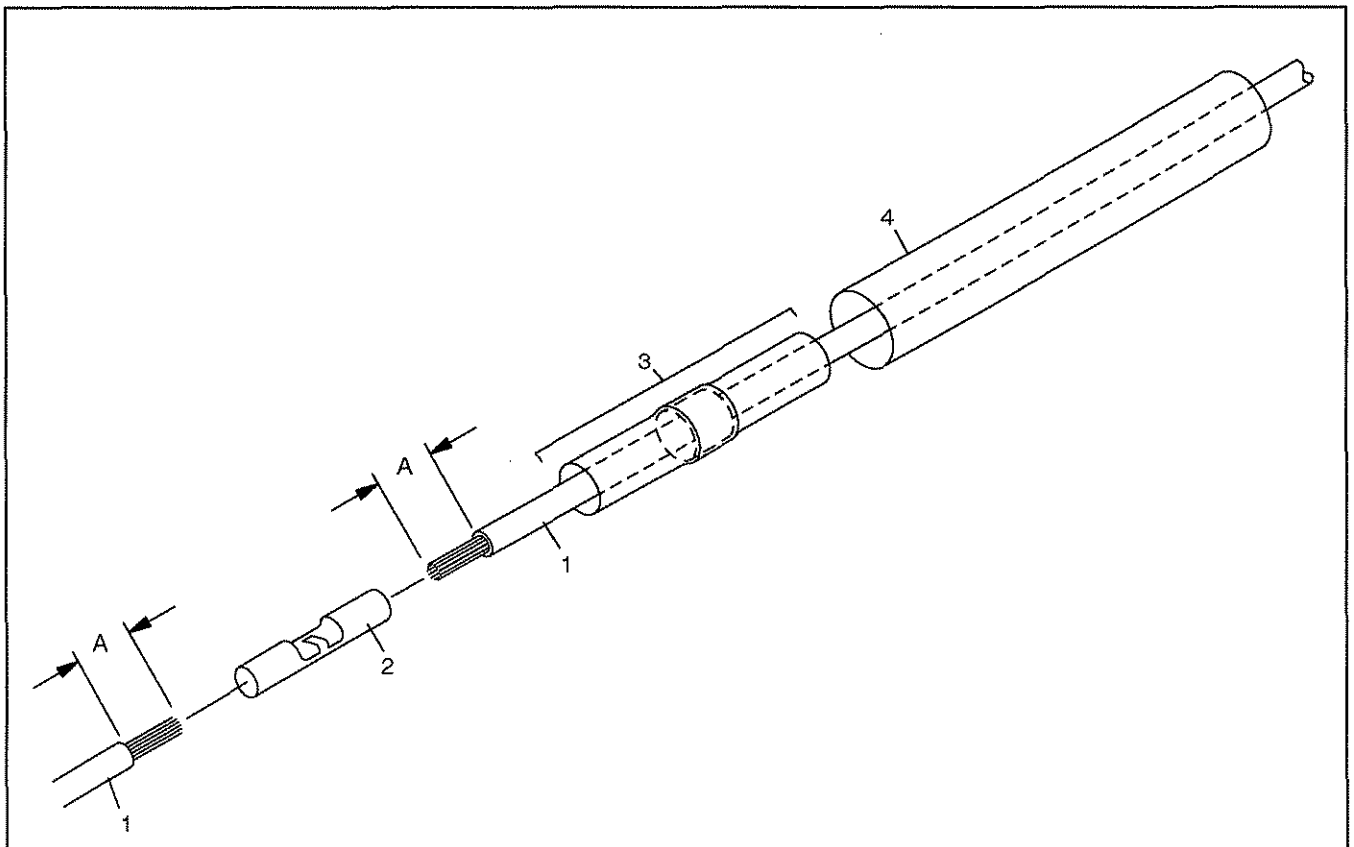
Table 2, Approved Dielectric Red Enamel

REPAIRING BROKEN WIRE

IMPORTANT: The following procedure is the only approved method of repairing broken wires on Freightliner vehicles. This procedure (solder splicing) is done using solder repair kit ESYES66 404, and is for 14-or 16-gauge wire. Don't repair wire that is 12 gauge or larger; replace it.

Wiring Repair and Replacement

1. Strip the ends of the wire to be repaired. Make sure the stripped ends are 3/8- to 1/2-inch (10- to 13-mm) long.
2. If repairing an exterior wire, slip a 3-inch (75-mm) long piece of shrink tube over one end of the wire. See **Fig. 1**, Ref. 4.
3. Slip a solder sleeve from kit ESYES66 404 over one end of the wire. See **Fig. 1**, Ref. 3.
4. Using a suitable crimp tool and a crimp splice from the kit, crimp the ends of the wire as follows (see **Fig. 2**):
   - 4.1 Insert a stripped wire end into the crimp splice until it touches the wire stop (Ref. 1) in the middle of the crimp splice.
   - 4.2 Center the crimping tool between the wire stop and the end of the crimp splice, then crimp the wire.
   - 4.3 Repeat the two substeps above for the other wire end.
5. Check the crimp, making sure the crimping tool impression is on both ends of the crimp splice.
6. Slide the solder sleeve over the crimp splice so the solder ring is over the center of the crimp splice (see **Fig. 3**). Then apply 250°F (121°C) heat



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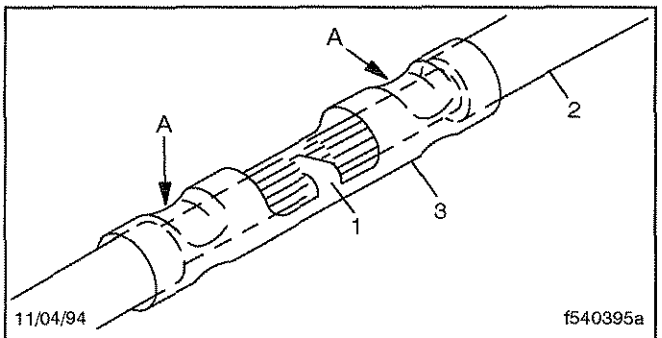
A. 3/8 to 1/2 Inch (10 to 13 mm)

1. Wire End
2. Crimp Splice
3. Solder Sleeve
4. Shrink Tube

Fig. 1, Exterior Wire Repair



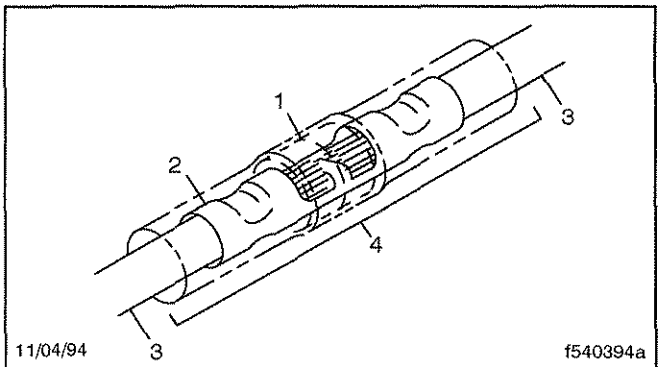
A. Center crimping tool here.

1. Wire Stop
2. Wire
3. Crimp Splice (shown crimped)

Fig. 2, Centering the Crimping Tool

until the solder flows into the splice crimp, and the plastic sleeve has shrunk completely against the wire.

7. Slide the shrink tubing over the splice; then apply 250°F (121°C) heat to it until completely shrunk against the wire insulation. Some of the sealant material should be bubbling out from the ends of the shrink tube.



1. Solder
2. Crimp Splice (shown crimped)
3. Wire
4. Solder Sleeve

Fig. 3, Wire Ready for Soldering

Basic Wiring Diagrams

To see a specific wiring diagram, refer to the figure or section listed in **Table 1**.

Basic Wiring Diagrams	
Wiring Diagram	**Reference**
Basic cab wiring (Caterpillar engine shown)	**Fig. 1**
Instrumentation control unit	**Fig. 2**
Main power distribution module	Section 54.05
Auxiliary power distribution module	**Fig. 3**
Proprietary cab wiring	**Fig. 4**
(Caterpillar, Cummins, and Detroit Diesel engines)	
Frontwall wiring	
Caterpillar engine	**Fig. 5**
Cummins engine	**Fig. 6**
Detroit Diesel engine	**Fig. 7**
Chassis wiring (all vehicles)	**Fig. 8**
SleeperCab wiring (all vehicles)	**Fig. 9**
Frontwall harness	
For vehicles built from November 28, 1997	**Fig. 10**
For vehicles built before November 28, 1997	**Fig. 11**
Main cab harness	**Fig. 12**
Enlarged partial views	**Fig. 13, Fig. 14, Fig. 15, Fig. 16,** and **Fig. 17**
Trailer ABS overlay	**Fig. 18**

Table 1, Basic Wiring Diagrams

NOTE: Seven air pressure switches are installed in the air manifold assembly. See **Fig. 19**. The manifold is located in the cab under the dash. For air manifold plumbing information, refer to **Group 42**.

Specifications

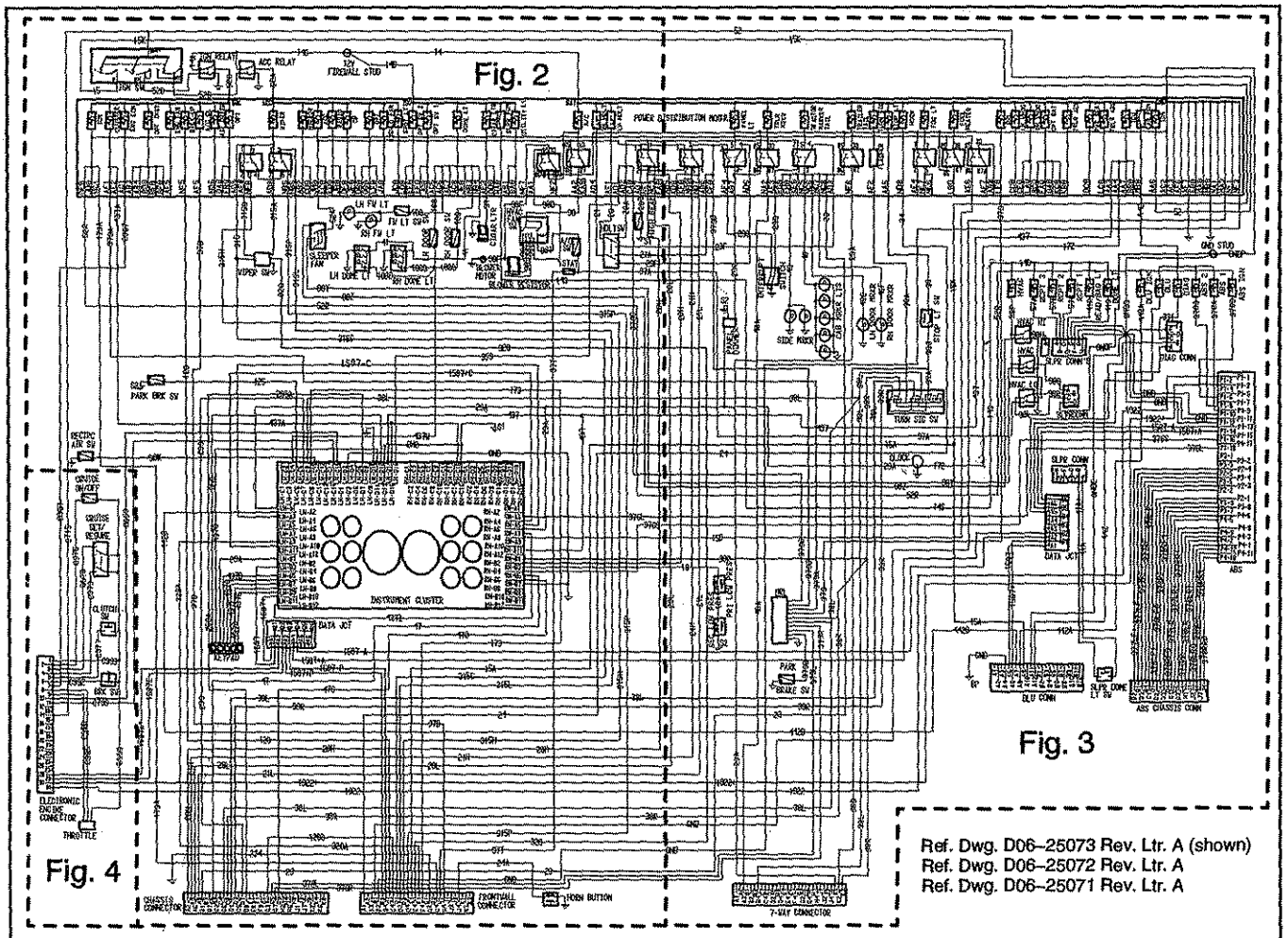


Fig. 1, Basic Cab Wiring (Caterpillar engine version shown)

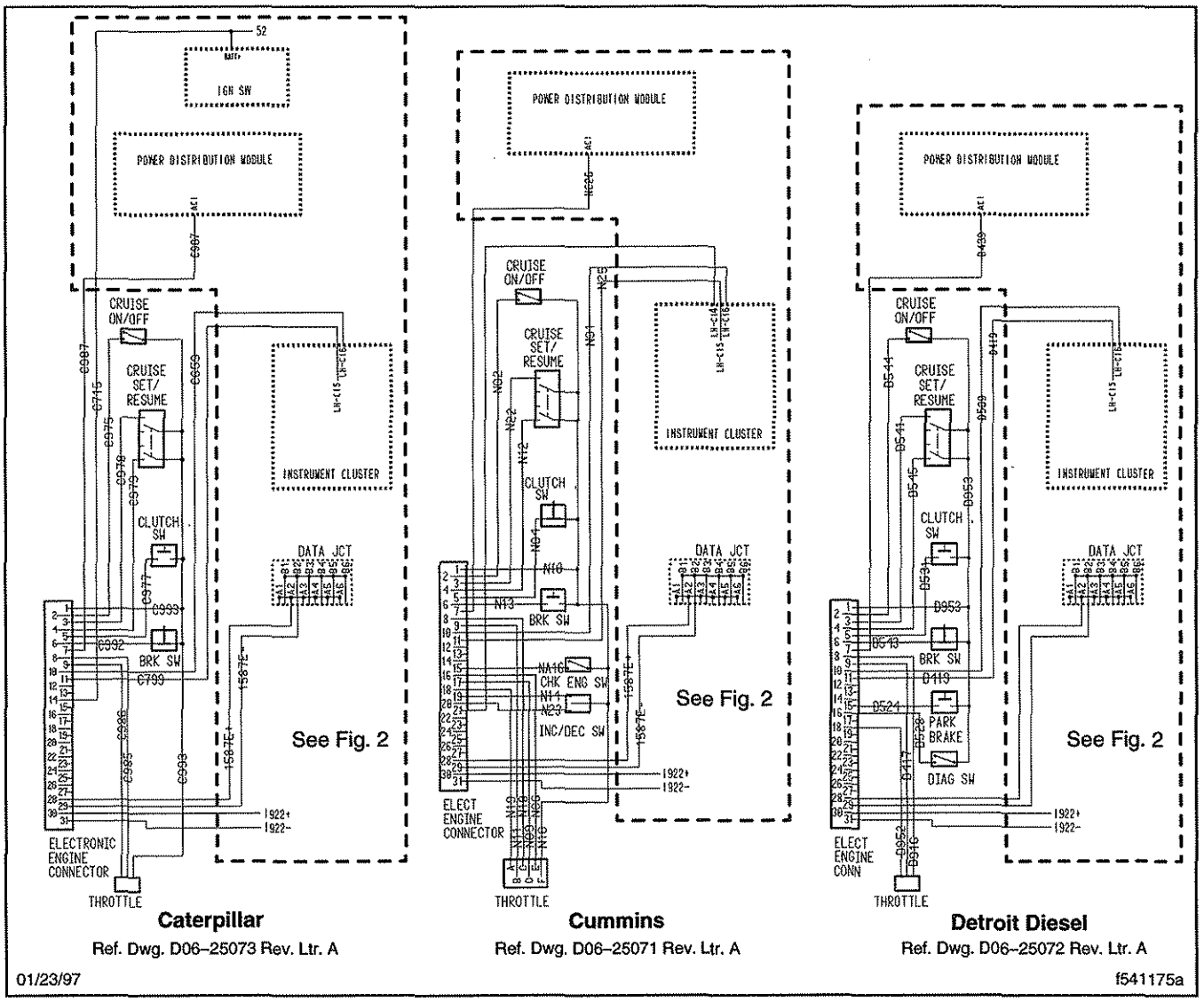


Fig. 4, Engine Manufacturer's Proprietary Cab Wiring

Specifications

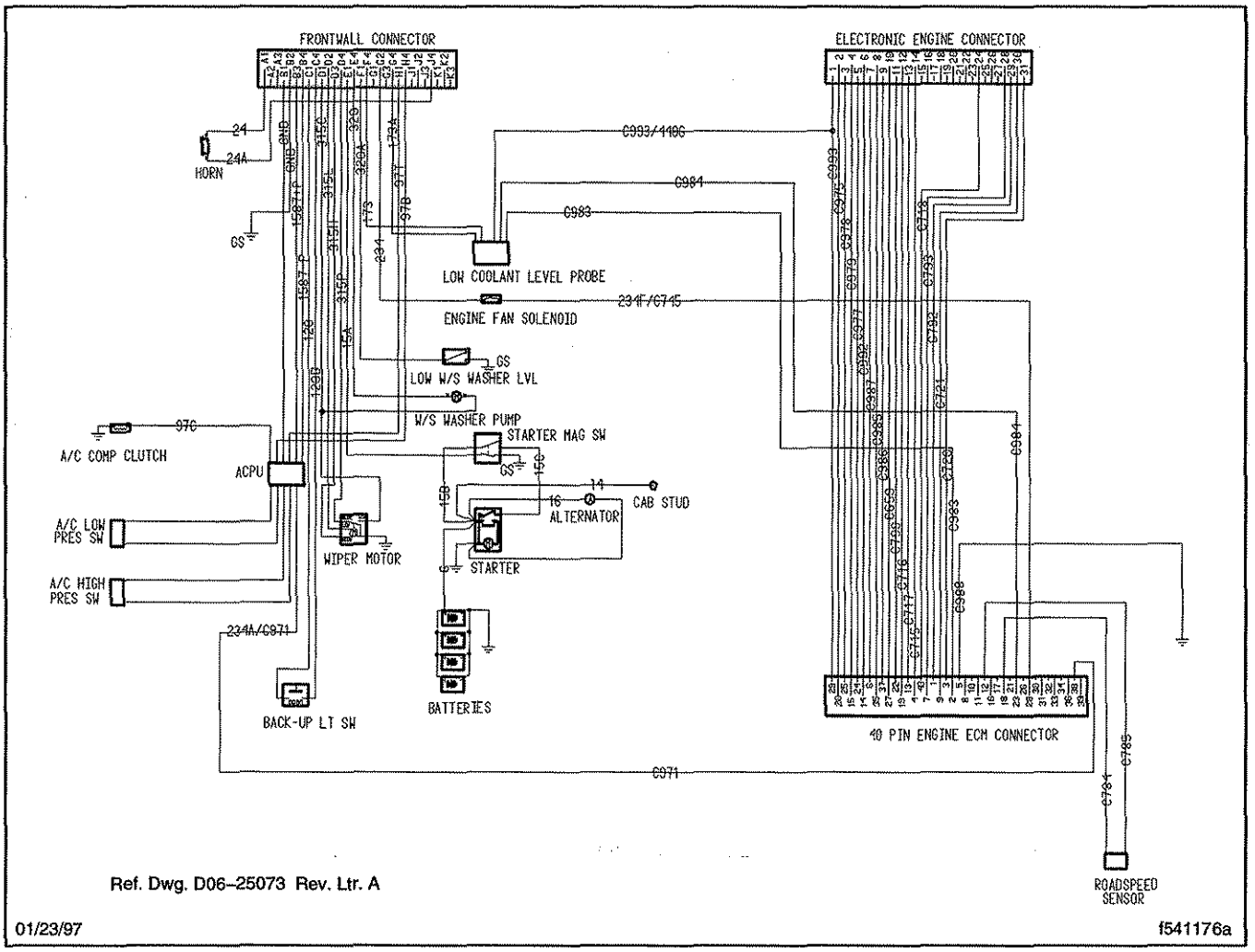


Fig. 5, Basic Frontwall and Engine Wiring, Vehicles With Caterpillar Engines

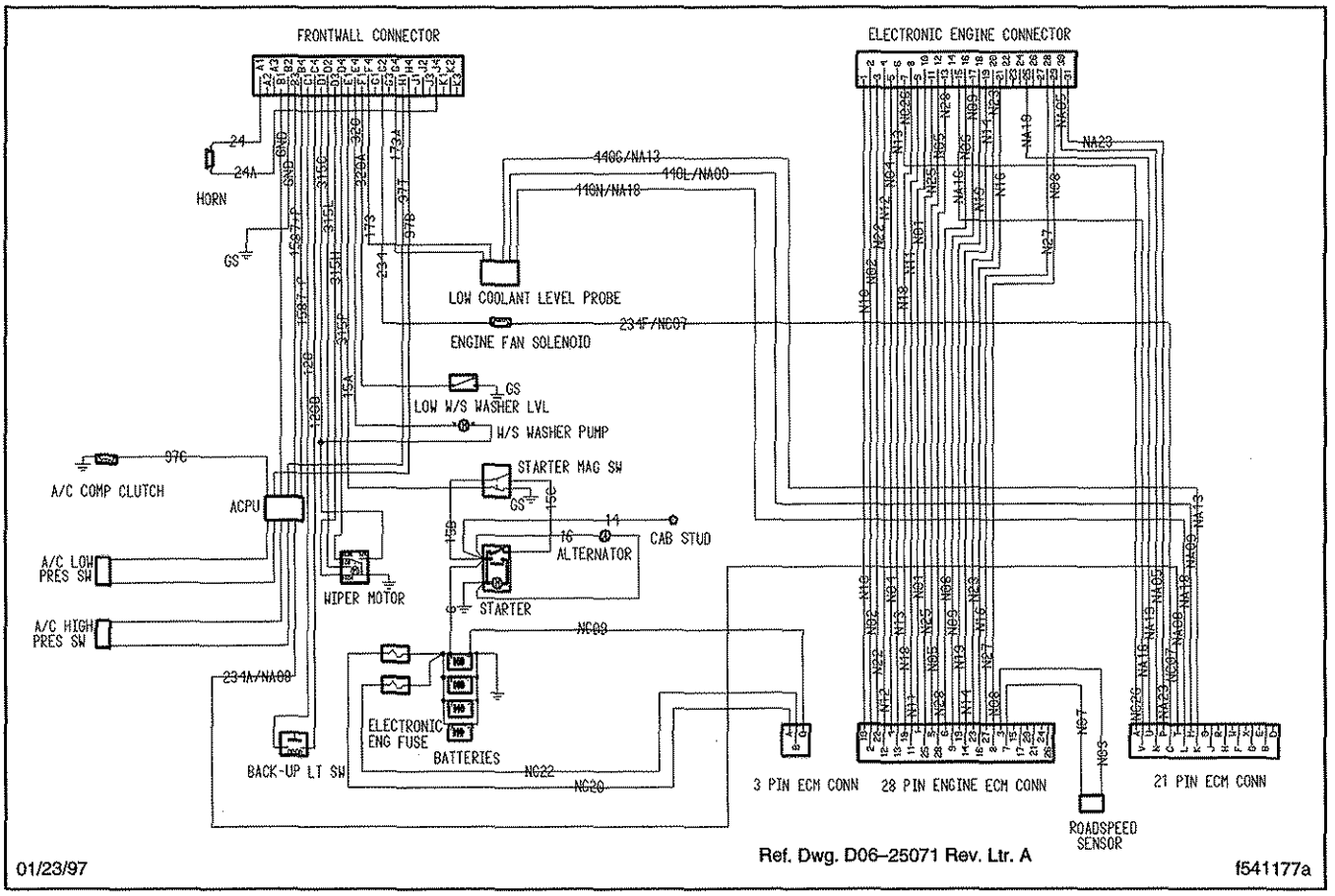


Fig. 6, Basic Frontwall and Engine Wiring, Vehicles With Cummins Engines

Specifications

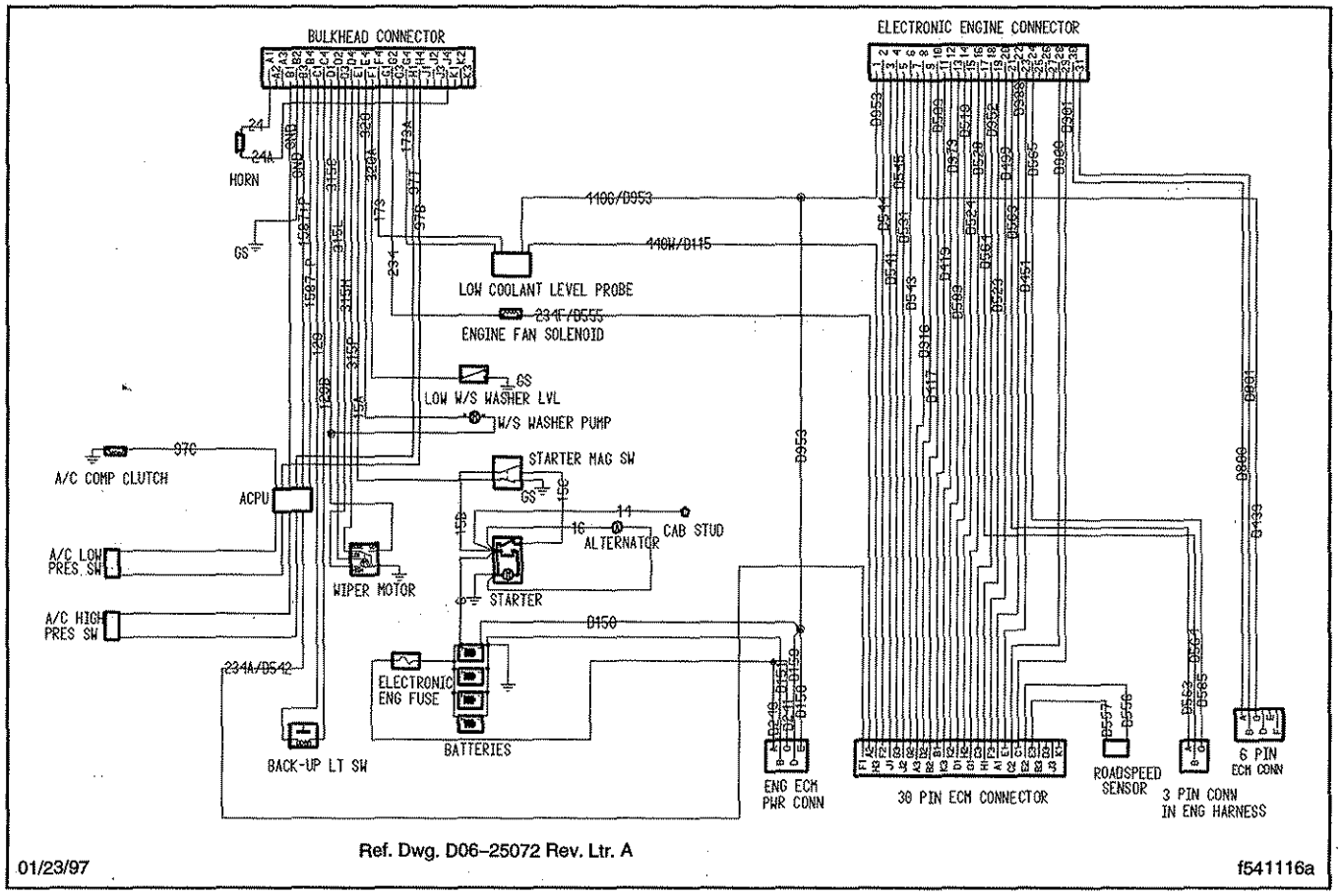


Fig. 7, Basic Frontwall and Engine Wiring, Vehicles With Detroit Diesel Engines

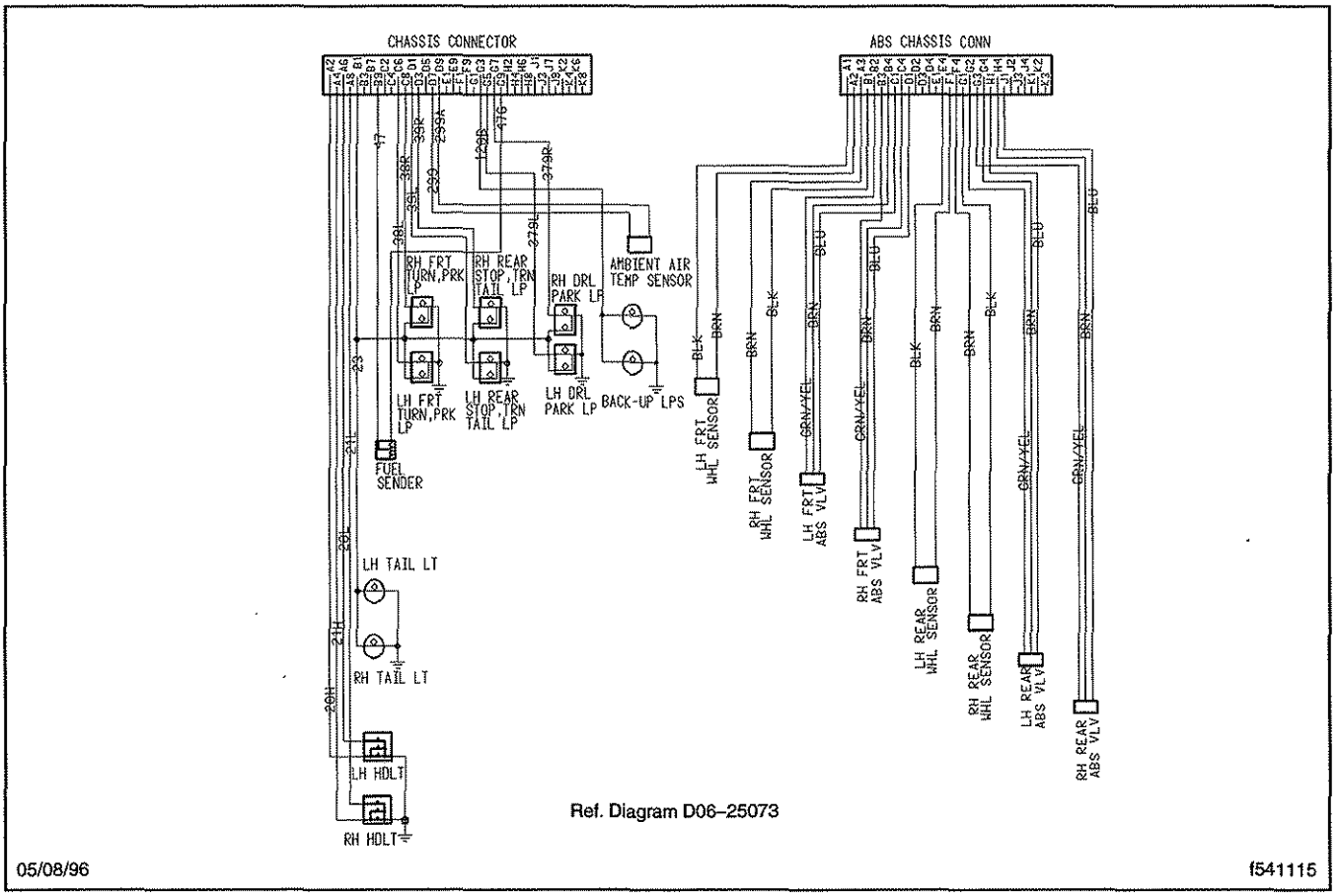


Fig. 8, Basic Chassis Wiring, All Vehicles

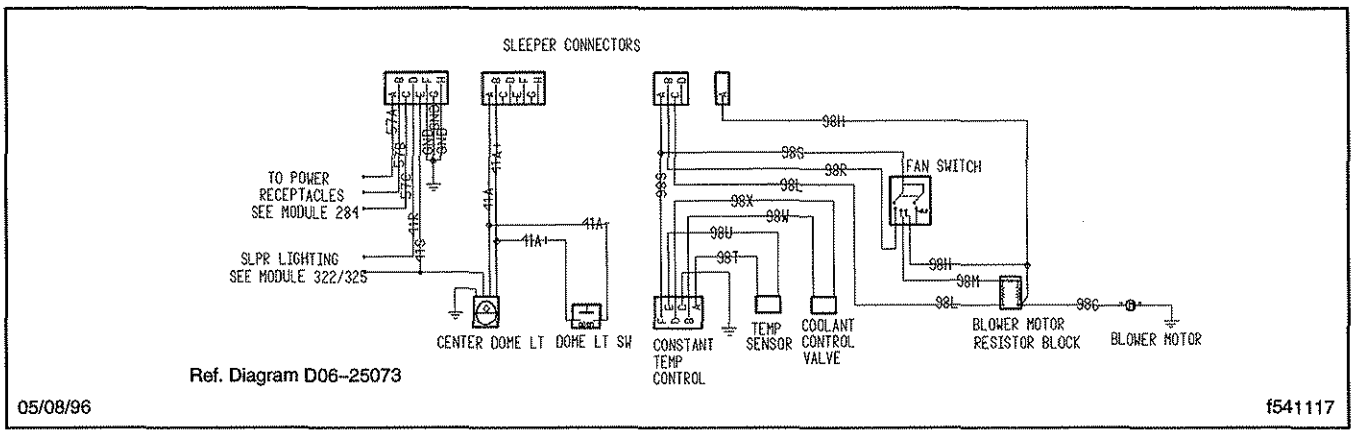


Fig. 9, Basic SleeperCab Wiring, All Vehicles

Specifications

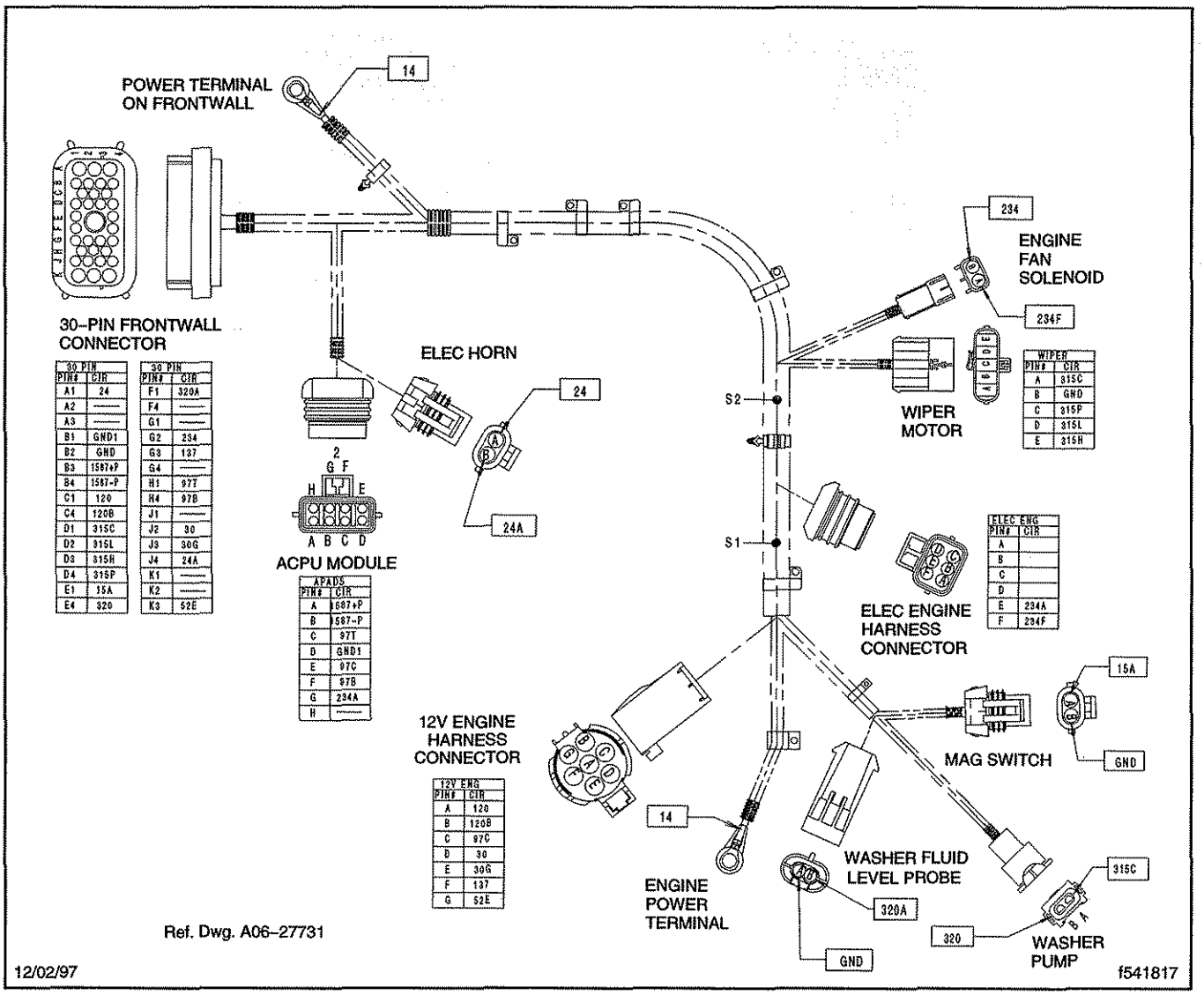
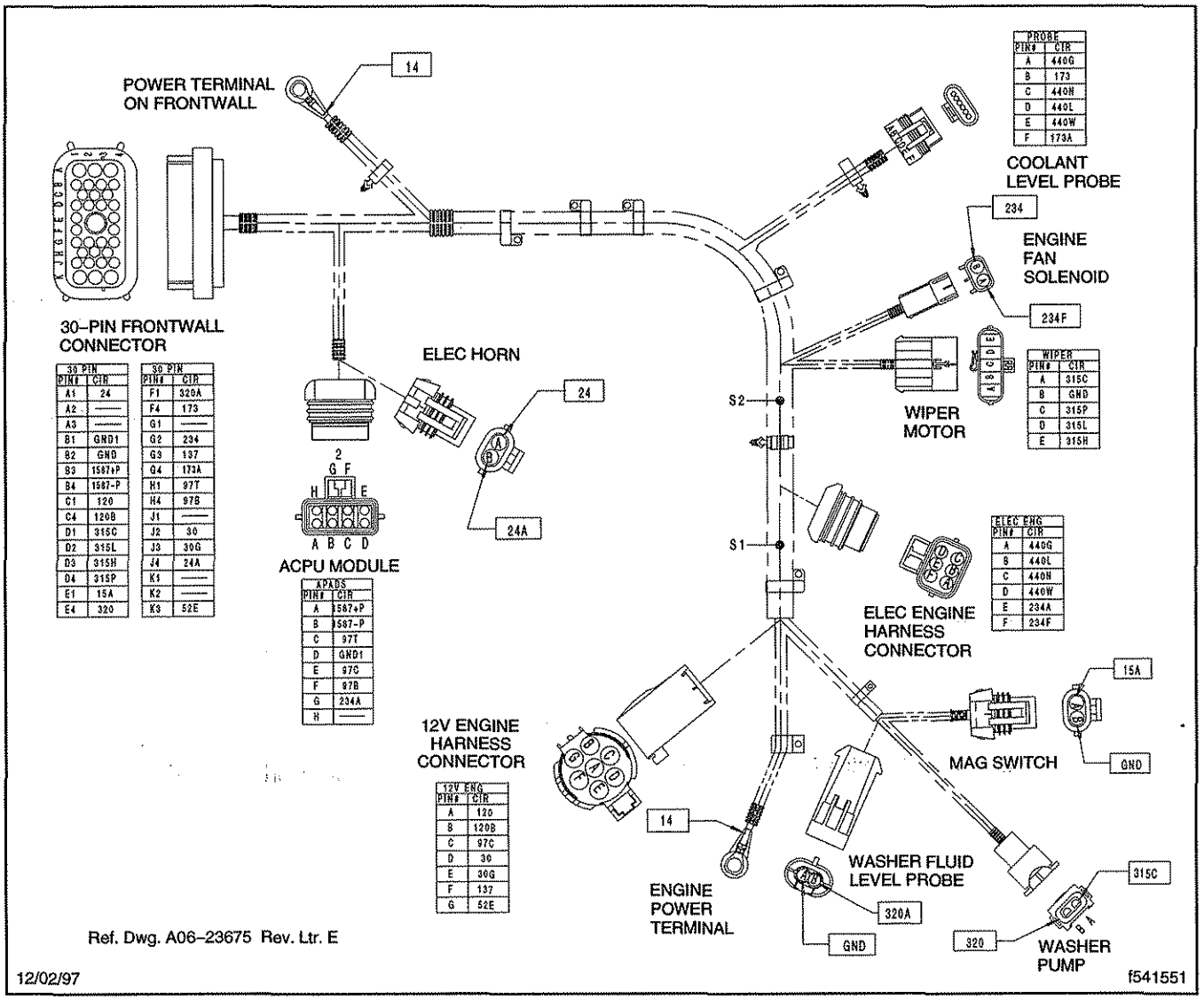


Fig. 10, Frontwall Harness on Vehicles Built from November 28, 1997



30 PIN	
PIN#	CIR
A1	24
A2	——
A3	——
B1	GND1
B2	GND
B3	1587+P
B4	1587-P
C1	120
C4	120B
D1	315C
D2	315L
D3	315H
D4	315P
E1	15A
E4	320

30 PIN	
PIN#	CIR
F1	320A
F4	173
G1	——
G2	234
G3	137
G4	173A
H1	97T
H4	97B
J1	——
J2	30
J3	30G
J4	24A
K1	——
K2	——
K3	52E

APADS	
PIN#	CIR
A	1587+P
B	1587-P
C	97T
D	GND1
E	97C
F	97B
G	234A
H	——

12V ENG	
PIN#	CIR
A	120
B	120B
C	97C
D	30
E	30G
F	137
G	52E

PROBE	
PIN#	CIR
A	440G
B	173
C	440N
D	440L
E	440W
F	173A

WIPER	
PIN#	CIR
A	315C
B	GND
C	315P
D	315L
E	315H

ELEC ENG	
PIN#	CIR
A	440G
B	440L
C	440N
D	440W
E	234A
F	234F

Fig. 11, Frontwall Harness on Vehicles Built before November 28, 1997

Specifications

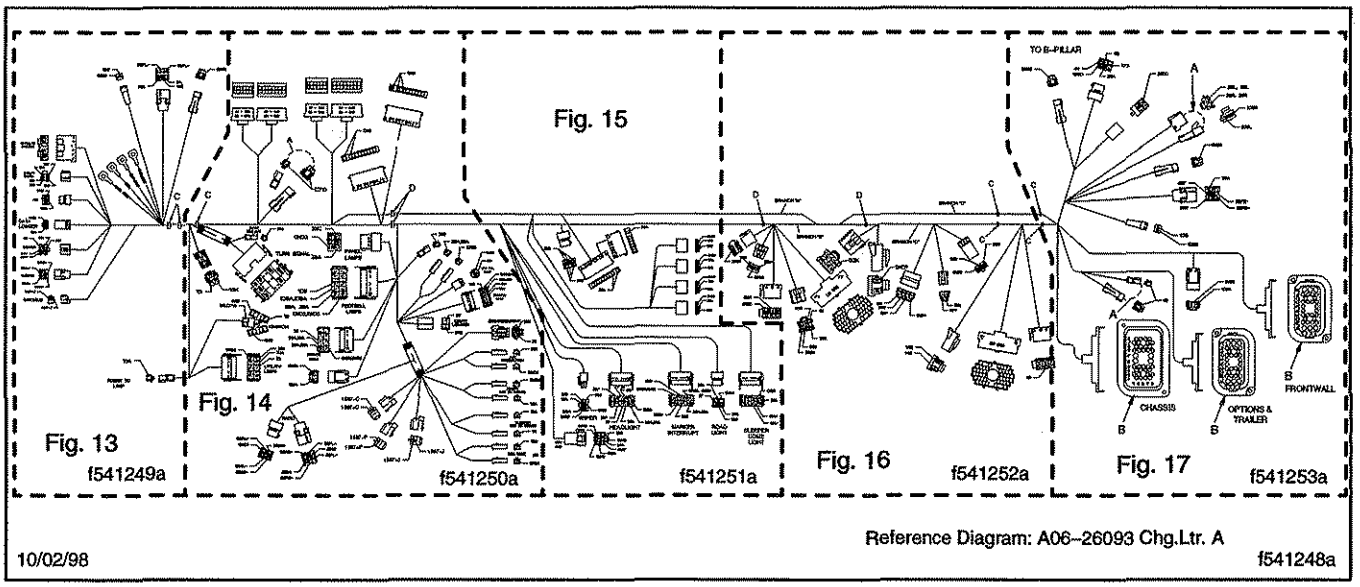


Fig. 12, Main Cab Harness Diagram

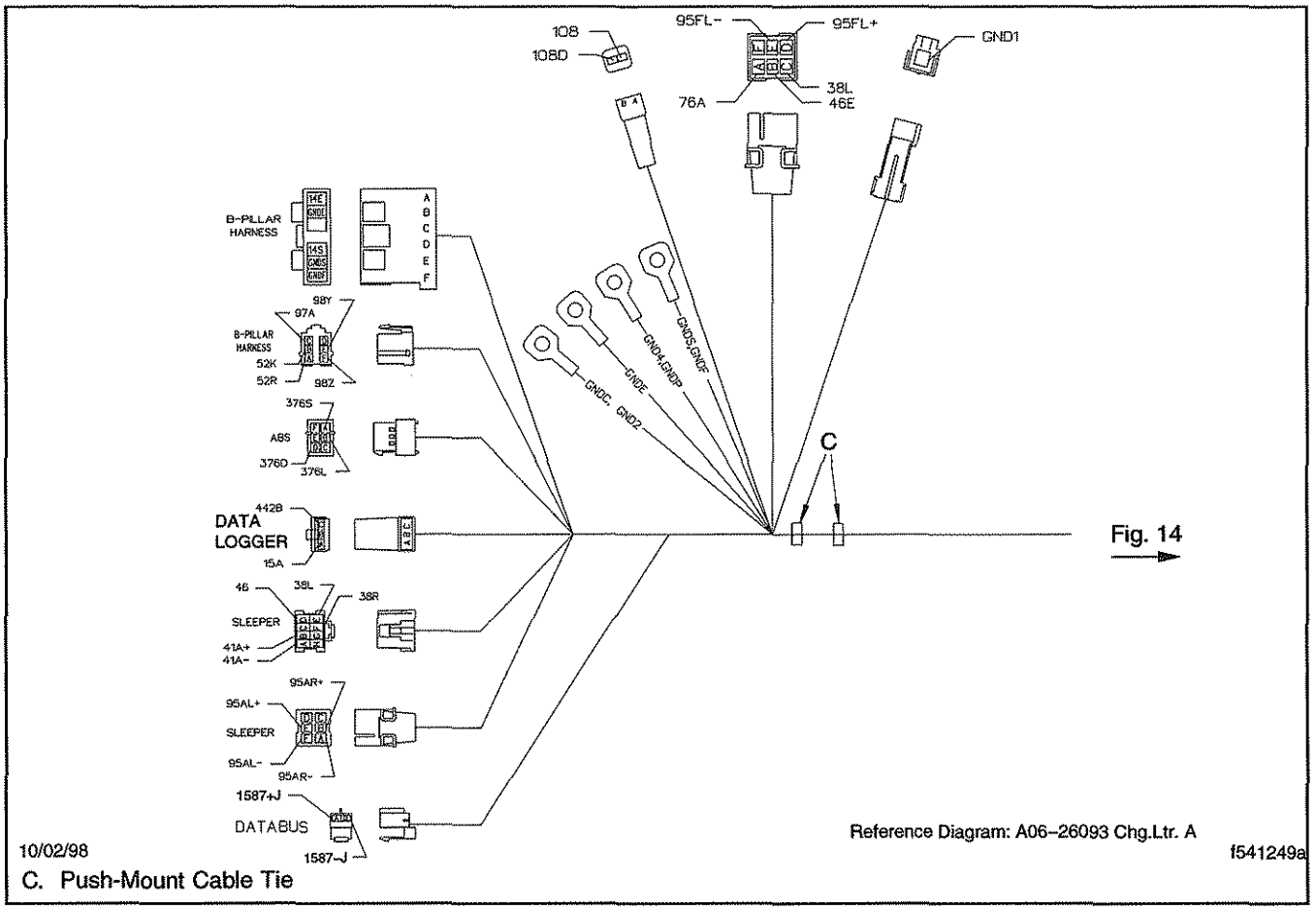
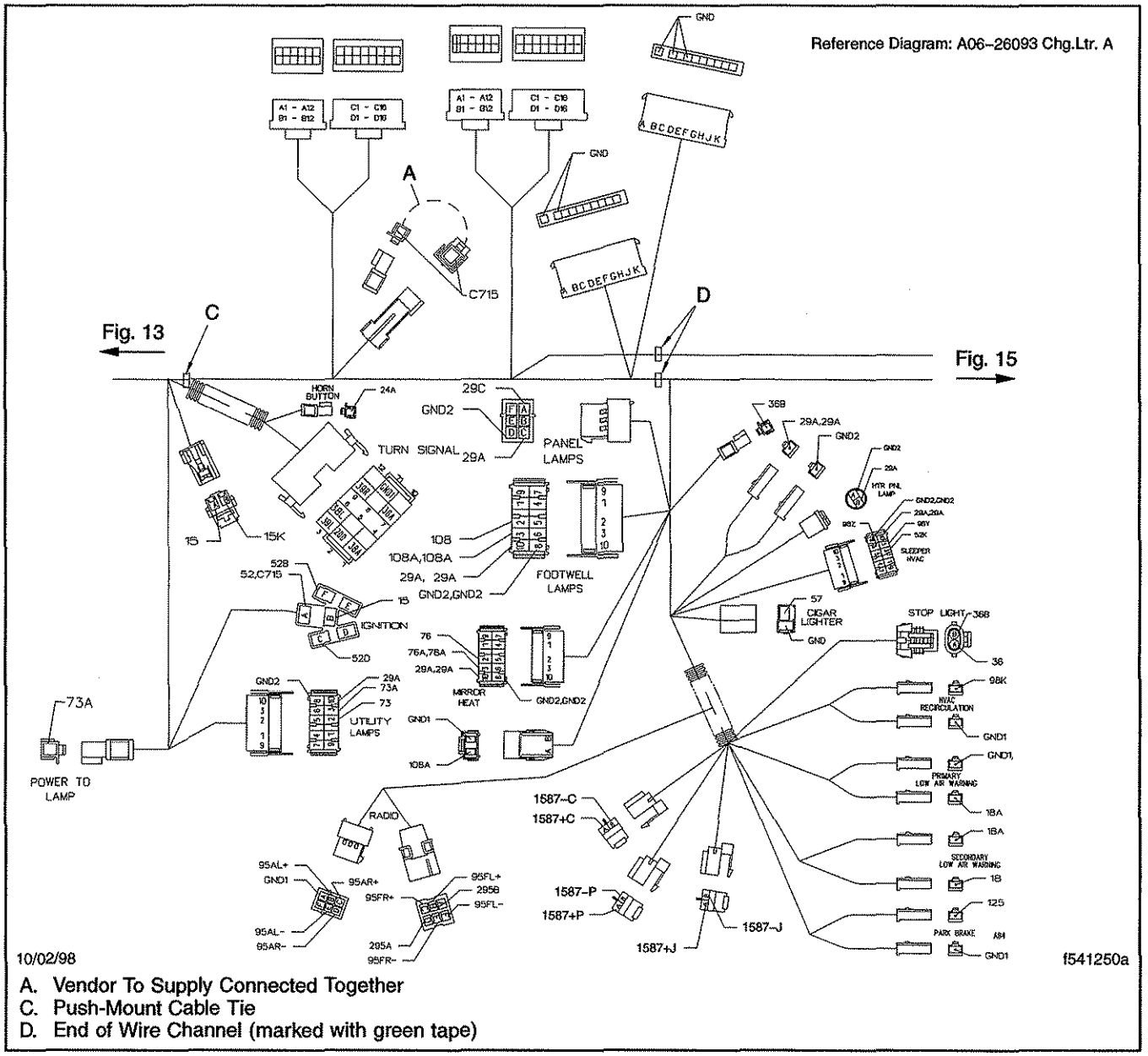


Fig. 13, Main Cab Harness Diagram (partial view)

Specifications



A. Vendor To Supply Connected Together
C. Push-Mount Cable Tie
D. End of Wire Channel (marked with green tape)

Fig. 14, Main Cab Harness Diagram (partial view)

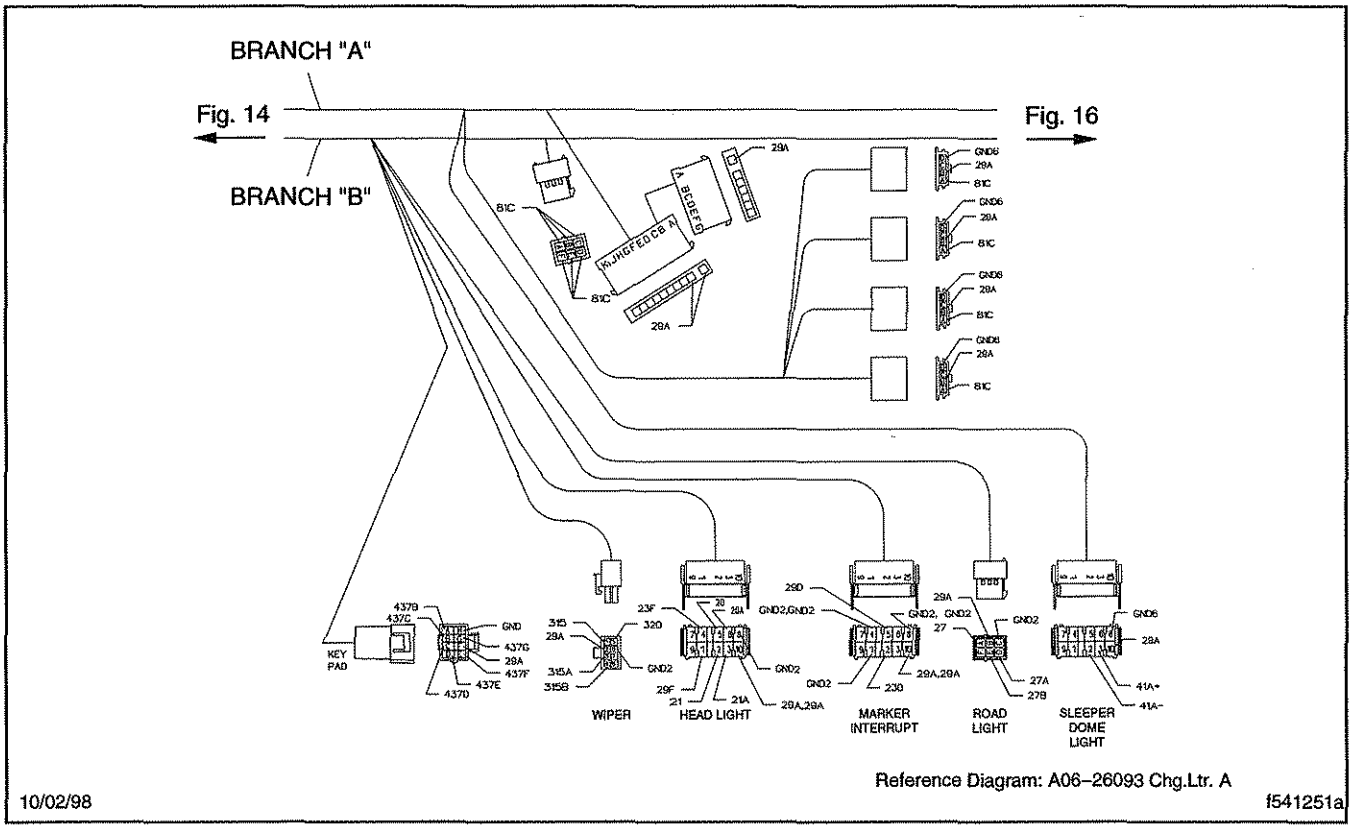
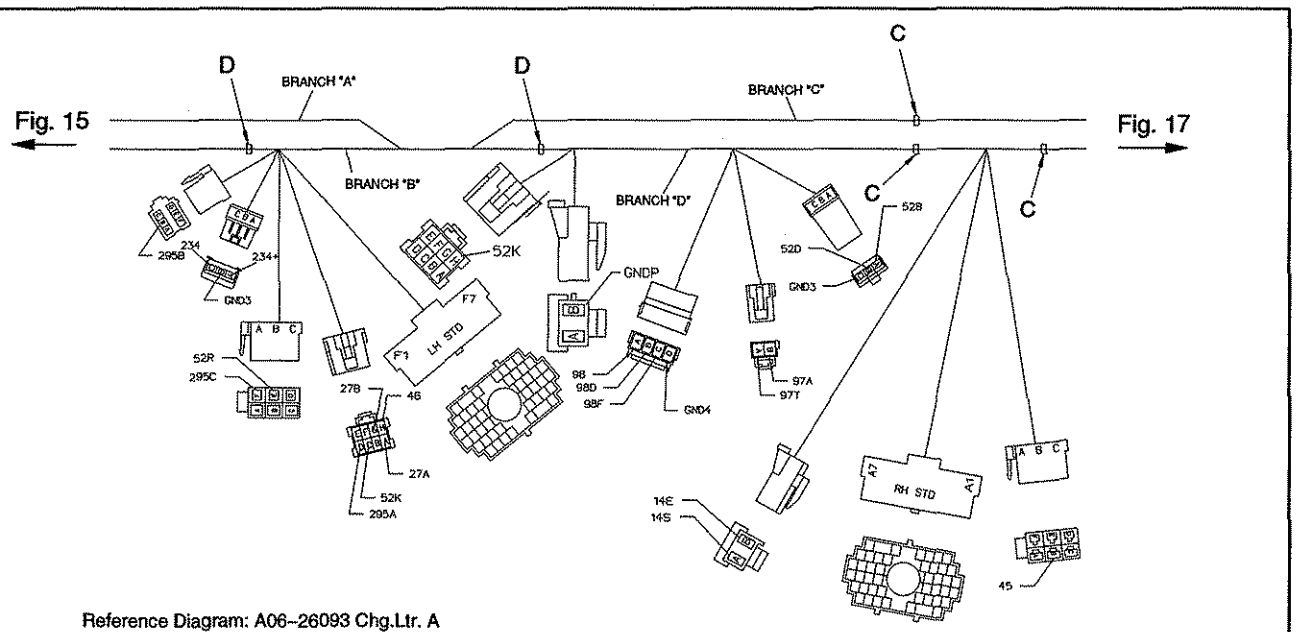


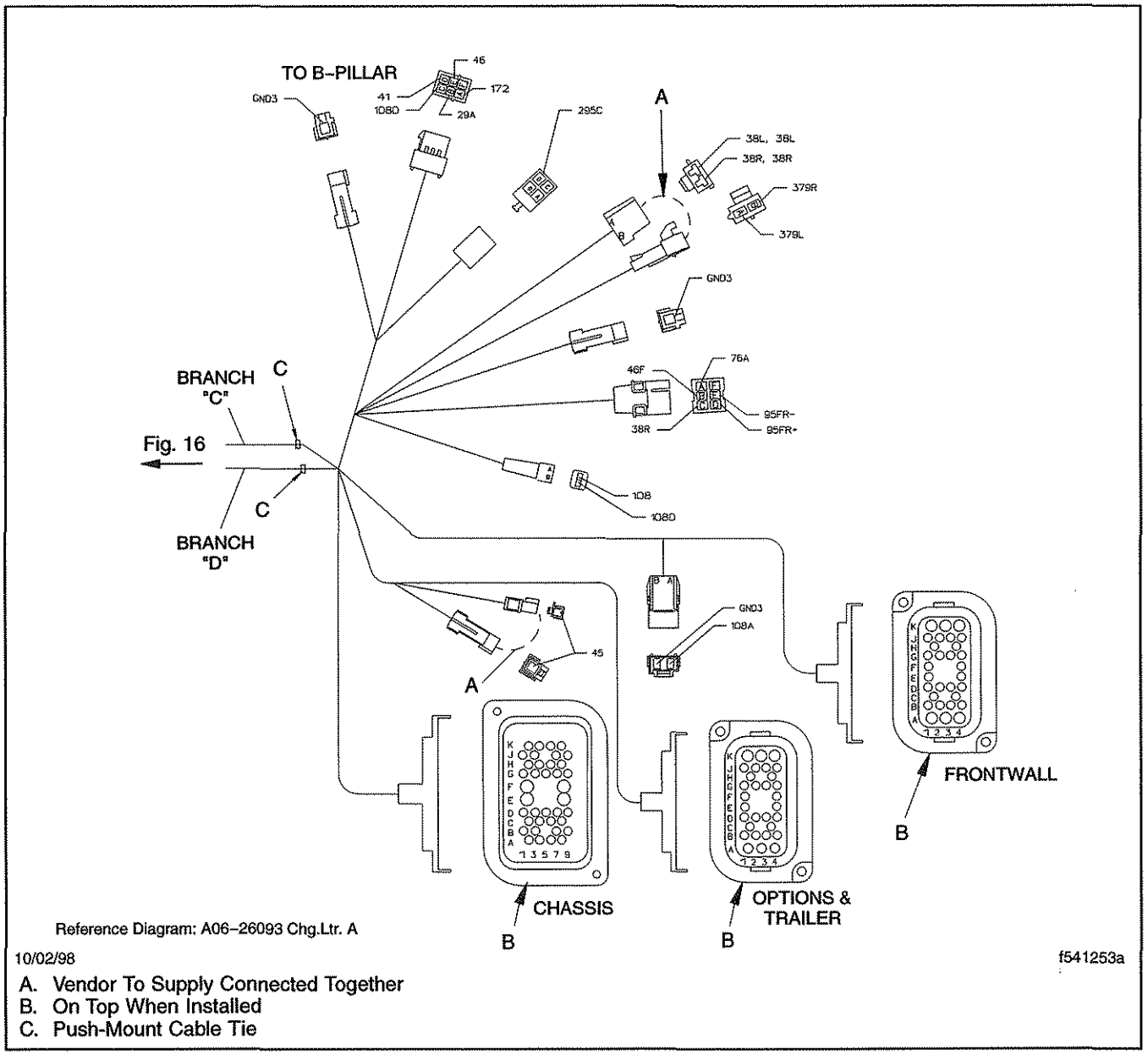
Fig. 15, Main Cab Harness Diagram (partial view)

Specifications



C. Push-Mount Cable Tie
D. End of Wire Channel (marked with green tape)

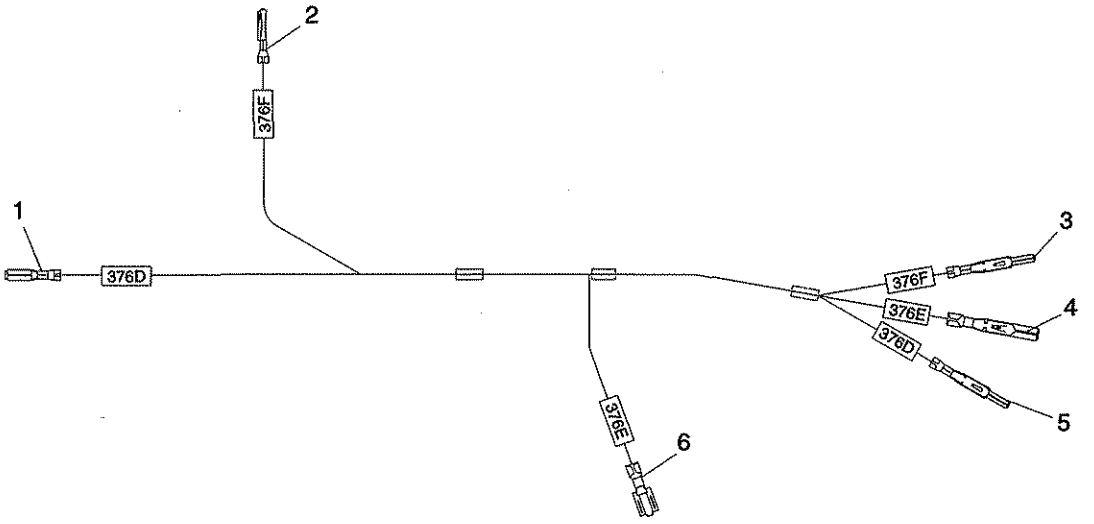
Fig. 16, Main Cab Harness Diagram (partial view)



A. Vendor To Supply Connected Together
B. On Top When Installed
C. Push-Mount Cable Tie

Fig. 17, Main Cab Harness Diagram (partial view)

Specifications



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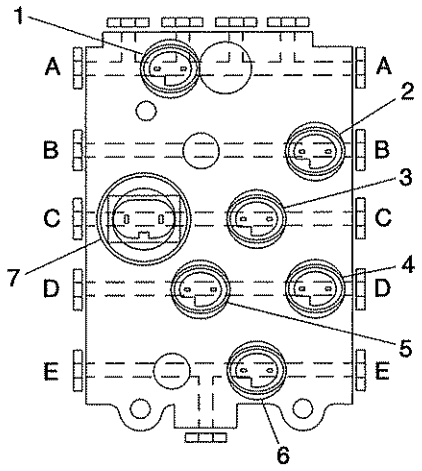
1. ABS L/H B-Pillar Harness
2. ICU LH Connector Pin A6
3. 7-Way Connector Pin B1
4. 7-Way Connector Pin A1
5. 7-Way Connector Pin B2
6. PDM Connector L, Pin C

Fig. 18, Trailer ABS Overlay



NOTE: The air manifold assembly is located in the cab under the dash.

A. Auxiliary Air
B. Primary Air
C. Application Air
D. Parking Brake Air
E. Secondary Air

1. Fan Pressure Switch
2. Primary Low Air Warning Pressure Switch
3. Cruise Control Cutout Pressure Switch
4. Engine Idle Timer Pressure Switch
5. Daytime Running Lights Pressure Switch
6. Secondary Low Air Warning Pressure Switch
7. Stop Light Pressure Switch

Fig. 19, Air Manifold and Pressure Switch Assembly

Wiring List

Circuits 1 through 21L

Circuits 1 through 21L			
Circuit	**Gauge**	**From**	**To**
1	000	Battery (– terminal)	Main Battery Cable Ground
1A	00	Battery (– terminal)	Cab Side of Ground Shut-Off Switch
6	000	Battery (+ terminal)	Starter Battery Terminal (3-Battery System)
6	00	Battery (+ terminal)	Starter Battery Terminal (4-Battery System)
6A	00	Battery (+ terminal)	Cab Side of Power Shut-Off Switch
14	10	Starter	PDM BAT Bus
14A	10	Circuit 14C Splice	IGN Relay (terminal 87)
14B	10	Cab/Frontwall Stud	PDM ISO Bus
14C	10	Cab/Frontwall Stud	ACC Relay (terminal 87)

Specifications

Circuits 1 through 21L			
Circuit	**Gauge**	**From**	**To**
14E	10	40-Amp Circuit Breaker	Auxiliary PDM Circuit 14E Bus Connector
14S	8	60-Amp Circuit Breaker	Auxiliary PDM Circuit 14S Bus Connector
15	16	Ignition Keyswitch	Splice Connector
15A	16	Magnetic Switch (coil terminal)	Data Logging Unit
15B	16	Starter (BAT terminal)	Magnetic Switch (switch terminal)
15C	16	Magnetic Switch (switch terminal)	Starter (S terminal)
15D	16	Starter	Starter Lockout Coil
15K	16	Splice Connector	Circuit 15A Splice
15T	16	Starter Temperature Switch	Magnetic Switch (coil terminal)
16	6	Alternator (output terminal)	Starter (battery terminal)
18	16	ICU Pin RH-B3 (blue connector)	Low Air Pressure Switch (secondary)
18A	16	Low Air Pressure Switch (secondary)	Low Air Pressure Switch (primary)
20	14	15-Amp Circuit Breaker (LH)	Headlight Switch
20A	14	Headlight Switch	LH Headlight Micro Relay (terminal 3)
20D	14	LH Headlight Micro Relay (terminal 2)	Headlight Dimmer Switch
20D	14	RH Headlight Micro Relay (terminal 2)	Headlight Dimmer Switch
20H	14	LH Headlight Micro Relay (terminal 5)	LH Headlight High Beams
20H	14	LH Headlight Micro Relay (terminal 5)	High Beam Indicator Light (ICU pin RH-B2)
20L	14	LH Headlight Micro Relay (terminal 4)	LH Headlight Low Beams
21	14	15-Amp Circuit Breaker (RH)	Headlight Switch
21A	14	Headlight Switch	RH Headlight Micro Relay (terminal 3)
21H	14	RH Headlight Micro Relay (terminal 5)	RH Headlight High Beams
21L	14	RH Headlight Micro Relay (terminal 4)	RH Headlight Low Beams

Circuits 23 through 29F

Circuits 23 through 29F			
Circuit	**Gauge**	**From**	**To**
23	10	Tractor Marker/Taillight Micro Relay (terminal 3)	Tractor Taillight Feed (chassis connector pin B1)
23A	14	Trailer Taillight Mini Relay (terminal 87)	Trailer Taillight Feed (7-way connector pin K1)
23D	16	Tractor Marker/Taillight Micro Relay (terminal 1)	Marker Light Interrupt Switch
23F	14	Tractor Marker/Taillight Relay (terminal 4)	Headlight Switch
24	14	15-Amp Circuit Breaker	Horn
24A	14	Horn	Horn Button
27	16	Road Light Switch	Road Light Micro Relay
27A	14	RH Headlight Micro Relay (terminal 4)	Road Light Switch

Circuits 23 through 29F			
Circuit	**Gauge**	**From**	**To**
27B	14	Tractor Marker/Taillight Micro Relay (terminal 5)	Road Light Switch
27L	14	Road Light Switch	Left-Hand Road Light
27R	14	Road Light Switch	Right-Hand Road Light
29A	16	Panel Light Dimmer	ICU Pin LH-A1 (pink connector)
29A	16	Panel Light Dimmer	ICU Pin RH-A6 (blue connector)
29A	16	ICU Pin LH-B1 (pink connector)	ICU Keypad
29A	16	Panel Light Dimmer	Utility Light Switch
29A	16	Panel Light Dimmer	Footwell Lights
29A	16	Panel Light Dimmer	Road Light Switch
29A	16	Panel Light Dimmer	Mirror Heat Switch
29A	16	Panel Light Dimmer	Wiper/Washer Switch
29A	16	Panel Light Dimmer	Clock
29A	16	Panel Light Dimmer	Sleeper Dome Lights
29A	16	Panel Light Dimmer	Marker Light Interrupt Switch
29A	16	Panel Light Dimmer	Headlight Switch
29A	16	Panel Light Dimmer	Flipper Switch 1
29A	16	Panel Light Dimmer	Flipper Switch 2
29A	16	Panel Light Dimmer	Flipper Switch 3
29A	16	Panel Light Dimmer	Flipper Switch 4
29A	16	Panel Light Dimmer	Splice Pak
29A	16	Panel Light Dimmer	Splice
29A	16	Splice	Splice
29A	16	Splice Pak	Splice
29A	16	Panel Light Dimmer	Heater Panel Light
29A	16	Panel Light Dimmer	HVAC Panel Light
29C	14	Panel Light Relay (terminal 3)	Panel Light Dimmer
29D	14	Panel Light Relay (terminal 1)	Marker Light Interrupt Switch
29F	16	Headlight Switch	Panel Light Relay (terminal 4)

Circuits 30 through 41S

Circuits 30 through 41S			
Circuit	**Gauge**	**From**	**To**
30	18	Transmission Fluid Temperature Gauge (+)	ICU Pin RH-D7 (blue connector)
30G	18	ICU Pin RH-D6 (blue connector)	Transmission Fluid Temperature Gauge (–)
36	12	25-Amp Circuit Breaker	Brake Light Switch

Specifications

Circuits 30 through 41S			
Circuit	**Gauge**	**From**	**To**
36A	14	Circuit 36B Splice	Turn Signal Switch Pin TS-7
36B	10	Brake Light Switch	Circuit 36B Splice
36B	20	Circuit 36B Splice	Trailer Brake Lights
38A	12	Turn Signal Flasher	Turn Signal Switch Pin TS-1
38L	12	Turn Signal Switch Pin TS-6	Circuit 38L Splice
38L	14	Circuit 38L Splice	Front Left Turn Signals
38L	14	Circuit 38L Splice	Trailer Left Turn Signals
38L	16	Circuit 38L Splice	ICU Pin LH-C8 (pink connector)
38L	14	Circuit 38L Splice	Side Fairing Clearance Light Turn Signals
38L	14	Circuit 38L Splice	Daytime Running Light (DRL) Module
38R	12	Turn Signal Switch Pin TS-12	Circuit 38R Splice
38R	14	Circuit 38R Splice	Front Right Turn Signals
38R	14	Circuit 38R Splice	Trailer Right Turn Signals
38R	14	Circuit 38R Splice	ICU Pin RH-B1 (blue connector)
38R	14	Circuit 38R Splice	Side Fairing Clearance Light Turn Signals
38R	14	Circuit 38R Splice	Daytime Running Light (DRL) Module
39L	14	Turn Signal Switch Pin TS-3	Rear Left Turn Signals/Brake Lights
39R	14	Turn Signal Switch Pin TS-9	Rear Right Turn Signals/Brake Lights
41	16	15-Amp Circuit Breaker	Cab Dome Light
41A+	14	Circuit 41 Splice	SleeperCab Dome Light #1
41A–	14	SleeperCab Dome Light #1	SleeperCab Dome Light Switch
41B+	14	Circuit 41 Splice	SleeperCab Dome Light #2
41B–	14	SleeperCab Dome Light #2	SleeperCab Dome Light Switch
41C+	14	Circuit 41 Splice	SleeperCab Dome Light #3
41C–	14	SleeperCab Dome Light #3	SleeperCab Dome Light Switch
41R	14	15-Amp Circuit Breaker (aux. PDM–Plug B2-2A)	Reading Lamp Switch
41RA	14	Reading Lamp Switch	Reading Lamp A
41RB	14	Reading Lamp Switch	Reading Lamp B
41S	14	15-Amp Circuit Breaker (aux. PDM–Plug B2-2C)	SleeperCab Dome Light

Circuits 42 through 78A

Circuits 42 through 78A			
Circuit	**Gauge**	**From**	**To**
42	18	Forward-Rear-Axle Oil Temperature Sensor (+)	ICU Pin RH-D5 (blue connector)
42G	18	ICU Pin RH-C5 (blue connector)	Forward-Rear-Axle Oil Temperature Sensor (–)

Specifications

Circuits 42 through 78A			
Circuit	**Gauge**	**From**	**To**
43	18	Rearmost-Axle Oil Temperature Sensor (+)	ICU Pin RH-D4 (blue connector)
43G	18	ICU Pin RH-C4 (blue connector)	Rearmost-Axle Oil Temperature Sensor (–)
46	16	Tractor Marker/Taillight Relay (terminal 3)	Cab Marker Lights
46	16	Tractor Marker/Taillight Relay (terminal 3)	Side Marker Lights
46A	10	Trailer Marker Light Relay (terminal 87)	7-Way Connector
46E	14	Tractor Marker/Taillight Relay (terminal 3)	Left-Hand Cab Door Marker Light
46F	14	Tractor Marker/Taillight Relay (terminal 3)	Right-Hand Cab Door Marker Light
47	18	Fuel Level Sensor (+)	ICU Pin RH-B5 (blue connector)
47G	18	ICU Pin RH-B6 (blue connector)	Fuel Level Sensor (–)
52	16	10-Amp Circuit Breaker	IGN Switch (BAT+ terminal)
52A	16	ACC Relay (terminal 30)	PDM (ACC bus)
52B	16	Ignition Switch (ACC terminal)	ACC Relay (terminal 85)
52C	16	IGN Relay (terminal 30)	PDM (IGN bus)
52D	16	Ignition Switch (IGN terminal)	IGN Relay (terminal 85)
52K	14	Sleeper HVAC IGN Power Relay–Plug B1-1C	Sleeper HVAC
52K	14	15-Amp Circuit Breaker (aux. PDM–plug B2-5D)	SleeperCab Lighting ACC Feed
52R	14	15-Amp Circuit Breaker (main PDM–pin DE)	10-Amp Circuit Breaker (aux. PDM–plug B3-6D)
57	14	15-Amp Circuit Breaker	Dash Cigar Lighter
57A	14	15-Amp Circuit Breaker	SleeperCab Cigar Lighter #1
57B	14	15-Amp Circuit Breaker	SleeperCab Cigar Lighter #2
57C	14	15-Amp Circuit Breaker	SleeperCab Cigar Lighter #3
73	14	10-Amp Circuit Breaker	Utility Light Switch
73A	14	Utility Light Switch	Utility Lights
76	14	Mirror Heat Switch	Right Mirror Heat (high)
76A	14	Mirror Heat Switch	Left Mirror Heat (low)
76A	14	Mirror Heat Switch	Mirror Heat Indicator Light
78	14	10-Amp Circuit Breaker	Spotlight Switch
78A	—	Spotlight Switch	Spotlight

Circuits 81C through 97T

Circuits 81C through 97T			
Circuit	**Gauge**	**From**	**To**
81C	16	10-Amp Circuit Breaker	Circuit 81C Splice
81C	16	Circuit 81C Splice	Flipper Valve 1
81C	16	Circuit 81C Splice	Flipper Valve 2

Specifications

Circuits 81C through 97T			
Circuit	**Gauge**	**From**	**To**
81C	16	Circuit 81C Splice	Flipper Valve 3
81C	16	Circuit 81C Splice	Flipper Valve 4
81C	16	10-Amp Circuit Breaker	Circuit 81C1 Splice
81C	16	Circuit 81C1 Splice	Engine Brake Switch
81C	16	Circuit 81C1 Splice	Cruise Control Switch
81C	16	Circuit 81C1 Splice	Engine Fan Override Switch
81C	16	Circuit 81C1 Splice	Optional Constant IGN Power
81C	16	Circuit 81C1 Splice	Optional Constant IGN Power
93	16	10-Amp Circuit Breaker	Radio ACC Power
94	14	10-Amp Circuit Breaker	Air Dryer Heater Element
95FL+	16	Radio Left Front Speaker Power	Left Front Speaker (+ terminal)
95FR+	16	Radio Right Front Speaker Power	Right Front Speaker (+ terminal)
95ML+	16	Radio or Fader Left Rear Speaker Power	Left Mid-Cab Speaker (+ terminal)
95MR+	16	Radio or Fader Right Rear Speaker Power	Right Mid-Cab Speaker (+ terminal)
95AL+	16	Radio or Fader Left Rear Speaker Power	Left Rear Speaker (+ terminal)
95AR+	16	Radio or Fader Right Rear Speaker Power	Right Rear Speaker (+ terminal)
97A	16	A/C Switch	Sleeper HVAC Low-Speed Relay (terminal 1)
97B	14	10-Amp Circuit Breaker	A/C Protection Unit
97C	14	A/C Protection Unit	A/C Compressor Clutch
97H	14	A/C Protection Unit	A/C High Pressure Switch
97J	14	A/C High Pressure Switch	A/C Protection Unit
97L	14	A/C Protection Unit	A/C Low Pressure Switch
97M	14	A/C Low Pressure Switch	A/C Protection Unit
97T	14	A/C Thermostat	A/C Protection Unit

Circuits 98 through 98Z

Circuits 98 through 98Z			
Circuit	**Gauge**	**From**	**To**
98	12	HVAC Regular-Speed Relay (terminal 87)	HVAC Fan Switch
98A	12	HVAC Fan Switch, Speed 1	Blower Resistor
98B	12	HVAC Fan Switch, Speed 2	Blower Resistor
98C	12	HVAC Fan Switch, Speed 3	Blower Resistor
98D	12	HVAC Fan Switch, Speed 4	HVAC High-Speed Relay (terminal 85)
98E	12	HVAC Fan Switch "On" Signal	A/C Switch
98F	12	Blower Resistor	Blower Motor

Circuits 98 through 98Z			
Circuit	**Gauge**	**From**	**To**
98G	–	Sleeper HVAC Blower Resistor	Sleeper HVAC Blower Motor
98H	–	Sleeper HVAC High-Speed Relay (terminal 87)	Sleeper HVAC Switch Speed 4
98H	–	Sleeper HVAC High-Speed Relay (terminal 87)	Blower Resistor
98K	16	Recirculation Pressure Switch	ICU Pin LH-C10 (pink connector)
98L	–	Sleeper HVAC Low-Speed Relay (terminal 85)	Resistor Block
98M	–	Blower Switch	Resistor Block
98P	–	30-Amp Circuit Breaker	Sleeper HVAC Relays
98R	–	Blower Switch	Low-Speed HVAC Relay (terminal 87)
98S	–	Sleeper HVAC Power Relay (terminal 87)	Sleeper HVAC Fan Switch
98S	–	Sleeper HVAC Power Relay (terminal 87)	Sleeper HVAC Constant Temperature Control
98T	–	Sleeper HVAC Constant Temperature Control	Sleeper HVAC Thermistor
98U	–	Sleeper HVAC Thermistor	Sleeper HVAC Constant Temperature Control
98W	–	Sleeper HVAC Constant Temperature Control	Sleeper HVAC Coolant Control Valve
98X	–	Sleeper HVAC Coolant Control Valve	Sleeper HVAC Constant Temperature Control
98Y	14	Sleeper Fan	Sleeper HVAC Power Relay (terminal 87)
98Z	14	Sleeper Fan	Sleeper HVAC High-Speed Relay (terminal 87)

Circuits 108 Through 196

Circuits 108 through 196			
Circuit	**Gauge**	**From**	**To**
108	14	15-Amp Circuit Breaker (main PDM–pin AC5)	Left Door Switch
108	14	15-Amp Circuit Breaker (main PDM–pin NB3)	Right Door Switch
108	14	15-Amp Circuit Breaker (main PDM–pin AC6)	Footwell Light Switch
108A	14	Footwell Light Switch	Left Footwell Light
108A	14	Circuit 108A Splice	Right Footwell Light
108D	14	Left Door Switch	Dome Light
108D	14	Right Door Switch	Dome Light
113	14	—	Baggage Compartment Light Switch
113A	14	Baggage Compartment Light Switch	Baggage Compartment Light
120	14	10-Amp Circuit Breaker	Back-Up Light Switch
120B	14	Back-Up Light Switch	Back-Up Lights
125	16	Parking Brake Indicator Light	Parking Brake Sensor
137	16	Alternator "I" Terminal	Alternator Warning Light
157	16	15-Amp Circuit Breaker	Power Mirror Switch
157A	16	Power Mirror Switch	LH Power Mirror Vertical Feed

Specifications

Circuits 108 through 196			
Circuit	**Gauge**	**From**	**To**
157B	16	Power Mirror Switch	LH Power Mirror Horizontal Feed
157C	16	Power Mirror Switch	Power Mirror Motor Common Feed
157D	16	Power Mirror Switch	RH Power Mirror Vertical Feed
157E	16	Power Mirror Switch	RH Power Mirror Horizontal Feed
166	16	Starter Switch	Ether Solenoid
166A	16	Engine Temperature Switch (ground)	Ether Solenoid Temperature Switch
172	16	Circuit Breaker	Electric Clock
173	18	Low Coolant Level Sensor	Low Coolant Level Indicator Light
173A	18	10-Amp Circuit Breaker	Low Coolant Level Sensor
185	—	—	Vehicle Anti-Theft Alarm
196	—	—	Fuel/Water Separator Heater

Circuits 218 Through 299A

Circuits 218 through 299A			
Circuit	**Gauge**	**From**	**To**
218	—	10-Amp Circuit Breaker	Pyrometer
221	—	—	Suspension Dump Warning
234	16	Frontwall Connector Pin G2	Engine Fan Solenoid
234+	16	10-Amp Circuit Breaker	Frontwall Connector Pin G2 (DDC engines only)
234+	16	Ground (in cab)	Frontwall Connector Pin G2 (CAT & CUM engines)
234*	16	Engine Fan Override Switch	Engine Fan Solenoid
234A	—	Engine Fan Override Switch	Engine ECU
234F	—	Engine Fan Solenoid	Engine ECU
242	—	30-Amp Circuit Breaker	Power Seat Control
295A	16	10-Amp Circuit Breaker (pin ED0)	Radio (IGN power)
295B	16	10-Amp Circuit Breaker (pin BB)	Radio (BAT power)
295C	16	10-Amp Circuit Breaker (pin DF)	CB Radio (overhead panel)
299	16	Outside Cab Air Temperature Sensor (+)	ICU Pin LH-C7 (pink connector)
299A	16	ICU Pin LH-D7 (pink connector)	Outside Cab Air Temperature Sensor (–)

Circuits 315 Through 363E

Circuits 315 through 363E			
Circuit	**Gauge**	**From**	**To**
315	14	15-Amp Circuit Breaker	Wiper Switch
315A	16	Wiper Switch	Wiper Low-Speed Micro Relay (terminal 2)
315B	16	Wiper Switch	Wiper High-Speed Micro Relay (terminal 2)
315C	14	Circuit 315 Splice	Wiper Motor
315H	14	Wiper High-Speed Micro Relay (terminal 5)	Wiper Motor
315L	14	Wiper Low-Speed Micro Relay (terminal 3)	Wiper Motor
315P	14	Wiper Low-Speed Micro Relay (terminal 4)	Wiper Motor
320	14	Wiper Switch	Washer Motor
320A	16	Washer Level Sensor	ICU Pin LH-A9 (pink connector)
331	—	10-Amp Circuit Breaker (aux. PDM)	Datalink Diagnostic Connector
359	16	Main PDM Pin AD1 (headlight sensing circuit)	ICU Pin LH-D16 (pink connector)
363	—	15-Amp Circuit Breaker	Power Window Motor
363A	—	Power Window Motor	Left-Hand Window, Up
363B	—	Power Window Motor	Left-Hand Window, Down (express mode)
363C	—	Power Window Motor	Right-Hand Window, Up
363D	—	Power Window Motor	Right-Hand Window, Down
363E	—	Left-Hand Window, Down	Power Window Motor

Circuits 376A Through 378T

Circuits 376A through 378T			
Circuit	**Gauge**	**From**	**To**
376A	16	15-Amp Circuit Breaker (aux. PDM)	ABS Controller
376B	16	15-Amp Circuit Breaker (aux. PDM)	ABS Controller
376C	16	10-Amp Circuit Breaker (aux. PDM)	ABS Controller
376D	16	ABS Controller	7-Way Connector Pin B2
376E	10	30-Amp C/B (main PDM pin LC)	7-Way Connector Pin A1
376F	18	7-Way Connector Pin B1	TRL ABS Light (ICU pin LH-A6)
376L	16	ABS Controller	TRAC ABS Light (ICU pin RH-A3)
376S	16	ABS Controller	WHL SPN Light (ICU pin RH-B4)
377LF+	16	ABS Controller	ABS Wheel Sensor, LH Forward
377LF–	16	ABS Wheel Sensor, LH Forward	ABS Controller
377LR+	16	ABS Controller	ABS Wheel Sensor, LH Rear
377LR–	16	ABS Wheel Sensor, LH Rear	ABS Controller

Specifications

Circuits 376A through 378T			
Circuit	**Gauge**	**From**	**To**
377LT+	16	ABS Controller	ABS Wheel Sensor, LH Tag (rearmost axle)
377LT–	16	ABS Wheel Sensor, LH Tag (rearmost axle)	ABS Controller
377RF+	16	ABS Controller	ABS Wheel Sensor, RH Forward
377RF–	16	ABS Wheel Sensor, RH Forward	ABS Controller
377RR+	16	ABS Controller	ABS Wheel Sensor, RH Rear
377RR–	16	ABS Wheel Sensor, RH Rear	ABS Controller
377RT+	16	ABS Controller	ABS Wheel Sensor, RH Tag (rearmost axle)
377RT–	16	ABS Wheel Sensor, RH Tag (rearmost axle)	ABS Controller
378LFI	16	ABS Controller	ABS Valve, LH Forward In
378LFO	16	ABS Controller	ABS Valve, LH Forward Out
378LF–	16	ABS Controller	ABS Valve, LH Rear Ground
378LRI	16	ABS Controller	ABS Valve, LH Rear In
378LRO	16	ABS Controller	ABS Valve, LH Rear Out
378LR–	16	ABS Controller	ABS Valve, LH Forward Ground
378RFI	16	ABS Controller	ABS Valve, RH Forward In
378RFO	16	ABS Controller	ABS Valve, RH Forward Out
378RF–	16	ABS Controller	ABS Valve, RH Rear Ground
378RRI	16	ABS Controller	ABS Valve, RH Rear In
378RRO	16	ABS Controller	ABS Valve, RH Rear Out
378RR–	16	ABS Controller	ABS Valve, RH Forward Ground
378T+	16	ABS Controller	ABS Traction Control Valve (+)
378T–	16	ABS Controller	ABS Traction Control Valve (–)

Circuits 379 Through 1587S

Circuits 379 through 1587S			
Circuit	**Gauge**	**From**	**To**
379	14	10-Amp Circuit Breaker	Daytime Running Light Module
379A	14	15-Amp Circuit Breaker	Daytime Running Light Module
379B	14	Daytime Running Light Module	Parking Brake Switch
379C	14	Daytime Running Light Module	Left Headlight Micro Relay (terminal 3)
379L	14	Daytime Running Light Module	LH Daytime Running Light
379R	14	Daytime Running Light Module	RH Daytime Running Light
437	16	10-Amp Circuit Breaker	Circuit 437 Splice
437	16	Circuit 437 Splice	ICU Pin LH-D14 (pink connector)
437	16	Circuit 437 Splice	ICU Pin RH-D11 (blue connector)

Specifications

Circuits 379 through 1587S			
Circuit	**Gauge**	**From**	**To**
437A	16	10-Amp Circuit Breaker	ICU Pin LH-D15 (pink connector)
437A	16	10-Amp Circuit Breaker	ICU Pin RH-C15 (blue connector)
437B	16	ICU Pin LH-B8 (pink connector)	Keypad Pin 1
437C	16	ICU Pin LH-B6 (pink connector)	Keypad Pin 2
437D	16	ICU Pin LH-B5 (pink connector)	Keypad Pin 3
437E	16	ICU Pin LH-B9 (pink connector)	Keypad Pin 4
437F	16	ICU Pin LH-B7 (pink connector)	Keypad Pin 5
437W	16	LH Door Switch	ICU Pin LH-C4 (pink connector)
437Z	18	ICU Pin LH-B12 (buzzer enable circuit)	ICU Pin RH-A7 (blue connector)
442	18	10-Amp BAT Circuit Breaker (aux. PDM)	Data Logging Unit
442A	18	10-Amp IGN Circuit Breaker (aux. PDM)	Data Logging Unit
442B	18	ICU Pin LH-A2 (pink connector)	Data Logging Unit
1587+	18	J1587 Databus	Data Logging Unit
1587–	18	Data Logging Unit	J1587 Databus
1587A+	18	J1587 Databus	ABS Controller
1587A–	18	ABS Controller	J1587 Databus
1587C+	18	J1587 Databus	ICU Pin LH-B10 (pink connector)
1587C–	18	ICU Pin LH-B3 (pink connector)	J1587 Databus
1587D+	18	J1587 Databus	Diagnostic Connector
1587D–	18	Diagnostic Connector	J1587 Databus
1587E+	18	J1587 Databus	Engine ECU
1587E–	18	Engine ECU	J1587 Databus
1587L+	18	J1587 Databus	Data Logging Unit
1587L–	18	Data Logging Unit	J1587 Databus
1587P+	18	ICU Pin LH-B11 (pink connector)	A/C Protection Unit
1587P–	18	A/C Protection Unit	ICU Pin LH-B4 (pink connector)
1587S+	18	J1587 Databus	ECAS ECU
1587S–	18	ECAS ECU	J1587 Databus

Contents

Subject	Subject Number
General Information	050
Service Operations	
Exterior Light Replacement	100
Interior Light Replacement	110
Headlight Dimmer and Turn-Signal Switch Replacement	120
Headlight Aim Checking and Adjusting	130
Troubleshooting	300
Specifications	400

General Information

The exterior lighting system includes the following lighting circuit functions:

- Headlights
- Daytime Running Lights
- Turn Signals (front, side, side fairing, and rear; can also be activated as 4-way flashers)
- Parking Lights
- Road Lights
- Marker Lights (front, side, and side fairing clearance)
- Taillights and Stoplights
- Back-Up Lights

Each of these lighting functions illuminates one or more bulbs on the vehicle. For example, the parking light circuit illuminates the front turn signal, side marker, and taillight bulbs.

A lighting fixture may have more than one functional circuit. For example, the dual-filament bulb in the front turn signal is connected to the turn signal, daytime running light, and parking light circuits.

In the front of the vehicle there are headlights, front turn signals, road lights, and front marker lights. See **Fig. 1** and **Fig. 2**. The front turn signal light with the amber dual-filament bulb doubles as a daytime running light and turn signal.

The parking lights operate a second filament in the dual-filament bulbs located in the front turn signals, side marker lights, and taillights (red utility lights).

Optional road lights are installed on the front bumper.

The front marker lights are installed on the sun visor. On vehicles with no sun visor installed, they are located on the cab roof.

On each side of the vehicle, there is a side marker light with a dual-filament bulb. The first filament doubles as a turn signal, and the second filament is for the parking lights. In addition, there is a clearance light on the cab side, which also doubles as a turn signal.

On the rear of the Century Class Conventional vehicle, there are three utility lights. The utility lights with the red lenses have dual-filament bulbs, with one filament being a combination taillight, brake light, and rear turn signal, while the other filament is for the parking lights. The utility light with the white lens is a back-up light.

There are two utility lights on the rear of the Argosy COE vehicle, each of which controls all rear exterior lighting functions for that side: taillight, brake light, rear turn signal, parking light and back-up light.

For vehicles equipped with daytime running lights, switching on the ignition and releasing the parking brakes automatically activates the daytime running light at reduced voltage. The daytime running lights share with the turn signals the smaller (amber) light next to the headlight. This light will operate as a daytime running light until the parking brakes are applied, the headlight switch is turned on, or the turn signals are activated.

⚠ CAUTION

Before performing any electric welding on a vehicle, disconnect the battery power and ground cables and the electrical connector at the bottom of the daytime running lights (DRL) module. See Troubleshooting 300 in this section for instructions. Electric currents produced during electric welding can damage various electronic components on the vehicle.

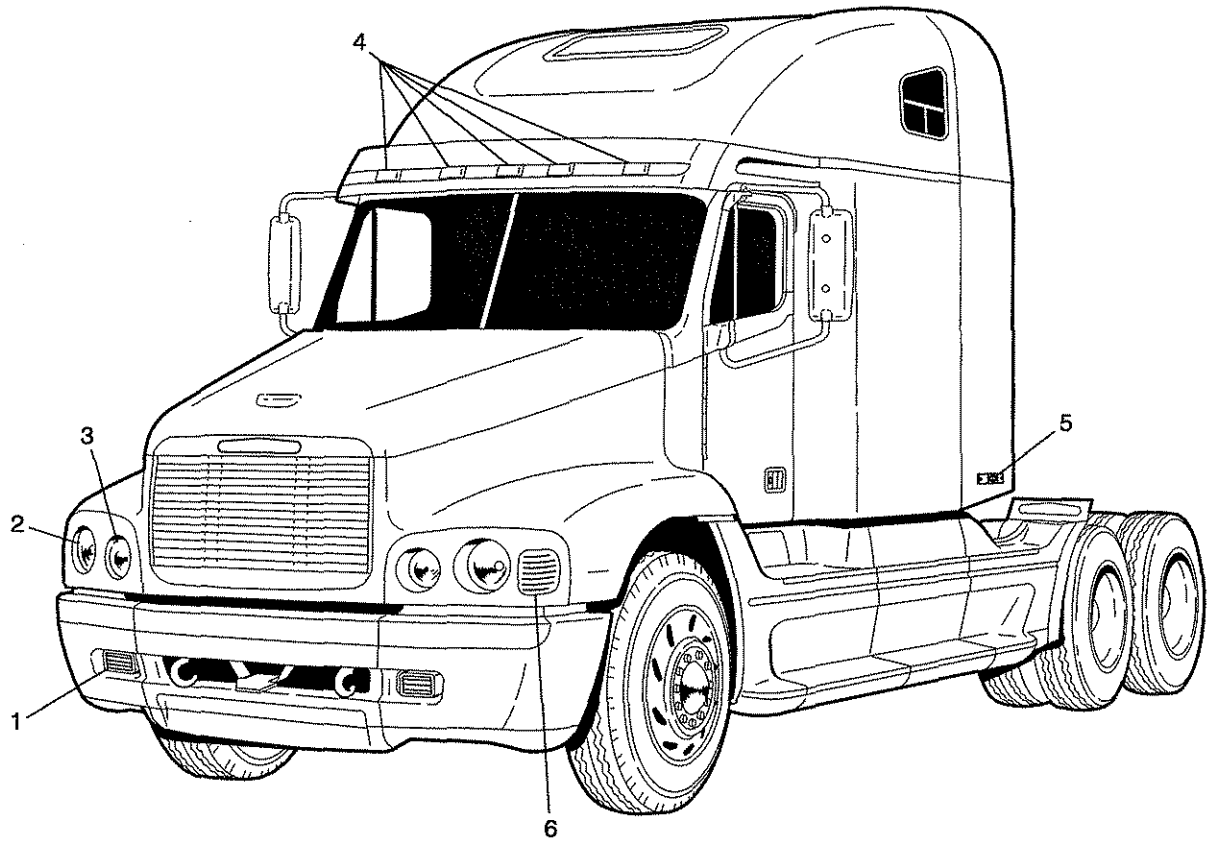
NOTE: For vehicles built to operate in the United States, the low-beam headlights must be turned on before the road lights can be turned on. The road lights will not go on if the high-beam headlights are already on, and switching from low beams to high beams will switch off the road lights.

For vehicles built to operate in Canada, the taillights and clearance lights must be on before the road lights can be turned on. Unless the headlight switch is all the way up (headlights, taillights, clearance lights, marker lights, and panel lights on) or down (taillights, clearance lights, marker lights, and panel lights on), the road light switch will not turn on the road lights.

Inside the cab are the following lights:

- Dome lights (with map and reading lights)
- Courtesy lights in both driver's and passenger's footwells
- An instrument panel that features fully lighted gauges and panels

General Information



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1. Road Light
2. Headlight
3. Front Turn Signal/Daytime Running Light
4. Front Marker Lights
5. Side Fairing Clearance Light
6. Side Marker Light

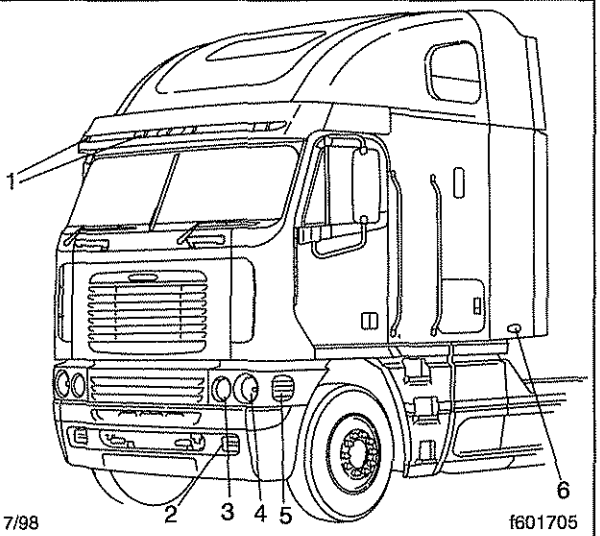
Fig. 1, Cab Exterior Lighting, Front, Century Class Conventional

The steering column-mounted turn-signal switch has the headlight dimmer switch built into it.

In the bunk or sleeper are dome lights, under-bunk storage compartment lights, and reading lights. Baggage compartments may be equipped with accessory lights.

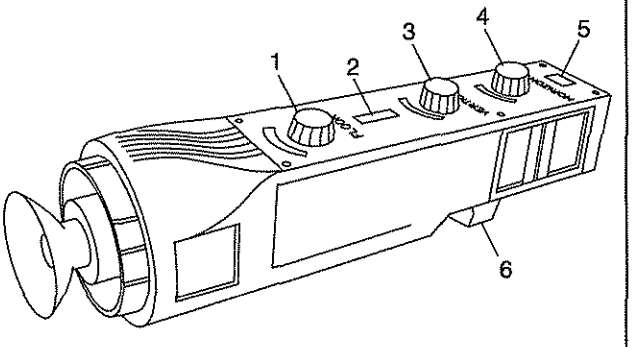
Headlight aim can be checked and adjusted most easily, using the Hopkins mechanical aimer. The aimer attaches to the headlight with a vacuum cup activated by pushing the piston handle located on the base of the aimer. See **Fig. 3**.

To adjust the horizontal aim, turn the horizontal adjusting screw on the headlight until the split image aligns in the split image view port. To adjust the vertical aim, turn the vertical adjusting screw on the headlight until the bubble is centered in the level vial.



1. Front Marker Lights
2. Road Light
3. Front Turn Signal/Daytime Running Light
4. Headlight
5. Side Marker Light
6. Side Fairing Clearance Light

Fig. 2, Cab Exterior Lighting, Front, Argosy COE



1. Floor Slope Dial
2. Level Vial
3. Vertical Dial
4. Horizontal Dial
5. Split Image View Port
6. Piston Handle

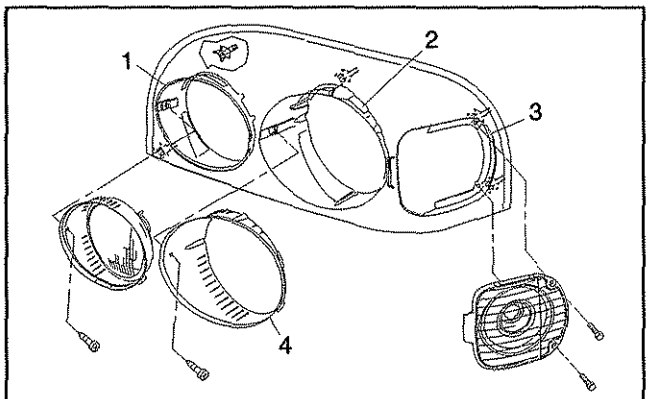
Fig. 3, Headlight Aimer

Headlight Replacement

Century Class and Argosy COE

NOTE: The Century Class headlight bezel contains the headlight, front turn signal/daytime running light, and the side marker light. See **Fig. 1**. The side marker light also functions as a turn signal.

1. Park the vehicle on a level surface, apply the parking brake, shut down the engine, and chock the front and rear tires.
2. Remove the headlight trim cone from the headlight bezel or the headlight housing. See **Fig. 2**.
   - 2.1 Remove the Torx®-head mounting screw on the side of the headlight trim cone.
   - 2.2 Rotate the free side of trim cone out until the two mounting tabs on the other side of the trim cone come loose.
   - 2.3 Remove the trim cone.
3. Remove the retaining ring screws. See **Fig. 3**.
4. Remove the retaining ring.
5. Remove the sealed-beam headlight from the housing; disconnect the wiring connector from the back of the light.
6. To provide corrosion protection, coat the prongs and base of the new light with dielectric grease. Refer to the approved electrical lubricants table in **Specifications, 400**.
7. Push the wiring connector onto the prongs at the rear of the new light.
8. Place the new light in the headlight housing.
9. Place the retaining ring over the light and install the retaining ring screws; tighten them securely.



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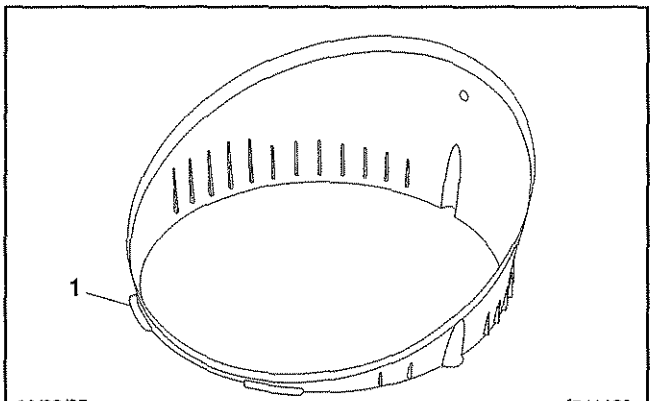
NOTE: The front turn signal doubles as a daytime running light (DRL), when DRLs are installed.

1. Front Turn Signal Bucket
2. Headlight Bucket
3. Side Marker Light Bucket
4. Headlight Trim Cone

Fig. 1, Headlight Bezel, Century Class Conventional



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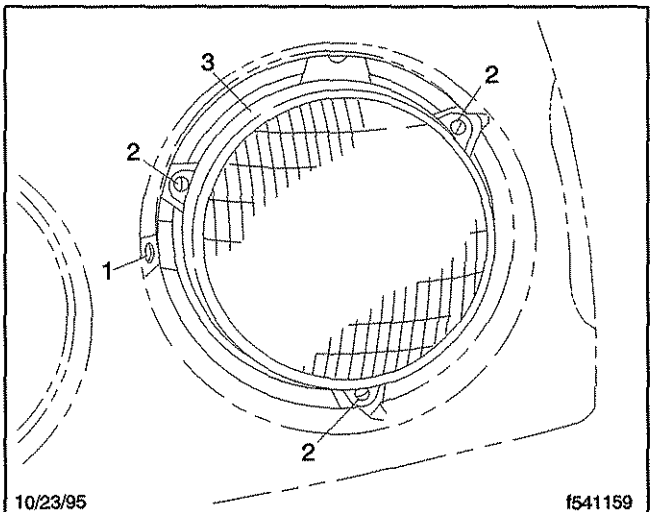
1. Mounting Tab

Fig. 2, Headlight Trim Cone



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1. Trim Cone Screw Hole
2. Retaining Ring Screws
3. Headlight Bucket

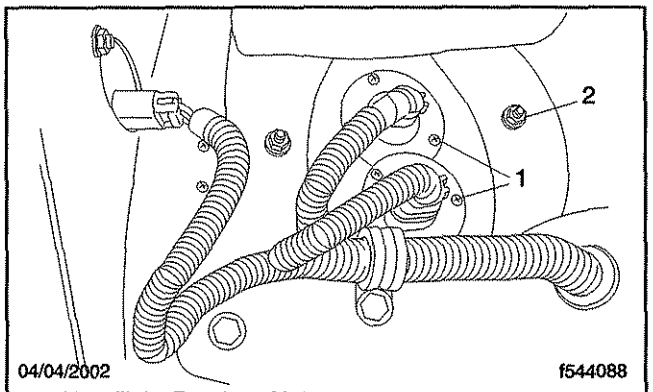
Fig. 3, Headlight Retaining Ring Screws

Exterior Light Replacement

10. Check and, if necessary, adjust the headlight aim.
11. Install the headlight trim cone.
    - 11.1 Work the two mounting tabs on the trim cone under the edge of the headlight bezel.
    - 11.2 Rotate the opposite side of the trim cone into the bezel.
    - 11.3 Secure the trim cone to the bezel with the mounting screw.
12. Remove the chocks from the tires.

Coronado

1. Park the vehicle on a level surface, apply the parking brake, shut down the engine, and chock the front and rear tires.
2. Tilt the hood.
3. Lift the interior mudflap to access the headlight assembly. See **Fig. 5**.
4. Disconnect the wiring connectors.
5. Remove the retainer nuts from the headlight assembly, located on the inside of the hood. See **Fig. 4**
6. Remove the headlight assembly by pulling the assembly from the front of the hood.
7. To provide corrosion protection, coat the prongs and base of the new light with dielectric grease. Refer to the approved electrical lubricants table in **Specifications, 400.**
8. Push the wiring connectors onto the prongs at the rear of the new light.
9. Install the retaining nuts and tighten securely.
10. Check and, if necessary, adjust the headlight aim.
11. Return the hood to the operating position.
12. Remove the chocks from the tires.



1. Headlight Retainer Nuts
2. Capscrews

Fig. 4, Inner Cab Headlight Assembly

Turn Signal/Daytime Running Light Replacement

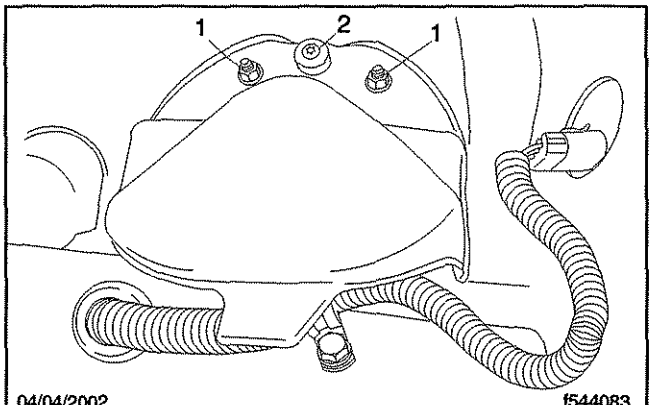
Front Turn Signal/Daytime Running Light

1. Park the vehicle on a level surface, apply the parking brake, shut down the engine, and chock the front and rear tires.

NOTE: The front turn signal light has an amber dual-filament bulb and a clear lens. In vehicles so equipped, the turn signal filament doubles as a daytime running light. The other filament functions as a parking light through a separate circuit.

2. On the Century Class Conventional vehicle, tilt the hood. It is easier and more efficient to remove the bulb through the bottom of the bezel. See **Fig. 6.**

   On the Argosy COE vehicle, remove the Torx-head screw from the turn signal/DRL bezel, then remove the light assembly from the housing.



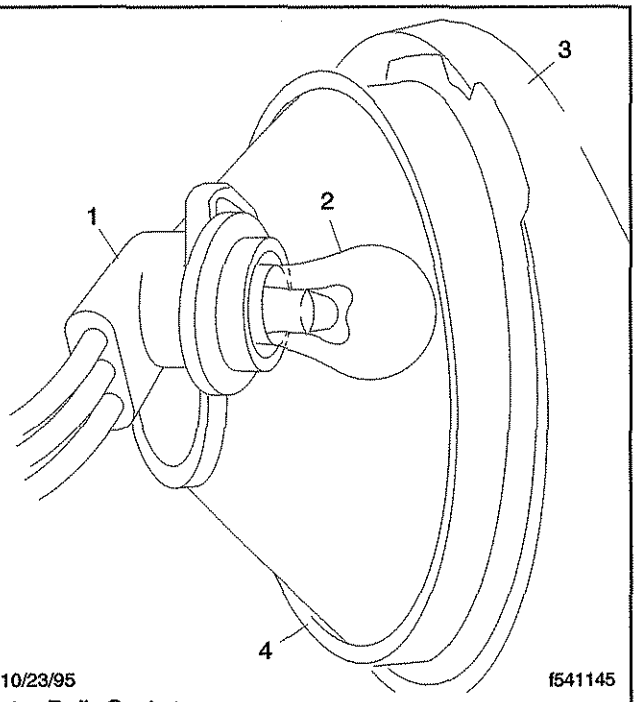
1. Nuts
2. Center Adjusting Screw

Fig. 5, Interior Mud Flap

3. Twist the socket counterclockwise one-quarter turn to unlock.
4. Replace the bulb. To provide corrosion protection, coat the prongs and base of the new bulb with dielectric grease. Refer to the approved electrical lubricants table in **Specifications, 400.**
5. Check the bulb for proper operation.
6. Twist the socket clockwise and press in on the locking tab to install it. Tug gently on the socket to make sure it is locked in place.
7. Lower the hood of the Century Class Conventional vehicle, or, on the Argosy COE vehicle, install the light assembly into the housing, and secure it with the Torx-head screw.
8. Remove the chocks from the tires.

Side Turn Signal

See "Side Marker Light" for instructions on replacing the side turn signal light bulbs.



1. Bulb Socket
2. Amber Bulb
3. Back of Headlight Bezel
4. Turn Signal Trim Cone

Fig. 6, Front Turn Signal

Side Fairing Turn Signal

See "Clearance Light" for instructions on replacing the side turn signal light bulbs.

Rear Turn Signal

See "Utility Light Replacement" for instructions on replacing the rear turn signals.

Road Light Replacement

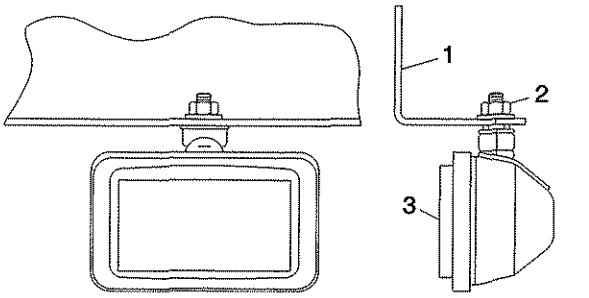
1. Park the vehicle on a level surface, apply the parking brake, shut down the engine, and chock the front and rear tires.
2. Remove the nut attaching the road light to the bumper. See **Fig. 7.**
3. Unplug the electrical connector.
4. Install a new road light. Attach the mounting nut to the bumper.
5. To provide corrosion protection, coat the pins and base of the connector with dielectric grease. Refer to the approved electrical lubricants table in **Specifications, 400.**
6. Plug in the electrical connector.
7. Wipe the lens with a clean cloth to remove any dirt or skin oil.
8. Test the light for proper operation.
9. Check the alignment of the light. Make sure the light is pointing forward and slightly toward the shoulder side of the road.
10. Remove the chocks from the tires.

Marker Light Replacement

Front Marker Light

1. Park the vehicle on a level surface, apply the parking brake, shut down the engine, and chock the front and rear tires.
2. Remove the two Torx-head screws on the amber front marker light lens. Remove the lens. See **Fig. 8.**

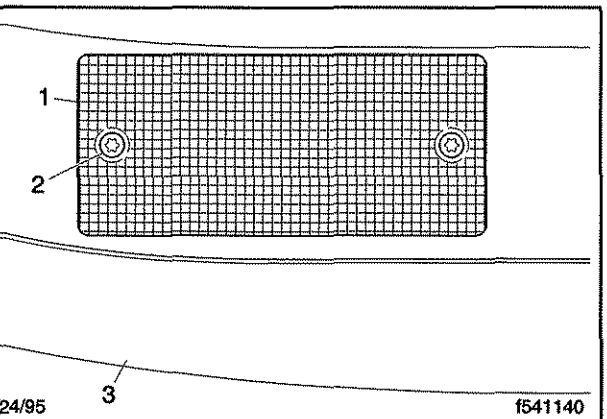
Exterior Light Replacement



1. Bumper
2. Mounting Nut
3. Road Light

Fig. 7, Road Light

3. Twist the bulb socket counterclockwise one-quarter turn to remove.
4. Replace the bulb. To provide corrosion protection, coat the prongs and base of the new bulb with dielectric grease. Refer to the approved electrical lubricants table in **Specifications, 400**.
5. Twist the socket clockwise and press in on the locking tab to install it. Tug gently on the socket to make sure it is locked in place.
6. Check the bulb for proper operation.
7. Install the amber marker light lens. Tighten the two Torx-head screws firmly.



1. Front Marker Light
2. Torx-Head Screw
3. Sun Visor

Fig. 8, Front Marker Light

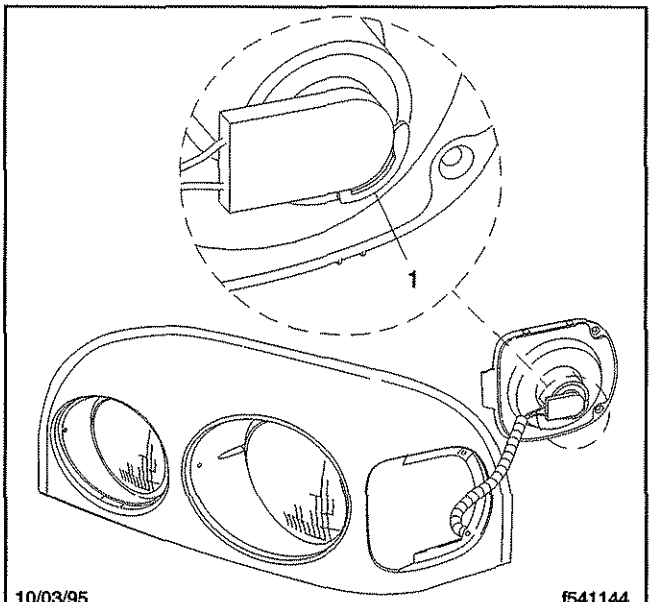
8. Remove the chocks from the tires.

Side Marker Light

1. Park the vehicle on a level surface, apply the parking brake, shut down the engine, and chock the front and rear tires.

NOTE: The side marker light has a dual-filament bulb. The side marker light filament doubles as a side turn signal. The other filament is for the parking lights through a separate circuit.

2. Remove the two Torx-head screws on the amber side marker light lens.
3. Twist the socket counterclockwise one-quarter turn to remove. See **Fig. 9**.
4. Replace the bulb. To provide corrosion protection, coat the prongs and base of the new bulb with dielectric grease. Refer to the approved electrical lubricants table in **Specifications, 400**.
5. Check the bulb for proper operation.
6. Twist the socket clockwise and press in on the locking tab to install it. Tug gently on the socket to make sure it is locked in place.



1. Locking Clip

Fig. 9, Side Marker Light, Century Class Conventional

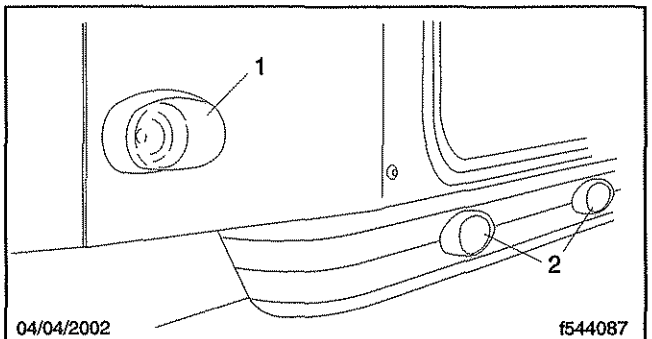
7. Install the two Torx-head screws on the amber lens.
8. Remove the chocks from the tires.

Accent Lights, Coronado

1. Park the vehicle on a level surface, apply the parking brake, shut down the engine, and chock the front and rear tires.

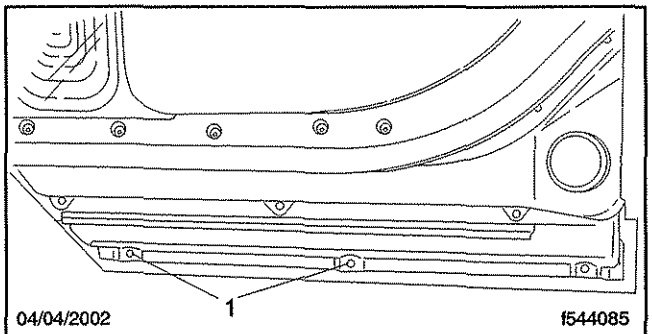
NOTE: These steps apply to the accent lights and the marker light on the side of the cab. See **Fig. 10.**

2. If replacing accent lights on the hood, tilt the hood.
3. If replacing the accent lights on the cab door, first remove the door lower interior trim panel. See **Fig. 11.**
   - 3.1 Remove the six capscrews that attach the inner door trim panel to the cab door.
   - 3.2 Remove the trim panel.



1. Marker Light
2. Accent Lights

Fig. 10, Coronado Accent and Marker Lights



1. Trim Panel Capscrews

Fig. 11, Lower Interior Door Trim Panel

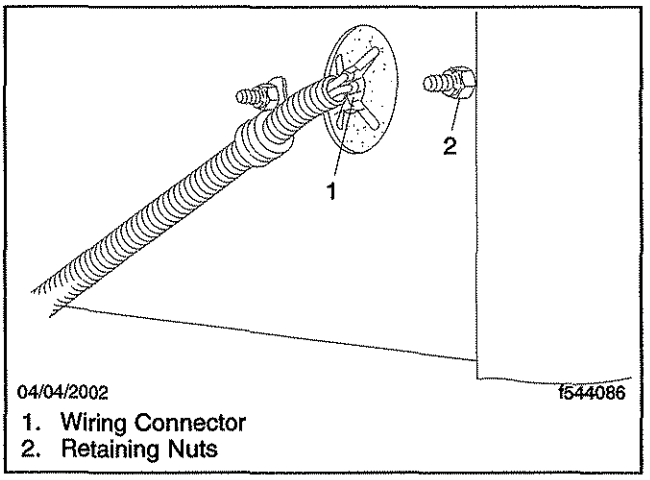
4. Disconnect the wiring connector from the light. See **Fig. 12.**
5. Remove the retaining nuts.
6. Remove the accent light from the cab.
7. Push the wiring connector onto the prongs at the rear of the new light.
8. Position the new accent light on the cab.
9. Install the retaining nuts onto the accent light and tighten securely.
10. If necessary, install the door lower interior trim panel.
    - 10.1 Position the trim panel on the cab door interior.
    - 10.2 Install the six screws and tighten securely.
11. If necessary, lower the hood.
12. Remove the chocks from the tires.

Clearance Light, Century Class Conventional

1. Park the vehicle on a level surface, apply the parking brake, shut down the engine, and chock the front and rear tires.

NOTE: The clearance light doubles as a side fairing turn signal. See **Fig. 13.**

2. Remove the two 3/8-inch lag nuts on the rear of the cab side fairing. See **Fig. 14.**

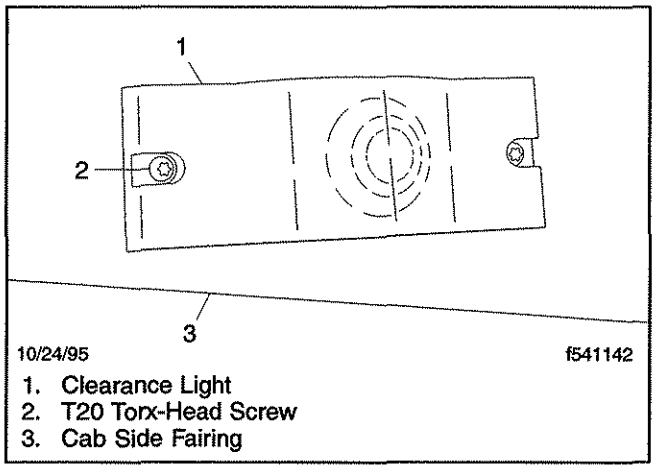


1. Wiring Connector
2. Retaining Nuts

Fig. 12, Accent Light Screws

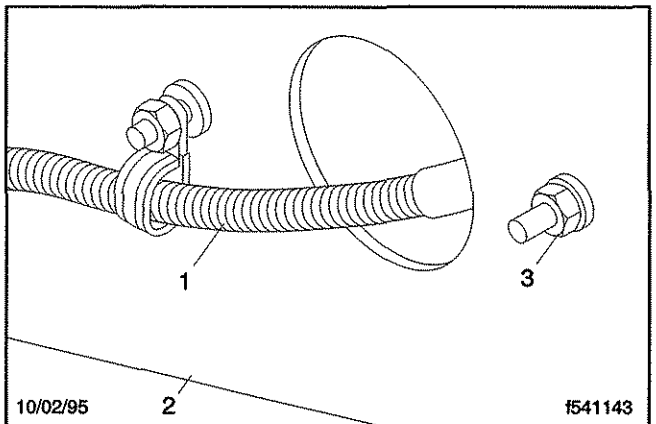
Exterior Light Replacement

3. Remove the lens housing, bulb and electrical cable. It is a sealed unit.
4. Disconnect the electrical connector.
5. Connect a new sealed unit to the electrical connector.
6. Test the light for correct operation.
7. Install the new unit on the front of the fairing; make sure that it is fully seated. Tighten the 3/8-inch nuts firmly.
8. Remove the chocks from the tires.



1. Clearance Light
2. T20 Torx-Head Screw
3. Cab Side Fairing

Fig. 13, Clearance Light Installation



1. Electrical Cable
2. Cab Side Fairing (from back)
3. 3/8-Inch Lag Nut

Fig. 14, Clearance Light Installation (rear view)

Clearance Light, Argosy COE

1. Park the vehicle on a level surface, apply the parking brake, shut down the engine, and chock the front and rear tires.

NOTE: The clearance light doubles as a side turn signal.

2. Remove the two Torx-head screws on the cab side. See **Fig. 13.**
3. Remove the lens housing, bulb and electrical cable.
4. Remove the amber lens cover.
5. Remove the bulb and install a new one.
6. Test the light for correct operation.
7. Replace the amber lens cover.
8. Install the assembly on the cab side; make sure that it is fully seated. Tighten the Torx-head screws firmly.
9. Remove the chocks from the tires.

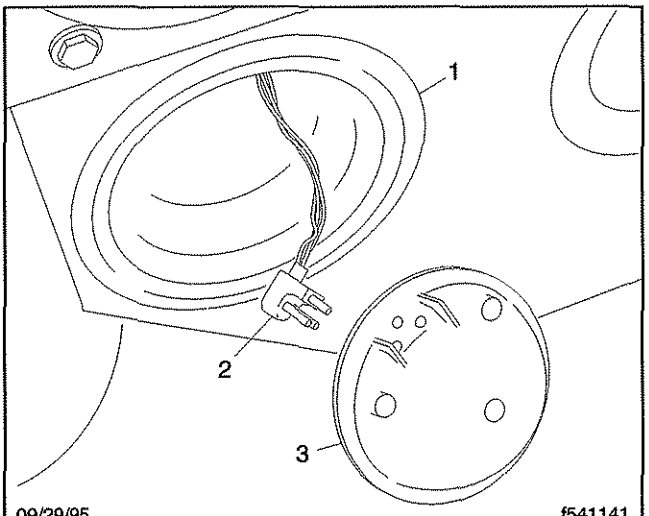
Utility Light Replacement

Century Class Conventional

1. Park the vehicle on a level surface, apply the parking brake, shut down the engine, and chock the front and rear tires.

NOTE: The utility light with the red lens has a dual-filament bulb. One filament serves as a taillight, stop-light, and rear turn signal. The other filament is for the parking lights. The utility light with the white lens serves as a back-up light.

2. Press outward on the rear of the utility light until it comes out of the gasket. See **Fig. 15.**
3. Pull the tab on the electrical connector and remove it from the back of the utility light.
4. Press a new sealed utility light unit into the gasket until it is firmly seated.
5. Attach the electrical connector and tug gently on it to make sure the tab on the connector is seated. Test the bulb for proper operation.
6. Remove the chocks from the tires.



NOTE: The utility light with the red lens has a dual-filament bulb. One filament serves as a taillight, stoplight, and rear turn signal. The other filament is for the parking lights. The utility light with the white lens serves as a back-up light.

1. Gasket
2. Electrical Connector
3. Utility Light

Fig. 15, Utility Light Replacement, Century Class Conventional

Argosy COE

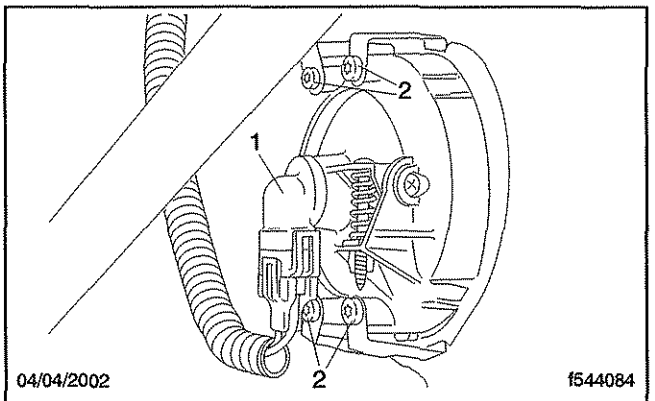
1. Park the vehicle on a level surface, apply the parking brake, shut down the engine, and chock the front and rear tires.
2. Remove the four Phillips-head screws.
3. Pry the lens cover off the housing.

NOTE: The upper bulb is the back-up light; the bottom combination bulb is the taillight, parking light, brake light, and turn signal.

4. Twist the bulb counterclockwise one-quarter turn to remove it.
5. To provide corrosion protection, coat the prongs and base of the new bulb with dielectric grease. Install the new bulb. Refer to the approved electrical lubricants table in **Specifications, 400.**
6. Test the bulb for proper operation.
7. Place the lens cover on the housing and tighten the four Phillips-head screws securely.
8. Remove the chocks from the tires.

Fog Light Replacement, Coronado

1. Park the vehicle, apply the parking brake, shut down the engine, and chock the front and rear tires.
2. Open the hood.
3. Disconnect the wiring connector. See **Fig. 16.**
4. Remove the four capscrews securing the fog light to the bumper.
5. Remove the fog light.
6. Position the new fog light on the bumper.
7. Install the four capscrews, and tighten securely.
8. Connect the wiring.
9. Lower the hood.
10. Remove the chocks from the tires.



1. Light Bulb
2. Capscrews

Fig. 16, Fog Light Assembly

Dome/Map Light Replacement

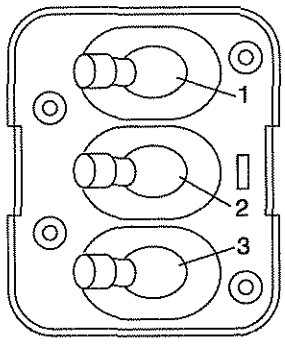
NOTE: On vehicles with an overhead console, the dome/map light has three lights: a diffuse dome light, a clear spotlight (reading light), and a red map light. See **Fig. 1**. On vehicles without an overhead console, the dome light has a single white light.

1. Remove the dome light lens, which snaps on to the lens holder. See **Fig. 2**.
2. Twist the bulb holder one-quarter turn clockwise to remove the bulb that needs changing.
3. Press the new bulb into its socket and check that it is firmly in place.
4. Test the light for correct operation.
5. Snap the dome light lens into place.

Courtesy Lights

DRIVER'S FLOOR COURTESY LIGHT

1. Reach in under the dash and snap the lens off the lamp base. See **Fig. 3**.
2. Replace the light bulb.
3. Snap the lens back in place on the lamp base.



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1. Red Dome Light
2. Clear Spotlight
3. Diffuse Dome Light

Fig. 1, Dome/Map Light Bulbs

PASSENGER'S FOOTWELL COURTESY LIGHT

1. Reach into the recess in the HVAC cover and snap the lens off the lamp base. See **Fig. 4**.
2. Replace the bulb.
3. Snap the lens back into place on the lamp base.
4. Install the HVAC cover. For instructions, see **Section 60.08**.

Dash Panel Lights

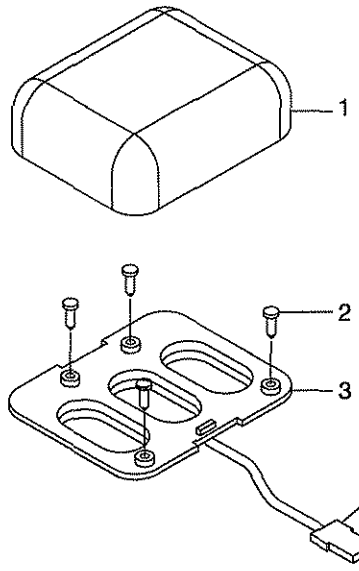
INSTRUMENT PANEL GAUGE LIGHTS

To replace instrument panel gauge lights, see Section 54.03, **Subject 120**.

INSTRUMENT PANEL SWITCH LIGHTS

Wiper/Washer Switch

NOTE: The wiper/washer switch is the only double-paddle switch installed on the dash.



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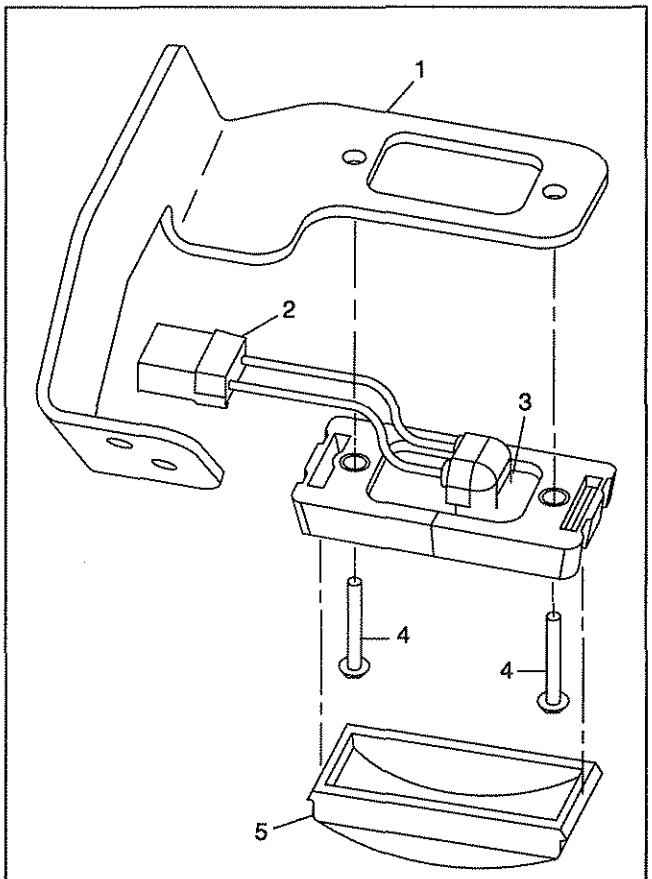
1. Dome Light Lens
2. 10–14 Thread-Rolling Screw
3. Dome Light Lens Holder
4. Electrical Connector

Fig. 2, Lens Removal

Interior Light Replacement



1. Steering Column Light Bracket
2. Electrical Connector
3. Lamp Base
4. 3/16-Inch Monobolt
5. Lens

Fig. 3, Driver's Floor Courtesy Light

1. Remove the auxiliary instrument panel from the dash. For procedures, see Section 54.03, **Subject 100**.

NOTE: In some installations, the bulb is on the side of the switch. On these switches, it is not necessary to remove the switch from the panel.

2. Remove the switch from the auxiliary instrument panel (if necessary). For procedures, see Section 54.03, **Subject 110**.

3. Locate the bulb base on the side of the switch. Using a small screwdriver, turn the bulb base one-quarter turn to remove it. See **Fig. 5**.

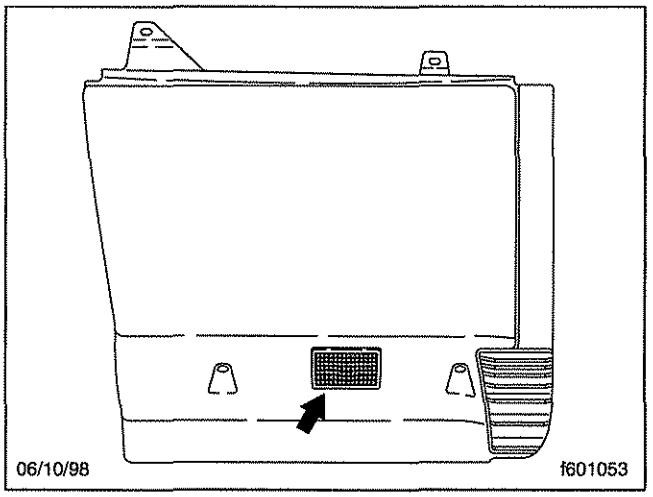


Fig. 4, Passenger's Footwell Courtesy Light

NOTE: The base is part of the bulb assembly and must be replaced with the bulb.

4. Install a new bulb and base assembly on the back of the valve. See **Fig. 6**.

5. Install the switch (if removed) in the auxiliary instrument panel. For procedures, see Section 54.03, **Subject 110**.

6. Install the auxiliary instrument panel. For procedures, see Section 54.03, **Subject 100**.

Rocker Switches

1. Turn the switch on.

2. With the switch on, slip a small screwdriver under the top end of the rocker panel and pop it off of the switch body, exposing the bulb. See **Fig. 7**.

3. Using needle-nose pliers (or a small plastic tube or straw), remove the burned-out bulb.

NOTE: If using a tube or straw, rock the bulb and pull on it gently to remove it.

4. Install the new bulb in the socket.

   4.1 Push the new bulb onto the end of the small plastic tube or straw.

   NOTE: If using the bulb replacement tool located underneath the dash message center bezel, use care because the rocker switch bulbs are slightly smaller than the warning and indicator light bulbs in the dash message center.

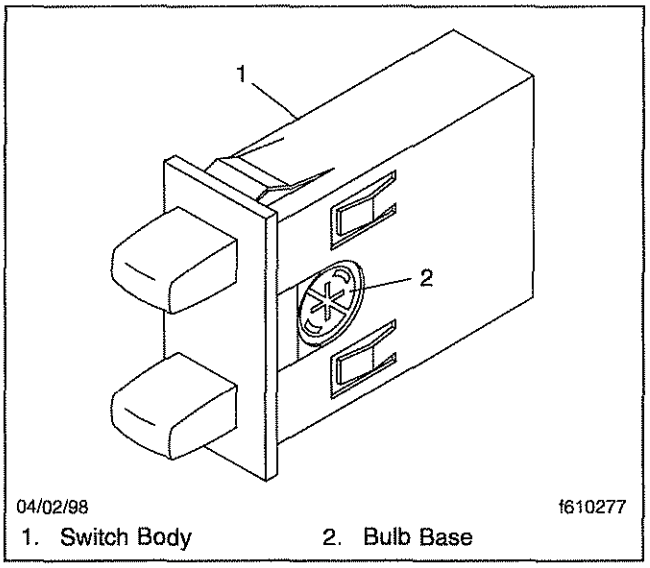


Fig. 5, Wiper/Washer Switch Light

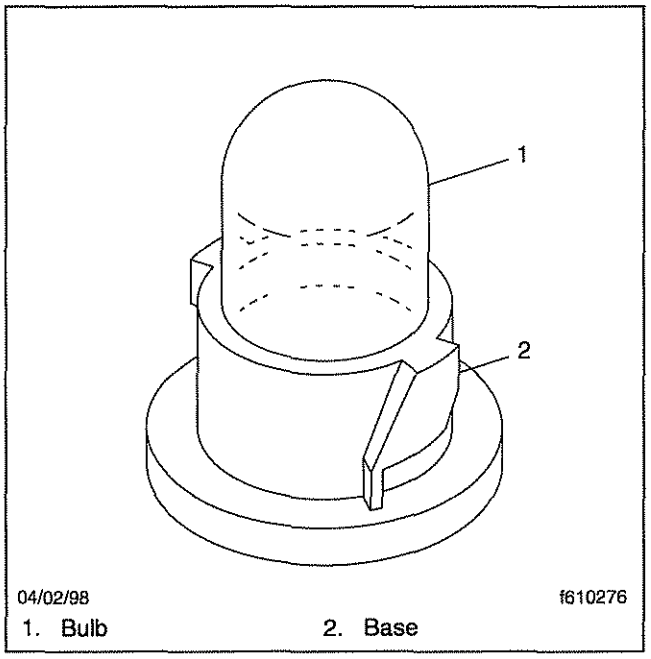


Fig. 6, Bulb Base

4.2 Holding the bulb on the end of the tube, insert it into the socket.

4.3 Rotate the straw until the bulb is seated; then pull on the straw to remove it from the bulb.

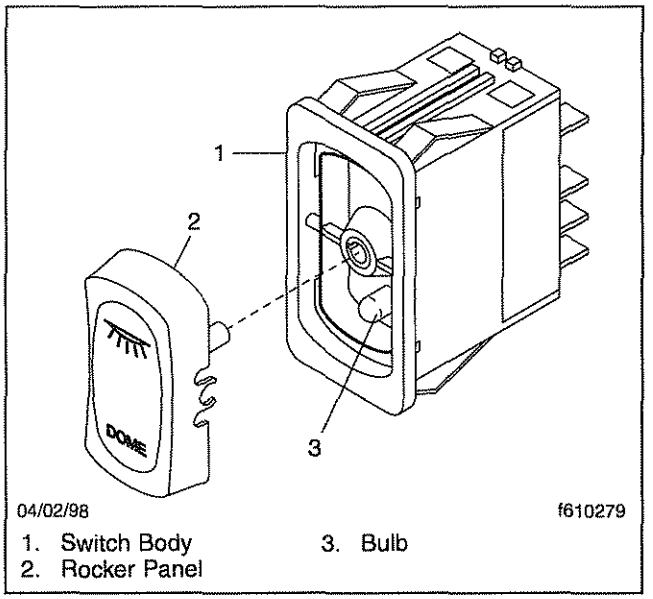


Fig. 7, Rocker Switch Light Bulb

5. Check that the rocker panel is right side up. Snap it back onto the switch body.

Single-Paddle Switches

1. With the switch on, slip a small screwdriver under the side of the lens and pry it off of the switch body, exposing the bulb. See **Fig. 8**.

IMPORTANT: Be careful not to scratch the switch body.

2. Using needle-nose pliers (or a small plastic tube or straw), remove the burned-out bulb.

NOTE: If using a tube or straw, rock the bulb and pull on it gently to remove it.

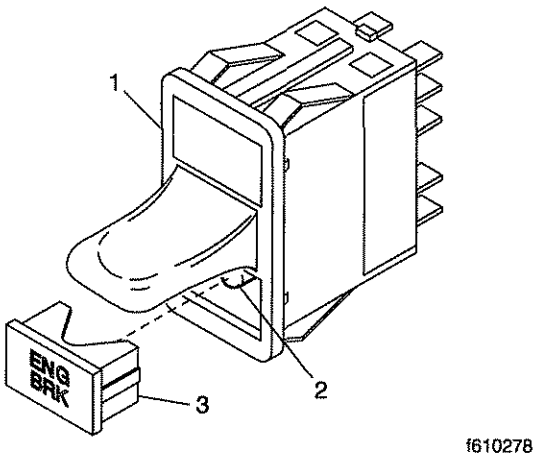
3. Install the new bulb in the socket.

   3.1 Push the new bulb onto the end of the small plastic tube or straw.

   NOTE: If using the bulb replacement tool located underneath the dash message center bezel, use care because the rocker switch bulbs are slightly smaller than the warning and indicator light bulbs in the dash message center.

   3.2 Holding the bulb on the end of the tube, insert it into the socket.

Interior Light Replacement



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1. Switch Body
2. Bulb
3. Lens

Fig. 8, Single-Paddle Switch Light Bulb

3.3 Rotate the straw until the bulb is seated; then pull on the straw to remove it from the bulb.

4. Check that the lens is right side up. Insert it back into the switch body.

INSTRUMENT PANEL FLIPPER VALVE LIGHTS

1. Remove the auxiliary instrument panel from the dash. For procedures, see Section 54.03, **Subject 100**.
2. Locate the bulb base on the back of the flipper valve. Using a small screwdriver, turn the bulb base one-quarter turn to remove it. See **Fig. 9**.

NOTE: The base is part of the bulb assembly and must be replaced with the bulb.

3. Install a new bulb and base assembly on the back of the valve. See **Fig. 6**.
4. Install the auxiliary instrument panel. For procedures, see Section 54.03, **Subject 100**.

WARNING AND INDICATOR LIGHTS

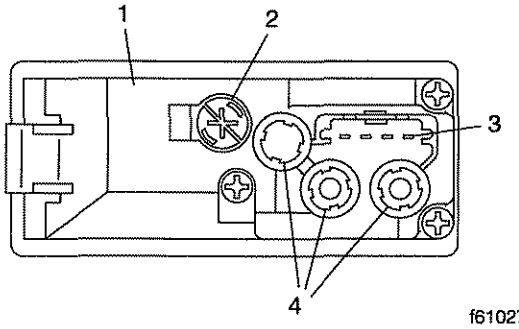
To replace warning and indicator lights, see Section 54.03, **Subject 120**.

Sleeper Cab Light Replacement

MID-ROOF DOME LIGHT

NOTE: This light is installed on sleeper cabs only. See **Fig. 10**. The front overhead dome/map light is installed on all cabs.

1. Press in on each side of the mid-roof dome light lens to release the mounting tabs (see **Fig. 11**). Remove the lens from the light receptacle.
2. Remove the fluorescent bulb from the socket.
3. Install a new fluorescent bulb. Make sure it is secure under the retaining clip. See **Fig. 11**.
4. Test the dome light for correct operation.



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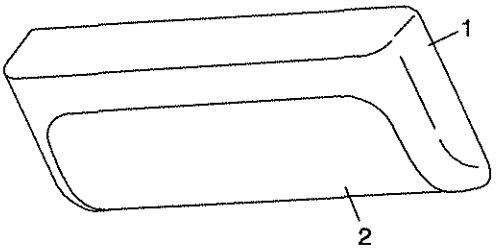
Flipper valve shown in rear view.

1. Valve Body
2. Bulb Base
3. Electrical Connector
4. Air Line Connectors

Fig. 9, Flipper Valve Light



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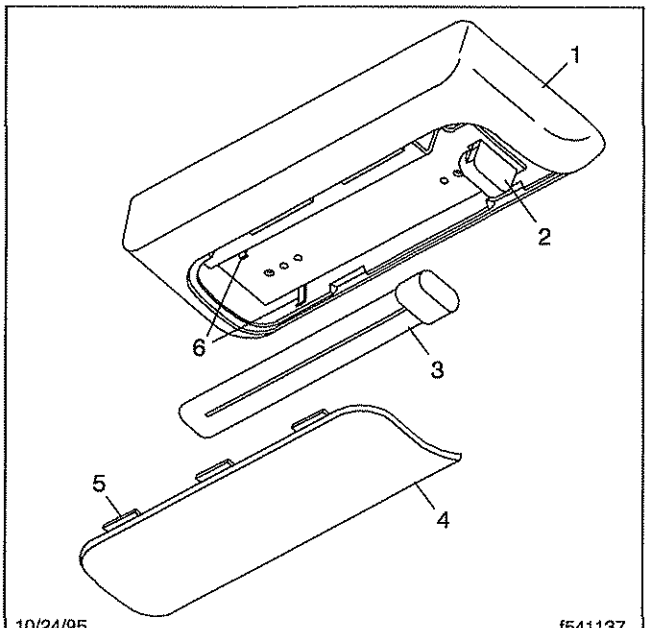
1. Dome Light
2. Dome Light Lens

Fig. 10, Mid-Roof Dome Light Installed

Interior Light Replacement



1. Dome Light
2. Socket
3. Fluorescent Bulb
4. Lens
5. Mounting Tab
6. Retaining Clip

Fig. 11, Mid-Roof Dome Light Bulb

5. Press the lens onto the lens housing. Make sure the mounting tabs snap into place.

BUNK READING LIGHT

NOTE: This light is installed on sleeper cabs only.

The reading light is installed on the bunk control panel.

Lights Without Removable Bulbs

1. Twist the light counterclockwise and press in to free it from the panel. See **Fig. 12.**
2. Install a new reading light. Align the light with the three notches in the panel and snap into position.
3. Test the reading light for correct operation.

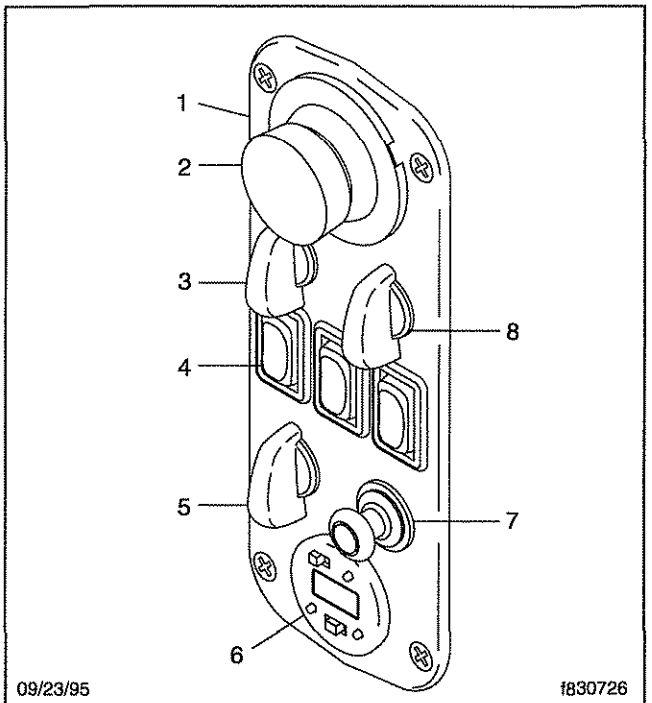
Lights With Removable Bulbs

1. Remove the lens and rubber guard assembly from the lamp swivel.
2. Remove the blown light bulb.
3. Install a new light bulb.
4. Snap the lens and rubber guard assembly onto the lamp swivel.

UNDER-BUNK STORAGE COMPARTMENT LIGHT

NOTE: This light is installed on sleeper cabs only.

1. Open up the bunk to gain access to the storage compartment light and switch. See **Fig. 13.**
2. Remove the four screws from the light receptacle to expose the bulb.
3. Remove the bulb from the socket.
4. Install a new bulb.



NOTE: Number and placement of switches may vary.

1. Control Panel
2. Reading Light
3. Fan Control Knob
4. Dome and Reading Light Switches
5. Volume Control Knob
6. Clock
7. Cigarette Lighter
8. A.T.C. Control Knob

Fig. 12, Bunk Reading Light

Interior Light Replacement

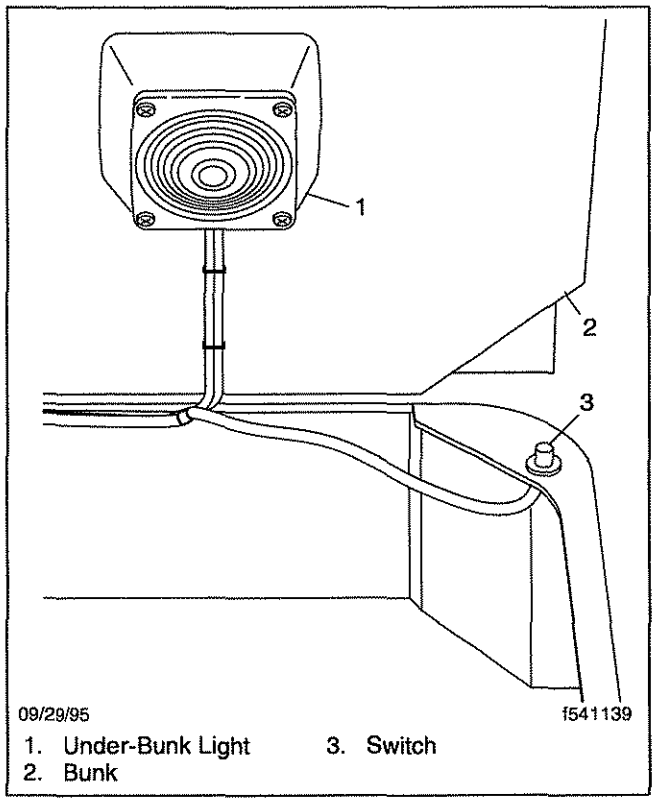


Fig. 13, Under-Bunk Light

5. Test the under-bunk light for correct operation.

Headlight Dimmer and Turn-Signal Switch Replacement

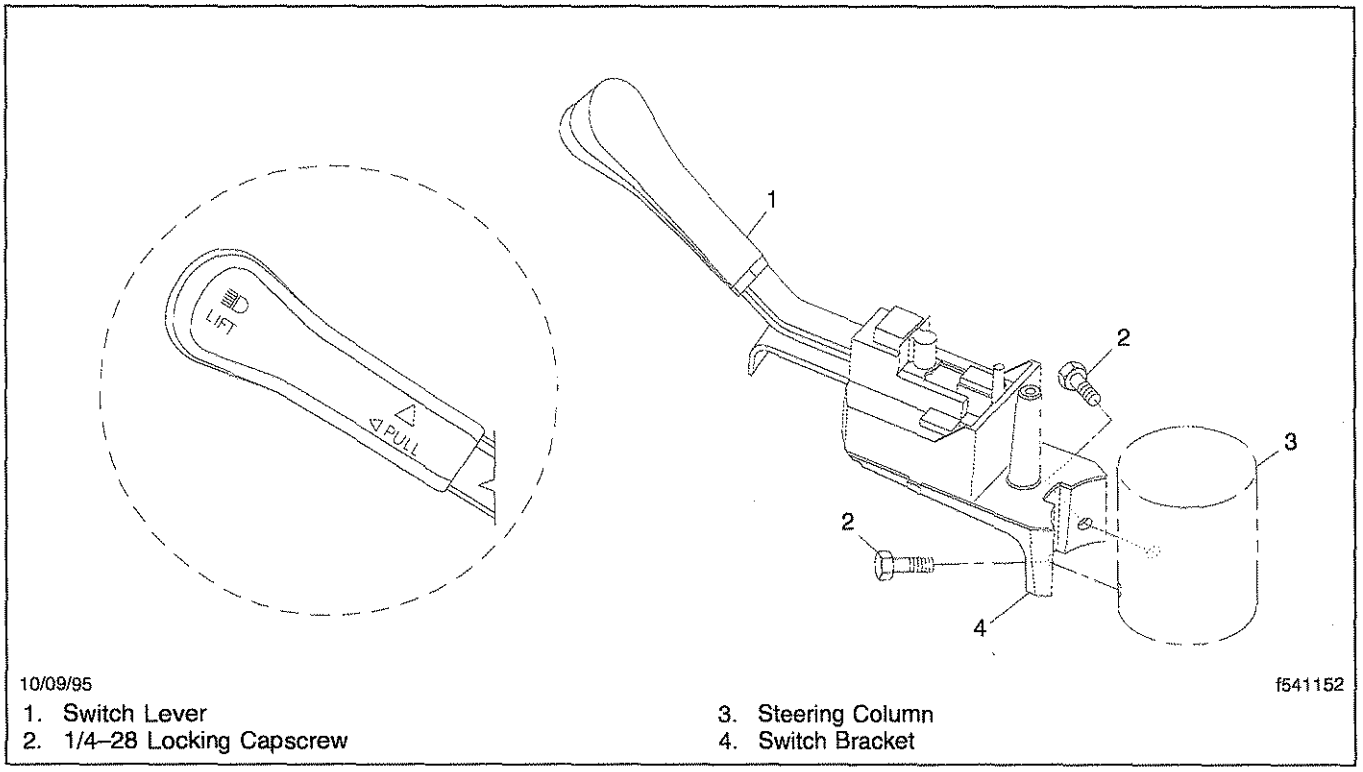
Replacement

NOTE: Before replacing the dimmer and turn-signal switch, make sure that the trouble is in the switch and not elsewhere in the circuit. Check that the circuit breaker and fuse are working, and inspect the signal light bulbs for broken filaments. Also, check the flasher relay, and replace it if necessary.

1. Remove the steering column cover (clamshell cover). For instructions, see **Section 46.07**.

NOTE: Some headlight dimmer and turn signal switches also have a horn button installed on the end of the switch.

2. Using a 7/16-inch wrench, loosen the two 1/4–28 locking capscrews attaching the headlight dimmer and turn signal switch to the steering column. Remove the turn signal switch mounting assembly from the steering column. See **Fig. 1**.
3. Unsnap the wiring connector from the turn-signal switch.
4. Connect the wiring connector to the new switch.
5. Install the turn signal switch.
   - 5.1 Position the switch on the steering column. Align the switch so that it is pointing directly to the left, toward the driver's door.
   - 5.2 Install the two locking capscrews and tighten them firmly.
6. Check the turn signals, headlight dimmer, horn (if installed), and 4-way flashers for correct operation.



1. Switch Lever
2. 1/4–28 Locking Capscrew
3. Steering Column
4. Switch Bracket

Fig. 1, Headlight Dimmer/Turn Signal Switch

Headlight Aim Checking and Adjusting

IMPORTANT: Before checking or adjusting the headlight aim, do the following:

- Remove large amounts of mud or ice from the underside of the fenders.
- Check the springs for sagging or broken leaves.
- Check the suspension for proper functioning of the leveling mechanism. On cabs with air suspensions, make sure that the height is properly adjusted.
- Check for damage to the hood and hinge assembly. Repair as necessary.
- Clean the headlight lenses.
- With the vehicle unloaded, check that the tires are inflated to the recommended air pressure.

Century S/T and Argosy

Checking

For a quick check to see if the headlights need aiming, do the following procedure.

1. Move the vehicle onto a flat surface that has been calibrated for slope. Shut down the engine, set the parking brake, and chock the tires.
2. Attach a headlight aimer to each headlight.
   - 2.1 Attach the seven-inch circular adaptor to the aimer. See **Fig. 1**.
   - 2.2 Align the adaptor with the aiming pads on the headlight lens.
   - 2.3 Push the piston handle on the base of the aimer forward to engage the vacuum cup. Immediately pull the handle backward until it locks. See **Fig. 2**.
   - 2.4 Do the same procedure with the other aimer.
3. Check the floor slope dial for the correct setting. See **Fig. 3**.
4. Check the horizontal aim. See **Fig. 4**.
   - 4.1 Turn the horizontal dial until the split image is in alignment.
   - 4.2 If the horizontal dial scale on either aimer reads more than "4," re-aim the headlight.

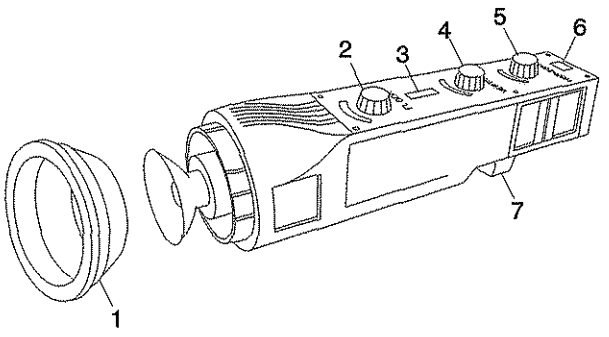
   NOTE: If adjustment is required, see the procedures under "Adjusting" below.
5. Check the vertical aim. See **Fig. 5**.
   - 5.1 Turn the vertical dial until the level vial is centered.
   - 5.2 If the vertical dial scale on either aimer reads more than "4," re-aim the headlight.

   NOTE: If adjustment is required, see the procedures under "Adjusting" below.
6. Remove the two headlight aimers. Hold each aimer securely, and then press the vacuum release button.
7. Remove the chocks from the tires.

Adjusting

If the headlights need adjusting, do this procedure.

1. If not already there, move the vehicle onto a flat surface that has been calibrated for slope. Shut down the engine, set the parking brake, and chock the tires.
2. Attach a headlight aimer to each headlight. See the procedures above under "Checking" for detailed instructions.



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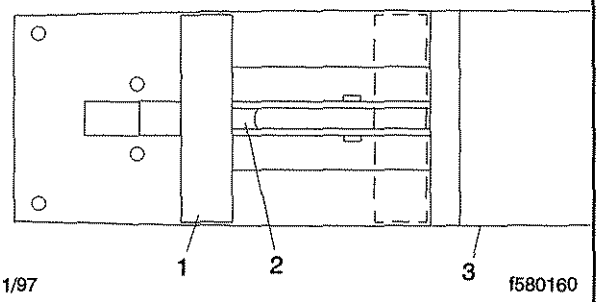
1. Seven-Inch Circular Adaptor
2. Floor Slope Dial
3. Level Vial
4. Vertical Dial
5. Horizontal Dial
6. Split Image View Port
7. Piston Handle

Fig. 1, Seven-Inch Circular Adaptor

Headlight Aim Checking and Adjusting



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To attach, push the piston handle forward to engage the vacuum cup. Immediately pull the handle backward until it locks.

To remove, press the vacuum release button.

1. Piston Handle
2. Vacuum Release Button
3. Base of Aimer

Fig. 2, Aimer Attachment and Removal

3. Check the floor slope dial for the correct setting. See **Fig. 3.**

4. Adjust the horizontal aim. See **Fig. 4.**

   4.1 Set the horizontal dial to "0" (zero).

   4.2 Look in the viewing port for the split image target lines. If necessary, rotate either or both aimers until the lines are visible.

   4.3 Turn the horizontal adjustment screw as needed to make the split image appear as one solid line. See **Fig. 6.**

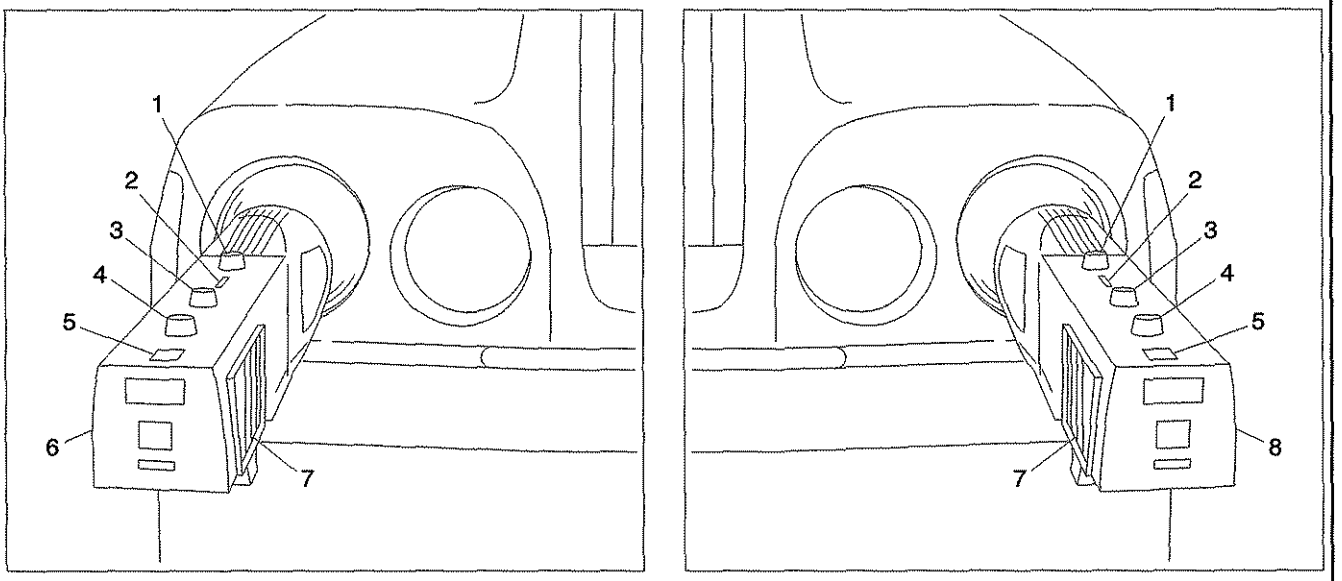
   IMPORTANT: To avoid backlash, make the final adjustment by turning the screw clockwise.

   4.4 Do the same procedure for the other headlight.

5. Adjust the vertical aim. See **Fig. 5.**

   5.1 Set the vertical dial to "0" (zero).

   5.2 Turn the vertical adjustment screw as needed to center the bubble in the level vial between the lines. See **Fig. 6.**



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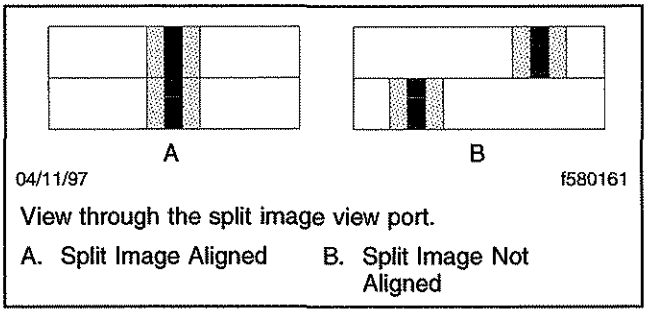
The sight openings must face each other.

1. Floor Slope Dial
2. Vertical Aim Level Vial
3. Vertical Dial
4. Horizontal Dial
5. Split Image View Port
6. Aimer (RH side)
7. Sight Opening
8. Aimer (LH side)

Fig. 3, Set-Up for Aiming



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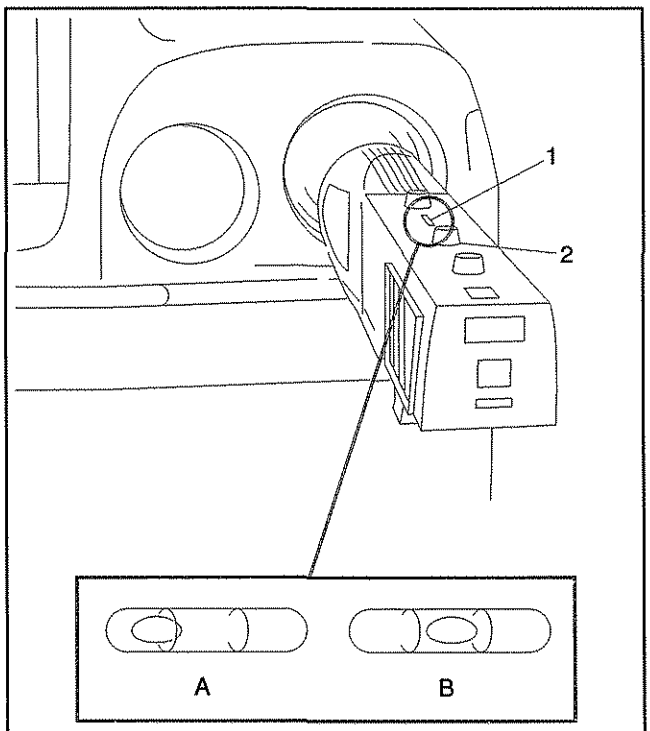
View through the split image view port.

A. Split Image Aligned B. Split Image Not Aligned

Fig. 4, Horizontal Aim Split Image



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Set the vertical dial to "0" (zero).

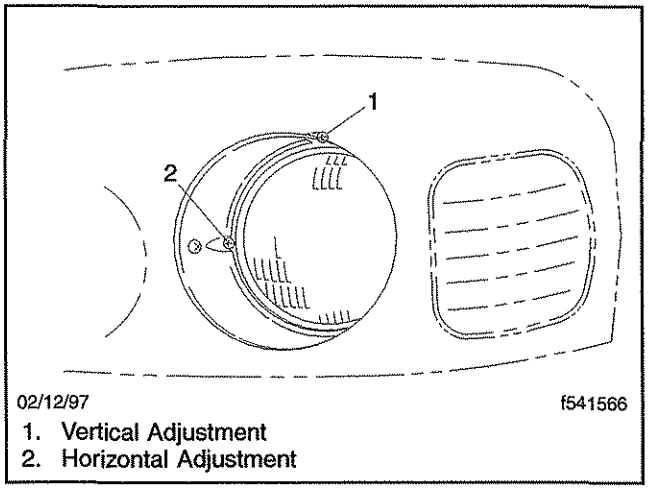
A. Bubble Not Centered B. Bubble Centered

1. Level Vial 2. Vertical Dial

Fig. 5, Vertical Aim Level Vial

IMPORTANT: To avoid backlash, make the final adjustment by turning the screw clockwise.

5.3 Do the same procedure for the other headlight.



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1. Vertical Adjustment
2. Horizontal Adjustment

Fig. 6, Headlight Adjustment Screws

6. Recheck the horizontal alignment on both aimers. Readjust if necessary.
7. Remove both headlight aimers. While holding the aimer securely, press the vacuum release button. See **Fig. 2.**
8. Remove the chocks from the tires.

Coronado

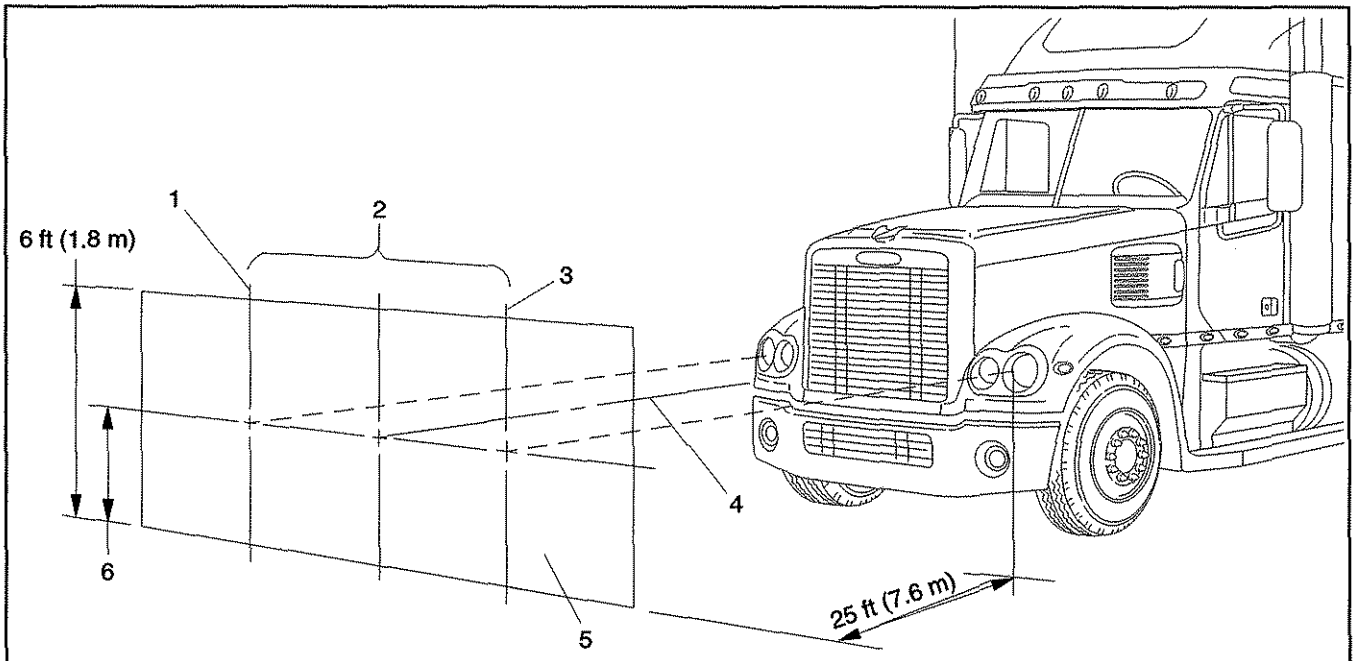
Checking

1. Park the vehicle on a level surface 25 ft (7.6 m) from a screen or wall that can be used for aiming the headlights. Shut down the engine, apply the parking brake, and chock the front tires. See **Fig. 7.**

NOTE: The low-beam headlight is the top bulb in the dual-beam assembly.

2. On each headlight, find the bulb center. See **Fig. 8.**
3. Measure the distance from the ground to the center of each low-beam bulb. Note those distances.
4. On the screen or wall 25 ft (7.6 m) away, make the appropriate markings directly across from each headlight and at the same height as measured for the headlight.

Headlight Aim Checking and Adjusting



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1. Vertical Centerline of Right Headlight
2. Distance Between Headlights
3. Vertical Centerline of Left Headlight
4. Projected Vehicle Centerline
5. Screen or Wall
6. Height of Lamp Centers

Fig. 7, Headlight Aiming Screen or Wall

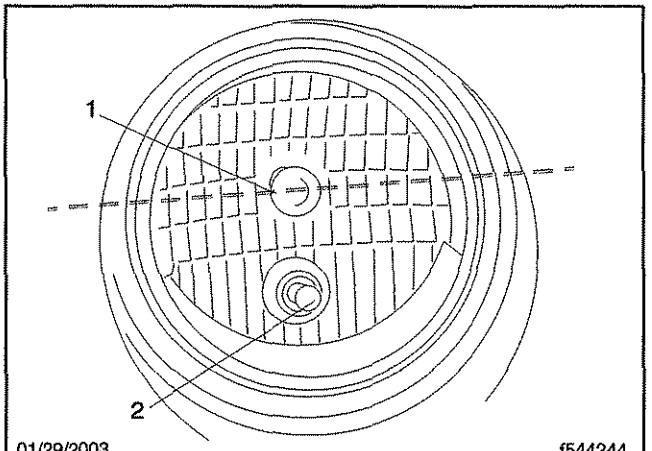
5. Turn on the headlights to the low-beam setting. See **Fig. 9** for the acceptable pattern for both headlights.
   - If either or both headlights do not aim into the inner edges of the centerline, follow the adjusting procedure below.
   - If both headlights come close to the inside of each headlight centerline (as shown), no further work is needed. Turn off the headlights and remove the chocks from the front tires.

Adjusting

1. Lift the flap over the rear end of the headlight bucket to expose the plastic adjusting knob on each headlight. See **Fig. 10**.

NOTE: Horizontal aim is not adjustable in the field.

2. With the vehicle parked 25 ft (7.6 m) from the screen or wall, put the headlights on low beams, and turn the adjusting knob as needed until the



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Measure beam height from the ground to the center of the low-beam bulb.

1. Low-Beam Bulb and Reflector
2. High-Beam Bulb

Fig. 8, Headlight Beam Height, Coronado

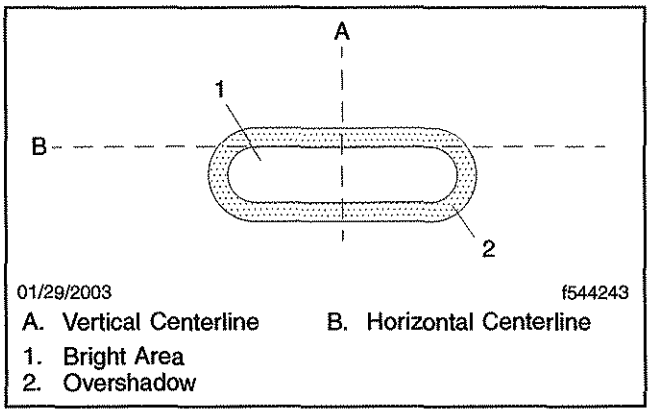


Fig. 9, Headlight Beam Pattern, Coronado

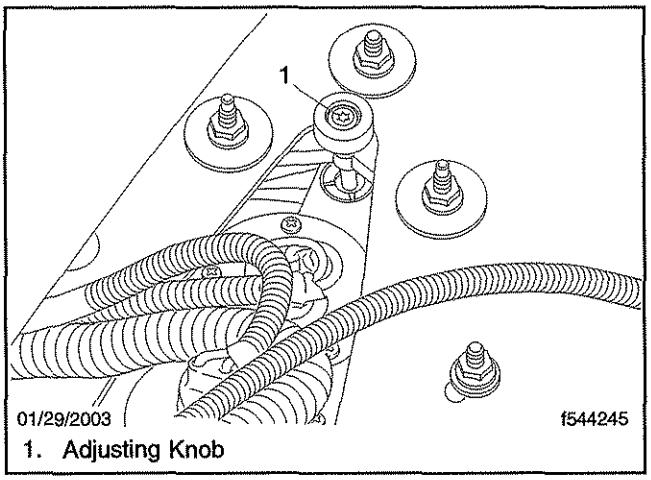


Fig. 10, Headlight Adjusting Knob, Coronado

beam pattern meets the acceptable standard in **Fig. 9.**

NOTE: Blocking off each light is not necessary, but it can help to present a clearer beam pattern.

3. Remove the chocks from the front tires.

Troubleshooting

DAYTIME RUNNING LIGHT TEST

Before troubleshooting the daytime running lights (DRLs), do the following test of DRL operation.

1. Be sure the ignition keyswitch, headlights and turn signals are off. Set the parking brake and be sure that the DRLs are off.
2. Turn on the ignition keyswitch. Make sure that the DRLs stay off.
3. With the air system fully charged, release the parking brake. Make sure that both DRLs turn on.

NOTE: The bulb for the DRLs is a dual-filament bulb. When the DRLs are on, the brighter filament is operating. When the marker lights are on, the other, less bright filament is operating.

4. Turn the headlight switch on. Make sure that the headlights and marker lights come on and the DRLs turn off.
5. Turn on the left, and then the right, turn signals and check them for proper operation. Make sure that front turn signals, side turn signals, and rear tractor and trailer turn signals (if equipped) all flash on and off at the same time.
6. Turn the headlight switch off. Check the turn signal operation again. Make sure that the front turn signals (DRLs) now flash alternately with the side turn signals, not at the same time.

   When the left turn signal is flashing, make sure that the right DRL is on.

   When the right turn signal is flashing, make sure that the left DRL is on.
7. Set the parking brake and shut down the engine. Be sure that the DRLs turn off.

DAYTIME RUNNING LIGHT TROUBLESHOOTING

If the DRLs are not operating properly, do the following steps.

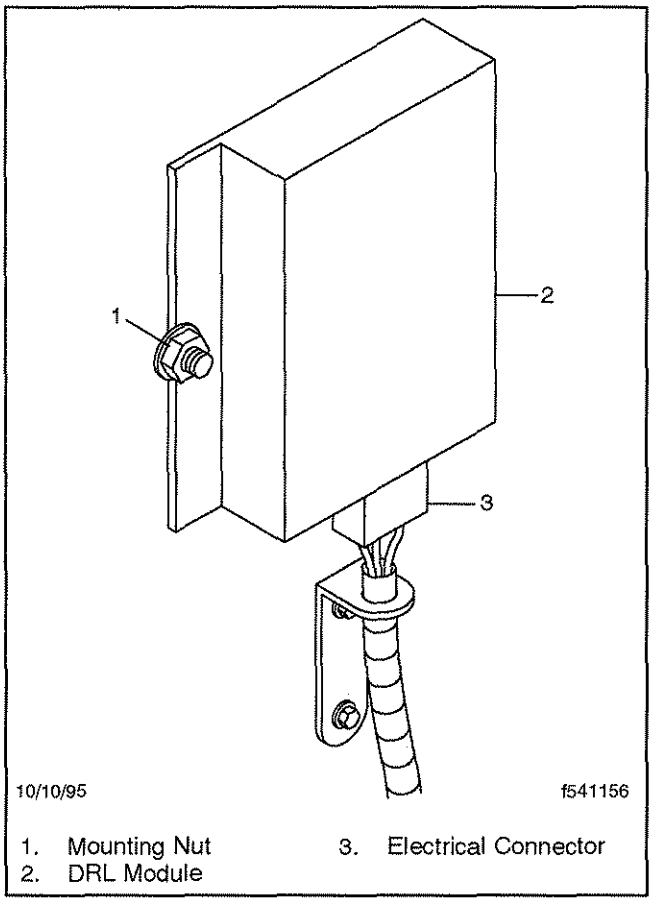
1. Check the bulbs in the DRLs. Replace any bulb that is burned out.
2. Disconnect the electrical connector to the DRL module (**see Fig. 1**) and check the pins for proper contact with the plug. Reconnect the DRL module and test again.
3. If the DRLs are still not operating, disconnect the electrical connector again and use a volt/ohmmeter (VOM) to do a voltage test on each pin (use the harness side). For the correct voltages, **see Table 1**.

DRL Module Pin Voltages

No.	Name	Instructions	Voltage
A	Left Output	None	0
B	Ground	None	0
C	Park Brake	Set Park Brake and connect a VOM between pins C and D	0
		Release Park Brake and connect a VOM between pins C and D	12
D	Battery	None	12
E	Right Output	None	0
F	Right Turn Signal	Right Turn Signal Off	0
		Right Turn Signal On	0/12 (alternating)
G	Ignition	Ignition Off	0
		Ignition On	12
H	Right Headlight	Headlights Off	0
		Headlights On	12
J	Left Headlight	Headlights Off	0
		Headlights On	12
K	Left Turn Signal	Left Turn Signal Off	0
		Left Turn Signal On	0/12 (alternating)

Table 1, Daytime Running Light Module Pin Voltages

Troubleshooting



1. Mounting Nut
2. DRL Module
3. Electrical Connector

Fig. 1, Daytime Running Light (DRL) Module

4. If any voltage tested does not match the value given **in Table 1**, correct the fault and do the test again.

5. If one or both of the DRLs still do not function at this point, check the wiring to the DRLs for open circuits or circuits shorted to ground. When only one DRL is not working, the typical cause is a failure in one of these wires.

6. If the DRLs are still not working, replace the DRL module.

Specifications

Manufacturer	Lubricant or Part Number
Shell Oil Co.	No. 71032; No. 71306
Texaco, Inc.	No. 955
Quaker State	No. NYK-77

Table 1, Approved Electrical Lubricants

For a wiring diagram of the headlight circuits, see **Fig. 1**.

For a wiring diagram of the turn signal and brake light circuits, see **Fig. 2**.

For a wiring diagram of the daytime running light (DRL) circuits, see **Fig. 3**.

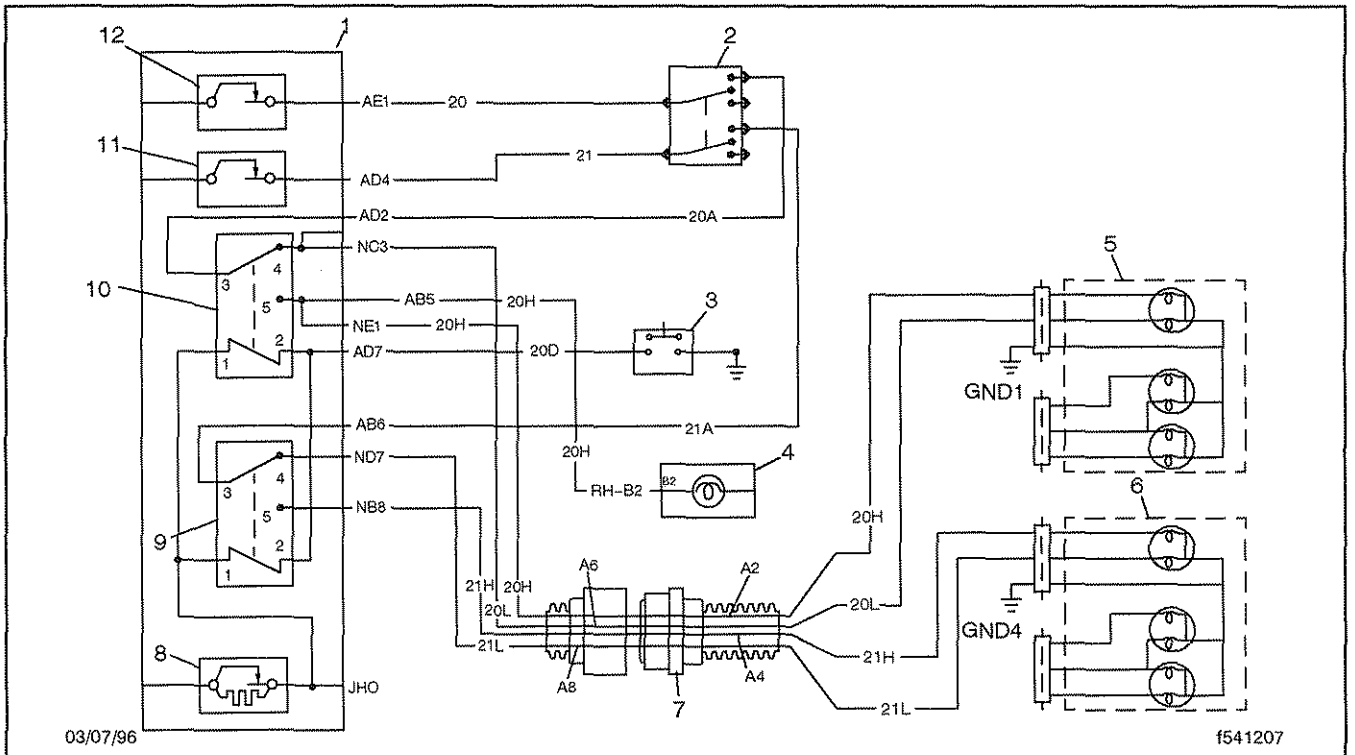
For a wiring diagram of the internal lighting circuits showing the bunk light wiring, see **Fig. 4**.

For a wiring diagram of the internal lighting circuits showing the dome light wiring connections, see **Fig. 5**.

For a wiring diagram of the internal lighting circuits showing the dome light wiring, see **Fig. 6**.

For a wiring diagram of the internal lighting circuits showing the overhead console wiring, see **Fig. 7**.

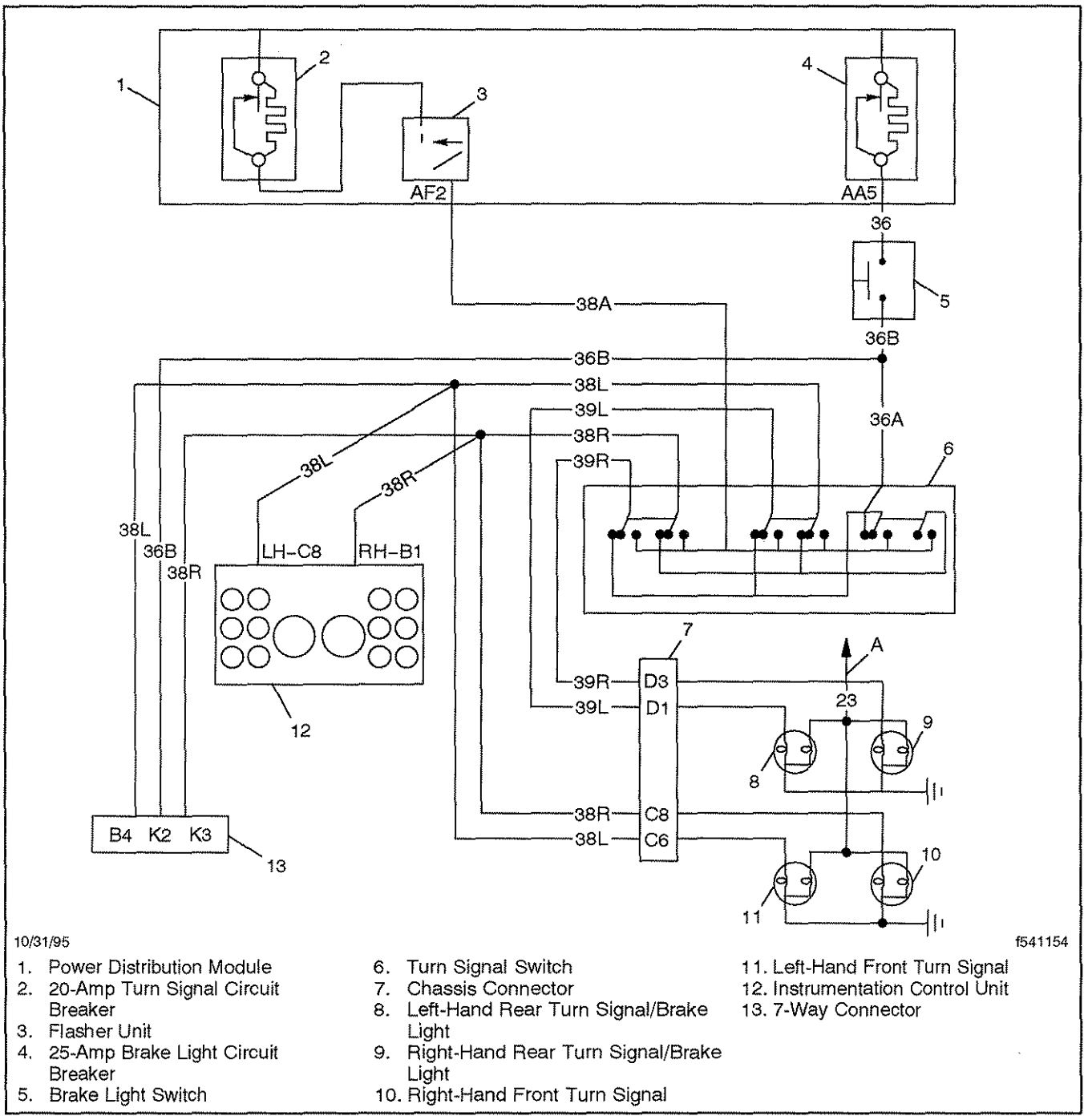
For a wiring diagram of the dash accessory circuits, see **Fig. 8**.



1. Power Distribution Module
2. Headlight Switch
3. Dimmer Switch
4. High Beam Indicator Light
5. Left-Hand Headlight Assembly
6. Right-Hand Headlight Assembly
7. Chassis Connector
8. 15-Amp ACC Power Circuit Breaker
9. Right Headlight Micro Relay
10. Left Headlight Micro Relay
11. 15-Amp Right Headlight Circuit Breaker
12. 15-Amp Left Headlight Circuit Breaker

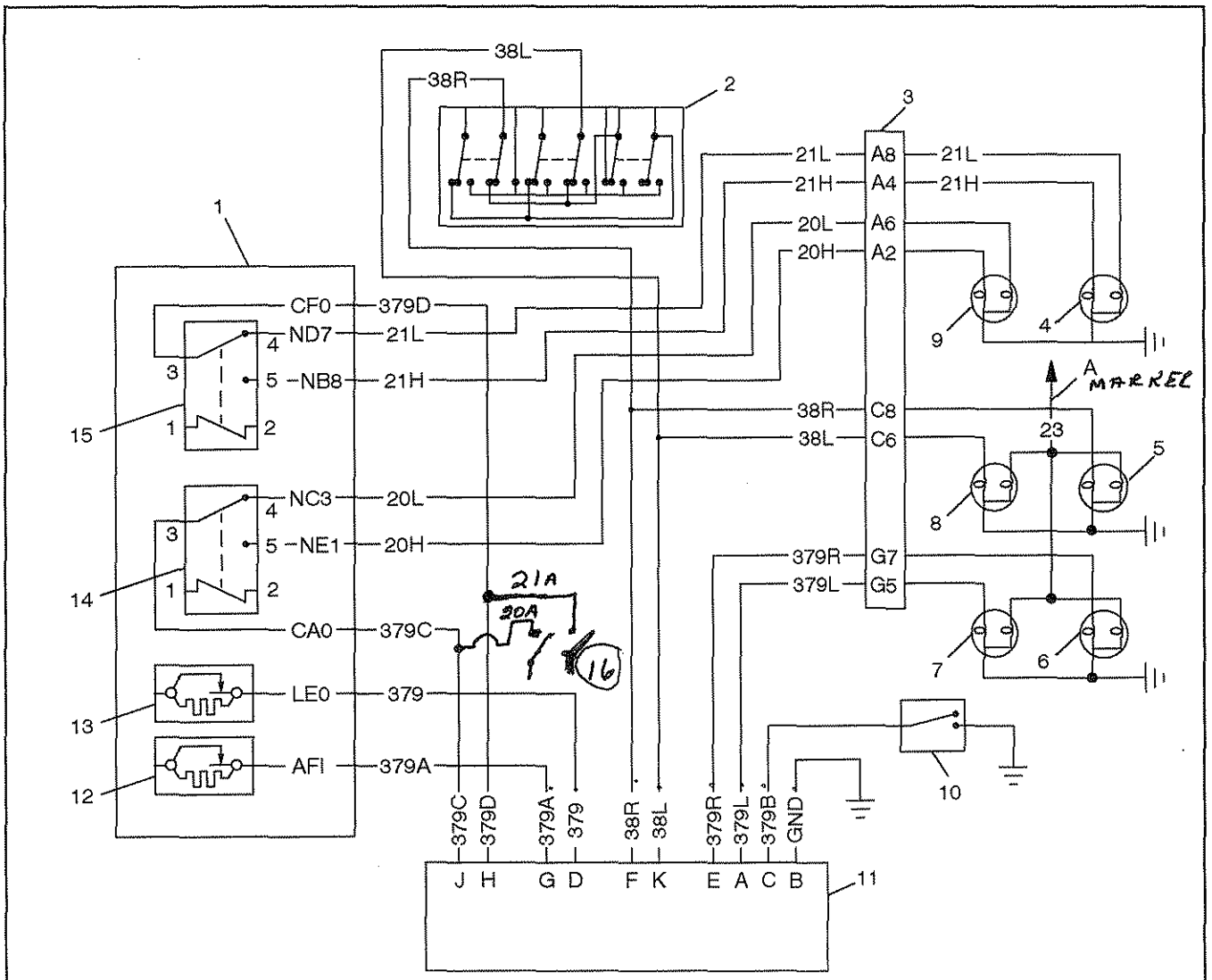
Fig. 1, Headlight Wiring

Specifications



1. Power Distribution Module
2. 20-Amp Turn Signal Circuit Breaker
3. Flasher Unit
4. 25-Amp Brake Light Circuit Breaker
5. Brake Light Switch
6. Turn Signal Switch
7. Chassis Connector
8. Left-Hand Rear Turn Signal/Brake Light
9. Right-Hand Rear Turn Signal/Brake Light
10. Right-Hand Front Turn Signal
11. Left-Hand Front Turn Signal
12. Instrumentation Control Unit
13. 7-Way Connector

Fig. 2, Turn Signal and Brake Light Wiring



1. Power Distribution Module
2. Turn Signal Switch
3. Chassis Connector
4. Right Headlight
5. Right-Hand Turn Signal
6. Right-Hand DRL
7. Left-Hand DRL
8. Left-Hand Turn Signal
9. Left Headlight
10. Parking Brake Switch
11. DRL Module
12. 10-Amp Cluster Circuit Breaker
13. 10-Amp DRL Circuit Breaker
14. Left Headlight Micro Relay
15. Right Headlight Micro Relay

Fig. 3, Daytime Running Lights (DRL) Wiring 16 HEAD LAMP SW

Specifications

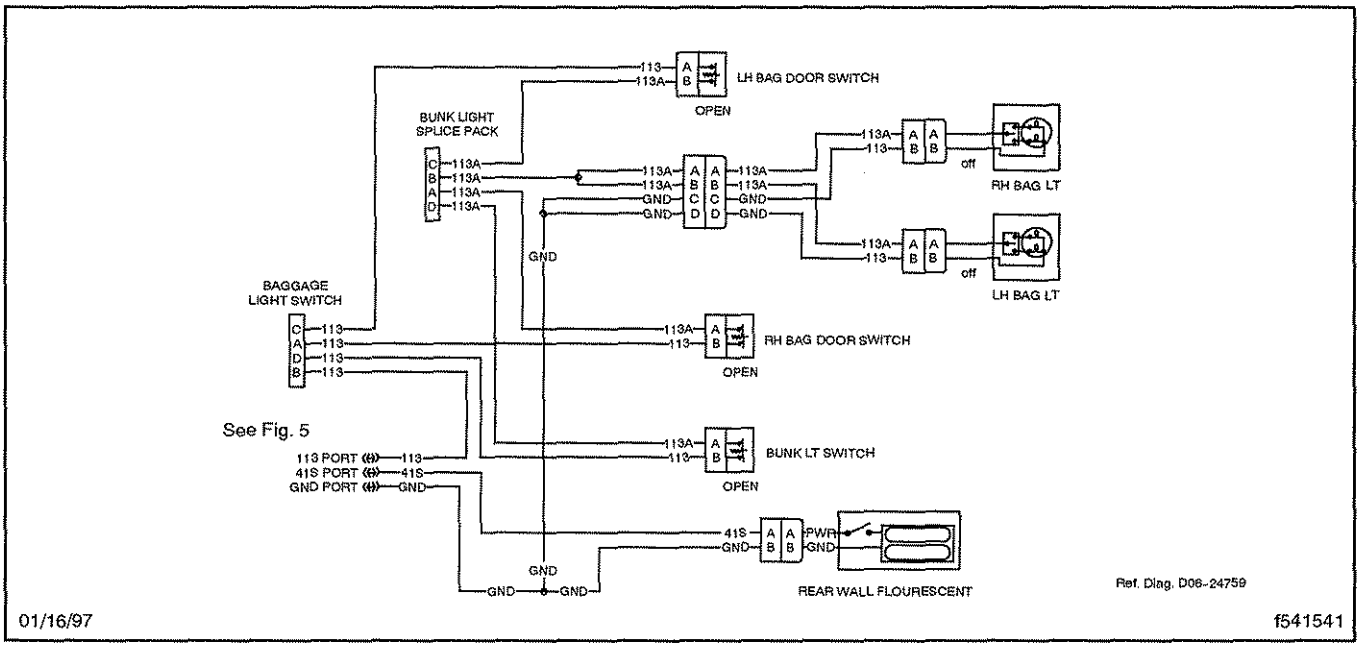


Fig. 4, Bunk Light Wiring

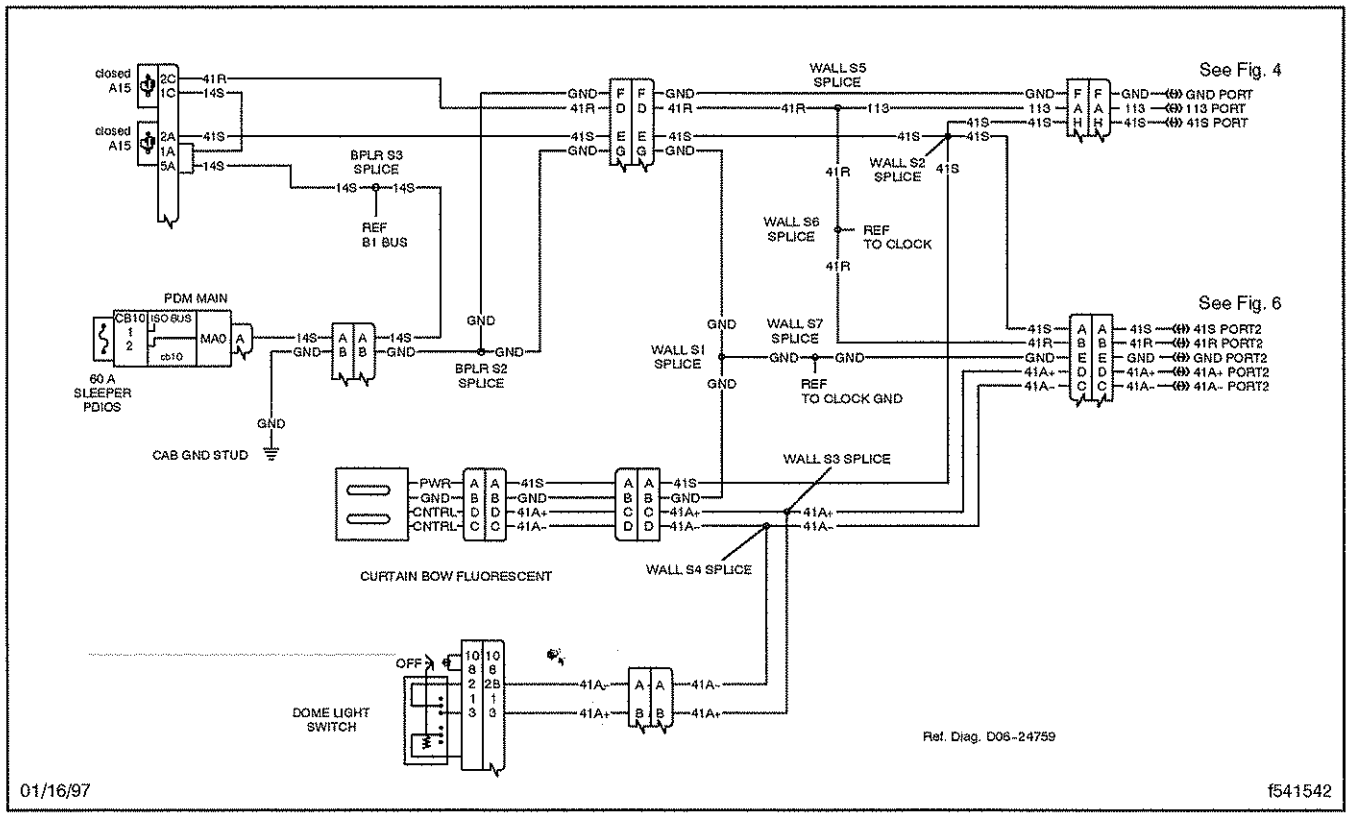


Fig. 5, Dome Light Wiring Connections

Specifications

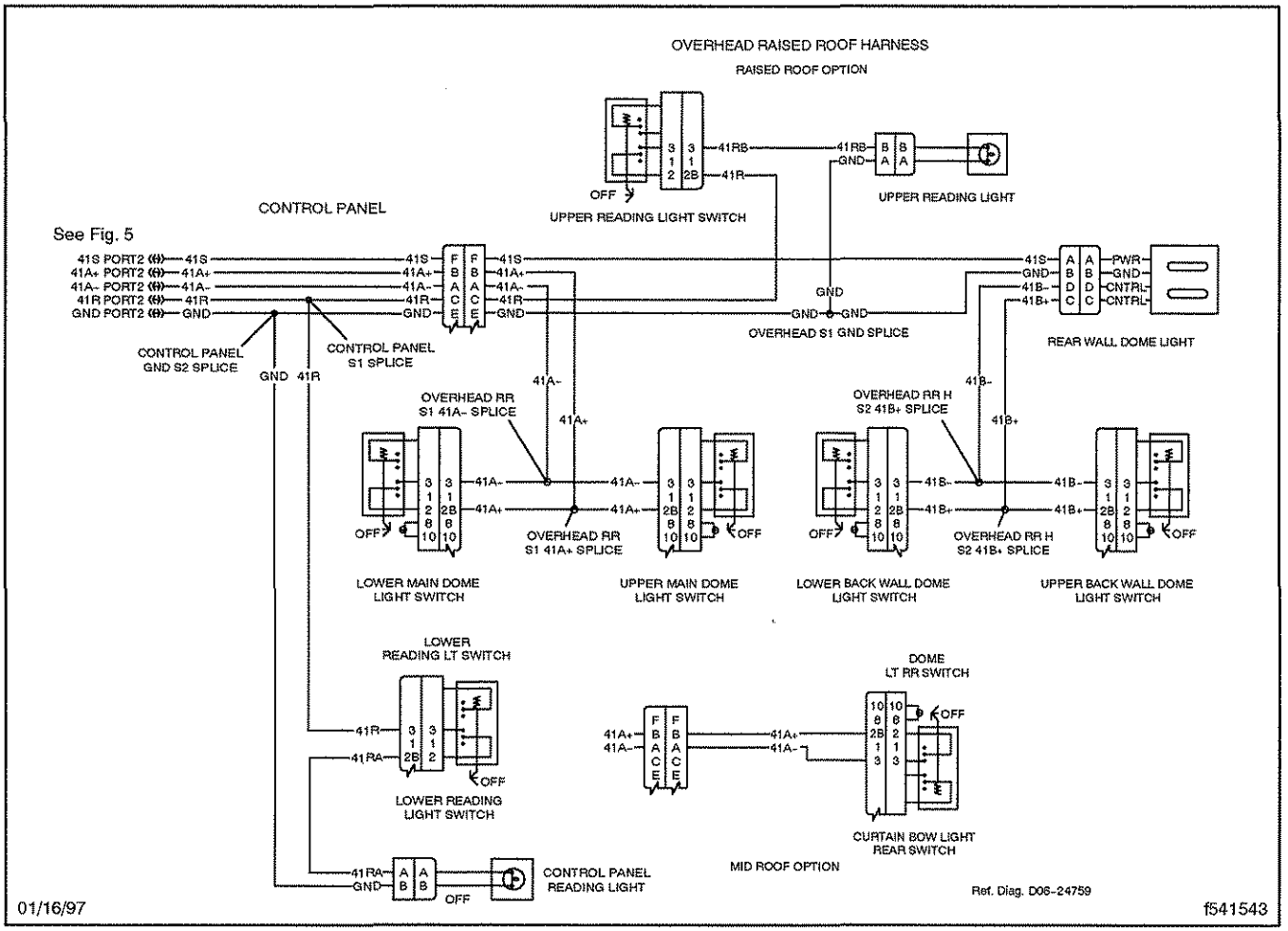


Fig. 6, Dome Light Wiring

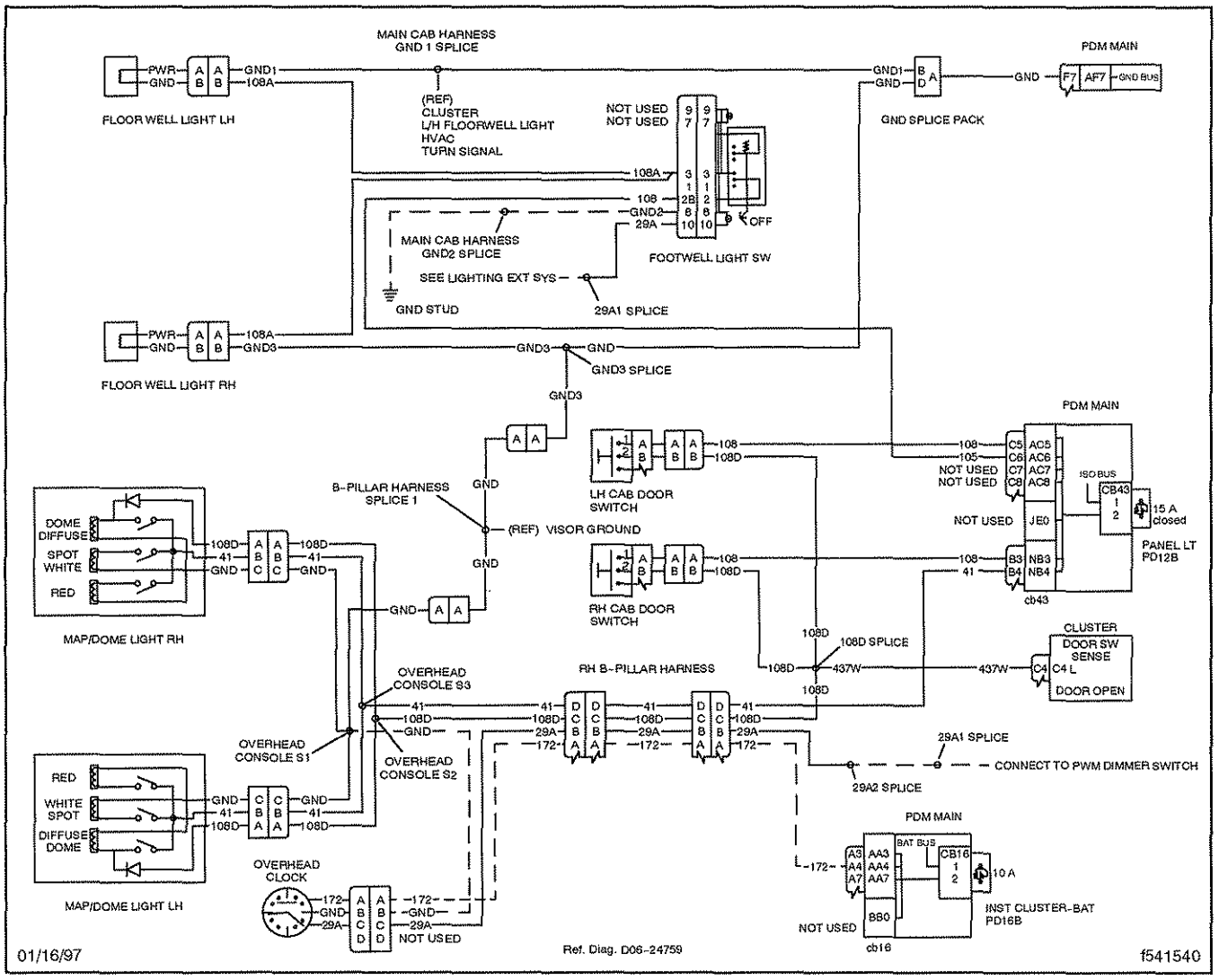


Fig. 7, Overhead Console Wiring

Specifications

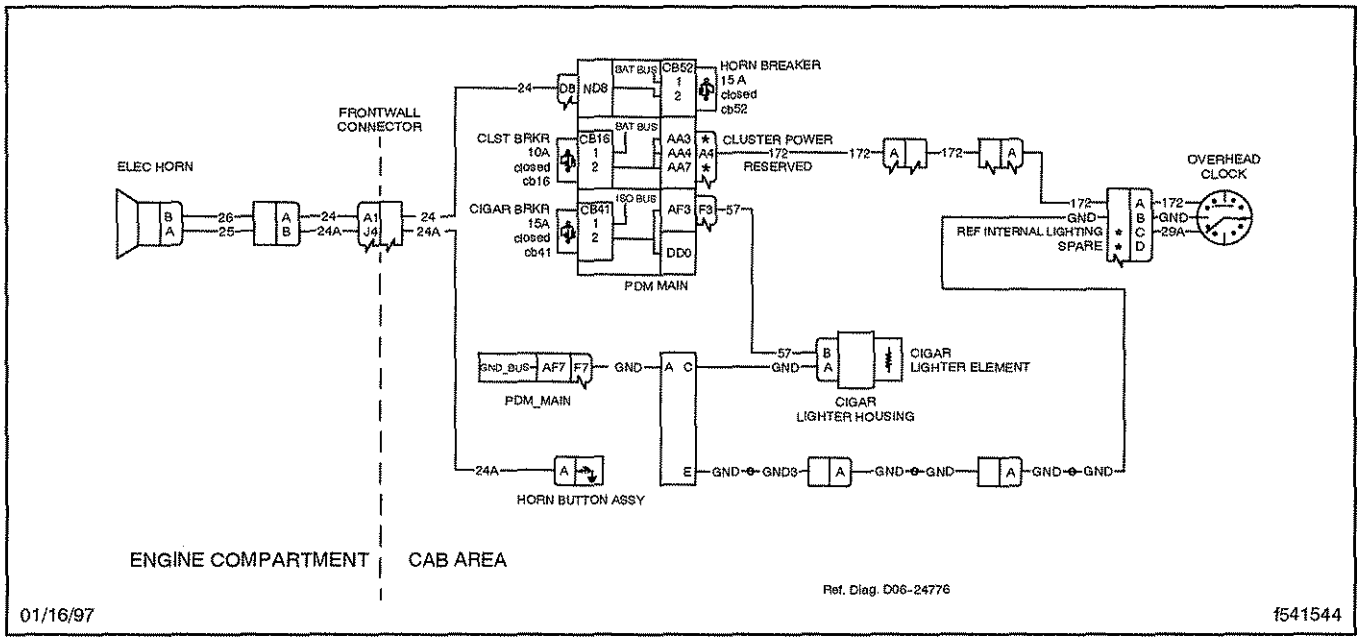


Fig. 8, Dash Accessory Wiring

Contents

Subject	Subject Number
General Information	050
Service Operations	
Selecting a Replacement Battery	100
Battery Storage	110
Battery Safety Precautions	120
Emergency (Jump) Starting a Battery	130
Battery Testing	140
Battery Charging	150
Battery Removal, Cleaning and Inspection, and Installation	160
Troubleshooting	300
Specifications	400

General Information

ALL LEAD-ACID BATTERIES

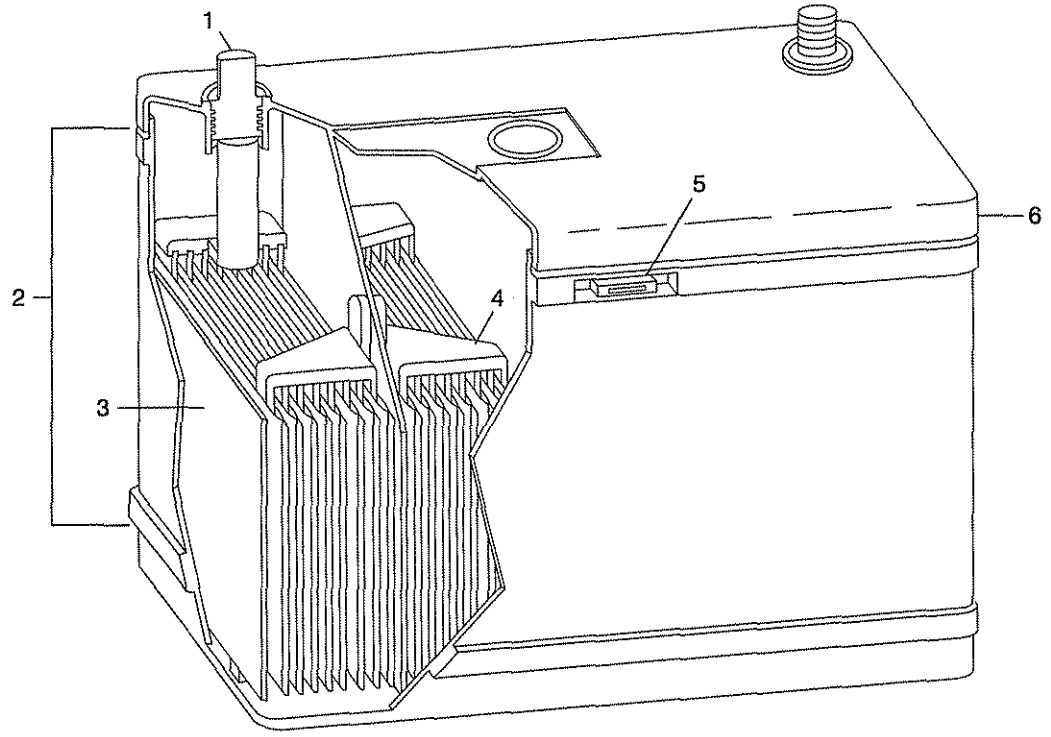
Maintenance-free lead-acid batteries, both liquid-electrolyte batteries and gel cells, are electrochemical devices that store chemical energy. When the battery is connected to an external load, such as a starter, the chemical energy is converted into electrical energy and current flows through the circuit.

The modern automotive battery has three functions:

- To supply power to the starter and ignition system so the engine can be cranked and started.
- To stabilize the voltage in the electrical system by reducing temporary high voltages in the electrical system. These high transient voltages could damage other electrical components if they were not protected by the battery.
- To supply extra power when the vehicle's electrical load requirements go beyond what the charging system can supply, or when the engine is not running.

All lead-acid batteries use plates made of two unlike metals held apart by separators. One of the metals becomes the positive plate, the other the negative plate. These plates are then grouped in pairs, alternating negative and positive. The groups are connected in series, and each plate group (cell) produces about two volts. Thus, a battery with six cells is a 12-volt battery. See **Fig. 1**.

In conventional liquid-electrolyte batteries (wet cells), each battery contains a group of plates immersed in a



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1. Terminal
2. Electrolyte Reservoir
3. Positive Plate Envelope
4. Intercell Connection
5. Vent Hole
6. Plastic Cover

Fig. 1, Typical Maintenance-Free 12-Volt Battery

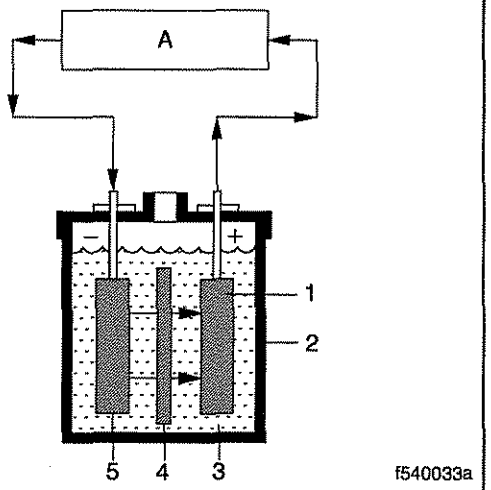
General Information

solution of electrolyte (dilute sulfuric acid). In a gel cell battery, the electrolyte is a solid gel, not a liquid.

Maintenance-free wet cells use calcium rather than antimony to improve grid strength. Calcium reduces the tendency for the battery to produce gas at normal charging voltages. Therefore, little water is lost, unless the battery has been charged at a very high rate. There are no filler caps in the cover. The battery is sealed, except for small vent holes in the cover. The vents allow the escape of gases produced in the battery.

Electrical energy is produced in each cell by chemical changes in the plates (and in the electrolyte whenever a battery is discharged). See **Fig. 2**. A battery produces maximum electrical energy only when the cells are fully charged. As the cells discharge, chemical changes in the plates gradually reduce the potential electrical energy available. Recharging the battery with an opposite flow of direct current reverses the chemical changes within the cells and restores them to their active state. See **Fig. 3**.

NOTE: Liquid-electrolyte batteries must be kept in an upright position to prevent electrolyte leakage. Tipping a wet cell beyond a 45-degree angle in any direction can allow a small amount of electrolyte to leak out the vent holes.



A. External Electrical Load (such as a starter)
1. Positive Plate
2. Battery Case
3. Electrolyte
4. Separator
5. Negative Plate

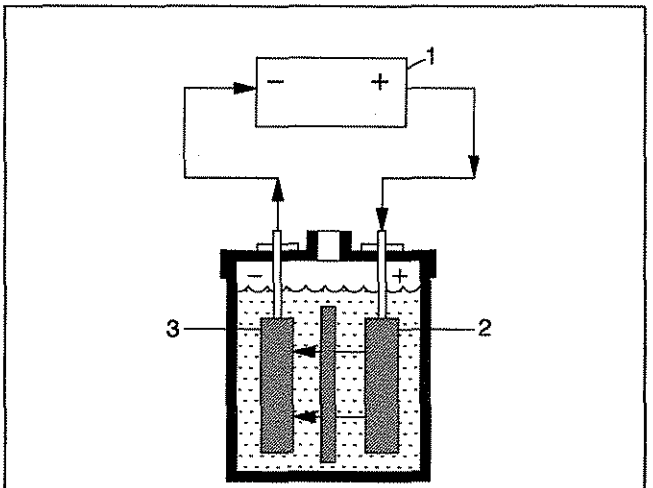
Fig. 2, Discharging the Battery

In standard Century Class Conventional installations with single fuel tanks, the batteries are contained in a side-rail battery box, long side to rail, which can be installed with or without a step and a diamond plate side cover. See **Fig. 4**. For Century Class Conventional dual-tank installations, a plastic battery box located between the rails is available. See **Fig. 5**. Standard installation for the Argosy COE is an aluminum battery box mounted over the frame rails behind the engine. See **Fig. 6**. Side rail boxes are available for the Argosy COE.

Only good care can ensure long battery life. Proper testing will indicate the battery condition. For more information, see **Subject 140**.

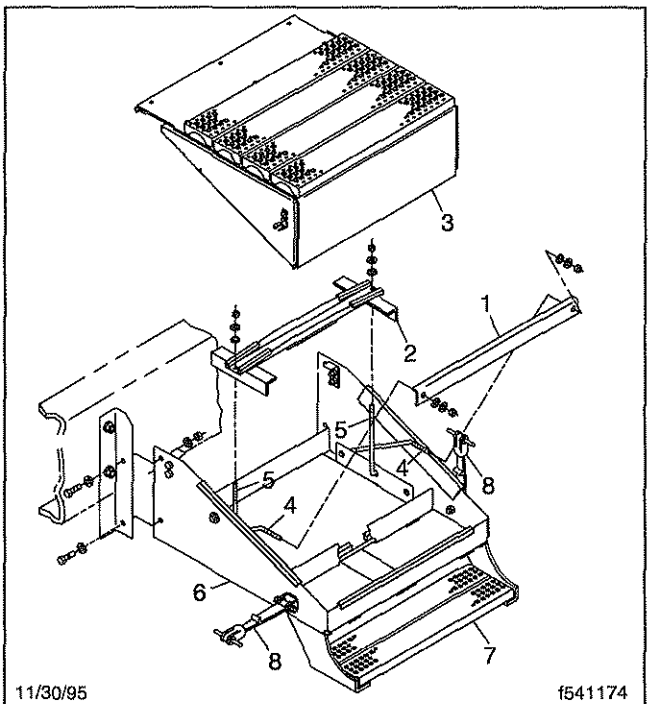
GEL CELLS (ISOLATED BATTERY SYSTEM)

The purpose of an isolated battery system is to prevent the starting batteries from becoming discharged by overuse of accessories when the vehicle is not operating. When the engine is running, the isolated battery is charged like the starting batteries. When the engine is shut down, the isolator relay disconnects the starting batteries from the accessory power circuits, directing the entire load to the isolated battery. The starting batteries can start the vehicle even if the isolated battery is completely drained.



1. Charger
2. Positive Plate
3. Negative Plate

Fig. 3, Charging the Battery



1. Hold-Down Angle
2. Retainer Assembly
3. Cover
4. Hold-Down Bolt
5. Retainer Bolt
6. Battery Box
7. Step
8. Latch

Fig. 4, Side-Rail Battery Box

Since March 1, 1996, vehicles with battery isolator systems are equipped with the Freightliner gel cell as the isolated battery.

A gel cell is a lead-acid electric storage battery with the following features:

- It is pressurized and sealed using special vents, and therefore *it should never be opened.*
- The only maintenance it needs is periodic cleaning of the terminals and tightening of the cable connectors.
- It uses a thixotropic gelled electrolyte that liquefies when stirred or shaken, but returns to a solid state when allowed to rest.
- It never needs filling, because it uses a special recombination technique to replace the oxygen and hydrogen normally lost in a standard wet cell, particularly when used in deep-cycle applications.
- It is non-spillable, and can be operated in virtually any position (upside-down installation is not recommended).

At 14 volts, a gel cell has a very high charge acceptance rate. Because a truck charging system operates at approximately 14 volts, under normal conditions a gel cell should never need to be recharged with an external charger.

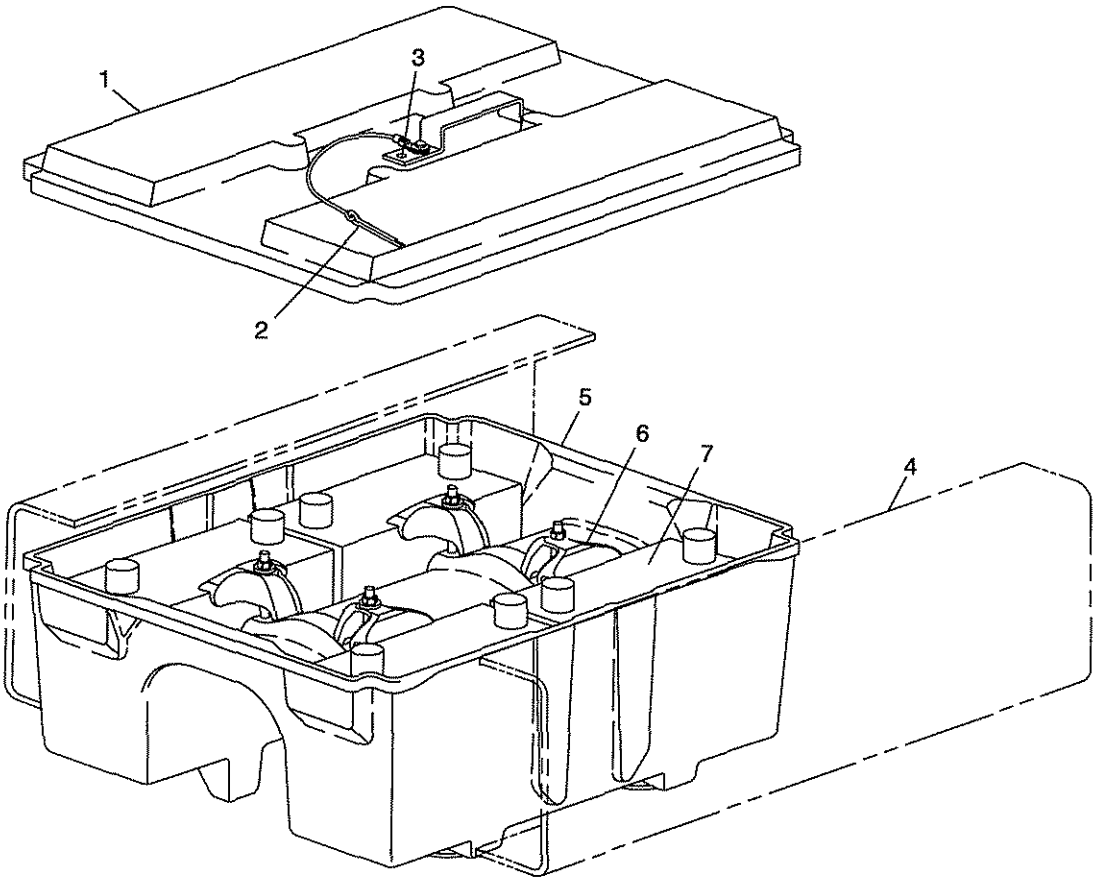
⚠ CAUTION

Do not attempt to charge a gel cell with a standard battery charger. All standard battery chargers supply at least 16 volts to the battery. This will damage the gel cell.

Neither type of maintenance-free battery (see **Fig. 1**) needs additional water during normal service life.

A gel cell is a "recombinant" battery. The oxygen that is normally produced at the positive plate (in all lead-acid batteries) recombines (in a gel cell) with the hydrogen given off at the negative plate. The recombination of hydrogen and oxygen produces water (H_2O), which replenishes the moisture in the battery. Therefore, the gel cell is maintenance-free, as it never needs added water.

General Information



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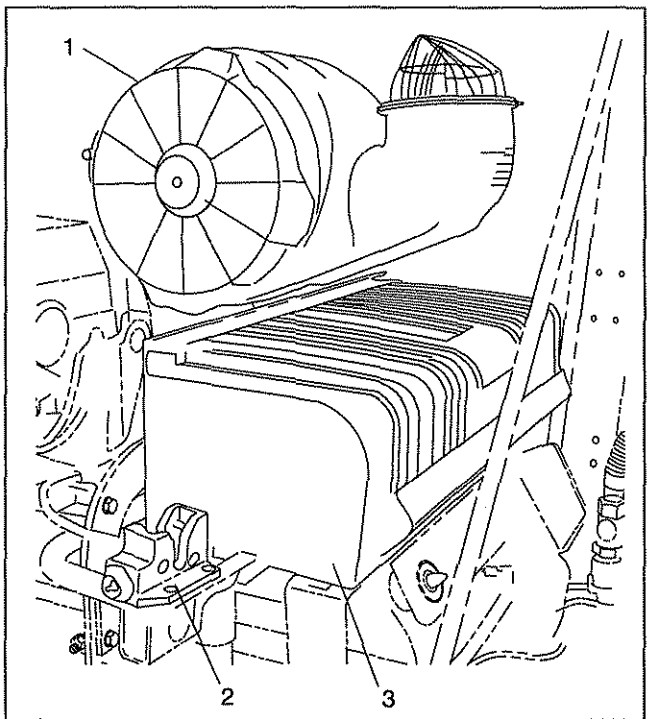
1. Battery Box Lid
2. Spring Pin (if installed)
3. Spring Pin Insert Hole
4. Frame Rail
5. Battery Box
6. Battery Hold-Down
7. Battery

Fig. 5, Between-Rail Battery Box



1. Air Intake Filter Assembly
2. Rear Cab Latch
3. Battery Box

Fig. 6, Over-the-Rail Battery Box, Argosy COE

Selecting a Replacement

Long and trouble-free service is assured when the reserve capacity of the battery is equal to or exceeds 160 minutes and the cold cranking amp (CCA) rating of each replacement battery is at least 625 amperes. The CCA rating of the battery is a measure of its ability to supply high cranking power to the cranking motor at 0°F (–18°C).

The use of an undersized battery may cause poor performance and early failure. It may also cause damage to or reduced life of the starter. With falling temperatures, battery power decreases while the need for engine cranking power increases. Subzero temperatures reduce the capacity of a fully charged battery to 45 percent of the normal power, and at the same time, increase cranking load to 3-1/2 times the normal warm-weather load.

Batteries of a greater capacity should be considered if the electrical load has been increased through the addition of accessories, or if driving conditions are such that the charging system cannot keep the batteries charged.

IMPORTANT: Don't replace a battery with one designed for automobiles and light trucks. The cold cranking amp (CCA) rating may be the same or higher, but the plates are lighter, and the battery won't provide the reserve life that is needed. Also, these batteries don't have the extra vibration protection or temperature resistance required on a heavy-duty vehicle.

Storage

Always store batteries in an upright position. Don't store batteries on their sides, as electrolyte may escape through the vent holes.

Maintain inventory levels in balance with demand and always rotate battery stock on a strict first-in, first-out basis. To protect against self-discharge, check the date codes stamped on the battery cartons and on the batteries themselves.

IMPORTANT: One of the major causes of problems with replacement batteries is failure to follow the first-in, first-out stock procedure.

Roller racks provide the best way to store batteries. If loaded properly from the back, they insure that the oldest battery of a particular type will always appear in the front.

Mark the racks clearly, both front and back, to ensure that the same battery type will go in the same rack every time.

If roller racks are not available, use wooden shelving reachable from both the front and the back. Otherwise, old batteries must be removed, to put new batteries in the back.

Never stack batteries on top of one another. If nothing else is available, simple battery storage racks can be made from loose, flat boards.

Maintenance-free batteries can have a shelf life of up to twelve months or more, depending upon storage temperatures, before charging is needed.

NOTE: Batteries in vehicles that are not in service are considered to be in storage. When a vehicle is to be out of service for 30 days or more, disconnect the negative ground terminal of each battery to prevent self-discharge caused by various components.

To minimize self-discharge, store batteries in as cool a place as possible, away from heat ducts in winter, and shielded from direct sunlight in summer.

The best storage conditions are in clean, dry areas where ambient temperatures are stable between 32° and 80°F (0° and 27°C). Storage in temperatures above 80°F (27°C) is not recommended, as this increases the rate of self-discharge. Avoid temperatures below 32°F (0°C) to prevent freezing if a battery becomes discharged.

General Safety Precautions

⚠ WARNING

Keep sparks, flames, burning cigarettes, etc. away from batteries. Batteries generate explosive gases, which could cause a battery to explode, causing serious personal injury, including blindness.

When charging the batteries, gas forms in each cell and escapes through the vent holes. In poorly ventilated areas, the gas lingers around the battery several hours after it has been charged. The gas is explosive around sparks, flame, or other intense heat; if ignited, it could cause the battery to explode. Follow these precautions when charging the batteries:

1. Wear safety glasses or a face shield when working with batteries. When many batteries are handled, wear rubber gloves and an apron to protect clothing.
2. Make sure that the area is well ventilated.

⚠ WARNING

Do not install any lead-acid battery in a sealed container or enclosure. Allow hydrogen gas caused by overcharging to escape. Exploding hydrogen gas can cause blindness or other bodily injury.

3. Make certain that the charger cable leads are clean and making good connections. A poor connection could cause an electrical arc which could ignite the gas mixture and explode the battery.
4. Do not break live circuits at the terminals because a spark usually occurs at the point where a live circuit is broken. Use care when connecting or disconnecting booster leads or cable clamps on chargers.
5. Don't smoke near batteries that are being charged or have recently been charged. Keep the batteries away from open flames or sparks.
6. If the battery is frozen, let it reach room temperature before trying to charge it. Check for leaks and cracks before charging the battery. Replace the battery if leaks or cracks are seen.
7. Take care that tools or metal objects do not fall across the battery terminals.

⚠ CAUTION

If a metal object connects an ungrounded battery terminal to a nearby metal part of the vehicle which is grounded, it could short out the batteries, causing sparks and possible property damage.

Battery Electrolyte Safety Precautions

⚠ WARNING

Protect skin and eyes from battery electrolyte (acid). Electrolyte is corrosive and could result in serious personal injury if splashed on your skin or in your eyes.

If electrolyte is splashed on your skin or in your eye, force the eye open, rinse it with cool, clean water for about five minutes, and call a doctor immediately. Do not add eye drops or other medication unless advised by the doctor.

If electrolyte is swallowed, drink several large glasses of milk or water. Follow with milk of magnesia, a beaten raw egg, or vegetable oil. Call a doctor immediately.

Use extreme care to avoid spilling or splashing electrolyte. Electrolyte spilled or splashed on your body or clothing should be neutralized with baking soda or household ammonia and then rinsed with clean water.

Electrolyte can also damage painted or unpainted metal vehicle parts. If electrolyte is spilled or splashed on any metal surface, neutralize and rinse it with clean water.

To prevent possible skin burns, do not wear watches, rings, or other jewelry while performing maintenance work on the batteries.

⚠ WARNING

Do not apply pressure to the end walls of a plastic-case battery. This could cause electrolyte to squirt from the vents, possibly resulting in serious injury to skin or eyes.

When handling plastic-case batteries, use a battery carrier. If one is not available, lift these batteries with your hands placed at opposite corners of the battery.

Battery Safety Precautions

Gel Cell Charging Precautions

GEL CELLS ARE SENSITIVE TO OVERCHARGING

⚠ CAUTION

To avoid shortening the life of a gel cell, carefully regulate the charging voltage—between 13.8 and 14.1 volts. Use only a reliable, automatic, temperature-sensing, voltage-regulated charger. Use only the gel cell charging procedures in Subject 150. *Never* **use a constant current charger.** *Never* **leave any battery, including a gel cell, on a trickle charger.**

Because gel cells normally give off little or no hydrogen gas, they do not cause explosions unless extremely overcharged. This is why they are safe around sensitive electronic equipment, and do not cause surrounding metals to corrode.

However, gel cells are very sensitive to overcharging. If overcharged, the oxygen and hydrogen are produced too rapidly and are vented away. Since they are no longer present inside the battery, they cannot recombine to form water. The water loss to the battery is permanent.

⚠ CAUTION

Never overcharge a gel cell. If a gel cell is charged to more than 14.1 volts, it will dry out and be unable to perform.

CONTINUAL UNDERCHARGING CAN DAMAGE GEL CELLS

In many respects, undercharging is as harmful as overcharging. In an undercharged state, the positive grids corrode and the plates shed, dramatically shortening battery life.

Furthermore, an undercharged battery works harder (is more heavily loaded) than a fully-charged battery. This also shortens its life.

IMPORTANT: The warranty is void if improperly charged. Use only a charger that limits voltage to no more than 14.1 volts and no less than 13.8 volts at 68°F (20°C). The charger must be temperature-sensing to prevent over- or undercharging caused by temperature changes.

CHECK FOR VENT BLOCKAGE

Because the gel cell operates under internal pressure, it is normal for it to bulge slightly, particularly at higher temperatures, which make the polypropylene case more pliable. Severe bulging indicates a battery with a blocked vent. Bulging (swollen) gel cells should be taken out of service.

DO NOT CHARGE GEL CELLS ON THE VEHICLE

Because the gel cell is an isolated battery, it needs to be connected directly to the charger. To properly charge the gel cell, it must be removed from all electrical loads. The best way to accomplish this is to remove it from the vehicle.

Emergency (Jump) Starting

⚠ WARNING

Before jump starting a vehicle, read the instructions in Subject 120. Failure to follow the safety precautions could result in personal injury.

⚠ CAUTION

Do not attempt to charge gel cells (isolated batteries) with jumper cables. The gel cell requires a special charger and should be removed from the vehicle before charging. To avoid damage, follow the manufacturer's instructions.

Handle both the charged and the discharged batteries carefully when using jumper cables. Follow the procedure below, being careful not to cause sparks.

⚠ CAUTION

CAUTION: Make sure the starting systems on both vehicles have the same voltage outputs, and make connections as described below. Otherwise, the starter or the charging system could be damaged.

IMPORTANT: At no time during this operation should the vehicles touch each other, as this could establish a ground connection and offset the benefits of this procedure.

⚠ WARNING

Use the following procedure when jump starting. Incorrect battery handling procedures could result in battery explosion and severe personal injury, including blindness.

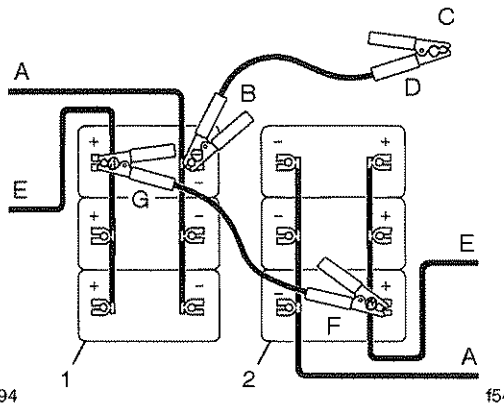
1. Apply the parking brakes. Turn off the lights, heater, and all other electrical loads.

IMPORTANT: If the vehicles are exposed to traffic, activate the warning flashers on the booster vehicle.

2. For your first connection, attach one end of the jumper cable to the positive terminal of the booster battery. For your second connection, attach the opposite end of the same cable to the positive terminal of the discharged battery. **See Fig. 1.**
3. For your third connection, attach one end of the other jumper cable to the negative terminal of the booster battery. For the fourth connection, attach the opposite end of that cable to a ground at least 12 inches (300 mm) from the battery of the vehicle being started. See **Fig. 1.** The vehicle frame is usually a good ground.

IMPORTANT: The final ground connection must provide good electrical conductivity and current-carrying capacity. To prevent sparks and explosions of hydrogen gas, don't connect directly to the negative post of the discharged battery.

4. Make sure that the clamps from one cable do not touch the clamps on the other cable. Don't lean over the batteries when making connections.
5. Make sure that everyone is standing away from the vehicles. Start the engine of the vehicle with the booster batteries. Wait a few minutes, then attempt to start the engine of the vehicle with the discharged batteries.



If the vehicle is equipped with an isolated battery system, make sure that the connections are made to the starting set of batteries, not to the gel cell(s).

NOTE: This procedure is for negative-ground vehicles only.

A. To Ground
B. Third Connection
C. To Frame
D. Fourth Connection
E. To Starter
F. Second Connection
G. First Connection
1. Booster Battery
2. Discharged Starting Battery

Fig. 1, Jumper Connections, 12-Volt Starting System

Emergency (Jump) Starting a Battery

Don't operate the starter longer than 30 seconds. Wait at least two minutes between starting attempts to allow the starter to cool. If the engine doesn't start after several attempts, check for the cause.

6. After starting, allow the engine to idle. Disconnect the ground connection from the vehicle with the discharged battery. Then disconnect the opposite end of the cable.
7. Disconnect the other cable from the discharged battery first, then disconnect the opposite end.

General Information

⚠ WARNING

Before testing a battery, see "Battery Safety Precautions" in this section. Failure to follow the safety precautions could result in personal injury.

Test any maintenance-free battery that does not hold a charge to see if it needs to be replaced, or if the problem lies elsewhere in the electrical system. Accuracy of the test depends on variables such as temperature and age of the battery. Follow the recommended testing instructions listed below.

IMPORTANT: Two types of battery tests are discussed in this subject. The first test uses the Midtronics Micro740 battery tester, and must be used by all U.S. and Canadian dealers for battery warranty claims. The second test is a load test using a carbon pile type tester and should **not** be used by U.S. or Canadian dealers for battery warranty claims.

Visual Inspection

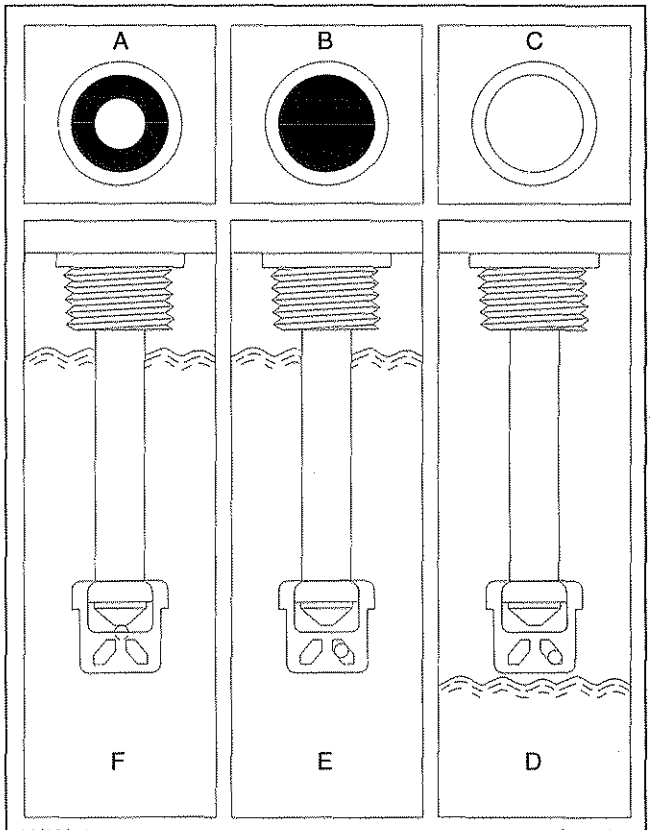
Check for obvious damage such as a cracked or broken case that could permit loss of electrolyte. If there is physical damage replace the battery. Find the cause of the damage and correct it as needed.

On maintenance-free batteries without a built-in hydrometer, perform the Midtronics PowerSensor Micro740 test or the load test.

On maintenance-free batteries with a built-in hydrometer, check the sight glass. If a green dot shows in the sight glass, test the battery. If the sight glass is dark, recharge the battery, then test it. See **Subject 150**. If the sight glass is clear, replace the battery. See **Fig. 1**.

Prior to Testing

1. Clean the battery terminals with a soft wire brush before testing.
2. At the start of the test, make sure all vehicle accessory loads are off and the ignition is in the off position.



A. Green Dot
B. Dark
C. Clear
D. Dead Battery
E. 65% or Less of Charge
F. 65% or More of Charge

Fig. 1, Built-In Hydrometer or Charge Indicator (on optional batteries only)

Midtronics PowerSensor Micro740 Test

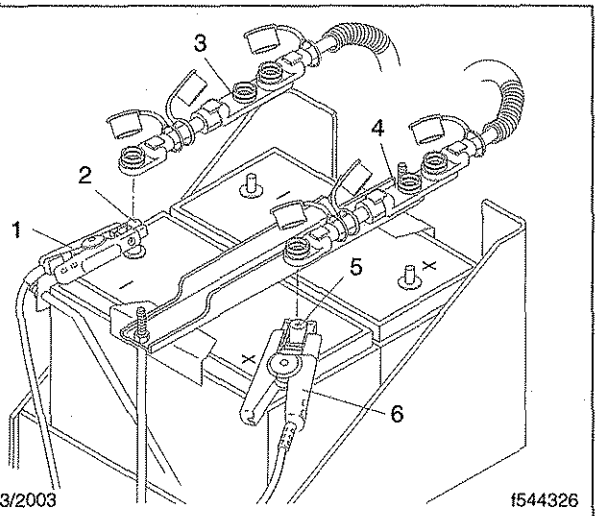
NOTE: This test must be used by all U.S and Canadian dealers for battery warranty claims.

Every battery in a pack of two or more must be disconnected before testing. If more than one battery is selected to be tested, the analyzer will test the first battery, then prompt you to connect to the next battery after the test has been completed. If the analyzer detects that the batteries are connected, it will remind you to disconnect the pack before starting the test.

Battery Testing

Connecting the Midtronics Tester

1. Screw an adapter onto the negative-terminal stud and one onto the positive-terminal stud. See **Fig. 2**.



1. Negative-Terminal Clamp
2. Negative-Terminal Stud Adaptor
3. Negative-Terminal Battery Jumper
4. Positive-Terminal Battery Jumper
5. Positive-Terminal Stud Adaptor
6. Positive-Terminal Clamp

Fig. 2, Battery Connection

IMPORTANT: For accurate test results, connect the clamps to the lead adaptors or to the lead bases of threaded studs. Lead stud adaptors are included with the Micro740. Do not connect the clamps directly onto the threaded studs or an inaccurate test result may occur.

2. Connect the red clamp to the positive-terminal stud adaptor.
3. Connect the black clamp to the negative-terminal stud adaptor.
4. Rock the clamps back and forth to ensure a secure connection. Both sides of the clamp must be firmly connected to the adaptors before testing. If the test message CHECK CONNECTION appears, clean the terminals and/or reconnect the clamps.

Battery Test

NOTE: If the analyzer displays a test message after you start the test, see *Test Messages* to determine the cause and remedy.

1. Use the arrow buttons at the top of the keypad to scroll to menu choices. Select BATTERY TEST. Press ENTER to select.
2. Enter the number of batteries being tested (1 to 6) and press ENTER to select.
3. Select the rating system; CCA, SAE, EN, IEC, DIN, or JIS then press ENTER.
4. Select the appropriate rating value (see **Table 1**) then press ENTER.
5. If the analyzer detects that the temperature of the battery may make a difference in the results it will ask you to select whether the battery temperature is above or below 32°F (0°C). It will resume the test after you make the selection and press ENTER.
6. At the end of the test, the Micro740 will display one of the following results from **Table 2** and the measured voltage and CCA, if applicable.

   If the result is REPLACE BATTERY or BAD CELL—REPLACE the analyzer will prompt you to press ENTER to generate a battery code.

   When the prompt BAT.SERIAL # appears enter the battery serial number. Use the ARROW buttons to scroll to the correct digit, then press ENTER to select it and move to the next digit. Pressing the BACK button will move the cursor back one space. When finished, press ENTER.
7. Turn on the printer and align the analyzer transmitter with the printer receiver. Press and hold the MENU button. Select PRINT RESULTS from the option menu by using the arrow buttons and pressing ENTER. It will take about 30 seconds to print all test results, which are displayed simultaneously on the screen.

Battery Rating Systems		
Rating System	**Description**	**Value Range**
CCA	Cold Cranking Amps, as specified by SAE. The most common rating for cranking batteries at 0°F (-18°C)	100 to 1700 A
SAE	European labeling of CCA	100 to 1700 A
EN	Europa-Norm	100 to 1700 A
IEC	International Electrotechnical Commission	100 to 1000 A
DIN	Deutsche Industrie-Norm	100 to 1000 A
JIS	Japanese Industrial Standard: (shown on a battery as a combination of numbers and letters, for example: 80D26)	43 values from 26A17 to 245H52

Table 1, Battery Rating Systems

Battery Test Results	
Result	**Recommendation**
Good Battery	Return to service.
Good—Recharge	The battery is good, but has an insufficient state of charge. Fully charge the battery and return to service.
Charge and Retest	The battery has a very low state of charge. Fully charge the battery and retest. Failure to fully charge the battery before retesting may cause false readings.
Replace Battery	Replace the battery and generate a test code.
Bad Cell—Replace	Replace the battery and generate a test code.

Table 2, Battery Test Results

Test Messages

Test Message—SYSTEM NOISE	
Possible Cause	**Remedy**
The analyzer has detected computer or ignition noise and will attempt to retest.	Make sure all vehicle loads are off and the ignition is in the off position. The analyzer will automatically retest when it no longer detects system noise
You may be testing too close to a noise source.	Move away from any high-current device and retest.
Battery charge is too low to test properly.	Recharge the battery and retest. If the message reappears, replace the battery.
Poor connection at battery terminal.	Connect the battery cables and retest.

Test Message—NON 12-VOLT BATTERY DETECTED	
Possible Cause	**Remedy**
You are attempting to test both batteries in a 24-volt system at the same time.	Disconnect the batteries and test each one individually.

Battery Testing

Test Message—INTERNAL ERROR, SERVICE REQUIRED	
Possible Cause	**Remedy**
The analyzer has detected a hardware or software problem.	See the Midtronics Micro740 *Instruction Manual.*

Test Message—REVERSE CONNECTION	
Possible Cause	**Remedy**
The clamps are connected in reverse polarity. i.e., Red to negative (–), and black to positive (+).	Disconnect the clamps and reclamp to proper polarity. i.e., Red to positive (+), and black to negative (–).

Test Message—UNSTABLE BATTERY	
Possible Cause	**Remedy**
Batteries that are very weak or that have just been charged may have sufficient electrical activity to alter test results. The analyzer will automatically retest when the battery has stabilized. Fully charged batteries should stabilize quickly.	Charge weak batteries and then retest.

Test Message—CHECK CONNECTION	
Possible Cause	**Remedy**
Poor connection. Both sides of the clamps must be firmly connected before testing.	Clean the battery terminals using a wire brush and a mixture of baking soda and water. Inspect and clean the clamps. Liberally apply baking soda and water with a clean cloth and thoroughly rub the jaw and spring. Use a soft wire brush to remove corrosion buildup. Rinse with water and let dry.

Load Test

NOTE: This test must **not** be used by U.S and Canadian dealers for battery warranty claims.

1. Test each battery separately, either installed or removed. Disconnect the battery cables from the battery, ground cable first.

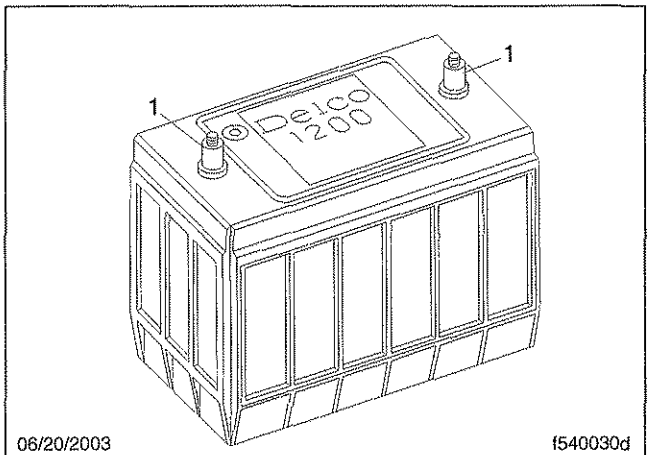
⚠ WARNING

Before charging a battery, see "Battery Safety Precautions" in this section. Failure to follow the safety precautions could result in personal injury.

When charging batteries, always wear eye protection. During charging, batteries give off explosive hydrogen gas. Exploding gas can cause blindness or other bodily injury.

2. Before beginning the load test, check the open circuit voltage (OCV) of each battery. If the voltage is below 12.4 volts, charge the battery on a shop charger for at least 2 hours. If the voltage is above 12.4 volts, proceed to the next step. See **Subject 150** for battery charging instructions.
3. Connect the tester leads to the battery terminals following the tester manufacturer's instructions. Batteries with sealed terminals require adaptors

to provide a place for attaching the tester's leads. See **Fig. 3**.



1. Terminal Adaptor

Fig. 3, Sealed Battery

4. Check the rated CCA of the battery. Apply a load equal to one-half the rated CCA across the terminals for 15 seconds to remove the surface charge from the battery. Remove the load and wait 15 seconds for the battery to recover.

   Example: For a battery rated at 620 CCA, apply a load of 310 amperes across the terminals.

5. Estimate the battery temperature by touch and by the ambient temperature the battery was exposed to before this test, then find the voltage in **Specifications 400** that must be maintained while the battery supplies a specified electrical load.

   Example: At 70°F (21°C) the battery must supply 9.6V minimum.

6. Apply the specified test load to the battery for 15 seconds. The test load (amperes) is equal to one-half of the cold-cranking amperes of the 0°F (–18°C) rating of the battery.

7. Read the terminal voltage at the end of 15 seconds with the load still connected. Do not keep the load attached for a longer period of time before reading the voltage, as this would alter the test results.

8. Remove the load after 15 seconds and note the tester reading.

If the voltage drops below the minimum listed in the table replace the battery.

If the voltage is the same or greater than the minimum listed in the table the battery is capable of further service.

⚠ WARNING

Before charging a battery, read the instructions in Subject 120. Failure to follow the safety precautions could result in personal injury.

When charging batteries, always wear eye protection. During charging, batteries give off explosive hydrogen gas. Exploding gas can cause blindness or other bodily injury.

Conventional Battery Charging

To charge a conventional liquid-electrolyte battery (wet cell), apply a charge rate in amperes for a period of hours. A 10-ampere charge rate for five hours would produce a 50 ampere-hour charge to the battery. Charge rates between 3 and 50 amperes are generally satisfactory for maintenance-free batteries.

An emergency boost-charge, or fast-charge, provides a high charging rate for a short period of time. Limit fast charges to specific charging times. See the charging table in **Specifications, 400**. The battery cannot be fully charged within these time periods, but it will receive a sufficient charge (70 to 90 percent) for practical service. To completely charge a battery, follow the fast-charge with a slow-charge.

IMPORTANT: Do not overcharge maintenance-free batteries. Overcharging causes excessive loss of water from the electrolyte and eventual battery damage.

On optional batteries with built-in hydrometers (charge indicators), the battery is sufficiently charged when the green dot in the hydrometer is visible. Gently shake or tilt the battery at hourly intervals during charging to mix the electrolyte and check to see if the green dot appears. Do not tilt the battery beyond a 45-degree angle.

If the green dot does not appear after a 75 ampere-hour charge, continue charging for another 50 to 75 ampere-hours. If the green dot still does not appear, replace the battery.

NOTE: Batteries with built-in hydrometers (charge indicators) can't be charged if the indicator color is clear or light yellow; this indicates low electrolyte level. Replace these batteries.

To charge a wet cell, do the following steps:

1. Clean the battery terminals.

NOTE: If the battery is cold, let it warm up. This will allow a normal charging rate.

2. Make sure that the charger is turned off.
3. Connect the charger to the battery following the manufacturer's instructions. Rock the charger lead clamps to make sure there is a good connection.
4. Turn on the charger and slowly increase the charging rate until the recommended ampere value is reached. See the charging table in **Specifications, 400**.

IMPORTANT: If the battery feels hotter than 125°F (52°C), or if rapid gassing or spewing of electrolyte occurs, lower the charging rate or stop charging the battery and allow it to cool.

5. Turn the charger off.

⚠ WARNING

Always turn the charger off before disconnecting it. Touching a charger lead when the circuit is live could create a spark and cause an explosion, resulting in personal injury.

6. Disconnect the charger cables from the battery.

NOTE: If the vehicle is equipped with an isolated battery system, be sure that both battery systems are charged.

7. If the engine does not crank satisfactorily when a charged battery is installed, load test the battery. For instructions, see **Subject 140**.

   If the battery passes the load test, check the fuel, ignition, cranking, and charging systems to find and correct the problem.

   If the battery does not pass the load test, replace it.

Gel Cell Charging

⚠ CAUTION

To avoid shortening the life of a gel cell, carefully regulate the charging voltage—between 13.8 and 14.1 volts.

Battery Charging

It is hard to determine how long to charge a gel cell. Recharging time depends on the following factors:

- Depth of discharge
- Temperature
- Size and efficiency of the charger
- Age and condition of the battery

Because the chemical charging reaction slows down as it nears completion, about 60% of the total charging time will be spent bringing the battery from 10.5 volts under load (11.8 volts with no load) to 90% of full charge (12.92 volts, including surface charge). The other 40% of the time is required to charge the remaining 10% (full charge = 13.0 volts, including surface charge).

Example: If it takes 3-1/2 hours to charge a battery to 90%, it will take another 2-1/2 hours to bring it to full (100%) charge.

See **Table 1** for a list of estimated charging times to 90% of full charge. See **Table 2** for a list of estimated charging times to 100% of full charge. All charging times are based on the initial charge current accepted by the battery, using an automatic, temperature-sensing, voltage regulating charger set at 13.8 volts (2.30 to 2.35 volts per cell) on a totally discharged battery (at 11.80 to 12.00 volts, with no load).

Charging Time to 90% of Full Charge			
Battery	Initial Amps Needed To Recharge In		
	13 Hours	6 Hours	3-1/2 Hours
G27	8	21	41
G31*	9	24	45

* Freightliner uses the G31 (Group 31) gel cell.

Table 1, Gel Cell Charging Guide (90% charge)

HOW TO USE THESE CHARTS: Read amps about one minute after the charger is first turned on. Use this initial reading to estimate the approximate charging time.

Example: If a G31 battery reads about 24 amps charge current when first turned on, the battery will be at 90% charge in about six hours, and will be fully charged (100%) in about ten hours.

Charging Time to 100% of Full Charge			
Battery	Initial Amps Needed To Recharge In		
	22 Hours	10 Hours	6 Hours
G27	8	21	41
G31*	9	24	45

* Freightliner uses the G31 (Group 31) gel cell.

Table 2, Gel Cell Charging Guide (100% charge)

To charge a gel cell, do the following steps:

1. Remove the gel cell from the vehicle.
2. Clean the battery terminals.

NOTE: If the gel cell is cold, let it warm up to 68°F (20°C). This will allow a normal charging rate.

3. Make sure that the charger is turned off.

⚠ CAUTION

Use a reliable, automatic, temperature-sensing, voltage-regulated charger to charge gel cells. Any other type of charger will damage the gel cell.

4. Connect the charger leads directly to the battery following the charger manufacturer's instructions. Rock the charger lead clamps to make sure there is a good connection.
5. Turn on the charger and set the charging rate between 13.8 and 14.1 volts (2.30 to 2.35 volts per cell).

⚠ CAUTION

To prevent damage, do not open a sealed gel cell or charge it in excess of 14.1 volts (2.35 volts per cell).

6. After about one minute, check the initial charge current. To charge to 90% of full charge, see **Table 1** to determine the approximate time of completion. To charge to 100% of full charge, see **Table 2** to determine the approximate time of completion.

IMPORTANT: If the battery feels hotter than 125°F (52°C), or if rapid gassing occurs, stop charging the battery and allow it to cool.

7. When finished, turn the charger off.

⚠ WARNING

Always turn the charger off before disconnecting it. Touching a charger lead when the circuit is live could create a spark and cause an explosion, resulting in personal injury.

8. Disconnect the charger cables from the battery.

Battery Removal, Cleaning and Inspection, and Installation

⚠ WARNING

Before doing any of the following procedures, read the instructions in Subject 120. Failure to follow the safety precautions could result in personal injury.

Removal

Before working on any battery box, make sure all electrical loads (lights, ignition, accessories) are turned off.

Note what type of battery box is installed. Removal procedures for the side-rail battery boxes are similar; those for the between-rail and the above-rail boxes are completely different.

Three basic battery box installations are available for Century Class Conventionals. First, the standard box, long side to rail with a step and diamond plate side cover (for vehicles with one fuel tank and standard cab entry with no side fairings). See **Fig. 1**.

Second, an optional box, long side to rail with no step. See **Fig. 2**.

Third, a between-rail plastic box for vehicles with dual fuel tanks. See **Fig. 3**.

The standard Argosy COE battery box is mounted above the frame rails in back of the engine (see **Fig. 4**), though battery boxes mounted on either frame rail are also available. All Argosy COE battery boxes are aluminum.

SIDE-RAIL BATTERY BOX

1. Remove the threaded fasteners that attach the air fairing panel (if equipped) in front of the battery box. Remove the air fairing panel. For instructions, see **Section 60.05**.

   If no air fairing panel is installed, remove the step plate.

2. Pull on the end of each hold-down latch until the end clears the cover-mounted catch. Pivot the latches out of the way, then lift off the battery box cover.

3. For assembly reference, note the locations of the battery positive and negative terminals in relation to surrounding components. Remove the battery cables.

4. Remove the battery retainer assembly. Remove the batteries from the carrier.

BETWEEN-RAIL BATTERY BOX, CENTURY CLASS CONVENTIONAL

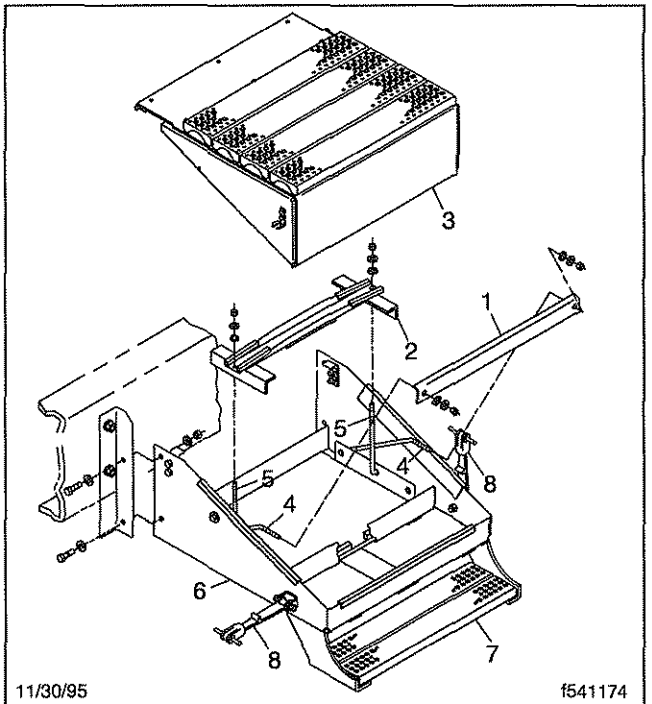
1. Remove the battery box lid. If equipped, remove the spring pin.

2. Disconnect the battery cables from the battery terminals and move the cables out of the way.

3. Remove the battery hold-downs. See **Fig. 5**.

   3.1 Remove the 5/16–18 hold-down locknut and washer.

   3.2 Slip the hold-down off the 5/16-inch rib-neck bolt.



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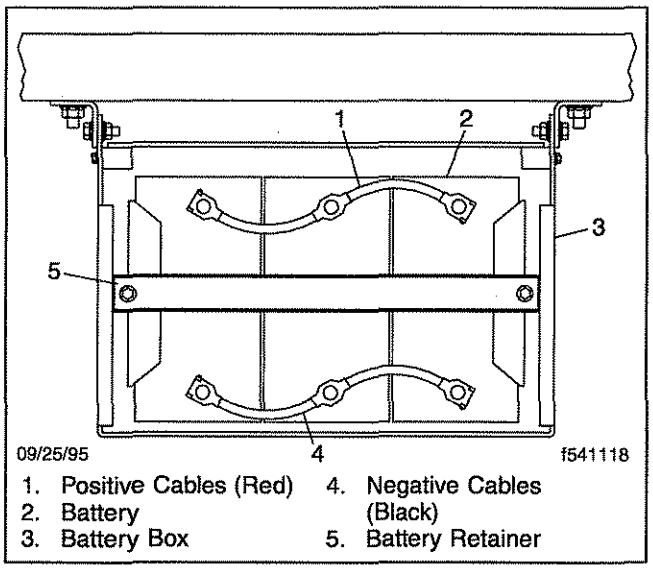
1. Hold-Down Angle
2. Retainer Assembly
3. Cover
4. Hold-Down Bolt
5. Retainer Bolt
6. Battery Box
7. Step
8. Latch

Fig. 1, Side-Rail Battery Box, Long Side to Rail, with Step and Diamond Plate Side Cover

Battery Removal, Cleaning and Inspection, and Installation



1. Positive Cables (Red)
2. Battery
3. Battery Box
4. Negative Cables (Black)
5. Battery Retainer

Fig. 2, Side-Rail Battery Box, Long Side to Rail, with Cover Removed

3.3 Remove the rib-neck bolt and set all hold-down hardware aside.

4. Remove the batteries from the vehicle. For assembly reference, note the locations of the battery positive and negative terminals in relation to surrounding components.

5. Remove the battery box. See **Fig. 6**.

5.1 From underneath the battery box, remove the 3/8–16 hexnut and flatwasher from the keeper assembly. Retain the keeper and spring.

5.2 Remove the battery box from the vehicle.

6. Remove the battery box bracket from the frame rail. See **Fig. 7**.

6.1 Remove the lock pin and collar from each huckspin. For instructions, see **Group 31**.

6.2 Remove the bracket from the frame rail. The plastic washers are attached to the bracket with pressure-sensitive adhesive and come off with the bracket.

OVER-THE-RAIL BATTERY BOX, ARGOSY COE

1. Park the vehicle on a level surface. Shut down the engine. Set the parking brake and chock the front and rear tires.

2. Tilt the cab. For detailed instructions, see **Group 60**.

3. Remove the air intake cleaner assembly.

3.1 Loosen the screw on the hose clamp that attaches the flexible duct to the air intake cleaner assembly, and separate the flexible duct from the air cleaner assembly.

3.2 Remove the four nuts from the air cleaner mounting bracket studs.

3.3 Remove the air cleaner assembly from the mounting bracket, and set the assembly aside.

4. Remove the battery box cover. See **Fig. 8**.

5. For assembly reference, label the locations of the battery positive and negative terminals in relation to surrounding components. Disconnect the battery cables from the battery terminals and move the cables out of the way.

6. Remove the battery hold-down, and lift the batteries from the vehicle.

7. Detach the battery cable clamp.

NOTE: Label all electrical connections before disconnecting them.

8. Remove the battery ON/OFF switch and the fuse box/mag switch cover panel.

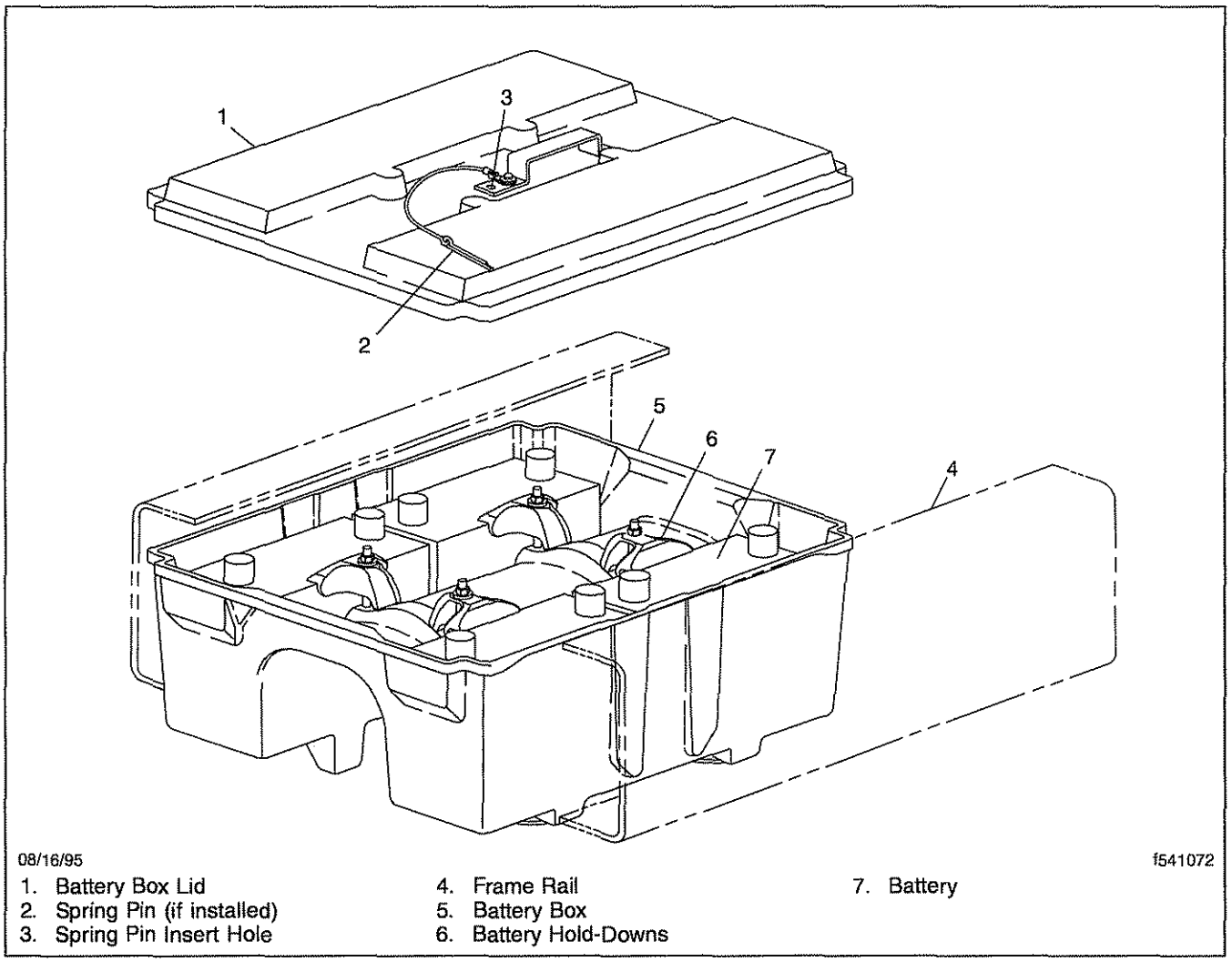
9. Remove the fuse box and the mag switch.

10. Remove the battery box. Take care to retain the spacers on the upper front of the air filter assembly mounting bracket.

Cleaning and Inspection

1. Inspect the battery cables for wear, and replace them if necessary. Clean the cable connector terminals with a wire brush.

Battery Removal, Cleaning and Inspection, and Installation



1. Battery Box Lid
2. Spring Pin (if installed)
3. Spring Pin Insert Hole
4. Frame Rail
5. Battery Box
6. Battery Hold-Downs
7. Battery

Fig. 3, Between-Rail Battery Box

2. Clean and tighten the battery ground cable, terminals, and clamps.
3. Inspect the retainer assembly (or battery hold-downs) and battery box. Replace worn or damaged parts. Remove any corrosion with a wire brush, and wash with a weak solution of baking soda and water. Rinse with clean water, and dry. Paint the retainer assembly, if needed, to prevent rusting.
4. Be sure foreign objects, such as stones, bolts, and nuts, are removed from the battery box.

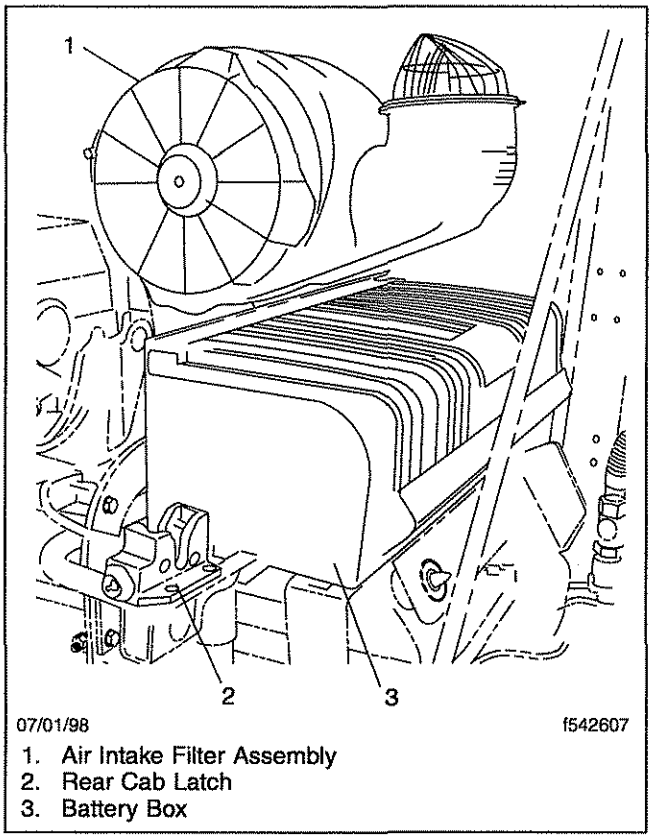
Installation

1. Be sure that the battery to be installed has a sufficient capacity to cover the electrical needs of the vehicle. For more information, see **Subject 100**.

⚠ CAUTION

Using an under-capacity battery will result in poor performance and premature battery failure, resulting in damage or reduced life of the starter.

Battery Removal, Cleaning and Inspection, and Installation



1. Air Intake Filter Assembly
2. Rear Cab Latch
3. Battery Box

Fig. 4, Over-the-Rail Battery Box, Argosy COE

2. Be sure the battery is at full charge when installed. If the battery has been in storage for some time, or if the installation is being made in subfreezing temperatures, give the battery a boost-charge before installing it. For instructions, see **Subject 150**.

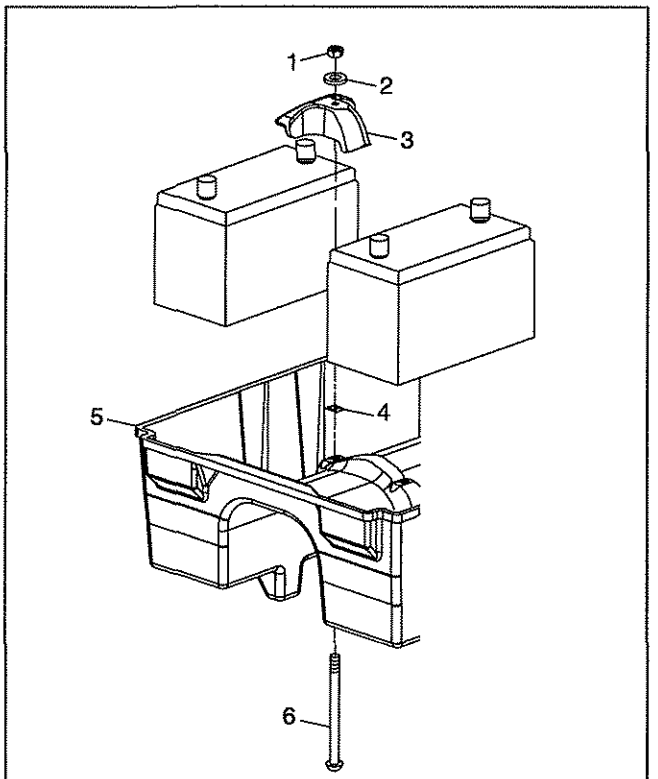
SIDE-RAIL BATTERY BOX

1. Place the batteries in the carrier with the terminals in the proper position, as referenced earlier. The batteries should rest level in the carrier.
2. Install the battery retainer assembly, and tighten it until the batteries are secure. See **Fig. 1**.

⚠ CAUTION

Do not overtighten the battery retainer assembly. Overtightening could damage the batteries.

3. Connect the battery cables to the batteries.



1. 5/16–18 Hold-Down Nut
2. Flatwasher
3. Hold-Down
4. Push-On Retainer
5. Battery Box
6. 5/16-Inch Rib-Neck Bolt

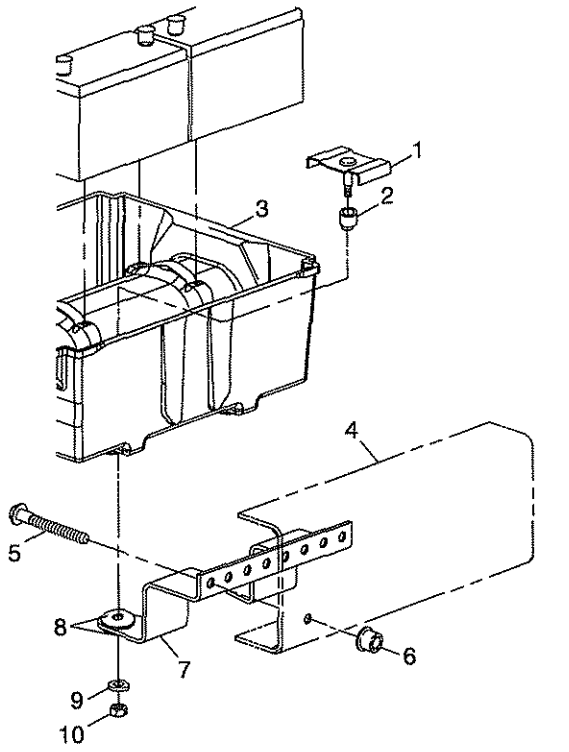
Fig. 5, Battery Hold-Downs

3.1 To provide corrosion protection, apply pumpable dielectric grease, part no. 48–02349–000, liberally to the terminal pads. For a list of approved suppliers, see **Specifications, 400**.

3.2 Install the battery cable interconnectors.

3.3 Tighten the battery cables to the torque specifications listed on the battery, generally 10 to 15 lbf·ft (14 to 20 N·m). Connect the ground cable last.

Battery Removal, Cleaning and Inspection, and Installation



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1. Keeper Assembly
2. Spring
3. Battery Box
4. Frame Rail
5. Huckspin Lock Pin
6. Huckspin Collar
7. Battery Box Bracket
8. Plastic Washer
9. Flatwasher
10. 3/8–16 Hexnut

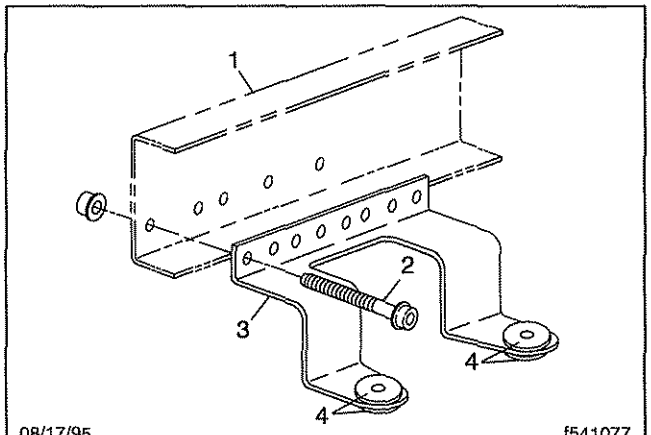
Fig. 6, Battery Box Removal

⚠ CAUTION

Make sure the polarity is correct. Reversed polarity may cause serious damage to the electrical system.

3.4 Check for correct polarity with respect to the vehicle.

4. Start the engine, and check the operation of the charging system. If needed, adjust or repair the charging system to obtain the correct charging output. For instructions, see the appropriate section in **Group 15**.



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1. Frame Rail
2. Huckspin Lock Pin
3. Bracket
4. Plastic Washers

Fig. 7, Battery Box Bracket Removal

⚠ CAUTION

Make sure all battery posts are covered with protective caps. Failure to do so could cause the battery box cover to short across the posts.

5. Install the battery box cover. Install the threaded fasteners that attach the air fairing panel (if equipped). For instructions, see **Section 60.05**.

   If removed, install the step plate.

BETWEEN-RAIL BATTERY BOX, CENTURY CLASS CONVENTIONAL

1. Install the battery box brackets on the frame rail. See **Fig. 7**. Install four new 5/8D huckspin lock pins and 5/8-inch collars on each bracket. For instructions, see **Group 31**.

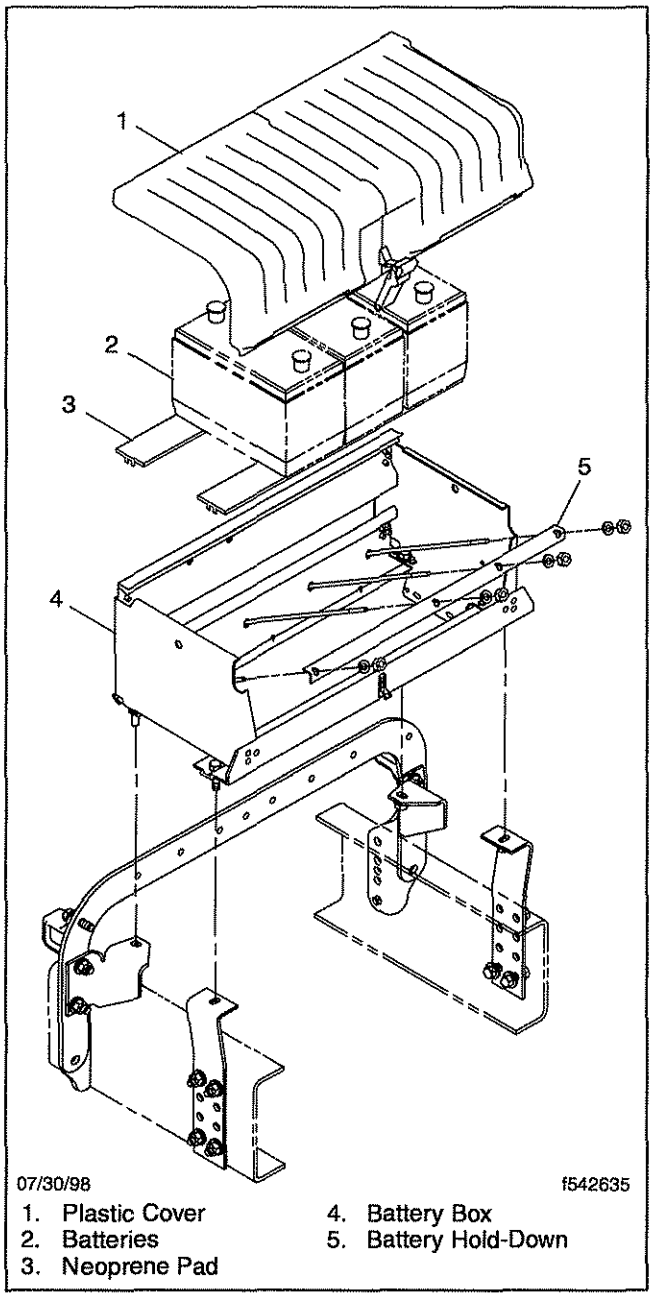
2. Install the battery box. See **Fig. 6**.

   2.1 Line up the holes in the bottom of the battery box with the holes in each bracket.

   2.2 Install four keeper assemblies and springs through the holes in the battery box and brackets.

   2.3 From underneath the battery box, install a 3/8–16 hexnut and flatwasher on each keeper assembly. Tighten to 18 lbf·ft (24 N·m).

Battery Removal, Cleaning and Inspection, and Installation



1. Plastic Cover
2. Batteries
3. Neoprene Pad
4. Battery Box
5. Battery Hold-Down

Fig. 8, Over-the-Rail Battery Box, Argosy COE

3. Place the batteries in the battery box with the terminals in the proper position, as referenced earlier. Make sure the batteries rest level in the box.
4. Install the battery hold-downs. See **Fig. 5**.
   - 4.1 Install a hold-down on each battery.
   - 4.2 Insert a rib-neck bolt up through each hold-down and thread onto it a 5/16–18 hold-down locknut and washer.

⚠ CAUTION

Do not overtighten the battery hold-downs. Overtightening could damage the batteries.

   - 4.3 Tighten each locknut 10 lbf·ft (14 N·m).
5. Connect the battery cables to the batteries.
   - 5.1 To provide corrosion protection, apply pumpable dielectric grease, part no. 48–02349–000, liberally to the terminal pads. For a list of approved suppliers, see **Specifications, 400**.
   - 5.2 Install the battery cable interconnectors.
   - 5.3 Tighten the battery cables to the torque specifications listed on the battery, generally 10 to 15 lbf·ft (14 to 20 N·m). Connect the ground cable last.
   - 5.4 Check for correct polarity with respect to the vehicle.

⚠ CAUTION

Make sure the polarity is correct. Reversed polarity may cause serious damage to the electrical system.

6. Start the engine, and check the operation of the charging system. If needed, adjust or repair the charging system to obtain the correct charging output. For instructions, see the appropriate section in **Group 15**.

⚠ CAUTION

Make sure all battery posts are covered with protective caps. Failure to do so could cause the battery box cover to short across the posts.

7. Install the battery box cover. If equipped, install the spring clip.

Battery Removal, Cleaning and Inspection, and Installation

OVER-THE-RAIL BATTERY BOX, ARGOSY COE

1. Install the battery box. See **Fig. 8**.
2. Install the mag switch and fuse box.
3. Install the battery ON/OFF switch.
4. Install the fuse box/mag switch cover.
5. Attach the battery cable clamp.
6. Place the two neoprene pads in the bottom of the battery box, snug against the front and back of the box.
7. Place the batteries in the battery box with the terminals in the proper position, as referenced earlier. Make sure the batteries rest level in the box.
8. Install the battery hold-down, and tighten it until the batteries are secure.

⚠ CAUTION

Do not overtighten the battery hold-down retainer. Overtightening could damage the batteries.

9. Connect the battery cables to the batteries.
   - 9.1 To provide corrosion protection, apply pumpable dielectric grease (part no. 48–02349–000) liberally to the terminal pads. For a list of approved suppliers, see **Specifications 400**.
   - 9.2 Install the battery cable interconnectors.
   - 9.3 Tighten the battery cables to the torque specifications listed on the battery, generally 10 to 15 lbf·ft (14 to 20 N·m). Connect the ground cable last.

⚠ CAUTION

Make sure the polarity is correct. Reversed polarity may cause serious damage to the electrical system.

   - 9.4 Check for correct polarity with respect to the vehicle.

⚠ CAUTION

Make sure all battery posts are covered with protective caps.

10. Install the battery box cover.
11. Install the air intake filter assembly.
    - 11.1 Place the air filter assembly on the mounting bracket studs.
    - 11.2 Install the four sets of locknuts and washers on the mounting bracket studs, and tighten the nuts 26 lbf·ft (35 N·m).
    - 11.3 Attach the air inlet duct to the filter assembly port, and secure the connection with the hose clamp. Tighten the screw on the hose clamp 35 to 40 lbf·in (400 to 450 N·cm).
12. Lower the cab. For detailed instructions, see **Group 60**.
13. Start the engine, and check the operation of the charging system. If needed, adjust or repair the charging system to obtain the correct charging output. For instructions, see the appropriate section in **Group 15**.
14. Remove the tire chocks.

Troubleshooting

If the starting batteries test good, but fail to perform satisfactorily in service, check for the following causes:

1. Accessories were left on overnight.
2. A slipping alternator belt, high resistance in the wiring, or an inoperative voltage regulator is causing the batteries to discharge.
3. The electrical load is exceeding the charging system capacity.
4. Wires in the electrical system are shorted or pinched.
5. There are loose or damaged battery cable-to-terminal connections.
6. The batteries are still connected in a vehicle that has been out of service. Small current drains of accessories that are connected all the time can discharge the batteries in six to eight weeks. Batteries left in a discharged condition for a prolonged period of time are subject to freezing and may become difficult to charge.

Problem—The Starting Batteries Are Undercharged

Problem—The Starting Batteries Are Undercharged	
Possible Cause	**Remedy**
The drive belt is loose.	Check the drive belt. Refer to the drive belt subject in the appropriate engine section in **Group 01** for instructions. If necessary, tighten to the manufacturer's specifications. Start the engine and check the alternator voltage and output. Refer to the troubleshooting subject in the appropriate alternator section **in Group 15** for instructions.
The drive belt is damaged or missing.	Check the drive pulleys for locked bearings. Repair or replace any damaged components. Replace the drive belt and start the engine. Check the alternator voltage and output. Refer to the troubleshooting subject in the appropriate alternator section **in Group 15** for instructions.
The batteries are undercharged.	Do a load test on the batteries. Refer to **Subject 140** for instructions. Charge or replace batteries as needed. If the batteries were discharged, start the engine and check the alternator voltage and output. Refer to the troubleshooting subject in the appropriate alternator section in **Group 15** for instructions.
The cranking circuit is broken.	If the batteries were fully charged and passed the load test, check the cranking circuit. Go to "Cranking Circuit Test" in **Section 15.00** for instructions. Make repairs as needed. Start the engine to verify the repair.
The control circuit is broken.	Check the starter wiring. Go to "Starter Wiring Test" in **Section 15.00** for instructions. Make repairs as needed. Start the engine to verify the repair.
The starter is cold.	Go to "Cold Weather Starting Test" in **Section 15.00** for instructions.
The battery cables do not deliver sufficient voltage to the starter.	Check the available cranking voltage. Go to "Available Cranking Voltage Test" in **Section 15.00** for instructions.
The starter ring gear or pinion gear is damaged.	Visually check the ring and pinion gears. Go to "Ring and Pinion Gear Test" in **Section 15.00** for instructions.
The starter is damaged.	Replace the starter.

Troubleshooting

Problem—The Starting Batteries Are Undercharged	
Possible Cause	**Remedy**
The alternator is malfunctioning.	Refer to the troubleshooting subject in the appropriate alternator section in **Group 15** for instructions.
The isolator relay is not operating correctly (optional battery isolator system only).	Replace the isolator relay with an exact replacement continuous duty relay.

Problem—The Starting Batteries Are Overcharged

Problem—The Starting Batteries Are Overcharged	
Possible Cause	**Remedy**
The voltage regulator is damaged.	Run engine at approximately 2000 RPM. Using a digital voltmeter, check the voltage at the alternator. Refer to the troubleshooting subject in the appropriate alternator section in **Group 15** for instructions. If the voltmeter reads 15.5V or above, replace the alternator.
The dash voltmeter is broken.	Run engine at approximately 2000 RPM. Using a digital voltmeter, check the voltage at the alternator. Refer to the troubleshooting subject in the appropriate alternator section in **Group 15** for instructions. If the voltmeter reads below 15.5V, check and, if necessary, replace the dash voltmeter.
The batteries are overheated.	Check battery temperatures. If 120° or above, connect cool, fully charged batteries and recheck the voltage at the alternator. Refer to the troubleshooting subject in the appropriate alternator section in **Group 15** for instructions. If 119° or below, load test the batteries. Refer to **Subject 140** for instructions.
The batteries need replacing.	Check battery temperatures. If 119° or below, load test the batteries. Refer to **Subject 140** for instructions.

Specifications

For a schematic of the battery, starting, and charging circuits for vehicles using conventional batteries only (no isolated battery), see **Fig. 1**. For a partial view of this schematic showing only the engine side, see **Fig. 2**. For a partial view of this schematic showing only the cab side, see **Fig. 3**.

For a schematic of the battery, starting, and charging circuits for vehicles using an isolated battery in addition to conventional batteries, see **Fig. 4** for installations using a 7V isolator relay. For a partial view of this schematic (isolated battery installed, 7V relay only) showing only the engine side, see **Fig. 5**. For a partial view of this schematic (isolated battery installed, both 7V and 12V relays) showing only the cab side, see **Fig. 6**.

For a schematic of the 12V isolator relay wiring, see **Fig. 7**.

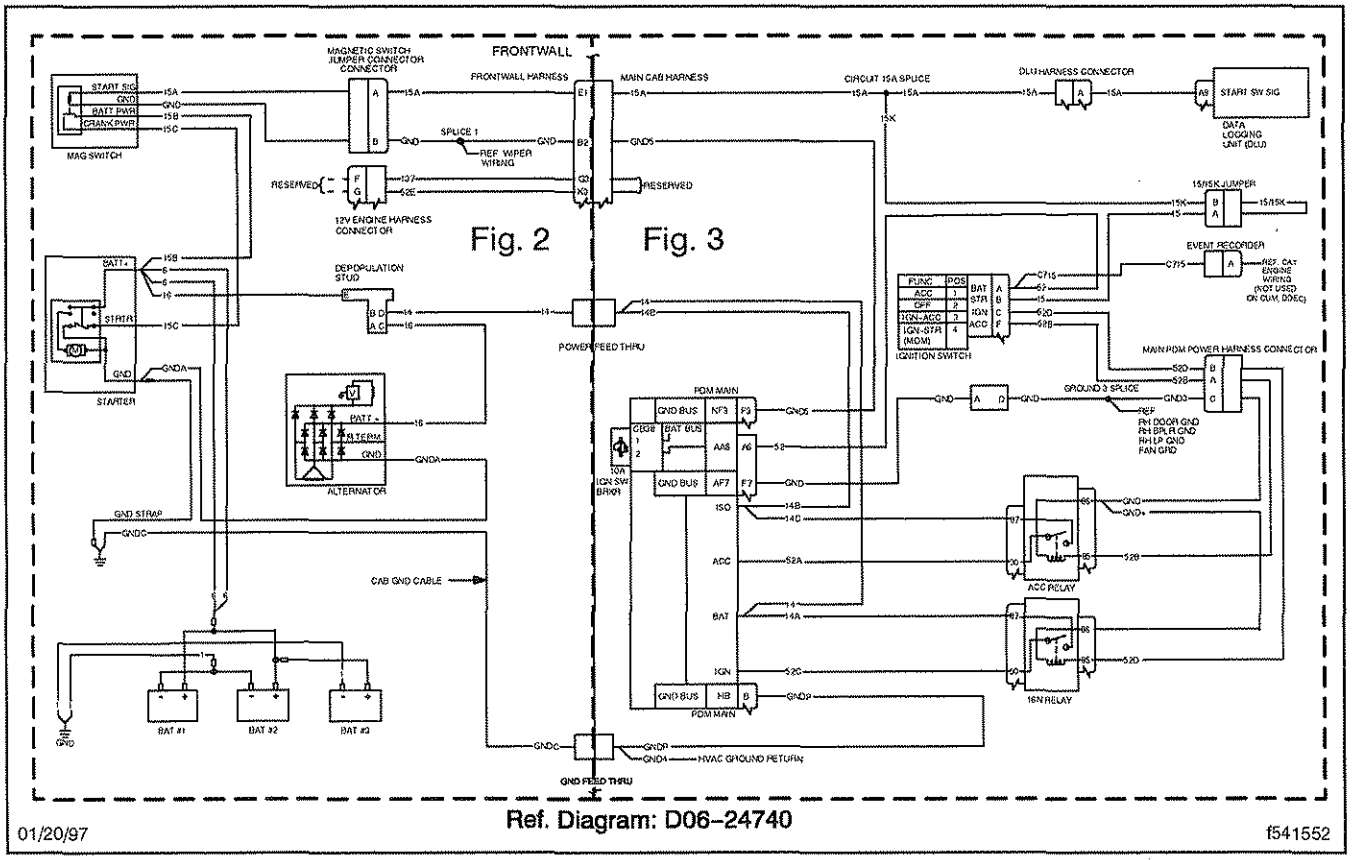
For a drawing of the isolated battery 7V relay harness, see **Fig. 8**.

For a drawing of the isolated battery engine harness for the 7V relay, see **Fig. 9**.

For a drawing of the isolated battery engine harness for the 12V relay, see **Fig. 10**.

NOTE: For the 12V relay, there is no separate relay harness.

For a drawing of the isolated battery dash harness, see **Fig. 11**.



Ref. Diagram: D06-24740

01/20/97 f541552

Fig. 1, Battery Circuits, Conventional Batteries Only

Specifications

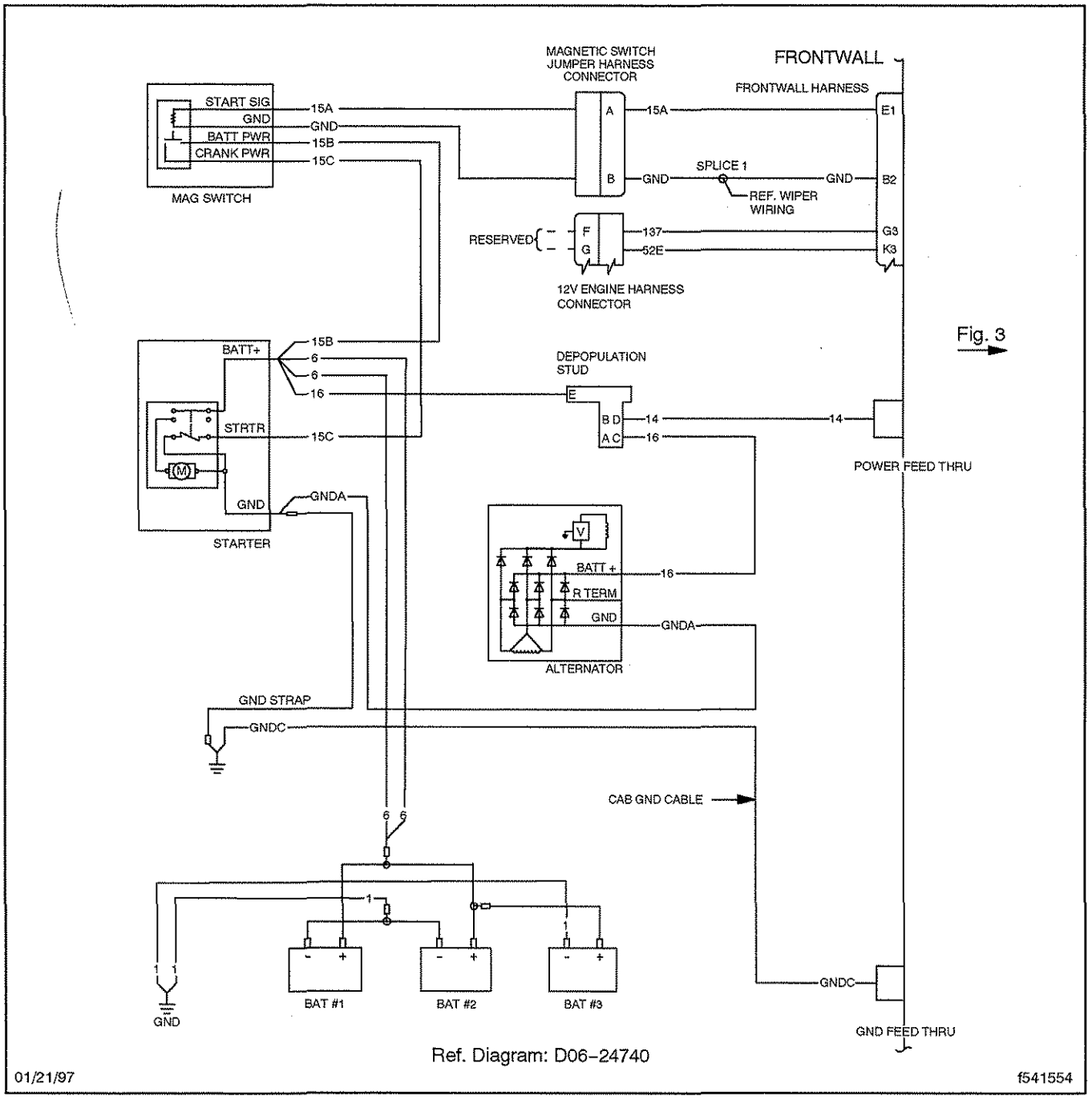


Fig. 2, Battery Circuits, Conventional Batteries Only (engine side)

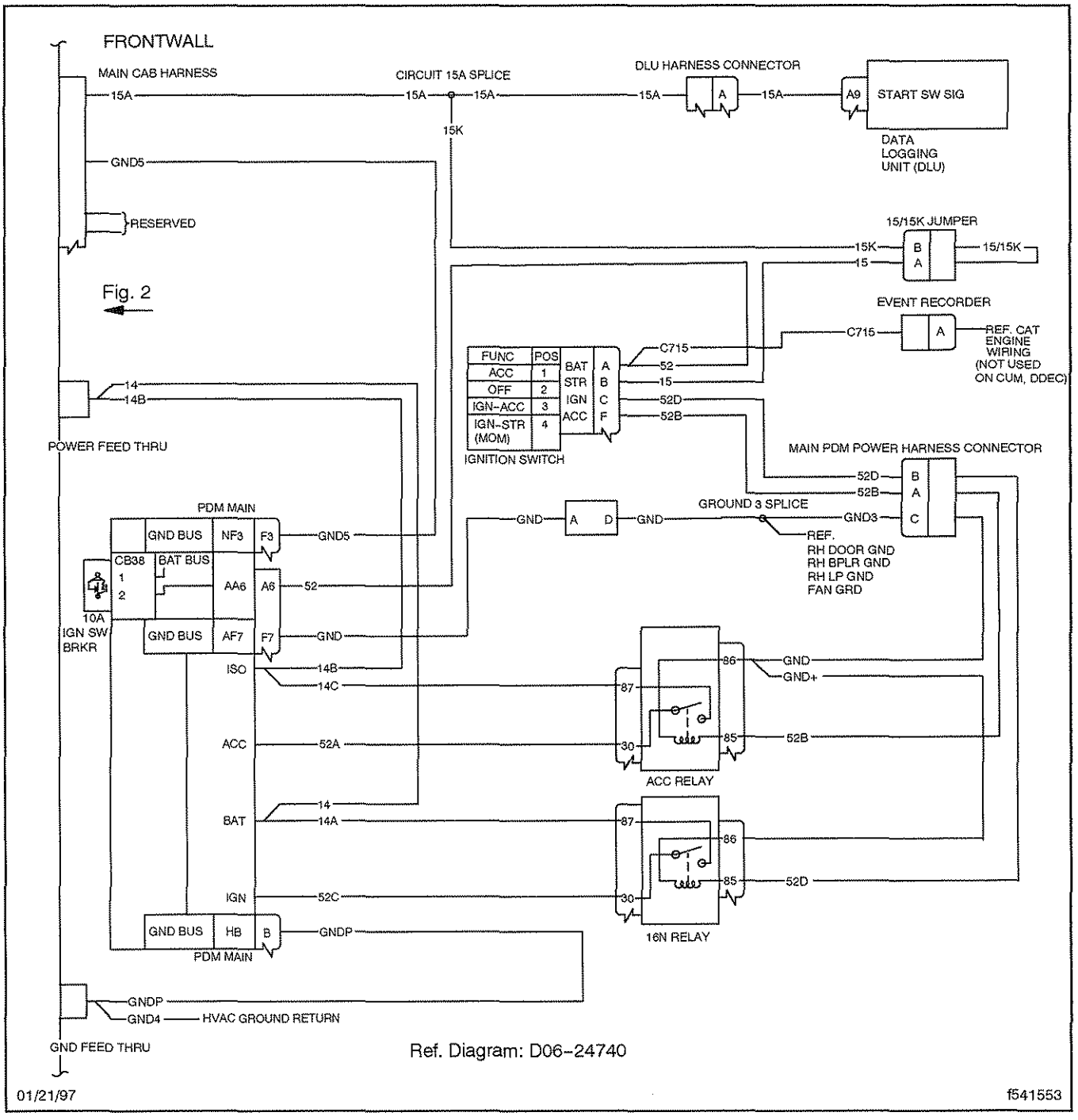


Fig. 3, Battery Circuits, Conventional Batteries Only (cab side)

Specifications

Minimum Permissible Voltages	
Ambient Temperature °F (°C)	Minimum Voltage (After 15 seconds at 300 amps)
	12-Volt
70 (21) and Above	9.6
60 (16)	9.5
50 (10)	9.4
40 (4)	9.3
30 (–1)	9.1
20 (–7)	8.9
10 (–12)	8.7
0 (–18)	8.5

Table 1, Minimum Permissible Voltage at Various Ambient Temperatures

Charging Rates for Starting Batteries				
Rated Battery Capacity (Reserve Minutes)	Slow Charge*		Fast Charge†	
	Hours @	Amperes	Hours @	Amperes
180	30	5	7-1/2	20
	15	10	5	30
			2-1/2	45

* Slow charging is recommended for completely charging the batteries.

† An emergency boost charge, which consists of a high charging rate, can be obtained by reducing the fast-charge time to half, while maintaining the same recommended ampere charge may be used to crank an engine.

Table 2, Charging Rates

Manufacturer	Lubricant or Part Number
Shell Oil Co.	No. 71032; No. 71306
Texaco, Inc.	No. 955
Quaker State	No. NYK–77

Table 3, Approved Electrical Lubricants

Reserve Capacity	Cold Cranking Amps (CCA)
180 minutes	750

Table 4, Standard Battery Specifications

Specifications

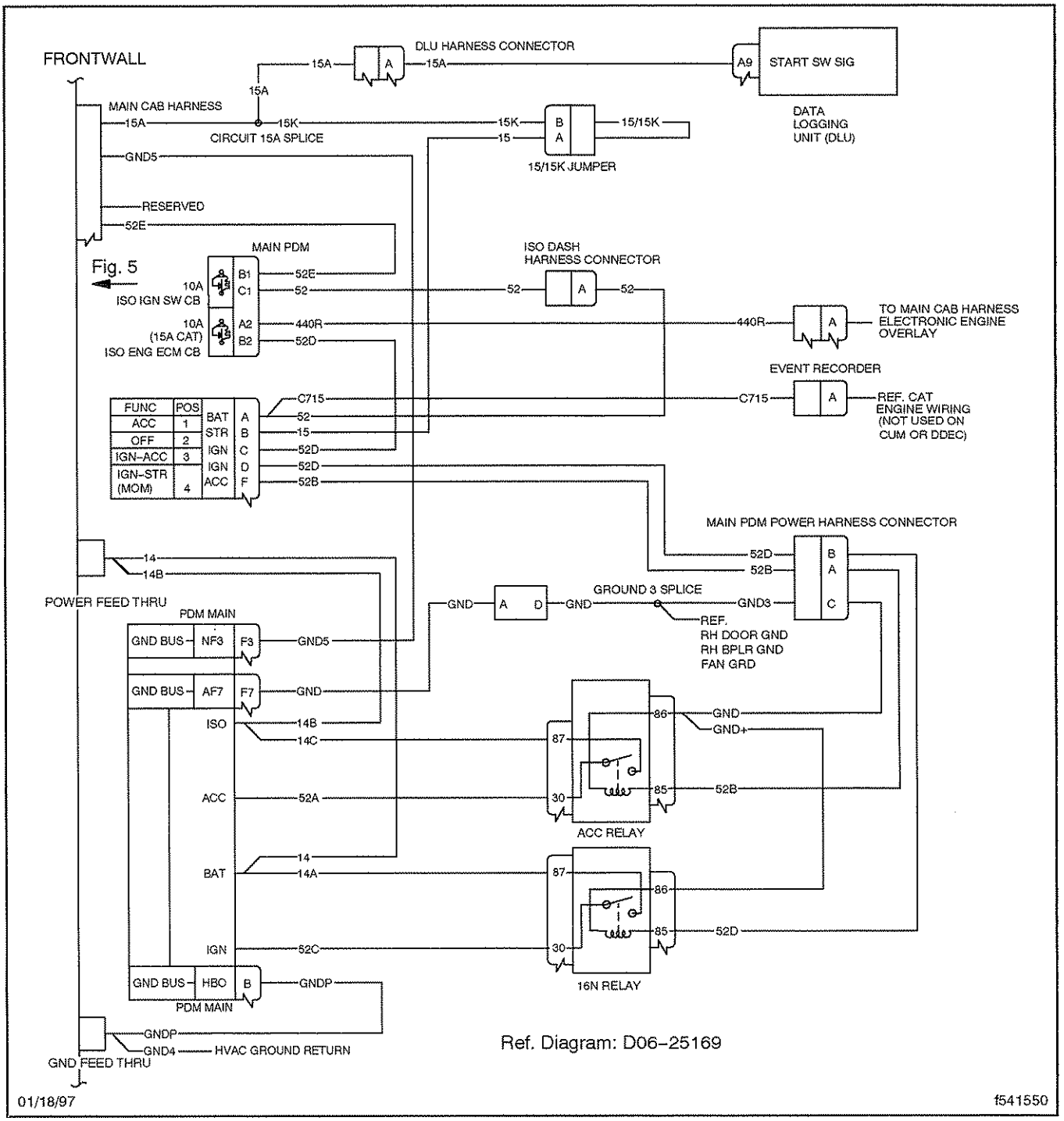


Fig. 6, Battery Circuits with Isolated Battery Installed (cab side, both 7V and 12V relays)

Specifications

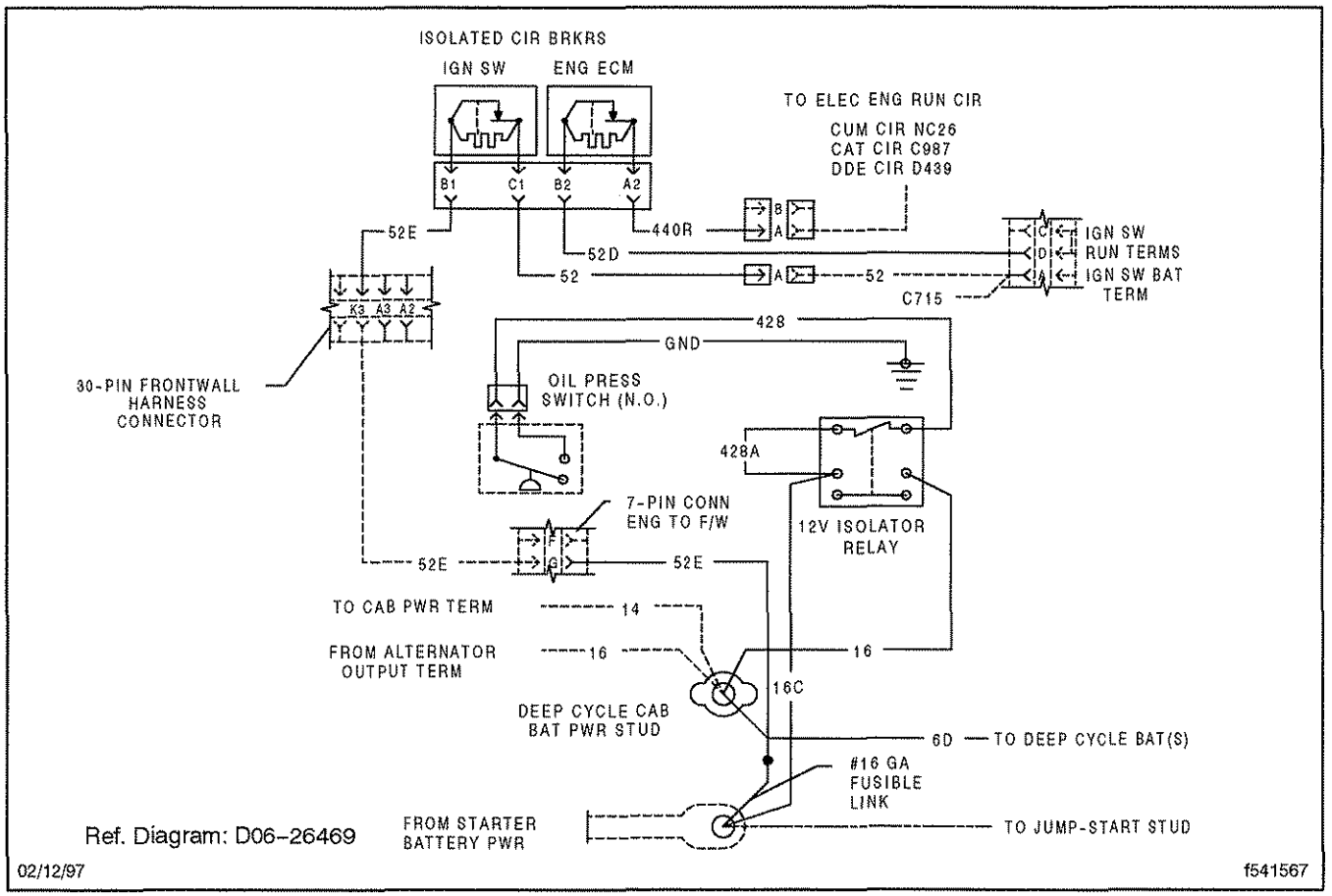


Fig. 7, 12V Isolator Relay Circuits

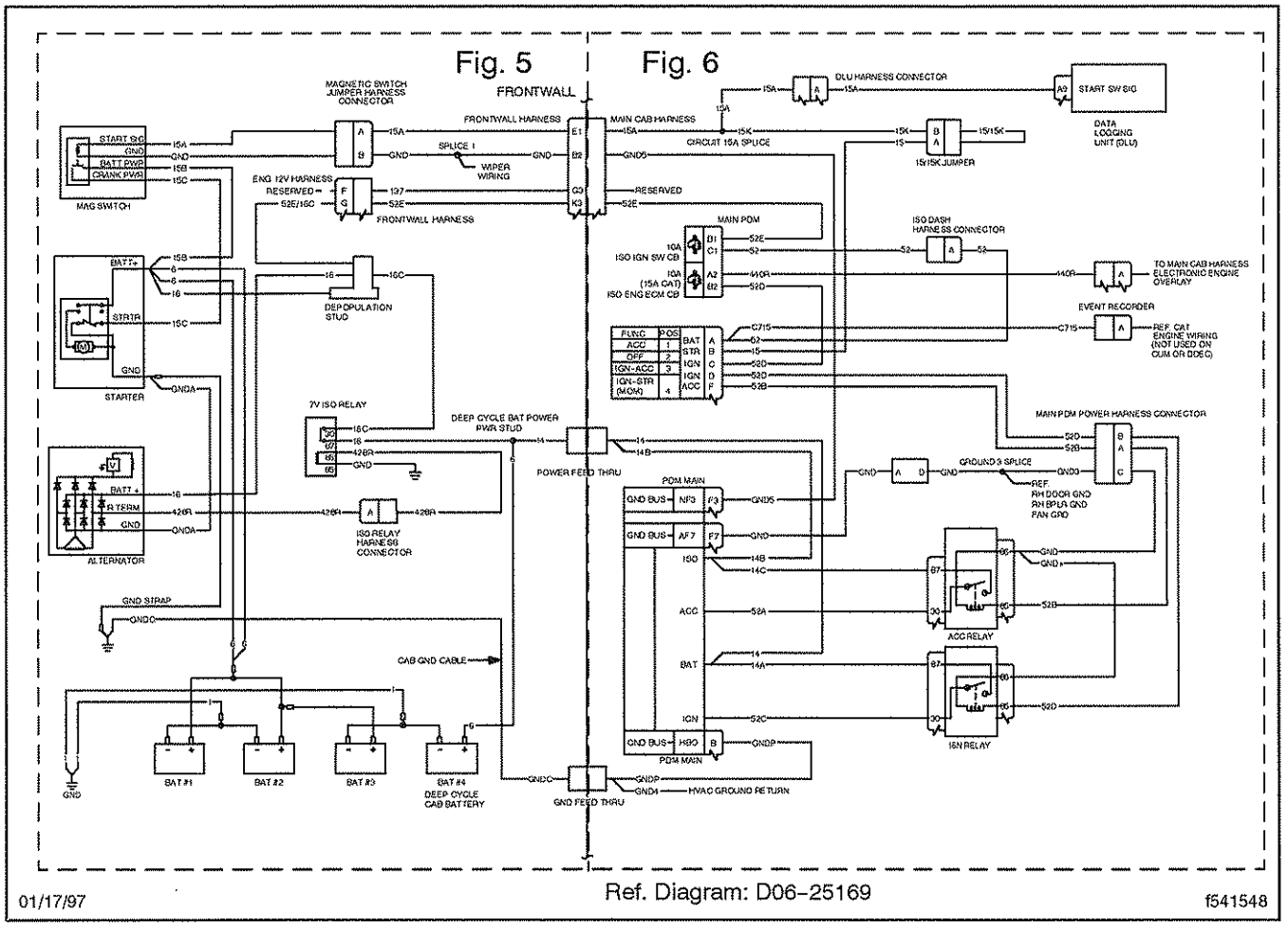


Fig. 4, Battery Circuits with Isolated Battery Installed (7V relay)

Specifications

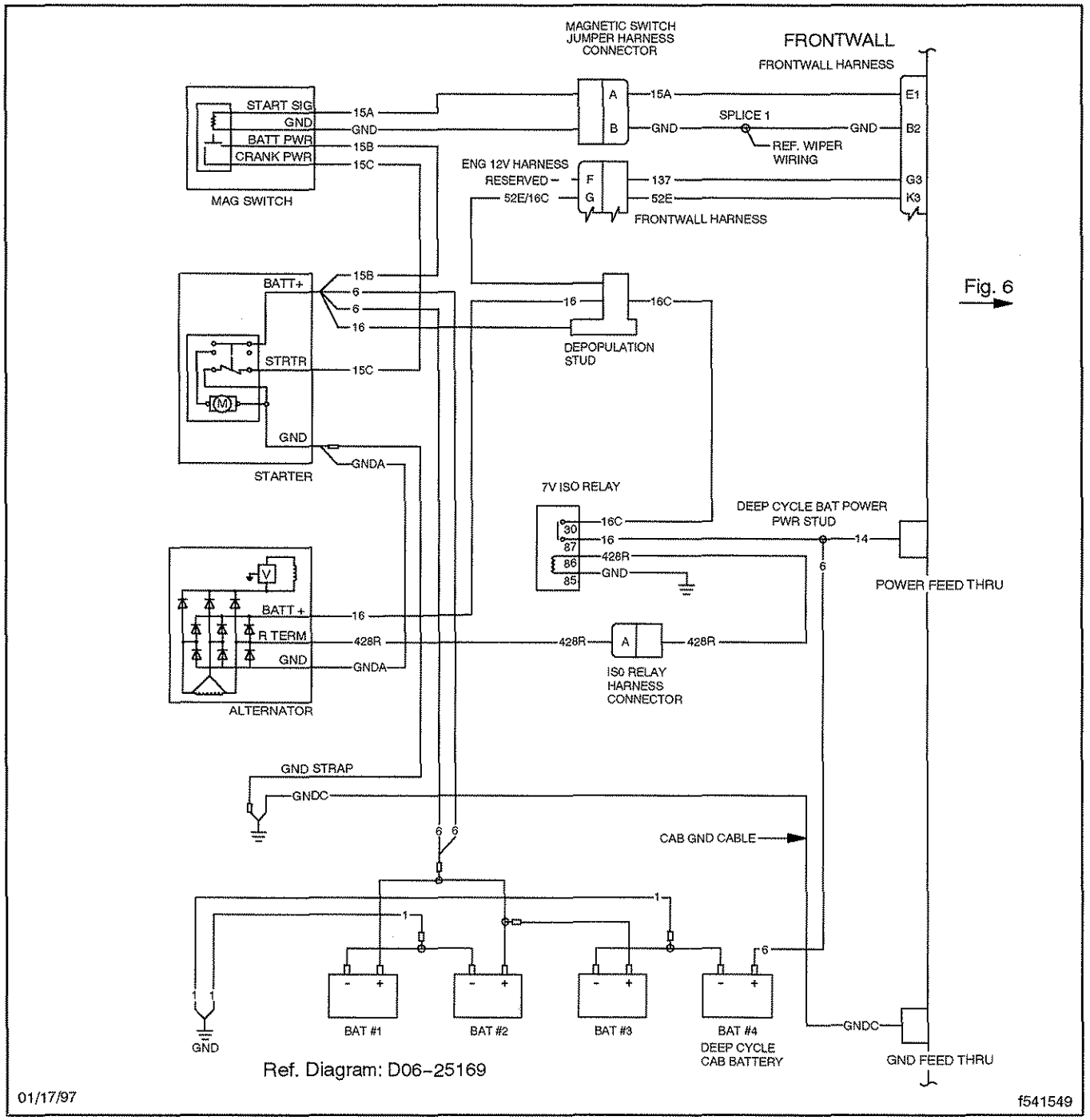


Fig. 5, Battery Circuits with Isolated Battery Installed (engine side; 7V relay only)

Specifications

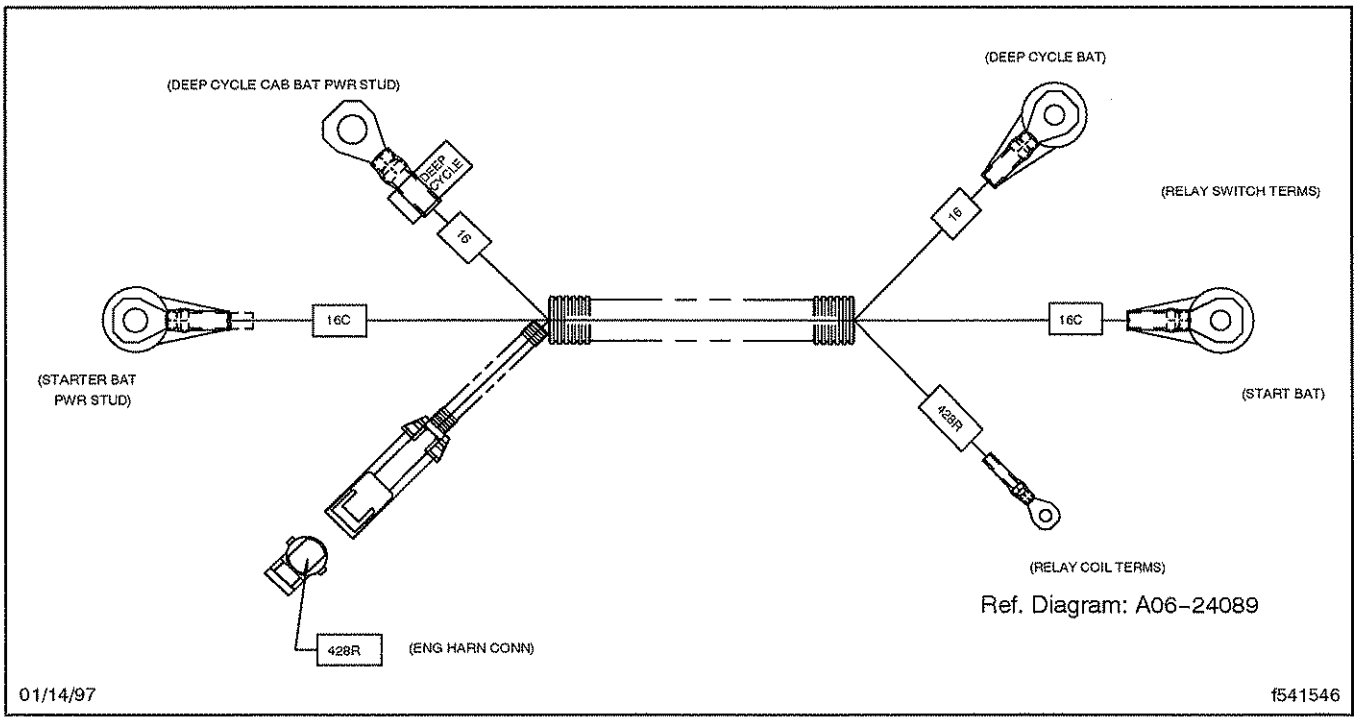


Fig. 8, Isolated Battery 7V Relay Harness

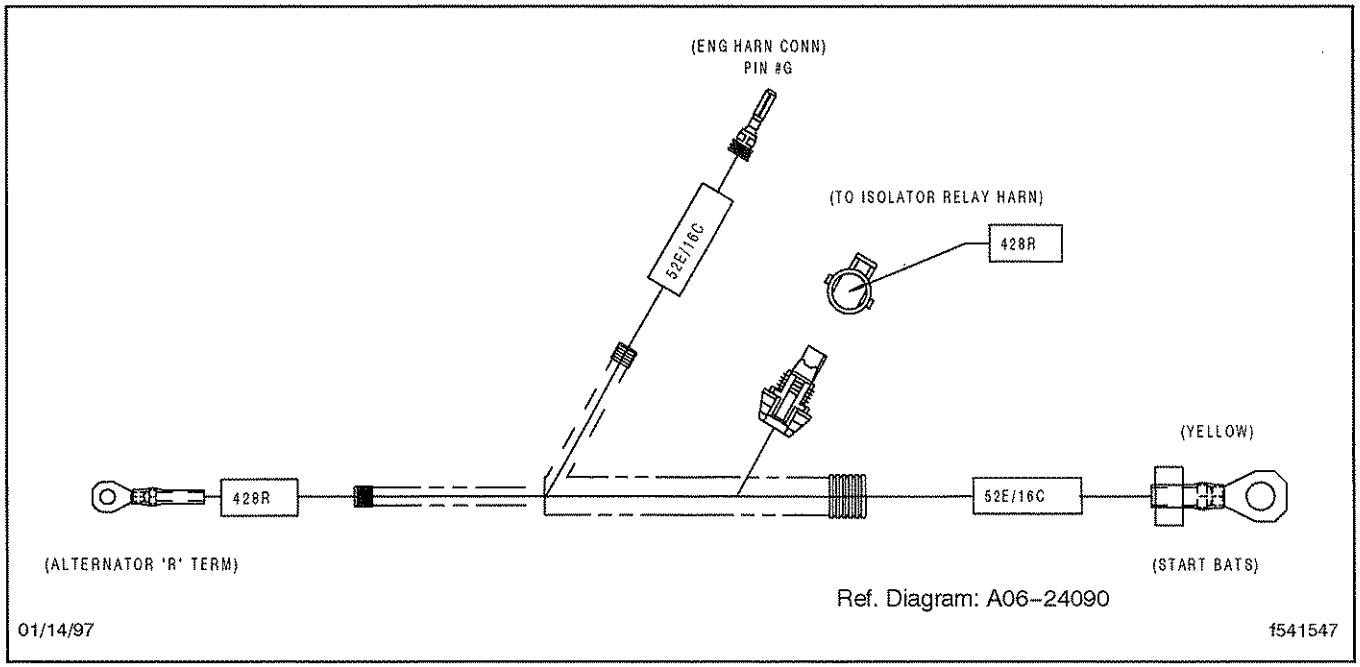


Fig. 9, Isolated Battery Engine Harness, 7V Relay

Specifications

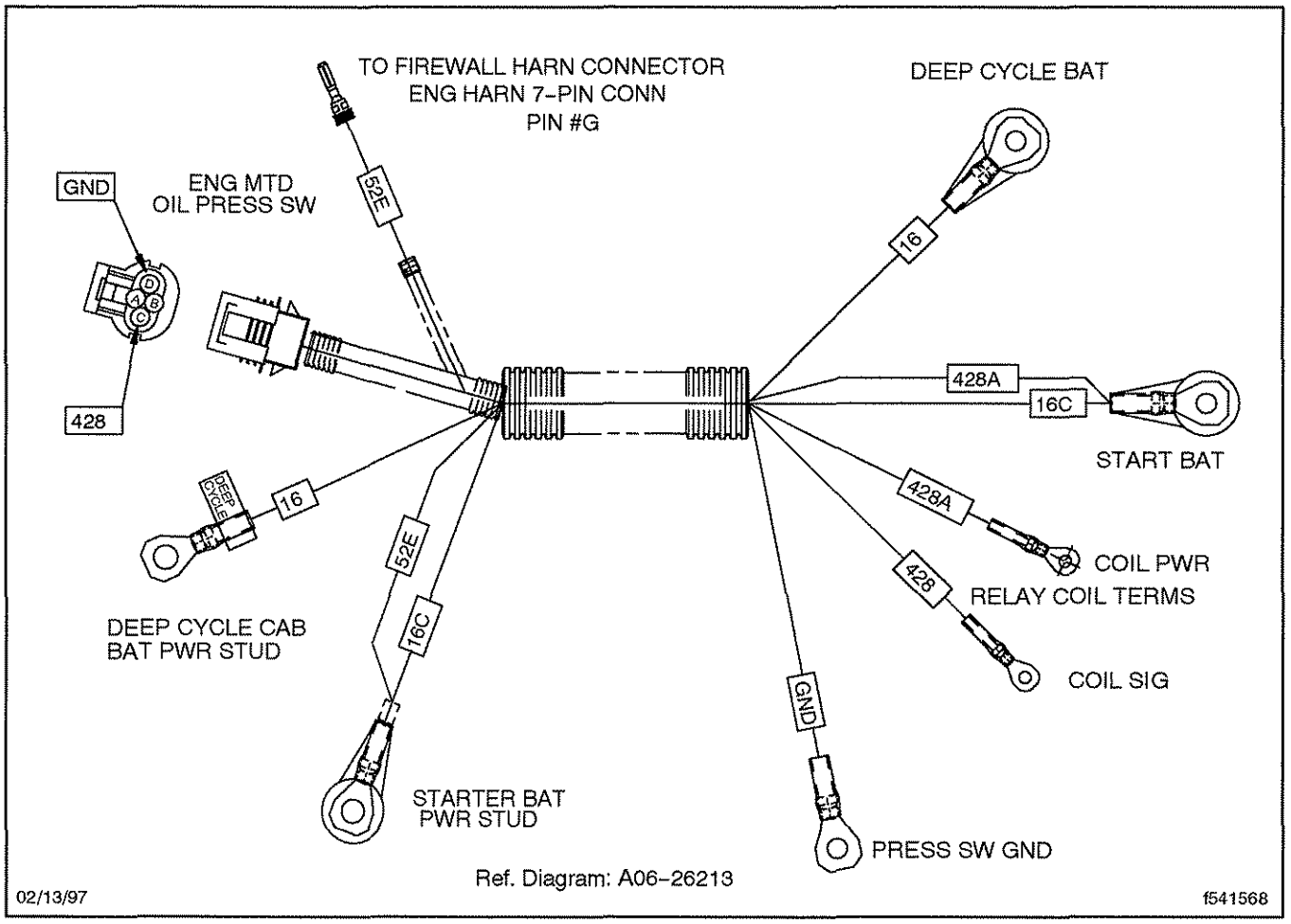


Fig. 10, Isolated Battery Engine Harness, 12V Relay

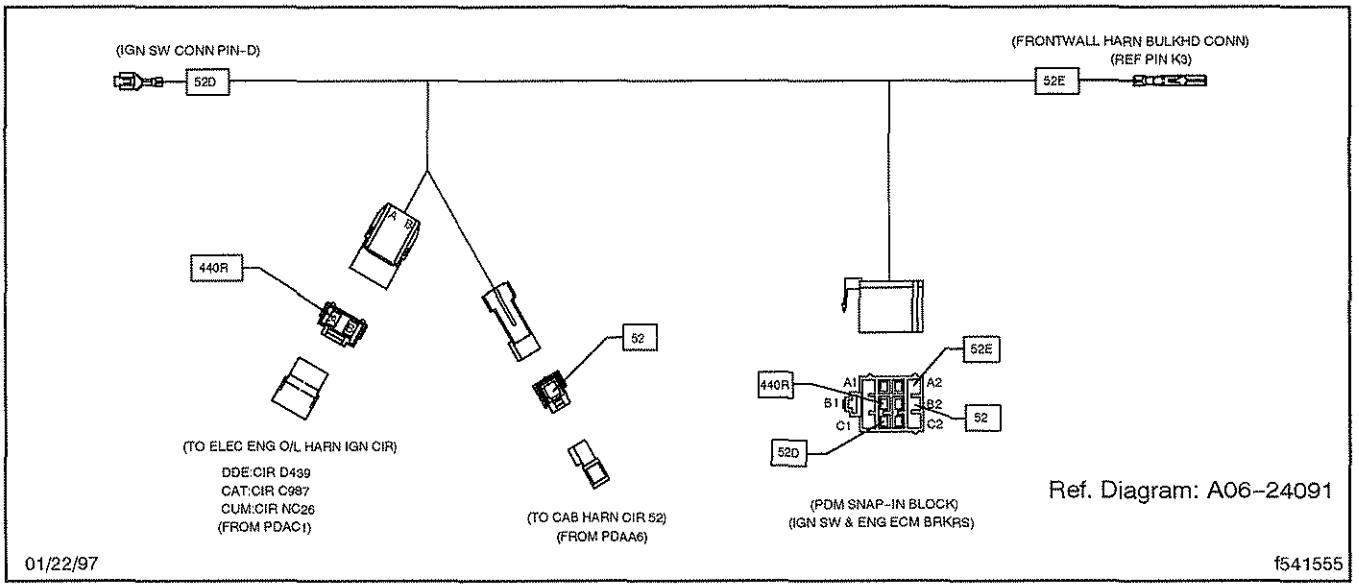


Fig. 11, Isolated Battery Dash Harness

Instrumentation Control Unit 54.03

Contents

Subject	Subject Number
General Information	050
Service Operations	
Instrumentation Control Unit and Auxiliary Instrument Panel Replacement	100
Dash Gauge, Valve, and Switch Replacement	110
ICU Bulb Replacement	120
Buzzer Replacement	130
Dash Driver Display Screen Replacement	140
ICU Keypad Replacement	150
ICU Reconfiguring	160
Display Message Parameter Changing	170
Buzzer Parameter Changing	180
System Configuration Parameter Changing	190
Additional Display Parameter Changing	200
Gauge/Indicator Light Parameter Changing	210
Parameter Changing, Right Microprocessor	220
Troubleshooting	300
Specifications	400

General Description

The instrumentation control unit (ICU) is an integrated electronic dashboard that accepts input from electrical/magnetic vehicle sensors and converts it into digital output that can be fed to an electronic gauge. Only air gauges operate mechanically.

There can be up to 14 gauges on the driver's instrument panel, and, if needed, the ICU can be set up to drive additional gauges located on the auxiliary instrument panel.

The heart of the ICU is the Driver Message Center. It has two parts, a set of 18 warning and indicator lights similar to those found on a conventional lightbar, and a dash driver display screen. The dash driver display screen is a 2-line by 20-character vacuum fluorescent display that provides a wide range of information to the driver.

Some of the information that can be provided by the message center includes:

- odometer readings
- outside air temperature
- messages from remote locations such as company docks and offices, shipper's terminals, etc. (if equipped with a communications system, such as Qualcomm)
- trip information, such as trip miles and hours, idle hours, average mph, and leg miles and hours
- fuel information, such as fuel used and miles per gallon, fuel used idling, and PTO fuel used
- engine information, such as miles, hours, gallons of fuel used, and PTO fuel used
- diagnostic information, such as listings of active faults and troubleshooting information
- vehicle information, such as datalink operation and use data, dash part number, and software number

The ICU is controlled by a keypad located on the auxiliary dash panel. See **Fig. 1**. This keypad, which has 10 keys, can be used to do the following things:

- Call up information onto direct access screens by pressing the appropriate key.
- Move about from screen to screen while the vehicle is stationary.
- Set up the display.
- Record significant data using the EVENT key.

NOTE: One key is blank and is not usable at this time.

To set, press the SET/RESET key once. To reset, press the SET/RESET key once. The confirmation screen appears: PUSH RESET AGAIN/TO CONFIRM CLEAR. Now press the SET/RESET key for a second time.

⚠ CAUTION

Before performing any electric welding on a vehicle, disconnect the battery power and ground cables and the four color-coded electrical connectors from behind the instrumentation control unit (ICU) housing. See Subject 100 in this section for instructions. Electric currents produced during electric welding can damage various electronic components on the vehicle.

Principles of Operation

IGNITION SEQUENCE

When the ignition is turned on, the ICU runs through the ignition sequence. See **Fig. 2**. If the headlights are turned on, the screen displays the odometer and waits for the ignition to be turned on.

IMPORTANT: When the ignition is first turned on, all the electronic gauges complete a full sweep of their dials, the warning and indicator lights light up for five seconds, and the buzzer sounds for two seconds.

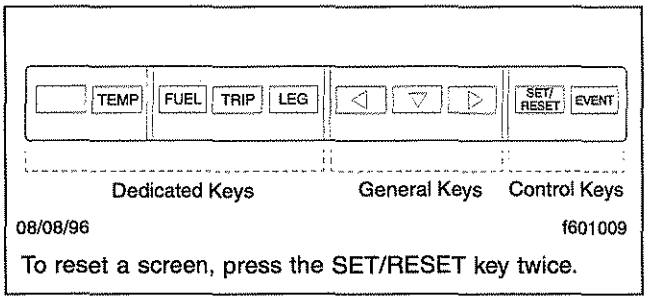
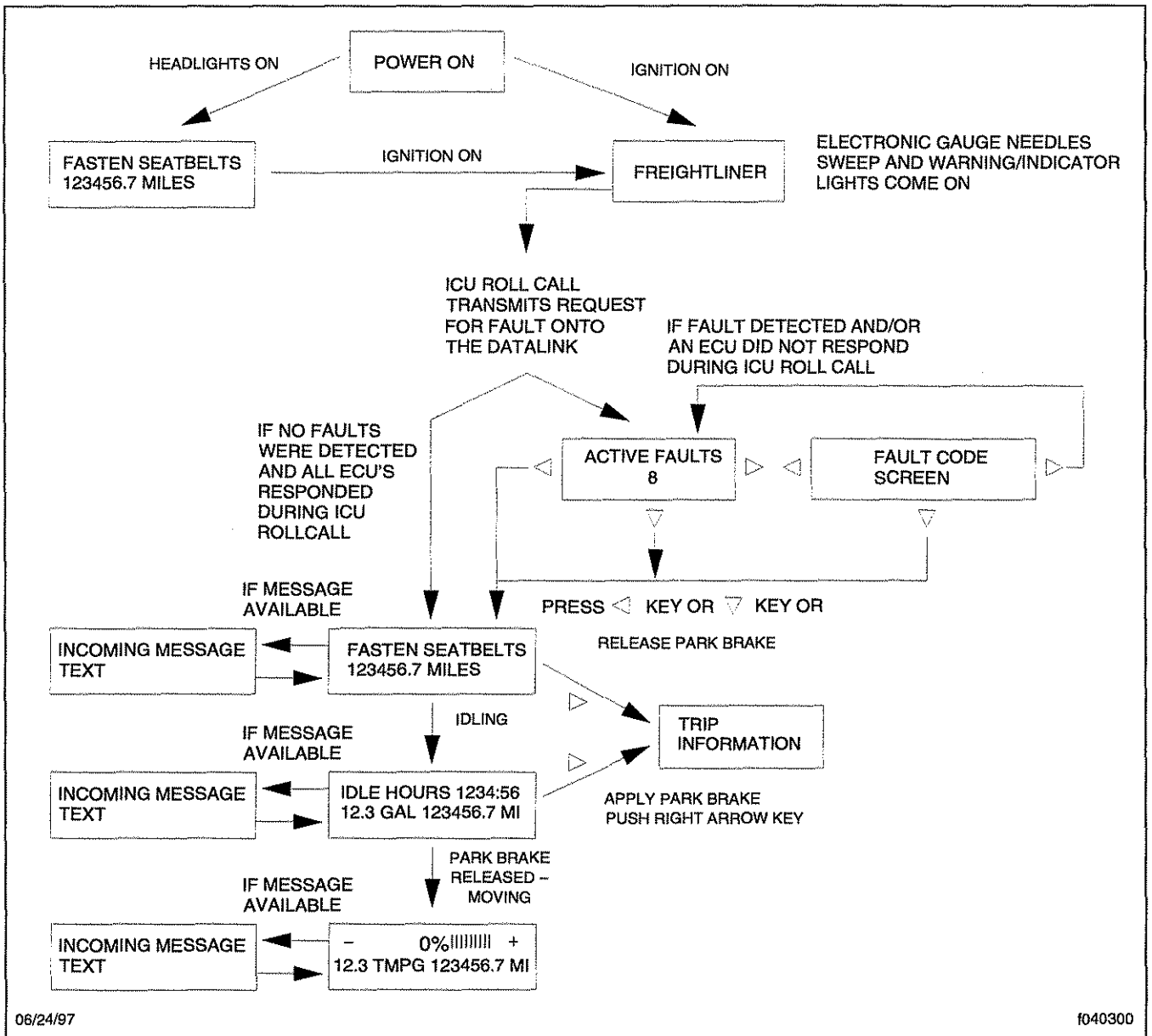


Fig. 1, Keypad

General Information



NOTE: The roll call and incoming message features appear only on ICUs installed with software version 8.4.0 or later (vehicles built on or after March 7, 1997).

Fig. 2, Ignition Sequence

Once the ignition has been turned on, the screen displays the "Freightliner" message. At the same time, the ICU conducts a roll call of all the electronic control units (ECUs) installed on the vehicle, looking for active faults.

NOTE: The roll call function is found only on ICUs installed with software version 8.4.0 or later (vehicles built on or after March 7, 1997).

If there are no active faults, the screen displays the "Fasten Seat Belts/Odometer" screen.

If, however, the ICU has received active fault codes, or an electronic control unit (ECU) fails to respond to the roll call, it shows the "Active Faults" screen and displays the number of active faults, up to a total of eight. If desired, press RIGHT ARROW to see the active fault codes. Otherwise, press LEFT ARROW, or, if the engine is on, release the parking brake to go on to the "Fasten Seat Belts/Odometer" screen.

Unless the engine is running, the ignition sequence ends with the "Fasten Seat Belts/Odometer" screen.

NOTE: At this point, if the vehicle has a communications system and an incoming message is available, it will be displayed. To dismiss the incoming message, press any key on the keypad.

With the engine idling (the vehicle not moving), the ignition sequence cycles on, and displays the "Idle Hours/Idle Gallons..Odometer" screen.

NOTE: To understand the information displayed on the message screen, here is an example of screen layout. On the "Idle Hours/Idle Gallons..Odometer" screen (see **Fig. 2**), idle hours are displayed on the top line with the words "Idle Hours" on the left side of the screen and the number of hours on the right. On the bottom line, the number of idle gallons is on the left and the odometer miles are on the right, with a space in between.

Once the parking brake is released (whether the vehicle is moving or not), the regular message screen display is the "MPG Graph/MPG Value..Odometer" screen. The MPG graph is a dynamic display graph demonstrating how the actions of the driver affect fuel economy. The graph moves to the right as fuel economy improves.

ICU ROLL CALL

NOTE: The roll call function is found only on ICUs installed with software version 8.4.0 or later (vehicles built on or after March 7, 1997).

Each time the ignition keyswitch is turned on, the ICU roll call function requests data from each ECU on the databus. If the ECU does respond to this request, the databus is communicating with that ECU and no fault code is displayed.

NOTE: Each ICU is configured to receive responses from a list of selected ECUs, as installed on that particular vehicle.

If the ECU does not respond to this request, the ICU displays an active fault code that indicates the databus is not communicating with that ECU. For sample fault codes of this type, see **Table 1**.

The roll call is initiated by the ICU, and so it is the ICU that actually reports these fault codes. Logically, a unit can not report that it is not reporting. However, for convenience in troubleshooting and to better identify the non-reporting unit, each fault code reports the MID of the non-responding ECU.

ICU Roll Call Fault Codes	
Fault Code	**Description**
ENG Controller NoRESPONSE128s254 07	The engine ECM did not respond
Trans Controller NoRESPONSE130s254 07	The electronic transmission ECU did not respond
Brake Controller NoRESPONSE136s254 07	The antilock brake system (ABS) ECU did not respond
CMPTR Controller NoRESPONSE179s254 07	The data logging unit (DLU) did not respond
Sat1 Controller NoRESPONSE181s254 07	The Qualcomm® communications system did not respond
A/C Controller NoRESPONSE190s254 07	The air conditioning protection unit (ACPU) did not respond

General Information

ICU Roll Call Fault Codes	
Fault Code	**Description**
Radar Controller NoRESPONSE219s254 07	The VORAD collision warning system did not respond
Sat1 Controller NoRESPONSE231s254 07	The HighwayMaster® communications system did not respond

Table 1, ICU Roll Call Fault Codes

ODOMETER

The odometer is a seven-digit display with one decimal point after the sixth digit, allowing it to display tenths of miles (or kilometers). To make it more similar to mechanical odometers, the odometer always displays seven digits, including leading zeros.

Example: 000456.7

NOTE: Other features that display numbers, such as trip miles (kilometers), or miles per gallon (kilometers per liter), only display meaningful digits, and do not show the leading zeros.

When first installed, the odometer starts at 000000.0 miles (or kilometers). When replaced, the odometer does not start with the engine miles, but starts again from 000000.0 and cannot be changed, either up or down.

IMPORTANT: Although the odometer uses data supplied by the engine ECM to update its count, it keeps its own mileage starting from the zero point, which marks where it was first installed.

ALERT SCREENS

Alert screens appear when the vehicle is moving; they override the regular screen display. They are warnings, cautions, or other messages that require the driver's attention, but not all of them are critical to the operation of the vehicle.

Alert screens appear whenever the condition occurs. All priority 1 and 2 messages, plus "Turn Signal On" (priority 5) show the word "WARNING," blinking on and off, on the first line of the display.

NOTE: Warning messages always display at full brightness.

There are currently eleven alert screens arranged in seven priority levels. See **Table 2**.

Priority	Alert Screen Description
1	Park Brake On
2	Low Oil Pressure
	High Coolant Temp
	Low Coolant Level
	Low Voltage
3	Faulty Speedo Gauge
4	HVAC Recirculation Messages*
5	Turn Signal On
6	Incoming Message*
7	No Datalink Activity

* Found only on ICUs installed with software version 8.4.0 or later (vehicles built on or after March 7, 1997).

Table 2, Alert Screen Priority Levels

Priority 1 Screen

The "Park Brake On" screen overrides any other screen message. See **Fig. 3**. It comes on, with the buzzer sounding, only when the vehicle is moving at a speed greater than 2.5 miles per hour. It can be dismissed, and the buzzer turned off, only by releasing the parking brake.

NOTE: If the "Park Brake On" screen remains on after the brake is physically released, check the parking brake switch for proper function.

Priority 2 Screens

The "Low Oil Pressure" screen comes on whether the vehicle is idling or in motion. See **Fig. 4**.

The "High Coolant Temp" screen has the same priority as "Low Oil Pressure." See **Fig. 5**. The same is true of "Low Coolant Level" (see **Fig. 6**) and "Low Voltage" (see **Fig. 7**).

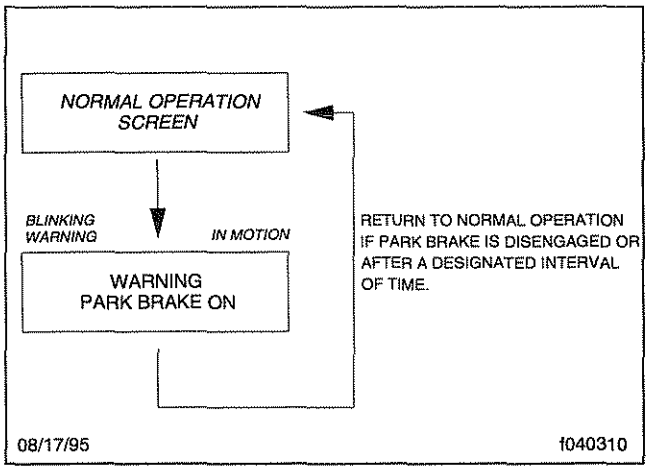


Fig. 3, Park Brake On

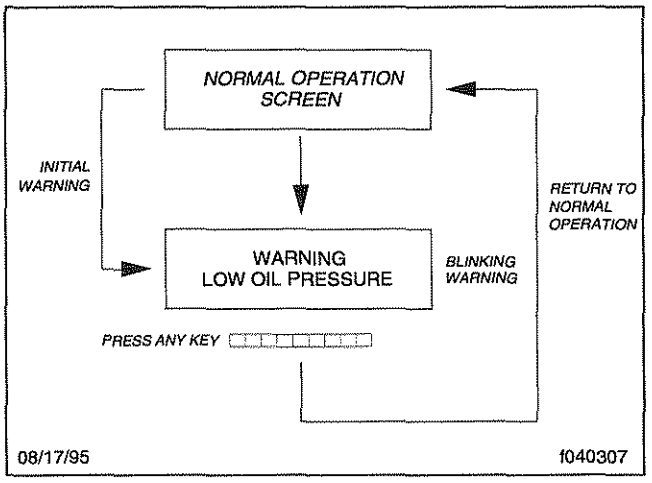


Fig. 4, Low Oil Pressure

Priority 2 screens appear on the dash display as soon as the message is received on the datalink and remain on until any key is pressed. After a key is pressed, the message is dismissed and the dash display returns to the previous screen.

If more than one alert screen message is received, pressing any key dismisses the first message and displays the next, and so on until all the messages have been received.

After 30 seconds, the message is displayed again, and can be dismissed, as before, by pressing any key.

NOTE: Priority 2 screens do not override the ignition sequence (the sequence that runs when the ignition keyswitch is first turned on). Instead, they are displayed as active faults. Press RIGHT ARROW to see the active faults. For more information on the ignition sequence, see "Ignition Sequence" in this subject.

Priority 3 Screen

The "Faulty Speedo Gauge" screen turns on the alternate speedometer when the ICU detects a faulty speedometer gauge. See **Fig. 8**. Once the alternate speedometer has been turned on, it replaces the "MPG Bar Graph" as the regular screen until the speedometer gauge is replaced.

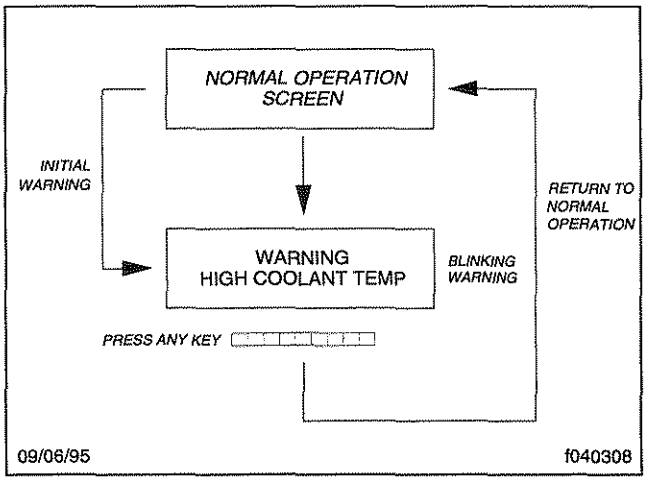


Fig. 5, High Coolant Temperature

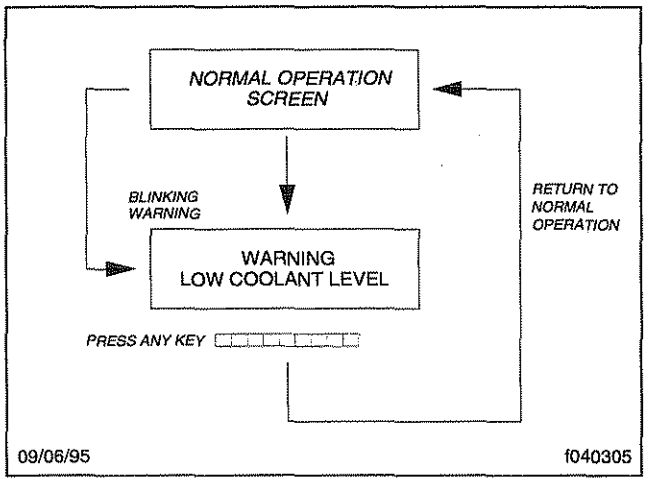


Fig. 6, Low Coolant Level

General Information

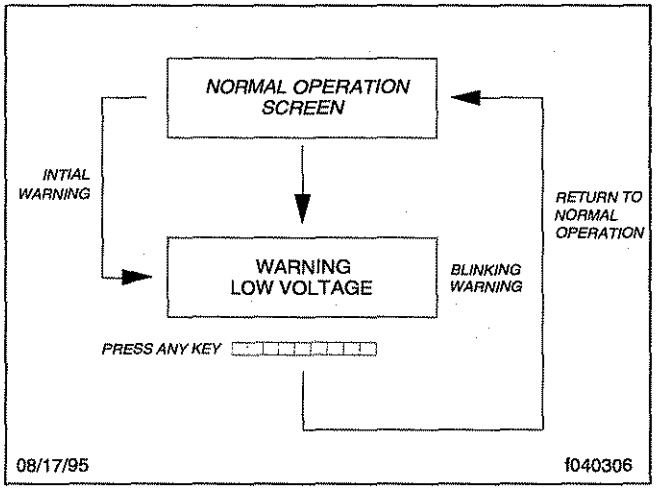


Fig. 7, Low Voltage

Priority 4 Screens

There are two HVAC (heating, ventilation, and air conditioning) recirculation screens: "Recirc Mode Engaged" and "Provide Fresh Air."

NOTE: HVAC recirculation screens appear only on ICUs installed with software version 8.4.0 or later (vehicles built on or after March 7, 1997).

The "Recirc Mode Engaged" screen comes on whenever recirculated air is selected on the fresh/air recirculation switch, or the air circulation switch is rotated to the maximum air conditioning position. See **Fig. 9.** It displays one time only for seven seconds and notifies the driver that recirculated air is being used and that fresh air needs to be provided within at least 20 minutes.

If fresh air is not provided within that time span, the "Provide Fresh Air Message" is displayed. See **Fig. 10.** It displays for seven seconds every 254 seconds until the driver switches to fresh air, either by selecting fresh air on the fresh/air recirculation switch, or by rotating the air circulation switch away from maximum air conditioning and to one of the other positions.

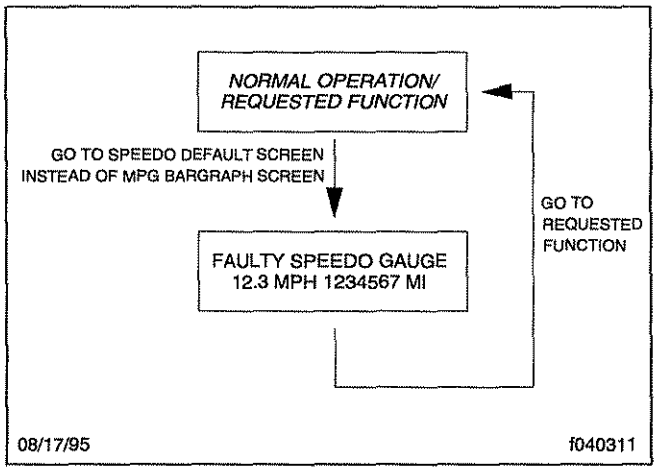


Fig. 8, Faulty Speedo Gauge, or Alternate Speedometer Screen

Priority 5 Screen

The "Turn Signal On" screen is also connected to the buzzer (the buzzer connection can be disabled, if desired). See **Fig. 11.** It notifies the driver that the turn signal is on. On vehicles equipped with daytime running lights, the daytime running light is not on when the turn signal is flashing.

To dismiss this screen, either turn off the turn signal, or press any key.

Priority 6 Screen

The "Incoming Message" screen comes on whenever the communications system receives a message. See **Fig. 12.** It displays one time only and can be dismissed by pressing any key.

NOTE: The incoming message screen appears only on ICUs installed with software version 8.4.0 or later (vehicles built on or after March 7, 1997).

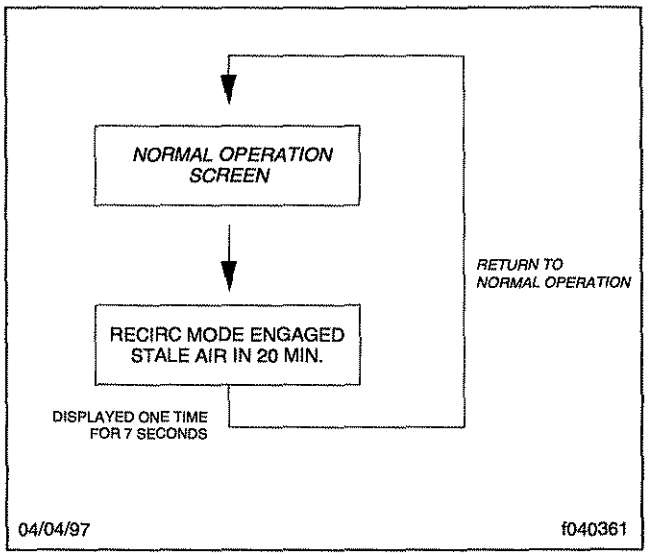


Fig. 9, Recirc Mode Engaged

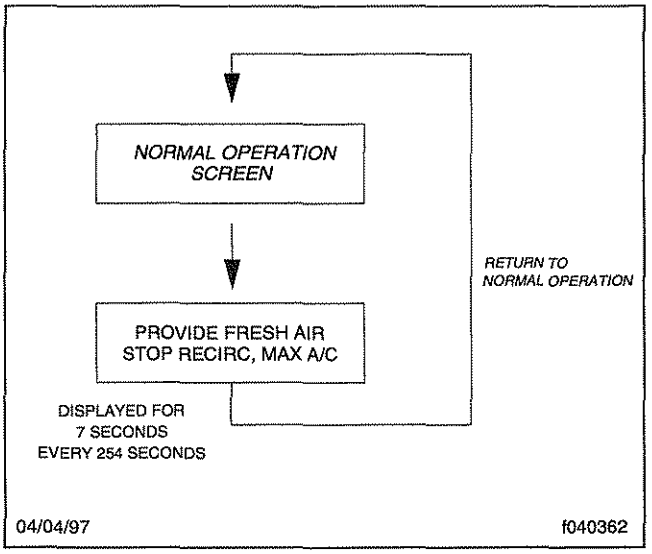


Fig. 10, Provide Fresh Air

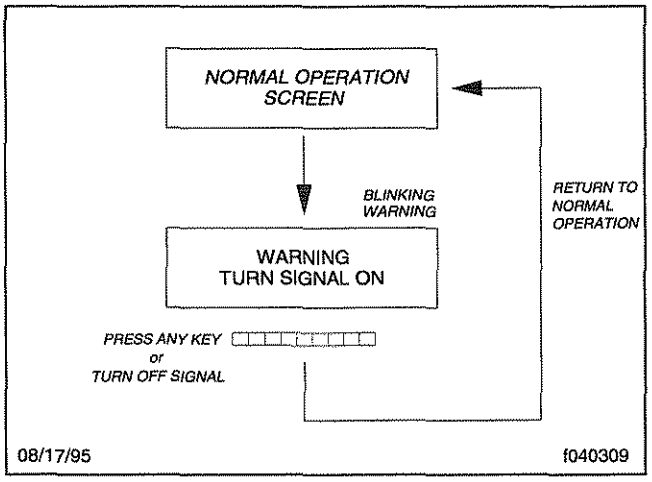


Fig. 11, Turn Signal On

NOTE: The "Incoming Message" screen also displays during the ignition sequence, in case a message came in while the vehicle was not operating.

Priority 7 Screen

The "No Datalink Activity" screen comes on whenever the datalink is not receiving data. See **Fig. 13**.

This screen is a diagnostic tool. For information on how to use this screen to check the datalink wiring, see **Troubleshooting 300**.

DIRECT ACCESS SCREENS

The driver can also override the regular screen display at any time by pressing the keypad to display one of the direct access screens. For a list of the direct access screens, see **Table 3**.

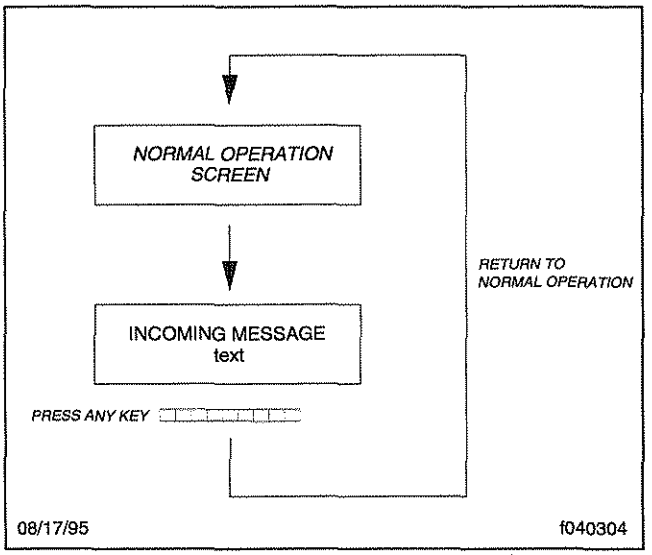


Fig. 12, Incoming Message

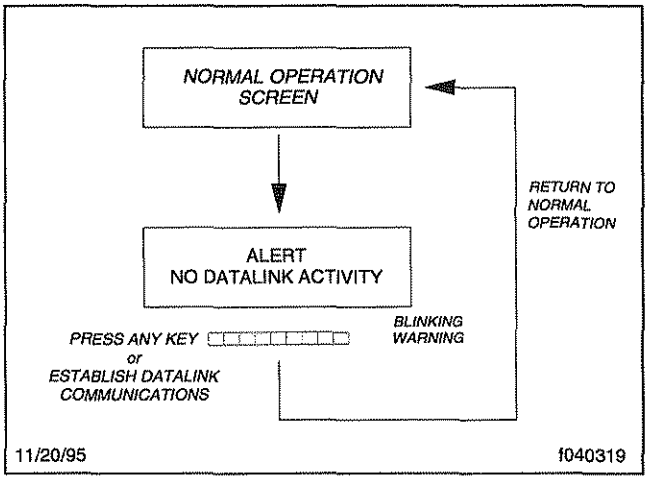


Fig. 13, No Datalink Activity

General Information

Key	Screen Contents	Reset?
TRIP	TRIP MILES 123456.7 TRIP HOURS 1234:56	Yes
FUEL	FUEL USED 12345.6 AVERAGE MPG 12.34	Yes
LEG	LEG MILES 123456.7 LEG HOURS 1234:56	Yes
EVENT	DATA BEING RECORDED	No
TEMP	OUTSIDE AIR TEMPERATURE -12F	No

Table 3, Direct Access Screens

To reset the data displayed on TRIP, FUEL or LEG screens back to zero, press the SET/RESET key twice with the screen displayed.

NOTE: Resetting "Leg Miles and Hours" also resets "Trip Miles and Hours."

Use the EVENT key to record data about a significant driving event (engine problem, driving problem, unusual vehicle operation, etc.). The other keys are used for informational purposes.

NOTE: Normally, the screen displays DATA BEING RECORDED as shown in **Table 3**. However, if the memory in the data logger is full, the screen instead displays MEMORY FULL/DATA NOT RECORDED. If the data logger is not connected or not responding, the screen displays DATA RECORDER/NOT RESPONDING. If the EVENT key was pressed recently (within the last two minutes), the screen displays STILL RECORDING/LAST EVENT.

All keys display their data for a programmable period of time. This time period is a *resetable parameter* and can be set individually for each direct access screen.

The three screens that display trip-related data (Trip, Fuel, and Leg) can have their display time reset independently of each other, to display for from one to 254 seconds at a time. Resetting the Trip, Fuel, or Leg screen in direct access also resets the display time for the corresponding screen when the vehicle is not moving. For more information, see "Stationary Access Screens."

The time of display on the other two direct access screens (Event and Temp) cannot be reset except at the factory.

STATIONARY ACCESS SCREENS

The stationary access screens are a series of informational displays that give driver, maintenance, and service information.

For reasons of safety, stationary access screens can be seen only when the vehicle is not moving and the parking brake is applied.

There are six sets of stationary access screens:

- Trip Information (see **Fig. 14**)
- Fuel Information (see **Fig. 14**)
- Engine Information (see **Fig. 14**)
- Diagnostic Information (see **Fig. 15**)
- Setup Information (see **Fig. 16**)
- Vehicle Information (see **Fig. 16**)

Each set of stationary access screens has a title screen followed by one or more data screens. To move forward and backward through these screens, use the three arrow keys as shown in **Fig. 14**, **Fig. 15**, and **Fig. 16**.

Trip Information

Trip information provides three data screens: "Trip Miles and Hours," "Idle Hours and Average MPH," and "Leg Miles and Hours." See **Fig. 14**.

"Trip Miles and Hours" displays the number of miles and hours driven since the start of the trip. At the start of a trip, press RESET (SET/RESET twice) to set trip miles and hours back to zero.

NOTE: Resetting "Trip Miles and Hours" also resets "Idle Hours and Average MPH."

"Idle Hours and Average MPH" displays the hours spent idling and the average miles per hour.

"Leg Miles and Hours" records the number of miles and hours driven since the start of the leg. At the start of a new leg, press RESET to set leg miles and hours back to zero.

NOTE: Resetting "Leg Miles and Hours" also resets "Trip Miles and Hours."

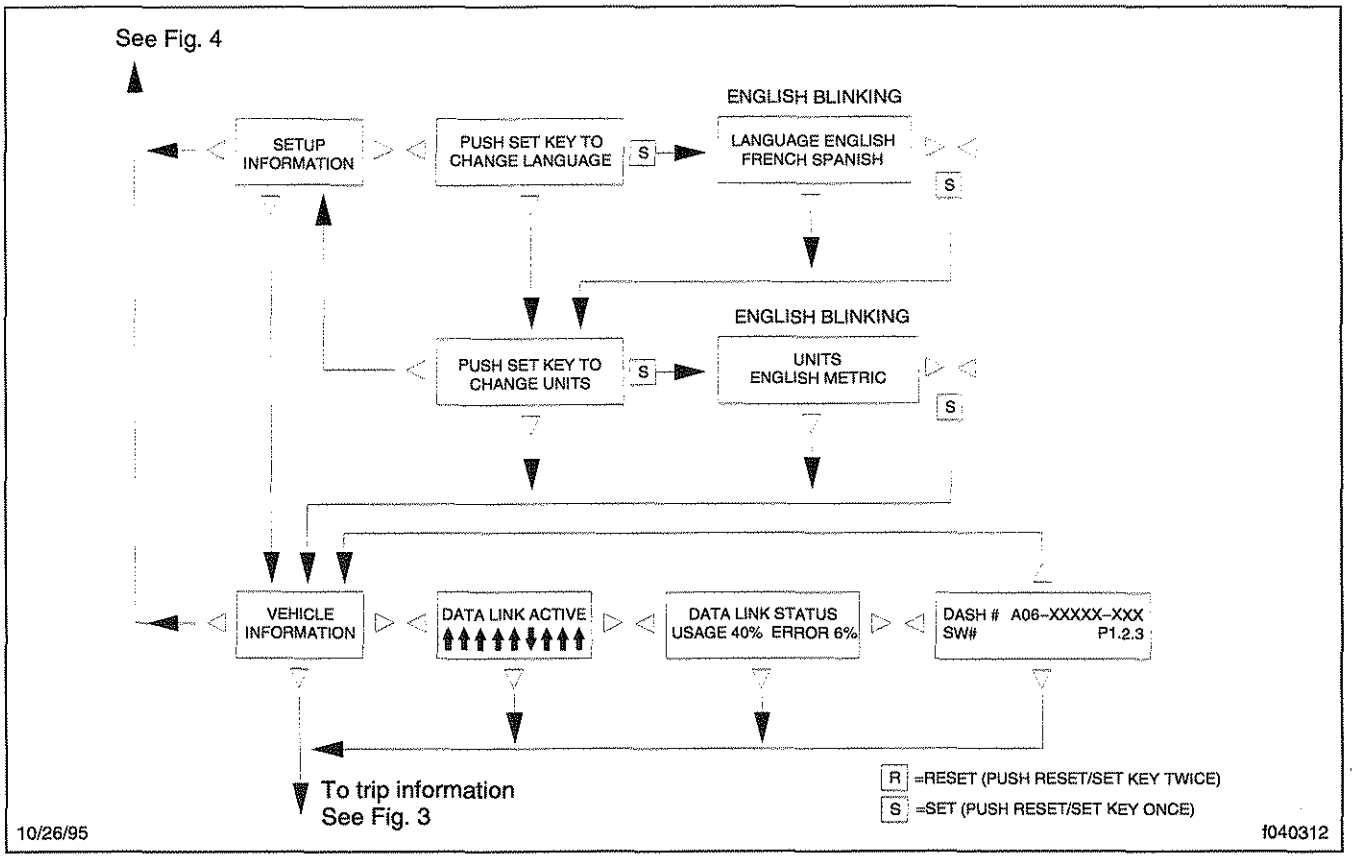


Fig. 16, Setup Information and Vehicle Information

"Historical Dash Faults" displays all dash faults since the last reset. The second line of the display shows the mileage the last time faults were cleared.

Setup Information

Setup information allows the user to change the language of the display (English, French, or Spanish), and the units of measurement (English/US conventional or metric).

When prompted by the screen, press SET (push the SET/RESET key once). The units that are settable will be blinking. Use the arrow keys (LEFT, RIGHT, and DOWN) until the display shows the desired setup. See **Fig. 16**.

Vehicle Information

Vehicle information displays important vehicle information, including datalink activity and status, ICU part number, and software identification number.

The "Datalink Active" screen is a dynamic display that shows if the datalink unit is active at the given time. If all the arrows are pointing down, the ICU has not received any information on the datalink since the last time the ignition keyswitch was turned on.

The "Datalink Status" screen is also dynamic, showing current datalink use and error rate. The other screen, which shows the ICU part number and the software identification number, is informational only. See **Fig. 16**.

After vehicle information, pressing the DOWN ARROW takes you back to trip information, and so on.

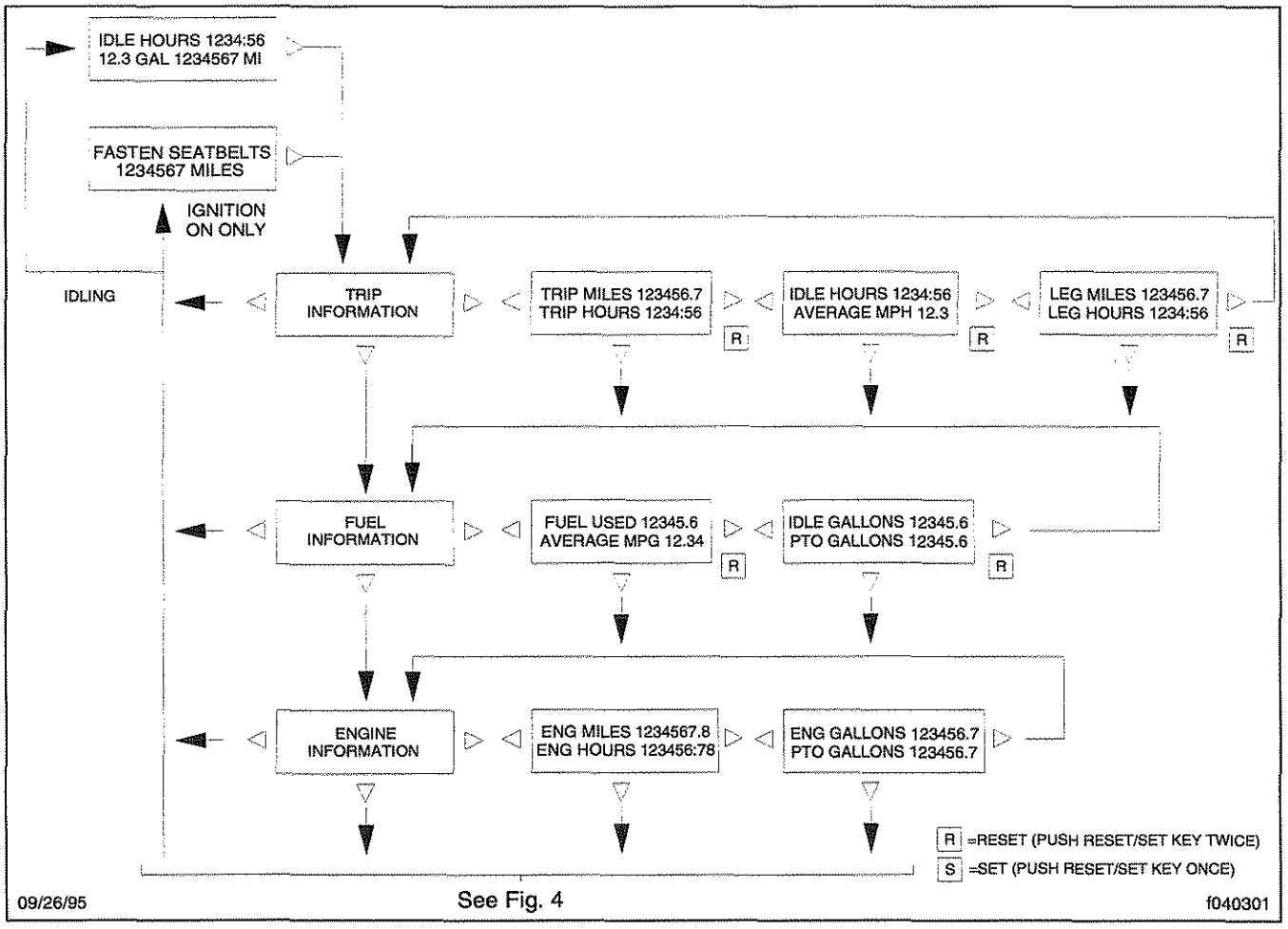


Fig. 14, Trip Information, Fuel Information, and Engine Information

Fuel Information

Fuel information provides two data screens: "Fuel Used and Average MPG," and "Idle Gallons and PTO Gallons." See **Fig. 14**.

"Fuel Used and Average MPG" displays the gallons of fuel used since the last reset. At the start of a trip, after refueling, or whenever desired, press RESET (SET/RESET twice) to set fuel used and average miles per gallon back to zero.

NOTE: Resetting "Trip Miles and Hours" does not also reset "Fuel Used and Average MPG" or "Idle Gallons and PTO Gallons." Fuel Information must be reset separately.

"Idle Gallons and PTO Gallons" displays the gallons of fuel used idling and to operate the Power Take Off unit (if installed). At the start of a trip or whenever desired, press RESET to set idle gallons and PTO gallons back to zero.

Engine Information

Engine information provides two data screens: "Engine Miles and Hours," and "Engine Gallons and PTO Gallons." See **Fig. 14**.

"Engine Miles and Hours" displays the total miles and hours logged by the engine since installation.

NOTE: Engine information is supplied by the engine Electronic Control Module (ECM). It cannot be reset except when installing a new engine.

General Information

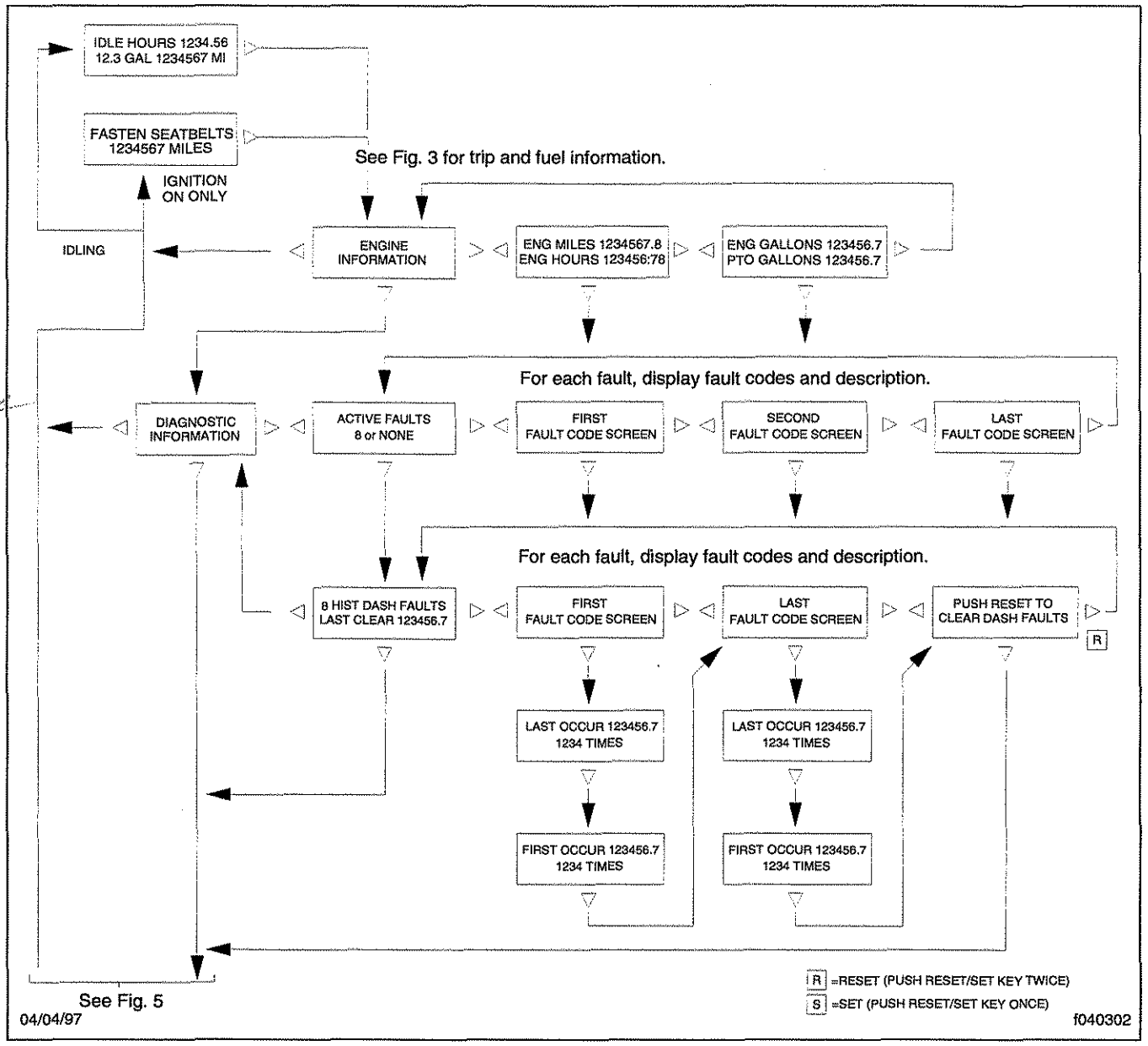


Fig. 15, Engine Information and Diagnostic Information

"Engine Gallons and PTO Gallons" displays the gallons of fuel used by the engine and PTO since installation.

Diagnostic Information

Diagnostic information provides two sets of data screens: "Active Faults," followed by a separate screen for each fault until all have been shown; and "Historical Dash Faults," also followed by a separate screen for each fault until all have been shown. See **Fig. 15**.

"Active Faults" cannot be reset. Active faults can be cleared only by correcting the fault.

Instrumentation Control Unit and Auxiliary Instrument Panel Replacement

Instrumentation Control Unit Replacement

The ICU includes the driver's instrument panel, the ICU housing, and the Driver Message Center (all installed as one unit). Input to the ICU comes from the keypad and the electronic gauges. See **Fig. 1**.

To replace a complete ICU with a new set of gauges, see "ICU (With Gauges)." To replace an ICU and reinstall the old set of gauges, see "ICU (Without Gauges)."

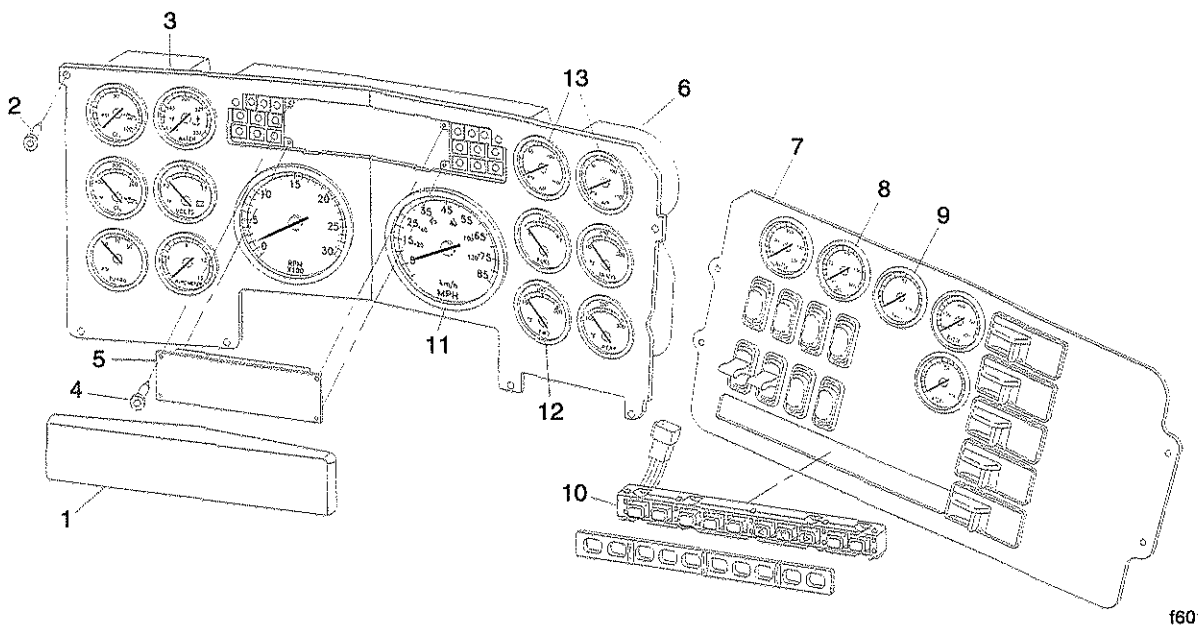
To replace individual gauges, switches, or flipper valves, see **Subject 110**. To replace light bulbs (gauge light, or warning and indicator light), see **Subject 120**. To replace the warning buzzer, see **Subject 130**. To replace the dash driver display screen, see **Subject 140**. To replace the keypad, see **Subject 150**.

ICU (With Gauges)

1. Remove the left-hand dash panels. Be sure the screws attaching the dash panel trimtop to the upper dash assembly have been removed. For instructions, see **Section 60.08**.
2. Remove the screw attaching the dash panel trimtop to the lower dash panel. This screw is located on the far left of the trimtop.

⚠ CAUTION

Electronic components of the ICU are vulnerable to damage from static electricity. If available, wear a wrist grounding strap connected to a ground in the cab or workbench. If a grounding strap is not available, touch a grounded component immediately before doing any work which could bring a tool or body part in contact with ICU circuitry.



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1. Message Center Bezel
2. Dog-Point Screw
3. Driver's Instrument Panel (A-panel)
4. Display Screen Screw
5. Dash Driver Display Screen
6. ICU Housing
7. Auxiliary Instrument Panel
8. Electrical or Electronic Gauge (B-panel mounted)
9. Mechanical Gauge (B-panel mounted)
10. Keypad
11. Electronic Gauge (large face)
12. Electronic Gauge (small face)
13. Mechanical Gauge (A-panel mounted)

Fig. 1, Instrumentation Control Unit

Instrumentation Control Unit and Auxiliary Instrument Panel Replacement

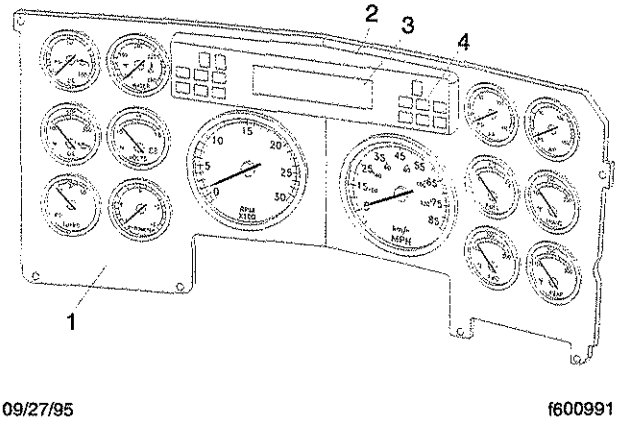
3. Remove the fasteners from the driver's instrument panel. See **Fig. 2**. Fasteners used on the ICU are T25 Torx-head dog-point screws. See **Fig. 3**.

   3.1 Remove the bezel from the Driver Message Center, exposing the two screws underneath it. For more information, see **Subject 140**.

   3.2 Remove the two screws underneath the Driver Message Center bezel.

   3.3 Remove the four screws on the bottom of the driver's panel.

   3.4 Remove the two screws on the sides of the driver's panel.



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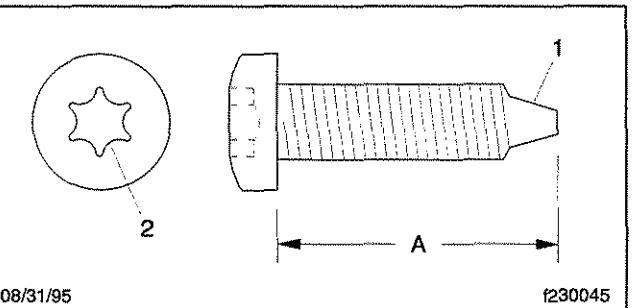
1. Driver's Instrument Panel (A-panel)
2. Driver Message Center
3. Dash Driver Display Screen
4. Warning and Indicator Lights

Fig. 2, Driver's Instrument Panel



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A. 3/4 Inch (19 mm)
1. Dog Point 2. Torx Head

Fig. 3, Dog-Point Screw

⚠ CAUTION

When removing the ICU, the wiring harness may have to be loosened before the driver's panel can be pulled free of the dash. Do not forcibly pull the driver's panel from the dash. This may disconnect wires from the harness electrical connectors on the back of the ICU housing and damage them.

4. Pull the ICU away from the dash.

   4.1 From behind the ICU housing, disconnect the four color-coded electrical connectors.

   4.2 Disconnect all air hoses. Using a paint pen, mark the hoses for ease of installation.

   4.3 Remove the ICU from the dash.

5. Remove the ICU from the dash. See **Fig. 4**.

   5.1 Remove the three screws and speed nuts attaching the dash panel trimtop to the ICU.

   5.2 Install the dash panel trimtop on the new ICU.

6. Install the ICU on the dash.

   6.1 Connect the air hoses to the air gauges as marked on removal.

   6.2 Connect the four color-coded electrical connectors, as removed.

   6.3 Place the new ICU in the dash and install the fasteners. Be sure to install the fasteners that attach the dash panel trimtop to the upper dash assembly and lower dash panel.

IMPORTANT: A typical warning and indicator light layout is shown in **Fig. 5**.

7. Install the Driver Message Center. See **Fig. 5**.

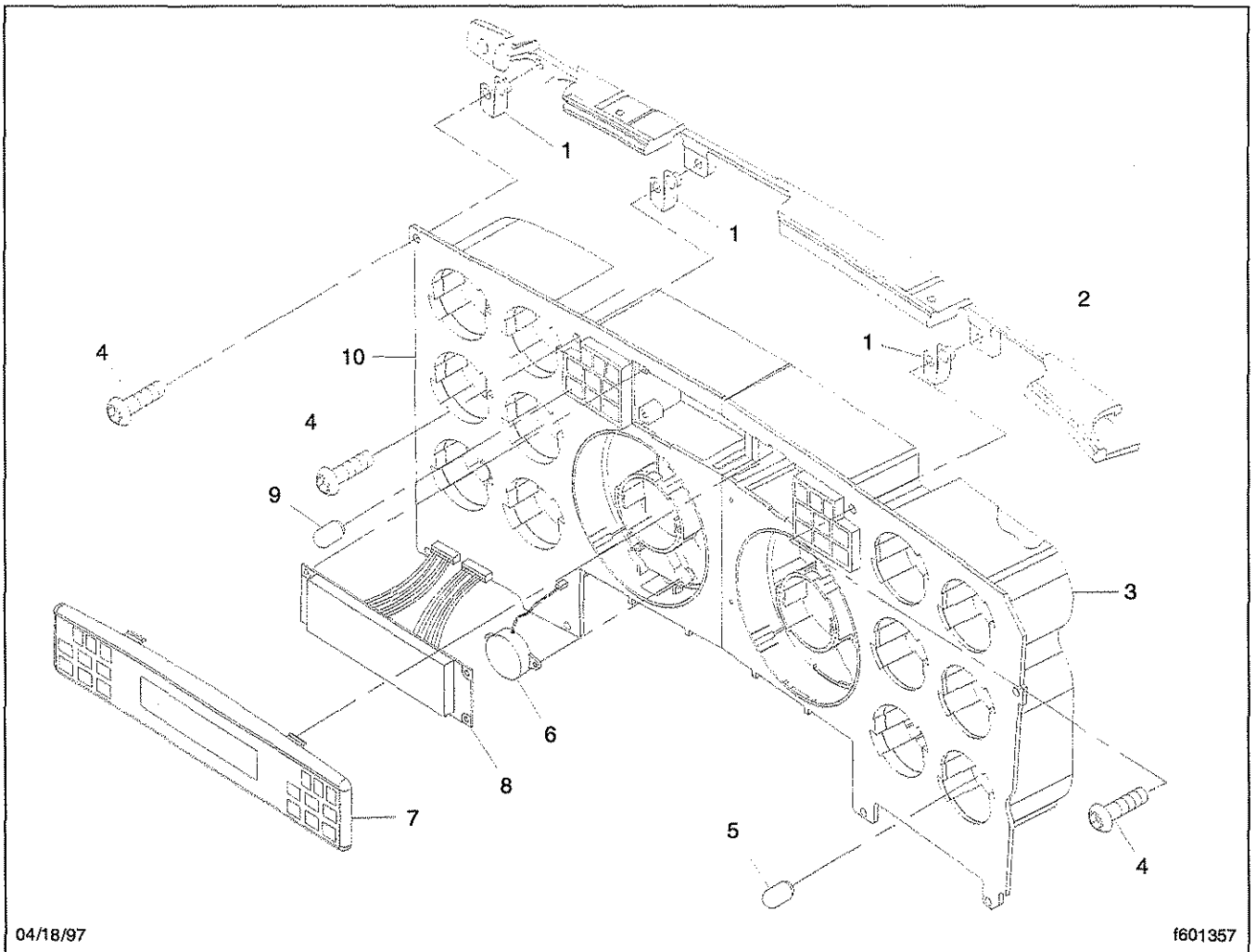
   7.1 Remove the bezel from the Driver Message Center on the old ICU.

⚠ CAUTION

Be careful not to scratch the bezel. Scratches on the inside of the bezel are visible from the front.

   7.2 Snap the old message center bezel into place on the new ICU.

Instrumentation Control Unit and Auxiliary Instrument Panel Replacement



NOTE: Gauges have been removed.

1. Speed Nut
2. Dash Panel Trimtop
3. ICU Housing, RH
4. T25 Dog-Point Screw
5. Gauge Light Bulb
6. Buzzer
7. Message Center Bezel
8. Dash Display Screen
9. Warning and Indicator Light Bulb
10. ICU Housing, LH

Fig. 4, ICU Housing

8. Check the gauge layout of the new unit and compare it to the old unit.

   8.1 If any positions are different, replace the gauge for that position with the correct gauge from the old unit. For gauge replacement procedures, see **Subject 110**.

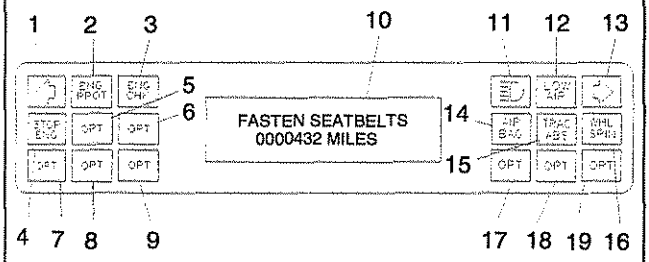
   8.2 Reconfigure the ICU to its original factory settings. For instructions, see **Subject 160**.

NOTE: Mechanical (air) gauges do not make a sweep.

9. Turn on the ignition and test the operation of the new ICU. All the electronic gauges (except the voltmeter) should make one complete sweep and return to their normal indicating positions; the warning and indicator lights should turn on, then off.

   If any gauges are not working properly, they will need to be serviced or replaced.

Instrumentation Control Unit and Auxiliary Instrument Panel Replacement



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Typical installation shown. Location and function of optional lights may vary.

1. Left Turn Indicator
2. Engine Protection Warning & Indicator
3. Check Engine Indicator
4. Stop Engine Warning (Cummins engine only)
5. ECAS Failure Warning (optional)
6. ECAS Transfer Indicator (optional)
7. Trailer ABS Warning (optional)
8. Alternator No Charge Warning (optional)
9. Automatic Transmission Warning (optional)
10. Dash Driver Display Screen
11. High Beam Indicator
12. Low Air Warning
13. Right Turn Indicator
14. Air Bag Warning (optional)
15. Tractor ABS Warning
16. Wheel Spin Warning
17. Optional Indicator 6
18. Low Voltage Warning (optional)
19. Optional Indicator 8

Fig. 5, Driver Message Center

ICU (Without Gauges)

1. Remove the left-hand dash panels. For instructions, see **Section 60.08**.
2. Remove the fasteners from the driver's instrument panel and dash panel trimtop. See **Fig. 2**. Fasteners used on the ICU are 10-16 Torx-head dog-point screws. See **Fig. 3**.
   - 2.1 Remove the bezel from the Driver Message Center, to expose the two screws underneath it. Remove these two screws.
   - 2.2 Remove the four screws on the bottom of the driver's panel.
   - 2.3 Remove the two screws on the sides of the driver's panel.
3. Note the gauge layout for later installation. Any gauge pigtails that have been rerouted on the disconnected ICU will have to be changed on the new ICU. Remove all the gauges. For instructions, see **Subject 110**. Set aside the gauges for later installation in the new panel.
   - 3.1 Remove the two large-face gauges from the center of the driver's panel. See **Fig. 6**.
   - 3.2 Remove the small-face gauges (six maximum) from the left-hand side of the driver's panel. See **Fig. 7**.
   - 3.3 Remove the small-face gauges (six maximum) from the right-hand side of the driver's panel. See **Fig. 8**.

⚠ CAUTION

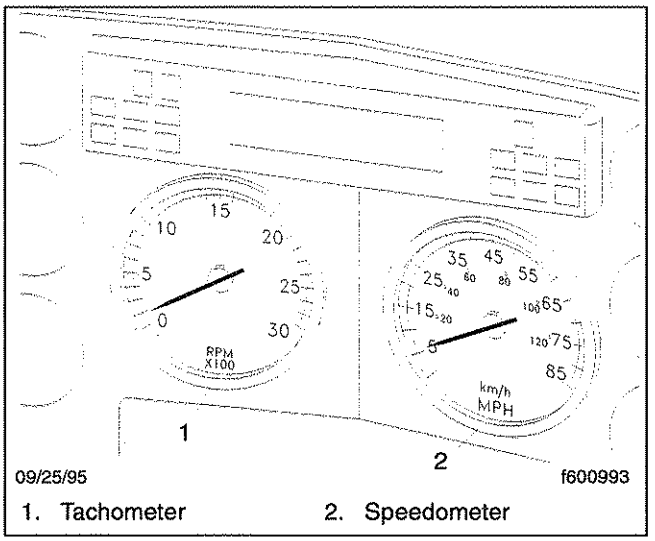
Do not lay gauges face down for long periods of time. The electronic gauges use an oil-dampening fluid that leaks out when the gauge is face down, causing dial movement to become erratic.

4. Remove the ICU from the dash. See **Fig. 4**.
   - 4.1 Remove the three screws and speed nuts attaching the dash panel trimtop to the ICU.
   - 4.2 Install the dash panel trimtop on the new ICU.
5. Install a new ICU in the dash.
   - 5.1 Install all the fasteners as removed, including the fasteners attaching the dash panel trimtop to the upper dashassembly and lower dash panel.
   - 5.2 Install all gauges in the positions from which they were removed. Insert each gauge into its correct hole and twist clockwise about 1/8 turn, until seated.
6. Snap the Driver Message Center bezel into place, using the four small tabs on the sides of the bezel.

NOTE: Mechanical (air) gauges do not make a sweep.

7. Turn on the ignition and test the operation of the gauges. All the electronic gauges (except the voltmeter) should make one complete sweep and return to their normal indicating positions; the warning and indicator lights should turn on, then off.

Instrumentation Control Unit and Auxiliary Instrument Panel Replacement



1. Tachometer 2. Speedometer

Fig. 6, Driver's Panel Gauge Layout – Typical (large-face gauges)

8. Reconfigure the ICU to its original factory settings. For instructions, see **Subject 160**.

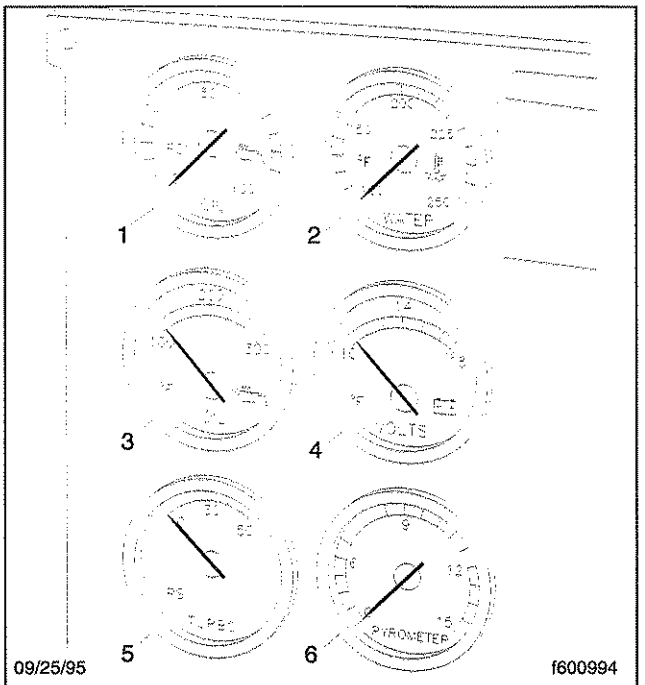
Auxiliary Instrument Panel Replacement

1. Remove the dash panel. For instructions, see the applicable subject in **Section 60.08**.
2. Remove the fasteners from the auxiliary instrument panel. See **Fig. 9**.
   - 2.1 Remove the two screws from the left-hand side of the auxiliary panel.
   - 2.2 Remove the two screws from the right-hand side of the auxiliary panel.

⚠ CAUTION

When removing the auxiliary panel, the wiring harness may have to be loosened before the panel can be pulled free of the dash. Do not forcibly pull the auxiliary panel from the dash. This may disconnect wires from the harness electrical connectors on the back of the auxiliary panel and damage them.

3. Pull the auxiliary panel away from the dash. See **Fig. 9**.



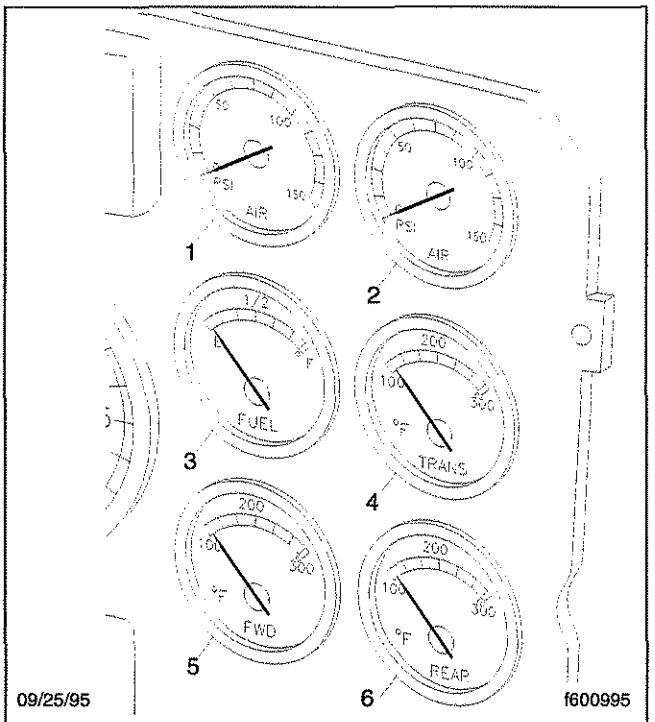
Gauge layouts may vary. To work properly, gauges must be installed in their correct locations or the pigtails must be rerouted.

1. Oil Pressure Gauge
2. Water Temperature Gauge
3. Oil Temperature Gauge (optional)
4. Voltmeter
5. Turbo Air Pressure Gauge (optional)
6. Pyrometer (optional)

Fig. 7, Driver's Panel Gauge Layout – Typical (left-hand side)

- 3.1 From behind the auxiliary panel, disconnect the electrical connectors from the keypad and each flipper valve. Using a paint pen, mark the connectors for ease of installation.
- 3.2 From behind the auxiliary panel, disconnect the electrical connectors from each rocker or paddle switch. Using a paint pen, mark the connectors and switches for ease of installation.
- 3.3 Disconnect all air hoses from the flipper valves and mechanical gauges. If not color-coded, use a paint pen to mark the hoses, valves and gauges for ease of installation.
- 3.4 Remove the keypad bezel. For instructions, see **Subject 150**.

Instrumentation Control Unit and Auxiliary Instrument Panel Replacement



Gauge layouts may vary. To work properly, gauges must be installed in their correct locations.

1. Primary Air Pressure Gauge
2. Secondary Air Pressure Gauge
3. Fuel Gauge
4. Transmission Fluid Temperature Gauge (optional)
5. Forward Axle Temperature Gauge (optional)
6. Rear Axle Temperature Gauge (optional)

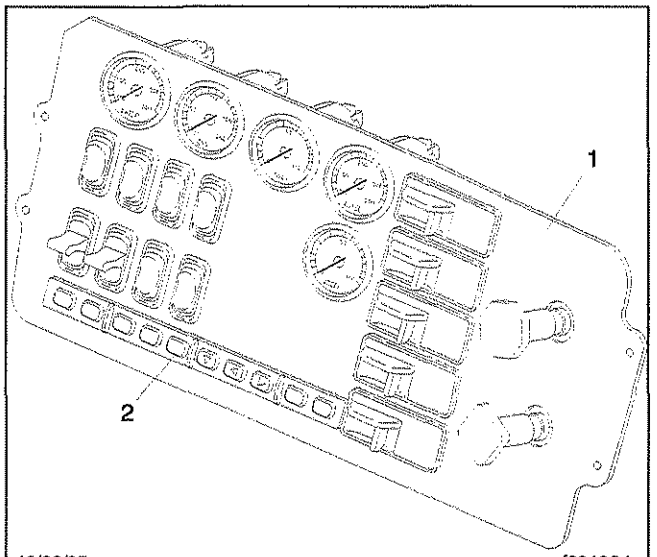
Fig. 8, Driver's Panel Gauge Layout (right-hand side)

4. Remove the auxiliary panel from the vehicle. Note the gauge, switch and flipper valve layout for later installation and remove all the panel components (gauges, gauge housings, switches and valves). For instructions, see **Subject 110**. Set aside the panel components for later installation in the new panel.

5. Install a new auxiliary panel. Install all gauges, switches and valves in the positions from which they were removed. For instructions on gauge, switch, and valve installation, see **Subject 110**.

   5.1 Connect the air hoses to the air gauges, as marked on removal.

   5.2 Connect the electrical connectors, as marked on removal.



1. Auxiliary Instrument Panel
2. Keypad

Fig. 9, Auxiliary Instrument Panel

   5.3 Place the new auxiliary panel on the dash and install the fasteners.

   5.4 Install the keypad bezel. For instructions, see **Subject 150**. Tug gently on the bezel to make sure the retainer hooks have snapped into position.

6. Turn on the ignition and the air system and test the operation of the gauges.

   Test each switch and flipper valve for correct operation.

Dash Gauge, Valve, and Switch Replacement

Gauge Replacement

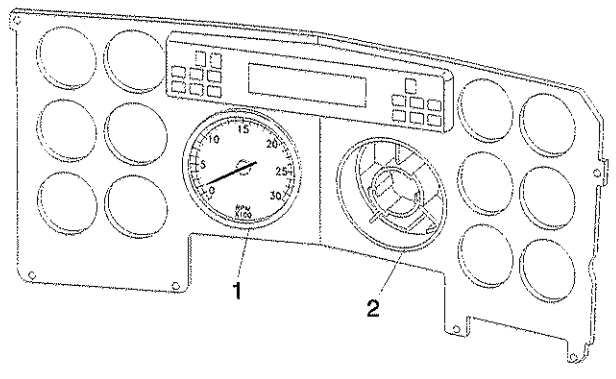
First, determine if the gauge to be replaced is an electronic or mechanical gauge. There are different procedures for electronic and mechanical gauges.

ELECTRONIC GAUGES

For large-face gauges, such as the speedometer or tachometer, and for small-face gauges located in the A-panel, see **Fig. 1**. For small-face electronic gauges located in the auxiliary panel, such as the voltmeter or fuel gauge, see **Fig. 2**.

IMPORTANT: Be sure to note gauge location before removal. A-panel gauges will not function correctly if moved to a new location, unless the gauge pigtail connection can be moved to the new position. B-panel gauge locations can be changed only if the gauge housing is also moved.

1. Grasp the gauge bezel with the fingertips and twist it counterclockwise until it comes free of the panel. Pull the gauge straight out of its housing.



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Be sure to note gauge location and gauge pigtail location before removal. Gauges will not function correctly if moved to a new location unless the gauge pigtail can be routed to the new location.

1. Large-Face Gauge
2. Large-Face Gauge Removed

Fig. 1, Large-Face Gauge Replacement

⚠ CAUTION

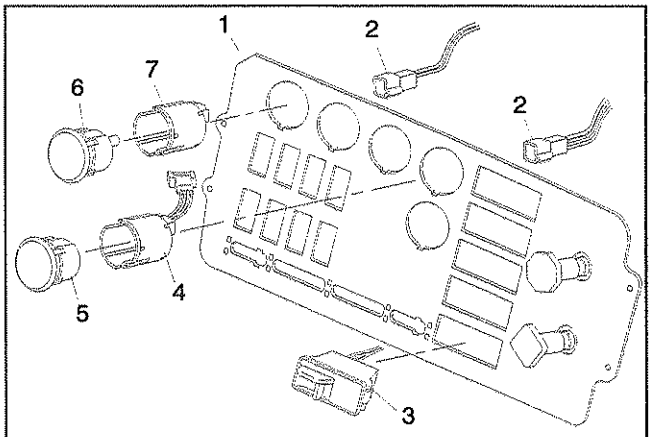
Be careful not to pinch the wires of the electrical harness. Pinched wires can cause the gauge to malfunction.

2. Disconnect the 4-wire pigtail harness from the gauge. Be careful not to pinch or kink any wires.

⚠ CAUTION

Do not lay gauges face down for long periods of time. The electronic gauges use an oil-dampening fluid that leaks out when the gauge is face down, causing dial movement to become erratic.

3. Insert the new gauge carefully into the opening in the panel. When fully inserted, grasp the bezel with fingertips and twist clockwise until the gauge clicks into position. Tug gently at the gauge to be sure it is properly seated.



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Be sure to note gauge and flipper valve location before removal. Gauges and flipper valves will not function correctly if moved to a new location with changing the wire routing.

1. Auxiliary Instrument Panel
2. Main Cab Harness Connector
3. Flipper Valve
4. Electronic Gauge Housing (auxiliary panel only)
5. Electronic Front-Removable Gauge
6. Mechanical Front-Removable Gauge
7. Mechanical Gauge Housing (auxiliary panel only)

Fig. 2, Small-Face Gauge, Gauge Housing, and Flipper Valve Replacement

Dash Gauge, Valve, and Switch Replacement

4. When finished, turn on the ignition and test the operation of the new gauge(s). All the electronic gauges (except the voltmeter) should make one complete sweep and return to their normal indicating positions; the warning and indicator lights should turn on, then off.

MECHANICAL GAUGES (see Fig. 2)

IMPORTANT: Be sure to note gauge location before removal. Air gauges will not function correctly if moved to a new location unless the air hose for the gauge is also moved to the new location.

1. Grasp the gauge bezel with the fingertips and twist it counterclockwise until it comes free of the panel. Pull the gauge straight out of its housing.

⚠ WARNING

Remove the compressed air from the air tanks before disconnecting the hoses to the air gauges. Failure to do so could cause the hoses to move uncontrollably and cause personal injury or damage to the equipment.

2. Remove the air hose from the gauge.
   - 2.1 Carefully pull the hose out through the panel housing.
   - 2.2 While holding the gauge in the palm of one hand, press on the colored collar around the hose. Remove the hose with the free hand.
3. Install the air hose in the new gauge.
   - 3.1 Insert the hose into the colored collar. Push on it gently to seat it, being careful not to kink the hose.
   - 3.2 Tug firmly on the hose to be sure it is well gripped by the collar.
   - 3.3 Lead the hose carefully back into the panel housing, being careful not to kink it.
4. Insert the new gauge carefully into the opening in the panel. When fully inserted, grasp the bezel with fingertips and twist until the gauge clicks into position. Tug gently at the gauge to be sure it is properly seated.
5. When finished, turn on the ignition (for air gauges, turn on the air system) and test the operation of the new gauge(s).

B-PANEL GAUGE HOUSINGS (see Fig. 2)

1. Remove the gauge. For procedures, see either "Electronic Gauge Replacement" or "Mechanical Gauge Replacement."
2. Remove the old front-removable gauge housing. From the back of the panel, unplug the main cab harness electrical connector from the gauge housing.
3. Install a new front-removable gauge housing.
   - 3.1 Install the electrical connector to the gauge housing.
   - 3.2 Place the tab on the back of the housing at 6 o'clock.
   - 3.3 Slide the housing into the panel from the front.
   - 3.4 Press in firmly until the housing snaps into position.
4. Install the gauge. For procedures, see either "Electronic Gauge Replacement" or "Mechanical Gauge Replacement."
5. When finished, turn on the ignition and test the operation of the new gauge(s). All the electronic gauges (except the voltmeter) should make one complete sweep and return to their normal indicating positions; the warning and indicator lights should turn on, then off.

Flipper Valve Replacement (see Fig. 2)

IMPORTANT: Be sure to note flipper valve location before removal. If moved to a new location, flipper valves will not function correctly without also relocating the associated hoses.

1. From the back of the valve, unplug the electrical connector. Hold on to the connector and avoid pulling on the wires.
2. Disconnect the air supply and distribution hoses.

⚠ WARNING

Relieve pressure in the compressed air tanks before attempting to remove any air hoses. A sudden release of air pressure can cause injury to eyes and ears. The disconnected ends of pressurized air hoses can move uncontrollably and cause personal injury or equipment damage.

2.1 If not color-coded, use a paint pen to mark the air supply and distribution ports and hoses for ease of installation.

2.2 Disconnect the air supply and distribution hoses.

2.3 Label and remove any jumper hoses.

3. To remove the old valve, press the retainer tab on the right side of the valve. While holding the retainer tab, gently roll the valve towards the left and out the front of the panel.

4. To install the new valve, align the groove on the left side of the valve with the cutout on the instrument panel and slip into place. Then roll the right side into the cutout until the valve snaps into place. Tug on the valve firmly to make sure it is properly seated.

5. Connect the air hoses and electrical connectors.

5.1 Support the valve on the front of the panel with one hand.

5.2 With the other hand, connect the air supply and distribution hoses as marked on removal. Connect any jumper hoses as marked.

5.3 While still supporting the valve with one hand, connect the electrical connector.

6. When finished, turn on the ignition and test the new flipper valve(s) for correct operation.

Rocker and Paddle Switch Replacement (see Fig. 3)

IMPORTANT: Be sure to note switch location before removal. If moved to a new location, switches will not function correctly without also relocating the associated wiring.

1. From the back of the panel, unplug the electrical connector. Hold on to the connector and avoid pulling on the wires.

2. Remove the old switch(es) from the panel.

2.1 If more than one switch is to be replaced, use a paint pen to mark the switch location and connector, for ease of installation.

2.2 From the back of the panel, depress the two locking clips and pull the switch out the front of the panel.

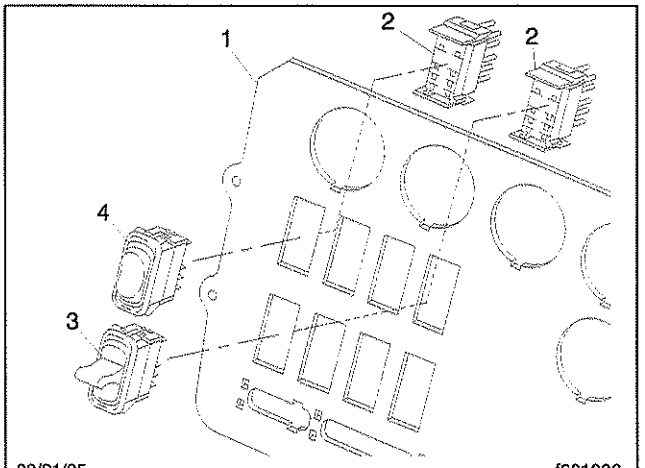
3. Install the new switch(es) in the panel.

3.1 Make sure the top of the switch is up when installed.

3.2 Press the switch into the panel from the front until it clicks into place. Tug firmly on the switch to make sure it is properly seated.

3.3 While supporting the switch with one hand, connect the electrical connector with the other. Be sure the locking tabs on the switch mesh with those on the connector.

4. When finished, turn on the ignition and test the new switch(es) for correct operation.



1. Auxiliary Instrument Panel
2. Switch Connector
3. Paddle Switch
4. Rocker Switch

Fig. 3, Rocker and Paddle Switch Replacement

ICU Bulb Replacement

This subject covers bulb replacement for gauges and for the warning and indicator lights.

Gauge Light Bulb Replacement

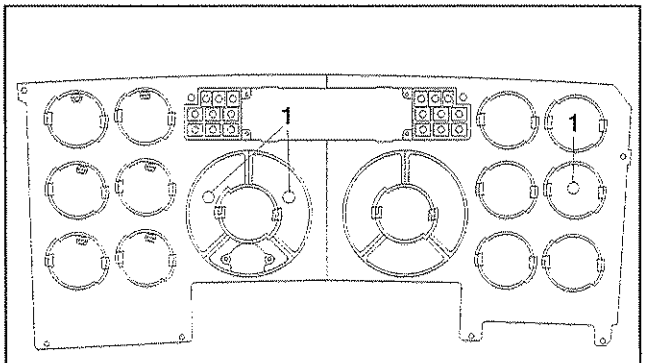
1. Remove the gauge. For instructions, see **Subject 110**.

NOTE: Small gauge bulbs are the same size as warning and indicator light bulbs. Large gauges have larger light bulbs.

2. Remove the old bulb by grasping it with the fingers and pulling until it comes out. There are two bulbs in large-face gauges, and one bulb in small-face gauges. See **Fig. 1**.

NOTE: If broken, the bulbs in the large-face gauges may be removed by twisting the bulb socket on the back of the ICU and removing the socket through the hole in back shield of the housing.

3. Install the new bulb by inserting it into the correct bulb socket and pushing it until it seats. Gently tug on the bulb to make sure it is properly seated.
4. Install the gauge. For instructions, see **Subject 110**.
5. Turn on the dash lights and check the new bulb(s) for proper operation.



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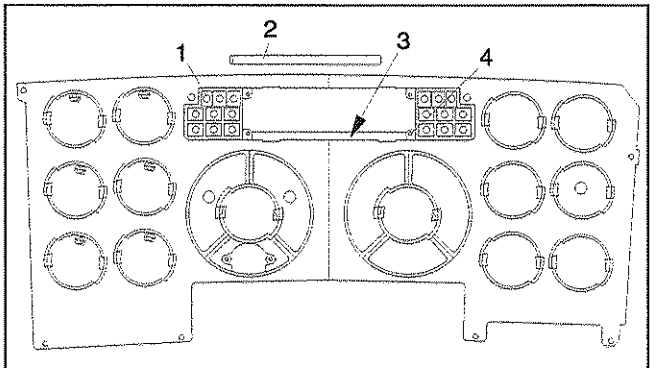
1. Bulb

Fig. 1, Gauge Light Bulb Replacement

Warning and Indicator Light Bulb Replacement

NOTE: Small gauge bulbs are the same size as warning and indicator light bulbs.

1. Remove the Driver Message Center bezel. For instructions, see **Subject 140**.
2. Retrieve the bulb replacement tool from its housing underneath the bezel. See **Fig. 2**.
3. Remove the old bulb from its socket.
   - 3.1 Gently press the tool onto the bulb until it fits snugly.
   - 3.2 Pull the tool outward to free the bulb from its socket.
   - 3.3 Remove the bulb from the tool when it is free of the socket. Hold the bulb with one hand and twist the tool with the other hand.
4. Insert the new bulb in the socket.
   - 4.1 Insert the new bulb into the end of the replacement tool.
   - 4.2 Gently push the new bulb into the socket until it seats. Gently twist while pulling outward on the tool to free it from the bulb.



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1. Bulb
2. Bulb Replacement Tool
3. Replacement Tool Housing
4. Screw

Fig. 2, Warning and Indicator Light Bulb Replacement

ICU Bulb Replacement

5. Return the bulb replacement tool to its housing underneath the bezel. See **Fig. 2.**
6. Install the Driver Message Center bezel. For instructions, see **Subject 140.**
7. Turn on the dash lights and check the new bulb(s) for proper operation.

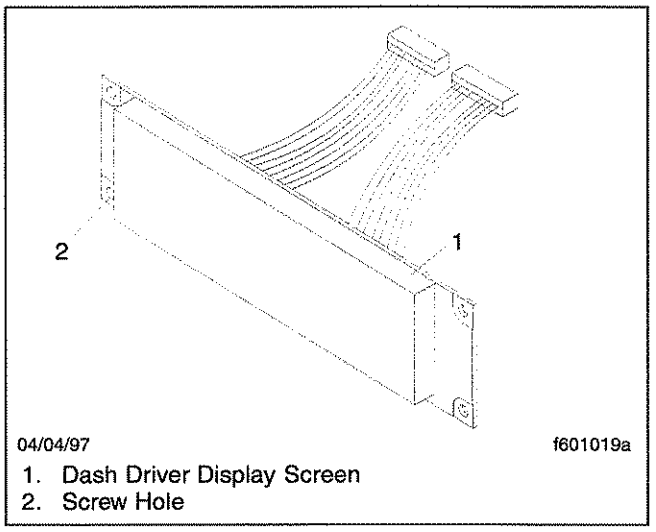
Dash Driver Display Screen Replacement

Replacement

⚠ CAUTION

Electronic components of the ICU are vulnerable to damage from static electricity. If available, wear a wrist grounding strap connected to a ground in the cab or workbench. If a grounding strap is not available, touch a grounded component immediately before doing any work which could bring a tool or body part in contact with ICU circuitry.

1. Remove the Driver Message Center bezel. Work the four small clips on the sides of the bezel out of the slots in the instrumentation control unit (ICU) housing.
   - 1.1 Grasp the bezel with both hands approximately 3 inches from each end, fingers on the top edge and thumbs below the bottom edge.
   - 1.2 Squeeze with enough pressure to disengage the retainer hooks.
   - 1.3 Roll the top edge of the bezel outward and down to remove it from the vehicle.
2. Remove the four screws attaching the dash driver display screen to the Driver Message Center. See **Fig. 1**.
3. Carefully disconnect the two keyed electrical connectors. Note the orientation of the connectors, for correct installation.
4. Insert the two electrical connectors into the printed circuit board, as removed.
5. Replace the display screen. Fasten the four screws.
6. Install the Driver Message Center bezel. Press the four small clips on the bezel into the slots in the ICU housing.
7. Turn on the ignition and check the new display for proper operation.



1. Dash Driver Display Screen
2. Screw Hole

Fig. 1, Dash Driver Display Screen Replacement

Buzzer Replacement

Replacement

1. Remove the tachometer from the driver's instrument panel. For procedures, see **Subject 110**.

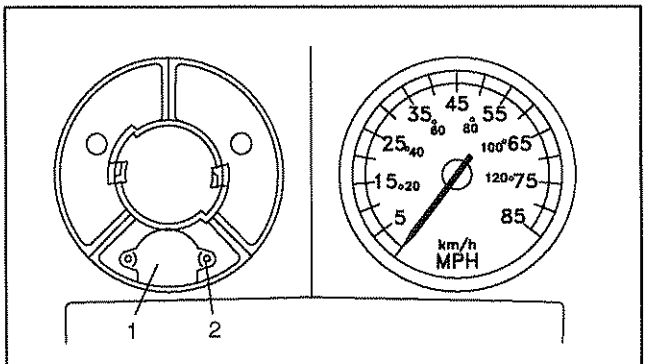
⚠ CAUTION

Electronic components of the ICU are vulnerable to damage from static electricity. If available, wear a wrist grounding strap connected to a ground in the cab or workbench. If a grounding strap is not available, touch a grounded component immediately before doing any work which could bring a tool or body part in contact with ICU circuitry.

2. The buzzer sits in the lower portion of the tachometer housing. Remove the old buzzer by unfastening the two mounting screws. See **Fig. 1**.
3. Remove the electrical connector by gently pulling on the wires. If it cannot be removed by finger pressure only, use a jeweler's screwdriver or needlenose pliers to pry it loose.
4. Insert the electrical connector into the printed circuit board.

⚠ CAUTION

Be sure that the wires are clear of the tachometer contact pins. Otherwise, the buzzer wiring may be damaged.



Viewed from front of driver's panel.

1. Buzzer 2. Screw

Fig. 1, Buzzer Replacement

5. Install the new buzzer by inserting it into the tachometer housing and fastening the two screws.
6. Install the tachometer in the driver's instrument panel. For procedures, see **Subject 110**.
7. Turn on the ignition and check the new buzzer for proper operation.

ICU Keypad Replacement

Replacement

1. Remove the auxiliary instrument panel. For instructions, see **Subject 100.**
2. Remove the keypad bezel. See **Fig. 1.**

   IMPORTANT: Proceed carefully with the keypad bezel removal. The locking tabs break easily when too much force is applied.

   2.1 Beginning at one end, insert a small screwdriver into one of the access holes on the bottom edge of the keypad housing to release a tab.

   2.2 Roll the bottom edge of the bezel outward and upward to disengage the locking tab. Insert a small screwdriver or blade under the bezel to prevent the bezel from snapping back into place.

   2.3 Continue this process until all five locking tabs are released.

   2.4 Carefully lift the edge of the keypad bezel over the keys to release the bezel from the keypad.

   NOTE: It may be helpful to press each of the keys to help the bezel clear the tops of the keys.
3. Remove the keypad housing.

   3.1 Pull the keypad housing away from the panel.

   3.2 Unplug the electrical connector.

   3.3 Remove the keypad housing from the vehicle.
4. Install the keypad housing.

   4.1 Snap the electrical connector into the wiring harness.

   4.2 Align the four tabs on the keypad housing with the four slots on the auxiliary instrument panel.
5. Install the keypad bezel.

   5.1 Insert the five lower retainer hooks into the notches in the panel.

   5.2 While holding the keypad housing from the back, roll the top edge of the bezel into the housing until the upper hooks snap into place and hold the housing against the panel.
6. Install the auxiliary instrument panel. For instructions, see **Subject 100.**
7. Turn on the ignition and check the new keypad for proper operation.

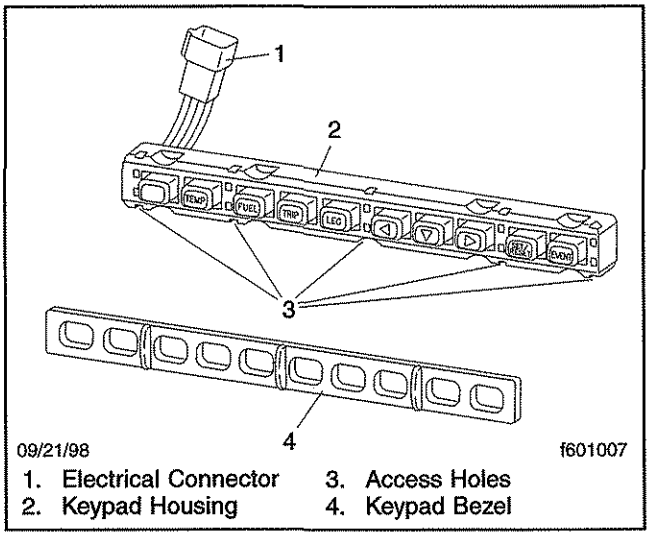


Fig. 1, Keypad Replacement

IMPORTANT: The Instrumentation Control Unit (ICU) must be reconfigured after replacement to avoid incorrect operation of the gauges.

NOTE: Using ServiceLink 2.0, the ICU can be reconfigured to original factory specifications either on or off the vehicle. Different procedures are required if the ICU is not installed in the vehicle. Please take care to choose the correct procedure.

For specific instructions on operating Servicelink 2.0, see the self-paced Freightliner training materials available for this subject. If ServiceLink 2.0 is not available, the ICU cannot be reprogrammed. Contact your District Service Manager for an ICU that is already programmed.

On-Vehicle Reconfiguring

NOTE: The Freightliner help desk, 1–503–735–7877, is available 24 hours a day to assist with problems during ICU reconfiguring.

1. Connect the computer to the diagnostic connector on the vehicle.
2. Turn the keyswitch to the ON position.
3. Start ServiceLink 2.0 and connect to the vehicle's datalink.

   NOTE: Follow the procedures in the Servicelink 2.0 documentation for downloading parameter files if the Servicelink 2.0 computer is not connected to the ALLPRO server at the same time that it is connected to the vehicle.
4. Enter the last six digits of the vehicle's serial number when prompted.

   NOTE: A replacement ICU will not contain a vehicle serial number.
5. Select the icon for the ICU and then click on the PARAMETERS tab.
6. To download parameters, click the RESET PARAMETERS button and choose the parameter set to be downloaded.
7. When complete, Servicelink 2.0 will query the ICU for current parameters.

IMPORTANT: The ICU does not store parameter changes until the keyswitch is in the OFF position for AT LEAST ten seconds. If the battery is disconnected at a battery disconnect switch before the ICU stores the changes, all changes will be lost.

8. Exit ServiceLink 2.0.
9. Disconnect the diagnostic connector from the vehicle and turn off the ignition keyswitch.

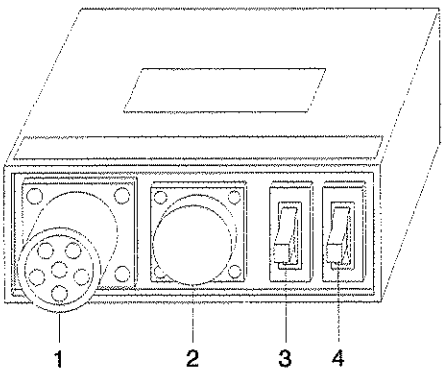
Off-Vehicle Reconfiguring

Before starting, make sure of the following:

- The computer is on and running Windows.
- The computer is either connected to the Freightliner network or has been set up for RAS access, via a modem, to the Freightliner host.
- There is an appropriate vehicle interface (a cable or an external interface device) connected to the computer.
- The technician knows the vehicle serial number for the unit that needs to be reconfigured.
- Kent-Moore Tool J–42139 is available. See **Fig. 1**. To order this tool, call the Kent-Moore Tool Company at 1–800–328–6657.

NOTE: The Freightliner help desk, 1–503–735–7877, is available 24 hours a day to assist with problems during ICU reconfiguring.

1. Connect the appropriate (pink/blue for ICU1, pink for ICU2M) connectors of the adapter harness



1. Adapter Plug (output)
2. Adapter Plug (input)
3. IGN Switch
4. On/Off Switch

Fig. 1, Kent-Moore Tool J-42139

ICU Reconfiguring

to the connectors on the back of the ICU. The gray connector is not used. Connect the adapter harness to Kent-Moore tool J–42139. See **Fig. 2**.

NOTE: The adapter harness is included with Kent-Moore tool J–42139.

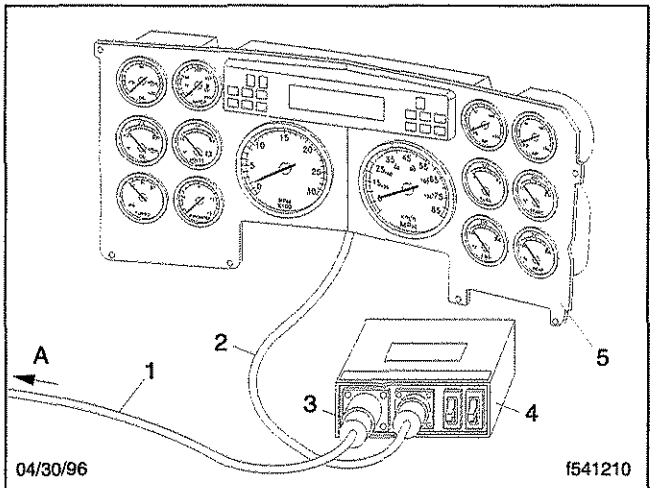
2. Connect the diagnostic connector from the computer to Kent-Moore tool J–42139.
3. Turn on both switches on the Kent-Moore tool J–42139.
4. Start ServiceLink 2.0 and connect to the vehicle's datalink.

   NOTE: Follow the procedures in the Servicelink 2.0 documentation for downloading parameter files if the Servicelink 2.0 computer is not connected to the ALLPRO server at the same time that it is connected to the vehicle.

5. Enter the last six digits of the vehicle's serial number when prompted.

   NOTE: A replacement ICU will not contain a vehicle serial number.

6. Select the icon for the ICU and then click on the PARAMETERS tab.



A. To Computer
1. Vehicle Interface Cable
2. Adapter Harness
3. Diagnostic Connector
4. Tool J–42139
5. ICU

Fig. 2, ICU Reconfiguring Set-Up

7. To download parameters, click the RESET PARAMETERS button and choose the parameter set to be downloaded.
8. When complete, Servicelink 2.0 will query the ICU for current parameters.

IMPORTANT: The ICU does not store parameter changes until the keyswitch is in the OFF position for AT LEAST ten seconds. If the battery is disconnected at a battery disconnect switch before the ICU stores the changes, all changes will be lost.

9. Exit ServiceLink 2.0.
10. Disconnect the diagnostic connector from the vehicle and turn off the ignition keyswitch.

Display Parameter Changing

To change display parameters (parms), display the parameter table in ServiceLink. Using one of the tables listed below, enter the desired range setting in the "Value" column in the parameter table.

NOTE: Not all parameters can be changed by every user. Some cannot be changed by users at all. Others require authorization. These files display in different colors on the ServiceLink screen and are designated by footnotes in the text.

Display Parameters			
Parm	**Units**	**Range**	**Description and Explanation of Screen**
1*	Sec	0–15	**Freightliner Screen:** Controls the length of time that the "Freightliner" screen shows on the dash driver display during the "Ignition ON" sequence.
		0=Off	Enter "0" (zero). The screen display is disabled (it does not display at all).
		7–15	Enter any number between "7" and "15." The screen displays for that number of seconds.
2*	Sec	0–15	**Monitored Systems OK Screen:** Controls the enabling of this screen and the length of time that it shows on the dash driver display during the "Ignition ON" sequence.
		0=Off	Enter "0" (zero). The screen display is disabled (it does not display at all).
		1–15	Enter any number between "1" and "15." The screen displays for that number of seconds.
3†	Sec	0–15	**Fasten Seat Belts/Odometer Screen:** Controls the length of time that the "Fasten Seat Belts/ Odometer" screen shows on the dash driver display.
		0=Off	Enter "0" (zero). The screen display is disabled (it does not display at all).
		3–15	Enter any number between "3" and "15." The screen displays for that number of seconds.
4	Sec	0–63	**Incoming Message Screen:** Controls the length of time that the "Incoming Message" screen shows on the dash driver display whenever the ICU receives a message from the data link.
		0=Off	Enter "0" (zero). The screen never displays at all.
		1–62	Enter any number between "1" and "62." The screen displays for that number of seconds.
		63	Enter "63." The screen displays until the operator dismisses it by pressing any key.
5	None	0 or 1	**Idle Hours and Gallons Screen:** Controls the enabling of this stationary access screen (accessed from the keypad).
		0=Off	Enter "0" (zero). The screen display is disabled (it does not display when requested).
		1=On	Enter "1." The screen display is enabled (it displays when requested).
6	None	0 or 1	**MPG Display Screen:** Controls the enabling of this screen. This is the basic display screen, showing the mpg bar graph (dynamic display), current mpg value and the odometer reading.
			For programming instructions, see parm #5.
7	None	0 or 1	**Trip Information Screen:** Controls the enabling of this title screen (accessed from the keypad).
			For programming instructions, see parm #5.
8	None	0 or 1	**Trip Miles and Trip Hours Screen:** Controls the enabling of this stationary access screen (accessed from the keypad).
			For programming instructions, see parm #5. For screen display time, see parm #26.
9	None	0 or 1	**Idle Hours and Average MPG Screen:** Controls the enabling of this screen (accessed from the keypad).
			For programming instructions, see parm #5.

* No access by users
† Authorization required

Table 1, Display Parameters (parms #1-9)

Display Parameter Changing

Display Parameters*			
Parm	**Units**	**Range**	**Description and Explanation of Screen**
10	None	0 or 1	**Leg Miles and Leg Hours Screen:** Controls the enabling of this stationary access screen (accessed from the keypad).
		0=Off	Enter "0" (zero). The screen display is disabled (it does not display when requested).
		1=On	Enter "1." The screen display is enabled (it does display when requested).
			NOTE: For screen display time, see parm #28.
11	None	0 or 1	**Fuel Information Screen:** Controls the enabling of this title screen (accessed from the keypad).
			For programming instructions, see parm #10.
12	None	0 or 1	**Fuel Used and Average MPG Screen:** Controls the enabling of this stationary access screen (accessed from the keypad).
			For programming instructions, see parm #10.
			NOTE: For screen display time, see parm #27.
13	None	0 or 1	**Idle Gallons and PTO Gallons Screen:** Controls the enabling of this screen (accessed from the keypad).
			For programming instructions, see parm #10.
14	None	0 or 1	**Engine Information Screen:** Controls the enabling of this title screen (accessed from the keypad).
			For programming instructions, see parm #10.
15	None	0 or 1	**Engine Miles and Engine Hours Screen:** Controls the enabling of this screen (accessed from the keypad).
			For programming instructions, see parm #10.
16	None	0 or 1	**Engine Gallons and PTO Gallons Screen:** Controls the enabling of this screen (accessed from the keypad).
			For programming instructions, see parm #10.
17†	None	0 or 1	**Active Faults Screen:** Controls the enabling of this screen (accessed from the keypad), alerting the driver that faults are present. This screen displays all vehicle active faults in the memory of the ICU, as received on the J1587 databus.
			For programming instructions, see parm #10.
18†	None	0 or 1	**Historical Faults Screen:** Controls the enabling of this screen (accessed from the keypad). This screen shows how many historic dash faults (both active and inactive) since the last reset, and the odometer reading at last reset.
			For programming instructions, see parm #10.
19†	Miles	0–254	**Reset Faults Screen:** Controls the enabling of this screen, whose purpose is to delete all the accumulated historical faults.
		0=Off	Enter "0" (zero). The screen display is disabled (it does not display when requested).
		1–254	Enter any number between "1" and "254." The screen function is enabled for from 1 to 254 odometer miles.
			NOTE: This function is used by the production plants only.

* All parameters in this table are accessible to users
† Authorization required

Table 2, Display Parameters (parms #10-19)

Display Parameters			
Parm	**Units**	**Range**	**Description and Explanation of Screen**
20*	None	0 or 1	**Set Brightness Screen:** Controls the enabling of this screen (accessed from the keypad). This screen allows the driver to adjust screen brightness to current conditions.
		0=Off	Enter "0" (zero). The screen display is disabled (it does not display when requested).
		1=On	Enter "1." The screen display is enabled (it does display when requested).
			NOTE: To set the basic screen brightness level, see parm #48.
21	None	0 or 1	**Set Language Screen:** Controls the enabling of this screen (accessed from the keypad). This screen allows the driver to change the language of the display (English, French, Spanish).
			For programming instructions, see parm #20.
22	None	0 or 1	**Set Units Screen:** Controls the enabling of this screen (accessed from the keypad). This screen allows the driver to choose between U.S. Customary (feet, pounds) and metric units of measurement.
			For programming instructions, see parm #20.
23*	None	0 or 1	**Part No. and Software Screen:** Controls the enabling of this screen (accessed from the keypad). This screen displays the ICU part number (see parm #159) and software version number (see parm #130).
			For programming instructions, see parm #20.
24*	Sec	0–15	**Set Screen Blinking Time:** Controls the blinking rate of screen displays.
		0=Off	Enter "0" (zero). Blinking is disabled (no screen displays blink).
		1–15	Enter any number between "1" and "15." The screen displays for one-half that number of seconds. For example, if the blinking time is set to "3," blinking displays will blink every 1.5 seconds.
25†	None	0 or 1	**Vehicle ID Number Screen:** Controls the enabling of this screen (accessed from the keypad). This screen displays vehicle ID number (see parm #142).
			For programming instructions, see parm #20.
26	Sec	0–254	**Trip Miles and Trip Hours Screen Display Time:** Controls the enabling of this direct access screen and the length of time that it shows on the dash driver display after pressing the TRIP key.
		0=Off	Enter "0" (zero). The screen display is disabled (it does not display at all).
		1–254	Enter any number between "1" and "254." The screen displays for that number of seconds.
27	Sec	0–254	**Fuel Used and Average MPG Screen Display Time:** Controls the enabling of this direct access screen and the length of time that it shows on the dash driver display after pressing the FUEL key.
			For programming instructions, see parm #26.
28	Sec	0–254	**Leg Miles and Leg Hours Screen Display Time:** Controls the enabling of this direct access screen and the length of time that it shows on the dash driver display after pressing the LEG key.
			For programming instructions, see parm #26.

* No access by users
† Authorization required

Table 3, Display Parameters (parms #20-28)

Display Parameter Changing

Display Parameters			
Parm	**Units**	**Range**	**Description and Explanation of Screen**
29*	Sec	0–254	**Low Coolant Level Warning Screen:** Controls the enabling of this alert screen, how often the display repeats, and whether the screen can be dismissed by the driver. This screen appears when the engine ECU reports a low coolant level fault.
			NOTE: See parm #49 when the coolant level sensor reports low coolant level.
		0=Off	Enter "0" (zero). The screen display is disabled (it does not display at all).
		1	Enter "1." The screen displays one time only for seven seconds.
		2	Enter "2." The screen displays for seven seconds, dismisses itself, and returns every 254 seconds until the fault is corrected.
		3–253	Enter any number between "3" and "253." The screen display repeats after that number of seconds. It continues its repeat cycle until the fault is corrected. Each time, it can be dismissed by the driver pushing any key.
		254	Enter "254." The screen displays continuously until the condition returns to normal. It can not be dismissed.
30†	Sec	0–254	**Low Voltage Warning Screen:** Controls the enabling of this alert screen, how often the display repeats, and whether the screen can be dismissed by the driver.
			See parm #29 for programming instructions.
31†	Sec	0–254	**Low Oil Pressure Warning Screen:** Controls the enabling of this alert screen, how often the display repeats, and whether the screen can be dismissed by the driver.
			See parm #29 for programming instructions.
32†	Sec	0–254	**High Coolant Temperature Warning Screen:** Controls the enabling of this alert screen, how often the display repeats, and whether the screen can be dismissed by the driver.
			See parm #29 for programming instructions.
33†	Mph	1–15	**Parking Brake Warning Screen (Vehicle MPH):** Controls the vehicle speed required to activate this alert screen (vehicle moving, parking brake on).
			Enter any number between "1" and "15." The alert screen displays when the vehicle is traveling at one-half that speed. For example, if the vehicle mph value is set to "5," the screen displays when the vehicle is traveling at a speed of 2.5 mph with the parking brake on.
34†	Sec	60–254	**Parking Brake Warning Screen (Time On):** Controls the number of seconds this alert screen displays (vehicle moving, parking brake on).
			Enter any number between "60" and "254." The alert screen displays for that number of seconds, then turns itself off.
35*	Sec	0–15	**Reset Key Valid Time:** When the "Reset Confirmation" screen is enabled (see parm #45), controls the number of seconds allowed to confirm a reset (prevents accidental resets).
		0=Off	Enter "0" (zero). This function is disabled (resets are not confirmed).
		1-15	Enter any number between "1" and "15." The reset is confirmed if the reset key is pressed within that number of seconds. If the reset key is not pressed within the allotted time, the screen being reset continues to report its old values.

* No access by users
† Authorization required

Table 4, Display Parameters (parms #29-35)

Display Parameters			
Parm	**Units**	**Range**	**Description**
36*	Sec	0–15	**Bulb Check Time On:** Controls the number of seconds that the bulbs illuminate during the "Ignition ON" sequence.
		0=Off	Enter "0" (zero). This function is disabled (the bulbs do not illuminate).
		1-15	Enter any number between "1" and "15." The bulbs illuminate for that number of seconds.
37*	Min	0–254	**Dash Active After Ignition Off:** Controls the number of minutes that the dash continues to remain active after the ignition keyswitch is turned OFF.
		0	Enter "0" (zero). When the ignition keyswitch is turned off, the dash turns inactive immediately.
		1–254	Enter any number between "1" and "254." After the ignition keyswitch has been turned off, the dash continues to remain active for that number of minutes.
			NOTE: The dash will appear to be turned off, even though the microprocessor remains active to perform these functions: door open, parking brake off (as enabled by parm #34); buzzer (as enabled by parms #100-118).
38*	Sec	0–7	**Buzzer Check Time On:** Controls the number of seconds that the buzzer sounds during the "Ignition ON" sequence.
		0=Off	Enter "0" (zero). The buzzer does not sound at all.
		1–7	Enter any number between "1" and "7." The buzzer sounds for that number of seconds.
39	None	None	This parameter is not used.
40	None	None	This parameter is disabled.
41†	Volts	5–135	**Low Voltage Warning Threshold:** Controls the voltage required to trigger the display of the "Warning–Low Voltage" screen.
			Enter any number between "5" and "135." The low voltage warning comes on when the voltage equals one-tenth that amount. For example, if this parameter is set to "122," the warning comes on at 12.2 volts.
42*	None	1–254	**Short Term Fuel Economy Average Coefficient:** On the mpg bar graph display (see parm #6), controls the amount of filtering done to the fuel economy data.
			Enter any number between "1" and "254." A lower number provides more filtering (a less responsive, slower to change graph). A higher number provides less filtering (a more responsive, faster to change graph).
43*	None	1–254	**Fuel Economy Rate of Change Coefficient:** On the mpg bar graph display (see parm #6), controls the amount of filtering done to the rate of change calculated by comparing current fuel usage to previous usage.
			Enter any number between "1" and "254." A lower number provides more filtering (a less responsive, slower moving graph). A higher number provides less filtering (a more responsive, faster moving graph).
44*	None	1–254	**Maximum Rate of Change Value MPG Bar Graph:** On the mpg bar graph display (see parm #6), sets a maximum value to the rate of change.
			Enter any number between "1" and "254." A lower number provides a lower maximum value for the rate change (graph moves in smaller jumps). A higher number provides a higher maximum value for the rate change (graph moves in bigger jumps).

* No access by users
† Authorization required

Table 5, Display Parameters (parms #36-44)

Display Parameter Changing

Display Parameters			
Parm	**Units**	**Range**	**Description**
45*	None	0 or 1	**Reset Confirmation Screen:** Controls the enabling of this screen, which appears when the reset button on the keypad is pressed.
		0=Off	Enter "0" (zero). The screen is disabled (it does not display when the reset button is pressed).
		1=On	Enter "1." The screen display is enabled (it displays when the reset button is pressed).
			NOTE: See parm #35, which sets the number of seconds required for confirmation.
46	None	0 or 1	**Turn Signal Warning Screen:** Controls the enabling of this alert screen, which appears when the turn signals have been left on. It also disables the turn signal buzzer (see parm #108).
		0=Off	Enter "0" (zero). The screen is disabled (it does not display at all).
		1=On	Enter "1." The screen display is enabled (it displays when the turn signals have been left on).
			NOTE: See parm #113, which controls the number of seconds the turn signals have to remain on before the alert screen activates, and parm #114, which controls the distance in miles the vehicle has to travel.
47*	None	0–254	**Low Windshield Wiper Water Level Alert Screen:** Controls the enabling of this alert screen, how often the display repeats, and whether the screen can be dismissed by the driver. This screen appears when the water level in the washer reservoir gets low.
		0=Off	Enter "0" (zero). The screen display is disabled (it does not display at all).
		1	Enter "1." The screen displays one time only for seven seconds.
		2	Enter "2." The screen displays for seven seconds, dismisses itself, and returns every 254 seconds until the fault is corrected.
		3–253	Enter any number between "3" and "253." The screen display repeats after that number of seconds. It continues its repeat cycle until the fault is corrected. Each time, it can be dismissed by the driver pushing any key.
		254	Enter "254." The screen displays continuously until the condition returns to normal. It can not be dismissed.
48*	None	0 or 254, 150–180	**VFD Brightness Control:** Establishes the basic brightness level of the dash driver display.
		0=Bright	Enter "0" (zero). The screen displays at maximum brightness.
		254=Off	Enter "254" (zero). The screen is turned off.
		150–180	Enter any number between "150" and 180." A higher number reduces the brightness of the screen.

* No access by users

Table 6, Display Parameters (parms #45-48)

Display Parameters			
Parm	**Units**	**Range**	**Description**
49*	None	0–254	**Add Engine Coolant Alert Screen:** Controls the enabling of this alert screen, how often the display repeats, and whether the screen can be dismissed by the driver. This screen appears when the coolant level in the radiator gets low, as reported by the coolant level sensor. NOTE: When the engine ECU reports low coolant level, see parm #29.
		0=Off	Enter "0" (zero). The screen display is disabled (it does not display at all).
		1	Enter "1." The screen displays one time only for seven seconds.
		2	Enter "2." The screen displays for seven seconds, dismisses itself, and returns every 254 seconds until the fault is corrected.
		3–253	Enter any number between "3" and "253." The screen display repeats after that number of seconds. It continues its repeat cycle until the fault is corrected. Each time, it can be dismissed by the driver pushing any key.
		254	Enter "254." The screen displays continuously until the condition returns to normal. It can not be dismissed.
50†	None	0–254	**Recirc Mode Engaged Alert Screen:** Controls the enabling of this alert screen, how often the display repeats, and whether the screen can be dismissed by the driver. This screen appears when the HVAC unit has been switched to recirculated air. See parm #49 for programming instructions. NOTE: To change the buzzer function, see parm #110.
51†	None	0–254	**Provide Fresh Air Alert Screen:** Controls the enabling of this alert screen, how often the display repeats, and whether the screen can be dismissed by the driver. This screen appears when the HVAC unit has been operating for 20 minutes on recirculated air. See parm #49 for programming instructions. NOTE: To change the buzzer function, see parm #110.
52‡	Sec	1–15	**Clock Screen Scroll Rate:** Controls rate at which the "Set Time" screen (parm #202) scrolls from one function to another (minutes, hours, day, month, year). Enter any number from "1" to "15." The screen scrolls that many times per second. NOTE: To change the blink rate on the "Set Time" screen, see parm #24.
54*	None	4.0.3-4.0.4	**CCP File Revision No:** Stores in memory the number of the current Cluster Configuration Parameter (CCP) file.

* No access by users
† Authorization required
‡ Found only on vehicles manufactured before March 7, 1997

Table 7, Display Parameters (parms 49-54)

Buzzer Parameter Changing

To change buzzer parameters (parms), display the parameter table in ServiceLink. Using one of the tables listed below, enter the desired range setting in the "Value" column in the parameter table.

NOTE: Not all parameters can be changed by every user. Some cannot be changed by users at all. Others require authorization. These files display in different colors on the ServiceLink screen and are designated by footnotes in the text.

Buzzer Parameters			
Parm	**Units**	**Range**	**Description**
100*	None	0–3	**Door Open, Headlights On, Ignition Off Buzzer:** Controls the enabling of this buzzer, and the type of sound: continuous buzzing (type 1), steady pulsing (type 2), or programmable pulsing (type 3). This buzzer sounds when the door is open or the headlights are on, but the ignition keyswitch is turned OFF.
		0=Off	Enter "0" (zero). The buzzer function is disabled (it does not sound).
		1	Enter "1." The buzzer sounds continuously until the problem is corrected.
		2	Enter "2." The buzzer pulses steadily until the problem is corrected.
		3	Enter "3." The buzzer pulses according to a programmed pattern until the problem is corrected.
			NOTE: To change the programmable pulsing function, see parm #115.
101*	None	0–3	**Door Open and Parking Brake Off Buzzer:** Controls the enabling of this buzzer, and the type of sound. This buzzer sounds when the door is open and the parking brake is off.
			For programming instructions, see parm #100.
102†	None	0–3	**Parking Brake On and Vehicle Moving Buzzer:** Controls the enabling of this buzzer, and the type of sound. This buzzer sounds when the vehicle is moving and the parking brake is on.
			For programming instructions, see parm #100.
103†	None	0–3	**Engine Protection Buzzer:** Controls the enabling of this buzzer, and the type of sound. This buzzer sounds when the engine protection light comes on.
			For programming instructions, see parm #100.
104*	None	0–3	**Low Air Buzzer:** Controls the enabling of this buzzer, and the type of sound. This buzzer sounds when the air pressure drops below the minimum.
			For programming instructions, see parm #100.
105†	None	0–3	**Low Coolant Level Buzzer:** Controls the enabling of this buzzer, and the type of sound. This buzzer sounds when the coolant level is too low.
			For programming instructions, see parm #100.
106†	None	0–3	**Low Oil Pressure Buzzer:** Controls the enabling of this buzzer, and the type of sound. This buzzer sounds when the oil pressure is too low.
			For programming instructions, see parm #100.
107†	None	0–3	**High Coolant Temperature Buzzer:** Controls the enabling of this buzzer, and the type of sound. This buzzer sounds when the coolant temperature is too high.
			For programming instructions, see parm #100.

* No access by users
† Authorization required

Table 1, Buzzer Parameters (parms #100-107)

Buzzer Parameter Changing

Buzzer Parameters			
Parm	**Units**	**Range**	**Description**
108	None	0–3	**Turn Signal ON Buzzer:** Controls the enabling of this buzzer, and the type of sound: continuous buzzing (type 1), steady pulsing (type 2), or programmable pulsing (type 3). This buzzer sounds when the turn signals are left on too long, as defined by time (see parm #113), distance (see parm #114), or both. NOTE: This buzzer is disabled when the "Warning–Turn Signal ON" screen is disabled (see parm #46). *0=Off* Enter "0" (zero). The buzzer function is disabled (it does not sound). *1* Enter "1." The buzzer sounds continuously until the problem is corrected. *2* Enter "2." The buzzer pulses steadily until the problem is corrected. *3* Enter "3." The buzzer pulses according to a programmed pattern until the problem is corrected. NOTE: To change the programmable pulsing function, see parm #115.
109*	None	0–3	**Axle Lock Buzzer:** Controls the enabling of this buzzer, and the type of sound. This buzzer sounds when the axle locks are left on. For programming instructions, see parm #108.
110*	None	0–3	**HVAC Input Buzzer:** Controls the enabling of this buzzer, and the type of sound. This buzzer sounds when either the Recirc Mode Engaged (parm #50) or Provide Fresh Air (parm #51) alert screens come on. For programming instructions, see parm #108.
111	None	0–3	**Buzzer Enable II:** Controls the enabling of this buzzer, and the type of sound. This is an optional buzzer function. For programming instructions, see parm #108.
112†	None	0–3	**Low Voltage Warning Buzzer:** Controls the enabling of this buzzer, and the type of sound. This buzzer sounds when the voltage goes below a preset minimum (see parm #41). For programming instructions, see parm #108.
113	Min	0–15	**Turn Signal Warning Activation Time:** Controls how long the turn signals have to remain ON before the buzzer warning activates and the dash driver display shows the "Warning–Turn Signal ON" screen. *0=Off* Enter "0" (zero). The warning does not activate (it does not come on at all). *1–15* Enter any number between "1" and "15." The warning activates, but only after that number of minutes has elapsed. NOTE: If both parm #113, turn signal activation time, and parm #114, turn signal activation distance, are turned on, the turn signal warning is activated by whichever condition becomes active first.

* No access by users
† Authorization required

Table 2, Buzzer Parameters (parms #108-113)

Buzzer Parameters			
Parm	**Units**	**Range**	**Description**
114	Miles	0–15	**Turn Signal Warning Activation Distance:** Controls how far the vehicle has to travel with the turn signals ON before the buzzer warning activates and the dash driver display shows the "Warning–Turn Signal ON" screen.
		0=Off	Enter "0" (zero). The warning does not activate (it does not come on at all).
		1–15	Enter any number between "1" and "15." The warning activates, but only after the vehicle has traveled one-tenth that number of miles. For example, if "5" is entered, the turn signal warning activates after the vehicle has traveled 0.5 (one-half) mile.
			NOTE: If both parm #113, turn signal activation time, and parm #114, turn signal activation distance, are turned on, the turn signal warning is activated by whichever condition becomes active first.
115	Sec	0–15	**Number of Seconds ON for Type 3 Buzzer Pulsed:** Controls the number of seconds each buzzer pulse lasts when the type 3 buzzer is selected.
		0=Off	Enter "0" (zero). The type 3 (programmable) buzzer function is disabled (this does not affect the other two types of buzzer function).
		1–15	Enter any number between "1" and "15." The buzzer remains ON for that number of seconds during each pulse.
116*	None	0–3	**Buzzer Enable III:** Controls the enabling of this buzzer, and the type of sound: continuous buzzing (type 1), steady pulsing (type 2), or programmable pulsing (type 3). This is an optional buzzer function.
		0=Off	Enter "0" (zero). The buzzer function is disabled (it does not sound).
		1	Enter "1." The buzzer sounds continuously until the problem is corrected.
		2	Enter "2." The buzzer pulses steadily until the problem is corrected.
		3	Enter "3." The buzzer pulses according to a programmed pattern until the problem is corrected.
			NOTE: To change the programmable pulsing function, see parm #115.
117*	None	0–3	**Buzzer Enable IV:** Controls the enabling of this buzzer, and the type of sound. This is an optional buzzer function.
			For programming instructions, see parm #116.
118*	None	0–3	**Low Windshield Wiper Water Level Buzzer:** Controls the enabling of this buzzer, and the type of sound. This buzzer comes on when the windshield washer water level gets too low.
			For programming instructions, see parm #116.

* No access by users

Table 3, Buzzer Parameters (parms #114-118)

System Parameter Changing

To change system parameters (parms), display the parameter table in ServiceLink. Using one of the tables listed below, enter the desired range setting in the "Value" column in the parameter table.

NOTE: Not all parameters can be changed by every user. Some cannot be changed by users at all. Others require authorization. These files display in different colors on the ServiceLink screen and are designated by footnotes in the text.

System Parameters			
Parm	**Units**	**Range**	**Description**
130*	None	12 bits	**Input Software Version Number:** Allows the input of the software version number installed in the ICU.
			This is a data input parameter. Enter the software version number.
142†	None	17 bits	**Input Vehicle ID Number:** Allows the input of the vehicle identification number.
			This is a data input parameter. Enter the vehicle identification number.
159*	None	21 bits	**Input Century Class ICU Part Number:** Allows the input of the ICU part number.
			This is a data input parameter. Enter the ICU part number.
189†	None	0 or 219	**VORAD:** Enables the ICU to look for an Eaton VORAD collision avoidance system installed on the vehicle and responding to the data link.
		0=Off	Enter "0" (zero) if no collision avoidance system is installed.
		219	Enter "219" if a collision avoidance system is installed.
190	None	0 or 136	**ABS:** Enables the ICU to look for an antilock brake system installed on the vehicle and responding to the data link.
		0=Off	Enter "0" (zero) if no antilock brake system is installed.
		136	Enter "136" if an antilock brake system is installed.
191	None	0 or 150	**ECAS:** Enables the ICU to look for an electronic suspension installed on the vehicle and responding to the data link.
		0=Off	Enter "0" (zero) if no electronic suspension is installed.
		150	Enter "150" if an electronic suspension is installed.
192	None	0 or 190	**ACPU:** Enables the ICU to look for an air conditioning protection unit installed on the vehicle and responding to the data link.
		0=Off	Enter "0" (zero) if no air conditioning protection unit is installed.
		190	Enter "190" if an air conditioning protection unit is installed.
193	None	0 or 130	**Transmission:** Enables the ICU to look for an electronic transmission installed on the vehicle and responding to the data link.
		0=Off	Enter "0" (zero) if no electronic transmission is installed.
		130	Enter "130" if an electronic transmission is installed.

* No access by users
† Authorization required

Table 1, System Parameters (parms #130-193)

System Parameter Changing

System Parameters			
Parm	**Units**	**Range**	**Description**
194	None	0, 181, or 231	**Communications:** Enables the ICU to look for a satellite communications system installed on the vehicle and responding to the data link.
		0=Off	Enter "0" (zero) if no communications system is installed.
		181	Enter "181" if a Qualcomm® communications system is installed.
		231	Enter "231" if a HighwayMaster® communications system is installed.
195	None	0 or 179	**Data Logging Unit:** Enables the ICU to look for a data logging unit installed on the vehicle and responding to the data link.
		0=Off	Enter "0" (zero) if no data logging unit is installed.
		179	Enter "179" if a data logging unit is installed.

Table 2, System Parameters (parms #194-195)

Additional Display Parameter Changing

To change the additional display parameters (parms), display the parameter table in ServiceLink. Using one of the tables listed below, enter the desired range setting in the "Value" column in the parameter table.

To change parms #196 through #200, see **Table 1**. To change parms #201 through #210, see **Table 2**.

NOTE: Not all parameters can be changed by every user. Some cannot be changed by users at all. Others require authorization. These files display in different colors on the ServiceLink screen and are designated by footnotes in the text.

Additional Display Message Parameters

Parm	Units	Range	Description
196*	Miles	0–254	**Maintenance Category (miles):** Allows the setting of custom maintenance intervals by mileage on the "Next Service" screen (see parm #201).
		0=Off	Enter "0" (zero). The screen display is disabled (it does not display at all).
		1–254	Enter any number between "1" and "254." The ICU establishes a maintenance interval benchmark for 250 times that number of miles. For example, if "40" is entered, the ICU establishes a 10,000-mile benchmark and calculates the "miles remaining to next service" backward from 10,000.
197*	Hours	0–254	**Maintenance Category (hours):** Allows the setting of custom maintenance intervals by engine hours on the "Next Service" screen (see parm #201).
		0=Off	Enter "0" (zero). The screen display is disabled (it does not display at all).
		1–254	Enter any number between "1" and "254." The ICU establishes a maintenance interval benchmark for 10 times that number of hours. For example, if "40" is entered, the ICU establishes a 400-hour benchmark and calculates the "hours remaining to next service" backward from 400.
198†	Sec	0–15	**Data Recorded Screen:** Controls the enabling of the data recording function screens, and how long they remain on. This function is accessed by pressing the EVENT key.
		0=Off	Enter "0" (zero). The screen displays for this function are disabled (they do not display at all).
		1–14	Enter any number between "1" and "14." The screen activated by this function displays for that number of seconds before dismissing itself.
		15	Enter "15." The screen activated by this function displays until the reset key is pressed.
			NOTE: When the EVENT key is pressed, this function displays one of three different screens. Normally, it displays "Data Being/Recorded." If the memory in the data logging unit (DLU) is full, it displays "Memory Full/Data Not Recorded." If the DLU is not connected, or not responding, it displays "Data Recorder/Not Responding."
199†	Sec	0–15	**Outside Temperature Screen:** Controls the enabling of this screen, and how long it remains on. This screen is accessed by pressing the TEMP key.
		0=Off	Enter "0" (zero). The screen display is disabled (it does not display at all).
		1–14	Enter any number between "1" and "14." The screen displays for that number of seconds before dismissing itself.
		15	Enter "15." The screen displays until the reset key is pressed.
200*	Sec	0–15	**Time Screen:** Controls the enabling of this direct access screen, and how long it remains on. This screen is accessed by pressing the TIME key.
			For programming instructions, see parm #199.

* No access by users
† Authorization required

Table 1, Additional Display Message Parameters (parms #196-200)

Additional Display Parameter Changing

Additional Display Message Parameters			
Parm	**Units**	**Range**	**Description**
201*	None	0–2	**Next Service Screen:** Controls the enabling of this screen, and whether it displays the next service interval in miles or engine hours.
		0=Off	Enter "0" (zero). The screen display is disabled (it does not display at all).
		1–2	Enter "1" to display the interval in miles. Enter "2" to display the interval in engine hours.
202*	None	0 or 1	**Set Time Screen:** Controls the enabling of this screen.
		0=Off	Enter "0" (zero). The screen display is disabled (it does not display at all).
		1=On	Enter "1." The screen display is enabled (it displays when requested).
203	None	0 or 1	**Diagnostic Information Screen:** Controls the enabling of this title screen.
		0=Off	Enter "0" (zero). The screen display is disabled (it does not display at all).
		1=On	Enter "1." The screen display is enabled (it displays when requested).
204*	None	0 or 1	**Service Information Screen:** Controls the enabling of this title screen.
			For programming instructions, see parm #203.
205	None	0 or 1	**Setup Information Screen:** Controls the enabling of this title screen.
			For programming instructions, see parm #203.
206	None	0 or 1	**Vehicle Information Screen:** Controls the enabling of this title screen.
			For programming instructions, see parm #203.
207	None	0 or 1	**Data Link Active Screen:** Controls the enabling of this dynamic display screen.
			For programming instructions, see parm #203.
208	None	0 or 1	**Data Link Status Screen:** Controls the enabling of this dynamic display screen.
			For programming instructions, see parm #203.
209†	Sec	0–254	**No Data Link Activity Alert Screen:** Controls the enabling of this alert screen, how often the display repeats, and whether the screen can be dismissed by the driver. This screen appears when the ICU cannot detect any response from the J1587 databus through the data link.
		0=Off	Enter "0" (zero). The screen display is disabled (it does not display at all).
		1	Enter "1." The screen displays one time only for seven seconds.
		2	Enter "2." The screen displays for seven seconds, dismisses itself, and returns every 254 seconds until the fault is corrected.
		3–253	Enter any number between "3" and "253." The screen display repeats after that number of seconds. It continues its repeat cycle until the fault is corrected. Each time, it can be dismissed by the driver pushing any key.
		254	Enter "254." The screen displays continuously until the condition returns to normal. It can not be dismissed.

* No access by users
† Authorization required

Table 2, Additional Display Message Parameters (parms #201-209)

Gauge/Indicator Light Parameter Changing

To change gauge and indicator light parameters (parms), display the parameter table in ServiceLink. Using one of the tables listed below, enter the desired range setting in the "Value" column in the parameter table.

Indicator light parameters control the type of input switched to a particular light, but they are not assigned specific functions.

Gauge parameters are of two types. Firstly, at each electronic gauge location, the gauge function is programmable. Each function is assigned a number based on the module number for that gauge. For a list of the gauge assignment numbers for each gauge function, see **Table 5**. When assigning gauge functions, use only the numbers in this table.

Secondly, at certain gauge locations the gauge sweep is programmable to either 90 degrees or 270 degrees.

NOTE: Not all parameters can be changed by every user. Some cannot be changed by users at all. Others require authorization. These files display in different colors on the ServiceLink screen and are designated by footnotes in the text.

ICU Left Microprocessor Indicator Light Parameters			
Parm	**Units**	**Range**	**Description**
220*	None	0–3	**Indicator Light Input WL008:** Controls the type of input switched to this indicator light, which is currently unassigned.
		0	Enter "0" (zero). The circuit receives ground-active input.
		1	Enter "1." The circuit receives ground-inactive input.
		2	Enter "2." The circuit receives power-active input.
		3	Enter "3." The circuit receives power-inactive input.
221*	None	0–3	**Indicator Light Input WL009:** Controls the type of input switched to this indicator light, which is currently unassigned. For programming instructions, see parm #220.
222*	None	0–3	**Indicator Light Input WL013:** Controls the type of input switched to this indicator light, which is currently unassigned. For programming instructions, see parm #220.
223*	None	0–3	**Indicator Light Input WL014:** Controls the type of input switched to this indicator light, which is currently unassigned. For programming instructions, see parm #220.
224*	None	0–3	**Indicator Light Input WL015:** Controls the type of input switched to this indicator light, which is currently unassigned. For programming instructions, see parm #220.

* No access by users

Table 1, ICU Left Microprocessor Indicator Light Parameters (parms #220-224)

Gauge/Indicator Light Parameter Changing

ICU Left Microprocessor Gauge Parameters			
Parm	**Units**	**Range**	**Description**
230	None	0–866	**Gauge Function DR001:** Specifies a gauge function at this location.
		0=Off	Enter "0" (zero) if no gauge is installed at gauge location DR001.
		810–866	Enter any number between "810" and "866" that corresponds to the assignment number of the gauge installed at this location. For example, if the engine oil pressure gauge is installed here, enter "852."
232	None	0–866	**Gauge Function DR002:** Specifies a gauge function at this location.
		0=Off	Enter "0" (zero) if no gauge is installed at gauge location DR002.
		810–866	Enter any number between "810" and "866" that corresponds to the assignment number of the gauge installed at this location. For example, if the engine oil temperature gauge is installed here, enter "856."
234	None	0–866	**Gauge Function DR003:** Specifies a gauge function at this location.
		0=Off	Enter "0" (zero) if no gauge is installed at gauge location DR003.
		810–866	Enter any number between "810" and "866" that corresponds to the assignment number of the gauge installed at this location. For example, if the coolant temperature gauge is installed here, enter "854."
236	None	0–866	**Gauge Function DR005:** Specifies a gauge function at this location.
		0=Off	Enter "0" (zero) if no gauge is installed at gauge location DR005.
		810–866	Enter any number between "810" and "866" that corresponds to the assignment number of the gauge installed at this location. For example, if the turbo air pressure gauge is installed here, enter "842."
238	None	0–866	**Gauge Function DR006:** Specifies a gauge function at this location.
		0=Off	Enter "0" (zero) if no gauge is installed at gauge location DR006.
		810–866	Enter any number between "810" and "866" that corresponds to the assignment number of the gauge installed at this location. For example, if the pyrometer is installed here, enter "858."
			NOTE: The gauge installed here is linked to the gauge sweep parameter for this location (parm #244). If a turbo pressure gauge (parm #238=842), the gauge sweep must be set to 90 degrees (parm #244=0). If a pyrometer (parm #238=858), the gauge sweep must be set to 270 degrees (parm #244=1).
240	None	0–866	**Gauge Function DR007:** Specifies a gauge function at this location.
		0=Off	Enter "0" (zero) if no gauge is installed at gauge location DR007.
		810–866	Enter any number between "810" and "866" that corresponds to the assignment number of the gauge installed at this location. For example, if the tachometer is installed here, enter "812."
242*	None	0 or 1	**Gauge Sweep Function DR001:** Controls the dial sweep on the gauge installed at this location.
		0	Enter "0" (zero) for a dial sweep of 90 degrees at gauge location DR001.
		1	Enter "1" for a dial sweep of 270 degrees at gauge location DR001.
243*	None	0 or 1	**Gauge Sweep Function DR002:** Controls the dial sweep on the gauge installed at this location.
		0	Enter "0" (zero) for a dial sweep of 90 degrees at gauge location DR002.
		1	Enter "1" for a dial sweep of 270 degrees at gauge location DR002.

* No access by users

Table 2, ICU Left Microprocessor Gauge Parameters (parms #230-243)

Additional Display Parameter Changing

Additional Display Message Parameters			
Parm	**Units**	**Range**	**Description**
210*	None	0 or 1	**Gauge Diagnostic Faults:** Controls the enabling of this function, which monitors the gauges connected to the ICU left microprocessor and reports any faults found.
		0=Off	Enter "0" (zero). The function is disabled (faults are not reported).
		1=On	Enter "1." The function is enabled (faults are reported).
211	None	0 or 1	**Parking Brake Off Warning Screen:** Controls the enabling of this alert screen, which comes on when the parking brake is off and the door open and/or the ignition keyswitch turned on.
		0=Off	Enter "0" (zero). The screen display is disabled (it does not display at all).
		1=On	Enter "1." The screen display is enabled (it displays when conditions require).
			NOTE: Found only on vehicles built before March 7, 1997.

* Authorization required

Table 3, Additional Display Message Parameters (parms #210-211)

ICU Right Microprocessor Indicator Light and Gauge Parameters			
Parm	**Units**	**Range**	**Description**
244	None	0 or 1	**Gauge Sweep Function DR006:** Controls the dial sweep on the gauge installed at this location. See note at parm #238.
		0	Enter "0" (zero) for a dial sweep of 90 degrees at gauge location DR006.
		1	Enter "1" for a dial sweep of 270 degrees at gauge location DR006.
257*	None	0–3	**Indicator Light Input WL016:** Controls the type of input switched to this indicator light (possible application: utility lights).
		0	Enter "0" (zero). The circuit receives ground-active input.
		1	Enter "1." The circuit receives ground-inactive input.
		2	Enter "2." The circuit receives power-active input.
		3	Enter "3." The circuit receives power-inactive input.
258*	None	0–3	**Indicator Light Input WL017:** Controls the type of input switched to this indicator light (possible application: differential lock).
			For programming instructions, see parm #257.
259*	None	0–3	**Indicator Light Input WL018:** Controls the type of input switched to this indicator light (possible application: air suspension warning)
			For programming instructions, see parm #257.
265	None	0–866	**Gauge Function DR008:** Specifies a gauge function at this location.
		0=Off	Enter "0" (zero) if no gauge is installed at gauge location DR008.
		810–866	Enter any number between "810" and "866" that corresponds to the assignment number of the gauge installed at this location. For example, if the speedometer is installed here, enter "810."
267	None	0–866	**Gauge Function DR011:** Specifies a gauge function at this location.
		0=Off	Enter "0" (zero) if no gauge is installed at gauge location DR012.
		810–866	Enter any number between "810" and "866" that corresponds to the assignment number of the gauge installed at this location. For example, if the fuel level gauge is installed here, enter "844."
269	None	0–866	**Gauge Function DR012:** Specifies a gauge function at this location.
		0=Off	Enter "0" (zero) if no gauge is installed at gauge location DR012.
		810–866	Enter any number between "810" and "866" that corresponds to the assignment number of the gauge installed at this location. For example, if the transmission fluid temperature gauge is installed here, enter "864."
271	None	0–866	**Gauge Function DR013:** Specifies a gauge function at this location.
		0=Off	Enter "0" (zero) if no gauge is installed at gauge location DR013.
		810–866	Enter any number between "810" and "866" that corresponds to the assignment number of the gauge installed at this location. For example, if the forward (or rear) axle temperature gauge is installed here, enter "866."

* No access by users

Table 3, Gauge and Indicator Light Parameters (parms #244-271)

Gauge/Indicator Light Parameter Changing

ICU Right Microprocessor Gauge Parameters			
Parm	**Units**	**Range**	**Description**
273	None	0–866	**Gauge Function DR014:** Specifies a gauge function at this location.
		0=Off	Enter "0" (zero) if no gauge is installed at gauge location DR014.
		810–866	Enter any number between "810" and "866" that corresponds to the assignment number of the gauge installed at this location. For example, if the rear (or forward) axle temperature gauge is installed here, enter "866."
275*	None	0 or 1	**Gauge Sweep Function DR011:** Controls the dial sweep on the gauge installed at this location.
		0	Enter "0" (zero) for a dial sweep of 90 degrees at gauge location DR011.
		1	Enter "1" for a dial sweep of 270 degrees at gauge location DR011.
276*	None	0–866	**Gauge Function AU011:** Specifies a gauge function at this optional location on the auxiliary instrument panel.
		0=Off	Enter "0" (zero) if no gauge is installed at gauge location AU011.
		810–866	Enter any number between "810" and "866" that corresponds to the assignment number of the gauge installed at this location. For example, if an axle temperature gauge is installed here, enter "866." See **Table 5**.
278*	None	0–866	**Gauge Function AU012:** Specifies a gauge function at this optional location on the auxiliary instrument panel.
		0=Off	Enter "0" (zero) if no gauge is installed at gauge location AU012.
		810–866	Enter any number between "810" and "866" that corresponds to the assignment number of the gauge installed at this location. For example, if a fuel pressure gauge is installed here, enter "843." See **Table 5**.
280*	None	0–866	**Gauge Function AU013:** Specifies a gauge function at this optional location on the auxiliary instrument panel.
			For programming instructions, see parm #278.
282*	None	0–866	**Gauge Function AU014:** Specifies a gauge function at this optional location on the auxiliary instrument panel.
			For programming instructions, see parm #278.

* No access by users

Table 4, ICU Right Microprocessor Gauge Parameters (parms #273-282)

Gauge/Indicator Light Parameter Changing

Gauge Assignment Numbers		
Value	**Function**	**Default Location**
0	Gauge Off	AU011, 12, 13 & 14
810	Speedometer	DR008
812	Tachometer	DR007
838	Application Air Pressure	DR012
842	Turbo Air Pressure	DR005
843	Fuel Pressure	None
844	Fuel Level	DR011
	Second Fuel Level	None
852	Engine Oil Pressure	DR001
854	Engine Coolant Temperature	DR003
856	Engine Oil Temperature	DR002
858	Pyrometer	DR006
864	Transmission Fluid Temperature	DR012
866	Forward-Rear Axle Temperature	DR013
	Rearmost Axle Temperature	DR014

Table 5, Gauge Assignment Numbers

Parameter Changing, Right Microprocessor

Certain parameters must be repeated for use of the ICU right microprocessor. These parameters are listed below.

To change the right microprocessor parameters (parms), display the parameter table in ServiceLink. Using one of the tables listed below, enter the desired range setting in the "Value" column in the parameter table.

NOTE: Not all parameters can be changed by every user. Some cannot be changed by users at all. Others require authorization. These files display in different colors on the ServiceLink screen and are designated by footnotes in the text.

ICU Right Microprocessor Display Parameters			
Parm	**Units**	**Range**	**Description**
284*	Sec	0–15	**Set Screen Blinking Time:** Controls the blinking rate of certain screen displays.
		0=Off	Enter "0" (zero). Blinking is disabled (screen displays do not blink).
		1–15	Enter any number between "1" and "15." The screen displays for one-half that number of seconds. For example, if the blinking time is set to "3," blinking displays will blink every 1.5 seconds.
			NOTE: This parameter is identical to parm #24, but repeated for use of the right microprocessor.
285*	Sec	0–15	**Bulb Check Time On:** Controls the number of seconds that the bulbs illuminate during the "Ignition ON" sequence.
		0=Off	Enter "0" (zero). This function is disabled (the bulbs do not illuminate).
			Enter any number between "1" and "15." The bulbs illuminate for that number of seconds.
			NOTE: This parameter is identical to parm #36, but repeated for use of the right microprocessor.
286*	Min	0–254	**Dash Active After Ignition Off:** Controls the number of minutes that the dash continues to receive power after the ignition keyswitch is turned OFF.
		0	Enter "0" (zero). When the ignition keyswitch is turned off, the dash turns inactive immediately.
		1–254	Enter any number between "1" and "254." After the ignition keyswitch has been turned off, the dash continues to receive power for that number of minutes.
			NOTE: When the dash is receiving power, it will appear to be turned off, even though the microprocessor remains active to perform these functions: door open, parking brake off (as enabled by parm #34); buzzer (as enabled by parms #100-118). This parameter is identical to parm #37, but repeated for use of the right microprocessor.
287*	Sec	0–7	**Buzzer Check Time On:** Controls the number of seconds that the buzzer sounds during the "Ignition ON" sequence.
		0=Off	Enter "0" (zero). The buzzer does not sound at all.
		1–7	Enter any number between "1" and "7." The buzzer sounds for that number of seconds.
			NOTE: This parameter is identical to parm #38, but repeated for use of the right microprocessor.
288*	Volts	5–135	**Low Voltage Warning Threshold:** Controls the voltage required to trigger the display of the "Warning–Low Voltage" screen.
			Enter any number between "5" and "135." The low voltage warning comes on when the voltage equals one-tenth that amount. For example, if this parameter is set to "122," the warning comes on at 12.2 volts.
			NOTE: This parameter is identical to parm #41, but repeated for use of the right microprocessor.

* No access by users

Table 1, ICU Right Microprocessor Display Parameters (parms #284-288)

Parameter Changing, Right Microprocessor

ICU Right Microprocessor Buzzer Parameters			
Parm	**Units**	**Range**	**Description**
289*	None	0–3	**Engine Protection Buzzer:** Controls the enabling of this buzzer, and the type of sound: continuous buzzing (type 1), steady pulsing (type 2), or programmable pulsing (type 3). This buzzer sounds when the engine temperature is too high.
		0=Off	Enter "0" (zero). The buzzer function is disabled (it does not sound).
		1	Enter "1." The buzzer sounds continuously until the problem is corrected.
		2	Enter "2." The buzzer pulses steadily until the problem is corrected.
		3	Enter "3." The buzzer pulses according to a programmed pattern until the problem is corrected.
			NOTE: To change the programmable pulsing function, see parm #295. This parameter is identical to parm #103, but repeated for use of the right microprocessor.
290*	None	0–3	**Low Air Buzzer:** Controls the enabling of this buzzer, and the type of sound. This buzzer sounds when the air pressure drops below the minimum.
			For programming instructions, see parm #289.
			NOTE: This parameter is identical to parm #104, but repeated for use of the right microprocessor.
291	None	0–3	**HVAC Input Buzzer:** Controls the enabling of this buzzer, and how it sounds: continuous buzzing, steady pulsing, or programmable pulsing. This buzzer sounds when either the Recirc Mode Engaged (parm #50) or Provide Fresh Air (parm #51) alert screens come on.
			For programming instructions, see parm #289.
			NOTE: This parameter is identical to parm #110, but repeated for use of the right microprocessor.
292*	None	0–3	**Buzzer Enable II:** Controls the enabling of this buzzer, and the type of sound. This is an optional buzzer function.
			For programming instructions, see parm #289.
			NOTE: This parameter is identical to parm #111, but repeated for use of the right microprocessor.
293*	Min	0–15	**Turn Signal Warning Activation Time:** Controls how long the turn signals have to remain ON before the buzzer warning activates and the dash driver display shows the "Warning–Turn Signal ON" screen.
		0=Off	Enter "0" (zero). The warning does not activate (it does not come on at all).
		1–15	Enter any number between "1" and "15." The warning activates, but only after that number of minutes has elapsed.
			NOTE: If both parm #293, turn signal activation time, and parm #294, turn signal activation distance, are turned on, the turn signal warning is activated by whichever condition becomes active first. This parameter is identical to parm #113, but repeated for use of the right microprocessor.

* No access by users

Table 2, ICU Right Microprocessor Buzzer Parameters (parms #289-293)

Parameter Changing, Right Microprocessor

ICU Right Microprocessor Buzzer and System Parameters			
Parm	**Units**	**Range**	**Description**
294*	Miles	0–15	**Turn Signal Warning Activation Distance:** Controls how far the vehicle has to travel with the turn signals ON before the buzzer warning activates and the dash driver display shows the "Warning–Turn Signal ON" screen.
		0=Off	Enter "0" (zero). The warning does not activate (it does not come on at all).
		1–15	Enter any number between "1" and "15." The warning activates, but only after the vehicle has traveled one-tenth that number of miles. For example, if "5" is entered, the turn signal warning activates after the vehicle has traveled 0.5 (one-half) mile.
			NOTE: If both parm #293, turn signal activation time, and parm #294, turn signal activation distance, are turned on, the turn signal warning is activated by whichever condition becomes active first. This parameter is identical to parm #114, but repeated for use of the right microprocessor.
295	Sec	0–15	**Number of Seconds ON for Type 3 Buzzer Pulsed:** Controls the number of seconds each buzzer pulse lasts when the type 3 buzzer.
		0=Off	Enter "0" (zero). The type 3 (programmable) buzzer function is disabled (this does not affect the other two types of buzzer function).
		1–15	Enter any number between "1" and "15." The buzzer remains ON for that number of seconds during each pulse.
			NOTE: This parameter is identical to parm #115, but repeated for use of the right microprocessor.
296*	None	0 or 136	**ABS:** Enables the ICU to look for an antilock brake system installed on the vehicle and responding to the data link.
		0=Off	Enter "0" (zero) if no antilock brake system is installed.
		136	Enter "136" if an antilock brake system is installed.
			NOTE: This parameter is identical to parm #190, but repeated for use of the right microprocessor.
297*	None	0 or 150	**ECAS:** Enables the ICU to look for an electronic suspension system installed on the vehicle and responding to the data link.
		0=Off	Enter "0" (zero) if no electronic suspension is installed.
		150	Enter "150" if an electronic suspension is installed.
			NOTE: This parameter is identical to parm #191, but repeated for use of the right microprocessor.
298*	None	0 or 190	**ACPU:** Enables the ICU to look for an air conditioning protection unit installed on the vehicle and responding to the data link.
		0=Off	Enter "0" (zero) if no air conditioning protection unit is installed.
		190	Enter "190" if an air conditioning protection unit is installed.
			NOTE: This parameter is identical to parm #192, but repeated for use of the right microprocessor.
299*	None	0 or 130	**Transmission:** Enables the ICU to look for an electronic transmission installed on the vehicle and responding to the data link.
		0=Off	Enter "0" (zero) if no electronic transmission is installed.
		130	Enter "130" if an electronic transmission is installed.
			NOTE: This parameter is identical to parm #193, but repeated for use of the right microprocessor.

* No access by users

Table 3, ICU Right Microprocessor Buzzer and System Parameters (parms #294-299)

Parameter Changing, Right Microprocessor

ICU Right Microprocessor Miscellaneous Parameters			
Parm	**Units**	**Range**	**Description**
300*	Sec	0–15	**Monitored Systems OK Screen:** Controls the enabling of this screen and the length of time that it shows on the dash driver display during the "Ignition ON" sequence.
		0=Off	Enter "0" (zero). The screen display is disabled (it does not display at all).
		1–15	Enter any number between "1" and "15." The screen displays for that number of seconds.
			NOTE: This parameter is identical to parm #2, but repeated for use of the right microprocessor.
301*	None	N/A	**Input Software Version Number:** Allows the input of the software version number installed in the ICU.
			This is a data input parameter. Enter the software version number.
			NOTE: This parameter is identical to parm #130, but repeated for use of the right microprocessor.
313*	None	N/A	**Input Century Class ICU Part Number:** Allows the input of the ICU part number.
			This is a data input parameter. Enter the ICU part number.
			NOTE: This parameter is identical to parm #159, but repeated for use of the right microprocessor.
334*	None	0 or 1	**Gauge Diagnostic Faults:** Controls the enabling of this function, which monitors the gauges connected to the ICU and reports any faults found.
		0=Off	Enter "0" (zero). The function is disabled (faults are not reported).
		1=On	Enter "1." The function is enabled (faults are reported).
			NOTE: This parameter is identical to parm #210, but repeated for use of the right microprocessor.

* No access by users

Table 4, ICU Right Microprocessor Miscellaneous Parameters (parms #300-334)

Troubleshooting

The instrumentation control unit (ICU) receives warnings via the J1708/1587 data bus and displays them as received.

The ICU presents this information to the operator or service technician in the form of alert screens (when the vehicle is moving) or diagnostic information data screens (when the vehicle is not moving).

IGNITION SEQUENCE

When the ignition switch is turned ON, the ICU performs an ignition sequence. The electronically driven gauges sweep from zero to full scale and then back to zero. The warning/indicator lights also activate for a certain number of seconds (the number of seconds can be programmed).

NOTE: The battery voltage, primary air, and secondary air gauges are not electronically driven and do not sweep.

During the ignition sequence, the ICU monitors and records any active vehicle electronic system fault codes transmitted on the datalink by other Electronic Control Units (ECUs). The ICU stores a maximum of 16 active fault codes (eight each for the ICU and for other vehicle systems). The ICU will store these active faults in memory until one of the following happens:

- The ignition switch is turned OFF or;
- The ICU receives a "DIAGNOSTIC CLEAR" message and the ECU stops transmitting the fault code.

The ICU can store eight ICU system historic, or inactive, fault codes. Clear ICU system historic fault codes with the SET/RESET keypad key or with ServiceLink.

SYSTEM FAULT ANALYSIS

When displaying fault codes, the ICU uses four kinds of code groups:

- Message Identifiers (MIDs)
- Parameter Identifiers (PIDs)
- Sub-System Identifiers (SIDs)
- Failure Mode Identifiers (FMIs)

For lists of MIDs, PIDs, SIDs, and FMIs, see **Specifications, 400**. For more information on these code groups and how to read them, see "Fault Codes" in this subject.

To correct an active fault, see the following sources:

- Engine ECM (MID 128)—use the engine manufacturer's literature.
- ABS ECU (MID 136)—see **Section 42.08** or use the antilock brake system manufacturer's literature.
- ICU (MIDs 140, 142, and 234)—see this section.
- DLU (MID 179)—see **Section 54.06**.
- ACPU (MID 190)—see **Section 83.02**.

1. To begin troubleshooting active fault codes, first turn the ignition switch OFF and then ON. This verifies that a fault is still active and allows the ICU to record any other faults currently being transmitted.

IMPORTANT: There are two central processing units (CPUs) in the ICU, each with its own MID. Left CPU faults are broadcast as MID 140. Right CPU faults were originally broadcast as MID 142, but on ICUs with software version 8.4.0, the MID has been changed to 234.

2. Correct the active fault. See below for information on specific faults. See **Table 1** for LH CPU faults (except keypad faults). See **Table 2** for RH CPU faults. See **Table 3** for keypad faults.
3. To verify that the problem is corrected and that the fault code is no longer displayed as active, turn the ignition switch OFF and then ON.

Troubleshooting

Instrumentation Control Unit (ICU) Fault Codes, Left-Hand CPU							
ICU Text Message			Problem	MID	Fault #	FMI	Correction
Instr	DR01 COIL	OPEN	Gauge at this position has an open coil	140	002	05	Install a gauge known to be good and perform the ignition sequence. If the test gauge sweeps full scale and back to zero, replace the original gauge with a new one. If the test gauge does not sweep, replace the ICU.
Instr	DR01 COIL	Short	Gauge at this position has a shorted coil	140	002	06	
Instr	DR02 COIL	OPEN	Gauge at this position has an open coil	140	003	05	
Instr	DR02 COIL	Short	Gauge at this position has a shorted coil	140	003	06	
Instr	DR03 COIL	OPEN	Gauge at this position has an open coil	140	004	05	
Instr	DR03 COIL	Short	Gauge at this position has a shorted coil	140	004	06	
Instr	DR04 COIL	OPEN	Gauge at this position has an open coil	140	005	05	
Instr	DR04 COIL	Short	Gauge at this position has a shorted coil	140	005	06	
Instr	DR05 COIL	OPEN	Gauge at this position has an open coil	140	006	05	
Instr	DR05 COIL	Short	Gauge at this position has a shorted coil	140	006	06	
Instr	DR06 COIL	OPEN	Gauge at this position has an open coil	140	007	05	
Instr	DR06 COIL	Short	Gauge at this position has a shorted coil	140	007	06	
Instr	DR07 COIL	OPEN	Gauge at this position has an open coil	140	008	05	
Instr	DR07 COIL	Short	Gauge at this position has a shorted coil	140	008	06	
Instr	ELECTR BD	Bad	Gauge drive circuit failure	140	017	12	Replace the ICU
Instr	EEPROM	Bad	EEPROM failure	140	019	12	Replace the ICU

Table 1, Instrumentation Control Unit (ICU) Fault Codes, Left-Hand CPU (non-keypad)

Instrumentation Control Unit (ICU) Fault Codes, Right-Hand CPU							
ICU Text Message			Problem	MID	Fault #	FMI	Correction
Instr	DR08 COIL	OPEN	Gauge at this position has an open coil	234	022	05	Install a gauge known to be good and perform the ignition sequence. If the test gauge sweeps full scale and back to zero, replace the original gauge with a new one. If the test gauge does not sweep, replace the ICU.
Instr	DR08 COIL	Short	Gauge at this position has a shorted coil	234	022	06	
Instr	DR11 COIL	OPEN	Gauge at this position has an open coil	234	023	05	
Instr	DR11 COIL	Short	Gauge at this position has a shorted coil	234	023	06	
Instr	DR12 COIL	OPEN	Gauge at this position has an open coil	234	024	05	
Instr	DR12 COIL	Short	Gauge at this position has a shorted coil	234	024	06	
Instr	DR13 COIL	OPEN	Gauge at this position has an open coil	234	025	05	
Instr	DR13 COIL	Short	Gauge at this position has a shorted coil	234	025	06	
Instr	DR14 COIL	OPEN	Gauge at this position has an open coil	234	026	05	
Instr	DR14 COIL	Short	Gauge at this position has a shorted coil	234	026	06	
Instr	AUX6 COIL	OPEN	Gauge at this position has an open coil	234	027	05	
Instr	AUX6 COIL	Short	Gauge at this position has a shorted coil	234	027	06	
Instr	AUX7 COIL	OPEN	Gauge at this position has an open coil	234	028	05	
Instr	AUX7 COIL	Short	Gauge at this position has a shorted coil	234	028	06	
Instr	AUX8 COIL	OPEN	Gauge at this position has an open coil	234	029	05	
Instr	AUX8 COIL	Short	Gauge at this position has a shorted coil	234	029	06	
Instr	AUX9 COIL	OPEN	Gauge at this position has an open coil	234	030	05	
Instr	AUX9 COIL	Short	Gauge at this position has a shorted coil	234	030	06	
Instr	EEPROM	Bad	Right-hand EEPROM failure	234	039	12	Replace the ICU

Table 2, Instrumentation Control Unit (ICU) Fault Codes, Right-Hand CPU

Instrumentation Control Unit (ICU) Fault Codes, Keypad Faults							
ICU Text Message			Problem	MID	Fault #	FMI	Correction
Instr	KEY 1	Bad	Key has failed or keypad connection open	140	009	12	Check keypad connection to cab harness, repair as required. Check circuit 437B from the keypad to the LH ICU pin B8 and 437G to LH ICU D11, repair as required. If circuits are OK, replace keypad.
Instr	KEY 2	Bad	Key has failed or keypad connection open	140	010	12	Check keypad connection to cab harness, repair as required. Check circuit 437C from the keypad to the LH ICU pin B6 and 437G to LH ICU D11, repair as required. If circuits are OK, replace keypad.
Instr	KEY 3	Bad	Key has failed or keypad connection open	140	011	12	Check keypad connection to cab harness, repair as required. Check circuit 437D from the keypad to the LH ICU pin B5 and 437G to LH ICU D11, repair as required. If circuits are OK, replace keypad.

Troubleshooting

Instrumentation Control Unit (ICU) Fault Codes, Keypad Faults							
ICU Text Message			Problem	MID	Fault #	FMI	Correction
Instr	KEY 4	Bad	Key has failed or keypad connection open	140	012	12	Check keypad connection to cab harness, repair as required. Check circuit 437E from the keypad to the LH ICU pin B9 and 437G to LH ICU D11, repair as required. If circuits are OK, replace keypad.
Instr	KEY 5	Bad	Key has failed or keypad connection open	140	013	12	Check keypad connection to cab harness, repair as required. Check circuit 437F from the keypad to the LH ICU pin B7 and 437G to LH ICU D11, repair as required. If circuits are OK, replace keypad.

Table 3, Instrumentation Control Unit (ICU) Fault Codes, Keypad Faults

DATALINK ACTIVITY

1. If the alert message "NO DATALINK ACTIVITY" is displayed, check the J1705/J1587 datalink wiring (twisted pairs).
2. Verify that all ECUs are connected.
3. Verify that the ECU J1587+ is connected to the datalink J1587+ and that ECU J1587– is connected to datalink J1587–.

GAUGES

Gauge Does Not Sweep

If a particular gauge does not sweep during the ignition sequence, then there is a problem either with the gauge or the ICU circuit board.

1. Turn the gauge counterclockwise and remove it from the ICU housing.
2. Install a gauge known to be good and repeat the ignition sequence.
3. If the test gauge sweeps full scale and back to zero, replace the original gauge with a new one. For replacement instructions, see **Subject 110**.
4. If the test gauge does not sweep, replace the ICU. For replacement instructions, see **Subject 100**.

NOTE: If one ICU circuit board has failed, replace the complete ICU housing containing both the left and right ICU circuit boards. Remove all gauges, the message center bezel, and the wood grain panel. Install these parts in the new ICU housing.

Gauge Does Sweep

If a gauge malfunctions but sweeps during the ignition sequence, the ICU is not at fault.

1. Check the circuits that supply input signals to the ICU.
2. Check the engine ECM programming.

WARNING/INDICATOR LIGHTS

Light Does Not Illuminate

Most warning and indicator lights illuminate during the ignition sequence. This can be used as a diagnostic test of these lights.

IMPORTANT: The following lights do not illuminate during the ignition sequence:

A. ENG PROT indicator light input WL002

B. CHK ENG indicator light input WL003

C. STOP ENG indicator light input WL007 (used on Cummins engines only)

D. TRAC ABS indicator light input WL011

If a warning/indicator light other than those listed above does not illuminate during the ignition sequence, either the light bulb or the ICU circuit board is malfunctioning. Replace the light bulb with a test bulb known to be good and repeat the ignition sequence.

1. Remove the message center bezel and replace the bulb with a test bulb. Use the bulb replacement tool provided.

2. If the test bulb lights, replace the original bulb with a new one. For replacement instructions, see **Subject 120**.

   If the test bulb does not light, replace the ICU. For replacement instructions, see **Subject 100**.

Light Illuminates

If a warning/indicator light malfunctions but illuminates during the ignition sequence, the ICU is not at fault.

1. Check the circuits that supply input signals to the ICU. These lights are activated by either a 12V power input or a ground input.
2. Check the ECU programming corresponding to the light.

BUZZER

Buzzer Does Not Operate

If the buzzer does not activate during the ignition sequence, either the buzzer or the ICU circuit board is malfunctioning. The buzzer is mounted behind the speedometer.

1. Install a buzzer known to be good and repeat the ignition sequence.
2. If the test buzzer functions, replace the original buzzer with a new one. For replacement instructions, see **Subject 130**.

   If the test buzzer does not function, replace the ICU. For replacement instructions, see **Subject 100**.

Buzzer Does Operate

If the buzzer operates during the ignition sequence but does not work properly for another function, then there is a problem with the ICU configuration or with ICU input circuits.

1. Check the ICU parameter (buzzer functions) configuration with ServiceLink. For more information, see **Subject 180**.
2. Check the circuits that supply input signals to the ICU.
3. Check the ECU programming corresponding to the buzzer function.

DASH DRIVER DISPLAY SCREEN

Screen Does Not Activate

If the dash driver display screen does not activate during the ignition sequence, either the display screen itself or the ICU circuit board is malfunctioning. The dash driver display screen is mounted behind the message center bezel.

1. Install a dash driver display screen known to be good and repeat the ignition sequence.
2. If the test screen functions, replace the original dash driver display screen with a new one. For replacement instructions, see **Subject 140**.

   If the test screen does not function, replace the ICU. For replacement instructions, see **Subject 100**.

Screen Does Activate

If the dash driver display screen operates during the ignition sequence, but does not work properly for another function, then there is a problem in the ICU configuration or the key pad.

1. Check the ICU parameter configuration (screen display functions) with ServiceLink.
2. Verify that the ICU parameter that controls the screen function which is having the problem is configured correctly.
3. If the parameter value is incorrect, change the parameter value and enable the screen function. For more information, see **Subject 170** or **Subject 200**. For screen functions controlled by the right-hand ICU microprocessor, see **Subject 220**.
4. Check the ICU dash driver display for the message "KEY PAD FAULT." See **Table 3**.

   If this message is displayed, check the keypad connection to the wiring harness and repair the circuit if necessary.
5. If the keypad to wiring harness connection is good, replace the keypad. For replacement instructions, see **Subject 150**.

ICU SMALL GAUGES

The oil pressure, coolant temperature, oil temperature, and turbo air pressure gauges are driven electronically by the ICU using data inputs from the engine ECM.

Troubleshooting

The ICU receives digital data from the engine ECM via the J1708/J1587 datalink.

1. First, to determine whether the fault lies in the ICU or the gauge input circuits, do the "Gauges" procedure above.
2. If the problem is found to be in the ICU, replace the ICU. For replacement instructions, see **Subject 100**.

   If the problem is found to be in the gauge input circuits, use the dash driver display, ServiceLink, or the engine manufacturer's diagnostic software tool, and determine if there is an active engine ECM fault code related to the problem.
3. If an active fault code is displayed, follow the engine manufacturer's instructions to correct the problem.

   If no active fault code is displayed, check the datalink connection from the engine ECM to the ICU.
4. Check the datalink for cross-wired connections from all ECUs.

VOLTMETER

The voltmeter is driven by the voltage input to the ICU. The voltmeter should function with the ignition switch in the ON position.

1. Replace a problem gauge with a test gauge known to be good and turn the ignition ON.
2. If the test gauge indicates 11 to 14V, replace the original gauge with a new one.

   If the test gauge indicates lower than 11V or higher than 14V, then check input voltages to the left-hand ICU board (pink connector) as follows:

   2.1 Check the 12V battery circuit: pin LH-D14 and wire 437.

   2.2 Check the 12V ignition circuit: pin LH-D15 and wire 437A.

   2.3 Check the ground circuit: pin LH-D13 and wire GND1.
3. Troubleshoot and repair any of the above circuits that shows a malfunction.

   If all the circuits above are functioning, replace the ICU. For replacement instructions, see **Subject 100**.

PYROMETER

The pyrometer is electronically driven by the ICU. The pyrometer input circuit to the ICU contains a thermocouple mounted on the turbocharger exhaust port and a thermocouple amplifier module (TAM). The thermocouple senses the exhaust temperature and sends a small voltage signal to the TAM. The TAM amplifies this voltage signal by a factor of 100 (typically 0 to 8 VDC) and sends it on to the ICU. The ICU receives the analog voltage signal from the TAM and converts it to the digital signal that drives the pyrometer.

1. First, to determine whether the fault lies in the ICU or the gauge input circuits, do the "Gauges" procedure above.
2. If the problem is found to be in the ICU, replace the ICU. For replacement instructions, see **Subject 100**.

   If the problem is found to be in the gauge input circuits, check for 12 VDC of ignition power at the vehicle side connector to the TAM (circuit 218). The TAM is located just above the right-hand wheel well. Repair a malfunctioning circuit if necessary.
3. Warm up the engine fully so that the thermocouple reaches operating temperature. Then shut down the engine and turn the ignition back on.

NOTE: Do not measure voltage using chassis ground as a reference.

4. Check the voltage output signal of the TAM.

   Example: At 300°F (150°C) = 5.14 VDC (acceptable); at 480°F (250°C) = 9.16 VDC (unacceptable).

   NOTE: To measure TAM output voltage, gain access the circuits at the right-hand wheel well or at the ICU left-hand connector pin C6 (218A+) and pin D6 (218A–).

   4.1 Check between circuits 218A+ (positive lead) and 218A– (negative lead). Voltage should be 4 to 8 VDC, depending on temperature.

4.2 If this measurement is not within the tolerances, then either the TAM or the thermocouple is malfunctioning.

NOTE: The TAM's output should be 100 times greater then the thermocouple output (TAM output = 5.14 VDC, thermocouple output = .0514 VDC).

NOTE: Do not measure voltage using chassis ground as a reference.

5. Check the voltage output signal of the thermocouple.

   Example: At 300°F (150°C) = 0.514 VDC (acceptable); at 480°F (250°C) = 0.916 VDC (unacceptable).

   NOTE: To measure thermocouple output voltage, gain access to the circuits at the right-hand wheel well.

   5.1 Check the voltage between circuits 218A+ (positive lead) and 218A– (negative lead). The voltage should be between 0.4 and 0.8 VDC.

   5.2 If this measurement is out of tolerance, the thermocouple is malfunctioning. Replace a malfunctioning thermocouple as required.

   If this measurement is within tolerance, but the measurement in the previous step was out of tolerance, the TAM is malfunctioning. Replace a malfunctioning TAM as required.

6. Check the circuits from the TAM to the ICU.

   6.1 Check for continuity between circuit 218A+ and ICU left-hand connector pin C6.

   6.2 Check for continuity between circuit 218A– and pin D6.

   6.3 Repair a malfunctioning circuit if necessary.

TRANSMISSION TEMPERATURE GAUGE

The transmission temperature gauge is electronically driven by the ICU. The ICU input circuit contains a temperature sensor (thermistor) mounted in the transmission housing. The sensor sends a resistance signal corresponding to the transmission temperature. The ICU receives this signal and converts it to a digital signal, which drives the electronic transmission temperature gauge.

NOTE: Do not measure resistance using chassis ground as a reference.

1. First, to determine whether the fault lies in the ICU or the gauge input circuits, do the "Gauges" procedure above.

2. If the problem is found to be in the ICU, replace the ICU. For replacement instructions, see **Subject 100**.

   If the problem is found to be in the gauge input circuits, check the resistance of the temperature sensor at the transmission. The resistance between the two sensor pins is typically 32 to 1 kilo ohms. Replace the sensor if necessary.

   Examples: At 32°F (0°C) = 32 kilo ohms; at 77°F (25°C) = 10 kilo ohms.

3. Check the continuity of the sensor-to-ICU circuits on the ICU right-hand (blue) connector. Repair a malfunctioning circuit if necessary.

   3.1 Check for continuity between wire 30 and pin RH-D7.

   3.2 Check for continuity between wire 30G and pin RH-D6.

DRIVE AXLE TEMPERATURE GAUGES

The temperature gauges for the forward-rear and rearmost drive axles are electronically driven by the ICU. The input circuits to the ICU contain temperature sensors (thermistors) mounted in the drive axle housings. The sensor sends a resistance signal corresponding to the axle temperature. The ICU receives the resistance signal and converts it to a digital signal which drives the electronic gauges.

NOTE: Do not measure resistance using chassis ground as a reference.

1. First, to determine whether the fault lies in the ICU or the gauge input circuits, do the "Gauges" procedure above.

2. If the problem is found to be in the ICU, replace the ICU. For replacement instructions, see **Subject 100**.

   If the problem is found to be in the gauge input circuits, check the resistance of the rear axle temperature sensors. The resistance between the

two sensor pins is typically 32 to 1 kilo ohms. Replace the sensor if necessary.

Examples: At 32°F (0°C) = 32 kilo ohms; at 77°F (25°C) = 10 kilo ohms.

3. Check the continuity of the circuits from the forward-rear drive axle sensors to the ICU right-hand (blue) connector. Repair a malfunctioning circuit if necessary.

   3.1 Check for continuity between wire 42 and pin RH-D5.

   3.2 Check for continuity between wire 42G and pin RH-C5.

4. Check the continuity of the circuits from the rear-most drive axle sensors to the ICU right-hand (blue) connector. Repair a malfunctioning circuit if necessary.

   4.1 Check for continuity between wire 43 and pin RH-D4.

   4.2 Check for continuity between wire 43G and pin RH-C4.

OUTSIDE AMBIENT AIR TEMPERATURE CIRCUIT

A temperature sensor (thermistor) is mounted under the front bumper step. The sensor sends a resistance value corresponding to the outside air temperature to the ICU which converts it to a digital signal. The ICU uses this digital signal to display the outside ambient air temperature on the dash driver display when the TEMP key is pressed on the keypad.

1. Turn the ignition switch to the ON position and push the TEMP key on the keypad to troubleshoot the outside ambient air temperature circuit.

2. If the temperature displayed is a large negative number, for example –34°F (–37°C), then there is an open circuit. Verify that the sensor is connected.

3. Check the continuity of circuit 299 (Air Temp+) from the front bumper step to the chassis connector, and from there to the left-hand (pink) ICU connector. Repair a malfunctioning circuit if necessary.

   3.1 Check for continuity between the front bumper step and chassis connector pin D7.

   3.2 Check for continuity between chassis connector pin D7 and ICU pin LH-C7.

4. Check the continuity of circuit 299A (Air Temp GND) from the front bumper step to the chassis connector, and from there to the left-hand (pink) ICU connector. Repair a malfunctioning circuit if necessary.

   4.1 Check for continuity between the front bumper step and chassis connector pin D9.

   4.2 Check for continuity between chassis connector pin D9 and ICU pin LH-D7.

NOTE: Do not measure resistance using chassis ground as a reference.

5. If the temperature displayed does not correspond to the air temperature, check the resistance of the temperature sensor. The resistance between the two sensor pins is typically 34 to 0.25 kilo ohms. Replace the sensor if necessary.

   Examples: At 59°F (15°C) = 1.5 to 1.6 kilo ohms; at 68°F (20°C) = 1.2 to 1.3 kilo ohms; and at 77°F (25°C) = 0.9 to 1.1 kilo ohms.

FUEL LEVEL GAUGE

The fuel level gauge is electronically driven by the ICU. The ICU input circuit contains a resistive fuel level sensor mounted in the fuel tank. The sensor transmits a resistance signal corresponding to the fuel level. The ICU receives this signal and converts it to a digital signal, which drives the electronic fuel level gauge.

NOTE: Do not measure resistance using chassis ground as a reference.

1. First, to determine whether the fault lies in the ICU or the gauge input circuits, do the "Gauges" procedure above.

2. If the problem is found to be in the ICU, replace the ICU. For replacement instructions, see **Subject 100**.

   If the problem is found to be in the gauge input circuits, check the resistance of the fuel level sensor at the fuel tank. The resistance between

the two sensor pins is typically 29 to 250 ohms. Replace the sensor if necessary.

Examples: Full tank = 29 to 33.5 ohms; empty tank = 244 to 250 ohms.

3. Check the continuity of the circuits from the fuel level sensor to the ICU right-hand (blue) connector. Repair a malfunctioning circuit if necessary.

   3.1 Check for continuity between wire 47 and ICU pin RH-B5.

   3.2 Check for continuity between wire 47G and ICU pin RH-B6.

FAULT CODES

The ICU displays four kinds of numerical code groups for reporting faults, accompanied by a text message which describes both the failed component and the failure mode, or cause of failure.

Each fault code displayed consists of three code groups. The first code group identifies the fault transmitter. It is referred to as the message identifier (MID). For a complete list of MIDs, see **Specifications, 400**.

The next code group consists of three digits also. This code identifies the system in which the fault was detected. It is either the parameter identifier (PID), or the sub-system identifier (SID). For lists of PIDs and SIDs, see **Specifications, 400**.

NOTE: Instrumentation control unit (ICU) faults have special fault numbers. For a list of ICU fault numbers for the LH CPU, see **Table 4**. For a list of ICU fault numbers for the RH CPU, see **Table 5**.

ICU Fault Numbers (MID=140)

Description	Text Message*	Fault #	FMI
J1587 Test	DATA LINK - Erratic	001	02
Engine Oil Pressure	DR01 COIL - Short	002	06
	DR01 COIL - OPEN		05
Engine Coolant Temp	DR02 COIL - Short	003	06
	DR02 COIL - OPEN		05
Engine Oil Temp	DR03 COIL - Short	004	06
	DR03 COIL - OPEN		05
Voltmeter	DR04 COIL - Short	005	05
	DR04 COIL - OPEN		06
Turbo Air Pressure	DR05 COIL - Short	006	06
	DR05 COIL - OPEN		05
Pyrometer	DR06 COIL - Short	007	06
	DR06 COIL - OPEN		05
Tachometer	DR07 COIL - Short	008	06
	DR07 COIL - OPEN		05
TEMP Key	KEY 1 - Bad	009	12
FUEL Key	KEY 2 - Bad	010	12
TRIP Key	KEY 2 - Bad	010	12
LEG Key	KEY 3 - Bad	011	12
DOWN ARROW Key	KEY 3 - Bad	011	12
LEFT ARROW Key	KEY 4 - Bad	012	12

Troubleshooting

ICU Fault Numbers (MID=140)			
Description	**Text Message***	**Fault #**	**FMI**
RIGHT ARROW Key	KEY 4 - Bad	012	12
SET/RESET Key	KEY 5 - Bad	013	12
EVENT Key	KEY 5 - Bad	013	12
Odometer	ODOMETER - Bad	015	12
Light Drive Circuit Failure	ELECTR BRD - Bad	016	12
Gauge Drive Circuit Failure	ELECTR BRD - Bad	017	12
Buzzer Drive Circuit Failure	ELECTR BRD - Bad	018	12
Programmable Memory Failure	EEPROM - Bad	019	12
Analog-to-Digital Converter Failure	ELECTR BRD - Bad	020	12

* Text messages specify the gauge location, not a particular gauge. The location of particular gauges can vary.

Table 4, ICU Fault Numbers (LH CPU)

ICU Fault Numbers (MID=142/234)			
Description	**Text Message***	**Fault #**	**FMI**
J1587 Fault (RH Side)	DATA LINK - Bad	021	12
Speedometer	DR08 COIL - Short	022	06
	DR08 COIL - OPEN		05
Fuel Level	DR11 COIL - Short	023	06
	DR11 COIL - OPEN		05
Trans Fluid Temp	DR12 COIL - Short	024	06
	DR12 COIL - OPEN		05
Forward Axle Temp	DR13 COIL - Short	025	06
	DR13 COIL - OPEN		05
Rear Axle Temp	DR14 COIL - Short	026	06
	DR14 COIL - OPEN		05
Fuel Pressure	AUX6 COIL - Short	027	06
	AUX6 COIL - OPEN		05
2nd Fuel Level	AUX7 COIL - Short	028	06
	AUX7 COIL - OPEN		05
Trans Fluid Pressure	AUX8 COIL - Short	029	06
	AUX8 COIL - OPEN		05
Turbo Oil Temp	AUX9 COIL - Short	030	06
	AUX9 COIL - OPEN		05
Odometer (RH side)	ODOMETER - Bad	035	12

ICU Fault Numbers (MID=142/234)			
Description	**Text Message***	**Fault #**	**FMI**
Programmable Memory Failure (RH side)	EEPROM - Bad	039	12
Circuit Board Fault (RH side)	ELECTR BRD - Bad	040	12

* Text messages specify the gauge location, not a particular gauge. The location of particular gauges can vary.

Table 5, ICU Fault Numbers (RH CPU)

Since the ICU gathers information electronically, any error message or warning displayed by the ICU can indicate one of two things: a fault in the vehicle system or a fault in the data. If the fault lies in a particular vehicle system, see the troubleshooting subject in the appropriate section of the workshop manual.

To help identify faults in the data, the ICU displays a two-digit code at the end of each fault message called the Failure Mode Identifier (FMI). The FMI gives information about where the fault lies. Is the circuit shorted, or open? Is the vehicle low on coolant, or is the coolant level sensor bad? For a complete list of FMIs, see **Specifications, 400**.

Fault Code Screens

Fault code screens provide troubleshooting information in a brief, easy-to-read format.

In release 8.4.0, the top line of the display gives a description of the fault code. The bottom line gives a short text description of the failure mode, followed by the fault code. See the example in **Table 5**.

In earlier releases, the top line of the display gives the fault code and the name of the reporting unit. The bottom line gives a text description of the fault code and failure mode, followed by the fault code. See the example in **Table 6**.

Release	Screen Contents
Release 8.4.0	ENG Coolant TEMP Low 128x110 01*
Earlier Releases	128 110 01 ENG ENGCOOLANTTEMP LOVLD

* x is blank for a PID, "s" for a SID.

Table 6, Fault Code Screens

NOTE: The second code group in the fault code can be either a PID or a SID. To tell them apart, all SIDs are preceded by an "s" in the space between the first code group (the MID) and the second code group. If the second code group is a PID, the space is blank.

Specifications

See **Fig. 1** for a schematic of the ICU keypad wiring and chassis sensor wiring (chassis sensors include the fuel level, transmission temperature, and axle temperature sensors).

For a schematic of the wiring connecting the ICU to ignition and battery power, showing the interconnections to the datalink wiring and to ground, see **Fig. 2** on vehicles built before August 30, 1996. See **Fig. 3** on vehicles built on or after August 30, 1996.

See **Fig. 4** for a schematic of the ICU wiring showing the discrete signals coming in from the engine ECM, ABS module, and other discrete sources located in the engine and cab.

Each ICU microprocessor has two connectors. Connector #1 has 24 pins, numbered A1 through A12, and B1 through B12. Connector #2 has 32 pins, numbered C1 through C16, and D1 through D16.

Number	Description	Wire
A1	Panel Lights	29A
A2	Data Logging Unit Manually Recorded Event	442B
A3	J1708(–) #1 Jumper (see RH-A5)*	1708–1
A4	Optional Indicator 5	GND
A5	Optional Indicator 4	GND
A6	Trailer ABS Indicator GND	376F
A7	Optional Indicator 2	GND
A8	Optional Indicator 1	GND
A9	Washer Level	320A

* Found only on vehicles built before August 30, 1996

Table 1, Left (Pink) Connector #1 Pin Assignments, Pins A1 through A9

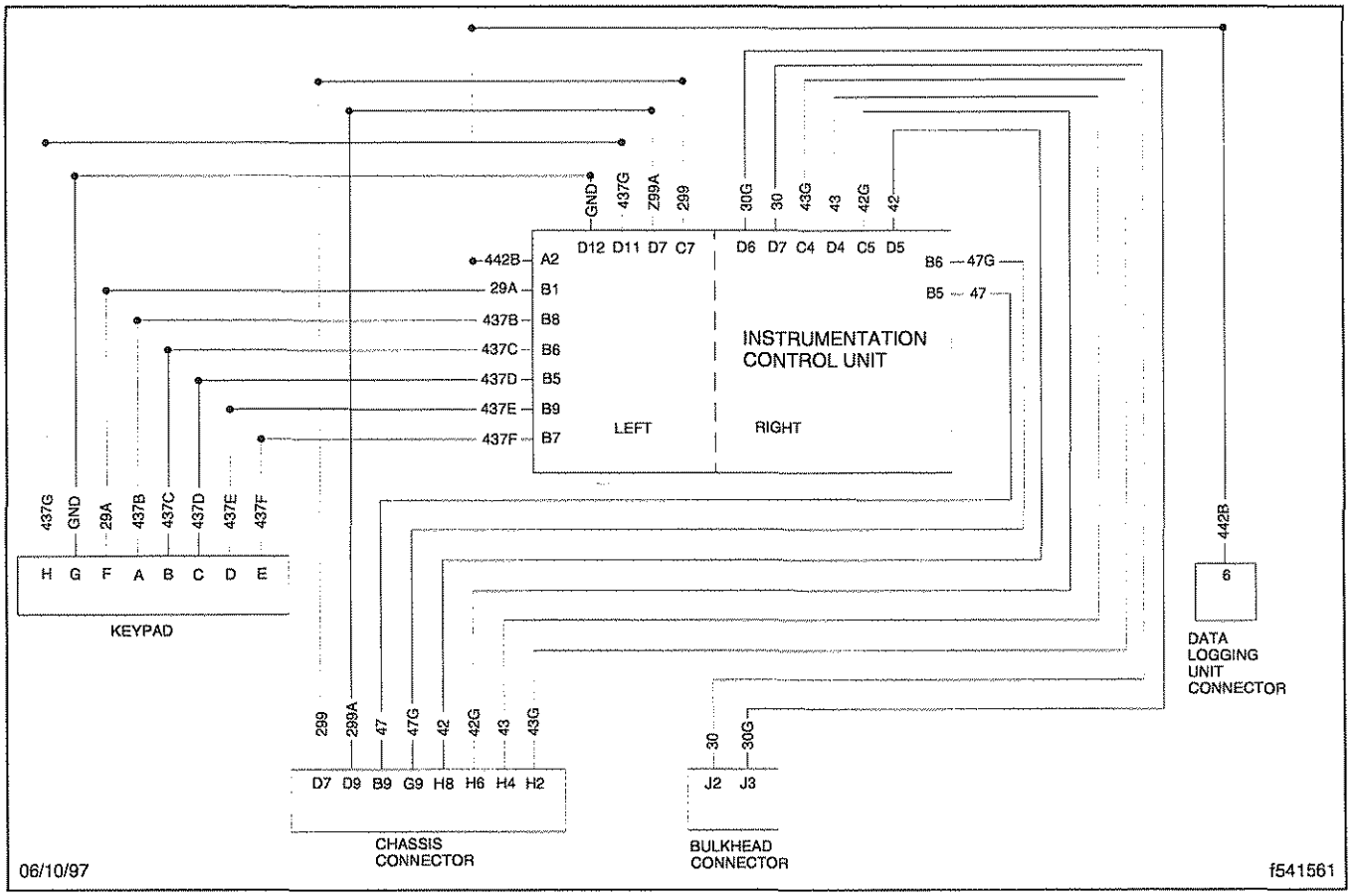


Fig. 1, ICU Keypad Wiring and Chassis Sensor Wiring

Specifications

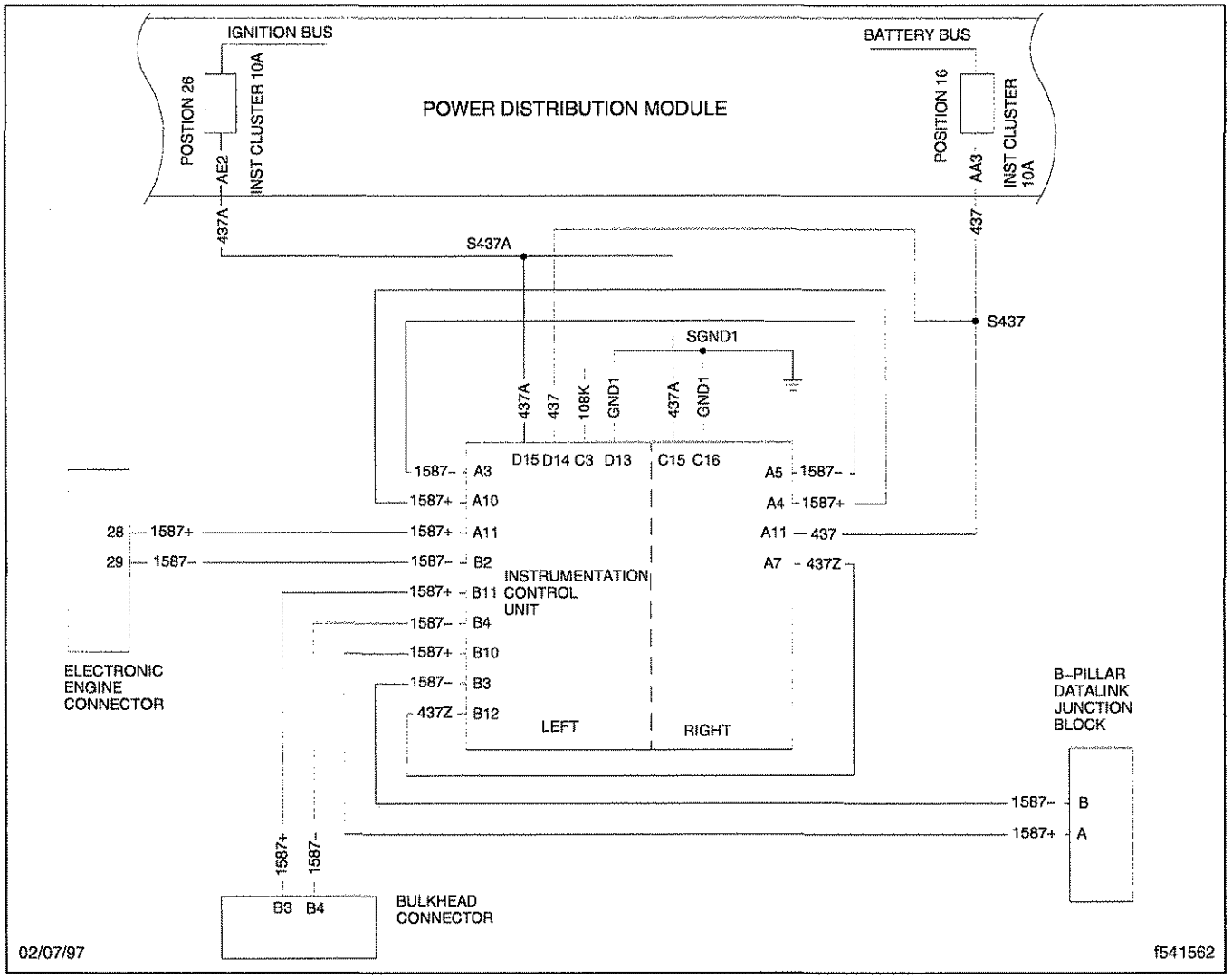


Fig. 2, ICU Power, Ground, and Datalink Interconnections, Vehicles Built Before August 30, 1996

Number	Description	Wire
A10	J1708(+) #1 Jumper (see RH-A4)*	1708+1
A11	J1708 Databus (+) #2*	1708+2
B1	Keypad Panel Lights	29A
B2	J1708 Databus (–) #2*	1708–2
B3	J1587 Databus (–)	1587–C
B4	ACPU (–)*	1587–P
B5	Wire 3 (keypad)	437D
B6	Wire 2 (keypad)	437C

Number	Description	Wire
B7	Wire 5 (keypad)	437F
B8	Wire 1 (keypad)	437B
B9	Wire 4 (keypad)	437E
B10	J1587 Databus (+)	1587+C
B11	ACPU (+)*	1587+P
B12	Buzzer Enable	437Z

* Found only on vehicles built before August 30, 1996

Table 2, Left (Pink) Connector #1 Pin Assignments, Pins A10 through B12

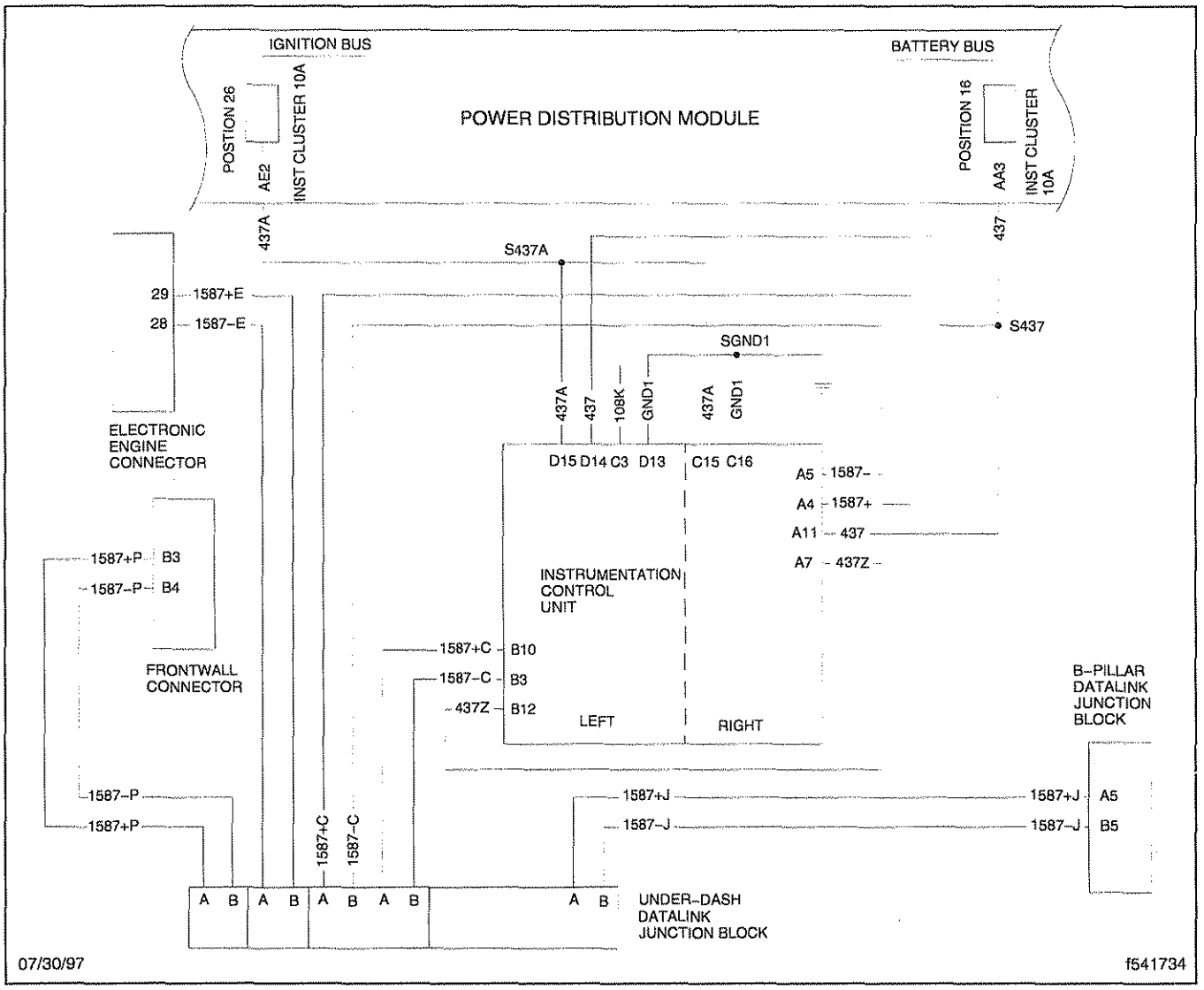


Fig. 3, ICU Power, Ground, and Datalink Interconnections, Vehicles Built On or After August 30, 1996

Number	Description	Wire
C3	Ignition Keyswitch Light	41/108K
C4	Door Open	437W
C5	Parking Brake	125
C6	Pyrometer (+)	218A+
C7	Ambient Air (+)	299
C8	Left Turn	38L
C9	Coolant Level	173

Number	Description	Wire
C10	Recirculation Pressure	98K
C14	Engine Protection (CUM only)	N16
C15	Check Engine	C799
		D419
		N25

Table 3, Left (Pink) Connector #2 Pin Assignments, Pins C3 through C15

Specifications

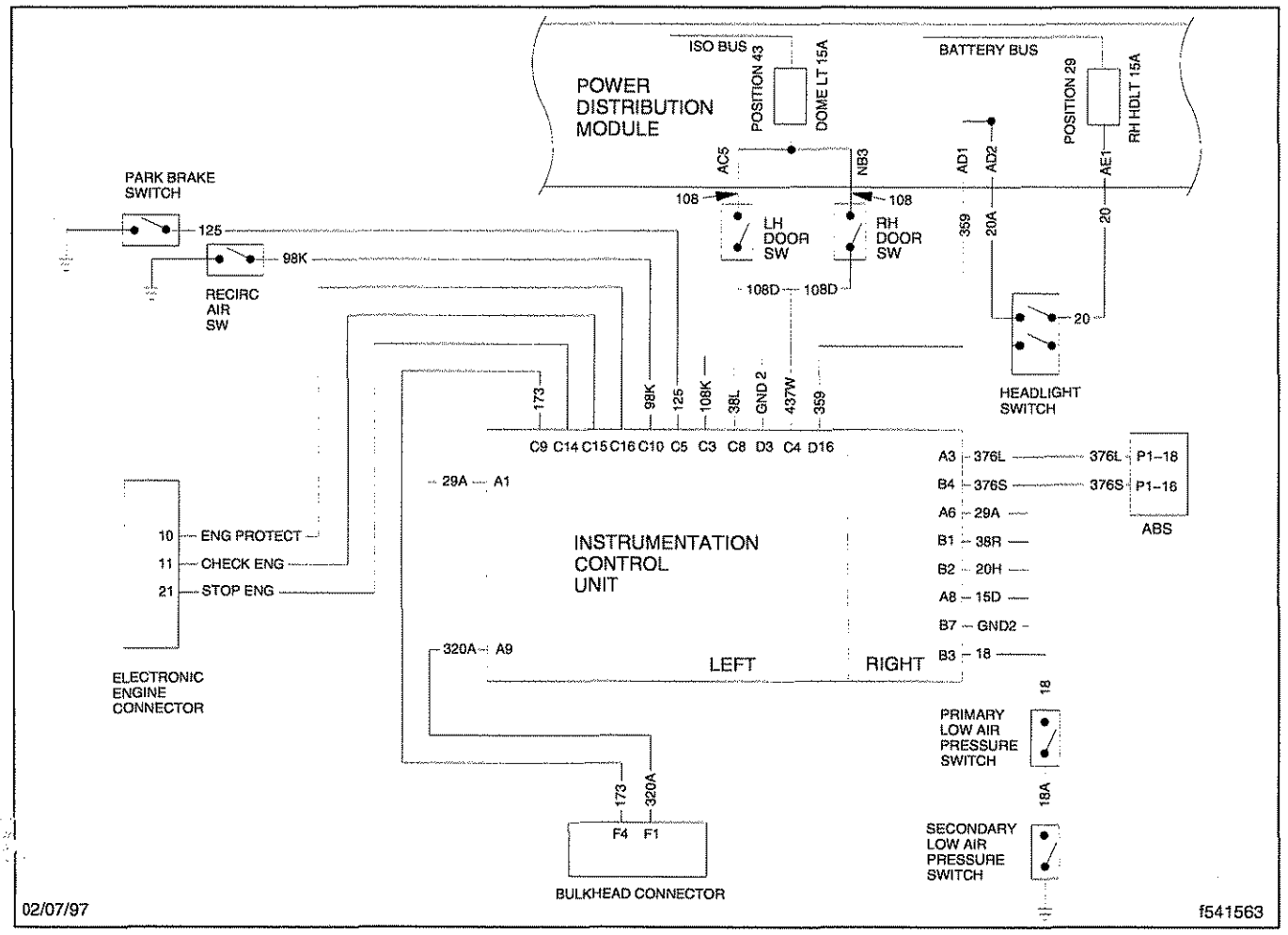


Fig. 4, ICU Discrete Signals

Number	Description	Wire
C16	Engine Shutdown	C659
		D509
		N01
D6	Pyrometer (–)	218A–
D7	Ambient Air (–)	299A
D11	Keypad Panel GND	437G
D12	Keypad Light GND	GND
D13	Ground Jumper (see RH-D16)	GND
D14	Battery	437

Number	Description	Wire
D15	Ignition	437A
D16	Headlights	359

Table 4, Left (Pink) Connector #2 Pin Assignments, Pins C16 through D16

Right (Blue) Connector #1 Pin Assignments		
Number	**Pin Assignment**	**Wire**
A1	Optional Indicator 7	—
A2	Optional Indicator 6	—
A3	Tractor ABS	376L
A4	J1708(+) #1 Jumper (see LH-A10)*	1708+1

Specifications

Right (Blue) Connector #1 Pin Assignments		
Number	**Pin Assignment**	**Wire**
A4	J1587+C†	1587+C
A5	J1708(–) #1 Jumper (see LH-A10)*	1708+1
A5	J1587–C†	1587–C
A6	Panel Lights	29A
A7	Buzzer Enable Jumper (see LH-B12)	437Z
A8	Starter Lockout	15D
A11	Battery	437
B1	Right Turn	38R
B2	Headlights (high beams)	20H
B3	Low Air Pressure	18
B4	Wheel Spin	376S
B5	Fuel Level (+)	47
B6	Fuel Level (–)	47G
B11	Battery Jumper (see LH-D14)	437

* Found only on vehicles built before August 30, 1996
† Found only on vehicles built on or after August 30, 1996

Table 5, Right (Blue) Connector #1 Pin Assignments

Right (Blue) Connector #2 Pin Assignments		
Number	**Pin Assignment**	**Wire**
C1	Optional Indicator 8	—
C3	Optional Gauge Type 2D (–)	—
C4	Rearmost-Axle Oil Temperature Sensor (–)	43G
C5	Forward-Rear-Axle Oil Temperature Sensor (–)	42G
C7	Gauge Return (AU07)	—
C8	Gauge Return (AU08)	—
C9	Gauge Return (AU09)	—

Right (Blue) Connector #2 Pin Assignments		
Number	**Pin Assignment**	**Wire**
C10	Gauge Ground (AU06)	GND
C11	Gauge Power (AU06)	—
C12	Gauge Power (AU07)	—
C13	Gauge Power (AU08)	—
C14	Gauge Power (AU09)	—
C15	Ignition	437A
C16	Chassis Ground	GND1
D1	Air Bag	454L
D2	Optional Buzzer C Power	—
D3	Optional Gauge Type 2D (+)	—
D4	Rearmost-Axle Oil Temperature Sensor (+)	43
D5	Forward-Rear-Axle Oil Temperature Sensor (+)	42
D6	Transmission Fluid Temperature Gauge (–)	30G
D7	Transmission Fluid Temperature Gauge (+)	30
D8	Optional Gauge Type 2E (–)	—
D9	Optional Gauge Type 2E (+)	—
D10	Optional Gauge Type 2F (–)	—
D11	Optional Gauge Type 2F (+)	—
D12	Optional Gauge Type 2G (–)	—
D13	Optional Gauge Type 2G (+)	—
D14	Optional Buzzer D	—
D15	Ignition Jumper (see LH-D15)*	437A
D16	Ground Jumper (see LH-D13)*	GND

* Found only on vehicles built before August 30, 1996

Table 6, Right (Blue) Connector #2 Pin Assignments

Specifications

Message Identifiers (MIDs)			
MID	**Description**	**Old Text Message**	**New Text Message***
128	Engine #1	ENGINE	ENG
130	Electronic Transmission	—†	Trans
136	Anti-Lock Brakes (ABS)	TRCTR BRK	Brake
140	Instrumentation Control Unit, Left	INSTRCLST	Instr
142	Instrumentation Control Unit, Right #1	INSTRCLST	MGMT
172	ServiceLink	DIAGNOSTC	DIAG
179	Data Logging Unit	LOG CMPTR	CMPTR
181	Communications Unit—Satellite	COMM SAT	Satl
190	Air Conditioning Protection Unit	ACPU	A/C
219	Collision Avoidance Radar	VORAD	Radar
231	Communications Unit—Cellular	COMM CELL	Phone
234	Instrumentation Control Unit, Right #2	INSTRCLST	Instr

* The new text messages appear on vehicles built on or after March 7, 1997.
† If there is no text message, the display area reserved for that text message will be blank. Only the MID number will display.

Table 7, Message Identifiers (MIDs)

Parameter Identifiers (PIDs) 51 through 63			
PID	**Description**	**Old Text Message**	**New Text Message***
51	Throttle Position	THROTTLE POS	Throttle Pos
52	Engine Intercooler Temperature	INTERCLR TEMP	Intercool TEMP
53	Transmission Synchronizer Clutch Value	SYNCRO CLUTCH	Synchro Clutch
54	Transmission Synchronizer Brake Value	SYNCRO BRAKE	Synchro Brake
55	Shift Finger Positional Status	SHFT FNGR POS	Shift FNGR Pos
56	Transmission Range Switch Status	RANGE SWITCH	RANGE Switch
57	Transmission Actuator Status #2	ACTTRSTATUS#2	Actuator #2
58	Shift Finger Actuator Status	SHFT FNGR ACT	Shift FNGR Act
59	Shift Finger Gear Position	SHFT FNGR GEAR	Shift FNGR Gear
60	Shift Finger Rail Position	SHFT FNGR RAIL	Shift FNGR Rail
61	Parking Brake Actuator Status	PRKBRKACTUATOR	Park Brake Act
62	Retarder Inhibit Status	RETARDRINHIBIT	RetardrInhibit
63	Transmission Actuator Status #1	ACT STATUS #1	Actuator #1

* The new text messages appear on vehicles built on or after March 7, 1997.

Table 8, Parameter Identifiers (PIDs) 51 through 63

Specifications

Parameter Identifiers (PIDs) 64 through 97			
PID	**Description**	**Old Text Message**	**New Text Message***
64	Direction Switch Status	DIRCTNSWCHSTAT	Dir Switch
65	Service Brake Switch Status	SVCBRK SW STAT	Serv Brake Sw
66	Vehicle Enabling Component Status	VEHENABLCMPTST	Veh ENABLING
67	Shift Request Switch Status	SHFT RQST SWCH	Shift RQST Switch
68	Torque Limiting Factor	TRQ LIMIT FCTR	TORQ LimitFctr
69	Two-Speed Axle Switch Status	2SPEEDAXLSWTCH	2 SPEEDAxl Sw
70	Parking Brake Switch	PARKBRK SWITCH	Park Brake Sw
71	Idle Shutdown Timer Status	IDLESHUTDWNTMR	IdleShutdwnTmr
72	Blower Bypass Valve Position	BLOWRBYPASSPOS	Blowr BYPASVal
73	Auxiliary Water Pump Pressure	AUXWATRPMPPRSS	Aux PUMP Press
74	Maximum Road Speed Limit	MAXROADSPEED	Max ROAD SPEED
75	Steering Axle Temperature	STRNGAXLTEMP	Str. Axle TEMP
76	Axle Lift Air Pressure	AXLLIFTAIRPRES	Axle Lift Pres
77	Forward-Rear Drive Axle Temperature	FWDRRDRVAXLTMP	FR DrvAxl TEMP
78	Rearmost (Rear-Rear) Drive Axle Temperature	RRRRDRVAXLTEMP	RR DrvAxl TEMP
79	Road Surface Temperature	ROAD SRFC TEMP	Road Surf TEMP
80	Washer Fluid Level	WASHRFLUIDLEVL	Washer Level
81	Particulate Trap Inlet Pressure	PARTTRAPINLPRS	PartTRAP Press
82	Air Start Pressure	AIRSTARTPRESS	Air Start Pres
83	Road Speed Limit Status	ROADSPDLIMITST	ROAD SPEED Lim
84	Road Speed	ROAD SPEED	ROAD SPEED
85	Cruise Control Status	CRUISECNTRLST	Cruise Status
86	Cruise Control Set Speed	CRUISE SET	Cruise Set
87	Cruise Control High—Set Limit Speed	CRUISE HI SET	Cruise Hi Set
88	Cruise Control Low—Set Limit Speed	CRUISE LO SET	Cruise Lo Set
89	Power Takeoff Status	PTO STATUS	PTO Status
90	PTO Oil Temperature	PTO OIL TEMP	PTO Oil TEMP
91	Percent Accelerator Pedal Position	ACCEL PDL POS%	Throttle Pedal
92	Percent Engine Load	ENG LOAD %	% ENG LOAD
93	Output Torque	OUTPUT TORQUE	OUTPUT TORQUE
94	Fuel Delivery Pressure	FUEL DLVR PRSS	Fuel DlvrPress
95	Fuel Filter Differential Pressure	FUEL FILTER	Fuel Filter
96	Fuel Level	FUEL LEVEL	Fuel Level
97	Water in Fuel Indicator	WATER IN FUEL	Water In Fuel

* The new text messages appear on vehicles built on or after March 7, 1997.

Table 9, Parameter Identifiers (PIDs) 64 through 97

Specifications

Parameter Identifiers (PIDs) 98 through 127			
PID	**Description**	**Old Text Message**	**New Text Message***
98	Engine Oil Level	OIL LEVEL	Oil Level
99	Engine Oil Filter Differential Pressure	OIL FLTR PRES	Oil Fltr Pres
100	Engine Oil Pressure	OIL PRESSURE	Oil Pressure
101	Crankcase Pressure	CRANKCASE PRES	CrankcasePress
102	Boost Pressure	BOOST PRESSR	Boost Press
103	Turbo Speed	TURBO SPEED	Turbo SPEED
104	Turbo Oil Pressure	TURBO OIL PRES	TurboOilPress
105	Intake Manifold Temperature	INTKMNFLDTEMP	IntakeAir TEMP
106	Air Inlet Pressure	AIR INLET PRSS	AirInlet Press
107	Air Filter Differential Pressure	AIR FILTER	Air Filter
108	Barometric Pressure	BAROM PRESSURE	Baro Press
109	Coolant Pressure	COOLNT PRESSR	Coolant Press
110	Engine Coolant Temperature	ENGCOOLANTTEMP	Coolant TEMP
111	Coolant Level	COOLANT LEVEL	Coolant Level
112	Coolant Filter Differential Pressure	CLNTFLTRDIFPRS	CoolFltDiffPrs
113	Governor Droop	GOVERNOR DROOP	Governor DROOP
114	Net Battery Current	NET BATT CURR	Battery AMPS
115	Alternator Current	ALTERNATORAMPS	Alternator AMPS
116	Brake Application Pressure	BRK APPL PRESS	APPLI Press
117	Brake Primary Pressure	BRK PRIM PRESS	Primary Press
118	Brake Secondary Pressure	BRK SEC PRESSR	Sec. Press
119	Hydraulic Retarder Pressure	HYD RTDR PRESS	Retarder Press
120	Hydraulic Retarder Oil Temperature	HYDRRTDROILTMP	Retdr Oil TEMP
121	Engine Retarder Status	ENGRTDRSTATUS	Retardr Status
122	Engine Retarder Percent	ENG RETARDER %	% Retarder
123	Clutch Pressure	CLUTCH PRESSR	Clutch Press
124	Transmission Oil Level	OIL LEVEL	Oil Level
125	Transmission Oil Level High/Low	TRANSOIL HI/LO	Oil Level
126	Transmission Filter Differential Pressure	FILTER PRESSUR	FilterDifPress
127	Transmission Oil Pressure	OIL PRESSURE	Oil Pressure

* The new text messages appear on vehicles built on or after March 7, 1997.

Table 10, Parameter Identifiers (PIDs) 98 through 127

Specifications

Parameter Identifiers (PIDs) 154 through 183			
PID	**Description**	**Old Text Message**	**New Text Message***
154	Auxiliary Input and Output Status #2	AUX INP/OUTP#2	Aux. In/Out #2
155	Auxiliary Input and Output Status #1	AUX IN/OUT #1	Aux. In/Out #1
156	Injector Timing Rail Pressure	AUX IN/OUT #1	Inj Time Press
157	Injector Metering Rail Pressure	INJ METR RLPRS	Inj Metr Press
158	Battery Potential (voltage)—Switched	BATTVLTGSWTCHD	Volts (BattSw)
159	Gas Supply Pressure	GAS SUPLY PRS	Gas Press
160	Main Shaft Speed	MAINSHAFTSPEED	MainShaftSPEED
161	Input Shaft Speed	INPUTSHAFT SPD	In Shaft SPEED
162	Transmission Range Selected	RANGE SELECTED	RANGE Selected
163	Transmission Range Attained	RANGE ATTAINED	RANGE Attained
164	Injection Control Pressure	INJ CTRL PRESR	Inj Ctrl Press
165	Compass Bearing	COMPASSBEARING	COMPASS Dir.
166	Rated Engine Power	RATED ENG PWR	Rated Power
167	Alternator Potential (voltage)	VOLTS (ALT)	Volts (Alt)
168	Battery Potential (voltage)	VOLTS (BATT)	Volts (Batt)
169	Cargo Ambient Temperature	CARGOAMBTEMP	CARGO TEMP
170	Cab Interior Temperature	CAB INT TEMP	CAB TEMP
171	Ambient Air Temperature	AMB AIR TEMP	Outside TEMP
172	Air Inlet Temperature	AIR INLET TEMP	Air Inlet TEMP
173	Exhaust Gas Temperature	EXH GAS TEMP	Exh Gas TEMP
174	Fuel Temperature	FUEL TEMP	Fuel TEMP
175	Engine Oil Temperature	ENG OIL TEMP	Oil TEMP
176	Turbo Oil Temperature	TURBO OIL TEMP	Turbo Oil TEMP
177	Transmission Oil Temperature	TRAN OIL TEMP	Oil TEMP
178	Front Axle Weight	FRONT AXLE WT	Front Axle Wt.
179	Rear Axle Weight	REAR AXLE WT	Rear Axle Wt.
180	Trailer Weight	TRAILER WEIGHT	Trailer WEIGHT
181	Cargo Weight	CARGO WEIGHT	CARGO WEIGHT
182	Trip Fuel	TRIP FUEL	TRIP Fuel
183	Fuel Rate	FUEL RATE	Fuel Rate

* The new text messages appear on vehicles built on or after March 7, 1997.

Table 11, Parameter Identifiers (PIDs) 154 through 183

Specifications

Parameter Identifiers (PIDs) 184 through 253			
PID	**Description**	**Old Text Message**	**New Text Message***
184	Instantaneous Fuel Economy	INST FUEL ECON	Inst Fuel Econ
185	Average Fuel Economy	AVG FUEL ECON	AVG. Fuel Econ
186	Power Takeoff Speed	PTO SPEED	PTO SPEED
187	Power Takeoff Set Speed	PTO SET SPEED	PTO Set SPEED
188	Idle Engine Speed	IDLE ENG SPEED	Idle ENG SPEED
189	Rated Engine Speed	RATED ENG SPD	Rated SPEED
190	Engine Speed	ENGINE SPEED	ENGINE SPEED
191	Transmission Output Shaft Speed	TRAN OUT SPEED	OUTPUT SPEED
232	DGPS Differential Correction	DGPS DIF CRCTN	DGPS Correctn
233	Power Unit Number	POWER UNIT #	—†
234	Software Identification	SOFTWARE ID	Software ID
235	Total Idle Hours	TOTL IDLE HRS	Total Idle Hrs
236	Total Idle Fuel Used	TOTL IDLE FUEL	Totl Idle Fuel
237	Vehicle Identification Number	VIN	VIN
238	Velocity Vector	VELOCITYVECTOR	VelocityVector
239	Vehicle Position	VEHICLE POS	Veh. Position
240	Change Reference Number	CHG REF #	CHANGE Ref #
241	Tire Pressure	TIRE PRESSURE	Tire Pressure
242	Tire Temperature	TIRE TEMP	Tire TEMP
243	Component Identification	COMPONENT ID	COMPONENT ID
244	Trip Distance	TRIP DISTANCE	TRIP Distance
245	Total Vehicle Distance	TOTAL VEH DIST	Total Veh Dist
246	Total Vehicle Hours	TOTAL VEH HRS	Total Veh Hrs.
247	Total Engine Hours	TOTAL ENG HRS	Total ENG Hrs.
248	Total PTO Hours	TOTAL PTO HRS	Total PTO Hrs.
249	Total Engine Revolutions	TOTAL ENG REVS	Total ENG Revs
250	Total Fuel Used	TOTAL FUELUSED	Total FUELUsed
251	Clock	CLOCK	Clock
252	Date	DATE	Date
253	Elapsed Time	ELAPSED TIME	ELAPSED Time

* The new text messages appear on vehicles built on or after March 7, 1997.
† If there is no text message, the display area reserved for that text message will be blank. Only the PID number will display.

Table 12, Parameter Identifiers (PIDs) 184 through 253

MID 128 Engine Sub-System Identifiers 1 through 32			
SID	Description	Old Text Message	New Text Message*
1	Injector Cylinder #1	CYL#1 INJECTR	Cyl #1 Injectr
2	Injector Cylinder #2	CYL #2 INJECTR	Cyl #2 Injectr
3	Injector Cylinder #3	CYL #3 INJECTR	Cyl #3 Injectr
4	Injector Cylinder #4	CYL #4 INJECTR	Cyl #4 Injectr
5	Injector Cylinder #5	CYL #5 INJECTR	Cyl #5 Injectr
6	Injector Cylinder #6	CYL #6 INJECTR	Cyl #6 Injectr
7	Injector Cylinder #7	CYL #7 INJECTR	Cyl #7 Injectr
8	Injector Cylinder #8	CYL #8 INJECTR	Cyl #8 Injectr
9	Injector Cylinder #9	CYL #9 INJECTR	Cyl #9 Injectr
10	Injector Cylinder #10	CYL 10 INJECTR	Cyl 10 Injectr
11	Injector Cylinder #11	CYL 11 INJECTR	Cyl 11 Injectr
12	Injector Cylinder #12	CYL 12 INJECTR	Cyl 12 Injectr
13	Injector Cylinder #13	CYL 13 INJECTR	Cyl 13 Injectr
14	Injector Cylinder #14	CYL 14 INJECTR	Cyl 14 Injectr
15	Injector Cylinder #15	CYL 15 INJECTR	Cyl 15 Injectr
16	Injector Cylinder #16	CYL 16 INJECTR	Cyl 16 Injectr
17	Fuel Shutoff Valve	FUEL SHUTOFF	Fuel Shutoff
18	Fuel Control Valve	FUEL CONTROL	Fuel Control
19	Throttle Bypass Valve	THROTTLE BYPAS	ThrottleBYPASS
20	Timing Actuator	TIMINGACTUATOR	TIMINGActuator
21	Engine Position Sensor	ENG POS SENSOR	PositionSensor
22	Timing Sensor	TIMING SENSOR	TIMING Sensor
23	Rack Actuator	RACK ACTUATOR	Rack Actuator
24	Rack Position Sensor	RACKPOS SENSOR	Rack Pos Sens
25	External Engine Protection Input	EXT ENG PROTCT	ExtENG Protect
26	Auxiliary Output Device Driver #1	AUXOUTDRIVER1	AuxOut Driver
27	Variable Geometry Turbocharger Actuator #1	TURBO ACTUATR1	Turbo Actuator
28	Variable Geometry Turbocharger Actuator #2	TURBO ACTUATR2	TurboActuator2
29	External Fuel Command Input	EXT FUEL INPUT	Ext Fuel INPUT
30	External Speed Command Input	EXT SPEEDINPUT	Ext SPEEDINPUT
31	Tachometer Signal Output	TACHSIGNLOUTPT	TACH OUTPUT
32	Wastegate Output Device Driver	WASTEGATEDRVR	WASTEGATE Drvr

* The new text messages appear on vehicles built on or after March 7, 1997.

Table 13, Engine SIDs 1 through 32

Specifications

MID 128 Engine Sub-System Identifiers 33 through 64			
SID	**Description**	**Old Text Message**	**New Text Message***
33	Fan Clutch Output Device Driver	FANCLTCH DRV	Fan Clutch Drv
34	Exhaust Back Pressure Sensor	EXH PRESSENSOR	Exh Press Sens
35	Exhaust Back Pressure Regulator Solenoid	EXH PRES SOL	Exh Press Sol
36	Glow Plug Lamp	GLOWPLUGLAMP	Glow PLUG LAMP
37	Electronic Drive Unit Power Relay	DRV UNITPWRRLY	Power Relay
38	Glow Plug Relay	GLOWPLUGRELAY	GlowPLUG Relay
39	Engine Starter Motor Relay	STARTER RELAY	Starter Relay
40	Auxiliary Output Device Driver #2	AUXOUT DRIVER2	Auxout Driver2
41	ECM 8 Volts DC Supply	ECM 8VDC SUPLY	ECM 8VDC
42	Injection Control Pressure Regulator	INJ PRES REG	Inj Press REG
43	Autoshift High Gear Actuator	AUTOSHFTHI GR	HIGH Gear Act.
44	Autoshift Low Gear Actuator	AUTOSHFTLO GR	Low Gear Act.
45	Autoshift Neutral Gear Actuator	AUTOSHFTNTL GR	Neutral Act.
46	Autoshift Common Low Side (Return)	AUTOSHFTCOMLO	Common
47	Injector Cylinder #17	CYL 17 INJECTR	Cyl 17 Injectr
48	Injector Cylinder #18	CYL 18 INJECTR	Cyl 18 Injectr
49	Injector Cylinder #19	CYL 19 INJECTR	Cyl 19 Injectr
50	Injector Cylinder #20	CYL 20 INJECTR	Cyl 20 Injectr
51	Auxiliary Output Device Driver #3	AUXOUT DRIVER3	Auxout Driver3
52	Auxiliary Output Device Driver #4	AUXOUT DRIVER4	Auxout Driver4
53	Auxiliary Output Device Driver #5	AUXOUT DRIVER5	Auxout Driver5
54	Auxiliary Output Device Driver #6	AUXOUT DRIVER6	Auxout Driver6
55	Auxiliary Output Device Driver #7	AUXOUT DRIVER7	Auxout Driver7
56	Auxiliary Output Device Driver #8	AUXOUT DRIVER8	Auxout Driver8
57	Auxiliary PWM Driver #1	AUX PWM DRVR 1	Aux PWM Drvr 1
58	Auxiliary PWM Driver #2	AUX PWM DRVR 2	Aux PWM Drvr 2
59	Auxiliary PWM Driver #3	AUX PWM DRVR 3	Aux PWM Drvr 3
60	Auxiliary PWM Driver #4	AUX PWM DRVR 4	Aux PWM Drvr 4
61	Variable Swirl System Valve	VAR SWIRL VALV	Swirl Valve
62	Prestroke Sensor	PRESTROKE SNSR	PreStroke Snsr
63	Prestroke Actuator	PRESTROKE ACTR	PreStroke actr
64	Engine Speed Sensor #2	SPEED SENSOR2	SPEED Sensor 2

* The new text messages appear on vehicles built on or after March 7, 1997.

Table 14, Engine SIDs 33 through 64

MID 128 Engine Sub-System Identifiers 65 through 78			
SID	**Description**	**Old Text Message**	**New Text Message***
65	Heated Oxygen Sensor	OXYGEN SENSOR	—†
66	Ignition Control Mode Signal	IG MODE SIGNAL	—†
67	Ignition Control Timing Signal	IG TIME SIGNAL	—†
68	Secondary Turbo Inlet Pressure	TURBO PRSSRE 2	—†
69	ACOC (Aftercooler/Oil Cooler) Coolant F	ACOC COOL TEMP	—†
70	Inlet Air Heater Driver #1	—†	—†
71	Inlet Air Heater Driver #2	—†	—†
72	Injector Cylinder #21	CYL 21 INJECTR	—†
73	Injector Cylinder #22	CYL 22 INJECTR	—†
74	Injector Cylinder #23	CYL 23 INJECTR	—†
75	Injector Cylinder #24	CYL 24 INJECTR	—†
76	Knock Sensor	KNOCK SENSOR	—†
77	Gas Metering Valve	GASMETER VALVE	—†
78	Fuel Supply Pump Actuator	—†	—†

* The new text messages appear on vehicles built on or after March 7, 1997.
† If there is no text message, the display area reserved for that text message will be blank. Only the SID number will display.

Table 15, Engine SIDs 65 through 78

MID 136 ABS Sub-System Identifiers 1 through 14			
SID	**Description**	**Old Text Message**	**New Text Message***
1	Wheel Sensor ABS Axle 1 Left	WH SNSR AXL 1L	Wh Snsr Axl 1L
2	Wheel Sensor ABS Axle 1 Right	WH SNSR AXL 1R	Wh Snsr Axl 1R
3	Wheel Sensor ABS Axle 2 Left	WH SNSR AXL 2L	Wh Snsr Axl 2L
4	Wheel Sensor ABS Axle 2 Right	WH SNSR AXL 2R	Wh Snsr Axl 2R
5	Wheel Sensor ABS Axle 3 Left	WH SNSR AXL 3L	Wh Snsr Axl 3L
6	Wheel Sensor ABS Axle 3 Right	WH SNSR AXL 3R	Wh Snsr Axl 3R
7	Pressure Modulation Valve ABS Axle 1 Left	PRSMOD VLV A1L	Mod. Valve A1L
8	Pressure Modulation Valve ABS Axle 1 Right	PRSMOD VLV A1R	Mod. Valve A1R
9	Pressure Modulation Valve ABS Axle 2 Left	PRSMOD VLV A2L	Mod. Valve A2L
10	Pressure Modulation Valve ABS Axle 2 Right	PRSMOD VLV A2R	Mod. Valve A2R
11	Pressure Modulation Valve ABS Axle 3 Left	PRSMOD VLV A3L	Mod. Valve A3L
12	Pressure Modulation Valve ABS Axle 3 Right	PRSMOD VLV A3R	Mod. Valve A3R
13	Retarder Control Relay	RTDR CNTRL RLY	Rtdr Cntrl Rly
14	Relay Diagonal 1	RLAY DIAGONAL1	Relay DIAG. 1

* The new text messages appear on vehicles built on or after March 7, 1997.

Table 16, ABS SIDs 1 through 14

Specifications

MID 136 ABS Sub-System Identifiers 15 through 47			
SID	**Description**	**Old Text Message**	**New Text Message***
15	Relay Diagonal 2	RLAY DIAGONAL2	Relay DIAG. 2
16	Mode Switch ABS	ABS MODE SWTCH	ABS Mode Swtch
17	Mode Switch ASR	ASR MODE SWTCH	ASR Mode Swtch
18	DIF 1-ASR Valve	ASR DIF1 VALVE	ASR Dif1 Valve
19	DIF 2-ASR Valve	ASR DIF2 VALVE	ASR Dif2 Valve
20	Pneumatic Engine Control	PNEU ENG CNTRL	Pneu ENG Cntrl
21	Electronic Engine Control (Servomotor)	ELEC ENG CNTRL	Elec ENG Cntrl
22	Speed Signal Input	SPN SGNL INPUT	SPEEDSIGNAL In
23	Warning Light Bulb	WARNLIGHT BULB	WarnLIGHT Bulb
24	ASR Light Bulb	ASR LIGHT BULB	ASR LIGHT Bulb
25	Wheel Sensor, ABS Axle 1 Average	SENSOR AX1 AVG	Sensor AX1 AVG
26	Wheel Sensor, ABS Axle 2 Average	SENSOR AX2 AVG	Sensor AX2 AVG
27	Wheel Sensor, ABS Axle 3 average	SENSOR AX3 AVG	Sensor AX3 AVG
28	Pressure Modulator, Drive Axle Relay Valve	PRSSRMODDRVAXL	Mod, Relay Valve
29	Pressure Transducer, Drive Axle Relay Valve	PRSSRXDCDRVAXL	Trans, Relay Vlv
30	Master Control Relay	MASTER RELAY	Master Relay
31	Trailer Brake Slack Out of Adjust Frwrd Axle Left	BRAKE ADJUST	Brake Adjust
32	Trailer Brake Slack Out of Adjust Frwrd Axle Right	BRAKE ADJUST	Brake Adjust
33	Trailer Brake Slack Out of Adjust Rear Axle Left	BRAKE ADJUST	Brake Adjust
34	Trailer Brake Slack Out of Adjust Rear Axle Right	BRAKE ADJUST	Brake Adjust
35	Tractor Brake Slack Out of Adjust Axle 1 Left	BRAKE ADJUST	Brake Adjust
36	Tractor Brake Slack Out of Adjust Axle 1 Right	BRAKE ADJUST	Brake Adjust
37	Tractor Brake Slack Out of Adjust Axle 2 Left	BRAKE ADJUST	Brake Adjust
38	Tractor Brake Slack Out of Adjust Axle 2 Right	BRAKE ADJUST	Brake Adjust
39	Tractor Brake Slack Out of Adjust Axle 3 Left	BRAKE ADJUST	Brake Adjust
40	Tractor Brake Slack Out of Adjust Axle 3 Right	BRAKE ADJUST	Brake Adjust
41	Ride Height Relay	—†	—†
42	Hold Modulator Valve Solenoid—Axle 1 Left	—†	—†
43	Hold Modulator Valve Solenoid—Axle 1 Right	—†	—†
44	Hold Modulator Valve Solenoid—Axle 2 Left	—†	—†
45	Hold Modulator Valve Solenoid—Axle 2 Right	—†	—†
46	Hold Modulator Valve Solenoid—Axle 3 Left	—†	—†
47	Hold Modulator Valve Solenoid—Axle 3 Right	—†	—†

* The new text messages appear on vehicles built on or after March 7, 1997.

† If there is no text message, the display area reserved for that text message will be blank. Only the SID number will display.

Table 17, ABS SIDs 15 through 47

Specifications

MID 136 ABS Sub-System Identifiers 48 through 80			
SID	Description	Old Text Message	New Text Message*
48	Dump Modulator Valve Solenoid—Axle 1 Left	—†	—†
49	Dump Modulator Valve Solenoid—Axle 1 Right	—†	—†
50	Dump Modulator Valve Solenoid—Axle 2 Left	—†	—†
51	Dump Modulator Valve Solenoid—Axle 2 Right	—†	—†
52	Dump Modulator Valve Solenoid—Axle 3 Left	—†	—†
53	Dump Modulator Valve Solenoid—Axle 3 Right	—†	—†
54	Hydraulic Pump Motor	—†	—†
55	Brake Light Switch 1	—†	—†
56	Brake Light Switch 2	—†	—†
57	Electronic Pressure Control, Axle 1	—†	—†
58	Pneumatic Back-Up Pressure Control, Axle 1	—†	—†
59	Brake Pressure Sensing, Axle 1	—†	—†
60	Electronic Pressure Control, Axle 2	—†	—†
61	Pneumatic Back-Up Pressure Control, Axle 2	—†	—†
62	Brake Pressure Sensing, Axle 2	—†	—†
63	Electronic Pressure Control, Axle 3	—†	—†
64	Pneumatic Back-Up Pressure Control, Axle 3	—†	—†
65	Brake Pressure Sensing, Axle 3	—†	—†
66	Electronic Pressure Control, Trailer Control	—†	—†
67	Pneumatic Back-Up Pressure Control, Trailer Control	—†	—†
68	Brake Pressure Sensing, Trailer Control	—†	—†
69	Axle Load Sensor	—†	—†
70	Lining Wear Sensor, Axle 1 Left	—†	—†
71	Lining Wear Sensor, Axle 1 Right	—†	—†
72	Lining Wear Sensor, Axle 2 Left	—†	—†
73	Lining Wear Sensor, Axle 2 Right	—†	—†
74	Lining Wear Sensor, Axle 3 Left	—†	—†
75	Lining Wear Sensor, Axle 3 Right	—†	—†
76	Brake Signal Transmitter	—†	—†
77	Brake Signal Sensor 1	—†	—†
78	Brake Signal Sensor 2	—†	—†
79	Tire Dimension Supervision	—†	—†
80	Vehicle Deceleration Control	—†	—†

* The new text messages appear on vehicles built on or after March 7, 1997.

† If there is no text message, the display area reserved for that text message will be blank. Only the SID number will display.

Table 18, ABS SIDs 48 through 80

Specifications

MID 190 ACPU Sub-System Identifiers			
SID	**Description**	**Old Text Message**	**New Text Message***
1	Refrigerant Charge	REFRGNT CHRG	REFRIG Pres
2	Refrigerant Moisture Level	REFRIG MOISTR	REFRIG Moistr
3	Non-Condensable Gas in Refrigerant	GAS IN REFRIGN	Gas In REFRIGN
4	Refrigerant Flow Control Solenoid	RFRG FLOW CTRL	RFRG Flow Ctrl
5	Low Pressure Switch	LOW PRS SWITCH	Low Pres SW
6	Refrigerant Clutch Circuit	CLUTCH CIRCUIT	Clutch Cir
7	Evaporator Thermostat Circuit	—†	Tstat Cir

* The new text messages appear on vehicles built on or after March 7, 1997.
† If there is no text message, the display area reserved for that text message will be blank. Only the SID number will display.

Table 19, ACPU SIDs

MID 219 VORAD Collision Avoidance Radar Sub-System Identifiers			
SID	**Description**	**Old Text Message**	**New Text Message***
1	Forward Antenna	—†	—†
2	Antenna Electronics	—†	—†
3	Brake Input Monitor	—†	—†
4	Speaker Monitor	—†	—†
5	Steering Sensor Monitor	—†	—†
6	Speedometer Monitor	—†	—†
7	Right Turn Signal Monitor	—†	—†
8	Left Turn Signal Monitor	—†	—†
9	Control Display Unit	—†	—†
10	Right Side Sensor	—†	—†
11	Left Side Sensor	—†	—†
12	Rear Sensor	—†	—†

* The new text messages appear on vehicles built on or after March 7, 1997.
† If there is no text message, the display area reserved for that text message will be blank. Only the SID number will display.

Table 20, VORAD Collision Avoidance Radar SIDs

Generic Sub-System Identifiers (Common to all MIDs) 151 through 153			
SID	**Description**	**Old Text Message**	**New Text Message***
151	System Diagnostic Code #1	—†	—†
152	System Diagnostic Code #2	—†	—†
153	System Diagnostic Code #3	—†	—†

* The new text messages appear on vehicles built on or after March 7, 1997.
† If there is no text message, the display area reserved for that text message will be blank. Only the SID number will display.

Table 21, Generic SIDs 151 through 153

Generic Sub-System Identifiers (Common to all MIDs) 154 through 248			
SID	**Description**	**Old Text Message**	**New Text Message***
154	System Diagnostic Code #4	—†	—†
155	System Diagnostic Code #5	—†	—†
219	Start Signal Indicator†	—	—†
220	Electronic Tractor/Trailer Interface (ISO 11992)	—†	—†
221	Internal Sensor Voltage Supply	—†	—†
222	Protect Light	—†	—†
223	Ambient Light Sensor	—†	—†
224	Audible Alarm	—†	—†
225	Green Light	—†	—†
226	Transmission Neutral Switch	—†	—†
227	Auxiliary Analog Input #1	—†	—†
228	High Pressure Switch	HI PRES SWITCH	HI Pres SW
229	Kickdown Switch	—†	—†
230	Idle Validation Switch	—†	—†
231	SAE J1939 Datalink	—†	—†
232	5-Volt DC Supply	—†	—†
233	Controller #2	—†	—†
234	Parking Brake ON Actuator	—†	—†
235	Parking Brake OFF Actuator	—†	—†
236	Power Connect Device	—†	—†
237	Start Enable Device	—†	—†
238	Diagnostic Light—Red	—†	—†
239	Diagnostic Light—Amber	—†	—†
240	Program Memory	—†	—†
242	Cruise Control RESUME Switch	—†	—†
243	Cruise Control SET Switch	—†	—†
244	Cruise Control ENABLE Switch	—†	—†
245	Clutch Pedal Switch #1	—†	—†
246	Brake Pedal Switch #1	—†	—†
247	Brake Pedal Switch #2	—†	—†
248	Proprietary Datalink	—†	—†

* The new text messages appear on vehicles built on or after March 7, 1997.
† If there is no text message, the display area reserved for that text message will be blank. Only the SID number will display.

Table 22, Generic SIDs 226 through 248

Specifications

Generic Sub-System Identifiers (Common to all MIDs) 249 through 254			
SID	**Description**	**Old Text Message**	**New Text Message***
249	SAE J1922 Datalink	SAE J1922	SAE J1922
250	SAE J1708 (J1587) Datalink	—†	—†
251	Power Supply	POWER SUPPLY	POWER SUPPLY
252	Calibration Module	—†	—†
253	Calibration Memory	—†	—†
254	Controller #1	CONTROLLER	Controller

* The new text messages appear on vehicles built on or after March 7, 1997.
† If there is no text message, the display area reserved for that text message will be blank. Only the SID number will display.

Table 23, Generic SIDs 249 through 254

Failure Mode Identifiers (FMIs)		
FMI	**Description and Comments**	**Text Message**
00	Above normal operating range, for example: engine overheating (required diagnostic information)	HIGH
01	Below normal operating range, for example: engine oil pressure too low (required diagnostic information)	Low
02	Erratic, intermittent, or incorrect data	Erratic
03	Voltage above normal or shorted high	Short Hi
04	Voltage below normal or shorted low	Short Lo
05	Current below normal or open circuit	OPEN
06	Current above normal or circuit shorted to ground	Short
07	Mechanical system not responding properly	NoRESPONSE
08	Abnormal frequency, pulse width, or period	SIGNAL
09	Abnormal update rate	UPDATE
10	Abnormal rate of change	Rate
11	Failure node not identifiable	Not Known
12	Bad intelligent device or component	Bad
13	Out of calibration	Calibrate
14	Special instructions	RSRVD
15	Reserved for future assignment	RSRVD

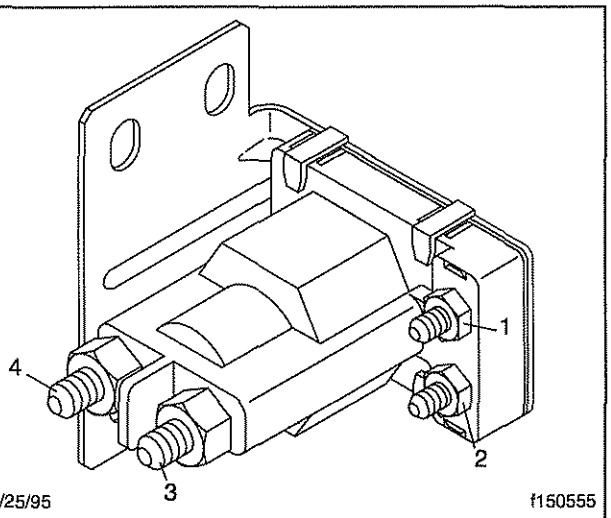
Table 24, Failure Mode Identifiers (FMIs)

Contents

Subject	Subject Number
General Information	050
Service Operations	
Magnetic Switch Replacement	100
Troubleshooting	300
Specifications	400

General Information

All 12-volt starting systems are equipped with a heavy duty starter relay, referred to as a magnetic switch (see **Fig. 1**). On the Century Class Conventional, the magnetic switch is attached to the lower left-hand frontwall. On the Argosy COE, the magnetic switch is mounted on the overslung crossmember. When the ignition switch is held in the extreme clockwise (start) position, the magnetic switch closes, connecting electrical current to the starter solenoid, which engages the starter motor pinion with the engine flywheel ring gear, and then energizes the starter motor.



1. Coil Terminal (To Ground)
2. Coil Terminal (To Ignition Switch)
3. Switch Terminal (To Solenoid)
4. Switch Terminal (To Starter BAT Terminal)

Fig. 1, Magnetic Switch

The magnetic switch consists of a winding, mounted around a hollow cylinder containing a movable core or plunger, with a contact disk that is assembled onto the plunger.

When the winding is energized, plunger movement causes the contact disk to be held tightly against the two main switch terminals; this closes the circuit between these terminals, and activates the starting motor. When the winding is de-energized, a return spring causes the plunger to return to its original position, opening the circuit to the starter motor.

Magnetic Switch Replacement

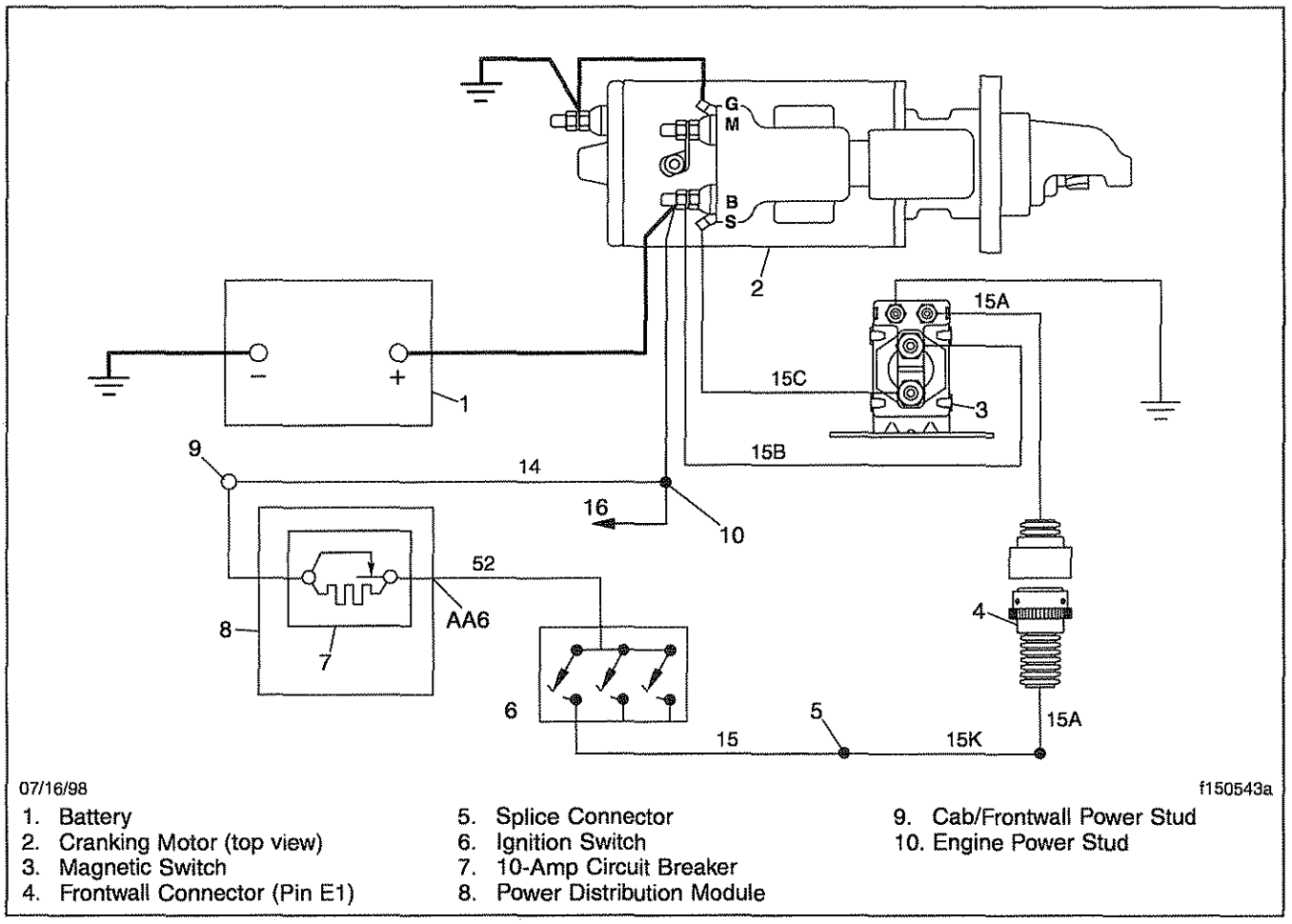
Before replacing the magnetic switch, or repairing or replacing any of the starting and charging circuits, do the preliminary checks and the magnetic switch circuit test in **Troubleshooting 300**.

Replacement

The magnetic switch cannot be disassembled. If the switch does not work, replace it.

1. Apply the parking brakes, and chock the tires.
2. Tilt the hood or cab. For cab tilting instructions, refer to **Group 60** in this workshop manual.
3. Disconnect the batteries.
4. On the Century Class Conventional, remove the inner fender splash shield to gain access to the magnetic switch.
5. Mark the wires for later reference, then disconnect the wires that are attached to the magnetic switch. See **Fig. 1**.
6. On the Century Class Conventional, remove the two mounting screws that attach the magnetic switch to the frontwall.

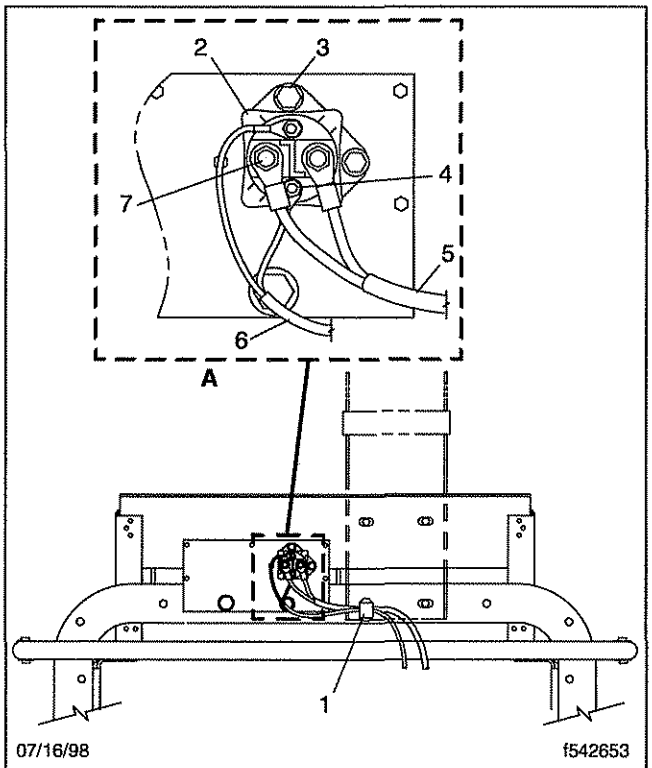
   On the Argosy COE, remove the two mounting screws that attach the magnetic switch to the overslung crossmember bracket. See **Fig. 2**.
7. Remove the two large terminal nuts.



1. Battery
2. Cranking Motor (top view)
3. Magnetic Switch
4. Frontwall Connector (Pin E1)
5. Splice Connector
6. Ignition Switch
7. 10-Amp Circuit Breaker
8. Power Distribution Module
9. Cab/Frontwall Power Stud
10. Engine Power Stud

Fig. 1, Magnetic Switch Wiring

Magnetic Switch Replacement



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A. Magnetic switch crossmember mounting.
1. Clamp Support
2. Ignition, Switch-Key
3. Capscrew, 1/4–20 x 5
4. Ground
5. Magnetic Switch Power Harness
6. Magnetic Switch Jumper Harness
7. Terminal Nuts

Fig. 2, Magnetic Switch, Argosy COE Installation

8. Disconnect the two-pin pigtail connector. Remove the magnetic switch.
9. On the Century Class Conventional, install the new magnetic switch on the frontwall.

   On the Argosy COE, install the new magnetic switch on the overslung crossmember bracket.

   9.1 Tighten the mounting screws 84 lbf·in (940 N·cm).

   9.2 Connect the wires to the magnetic switch, using the marks made on removal. Tighten the terminal nuts securely.

   9.3 Connect the two-pin pigtail connector.

10. Spray any exposed terminal connectors with dielectric red enamel. See **Table 1**.

Protectant Material	Approved Brand
Dielectric Red Enamel Spray	MMM 1602 IVI–Spray Sealer, Red Electric Grade (Spray-On B–6–665)

Table 1, Approved Dielectric Spray

11. On the Century Class Conventional, install the inner fender splash shield.
12. Connect the batteries and lower the hood or cab. For cab lowering instructions, refer to **Group 60** in this workshop manual.
13. Remove the chocks from the tires.

Preliminary Checks

Before replacing the magnetic switch, or repairing or replacing any of the starting and charging circuits, do these preliminary checks and the "Magnetic Switch Circuit Test."

1. Apply the parking brakes, and chock the tires.
2. Check the condition of the batteries. Follow the battery testing procedure in **Section 54.02**. Be sure the batteries are fully charged.

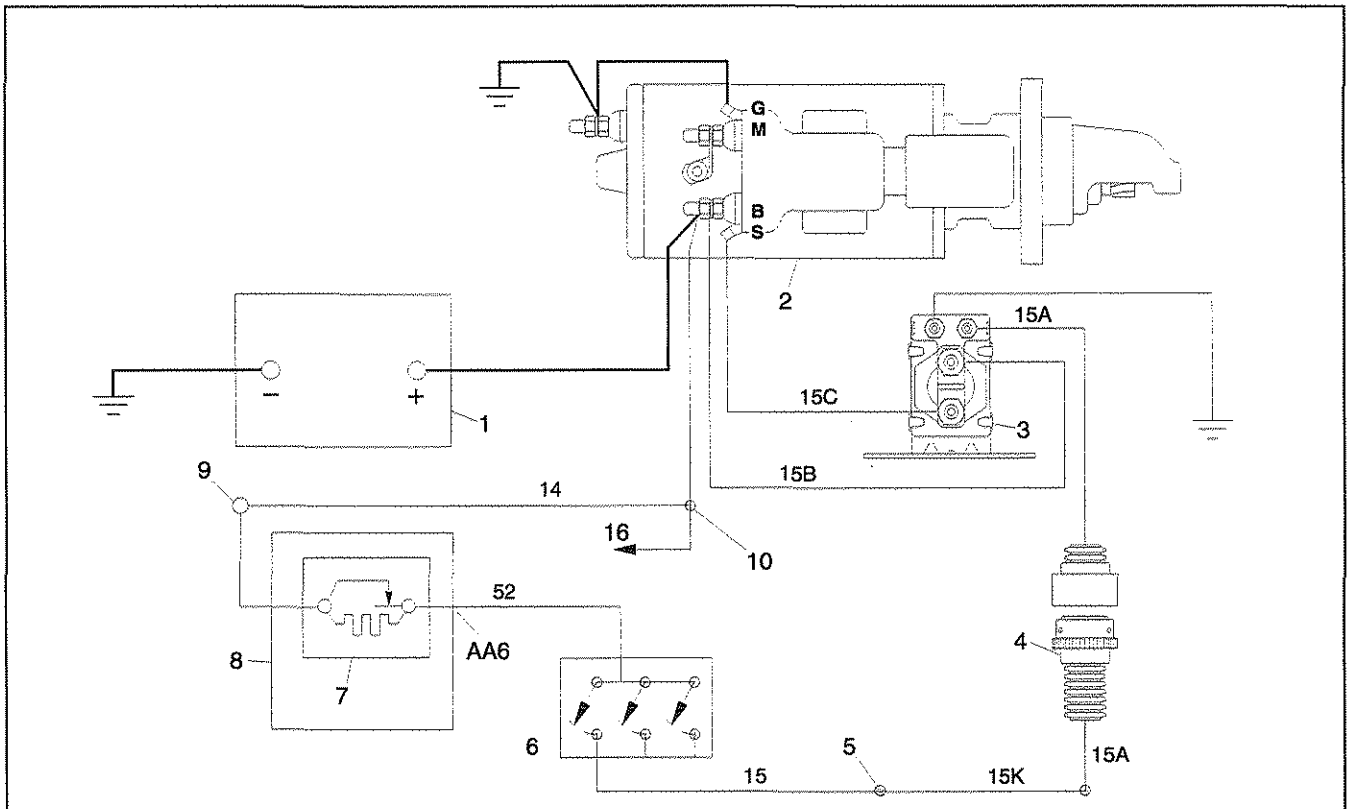
NOTE: The wiring, switches, and starter motor cannot be checked if the batteries are damaged or discharged.

3. Check the starting motor, ignition switch, and solenoid for damage or wear. Repair or replace the component(s), as needed.

Magnetic Switch Circuit Test

Before replacing the magnetic switch, or repairing or replacing any of the starting and charging circuits, do this test.

1. Apply the parking brakes, and chock the tires.
2. Check the wiring and the magnetic switch for wear or damage. See **Fig. 1**.
3. Check the circuit between the magnetic switch and the starter "B" terminal (circuit 15B) for correct voltage.
   - 3.1 Disconnect the circuit running from the starter "S" terminal to the magnetic switch (circuit 15C).



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1. Battery
2. Cranking Motor (top view)
3. Magnetic Switch
4. Frontwall Connector (Pin E1)
5. Splice Connector
6. Ignition Switch
7. 10-Amp Circuit Breaker
8. Power Distribution Module
9. Cab/Frontwall Power Stud
10. Engine Power Stud

Fig. 1, Magnetic Switch Wiring

Troubleshooting

3.2 Connect a voltmeter to the magnetic switch terminal where the circuit from the starter "B" terminal is connected (circuit 15B).

3.3 If the voltmeter reading is 0 volt, check for an open circuit.

If the voltmeter reading is less than 12.0 volts, check for corroded or loose connections.

If the voltmeter reading is 12.0 volts or more, go to the next step.

3.4 Repair or replace any damaged wires.

4. Check the magnetic switch ground circuit.

4.1 Connect an ohmmeter between the magnetic switch ground terminal and a known good ground.

4.2 If the ohmmeter reading is more than 0.5 ohm, check for corroded or loose connections.

4.3 Repair or replace any damaged wires.

5. Check the magnetic switch ignition wiring (circuit 15) for correct voltage.

NOTE: This check requires two persons.

5.1 Have one person turn on the ignition keyswitch and hold it in the "start" position.

5.2 Have the other person connect a voltmeter between the magnetic switch terminal where the ignition circuit is connected (circuit 15A) and a known good ground.

5.3 If the voltmeter reading is 0 volt, check for an open in circuit 15A.

If the voltmeter reading is less than 11.0 volts, check for corroded or loose connections.

If the voltmeter reading is 11.0 volts or more, go to the next step.

5.4 Repair or replace any damaged wires, circuit breakers, or relays.

6. Check the circuit between the magnetic switch and the starter "S" terminal (circuit 15C) for correct voltage.

NOTE: This check requires two persons.

6.1 Have one person hold the ignition keyswitch in the "start" position.

6.2 Have the other person connect a voltmeter between the magnetic switch terminal where the circuit from the starter "S" terminal is connected (circuit 15C) and a known good ground.

6.3 If the voltmeter reading is less than 12.0 volts, replace the magnetic switch.

7. Check the voltage to the magnetic switch again. If the voltmeter reading is now eleven volts or more, disconnect the voltmeter, and remove the chocks from the tires. If the reading is still less than eleven volts, replace the magnetic switch. For instructions, refer to **Subject 100**.

Magnetic Switch Contactor Test

The cranking circuit includes the battery, starter solenoid, cranking motor, magnetic switch, and ignition keyswitch.

If there is excessive voltage loss in the cranking circuit, the starter may not engage the flywheel at all, or it may drop out too soon when battery voltage goes down. In this case, check the cranking circuit and starter solenoid for voltage loss. For instructions, refer to **Section 15.00**.

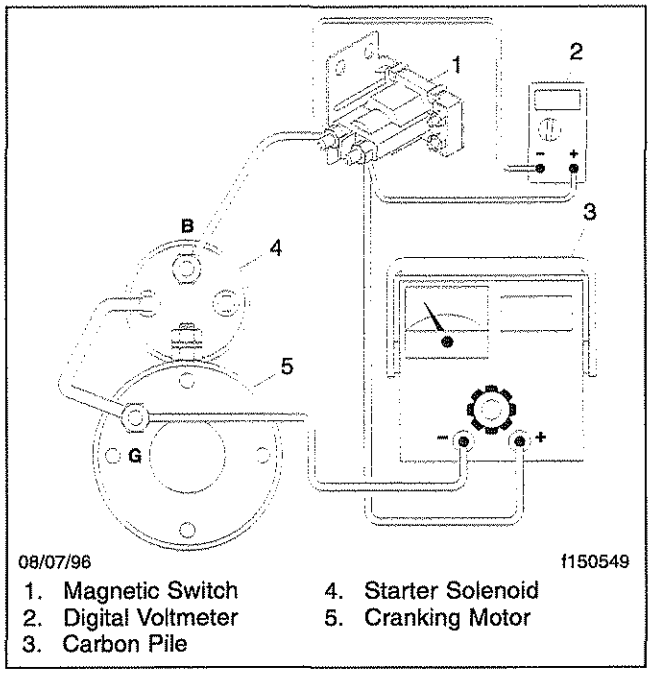
If the magnetic switch closes during the cranking circuit test and the starter wiring test, also check the magnetic switch contactors for voltage loss.

1. Disconnect the lead from the magnetic switch to the "S" (solenoid) terminal on the starter (leave as in "Starter Wiring Test").

2. Connect this lead to the positive lead of a carbon pile tester. Connect the negative lead of the carbon pile to the starter "G" (ground) terminal (leave as in "Starter Wiring Test").

3. Set a digital voltmeter on the low scale and connect the positive lead to the magnetic switch wire lead to which the carbon pile is already connected. Connect the negative lead to the other large terminal on the magnetic switch. See **Fig. 2**.

4. Hold the key to the start position and read the voltage on the voltmeter. It should read 0 volt.



1. Magnetic Switch
2. Digital Voltmeter
3. Carbon Pile
4. Starter Solenoid
5. Cranking Motor

Fig. 2, Magnetic Switch Contactor Test

5. Turn on the carbon pile and adjust it to a 100-amp load.

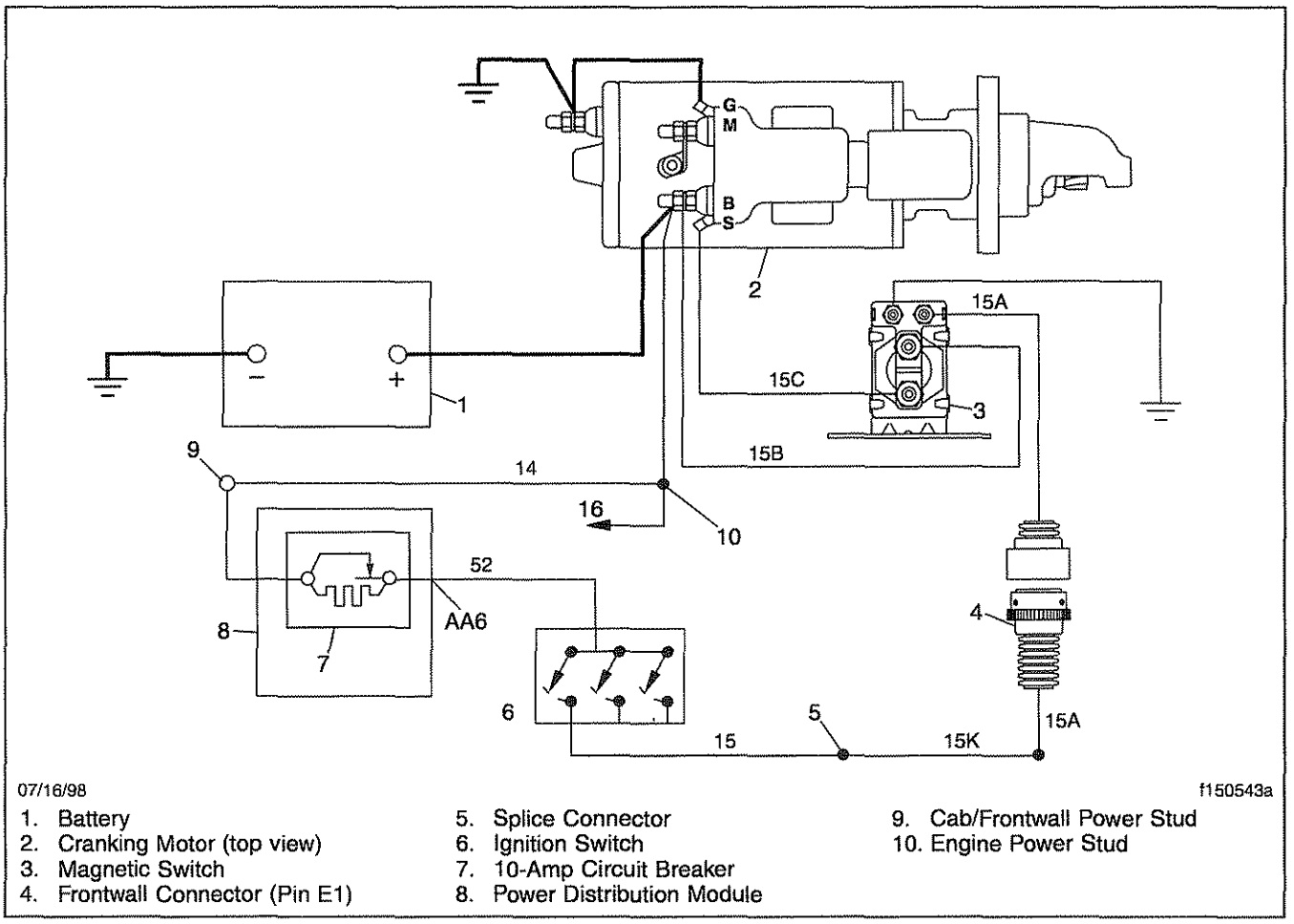
   5.1 Now read and record the voltage on the voltmeter. Turn off the carbon pile.

   5.2 If the voltage reads 0.5 volts or less, the magnetic switch contactors are OK.

   If the voltage reads more than 0.5 volts, replace the magnetic switch.

Specifications

For magnetic switch wiring, see **Fig. 1**.



1. Battery
2. Cranking Motor (top view)
3. Magnetic Switch
4. Frontwall Connector (Pin E1)
5. Splice Connector
6. Ignition Switch
7. 10-Amp Circuit Breaker
8. Power Distribution Module
9. Cab/Frontwall Power Stud
10. Engine Power Stud

Fig. 1, Magnetic Switch Wiring

Contents

Subject	Subject Number
General Information	050
Service Operations	
Main Power Distribution Module Removal and Installation	100
Auxiliary Power Distribution Module Removal and Installation	110
Troubleshooting	300
Specifications	400

General Information

Circuit protection is accomplished by routing all wiring through circuit breakers mounted in a power distribution module. There are two power distribution modules. The main power distribution module (see **Fig. 1**) is the electrical power center of the vehicle and is mounted underneath the electrical cover inside the upper dash assembly (right-hand panel).

There is also an auxiliary power distribution module mounted on the inside of the electrical compartment door located on the B-pillar on the left-hand side behind the seat. See **Fig. 2** for the Century Class Conventional and **Fig. 3** for the Argosy COE.

On the Century Class Conventional, the auxiliary power module consists of three blocks: block B1 protects the sleeper unit of the heating, ventilation, and air conditioning system (HVAC); block B2 protects the other sleeper electrical components; block B3 protects the Anti-Lock Braking System (ABS), and, if installed, the electronic suspension (ECAS). Blocks B1 and B2 are not installed on day cabs.

On the Argosy COE, the auxiliary power module has three horizontal rows:

- The top row contains several fuses for the sleeper lighting and one sleeper HVAC circuit breaker.
- The middle row contains three relays for the sleeper HVAC.

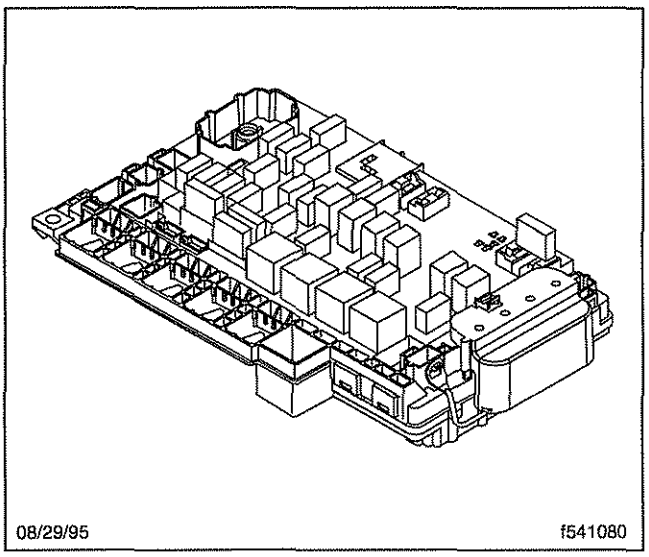
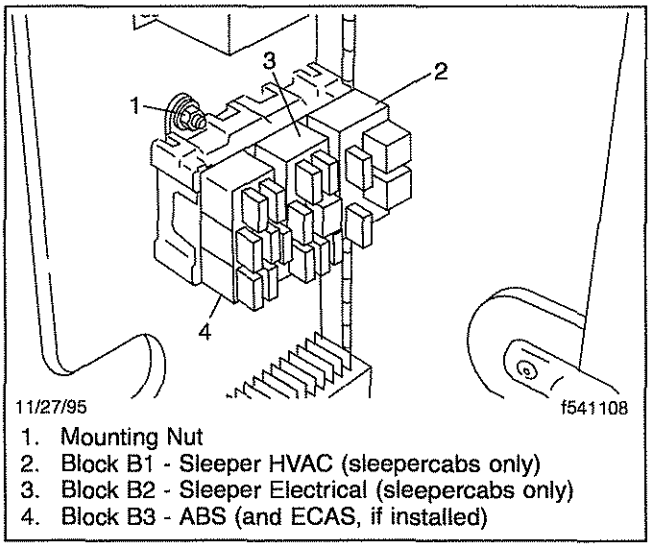
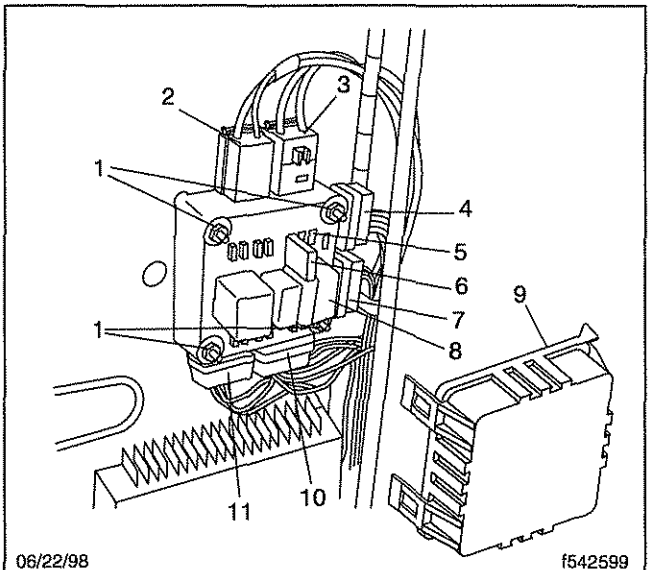


Fig. 1, Main Power Distribution Module



1. Mounting Nut
2. Block B1 - Sleeper HVAC (sleepercabs only)
3. Block B2 - Sleeper Electrical (sleepercabs only)
4. Block B3 - ABS (and ECAS, if installed)

Fig. 2, Auxiliary Power Distribution Module, Century Class Conventional



1. Locknut, 10–24
2. Connector P6
3. Connector P5
4. Connector P4
5. Fuse
6. Circuit Breaker
7. Connector P3
8. Relay
9. Cover
10. Connector P2
11. Connector P1

Fig. 3, Auxiliary Power Distribution Module, Argosy COE

General Information

- The bottom row contains ignition and battery power for the ABS and data logging unit (DLU).

The new auxiliary power module on the Argosy COE also has six plug-in connectors for easy disconnection of circuits during troubleshooting.

Main Power Distribution Module Removal and Installation

Removal

1. Apply the parking brakes and chock the tires. Disconnect the batteries.
2. Push the button to remove the electrical cover.
3. Remove the HVAC ducting.
   - 3.1 Remove the horizontal piece of ducting on top of the main power distribution module (PDM).
   - 3.2 Remove the two fasteners holding the vertical piece of ducting along the kick panel. Remove the ducting.
4. Remove the cover from the four PDM ring terminals on the right-hand side of the main PDM. Remove the ground connector from the right-hand aft corner of the PDM.
5. Remove the four ring connectors from their terminals. See **Fig. 1**. Mark with a paint pen for ease in installation.
6. Remove the PDM from the vehicle.
   - 6.1 Remove the two hold-down nuts and washers from the aft edge of the PDM.
   - 6.2 Remove the eight electrical connectors B through J from the top of the PDM by inserting a flat-blade screwdriver on the side of the plug to unfasten the clips. See **Fig. 2**. Remove the 7-mm capscrew attaching 46-pin connector A to the PDM.
   - 6.3 Unfasten the locking clips on the relays on the aft edge of the PDM. Push the relays through the holes in the PDM. Mark with a paint pen.
   - 6.4 Disconnect the accessory (ACC) and ignition (IGN) relays (the two relays fastened to the PDM with spade connectors). Then detach the clips from the PDM with care.

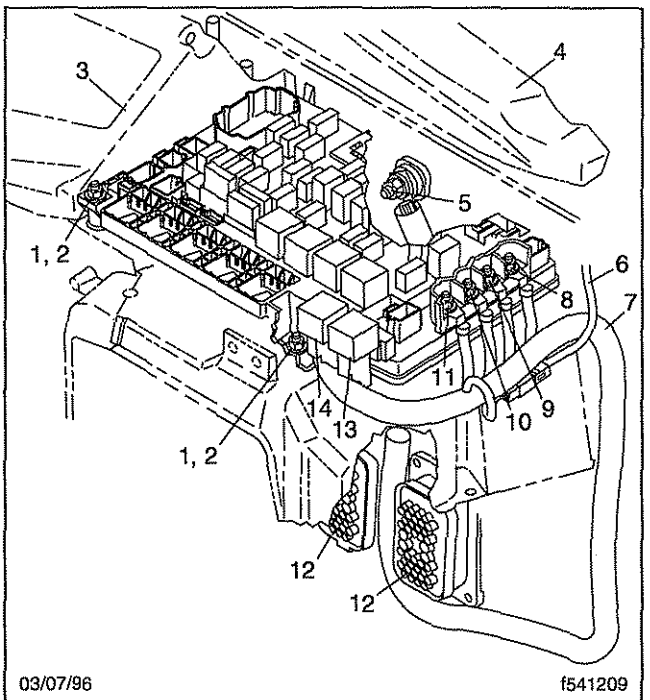
   IMPORTANT: Do not break the clip off the spade connector.

   - 6.5 Rotate the PDM to an angle of about 60° from vertical to expose the bottom of the PDM. If the PDM will not rotate that far because of binding from the electrical harness, disconnect the three main junction connectors and cut tie straps as needed to gain enough flexibility. See **Fig. 3**.

   NOTE: To disconnect the junction connectors, first disconnect, from the engine side, the cannon plugs leading to the junction connectors. Both the cannon plugs and the junction connectors fasten with clips on their top edges.

   - 6.6 Remove the electrical pins and connectors from the four terminals at the bottom of the PDM, including the large 46-pin connector N. See **Fig. 4**.

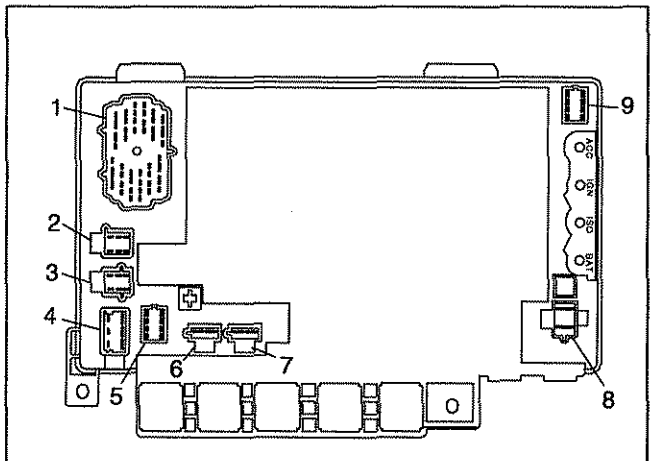
   NOTE: There is a 7-mm capscrew attaching 46-pin connector N to the PDM.



1. 1/4–20 Hold-Down Nut
2. 1/4-Inch Hold-Down Washer
3. Dash Panel
4. Main Defrost Duct
5. Cab Power Stud
6. Breakout from Main Dash Harness
7. PDM Power Harness
8. ACC Ring Terminal
9. IGN Ring Terminal
10. ISO Ring Terminal
11. BAT Ring Terminal
12. Cannon Plugs
13. ACC Relay
14. IGN Relay

Fig. 1, Main Power Distribution Module

Main Power Distribution Module Removal and Installation



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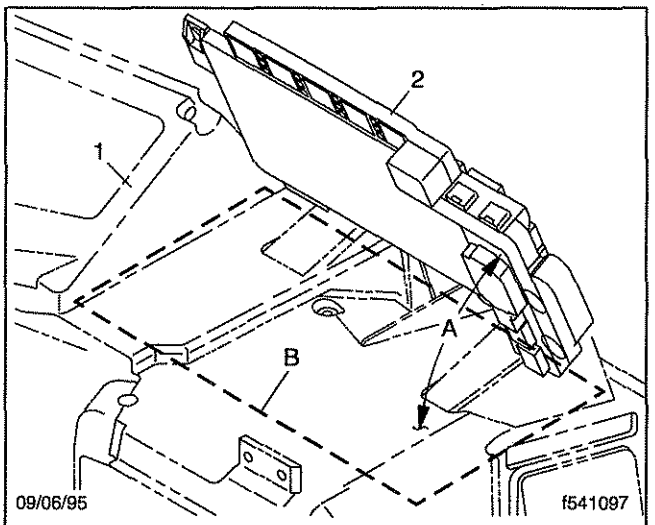
1. 46-Pin Connector A
2. 6-Pin Connector B
3. 6-Pin Connector C
4. 6-Pin Connector D
5. 8-Pin Connector E
6. 2-Pin Connector F
7. 2-Pin Connector G
8. 2-Pin Connector H
9. 8-Pin Connector J

Fig. 2, Pin Connectors (top view)



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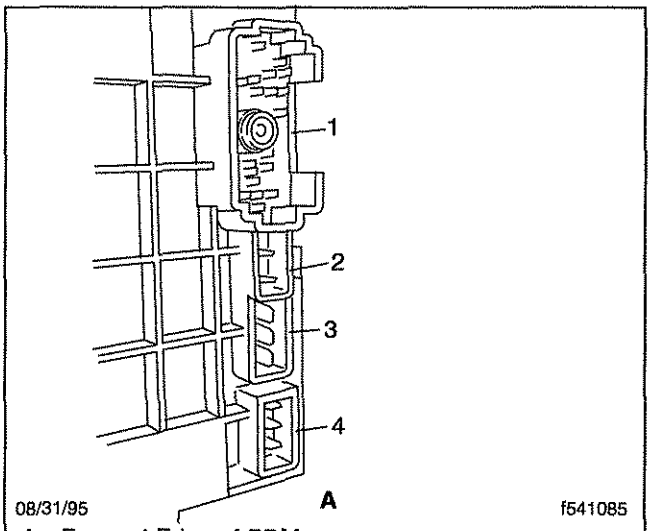
Tilt the PDM onto its forward edge. At Angle A, it can be removed from the vehicle more easily.

A. 60° Angle (approximate)
B. Original Position of PDM
1. Upper Dash Panel
2. Power Distribution Module

Fig. 3, Tilting the Power Distribution Module



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A. Forward Edge of PDM
1. 46-Pin Connector N
2. 2-Pin Connector M
3. 6-Pin Connector L
4. 6-Pin Connector K

Fig. 4, Pin Connectors (bottom view)

6.7 After all the plugs and connectors have been removed, remove the PDM from the vehicle.

Installation

1. With the PDM tilted upwards, install the connectors to the bottom of the PDM. Attach the 7-mm capscrew to 46-pin connector N. See **Fig. 4**.
2. Place the PDM over the two attaching studs with the holes lined up. Make sure the ground wire and all ring terminals, harnesses and electrical connectors are clear. See **Fig. 1**.
3. Install the PDM on the vehicle.
   - 3.1 Install the ground connector to the lower right-hand receptacle.
   - 3.2 Install the ring connectors using the markings made on removal. Install the attaching nuts and washers.
   - 3.3 Attach the 7-mm capscrew to the 46-pin connector and install it to the top of the PDM. See **Fig. 2**.
   - 3.4 Attach all relays and electrical connectors to the top of the PDM, using the markings

made on removal. Attach all locking clips and make sure the connections are firm.

IMPORTANT: Do not break the clip off the spade connector.

3.5 Fasten the PDM to the cab with the hold-down nuts and washers.

4. Install the HVAC ducting on the vehicle.

4.1 Install the vertical piece of ducting along the right-hand kick panel, using the two fasteners removed earlier.

4.2 Install the horizontal piece of ducting over the PDM.

5. If removed, install the junction connectors on the frontwall. Attach tie straps as needed and reroute the electrical harness to its correct position.

6. Install the electrical cover.

7. Connect the batteries. Then remove the chocks from the tires.

Auxiliary Power Distribution Module Removal and Installation

Century Class Conventional

REMOVAL

1. Apply the parking brakes and chock the tires. Disconnect the batteries.
2. Open the electrical compartment door on the left-hand B-pillar, behind the seat. See **Fig. 1**. The auxiliary power distribution module is installed on the inside of the door. Going from right to left, there are three separate blocks: B1, B2, and B3.

   The rightmost one is block B1. It protects the sleeper cab heating, ventilation, and air conditioning (HVAC) circuits. It is only installed on sleeper cabs.

   The center one is block B2. It protects the sleeper cab electrical lighting and accessory circuits. It is only installed on sleeper cabs.

   The leftmost one is block B3. It protects the anti-lock brake system (ABS) and also, if installed, the electronic suspension (ECAS) circuits.

NOTE: For a list of individual relays and circuit breakers installed on the Century Class Conventional auxiliary power module and their plug-in positions, see **Troubleshooting, 300.**

3. Remove the auxiliary power distribution module. See **Fig. 2.**
   - 3.1 Remove the two mounting hexnuts attaching the auxiliary power module to the B-pillar access door.
   - 3.2 Remove the auxiliary power module from the electrical compartment door.
4. To remove an individual block from the module base, insert a screw driver into the slot in the base. Press underneath the tab and the block will release.

NOTE: There is no electrical connector on the auxiliary power module. Circuits are hard-wired into the block.

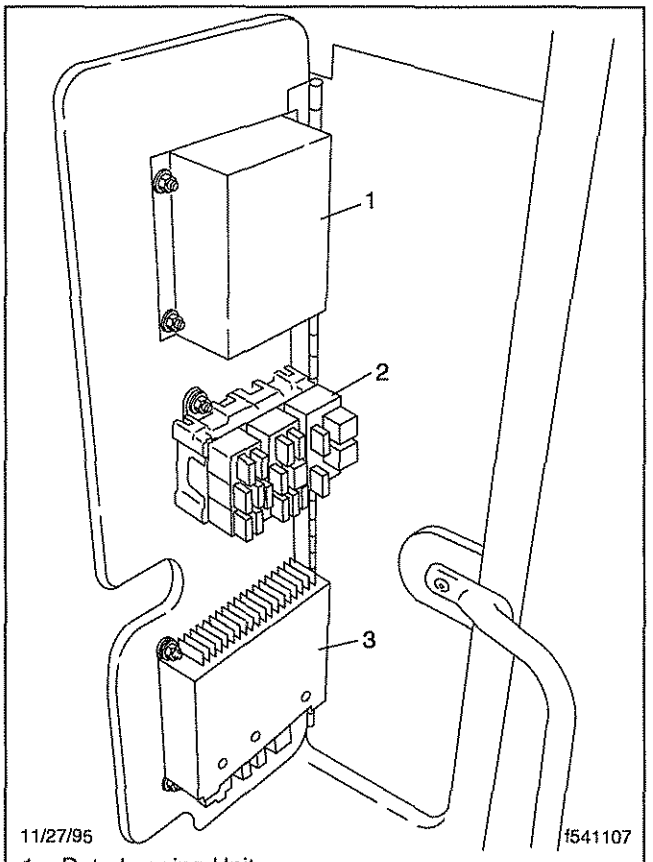
INSTALLATION

1. Install the auxiliary power distribution module onto the left-hand B-pillar electrical compartment door. See **Fig. 2.**
   - 1.1 Snap any removed blocks into the base.
   - 1.2 Install the two mounting hexnuts attaching the auxiliary power module to the B-pillar access door.
2. Close the electrical compartment door on the left-hand B-pillar. See **Fig. 1.**
3. Connect the batteries. Then remove the chocks from the tires.

Argosy COE

REMOVAL

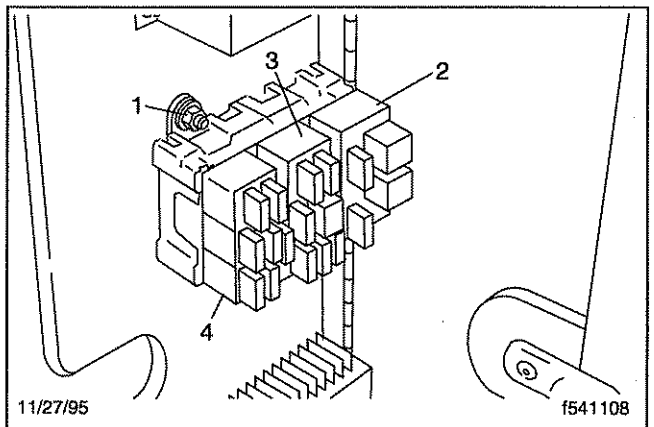
1. Apply the parking brakes and chock the tires. Disconnect the batteries.



1. Data Logging Unit
2. Auxiliary Power Distribution Module
3. ABS Controller

Fig. 1, Left-Hand B-Pillar Electrical Compartment, Century Class Conventional

Auxiliary Power Distribution Module Removal and Installation



1. Mounting Nut
2. Block B1 - Sleeper HVAC (sleeper cabs only)
3. Block B2 - Sleeper Cab Electrical (sleeper cabs only)
4. Block B3 - ABS (and ECAS, if installed)

Fig. 2, Auxiliary Power Distribution Module, Century Class Conventional

2. Open the electrical compartment door on the left-hand B-pillar, behind the seat. See **Fig. 3**. The auxiliary power distribution module is installed on the inside of the door.

NOTE: For a list of individual relays and circuit breakers installed on the Argosy COE auxiliary power module and their plug-in positions, see **Troubleshooting, 300**.

3. Remove the auxiliary power distribution module. See **Fig. 4**.

   3.1 Unplug the six electrical connectors (top, right-hand side, and bottom) and mark them for later installation.

   3.2 Remove the four 10–24 locknuts and washers attaching the auxiliary power module to the B-pillar access door.

   3.3 Remove the auxiliary power module from the electrical compartment door.

INSTALLATION

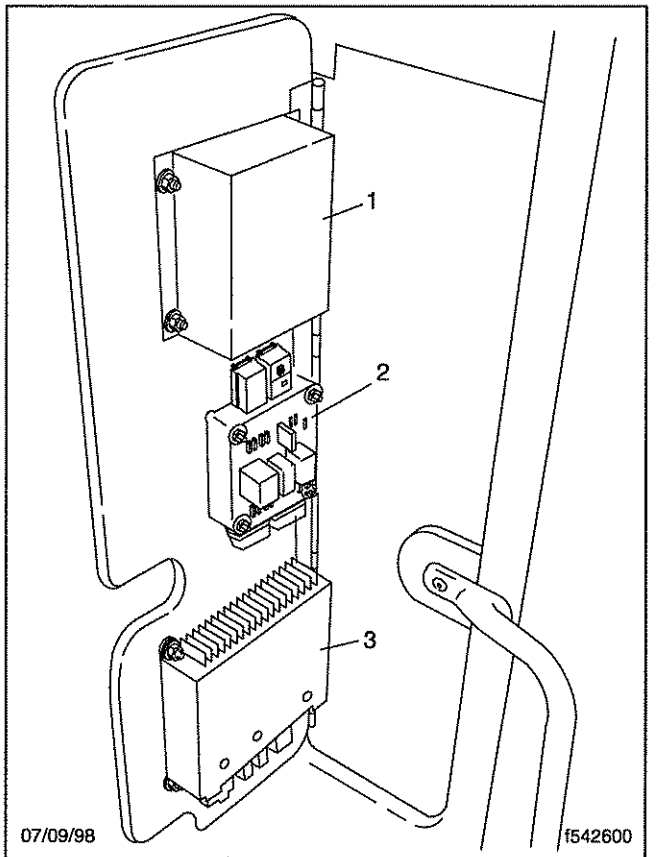
1. Install the auxiliary power distribution module onto the left-hand B-pillar electrical compartment door. See **Fig. 4**.

   1.1 Install the four mounting locknuts and washers attaching the auxiliary power module to the B-pillar access door.

   1.2 Attach the six electrical connectors, as removed.

2. Close the electrical compartment door on the left-hand B-pillar. See **Fig. 3**.

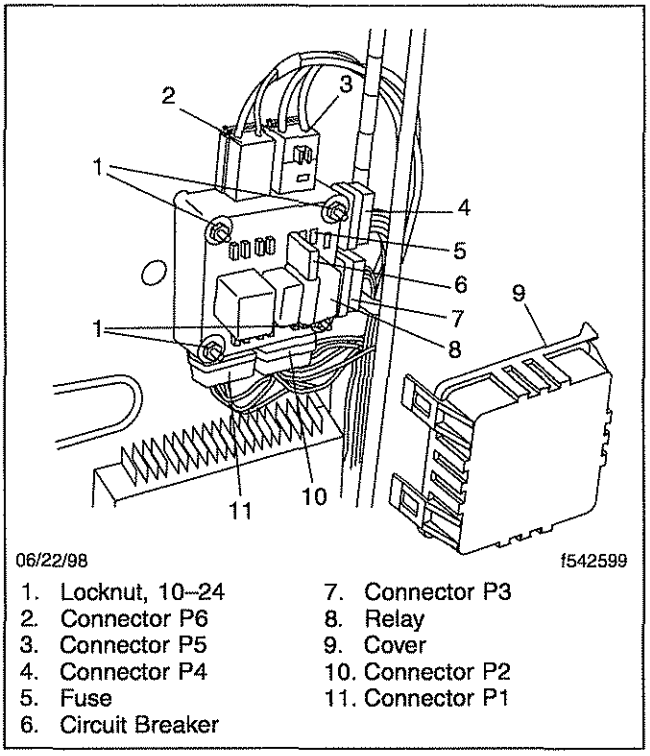
3. Connect the batteries. Then remove the chocks from the tires.



1. Data Logging Unit
2. Auxiliary Power Distribution Module
3. ABS Controller

Fig. 3, Left-Hand B-Pillar Electrical Compartment, Argosy COE

Auxiliary Power Distribution Module Removal and Installation



1. Locknut, 10–24
2. Connector P6
3. Connector P5
4. Connector P4
5. Fuse
6. Circuit Breaker
7. Connector P3
8. Relay
9. Cover
10. Connector P2
11. Connector P1

Fig. 4, Auxiliary Power Distribution Module, Argosy COE

Main Power Distribution Module

To troubleshoot malfunctioning circuit breakers (C/Bs) and relays, do the following:

1. Check the circuit breaker/relay location on the applicable figure.
2. Check the applicable table to find the breaker or relay size and note the pin (or plug) positions.
3. Replace the C/B or relay.
4. Find the pin-outs (or plug-ins) on the applicable figure and check the circuit again.

For circuit breaker and relay locations on the main power distribution module (PDM), see **Fig. 1**.

For a list of standard component circuit breakers and relays installed in the main PDM, see **Table 1**. For a list of optional component circuit breakers and relays installed in the main PDM, see **Table 2**.

For location of pin connectors on the top of the main PDM, see **Fig. 2**. For position of individual pin-outs on pin connectors A through G (main PDM—left-hand side), see **Fig. 3**. For position of individual pin-outs on pin connectors H and J (main PDM—right-hand side), see **Fig. 4**.

For location of pin connectors on the bottom of the main PDM, see **Fig. 5**.

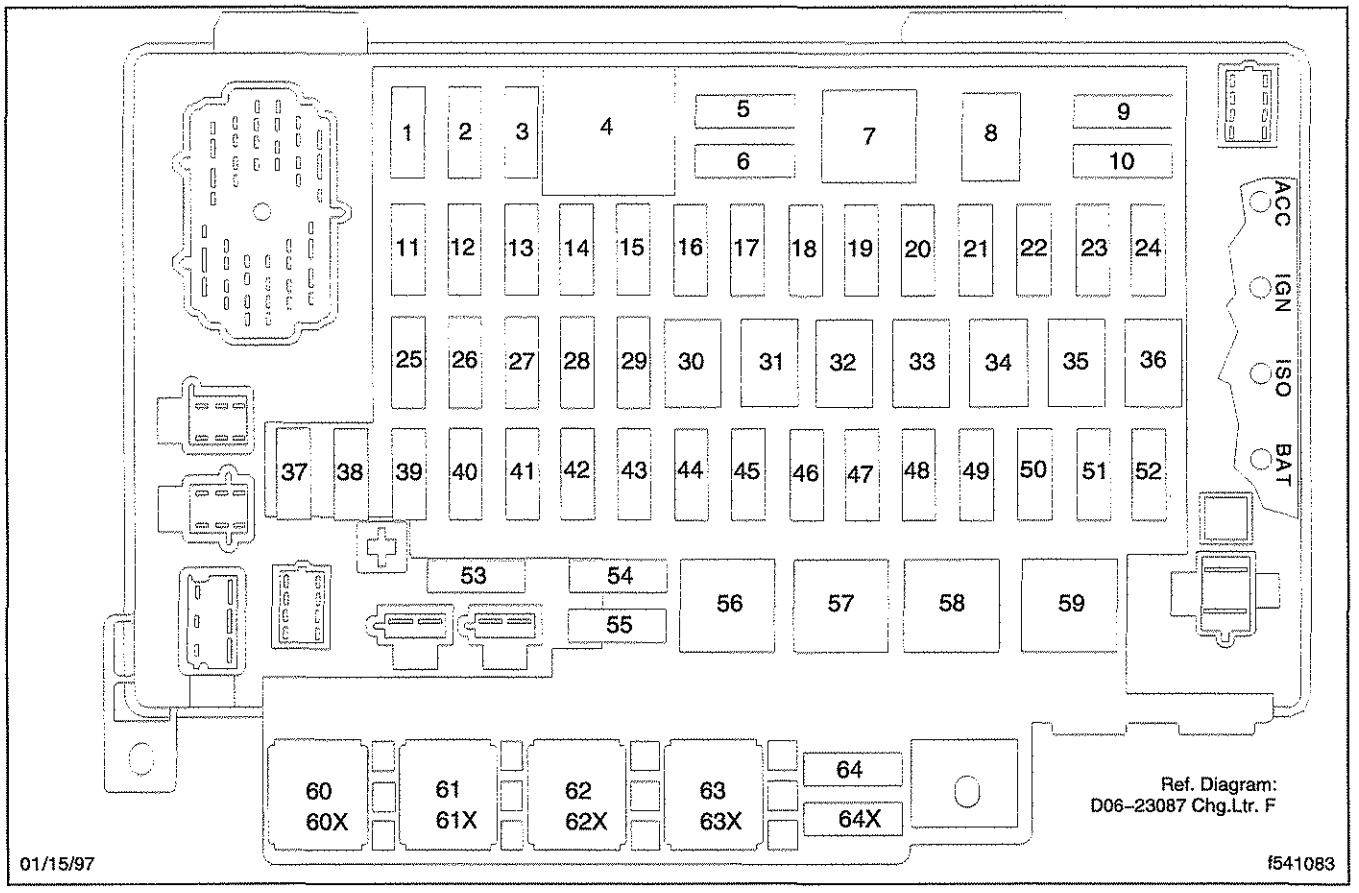


Fig. 1, Main PDM Circuit Breaker/Relay Locations

Troubleshooting

Circuit Breaker/Relay ID (standard components)			
Pos.	**Pin No.**	**Component**	**Description**
02	AF5	10-Amp C/B	A/C Clutch
04	AF2	Flasher	Turn Signal Flasher
08	AB8 AE6 AE7	Micro Relay	Starter Lock-Out (not used at this time)
09	MB	40-Amp Fuse	Cab Wiring
11	AF2	20-Amp C/B	Turn Signals
12	AB7 AF4 AD6	15-Amp C/B	Panel Lights
13	AB4 AB3 BD BE BF	10-Amp C/B	ICU Optional Gauges
16	AA3 AA4 AA7 BB	10-Amp C/B	ICU Battery Power
17	DE NC1 JD	15-Amp C/B	Ignition-Powered Options
26	AF1 AE2	10-Amp C/B	ICU Ignition Power
28	AE1	15-Amp C/B	Left Headlight
29	AD4	15-Amp C/B	Right Headlight
30	AB7 AF4 AD6	Micro Relay	Panel Lights
31	AE1*	Micro Relay	Left Headlight
32	AD4*	Micro Relay	Right Headlight
33	AE3* AD3*	Micro Relay	Tractor Tail & Marker Lights
35	AE8* NE8*	Micro Relay	High-Speed Wipers
36	AD8* NB5*	Micro Relay	Low-Speed Wipers
38	AA6	10-Amp C/B	Ignition Keyswitch
39	AE3* AD3*	15-Amp C/B	Tractor Taillights
40	AA5	25-Amp C/B	Stop Lights
41	AF3 DD	15-Amp C/B	Cigar Lighter
43	AC6*	15-Amp C/B	Dome Light
45	EC JH	15-Amp C/B	Accessory-Powered Options
48	NF5	10-Amp C/B	Back-Up Lights
49	AD5*	15-Amp C/B	Windshield Wipers
52	ND8	15-Amp C/B	Horn
53	NF8	30-Amp C/B	Trailer Taillights
54	NA2	30-Amp C/B	Trailer Marker Lights
55	AA2*	30-Amp C/B	HVAC
56	AA1* NF2* NF7*	Mini Relay	HVAC High-Speed
57	AA2* KA*	Mini Relay	HVAC Regular-Speed
58	NF6*	Mini Relay	Trailer Taillights
59	NA2*	Mini Relay	Trailer Marker Lights

* Pin assignments may vary

Table 1, Main PDM Circuit Breaker/Relay ID (standard components)

Circuit Breaker/Relay ID (optional components)			
Pos.	**Pin No.**	**Component**	**Description**
01	AE5	10-Amp C/B	Engine Fan
03	BC FA GA KC	10-Amp C/B	Power Door Locks
05	LB	30-Amp C/B	Fuel Heater
06	KB	30-Amp C/B	Trailer Aux

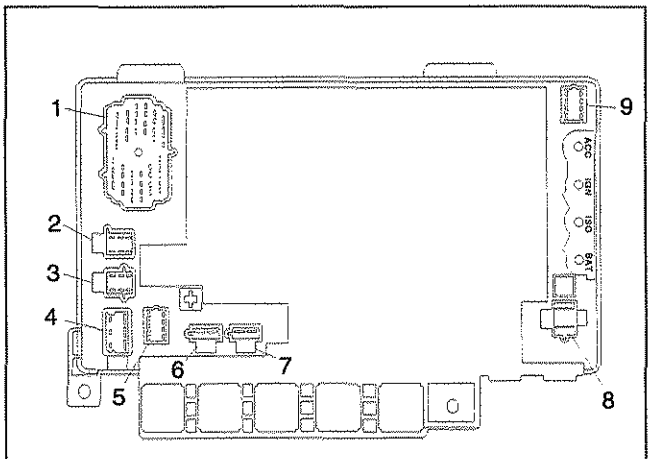
Circuit Breaker/Relay ID (optional components)			
Pos.	**Pin No.**	**Component**	**Description**
07	LB	Mini Relay	Fuel Heater
10	MA	60-Amp Fuse	Sleeper Cab Wiring
14	ED JB	10-Amp C/B	Radio (ACC Bus)
15	AB1 BA	15-Amp C/B	Utility Lights
18	CE LA	15-Amp C/B	Right-Hand Power Window
19	JA	10-Amp C/B	Windshield Fan
20	NE7 NE6 AE4	20-Amp C/B	Road Lights
21	DF JF	10-Amp C/B	CB Radio (ACC Bus)
22	LE	10-Amp C/B	Daytime Running Lights
23	JC	10-Amp C/B	Spotlight
24	LC	30-Amp C/B	Trailer ABS
25	CC	15-Amp C/B	Left-Hand Power Window
27	CB DB LF	30-Amp C/B	IGN Accessory-Powered Options
34	NE7 NE6 AE4	Micro Relay	Road Lights
37	AB2 CD	15-Amp C/B	Heated Mirror
42	AC1	10-Amp C/B	Engine ECM
44	EE LD	15-Amp C/B	Optional Switch Power (1)
46	DC	30-Amp C/B	Power Seat
47	EF JG	15-Amp C/B	Optional Switch Power (2)
50	ND6	15-Amp C/B	Air Dryer
51	FB DA	30-Amp C/B	Ignition-Powered Options
60	—	Mini Relay	Optimized Idle

Circuit Breaker/Relay ID (optional components)			
Pos.	**Pin No.**	**Component**	**Description**
61	—	Mini Relay	Optimized Idle
62	—	Mini Relay	Optimized Idle
63	—	10-Amp Fuse	Optimized Idle
64	—	10-Amp C/B	BAT Isolator (IGN Switch)
64X	—	10-Amp C/B (15-Amp with Caterpillar engines)	BAT Isolator (Engine ECM)

Table 2, Main PDM Circuit Breaker/Relay ID (optional components)

NOTE: To locate pin-outs, use this key: The first letter indicates the connector in which the pin is located. The second letter indicates the row of the connector. The number indicates the number of the pin in the row, if there is more than one. If there is only one pin in a row, this number is missing.

Examples: Pin number AF5 means connector A, row F, pin 5. Pin number BC means connector B, pin C.



1. 46-Pin Connector A
2. 6-Pin Connector B
3. 6-Pin Connector C
4. 6-Pin Connector D
5. 8-Pin Connector E
6. 2-Pin Connector F
7. 2-Pin Connector G
8. 2-Pin Connector H
9. 8-Pin Connector J

Fig. 2, Main PDM Pin Connectors (top view)

Troubleshooting

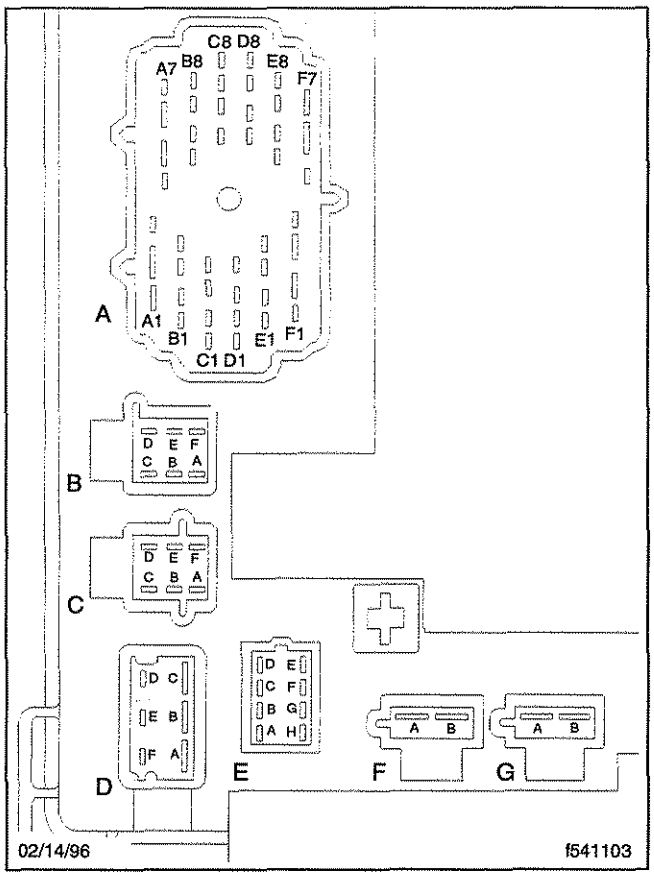


Fig. 3, Pin-Out Positions-Main PDM (left-hand side, top)

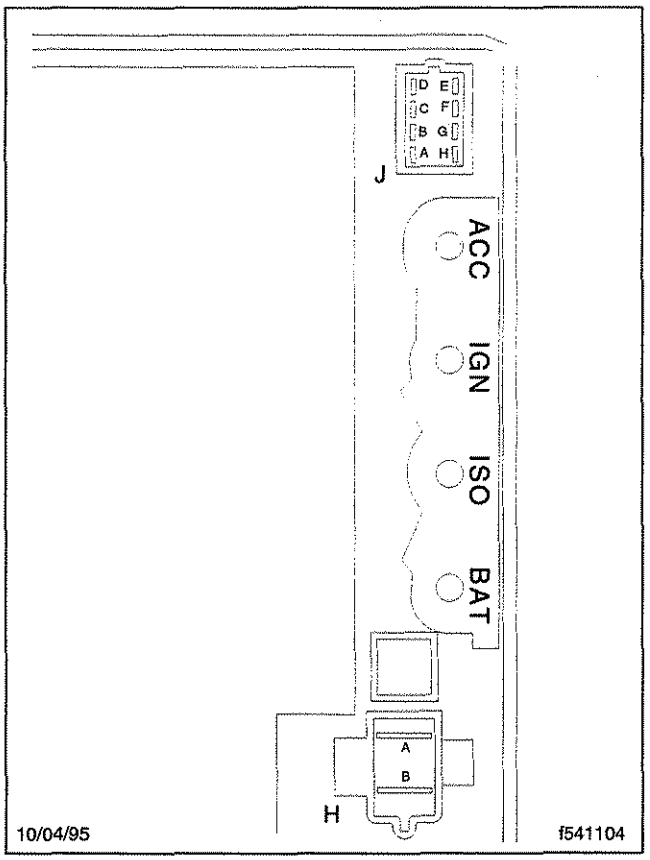
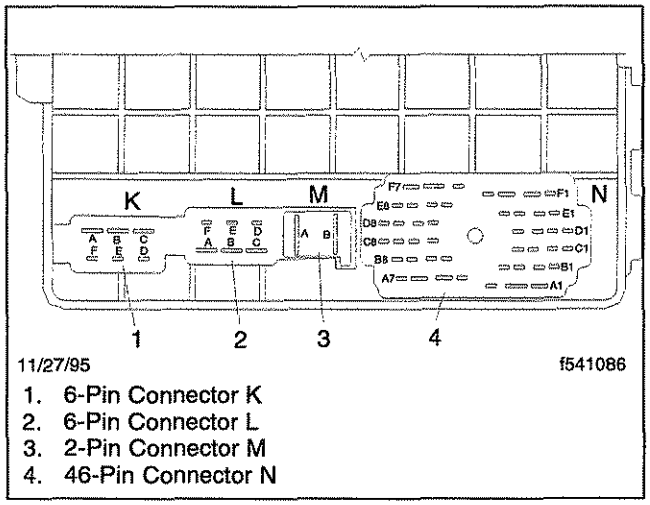


Fig. 4, Pin-Out Positions-Main PDM (right-hand side, top)



1. 6-Pin Connector K
2. 6-Pin Connector L
3. 2-Pin Connector M
4. 46-Pin Connector N

Fig. 5, Main PDM Pin Connectors (bottom view)

Auxiliary Power Distribution Module

There are two different modules: one installed on the Century Class Conventional, the other on the Argosy COE.

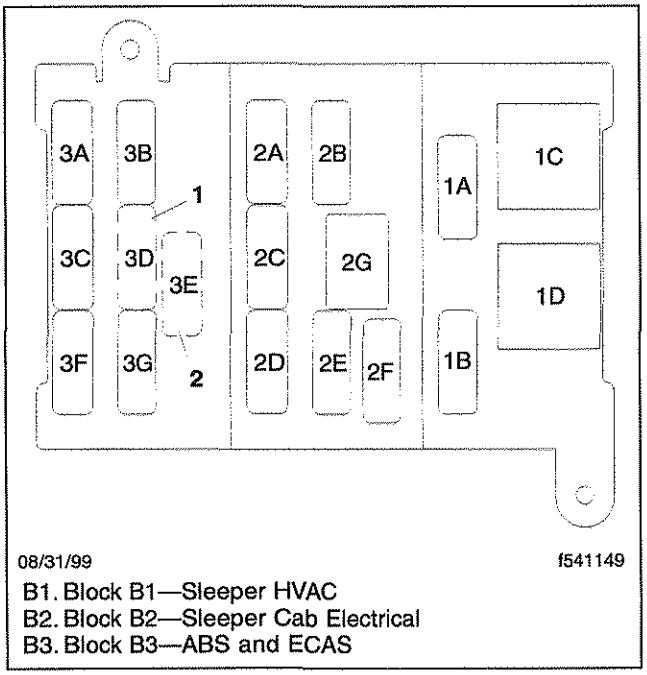
CENTURY CLASS CONVENTIONAL

For circuit breaker and relay locations on the Century Class Conventional auxiliary power module, see **Fig. 6**.

For a list of all component circuit breakers and relays (standard and optional) installed in the auxiliary power module, see **Table 3** for block B1, **Table 4** for block B2, and **Table 5** for block B3.

There are no pin connectors on the auxiliary power module. Circuits are hard-wired into the block. For this reason, plug-in terminal locations are given for each wire running into each block. Follow the wires to the plug-in locations on the front of the block and check for continuity.

NOTE: To locate plug-ins, use this key: Each block is numbered: B1, B2, or B3. Across all blocks, each horizontal row is assigned a number: 1 through 9. Within each block, each vertical column is assigned a letter: A, B, C, or D. *There are three "A" columns, one in each block.*



B1. Block B1—Sleeper HVAC
B2. Block B2—Sleeper Cab Electrical
B3. Block B3—ABS and ECAS

Fig. 6, Circuit Breaker/Relay Locations, Century Class Conventional Auxiliary PDM

Circuit Breaker/Relay ID (Block B1), Century Class Conventional Auxiliary PDM				
Pos.	**Plug No.**	**Circuit**	**Component**	**Description**
1A	2A 3A	OPT+ 14S	15-Amp C/B	Optional BAT Power*
1B	7A 8A	14S 98P	30-Amp C/B	Sleeper HVAC
1C	1C 1D 3C 3D	98P GND 98Z 98H	Mini Relay	Sleeper HVAC Remote High-Speed
1D	5C 7C 5D 7D	98P GND 98Y 98S	Mini Relay	Sleeper HVAC Power

* Optional; not installed on all vehicles

Table 3, Circuit Breaker/Relay ID (Block B1), Century Class Conventional Auxiliary PDM

Circuit Breaker/Relay ID (Block B2), Century Class Conventional Auxiliary PDM				
Pos.	**Plug No.**	**Circuit**	**Component**	**Description**
2A	1A 2A	14S 41S	15-Amp C/B	Dome Light
2B	1C 2C	14S 41R	15-Amp C/B	Reading/Baggage Light
2C	4A 5A	57A 14S	15-Amp C/B	Power Receptacle #1
2D	7A 8A	14S 57B	15-Amp C/B	Power Receptacle #2
2E	8B 9B	57C 14S	15-Amp C/B	Power Receptacle #3
2F	8D 9D	ACC+ 52K	10-Amp C/B	IGN Accessory Power, Sleeper AUX Fan*

Troubleshooting

Circuit Breaker/Relay ID (Block B2), Century Class Conventional Auxiliary PDM				
Pos.	**Plug No.**	**Circuit**	**Component**	**Description**
2G	4C	98L	Micro Relay	Sleeper HVAC Low-Speed
	6C	97A		
	4D	GND		
	5D	98R		
	6D	98P		

* Optional; not installed on all vehicles

Table 4, Circuit Breaker/Relay ID (Block B2), Century Class Conventional Auxiliary PDM

Circuit Breaker/Relay ID (Block B3), Century Class Conventional Auxiliary PDM				
Pos.	**Plug No.**	**Circuit**	**Component**	**Description**
3A	1A	14E	15-Amp C/B	ABS BAT #1
	2A	376A		
3B	1C	52R	10-Amp C/B	ABS IGN Power
	2C	376C		
3C	4A	376B	15-Amp C/B	ABS BAT #2 (with ATC)
	5A	14E		
3D	4C	442A	10-Amp C/B	DLU IGN Power*
	5C	52R		
3E	5D	14E	10-Amp C/B	DLU BAT Power*
	6D	442		
3F	7A	14E	10-Amp C/B	Diagnostic BAT
	8A	331		
3G	7C	52R	10-Amp C/B	ECAS IGN or Communications System*
	8C	434R		

* Optional; not installed on all vehicles

Table 5, Circuit Breaker/Relay ID (Block B3), Century Class Conventional Auxiliary PDM

Examples: Plug number 2A means row 2, column A. Checking the table for block B2, circuit 41S is wired into plug-in 2A. Checking the table for block B3, circuit 376A is wired into plug-in 2A.

For wiring and harness diagrams of the main and auxiliary power modules, see **Specifications, 400**.

ARGOSY COE

The Argosy COE has an auxiliary power module with six plug-in connectors (two each on the top, right-hand side, and bottom of the module case).

On the auxiliary power module itself, there are three rows:

- Row A, the top row, contains 6 fuses and one 30-amp HVAC circuit breaker.
- Row D, the middle row, contains 3 HVAC relays.
- Row G, the bottom row, contains between 3 and 8 fuses, depending on options installed.

For circuit breaker and relay locations on the Argosy COE auxiliary power module, see **Fig. 7**.

For lists of all component fuses (standard and optional), circuit breakers, and relays installed in the Argosy COE auxiliary power module, together with the connector and pin number of each circuit, see **Table 6** for Row A, **Table 7** for Row D, and **Table 8** for Row G.

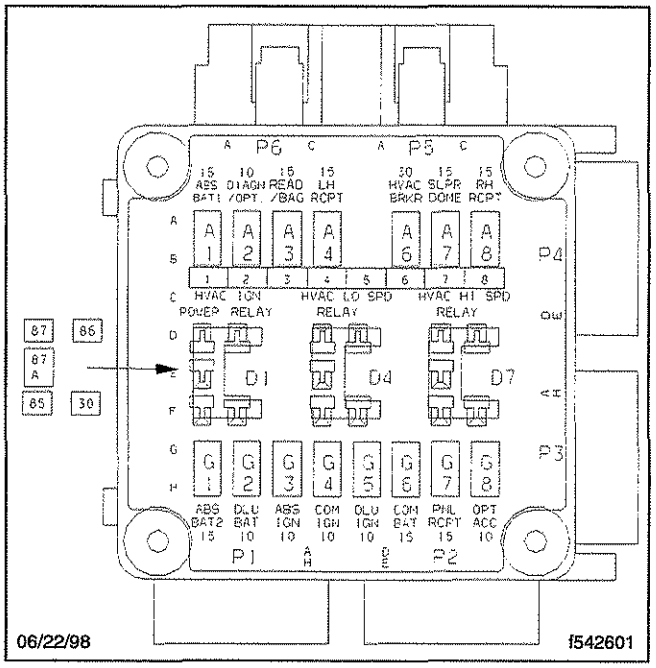


Fig. 7, Circuit Breaker/Relay Locations, Argosy COE Auxiliary PDM

Circuit Breaker/Fuse ID (Row A), Argosy COE Auxiliary PDM						
Pos.	Plug No.	Circuit	Connector	Pin No.	Component	Description
A1	A1	14E	P6	A	15-Amp Fuse	ABS BAT #1
	B1	376A	P1	F		
A2	A2	14E	P6	A	10-Amp Fuse	Diagnostic BAT
	B2	331	P1	G		
A3	A3	14S	P5	A	15-Amp Fuse	Reading/Baggage Light
	B3	41R	P4	H		
A4	A4	14S	P5	A	15-Amp Fuse	L/H Power Receptacle
	B4	57B	P4	G		
A6	A6	14S	P5	A	30-Amp C/B	Sleeper HVAC
	B6	+12V*	—	—		
A7	A7	14S	P5	A	15-Amp Fuse	Dome Light
	B7	41S	P4	C		
A8	A8	14S	P5	A	15-Amp Fuse	R/H Power Receptacle
	B8	57A	P4	B		

* The +12V circuit is internal to the auxiliary power module.

Table 6, Circuit Breaker/Fuse ID (Row A), Argosy COE Auxiliary PDM

Relay ID (Row D), Argosy COE Auxiliary PDM						
Pos.	Plug No.	Circuit	Connector	Pin No.	Component	Description
D1	D1	+12V*	—	—	Mini Relay	Sleeper HVAC Power
	D2	GND	P5	C		
	F1	98Y	P1	E		
	F2	98S	P3	A		
D4	D4	+12V*	—	—	Mini Relay	Sleeper HVAC Low-Speed
	D5	GND	P5	C		
	E4	98R	P4	F		
	F4	97A	P1	H		
	F5	98L	P3	H		
D7	D7	+12V*	—	—	Mini Relay	Sleeper HVAC Remote High-Speed
	D8	GND	P5	C		
	F7	98Z	P2	G		
	F8	98H	P3	G		

* The +12V circuit is internal to the auxiliary power module.

Table 7, Relay ID (Row D), Argosy COE Auxiliary PDM

Troubleshooting

Fuse ID (Row G), Argosy COE Auxiliary PDM						
Pos.	**Plug No.**	**Circuit**	**Connector**	**Pin No.**	**Component**	**Description**
G1	G1	14E	P6	A	15-Amp Fuse	ABS BAT #2
	H1	376B	P1	D		
G2	G2	14E	P6	A	10-Amp Fuse	DLU BAT Power*
	H2	442	P1	C		
G3	G3	52R	P6	C	10-Amp Fuse	ABS IGN Power
	H3	376C	P1	B		
G4	G4	52R	P6	C	10-Amp Fuse	Communications System*
	H4	434R	P1	A		
G5	G5	52R	P6	C	10-Amp Fuse	DLU IGN Power*
	H5	442A	P2	D		
G6	G6	14S	P5	A	15-Amp Fuse	Optional BAT Power*
	H6	OPT+	P2	C		
G7	G7	14S	P5	A	15-Amp Fuse	Panel Power Receptacle
	H7	57C	P3	C		
G8	G8	ACC+	P2	H	10-Amp Fuse	Optional Accessory Power*
	H8	52K	P2	A		

* Optional; not installed on all vehicles

Table 8, Fuse ID (Row G), Argosy COE Auxiliary PDM

For pin connector locations on the top of the main PDM, see **Fig. 1**.

For positions of individual pin-outs on the top of the main PDM, see **Fig. 2** for connectors A through G (left-hand side), and **Fig. 3** for connectors H and J (right-hand side).

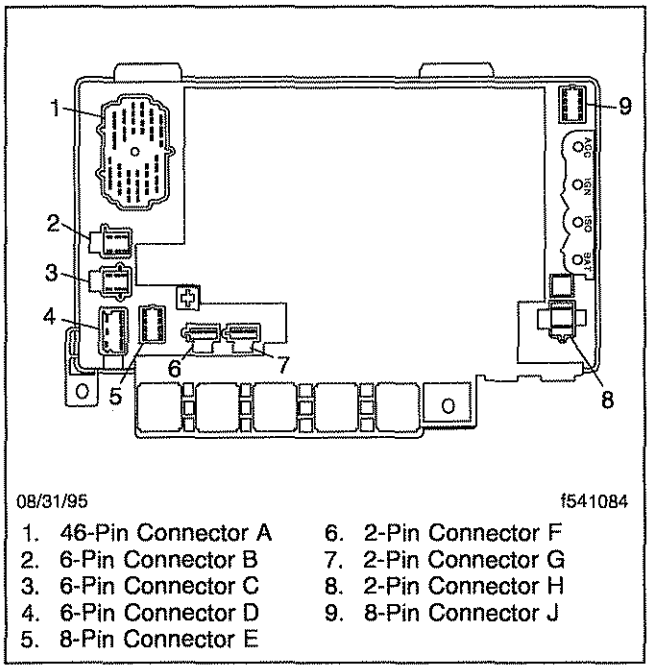
For location of pin connectors and individual pin positions on the bottom of the PDM, see **Fig. 4**.

NOTE: To locate pin-outs, use this key: The first letter indicates the connector in which the pin is located. The second letter indicates the row of the connector. The third number, if present, indicates the number of the pin in the row, if there is more than one. If there is only one pin in a row, this number is missing.

Examples: Pin number AF5 means connector A, row F, pin 5. Pin number BC means connector B, pin C.

For a list of circuit breakers and relays installed in the main and auxiliary power distribution modules, see **Troubleshooting, 300**.

For a full schematic view of the PDM wiring, see **Fig. 5**. For a detailed (partial) view of the PDM wiring schematic, see **Fig. 6** and **Fig. 7**.



1. 46-Pin Connector A
2. 6-Pin Connector B
3. 6-Pin Connector C
4. 6-Pin Connector D
5. 8-Pin Connector E
6. 2-Pin Connector F
7. 2-Pin Connector G
8. 2-Pin Connector H
9. 8-Pin Connector J

Fig. 1, Main PDM Pin Connectors (top view)

To identify relay terminals, first check the type of relay. On micro relays, the terminals are numbered 1 through 5, corresponding to the position numbers on the schematic. On all other relays, the terminals are numbered 30 through 87A, corresponding to positions 1 through 5 as shown in **Table 1**.

Mini Relay Terminal Numbers	
Position	**Terminal Number**
1	86
2	85
3	30
4	87A
5	87

Table 1, Mini Relay Terminal Numbers

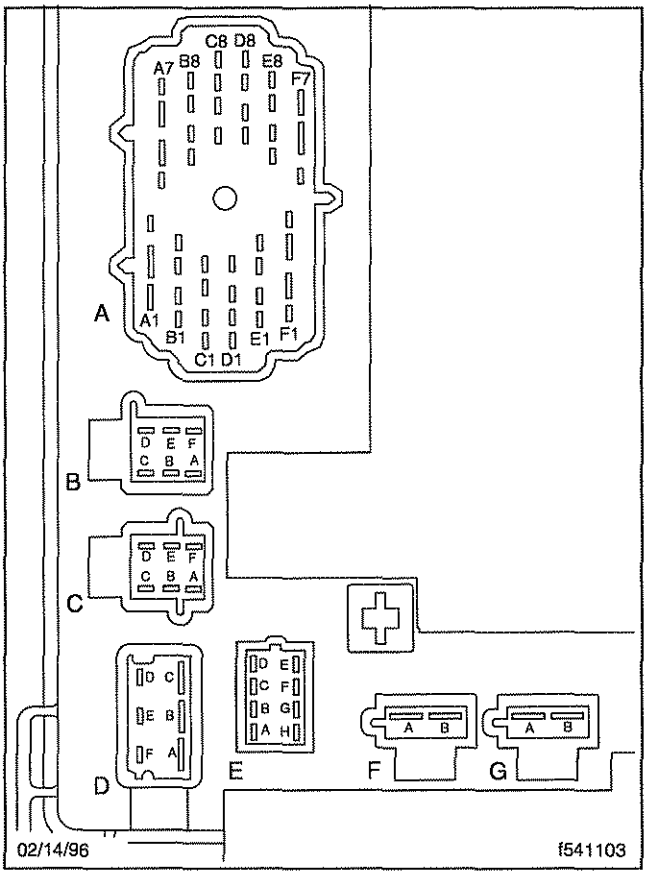


Fig. 2, Pin-Out Positions-Main PDM (left-hand side, top)

Specifications

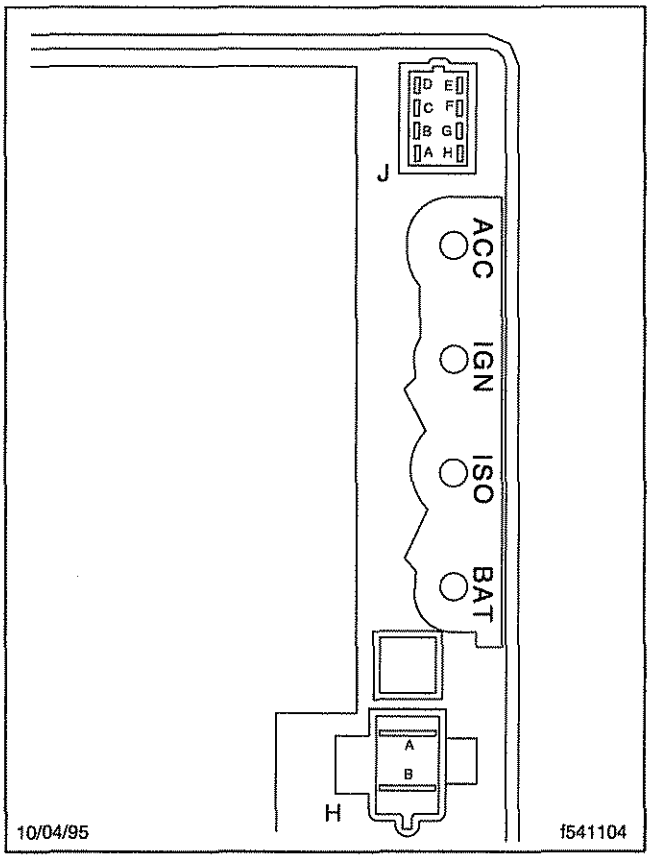
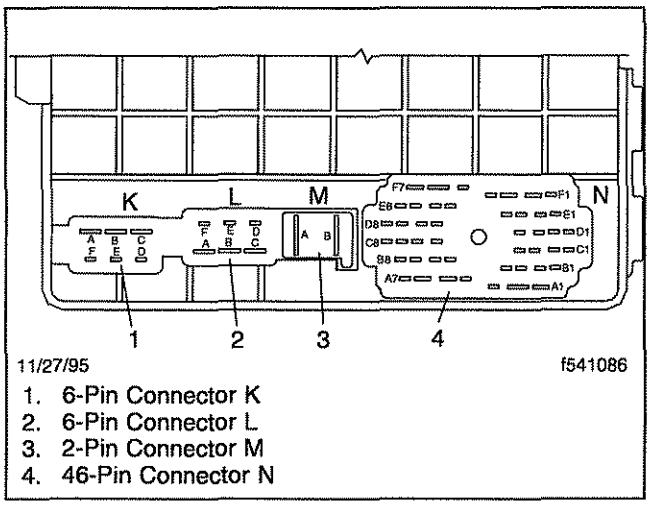


Fig. 3, Pin-Out Positions-Main PDM (right-hand side, top)



1. 6-Pin Connector K
2. 6-Pin Connector L
3. 2-Pin Connector M
4. 46-Pin Connector N

Fig. 4, Main PDM Pin Connectors (bottom view)

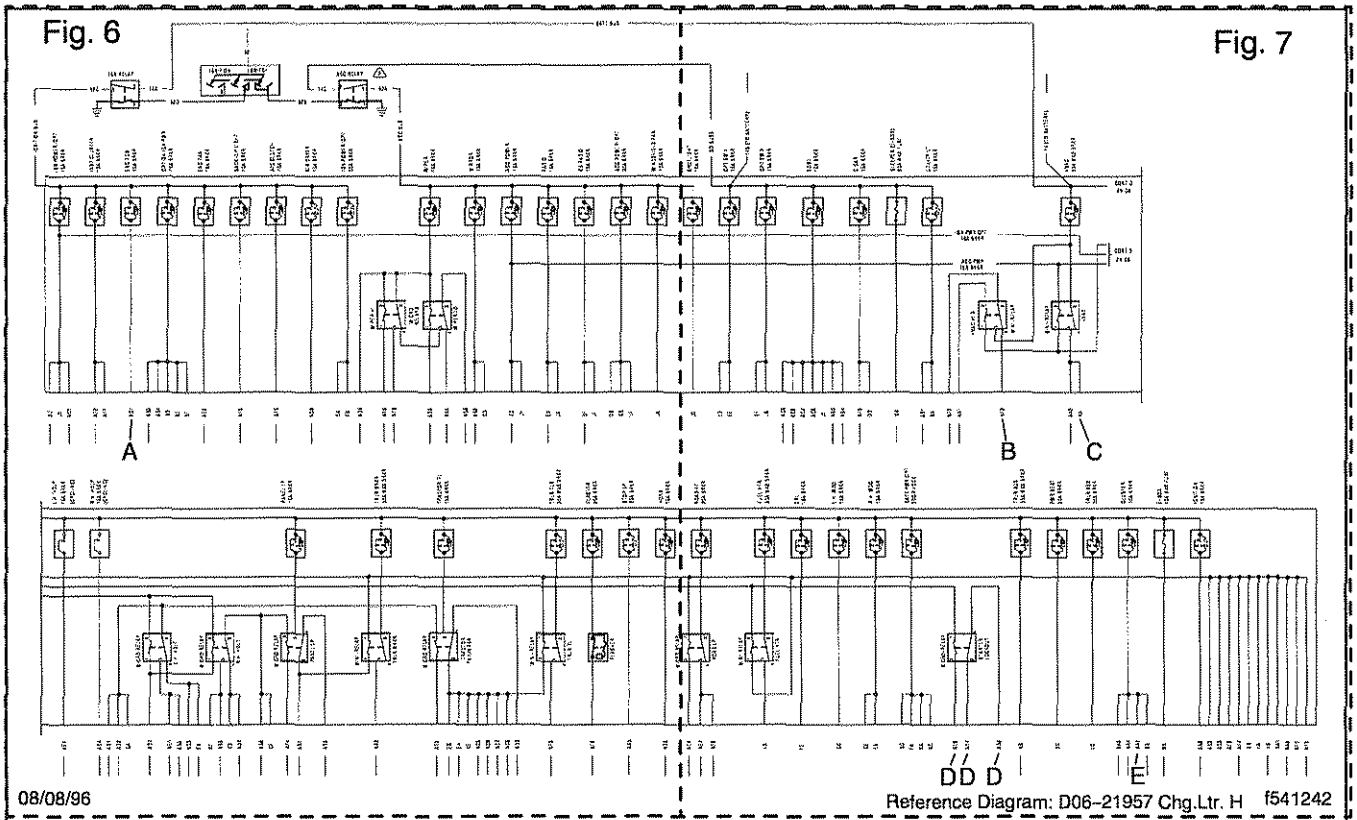
For a diagram of the PDM power harness, see **Fig. 8**.

For a full diagram of the Century Class Conventional "B" block auxiliary power module wiring harness, see **Fig. 9**. For a detailed (partial) view of the Century Class Conventional "B" block auxiliary power module wiring harness, see **Fig. 10** and **Fig. 11**.

For a full schematic view of the Century Class Conventional "B" block auxiliary power module wiring, see **Fig. 12**. For a detailed (partial) view of the Century Class Conventional "B" block auxiliary power module wiring, see **Fig. 13** and **Fig. 14**.

For a full schematic view of the Argosy COE "B" block auxiliary power module wiring, see **Fig. 15**. For a

detailed (partial) view of the Argosy COE "B" block auxiliary power module wiring, see **Fig. 16** and **Fig. 17**.



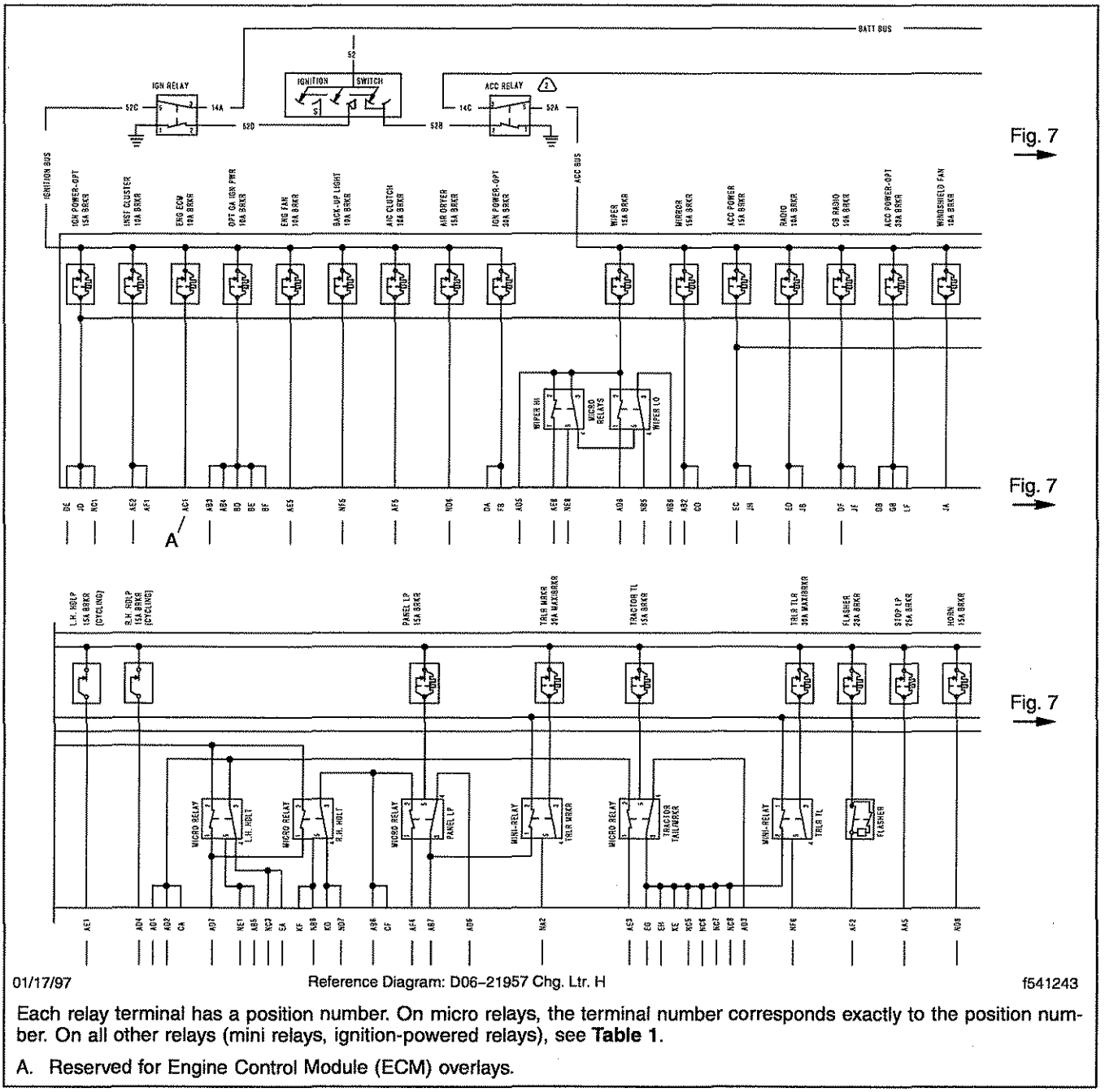
Each relay terminal has a position number. On micro relays, the terminal number corresponds exactly to the position number. On all other relays (mini relays, ignition-powered relays), see **Table 1**.

NOTE: Starter lockout circuitry not available at this time.

A. Reserved for Engine Control Module (ECM) overlays.
B. Do not use.
C. Circuit assignments to this optional pin position must be approved by Freightliner Engineering.
D. Reserved for starter lockout circuitry.
E. Reserved for ignition keyswitch courtesy light feed.

Fig. 5, Main PDM Wiring Schematic (full view)

Specifications

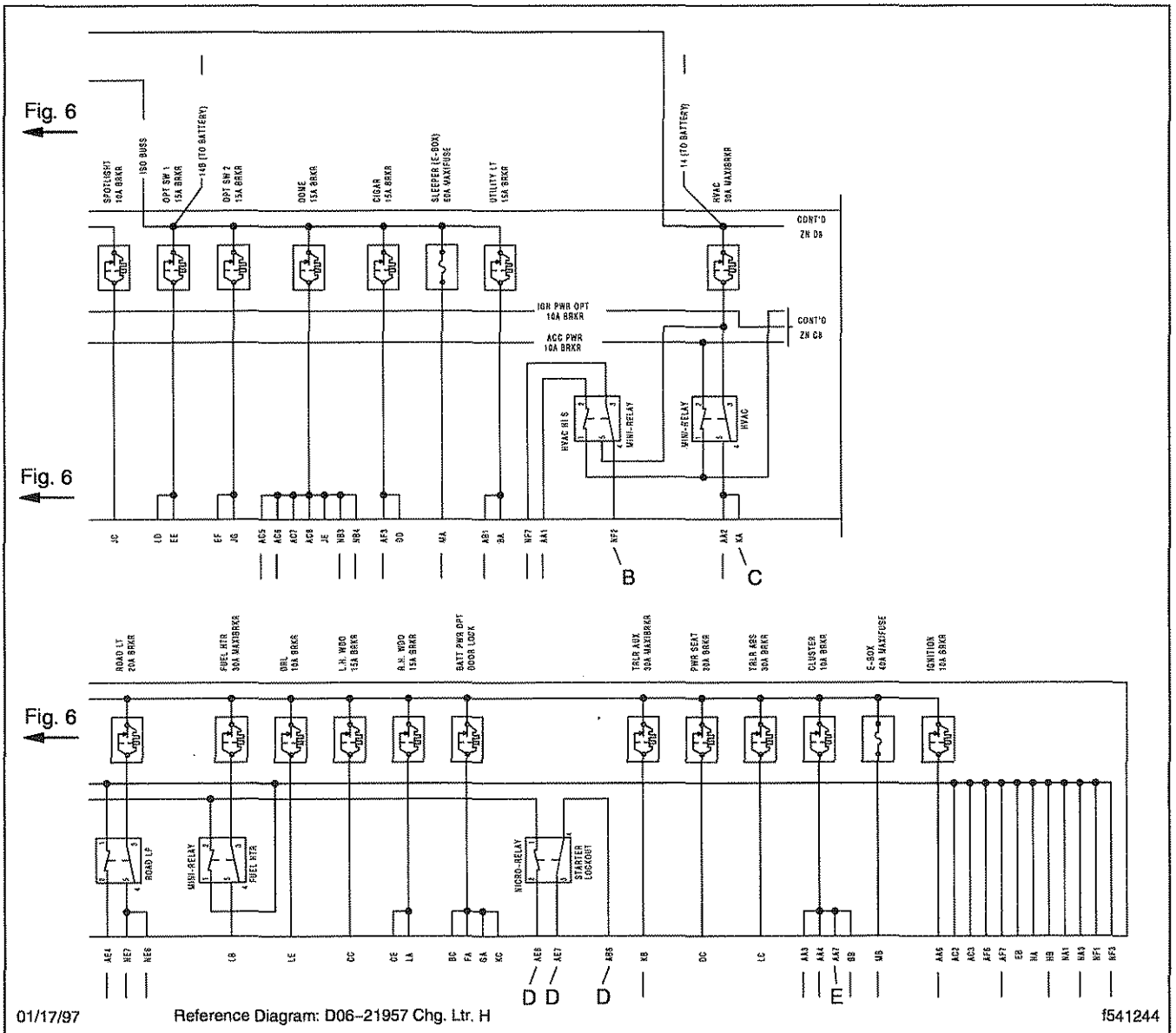


01/17/97 Reference Diagram: D06–21957 Chg. Ltr. H f541243

Each relay terminal has a position number. On micro relays, the terminal number corresponds exactly to the position number. On all other relays (mini relays, ignition-powered relays), see **Table 1**.

A. Reserved for Engine Control Module (ECM) overlays.

Fig. 6, Main PDM Wiring Schematic (partial view)



01/17/97 Reference Diagram: D06-21957 Chg. Ltr. H f541244

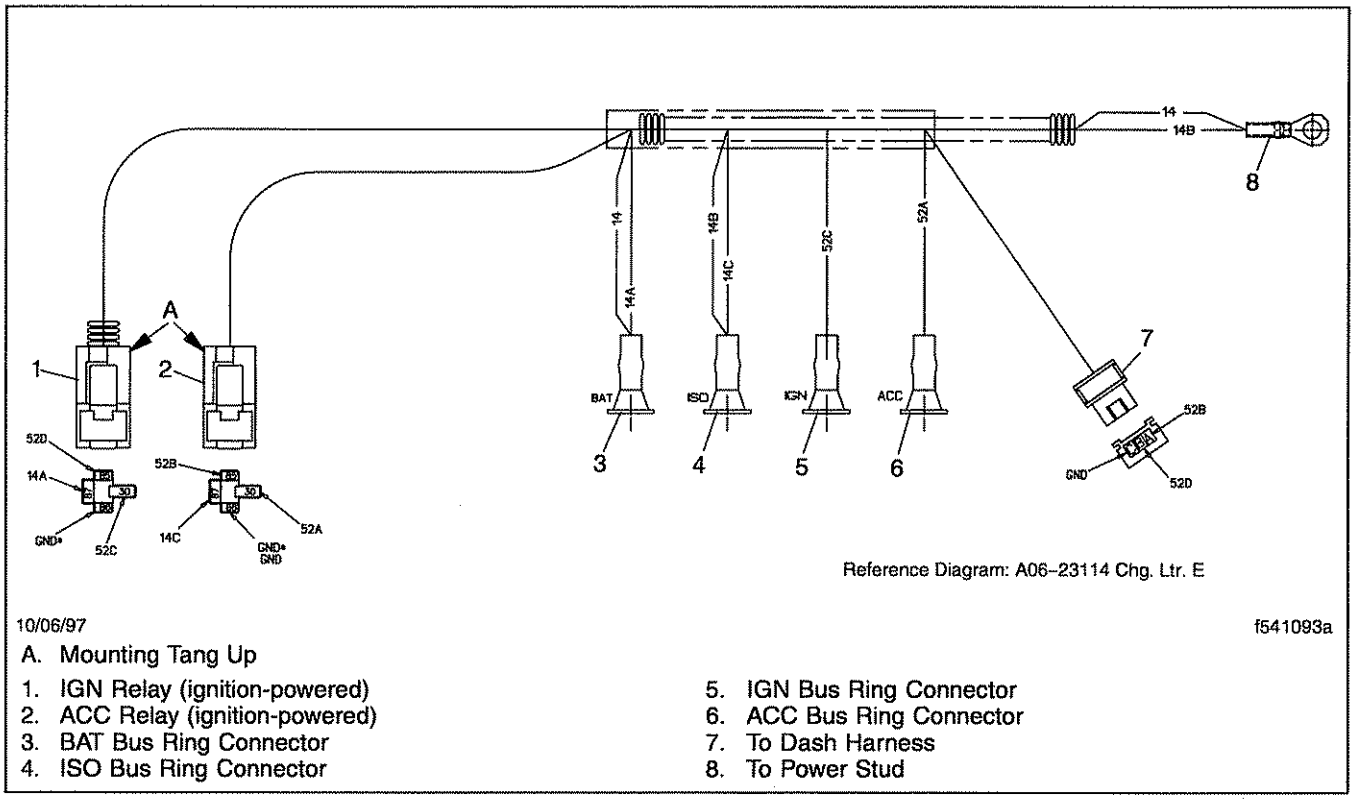
Each relay terminal has a position number. On micro relays, the terminal number corresponds exactly to the position number. On all other relays (mini relays, ignition-powered relays), see **Table 1**.

NOTE: Starter lockout circuitry not available at this time.

B. Do not use.
C. Circuit assignments to this optional pin position must be approved by Freightliner Engineering.
D. Reserved for starter lockout circuitry.
E. Reserved for ignition keyswitch courtesy light feed.

Fig. 7, Main PDM Wiring Schematic (partial view)

Specifications



A. Mounting Tang Up

1. IGN Relay (ignition-powered)
2. ACC Relay (ignition-powered)
3. BAT Bus Ring Connector
4. ISO Bus Ring Connector
5. IGN Bus Ring Connector
6. ACC Bus Ring Connector
7. To Dash Harness
8. To Power Stud

Fig. 8, Main PDM Power Harness

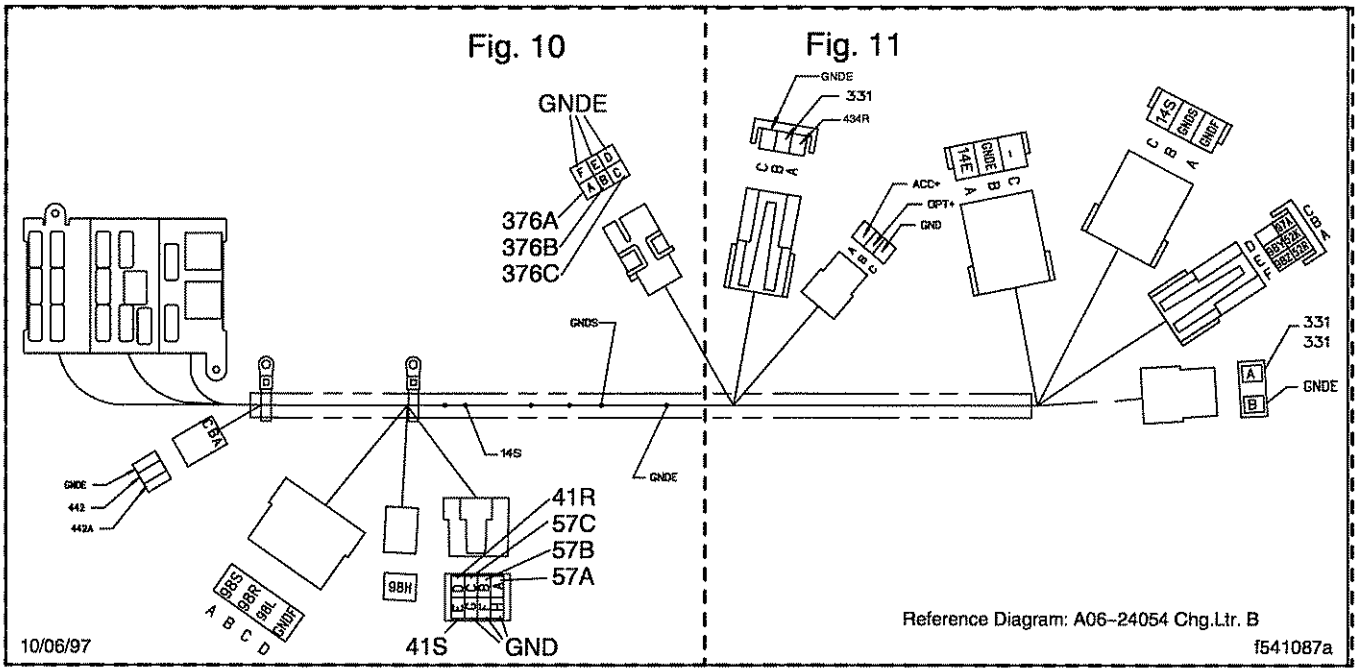
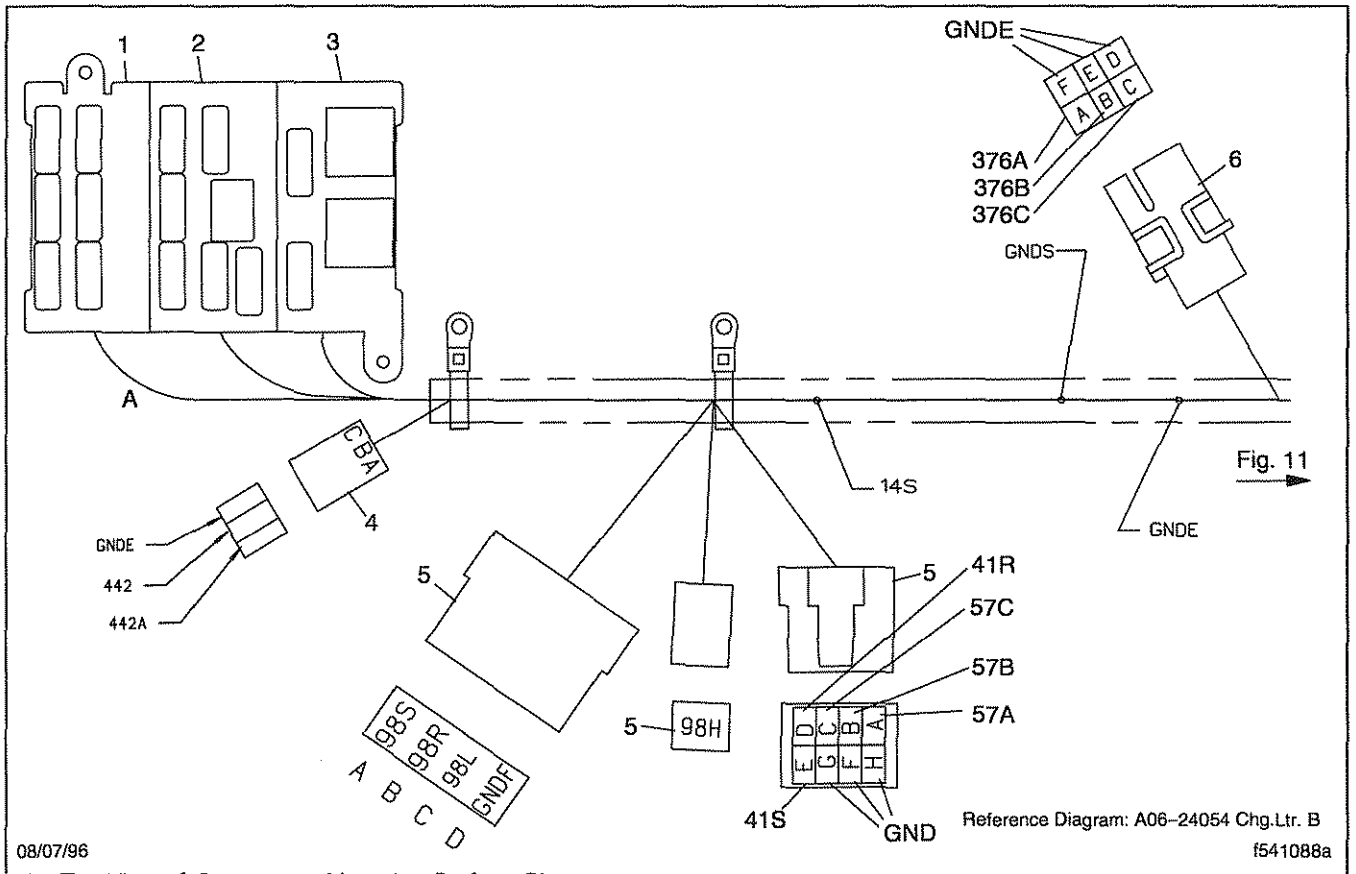


Fig. 9, Auxiliary Power Module Wiring Harness (full view), Century Class Conventional

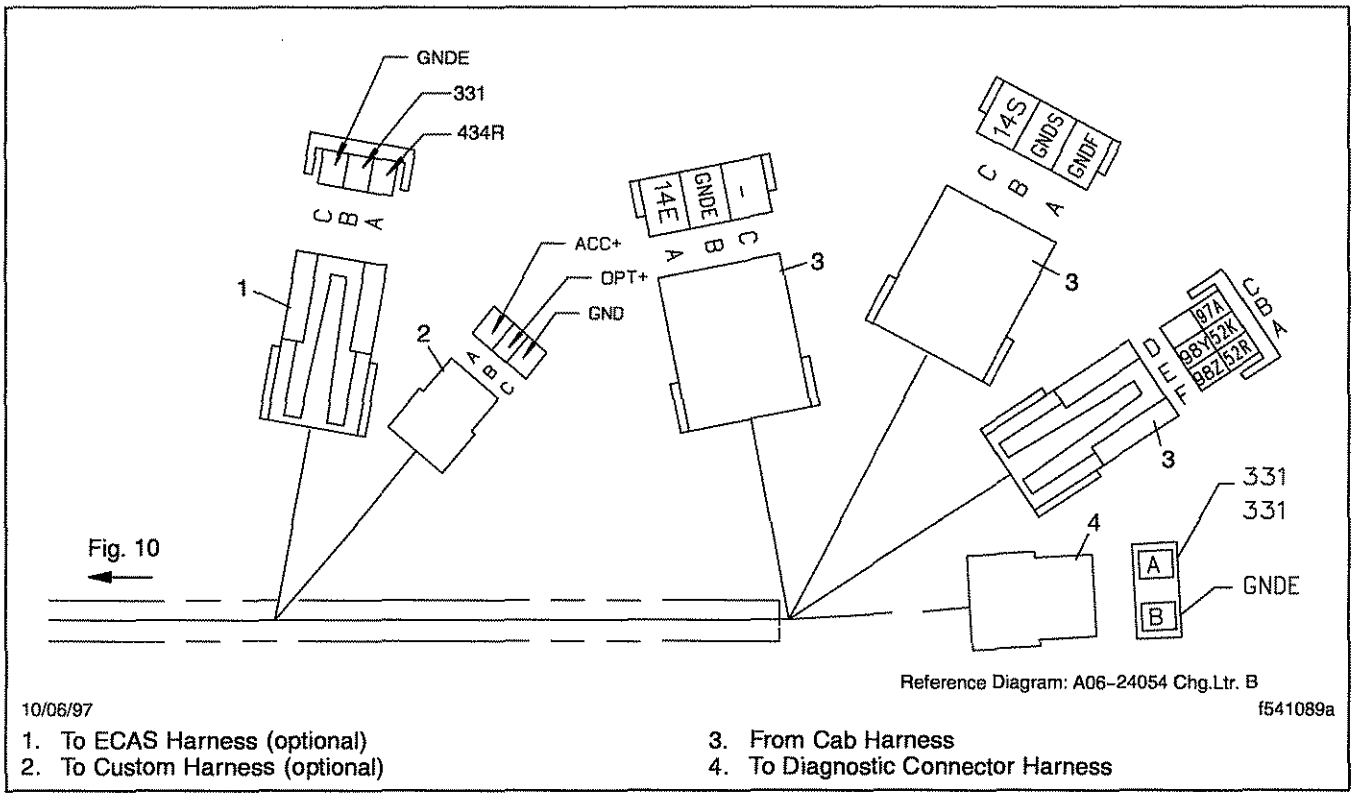


A. Top View of Component Mounting Surface Shown

1. Block B3—Antilock Brake System (ABS), Diagnostic Connector, and, if installed, Electronic Air Suspension (ECAS)
2. Block B2—Sleeper Cab Electrical Accessories
3. Block B1—Sleeper Cab Heating, Ventilation, and Air Conditioning System (Sleeper HVAC)
4. To Data Logging Unit Option Harness
5. To Sleeper Harness
6. To ABS Harness

Fig. 10, Auxiliary Power Module Wiring Harness (partial view), Century Class Conventional

Specifications



1. To ECAS Harness (optional)
2. To Custom Harness (optional)
3. From Cab Harness
4. To Diagnostic Connector Harness

Fig. 11, Auxiliary Power Module Wiring Harness (partial view), Century Class Conventional

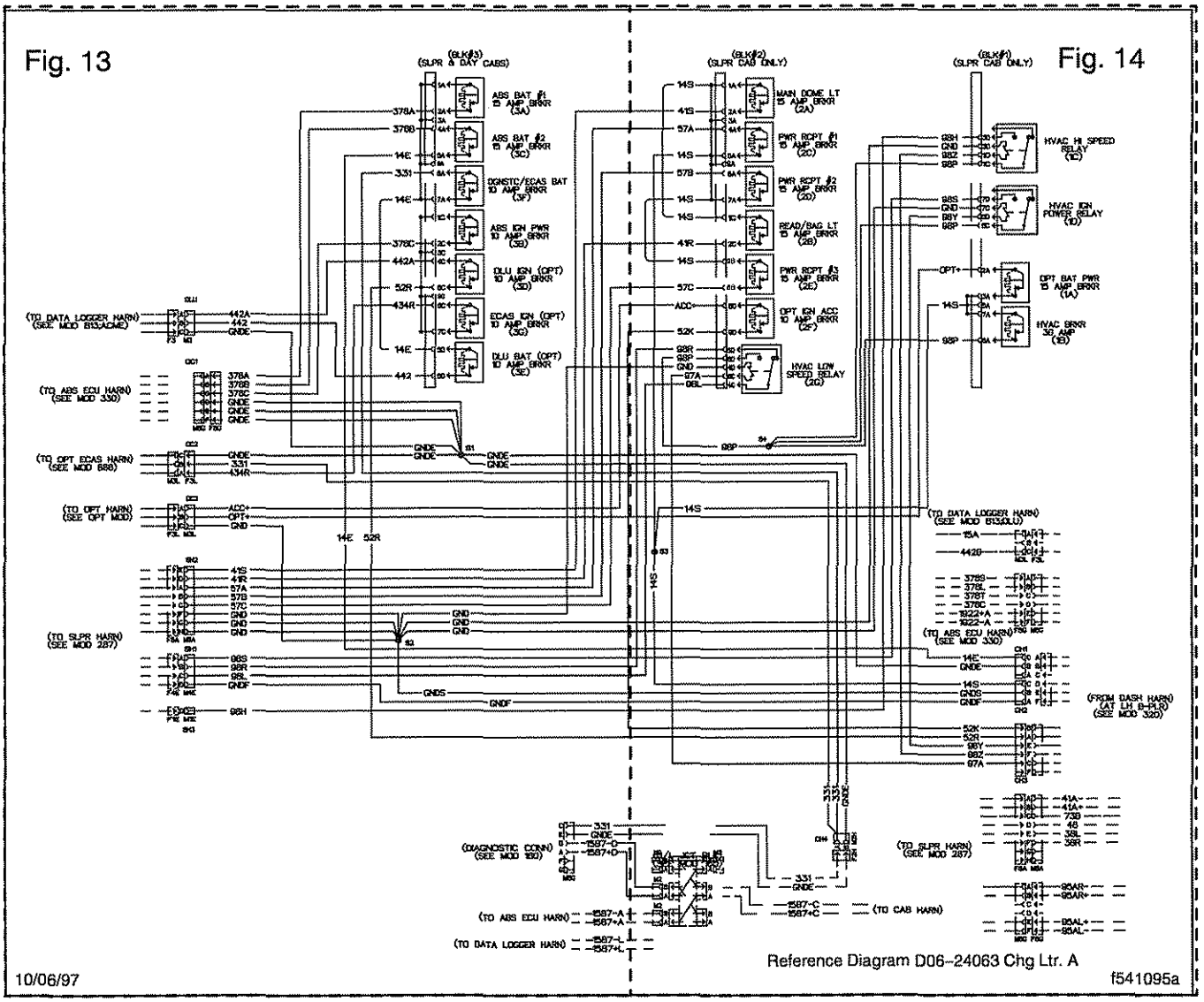
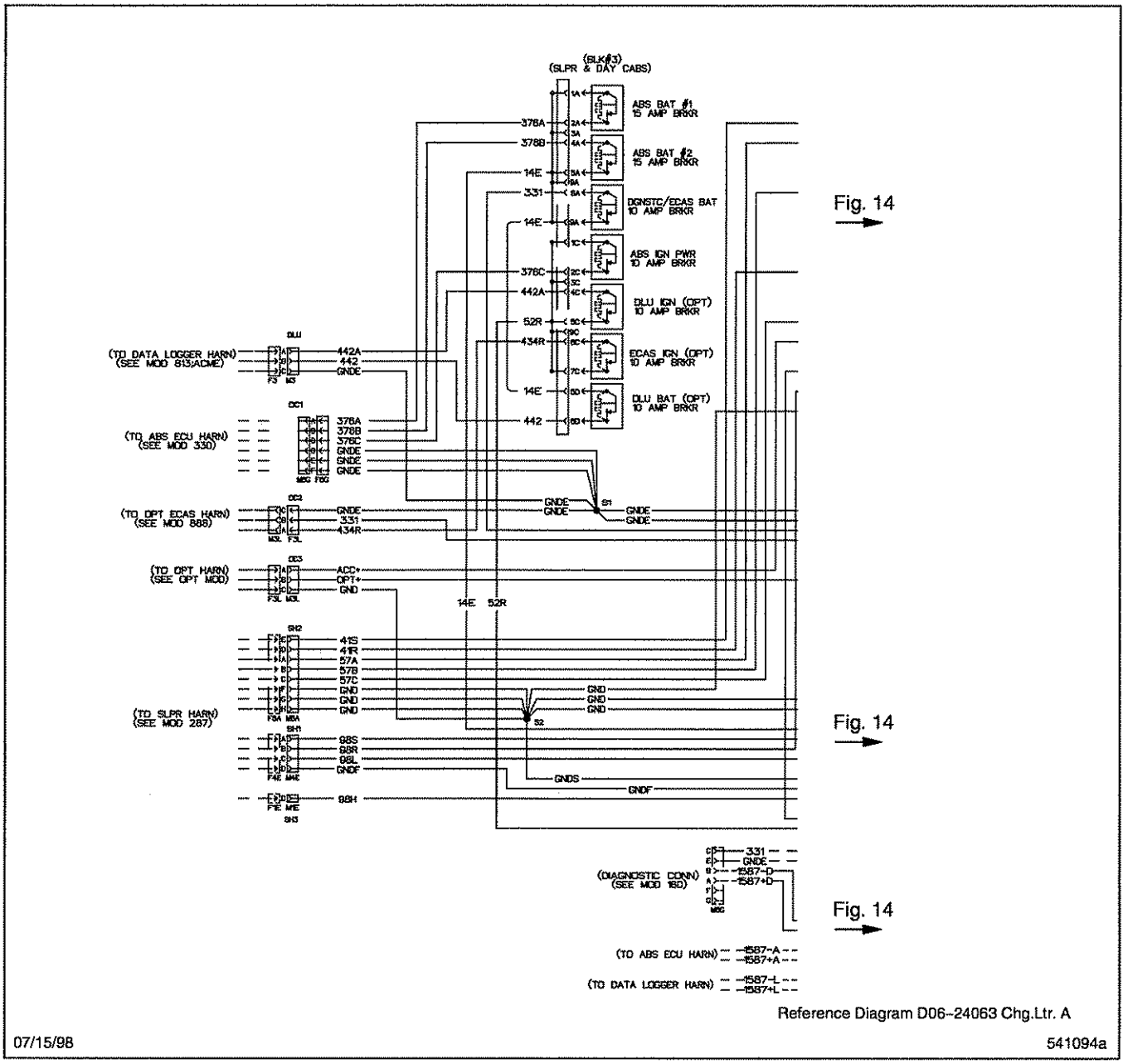


Fig. 12, Auxiliary Power Module Wiring Schematic (full view), Century Class Conventional

Specifications



Reference Diagram D06-24063 Chg.Ltr. A

07/15/98 541094a

Fig. 13, Auxiliary Power Module Wiring Schematic (partial view), Century Class Conventional

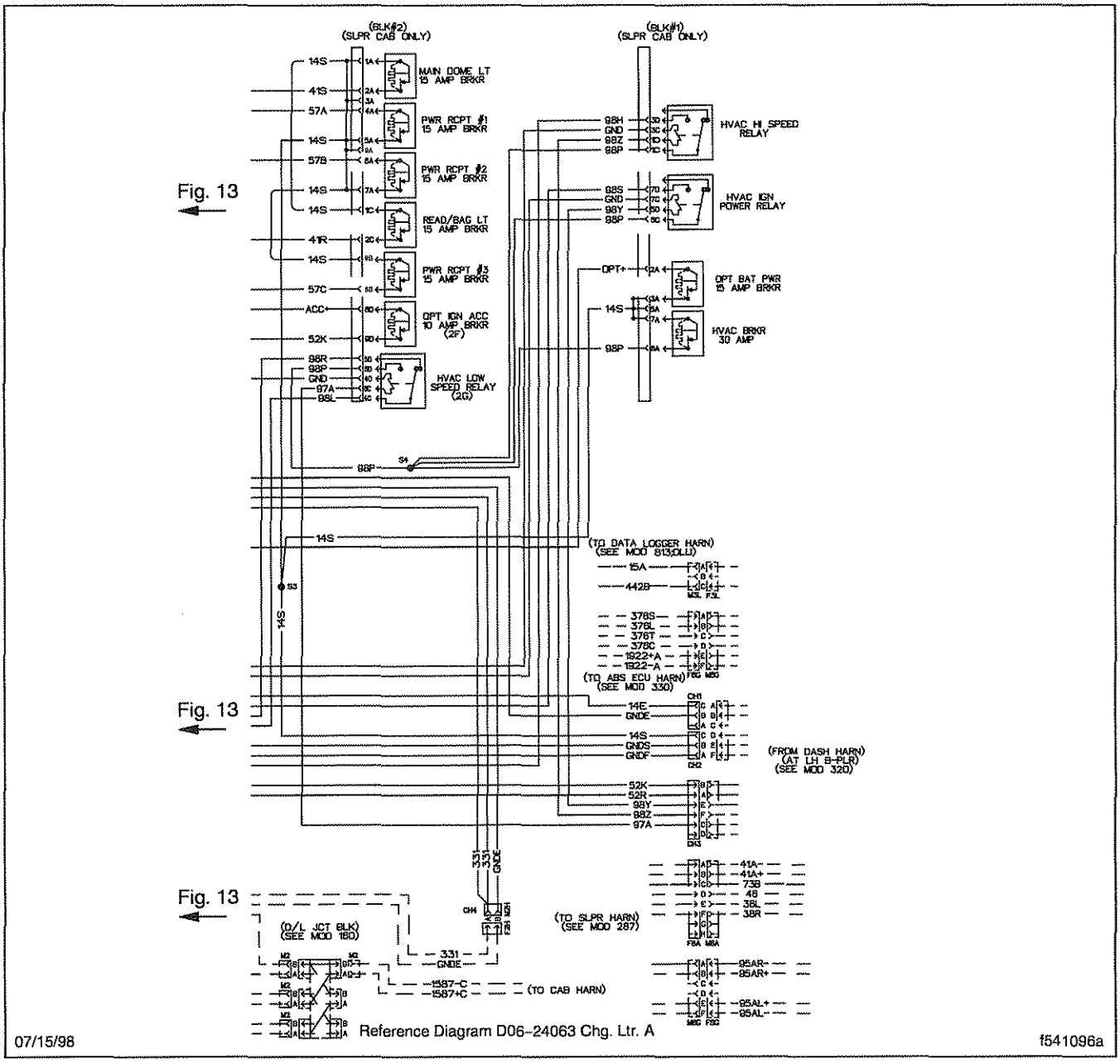
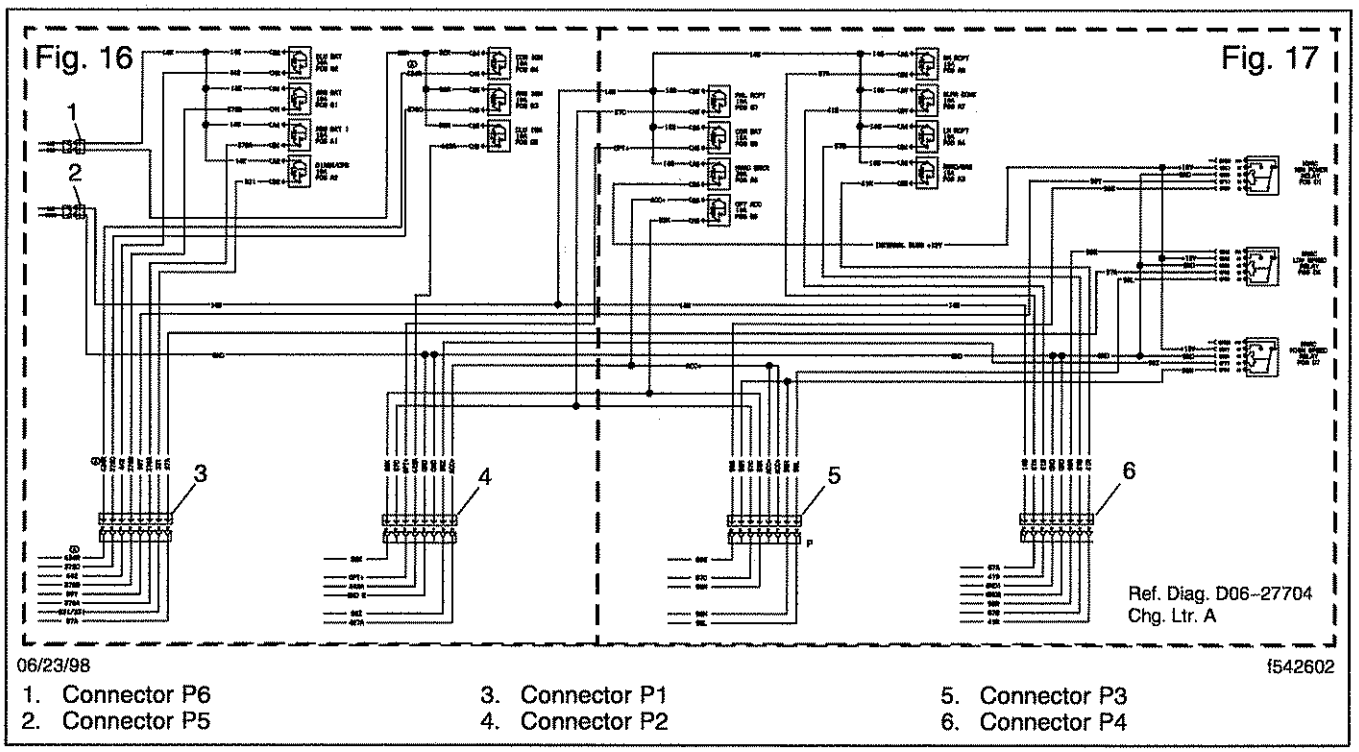


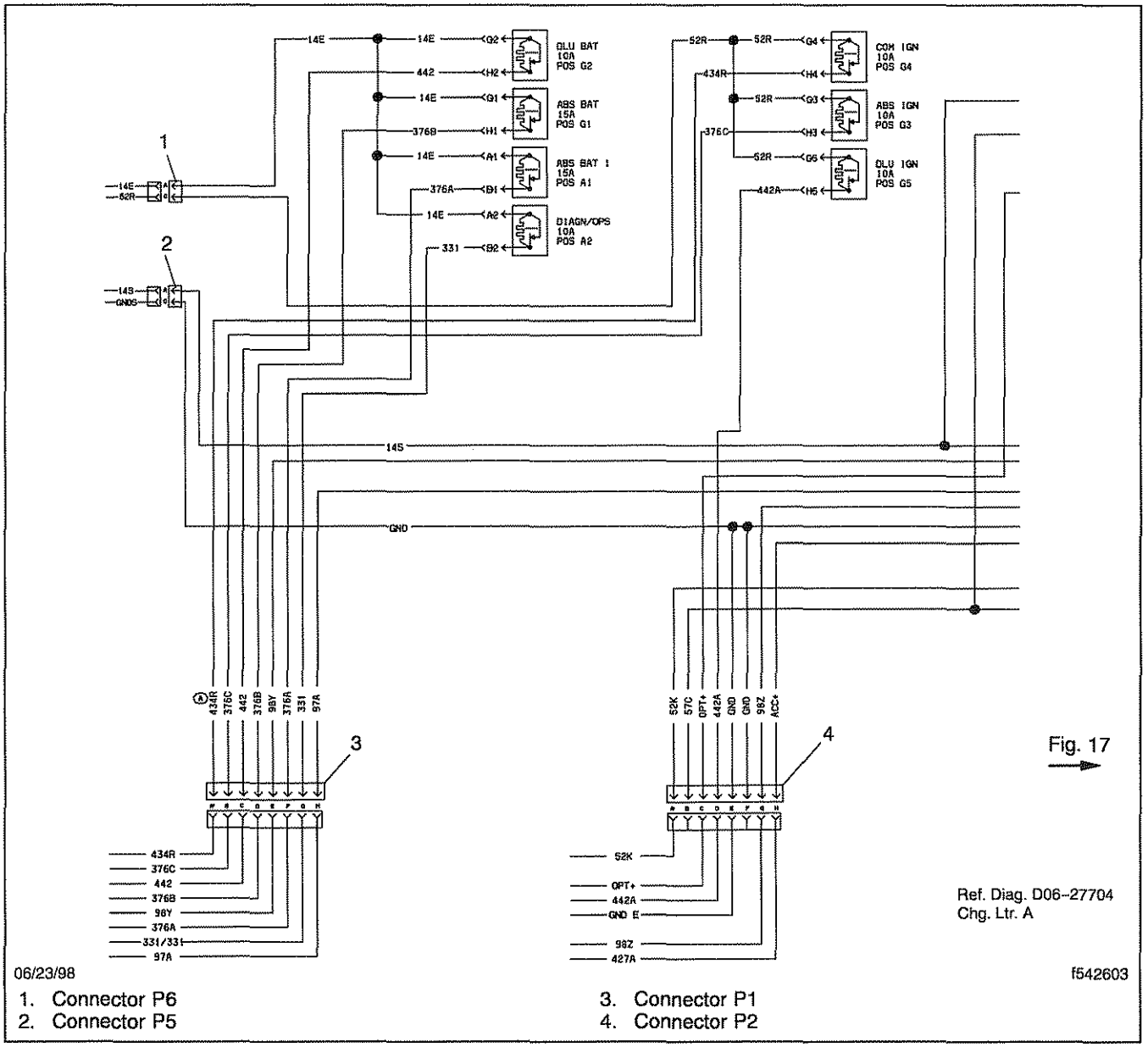
Fig. 14, Auxiliary Power Module Wiring Schematic (partial view), Century Class Conventional

Specifications



1. Connector P6
2. Connector P5
3. Connector P1
4. Connector P2
5. Connector P3
6. Connector P4

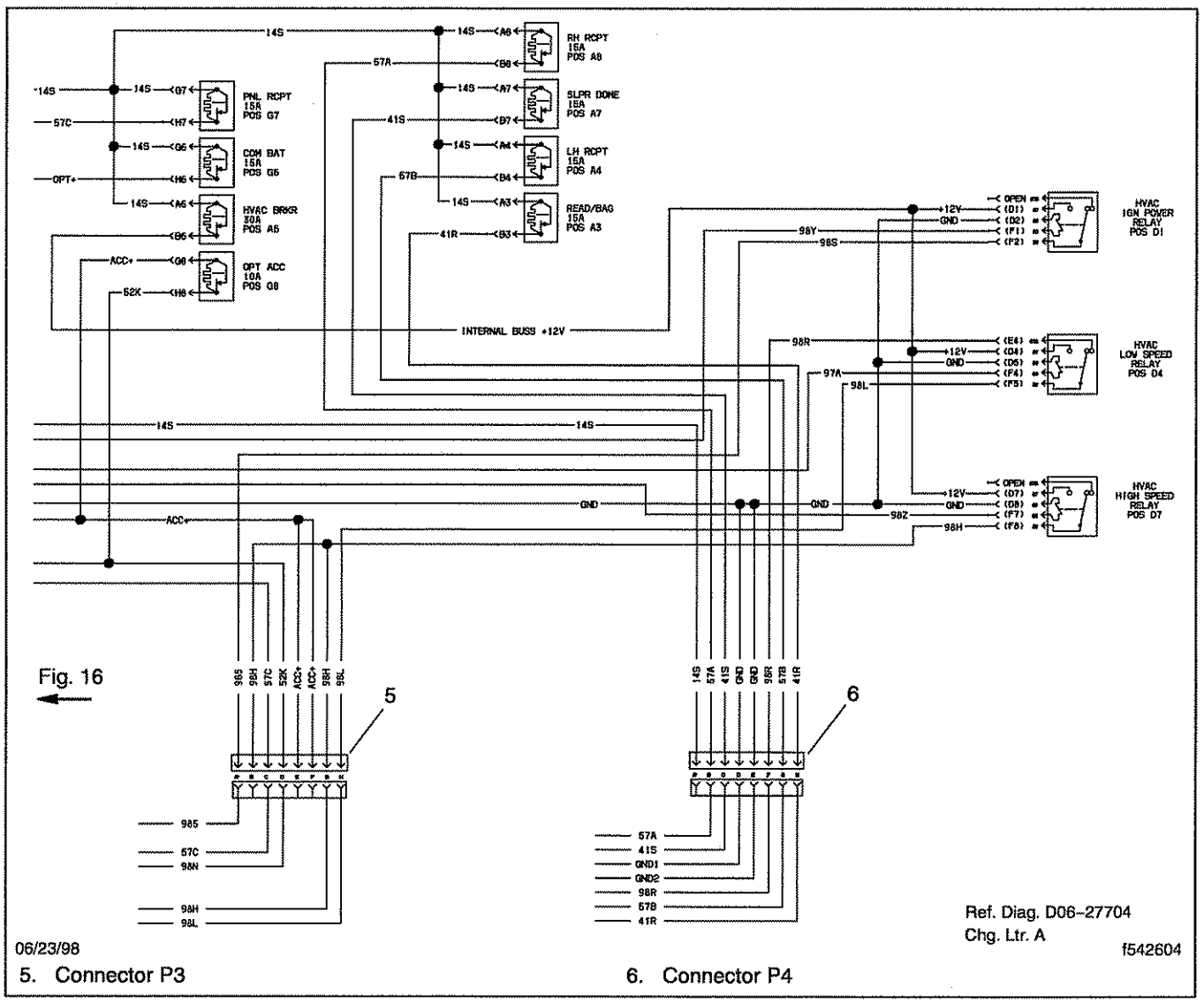
Fig. 15, Auxiliary Power Module Wiring Schematic (full view), Argosy COE



1. Connector P6
2. Connector P5
3. Connector P1
4. Connector P2

Fig. 16, Auxiliary Power Module Wiring Schematic (partial view), Argosy COE

Specifications



5. Connector P3

6. Connector P4

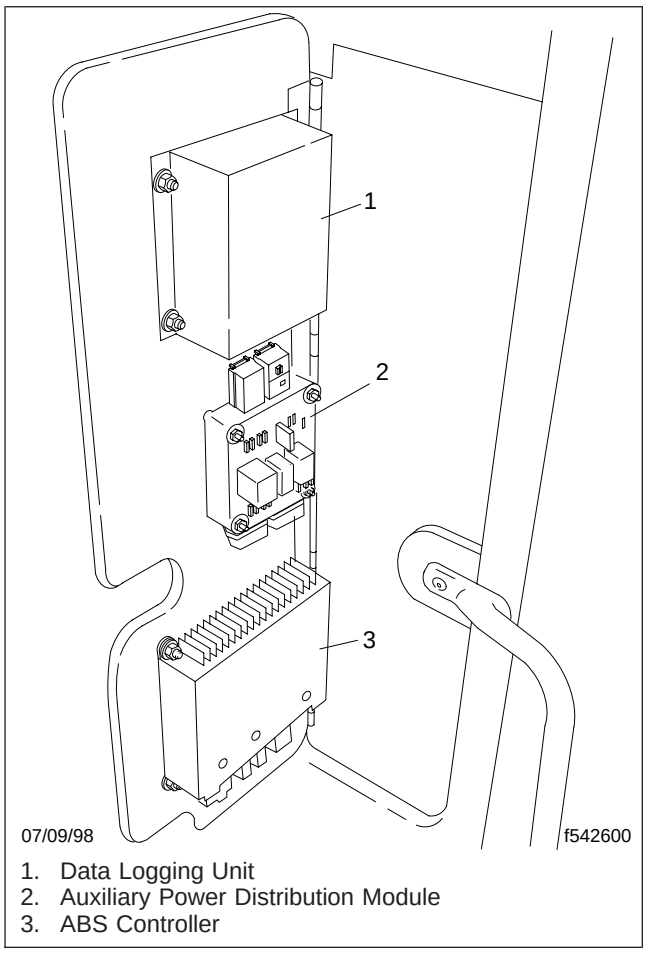
Fig. 17, Auxiliary Power Module Wiring Schematic (partial view), Argosy COE

Contents

Subject	Subject Number
General Information	050
Service Operations	
Data Logging Unit Removal and Installation	100
Data Logging Unit Reconfiguring	110
Troubleshooting	300
Specifications	400

General Information

The Freightliner data logging unit (DLU) is mounted on the inside of the electrical compartment door located on the left-hand B-pillar behind the seat. See **Fig. 1**.



1. Data Logging Unit
2. Auxiliary Power Distribution Module
3. ABS Controller

Fig. 1, Left-Hand B-Pillar Electrical Compartment

The DLU (see **Fig. 2**) monitors all data transmitted on the J1587 databus by the vehicle electronic control units (ECUs). It records all data defined in the vehicle parameter file (VPF).

The VPF identifies which data shall be monitored and recorded in rolling history as an event. An event is a snapshot of data recorded whenever the DLU reports a fault, or notes an out-of-range condition, and one is generated and stored whenever a parameter matches a value defined in the VPF.

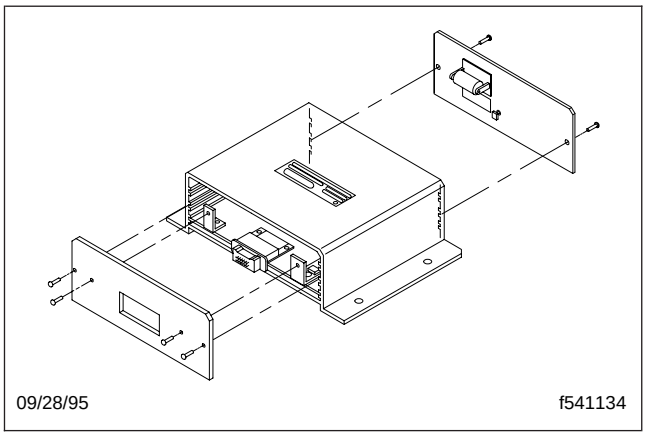


Fig. 2, Data Logging Unit

The VPF also contains information about the following:

- How long a fault condition must last for it to be recorded as an event
- How much time must pass between occurrences of a fault for it to be recorded as two separate events, rather than as a single one
- What high or low tolerance thresholds, if any, must be met to qualify as an out-of-range condition

Data parameters are stored in two history types: short term history and long term history. Any parameter associated with an event must come from either of these two history types.

- *Short Term History*—A short term history parameter is available for recording within the following time frame: from 60 seconds before the event to 60 seconds after the event. In a specific event, the sampling rate can be set from one sample per second to one sample every 60 seconds.
- *Long Term History*—A long term history parameter is available for recording 30 minutes before the event. In a specific event, the sampling rate can be set from one sample per minute to one sample every 30 minutes.

The DLU may be programmed to record events as defined by the VPF. The DLU can record the following types of events:

- Manually-triggered events
- PID 194 (ECU-triggered) events

General Information

- Out-of-range events
- Rapid deceleration events
- VIN (vehicle ID number) change events
- Parking brake ON events

For a description of these events, see **Table 1**.

CAUTION

Before performing any electric welding on a vehicle, disconnect the battery power and ground cables and the electrical connector at the bottom of the data logging unit (DLU). See Subject 100 in this section for instructions. Electric currents produced during electric welding can damage various electronic components on the vehicle.

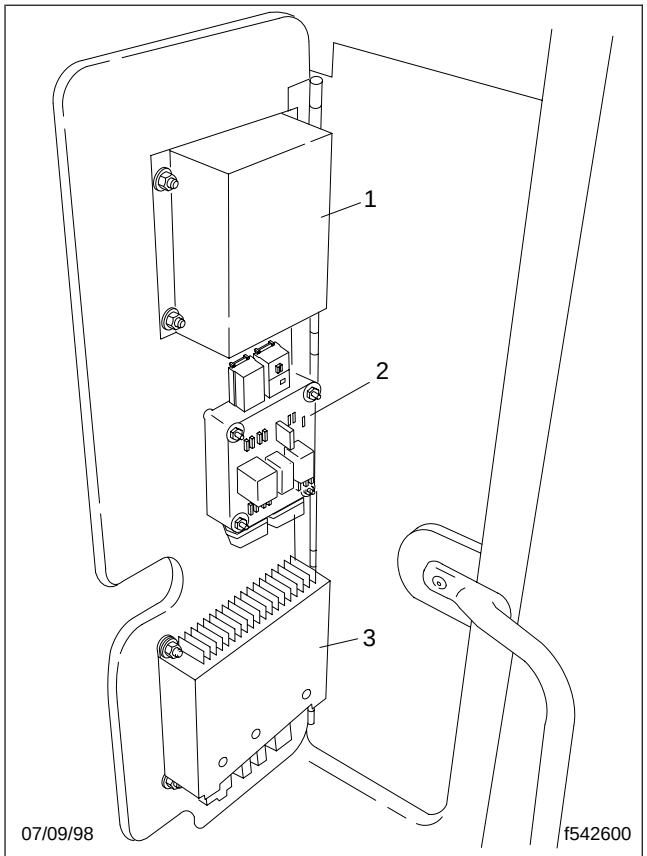
Data Logging Unit Events	
Type of Event	**Description**
Manually-triggered	Recorded when the EVENT key on the dash is pressed, or when commanded by the instrumentation control unit (ICU). All the vehicle parameters stored in short term history will be recorded.
PID 194 (ECU-triggered)	Recorded when the databus transmits a predetermined fault. Up to 30 different events can be selected (the VPF controls which events are selected), and each event may have as many as 20 parameters associated with it.
Out-of-range	Recorded when a transmitted parameter is determined to be beyond its normal range as defined in the VPF. Up to 15 different events can be selected (the VPF controls which events are selected), and each event may have as many as 12 parameters associated with it.
Rapid deceleration	Recorded when a vehicle decelerates at or above a pre-set rate. There are two types of rapid deceleration events: Customer-defined (defined in the VPF); and Freightliner (defined in the DLU).
VIN change	Generated every time the DLU receives a vehicle identification number (VIN) that is different from the number stored in the DLU.
Parking brake ON	Generated every time the parking brake is set and the vehicle is moving.

Table 1, Data Logging Unit Events

Data Logging Unit Removal and Installation

Removal

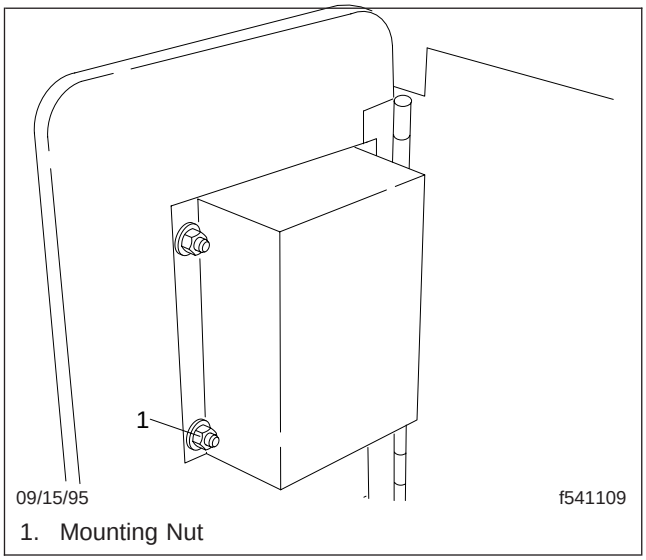
1. Apply the parking brakes and chock the tires. Disconnect the batteries.
2. Open the electrical compartment door on the left-hand B-pillar, behind the seat. The data logging unit is the top unit, above the auxiliary power distribution module. See **Fig. 1**.



1. Data Logging Unit
2. Auxiliary Power Distribution Module
3. ABS Controller

Fig. 1, Left-Hand B-Pillar Electrical Compartment

3. Remove the data logging unit. See **Fig. 2**.
   - 3.1 Remove the electrical connector from the bottom of the data logging unit.
   - 3.2 Remove the four mounting hexnuts, two on each side, from the mounting studs attached to the B-pillar access door.



1. Mounting Nut

Fig. 2, Data Logging Unit

   - 3.3 Remove the data logging unit from the electrical compartment door.

Installation

1. Install the data logging unit onto the left-hand B-pillar electrical compartment door. See **Fig. 2**.
   - 1.1 Position the data logging unit on the four mounting studs attached to the B-pillar electrical compartment door.
   - 1.2 Install the four mounting hexnuts and tighten them firmly.
   - 1.3 Plug the electrical connector into the bottom of the data logging unit.
2. Close the electrical compartment door on the left-hand B-pillar, behind the seat. See **Fig. 1**.
3. Connect the batteries and remove the chocks from the tires.

IMPORTANT: Using ServiceLink, the Data Logging Unit (DLU) can be reconfigured to original factory specifications either on or off the vehicle. Different procedures are required. Please take care to choose the correct procedure.

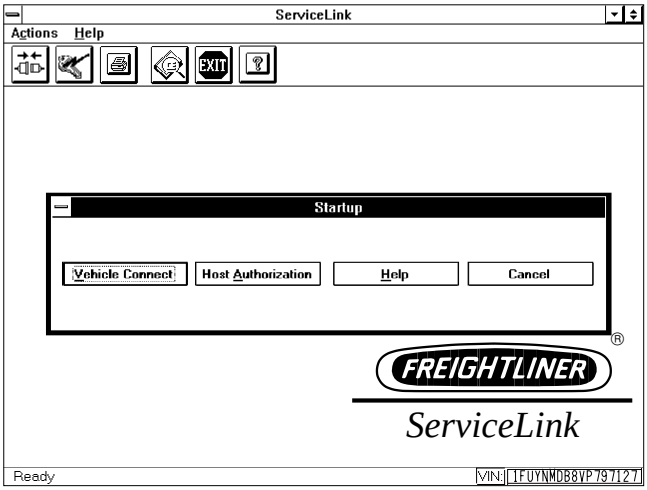
On-Vehicle Reconfiguring, ServiceLink Version 1

Before starting, make sure of the following:

- The computer is on and running Windows.
- The computer is either connected to the Freightliner network or has been set up for RAS access, via a modem, to the Freightliner host.
- There is a Flexible Vehicle Interface® (FVI) cable connected to the adapter in the computer.

NOTE: The Freightliner help desk, 1–503–735–7877, is available 24 hours a day to assist with problems during DLU reconfiguring.

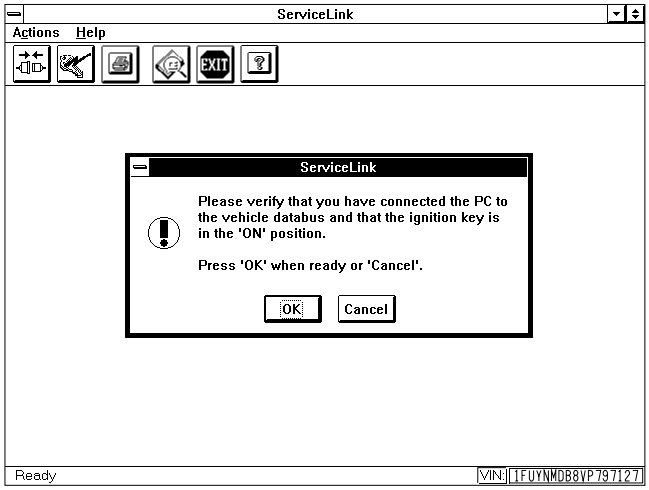
1. Connect the computer to the diagnostic connector on the vehicle.
2. Start ServiceLink.
3. When the "Startup" dialog box appears, click the "Vehicle Connect" button. See **Fig. 1**.



12/13/96 f120090

Fig. 1, Startup Dialog Box

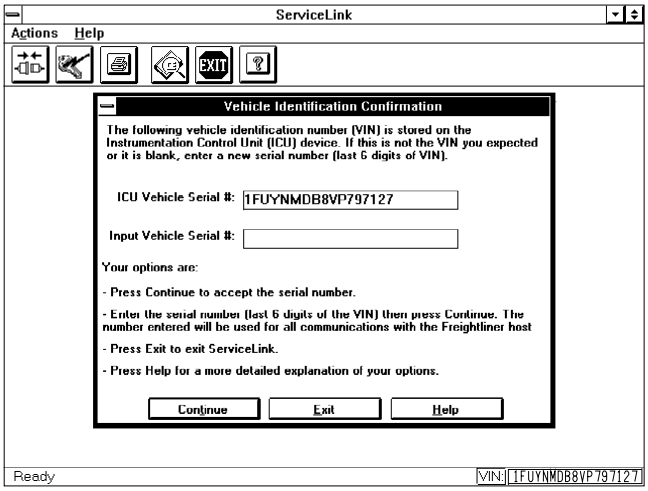
4. Then, when the "Verify Connections" dialog box appears, turn the ignition keyswitch to the correct (ON) position. See **Fig. 2**.



12/13/96 f120074a

Fig. 2, Verify Connections Dialog Box

5. The serial number of the vehicle is automatically downloaded when the "Vehicle Identification Confirmation" dialog box appears. Click the "Continue" button. See **Fig. 3**.



12/16/96 f120091

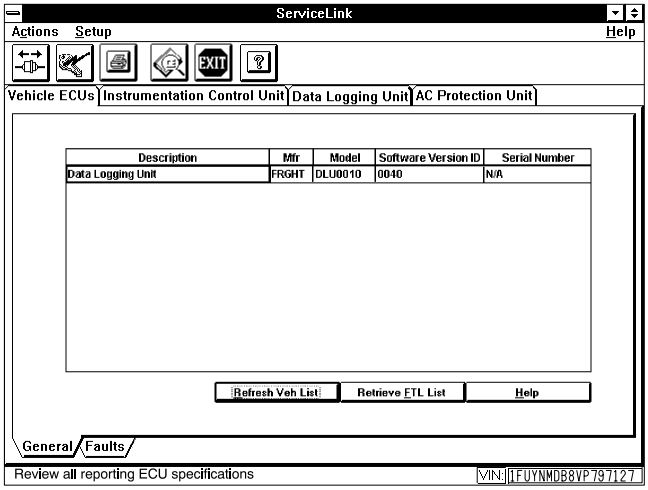
Fig. 3, Vehicle Identification Confirmation Dialog Box

6. In response, the ServiceLink software displays the "Review All Reporting ECU Specifications"

Data Logging Unit Reconfiguring

screen showing folders with tabs at both the top and bottom. See **Fig. 4**.

From this screen, click the "Data Logging Unit" top tab folder to display the "Review Data Logging Unit Specifications" screen. See **Fig. 5**.



12/13/96 f120081a

Fig. 4, Review All Reporting ECU Specifications Screen (with DLU connected)

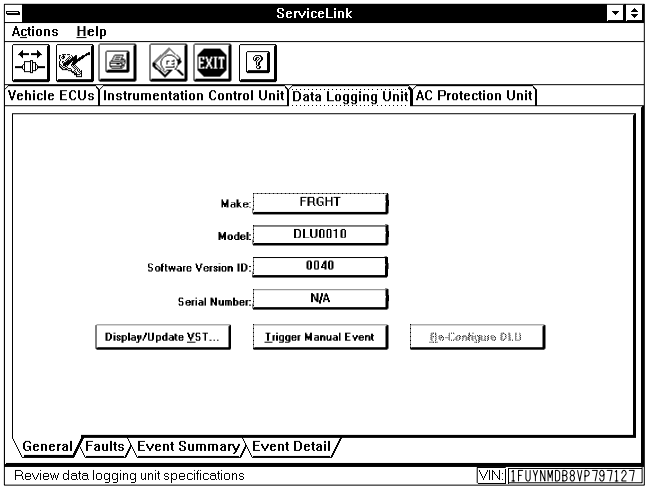


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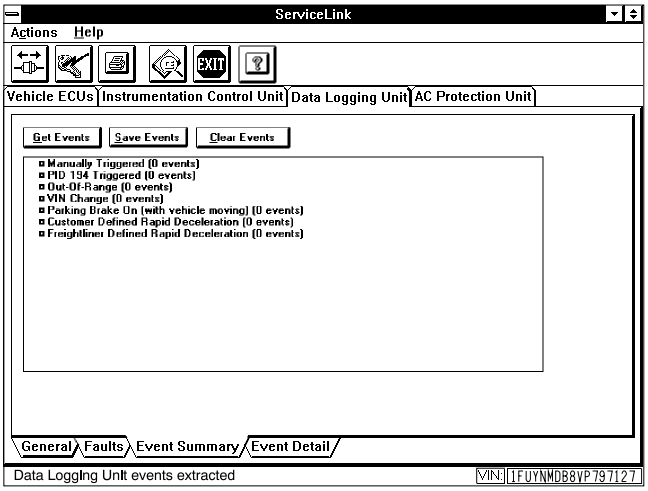
Fig. 5, Review Data Logging Unit Specifications Screen

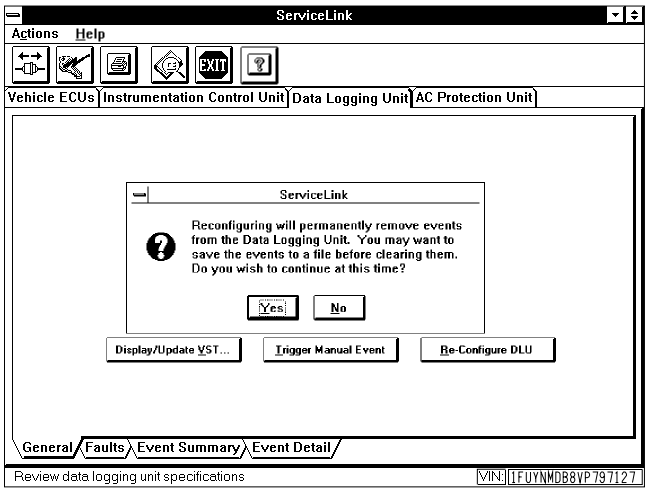
7. Display a list of events recorded by the DLU.
   - 7.1 From this screen, click the "Event Summary" bottom tab folder.
   - 7.2 Click on the "Get Events" button.
   - 7.3 Turn off the ignition keyswitch.
   - 7.4 When the dialog box appears, click on the OK button to display the "Data Logging Unit Events Extracted" screen. See **Fig. 6**.



12/13/96 f120084a

Fig. 6, Data Logging Unit Events Extracted Screen

8. Reconfigure the DLU to its original factory settings.
   - 8.1 Click the "General" bottom tab folder to display the "Review Data Logging Unit Specifications" screen again. See **Fig. 5**.
   - 8.2 Click on the "Reconfigure DLU" button. When the "Reconfigure DLU" dialog box appears, click on the OK button to continue. See **Fig. 7**.
   - 8.3 If the computer is connected to the network, ServiceLink will respond with a message, "Accessing the Freightliner Host..." When the dialog box appears, click on the OK button.
   - 8.4 After the computer has connected, a status bar will appear, counting to completion. When the status bar has finished its count and indicated 100% completion of this action, a message appears indicating that the program is being loaded into the DLU. When the message disappears from the screen, look in the lower left-hand corner of the screen for the status note "Parameter File Updated."



12/13/96 f120085a

Fig. 7, Reconfigure DLU Dialog Box

9. Exit ServiceLink.
10. Disconnect the diagnostic connector from the vehicle.

On-Vehicle Reconfiguring, ServiceLink Version 2

Before starting, make sure of the following:

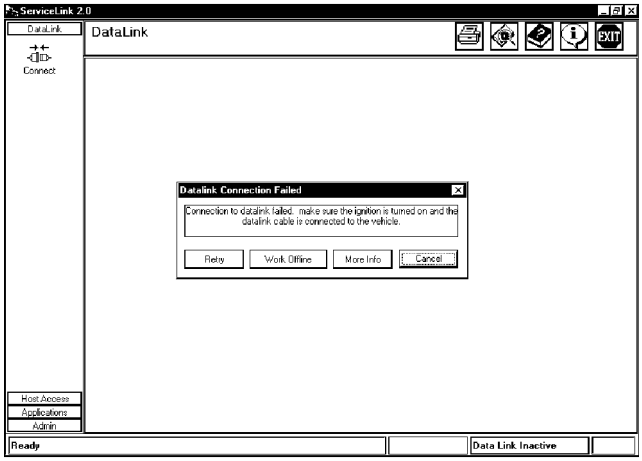
- The computer is on and running Windows.
- The computer is either connected to the Freightliner network or has been set up for RAS access, via a modem, to the Freightliner host.
- There is a flexible vehicle interface cable connected to the adapter in the computer.

NOTE: The Freightliner help desk, 1–503–735–7877, is available 24 hours a day to assist with problems during DLU reconfiguring.

1. Connect the computer to the diagnostic connector on the vehicle.
2. Turn the ignition keyswitch to the "ON" position.
3. Start ServiceLink Version 2.

NOTE: Starting ServiceLink before turning the ignition on will result in a dialog box indicating the DataLink connection failed. See **Fig. 8**. If this happens, make sure the ignition is turned on and the datalink cable is connected to the vehicle, then click "Retry".

4. The serial number of the vehicle is automatically downloaded when the "Vehicle Identification Confirmation" dialog box appears. Click the "Continue" button. See **Fig. 9**.



07/07/98 f542608

Fig. 8, DataLink Connection Failed

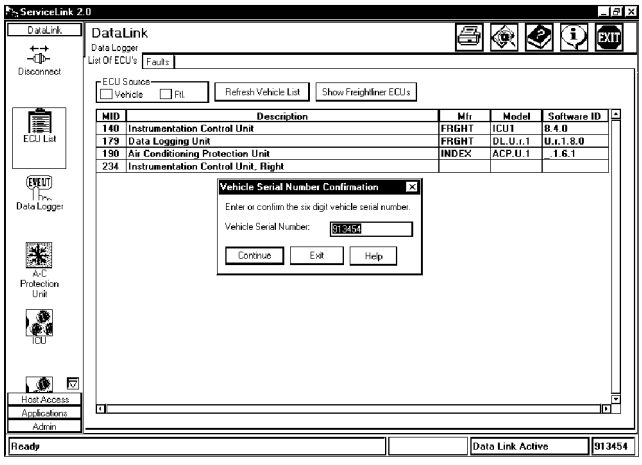


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Fig. 9, Vehicle Serial Number Confirmation

5. In response, the ServiceLink software displays the "List of ECU's" tab screen. See **Fig. 10**.

   From this screen, click the "Data Logger" icon on the left side of the screen. This will display the General Data Logger screen. See **Fig. 11**

Data Logging Unit Reconfiguring

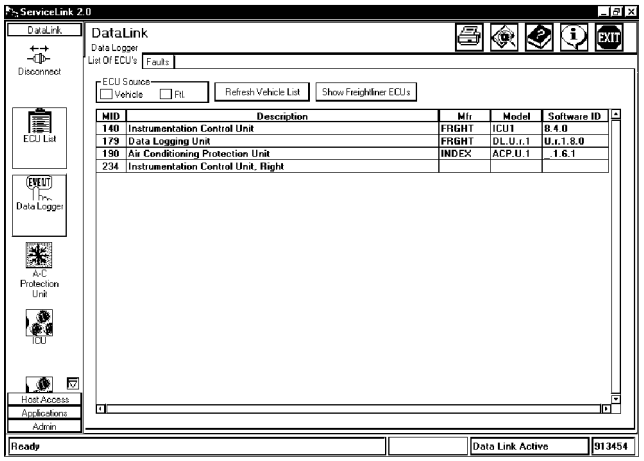

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Fig. 10, List of ECU's Tab

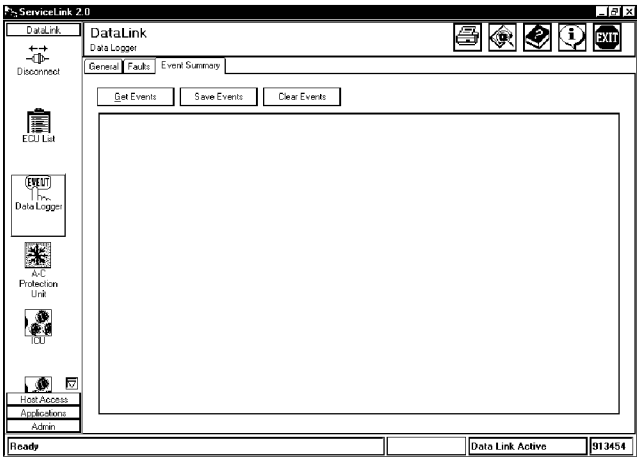

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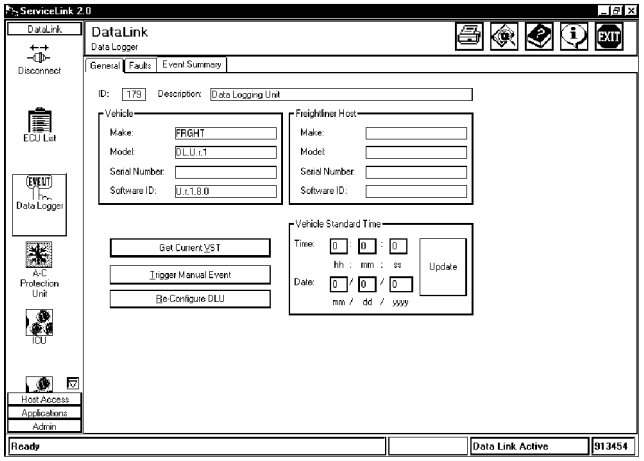
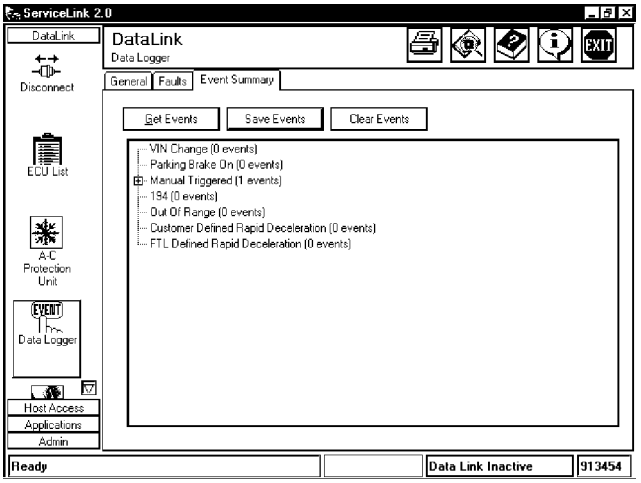
Fig. 12, Event Summary



07/07/98 f542611

Fig. 11, General Data Logger

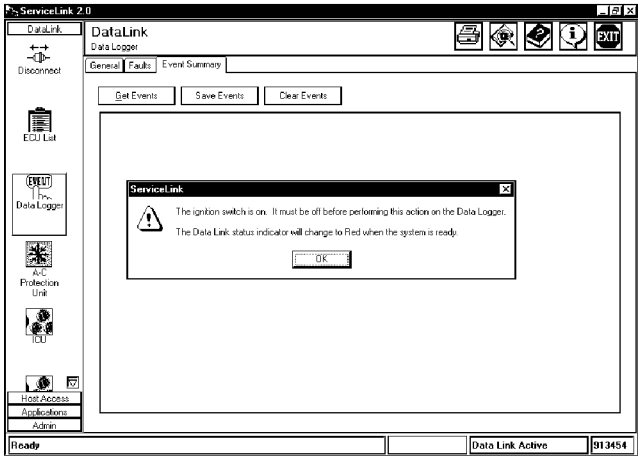


07/07/98 f542616

Fig. 13, Get Events, Event Summary

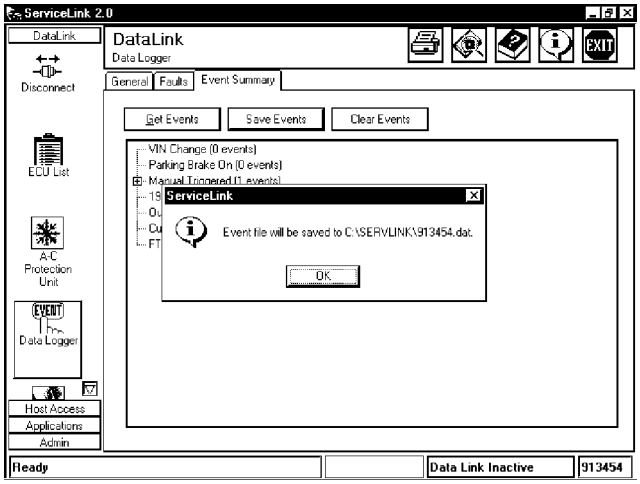
6. Display a list of events recorded by the DLU.
   - 6.1 From this screen click the "Event Summary" tab near the top of the screen. See **Fig. 12**.
   - 6.2 Turn off the ignition keyswitch.
   - 6.3 Click the "Get Events" button. See **Fig. 13**.

   NOTE: Clicking the "Get Events" button with the ignition on will result in an error message. See **Fig. 14**. Turn the ignition off and click "OK".
   - 6.4 If desired, click "Save Events" (see **Fig. 15**), then "OK". This will save the file to C:\SERVLINK\ *123456*.dat, where *123456* represents the vehicle serial number.
   - 6.5 To clear events, click the "Clear Events" button. This will remove all events from the DLU. Click "Yes" to clear events, or "No" to cancel. See **Fig. 16**.
7. Reconfigure the DLU to its original factory settings.



07/07/98 f542613

Fig. 14, Ignition Switch On Error Message



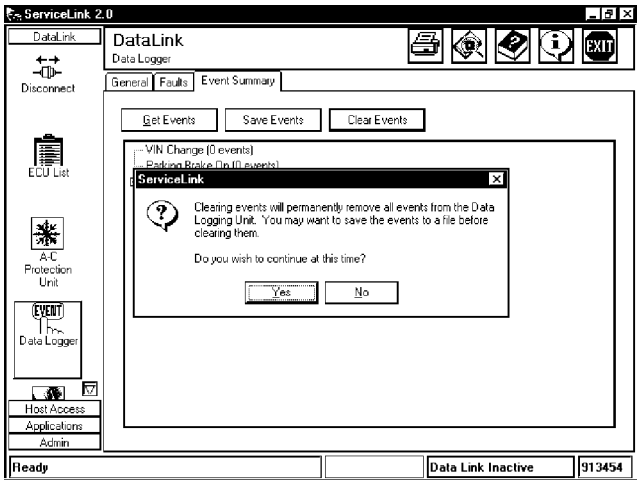
07/07/98 f542617

Fig. 15, Save Destination Confirmation

NOTE: Reconfiguring will delete all events. For instructions on saving event information before reconfiguring, see the previous step.

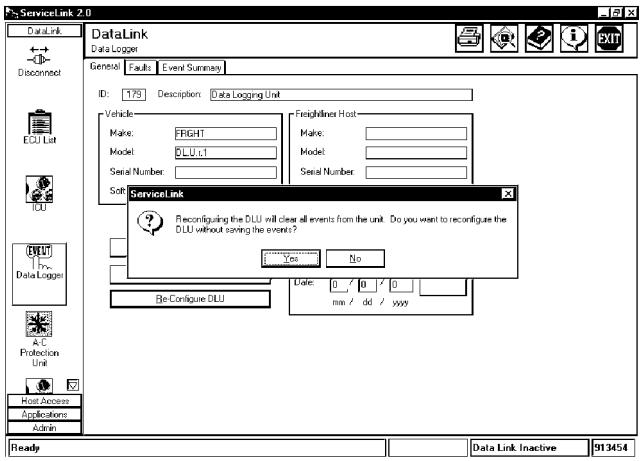
7.1 Click the "General" tab near the top of the screen to display the General Event Data Logger screen again. See **Fig. 11**.

7.2 Click on the "Reconfigure DLU" button. See **Fig. 17**. When the "Reconfigure DLU" dialog box appears, click on the "Yes" button to continue. ServiceLink will now reconfigure. This will take two or three minutes.



07/07/98 f542618

Fig. 16, Clear Events Confirmation



07/07/98 f542614

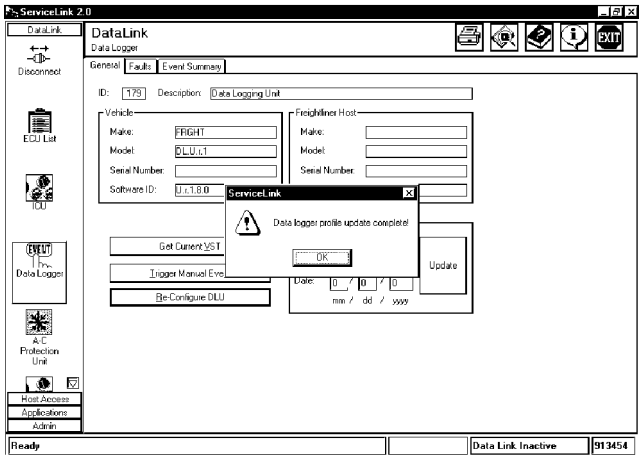
Fig. 17, Reconfiguring Confirmation

7.3 When finished, ServiceLink will display a dialog box "Data logger profile update complete." See **Fig. 18**. Click "OK".

8. To exit ServiceLink, click the exit icon at the upper right corner of the screen.

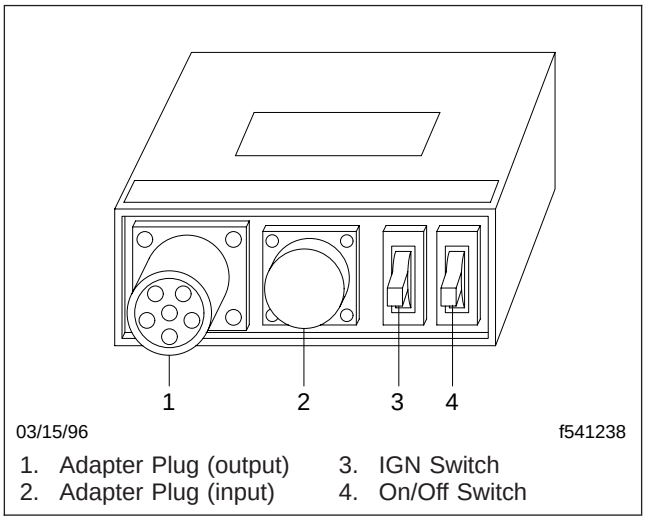
9. Disconnect the diagnostic connector from the vehicle.

Data Logging Unit Reconfiguring



07/07/98 f542615

Fig. 18, DLU Update Complete



03/15/96 f541238

1. Adapter Plug (output)
2. Adapter Plug (input)
3. IGN Switch
4. On/Off Switch

Fig. 19, Kent-Moore Tool J-42139

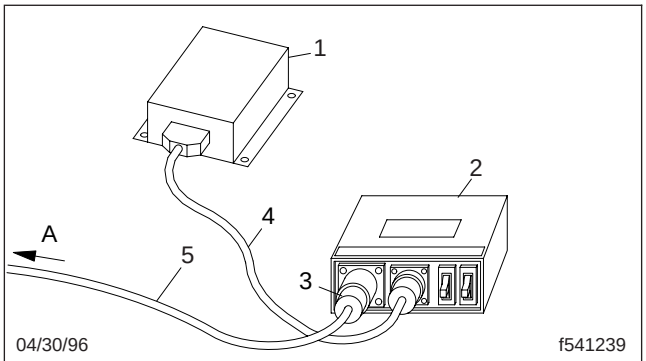
Off-Vehicle Reconfiguring, ServiceLink Version 1

Before starting, make sure of the following:

- The computer is capable of running ServiceLink. ServiceLink will run on Windows 3.1 or Windows for Workgroups 3.11.
- The computer is either connected to the Freightliner network or has been set up for RAS access, via a modem, to the Freightliner host.
- There is a Flexible Vehicle Interface cable connected to the adapter in the computer.
- The technician knows the vehicle serial number for the unit that needs to be reprogrammed.
- Kent-Moore Tool J–42139 is available to simulate the vehicle wiring and power supply. See **Fig. 19**. To order this tool, call the Kent-Moore Tool Company at 1–800–328–6657.

NOTE: The Freightliner help desk, 1–503–735–7877, is available 24 hours a day to assist with problems during DLU reconfiguring.

1. Connect the gray connector of the adapter harness to the connector on the DLU (the pink and blue connectors are not used). Connect the adapter harness to Kent-Moore tool J–42139. See **Fig. 20**.



04/30/96 f541239

A. To Computer
1. DLU
2. Tool J–42139
3. Diagnostic Connector
4. Adapter Harness
5. Flexible Vehicle Interface Cable

Fig. 20, DLU Reprogramming Set-Up

NOTE: The adapter harness is included with Kent-Moore tool J–42139.

2. Connect the diagnostic connector from the computer to Kent-Moore tool J–42139.
3. Turn on Kent-Moore tool J–42139.
4. Start ServiceLink.
5. When the "Verify Connections" dialog box appears, use the IGN switch on Kent-Moore tool J–42139 to simulate vehicle ignition. Flip this switch to the ON position. At the computer, click on the OK button when the dialog box appears. See **Fig. 1**.

6. Type in the 6-digit serial number of the vehicle when the "Vehicle Identification Confirmation" dialog box appears. Then click the "Continue" button. See **Fig. 3**.
7. In response, the ServiceLink software displays the "Review All Reporting ECU Specifications" screen showing folders with tabs at both the top and bottom. See **Fig. 4**.

   From this screen, click the "Data Logging Unit" top tab folder to display the "Review Data Logging Unit Specifications" screen. See **Fig. 5**.
8. Display a list of events recorded by the DLU.
   - 8.1 From this screen, click the "Event Summary" bottom tab folder.
   - 8.2 Click on the "Get Events" button.
   - 8.3 Turn off the IGN switch on Kent-Moore tool J–42139.
   - 8.4 When the dialog box appears, click on the OK button to display the "Data Logging Unit Events Extracted" screen. See **Fig. 6**.
9. Reconfigure the DLU to its original factory settings.
   - 9.1 Click the "General" bottom tab folder to display the "Review Data Logging Unit Specifications" screen again. See **Fig. 5**.
   - 9.2 Click on the "Re-configure DLU" button. When the "Re-configure DLU" dialog box appears, click on the Yes button to continue. See **Fig. 7**.
   - 9.3 If the computer is connected to the network, ServiceLink will respond with a message, "Accessing the Freightliner Host..." When the dialog box appears, click on the OK button.
   - 9.4 After the computer has connected, a status bar will appear, counting to completion. When the status bar has finished its count and has indicated 100% completion of this action, a message appears indicating that the program is being loaded into the DLU. When the message disappears from the screen, look in the lower left-hand corner of the screen for the status note "Parameter File Updated."
10. Exit ServiceLink.
11. Turn off the power switch on Kent-Moore tool J–42139 and disconnect it from the diagnostic connector on the computer and the gray connector of the adapter harness. Disconnect the other end of the gray connector from the back of the DLU.

Off-Vehicle Reconfiguring, ServiceLink Version 2

Before starting, make sure of the following:

- The computer is capable of running ServiceLink. ServiceLink will run on Windows 95.
- The computer is either connected to the Freightliner network or has been set up for RAS access, via a modem, to the Freightliner host.
- There is a flexible vehicle interface cable connected to the adapter in the computer.
- The technician knows the vehicle serial number for the unit that needs to be reprogrammed.
- Kent-Moore Tool J–42139 is available to simulate the vehicle wiring and power supply. See **Fig. 19**. To order this tool, call the Kent-Moore Tool Company at 1–800–328–6657.

NOTE: The Freightliner help desk, 1–503–735–7877, is available 24 hours a day to assist with problems during DLU reconfiguring.

1. Connect the gray connector of the adapter harness to the connector on the DLU (the pink and blue connectors are not used). Connect the adapter harness to Kent-Moore tool J–42139. See **Fig. 20**.

NOTE: The adapter harness is included with Kent-Moore tool J–42139.

2. Connect the diagnostic connector from the computer to Kent-Moore tool J–42139.
3. Turn on Kent-Moore tool J–42139.
4. Turn on the IGN switch on the Kent-Moore tool.
5. Start ServiceLink.
6. When the "Vehicle Serial Number Confirmation" dialog box appears, type in the 6-digit serial

Data Logging Unit Reconfiguring

number of the vehicle. Then click the "Continue" button. See **Fig. 9**.

7. In response, the ServiceLink software displays the "List of ECU's" tab screen. See **Fig. 10**.

   From this screen, click the "Data Logger" icon on the left side of the screen. This will display the General Data Logger screen. See **Fig. 11**.

8. Display a list of events recorded by the DLU.

   8.1 From this screen click the "Event Summary" tab near the top of the screen. See **Fig. 12**.

   8.2 Turn off the IGN switch on Kent-Moore tool J–42139.

   8.3 Click the "Get Events" button. See **Fig. 13**.

   NOTE: Clicking the "Get Events" button with the IGN switch on will result in an error message. See **Fig. 14**. Turn the IGN switch off and click "OK".

   8.4 If desired, click "Save Events" (see **Fig. 15**), then "OK". This will save the file to C:\SERVLINK\ *123456*.dat, where *123456* represents the vehicle serial number.

   8.5 To clear events, click the "Clear Events" button. This will remove all events from the DLU. Click "Yes" to clear events, or "No" to save events to a file before clearing. See **Fig. 16**.

9. Reconfigure the DLU to its original factory settings.

   NOTE: Reconfiguring will delete all events. For instructions on saving event information before reconfiguring, see the previous step.

   9.1 Click the "General" tab near the top of the screen to display the General Data Logger screen again. See **Fig. 11**.

   9.2 Click on the "Reconfigure DLU" button. See **Fig. 17**. When the "Reconfigure DLU" dialog box appears, click on the "Yes" button to continue. ServiceLink will now reconfigure. This will take two or three minutes.

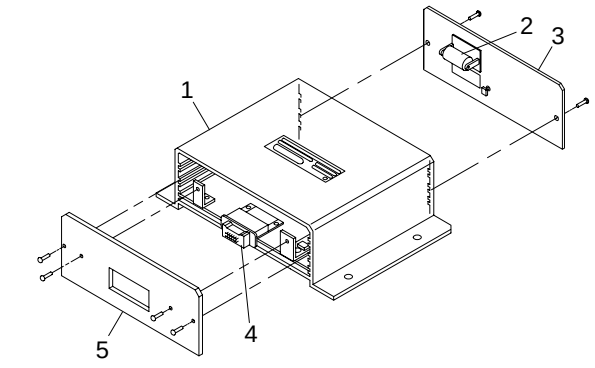
   9.3 When finished, ServiceLink will display a dialog box "Data logger profile update complete." See **Fig. 18**. Click "OK".

10. To exit ServiceLink, click the exit icon at the upper right corner of the screen.

11. Turn off the power switch on Kent-Moore tool J–42139 and disconnect it from the diagnostic connector on the computer and the gray connector of the adapter harness. Disconnect the gray connector, at the other end of the adapter harness, from the back of the DLU.

General Information

NOTE: The data logging unit or DLU (see **Fig. 1**) monitors data transmitted on the vehicle datalink. When an event occurs, the DLU saves a factory-defined set of vehicle data. See **Subject 050** for further information.



1. Data Logging Unit
2. Battery
3. Top Cover
4. Harness Connector
5. Bottom Cover

Fig. 1, Data Logging Unit

The DLU stores vehicle data in its memory if the following events occur:

- An event is triggered manually by pushing the event key on the keypad.
- An abnormal vehicle or driving condition occurs, as predefined in the DLU settings, and is specifically broadcast by an ECU. For example, low oil pressure, high or low engine coolant or oil temperature, or the parking brake is on.
- An abnormal, out of range, Freightliner selected and defined value occurs.

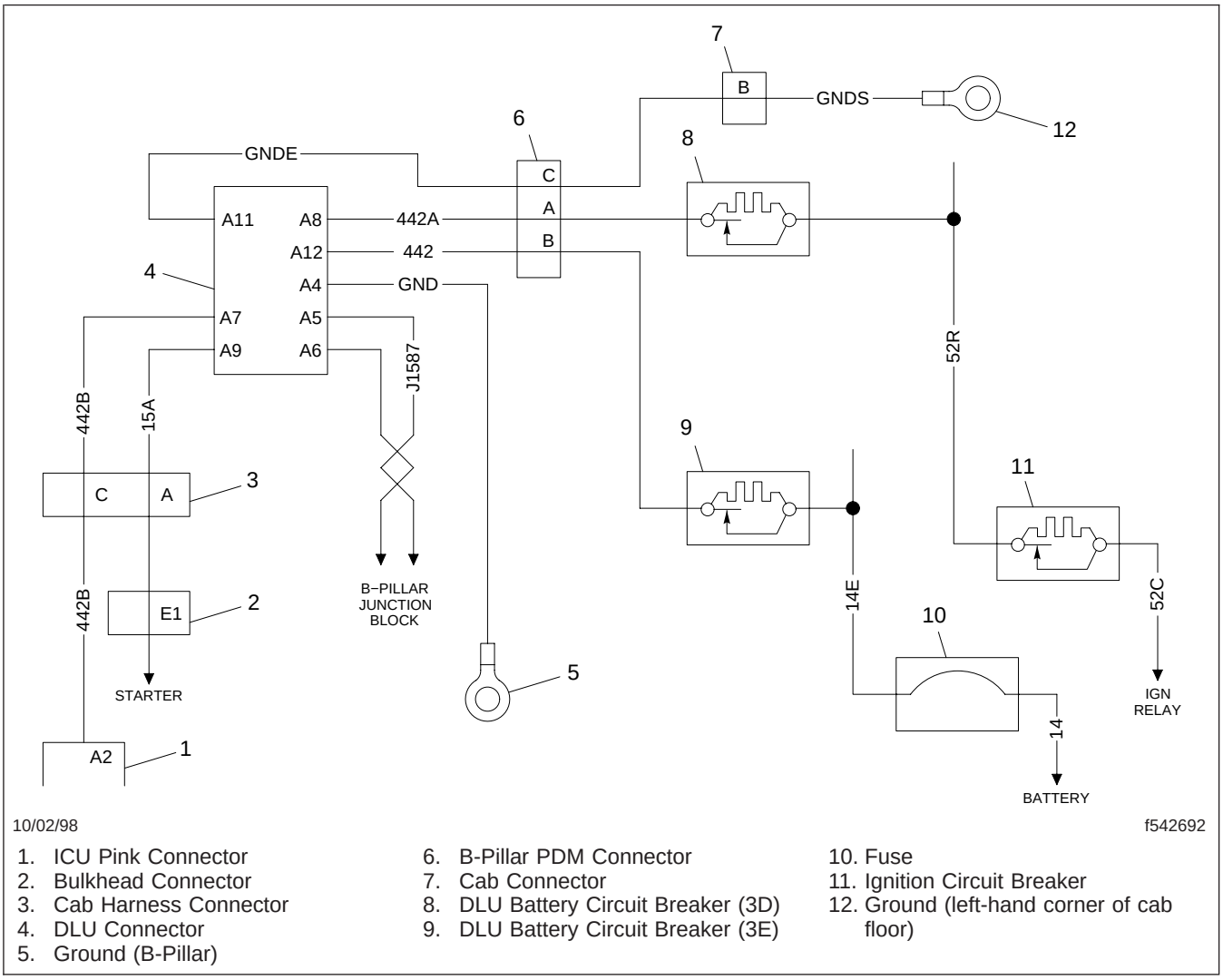
The events are stored with a date and time stamp. The DLU communicates with ServiceLink to configure or view logged events. The DLU does not store or transmit active or historic fault messages. If the DLU is not working properly, follow the procedures below.

Troubleshooting

"DATA RECORDER/NOT RESPONDING" MESSAGE

1. If the message NO DATALINK ACTIVITY is also displayed, troubleshoot this problem first. See SB 54-75.
2. Check the VEHICLE ECU list with ServiceLink.
3. If there is no entry on the VEHICLE ECU screen, continue troubleshooting the datalink.
   - 3.1 If the DLU and the ICU (instrumentation control unit) appear on the ServiceLink screen, VEHICLE ECUs, check wire 442B to the ICU. See **Fig. 2**.
   - 3.2 Disconnect the left (pink) ICU connector and check for 5 volts between terminal A2 and ground.
   - 3.3 If you measure 5 volts here, the ICU is not processing the event request.
   - 3.4 Replace the ICU with a test unit known to be good, turn the ignition switch ON, and press the event key.
   - 3.5 Check again for 5 volts between terminal A2 and ground.
   - 3.6 If you do not measure 5 volts here, check wire 442B to the DLU for an open or short to ground. See **Fig. 2**.
4. If the DLU does not appear on the screen VEHICLE ECUs, troubleshoot the DLU connections.
   - 4.1 Disconnect and then reconnect the DLU connector. See **Fig. 3**. If the problem disappears, check the DLU part number on the label. If the part number is A22–43854–000 or –001, replace the unit with a new part numbered A22–43854–004 or –005.
   - 4.2 Check circuit breakers 3D and 3E at the B-pillar PDM. See **Fig. 4**. If one of the circuit breakers has failed, check the wiring for a short to ground. Repair or replace the circuit breaker.
   - 4.3 With the ignition switch ON, check the voltage at the circuit breaker input. If there

Troubleshooting



1. ICU Pink Connector
2. Bulkhead Connector
3. Cab Harness Connector
4. DLU Connector
5. Ground (B-Pillar)
6. B-Pillar PDM Connector
7. Cab Connector
8. DLU Battery Circuit Breaker (3D)
9. DLU Battery Circuit Breaker (3E)
10. Fuse
11. Ignition Circuit Breaker
12. Ground (left-hand corner of cab floor)

Fig. 2, Data Logging Unit Wiring Diagram

is no battery voltage, check the wiring to the main PDM. See **Fig. 2**.

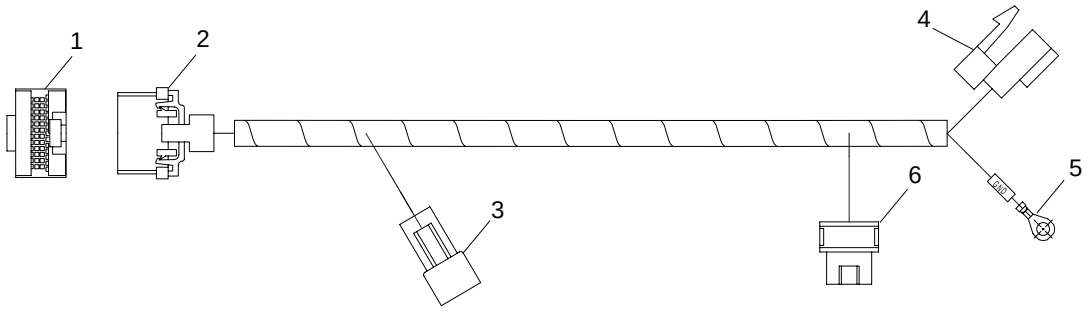
4.4 Check the voltages and the ground connection on the DLU connector. If one of the measurements is out of spec, check the wiring to the B-pillar PDM. Repair or replace wiring as necessary.

4.5 Check the datalink connection at the DLU connector. First disconnect the connector to the DLU and then turn the ignition switch to ON.

4.6 Use a multimeter set to the AC scale to check for a datalink signal on the twisted pair pins A5 and A6, at the vehicle harness connector. See **Fig. 2**.

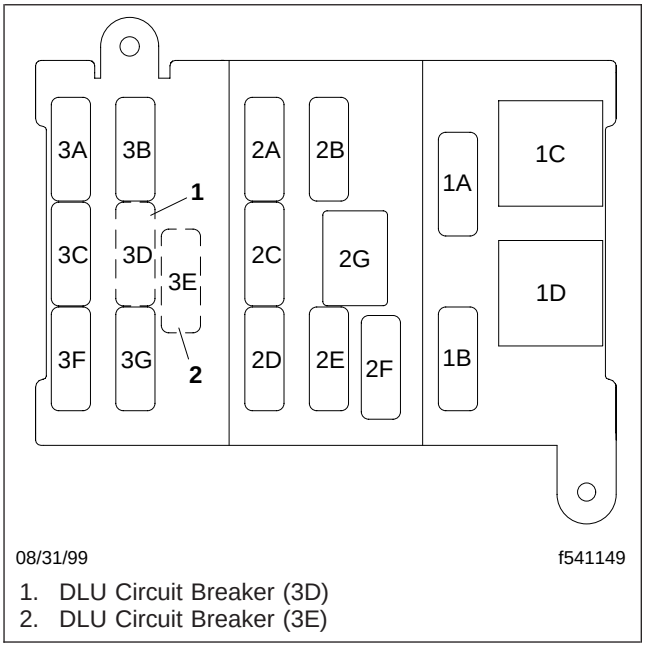
4.7 Check for an unstable, fluctuating voltage of one to three volts between the two wires of the twisted pair.

4.8 If the voltage is not within this range, check the wires to the B-pillar datalink junction for damage, loose connections, etc. and repair or replace wiring as necessary.



1. Data Logging Unit Pin Connector
2. Data Logging Unit Wire Harness Connector
3. B-Pillar Auxiliary Power Distribution Module Connector
4. J1587 Databus Connector
5. B-Pillar Ground Ring Terminal
6. Cab Harness Connector

Fig. 3, Data Logging Unit Wiring Harness



1. DLU Circuit Breaker (3D)
2. DLU Circuit Breaker (3E)

Fig. 4, Auxiliary Power Distribution Module Circuit Breaker Locations

4.9 Check the DLU connector connection and the pins for damage. See **Fig. 3**.

4.10 If necessary, replace the DLU with a new unit.

"CMPTR CONTROLLER NORESPONSE179S254 07" MESSAGE

NOTE: This message indicates a rollcall fault. During the ignition sequence the ICU polls the datalink for ECUs which are being broadcast. If any ECU, which should be present on the vehicle, is not broadcasting, the ICU generates and displays a fault. This message (CMPTR Controller NoResponse179s254 07) indicates that communication with the DLU has failed.

1. Turn the ignition switch OFF and then back ON, to start the ignition sequence.
2. Use ServiceLink to check if the DLU appears on the VEHICLE ECUs screen list.
3. If the DLU appears on the list, but the ICU does not, check the J1587 twisted pair datalink between the datalink junction and the dash datalink junction, behind the waste bin, for damage, loose connections, etc. See **Fig. 2**.

IMPORTANT: Three different datalink wiring versions exist, one for vehicles built through August 1996, one for vehicles built from August 1996 to June 1997, and another for vehicles built from June 1997. See SB 54-75.

4. If the DLU is not listed on the screen VEHICLE ECUs, disconnect and then reconnect the DLU connector. See **Fig. 3**.

Troubleshooting

4.1 If the problem disappears, check the DLU part number on the label. If the part number is A22–43854–000 or –001, replace the unit with a new part numbered A22–43854–004 or –005.

4.2 Check circuit breakers 3D and 3E at the B-pillar PDM. See **Fig. 4**.

4.3 If a circuit breaker has failed, check the wiring for a short to ground and repair or replace wiring as necessary.

4.4 With the ignition switch ON, check the voltage at the circuit breaker input. If there is no battery voltage, check the wiring to the main PDM. See **Fig. 2**.

4.5 Check voltage and the ground connection on the DLU connector. If one of the measurements is out of spec, check the wiring to the B-pillar PDM and repair or replace wiring as necessary.

4.6 Check the datalink connection at the DLU connector. First disconnect the connector to the DLU and then turn the ignition switch to ON.

4.7 Use a multimeter set to the AC scale to check for a datalink signal on the twisted pair pins A5 and A6, at the vehicle harness connector. See **Fig. 2**.

4.8 Check for an unstable, fluctuating voltage of one to three volts between the two wires of the twisted pair.

4.9 If the voltage is not within this range, check the wires to the B-pillar datalink junction for damage, loose connections, etc. and repair or replace wiring as necessary.

4.10 Check the DLU connector connection and the pins for damage. See **Fig. 3**.

4.11 If necessary, replace the DLU with a new unit.

"MEMORY FULL" MESSAGE

1. Use ServiceLink to retrieve events, then save the events if necessary.
2. Delete events and press the event key again.

NOTE: This message will only appear on vehicles having an ICU1 software version lower than 8.4.0. Select VEHICLE INFORMATION to display the software version on the ICU1. The MEMORY FULL message will appear on the ICU1 display when you push the event key while saving an event. Wait at least two minutes after pushing the event key before saving a second event.

"STILL RECORDING LAST EVENT" MESSAGE

This message appears if two event requests, using the event key, have been made less than two minutes apart.

NO REACTION ON THE ICU SCREEN AFTER PUSHING THE EVENT KEY

1. Ensure that the ICU has not been replaced with an ICU2L version. There are no keypad functions on the ICU2L version.

NOTE: The ICU2L version contains a 1-line by 6-character dash driver display screen. The original version contains a 2-line by 20-character display.

2. Turn the ignition switch OFF and then back ON again. If a keypad fault message appears on the ICU display, check the fault with ServiceLink. See **Section 54.03**, Subject 300.
3. If no fault message appears, disconnect the keypad and measure the resistance between pin H and pin E, at the keypad connector.

NOTE: Resistance should measure approximately 365 ohms. With the event button pushed, resistance should measure approximately 50 ohms.

4. Replace the keypad if you cannot measure these values.

THE DLU DOES NOT SAVE EVENTS

1. Check for messages indicating a DLU problem.

2. If the ICU screen displays DATA BEING RECORDED, after pressing the event key, and there is no stored data when viewing DLU events with ServiceLink, reconfigure the DLU. See **Subject 110** in this section and SB 54-58.
3. If there is still a problem, replace the DLU with a unit known to be good, reconfigure the DLU, and check to see that the problem has disappeared.

LOSS OF SAVED EVENT INFORMATION

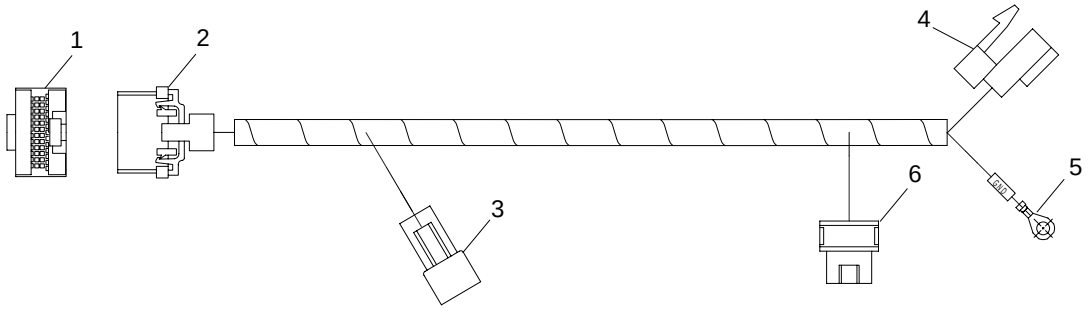
The DLU is equipped with a backup battery to support the ECU memory in case the DLU is disconnected from the vehicle battery. If saved event information is being lost, replace the DLU battery. See **Fig. 1**.

DLU BATTERY

The DLU battery is located in the DLU top cover. See **Fig. 1**.

IMPORTANT: If the battery is removed, all saved event information will be lost. Use ServiceLink to save event information onto the workshop computer.

For a diagram of the data logging unit wiring harness, see **Fig. 1**.



A. In areas shown, wrap bundle securely with tape.

1. Data Logging Unit Pin Connector
2. To Data Logging Unit
3. From B-Pillar Auxiliary Power Distribution Module
4. From J1587 Databus
5. Ground To B-Pillar
6. From Cab Harness

Fig. 1, Data Logging Unit Wiring Harness

General Information

An air restriction indicator (**see Fig. 1**) or gauge indicates how much air filter capacity has been used and how much remains. It registers the actual maximum restriction of the filter element (or elements, if two air cleaners are installed) when the engine is operating at full load.

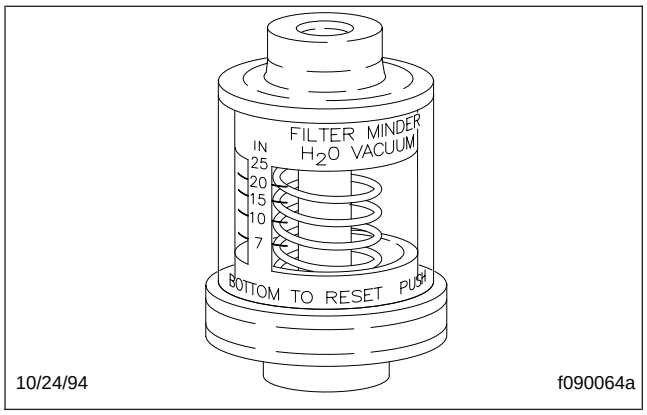


Fig. 1, Standard Air Restriction Indicator

Two types of spring-loaded air restriction indicators and one type of gauge with a pointer dial are available. The standard air restriction indicator is mounted on the air cleaner intake piping (**see Fig. 2**) and has a reset button located at the end opposite the mounting fitting.

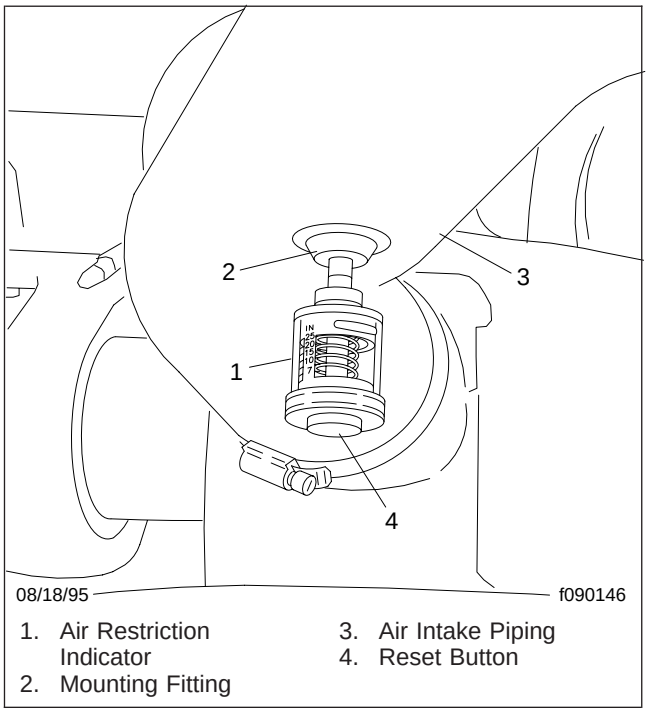
The other type of indicator is mounted on the auxiliary instrument panel (**see Fig. 3**). There is a reset button on the face of the indicator.

An optional mechanical dial gauge can also be mounted in the auxiliary instrument panel (**see Fig. 4**).

Inside the air restriction indicator is a yellow index marker that retains the reading so that the remaining capacity can be read even after the engine is shut down. To reset the indicator, press the reset button. The dial gauge automatically resets itself whenever the engine is shut down.

The air restriction gauge and tap fittings can sometimes become plugged from moisture or engine vapors, possibly causing an incorrect reading.

IMPORTANT: Most engine degreasers are harmful to the polycarbonate (Lexan) plastics that are used in air restriction gauges. When



1. Air Restriction Indicator
2. Mounting Fitting
3. Air Intake Piping
4. Reset Button

Fig. 2, Standard Air Restriction Indicator Mounted on the Intake Piping

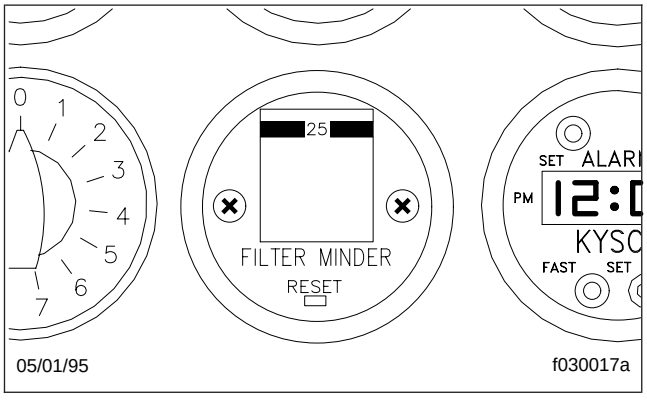


Fig. 3, Optional Air Restriction Indicator Mounted in the Auxiliary Instrument Panel

cleaning an engine or other components, avoid getting degreaser on these plastic parts.

General Information

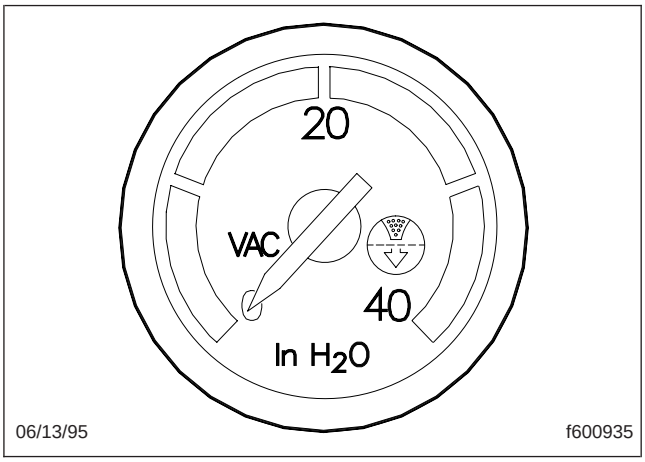


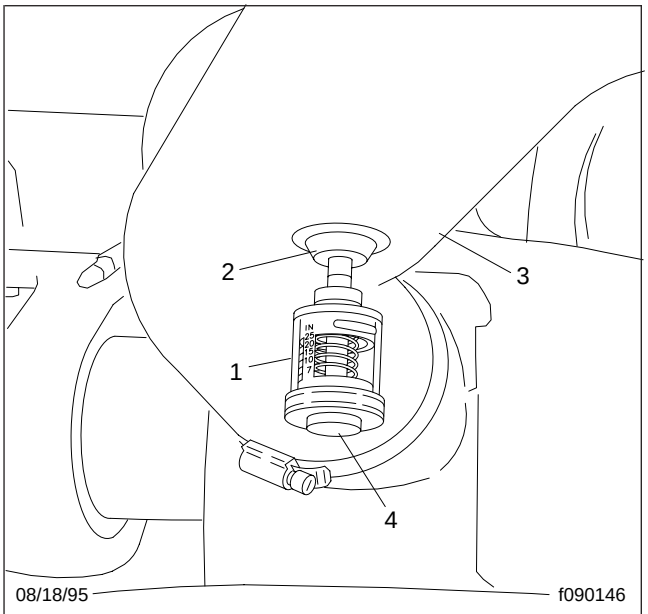
Fig. 4, Optional Air Restriction Dial Gauge Mounted in the Auxiliary Instrument Panel

Air Restriction Indicator/Gauge Replacement

Replacement

AIR RESTRICTION INDICATOR (MOUNTED ON THE AIR INTAKE PIPING)

1. Chock the tires, then tilt the hood. For instructions, refer to the vehicle driver's manual.
2. Using a wrench, unscrew the indicator from the air intake piping. **See Fig. 1.**



1. Air Restriction Indicator
2. Mounting Fitting
3. Air Intake Piping
4. Reset Button

Fig. 1, Standard Air Restriction Indicator

3. Install the new air restriction indicator in the fitting. Tighten it securely.

NOTE: The fitting in the intake duct is a special fitting incorporating an orifice and a filter. Be sure that the correct fitting is installed.

4. Remove the chocks from the tires.

AIR RESTRICTION INDICATOR/ GAUGE (MOUNTED IN THE AUXILIARY INSTRUMENT PANEL)

1. Apply the parking brakes, chock the tires, and shut down the engine.
2. Remove the auxiliary instrument panel. For instructions, refer to **Section 54.03**. Pull the panel out to gain access to the back of the air restriction indicator/gauge.
3. Remove the nuts and lockwashers that attach the mounting bracket to the indicator/gauge. Disconnect the air line.
4. Replace the indicator/gauge in the auxiliary instrument panel.
5. Connect the air line. Install the mounting bracket, using the mounting nuts and lockwashers.
6. Install the auxiliary instrument panel. For instructions, refer to **Section 54.03**.
7. Remove the chocks from the tires.

Problem—No Restriction Reading

Problem—No Restriction Reading	
Possible Cause	**Remedy**
The indicator leaks.	Remove the air restriction indicator. Apply a vacuum to the indicator until the yellow index marker reaches the red line. With your thumb on the mounting fitting, close the end of the indicator airtight. Hold in the reset button. The yellow index marker will drop slightly and then not move unless the indicator has a leak. If the indicator is functioning properly, install it and press the reset button. If the yellow index marker continues to move, replace the air restriction indicator. Repeat the troubleshooting procedure to verify that the new indicator does not leak. When the indicator is functioning properly, install it and press the reset button.
The intake pipe fitting or vacuum hose is plugged (panel-mounted indicator/gauge).	Remove the air restriction indicator/gauge. Apply a vacuum to the indicator until the yellow index marker reaches the red line. Connect the indicator/gauge to the intake pipe fitting or yellow hose (as appropriate), and reset the indicator/gauge. The yellow index marker or dial will fully return to zero unless the fitting or vacuum hose is plugged. (A slow return is normal due to the safety filter in the fitting.) If the indicator/gauge is functioning properly, reset the indicator/gauge. Return the indicator/gauge to its mounting. If the yellow index marker or dial does not fully return to zero, clear the fitting or vacuum hose and repeat the procedure.
The vacuum hose leaks (panel-mounted indicator/gauge).	First, check to be sure that the indicator is not leaking (see instructions above). Disconnect both ends of the vacuum hose. Apply vacuum to the indicator/gauge until the indicator reaches the red line. Connect the indicator/gauge to the vacuum hose and close the other end of the hose airtight. Reset the indicator/gauge. The yellow index marker or dial will drop slightly and then not move unless the vacuum hose has a leak. If the indicator/gauge is functioning properly, install the vacuum hose and return the indicator/gauge to the dash mounting; reset the indicator/gauge. If the yellow index marker or dial continues to move, replace the vacuum hose. Repeat the troubleshooting procedure to verify that the new hose does not also leak. When the indicator/gauge functions properly, install the vacuum hose and return the indicator/gauge to the panel mounting; reset the indicator/gauge.
Engine airflow is too low to generate a reading.	Turbocharged engines must be at full load to pull full engine airflow. Restrictions can be simulated by gradually closing off air intake. If there is still no restriction reading, check for leaks in the indicator/gauge or vacuum hose, as appropriate, and take corrective action.

Problem—High Restriction Readings

Problem—High Restriction Readings	
Possible Cause	**Remedy**
The element(s) is (are) plugged or poorly cleaned.	Ultra-fine particles are difficult to remove, and cleaning may not sufficiently lower the restriction. Carefully attempt to unplug or clean the element(s); if unsuccessful, install a new filter element or elements.
The safety filter is plugged (if equipped).	Do not clean the safety filter. Replace it with a new one.

Troubleshooting

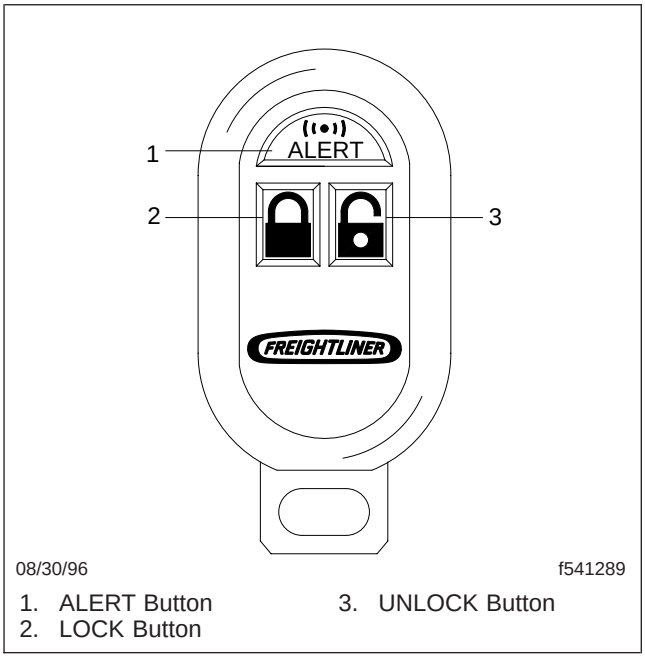
Problem—High Restriction Readings	
Possible Cause	**Remedy**
The air cleaner(s) is (are) undersized.	The air cleaner may be too small if a larger engine has been installed. Replace the undersized unit(s) with properly-sized air cleaner(s).
The air restriction indicator is too close to the intake of an engine blower or turbo.	Under certain circumstances, air turbulence near the blower intakes may cause a high vacuum reading. Locate the indicator away from the blower intake by at least 1-1/2 times the diameter of the intake tube.
The intake screens or ducts are plugged.	Check the system upstream from the air restriction indicator and remove any debris. Check for damage or improper installation, and take any necessary corrective action.
Heavy snow or rain.	Temporary high restriction can occur during a rain or snow storm and disappear after drying out. However, the cold air may be so dense that high restriction may not reduce the engine power before the element(s) is (are) damaged. If the indicator/gauge reads maximum restriction (red line), check the element(s) for damage and replace if necessary.

General Information

The Meritor keyless security system is a complete vehicle security system. It locks and unlocks the doors, protects against theft, and provides security for the driver while sleeping or resting inside the vehicle.

The system consists of the following components:

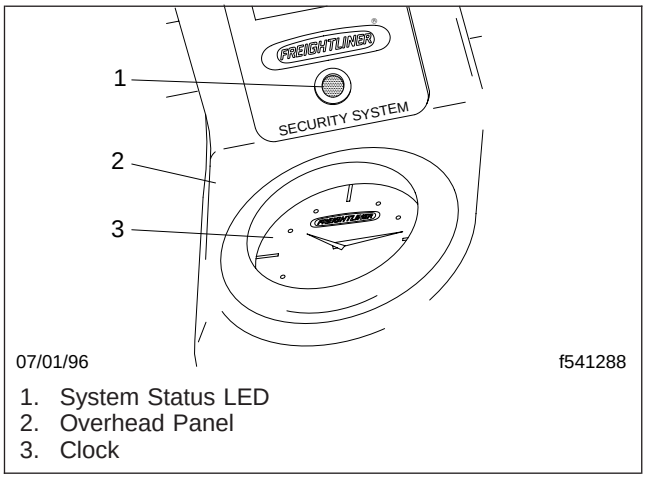
- A hand-held radio frequency transmitter that looks like a key chain fob. It acts as a remote control for locking the doors, unlocking the doors, or placing the system on alert. Each system allows as many as four different fobs. See **Fig. 1**.
- A red system status LED (light-emitting diode) mounted on the overhead panel above the clock. The LED flashes slow or fast to indicate what state the system is in: armed, alert, alarmed, or violated. It is off when the system is disarmed. See **Fig. 2**.



1. ALERT Button
2. LOCK Button
3. UNLOCK Button

Fig. 1, Key Chain Fob (radio transmitter)

- A Meritor relay module mounted behind the right-hand B-pillar electrical compartment door that arms and disarms the system and programs the fobs. See **Fig. 3**, Ref. 1.



1. System Status LED
2. Overhead Panel
3. Clock

Fig. 2, Red System Status LED

- A program switch on the Meritor relay module that places the relay module in the learning mode, which is the only state in which the system can learn fob ID codes. The switch is shown in its normal, or OFF, state (toggle pointing up). See **Fig. 3**, Ref. 2.
- A security system electronic control module (ECM), also mounted behind the right-hand B-pillar electrical compartment door, that monitors all the entry points, controls the door locks, operates the alarm, and interrupts the power to the engine, as necessary. There is also a PDM (power distribution module) relay module mounted on top of the left-hand side of the ECM. See **Fig. 3**, Refs. 3 and 6.

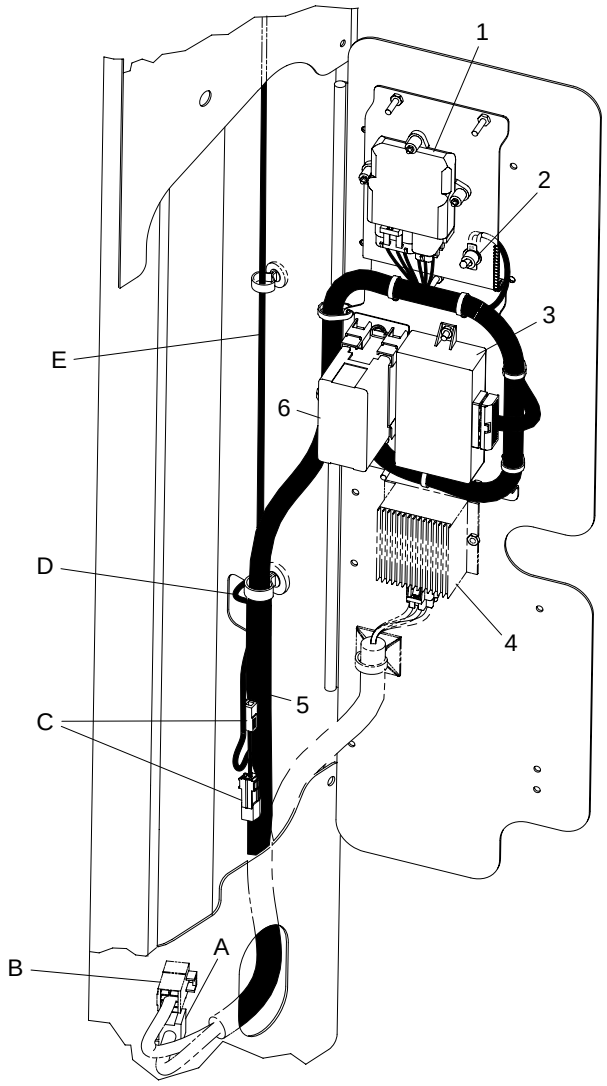
CAUTION

Before performing any electric welding on a vehicle, disconnect the battery power and ground cables and the electrical connectors at the side of the ECM and the bottom of the relay module. See Subject 110 in this section for instructions. Electric currents produced during electric welding can damage various electronic components on the vehicle.

For system schematics and harness drawings, see **Specifications 400**.

For fob programming procedures, see **Subject 100**. The fob is powered by a small watch battery. For battery replacement procedures, see **Subject 130**.

General Information



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A. From Main Security Harness (door actuator circuits)
B. From Main Security Harness (PDM circuits)
C. To Main Security Harness Ground
D. To Sleeper Cab Security Harness
E. To LED Security Harness

1. Meritor Relay Module
2. Program Switch
3. Electronic Control Module (ECM)
4. Daytime Running Light Module
5. B-Pillar Security Harness
6. PDM Relay Module

Fig. 3, Keyless Security System B-Pillar Components

Principles of Operation

The fob has three push-buttons: LOCK, UNLOCK, and ALERT. When a button is pushed, the fob sends a radio frequency signal to the ECM. The signal contains a unique vehicle access code that identifies the individual fob, plus codes that indicate which button has been pushed.

The ECM detects the signal sent by the fob, amplifies it and converts it to a digital sequence.

If the LOCK button is pressed, the ECM arms the system. It locks the two cab doors, begins to monitor

all the entry points (the two cab doors, the sleeper cab access door, and the two baggage doors, as installed), and instructs the relay module to start flashing the system LED at the slow rate. If any entry points are open, the ECM sounds the horn and flashes the cab marker lights twice. If the ignition keyswitch is turned off, the ECM interrupts ignition power to the engine.

The driver may be inside or outside the vehicle. However, if the engine is running at the time the LOCK button is pressed, the system still enters the armed state, except that the engine is not immobilized. This improves security for the occupant as well as comfort while sleeping or resting, because the system is armed, and the heating or air conditioning is operating without draining any batteries.

Once the system is armed, the alarm functions activate whenever one of the entry points is opened. In the alarmed state, the ECM does the following:

- Immobilizes the vehicle by cutting off power between the ignition keyswitch and the engine electronic control unit (ECU).
- Sounds the horn in pulses of 0.5 second on, 0.5 second off.
- Flashes the cab marker lights in pulses of 0.5 second on, 0.5 second off.
- Changes the blink rate of the LED from slow to fast.

If the UNLOCK button is pressed, the ECM disarms the system, if armed. It unlocks all the entry points, discontinues its monitoring of the entry points, instructs the relay module to stop flashing the system LED, and restores ignition power to the engine, if interrupted.

If the ALERT button is pressed, the ECM executes the unlock sequence and also activates the vehicle alarm functions (see above). To cancel an ALERT (to turn off the alarm), press the UNLOCK button.

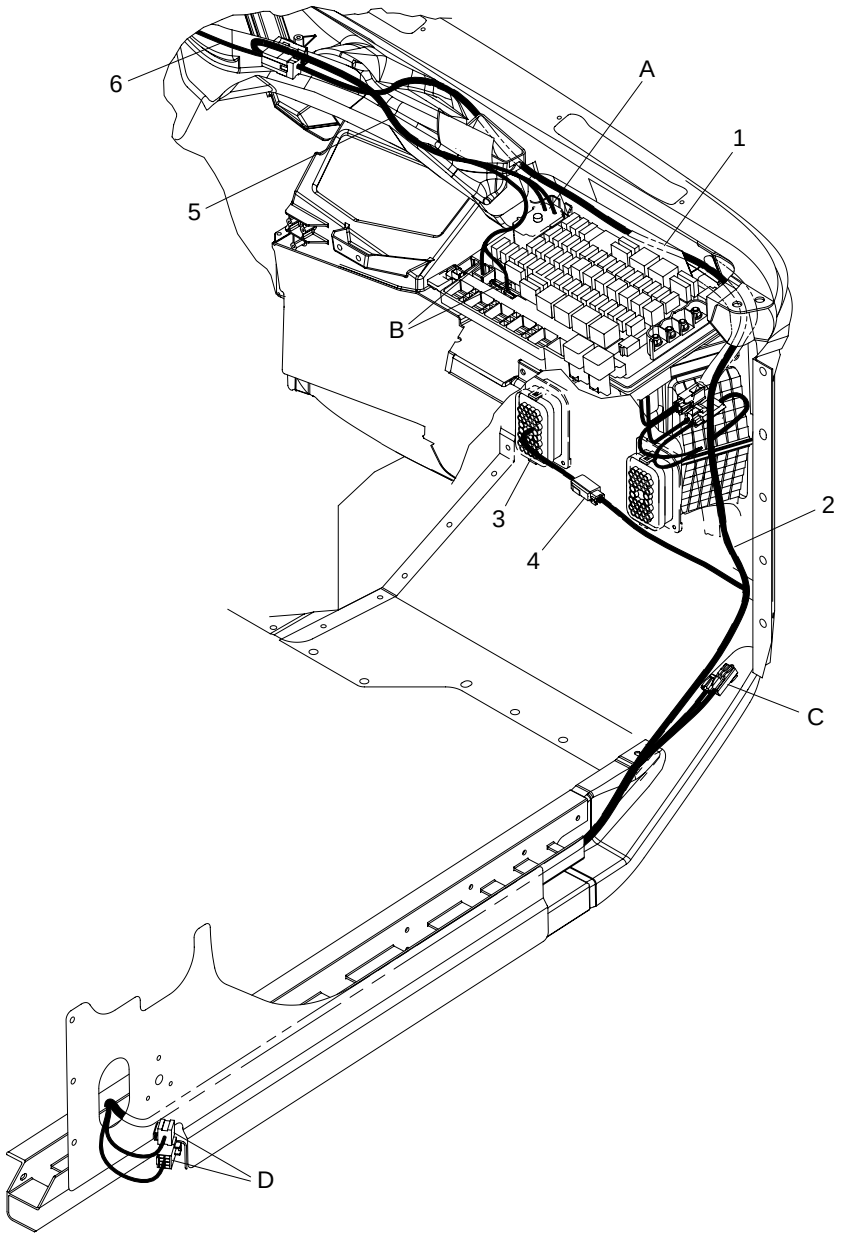
Once activated, the alarm sequence continues for 30 seconds unless deactivated by pressing the UNLOCK button on the fob. After 30 seconds in the alarmed state, the system automatically enters the violated state.

In the violated state, the horn does not sound and the cab marker lights do not flash, but the engine is still immobilized and the LED continues to blink at the fast rate. The vehicle remains in this state until the UNLOCK button is pressed.

The units described above are linked into a system by six wiring harnesses that allow control of the various functions such as interrupting engine ignition, flashing the cab marker lights, pulsing the horn, and controlling the door entry points. These six harnesses are:

- The main security harness (see **Fig. 4**), connecting the PDM to the B-pillar security harness and the right-hand door harness.
- The B-pillar security harness (see **Fig. 5**), connecting the B-pillar components (ECM, Meritor relay module, program switch, PDM relay module) to the main security harness, the sleeper cab security harness, and the LED security harness.
- The PDM security harness (see **Fig. 4**), connecting the PDM to the bulkhead security harness.
- The bulkhead security harness (see **Fig. 6**), connecting the PDM security harness to the left-hand door harness.
- The sleeper cab security harness (see **Fig. 7**), connecting the B-pillar security harness to the door switches in the sleeper cab, if installed.
- The LED security harness (see **Fig. 5**), connecting the B-pillar security harness to the system LED.

General Information



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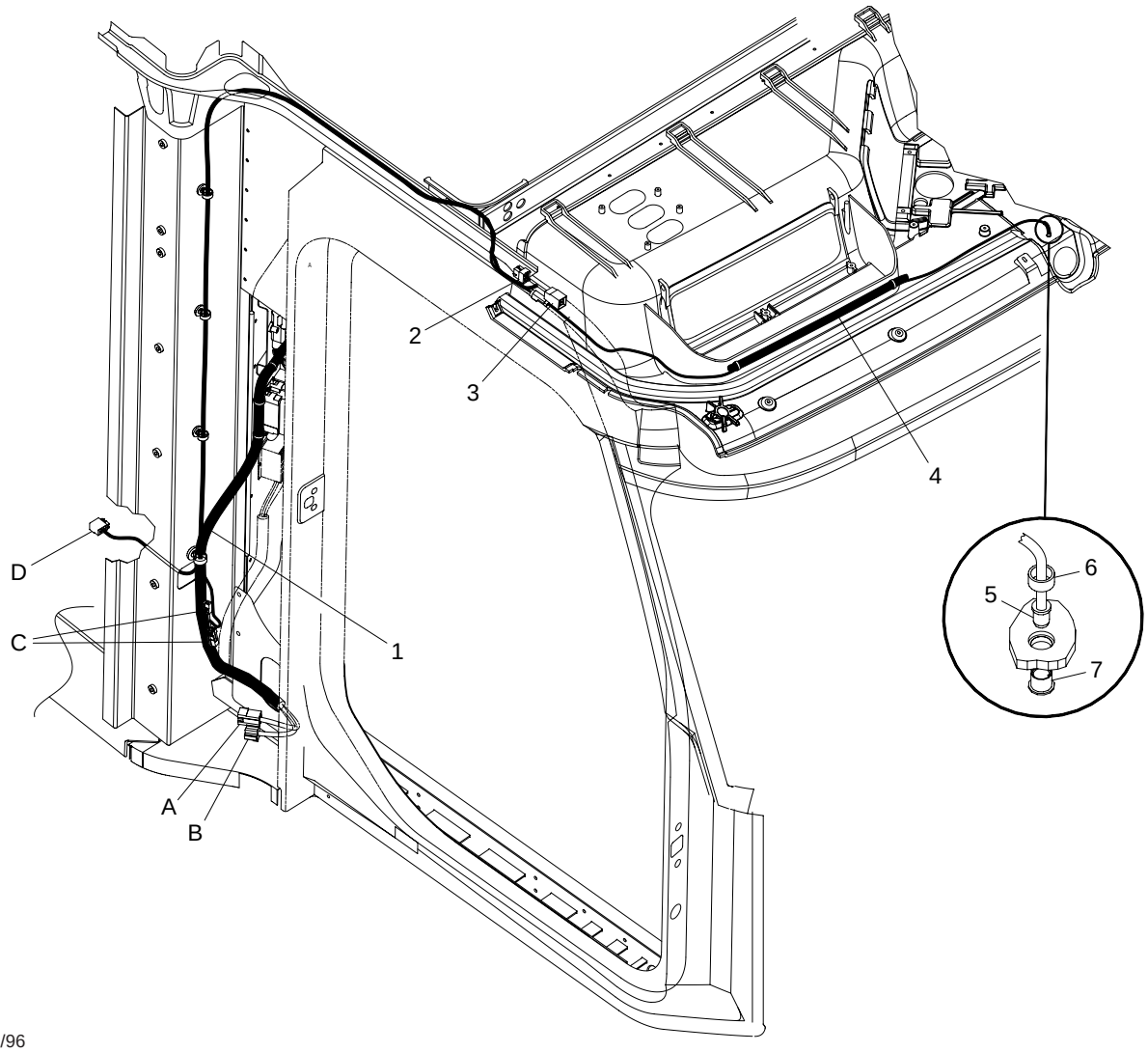
A. To PDM Connector "A"
B. To PDM Connectors "E" and "G"
C. To Right-Hand Door Harness
D. To B-Pillar Security Harness

1. Power Distribution Module (PDM)
2. Main Security Harness
3. Cannon Plug BL
4. Horn Connector
5. PDM Security Harness
6. Bulkhead Security Harness

Fig. 4, Main Security Harness and PDM Security Harness



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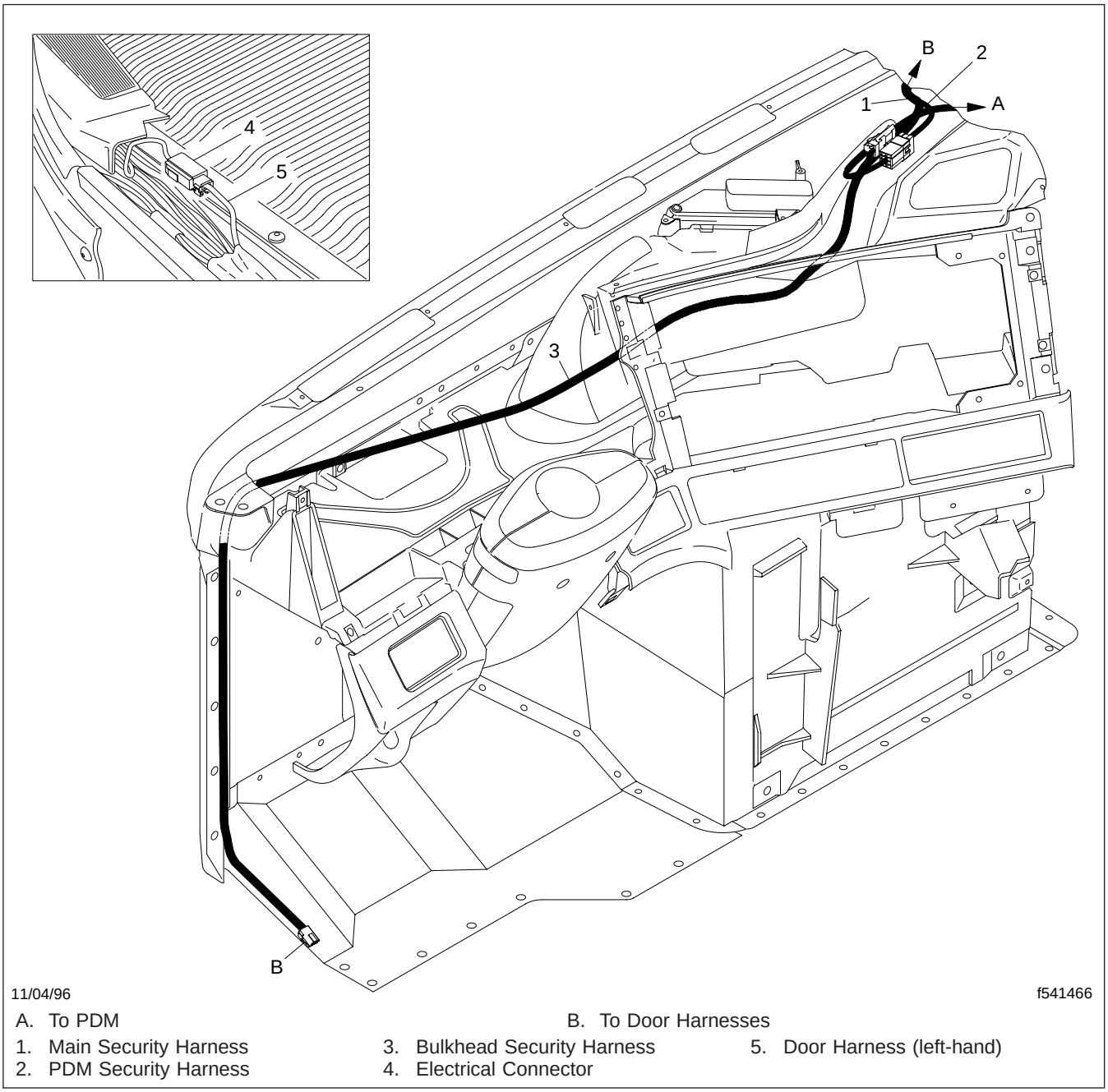
A. From Main Security Harness (door actuator circuits)
B. From Main Security Harness (PDM circuits)
C. To Main Security Harness Ground
D. To Sleeper Cab Security Harness

1. B-Pillar Security Harness
2. LED Harness Connector
3. Marker Light Connector
4. LED Security Harness
5. System LED
6. Collar
7. Retainer

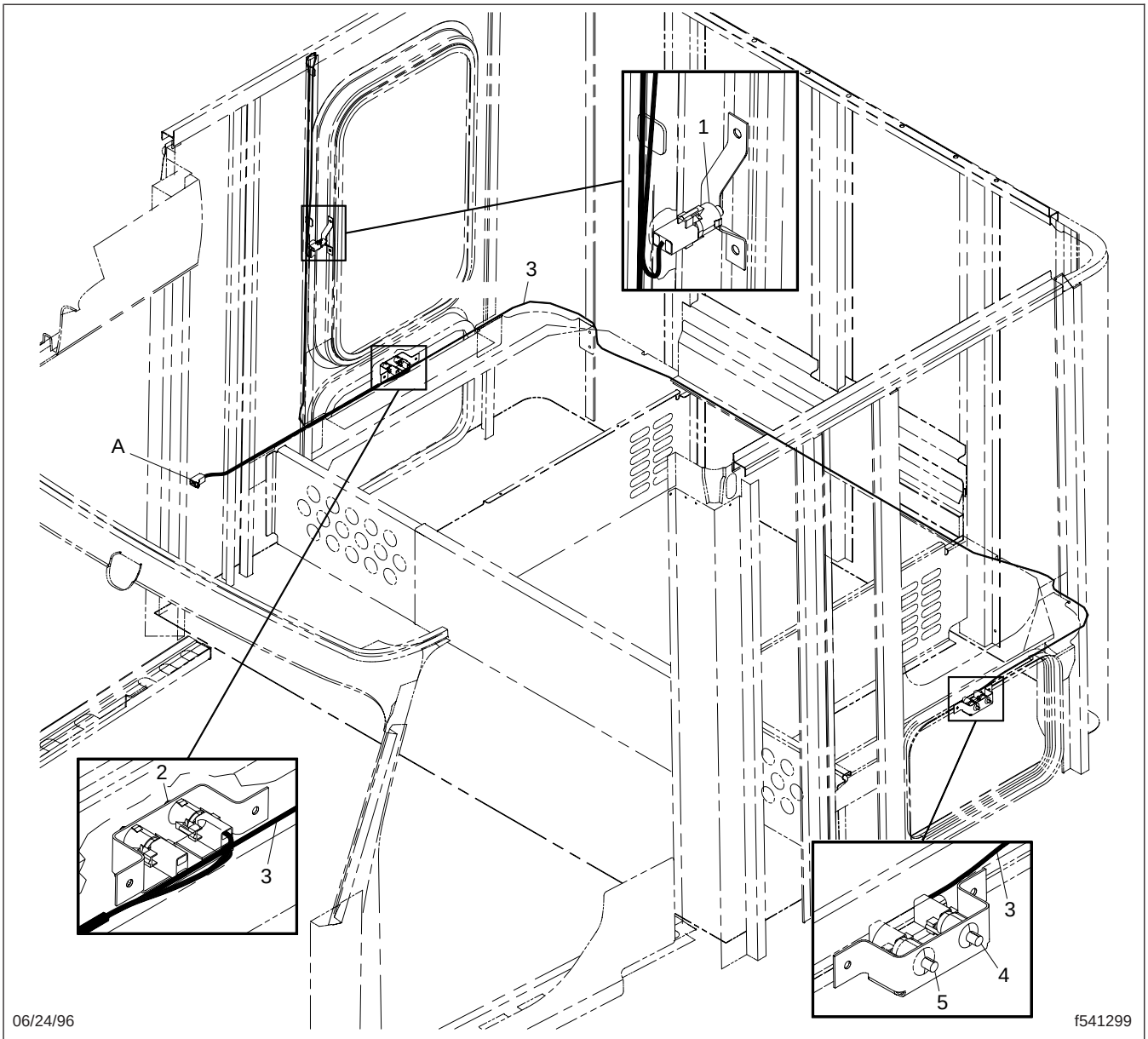
Fig. 5, B-Pillar Security Harness and LED Security Harness

General Information



A. To PDM
B. To Door Harnesses
1. Main Security Harness
2. PDM Security Harness
3. Bulkhead Security Harness
4. Electrical Connector
5. Door Harness (left-hand)

Fig. 6, Bulkhead Security Harness



A. To B-Pillar Harness
1. Alarm Switch (sleeper cab access door)
2. Alarm Switch (right-hand baggage door)
3. Sleeper Cab Security Harness
4. Alarm Switch (left-hand baggage door)
5. Light Switch (left-hand baggage door)

Fig. 7, Sleeper Cab Security Harness

Fob Programming

The security system ECM can store up to four fob identification codes. Once the first fob has been programmed, there are never any vacant memory locations.

IMPORTANT: As a security measure, all fobs must be coded during the same programming sequence. The first fob code is stored in all four memory locations. Taken together, these ensure that only the vehicle owner's fobs can be programmed into the system. If additional fobs are programmed, they over-write the original code in locations two, three, and four, in that order.

The ECM provides a 20-second time period to program each fob. If the fob is not programmed within this time span, the system will exit the programming sequence.

After each valid code storage sequence, the system LED will indicate the completion of a learning cycle by turning off the LED for approximately 0.5 second, and unlocking the doors.

To program a fob, do the following steps:

1. With the ignition keyswitch turned off, turn the program switch ON (flip the toggle DOWN). See **Fig. 1**.
2. Now turn the ignition keyswitch on. Note that the system LED illuminates continuously. See **Fig. 2**. This indicates that the ECM is ready to begin the learning sequence.

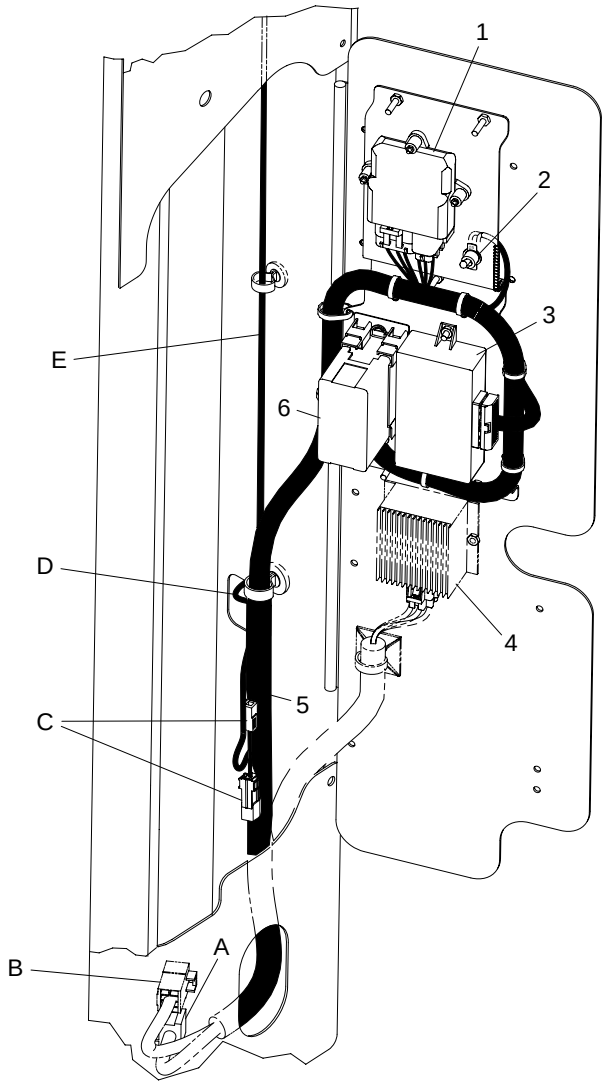
NOTE: If the LED does not illuminate continuously at this point, repeat the first two steps.

3. On the fob, press down both the LOCK and UNLOCK buttons at the same time and hold them down for at least three seconds. See **Fig. 3**. If the code was learned, the system LED flashes and the doors unlock.

IMPORTANT: If no valid code was received, the system does not erase any stored data in that memory location. This is a security measure to ensure that a fob ID cannot be erased accidentally.

4. Repeat the above step to program additional fobs, up to a total of four.
5. When the programming sequence is over, return the system to normal operation by turning the program switch OFF (flip the toggle UP).

Fob Programming



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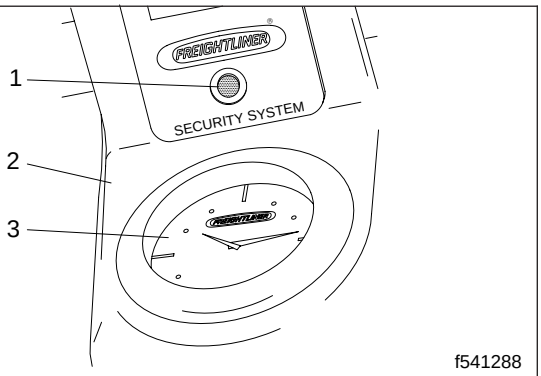
A. From Main Security Harness (door actuator circuits)
B. From Main Security Harness (PDM circuits)
C. To Main Security Harness Ground
D. To Sleeper Cab Security Harness
E. To LED Security Harness

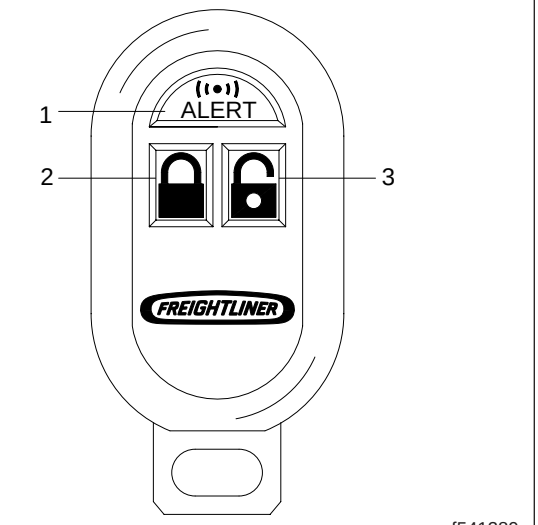
1. Rockwell Relay Module
2. Program Switch
3. Electronic Control Module (ECM)
4. Daytime Running Light Module
5. B-Pillar Security Harness
6. PDM Relay Module

Fig. 1, Keyless Security System B-Pillar Components



1. System Status LED
2. Overhead Panel
3. Clock

Fig. 2, Red System Status LED

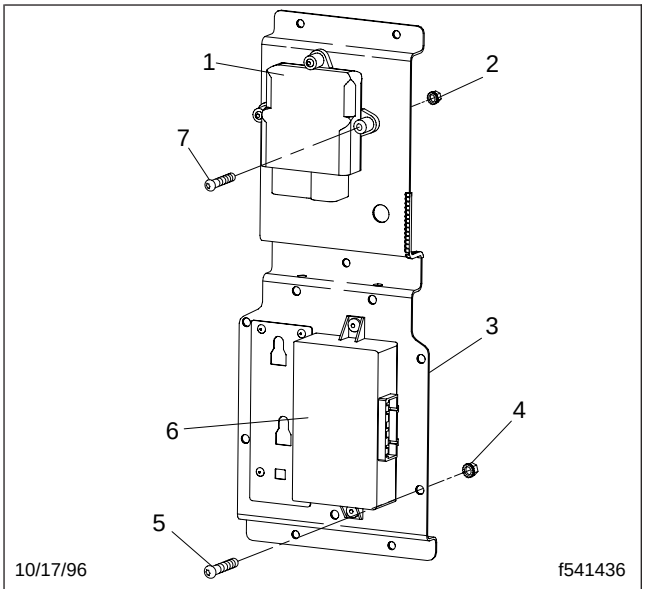


1. ALERT Button
2. LOCK Button
3. UNLOCK Button

Fig. 3, Key Chain Fob (radio transmitter)

Electronic Control Module Replacement

1. Apply the parking brakes and chock the tires. Disconnect the batteries.
2. Open the electrical compartment door on the right-hand B-pillar, behind the seat. The keyless security system modules are mounted on the long bracket above the daytime running light module. The electronic control module (ECM) is below the Rockwell relay module. See **Fig. 1**.



1. Rockwell Relay Module
2. Kep Nut (6–32)
3. Bracket
4. Kep Nut (10–24)
5. Machine Screw (10–24)
6. Electronic Control Module
7. Machine Screw (6–32)

Fig. 1, Electronic Control Module and Rockwell Relay Module

3. Remove the ECM.
   - 3.1 Remove the electrical connector from the side of the ECM.
   - 3.2 Remove the two 10–24 machine screws and kep nuts at the top and bottom of the ECM.
   - 3.3 Remove the ECM from the bracket.
4. Install the new ECM.
   - 4.1 Install the two 10–24 machine screws and kep nuts at the top and bottom of the ECM. Tighten them 13 lbf·ft (18 N·m).
   - 4.2 Connect the electrical connector in the side of the ECM.
5. Connect the batteries and check the keyless security system for correct operation.

NOTE: Program the fob identification codes into the new ECM. For detailed instructions, see **Subject 100**.

6. Remove the chocks from the tires.

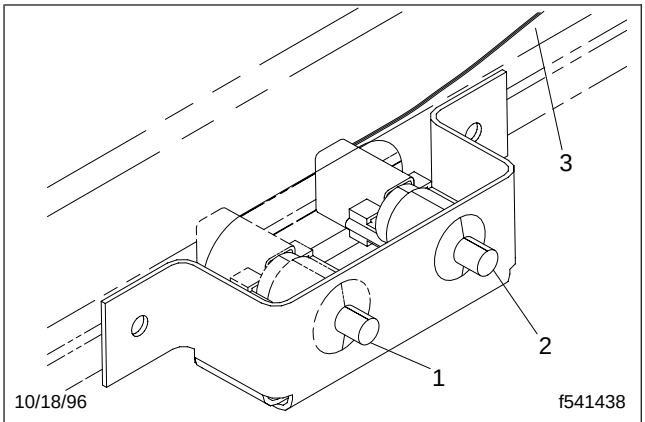
Rockwell Relay Module Replacement

1. Apply the parking brakes and chock the tires. Disconnect the batteries.
2. Open the electrical compartment door on the right-hand B-pillar, behind the seat. The keyless security system modules are mounted on the long bracket above the daytime running light module. The Rockwell relay module is above the ECM. See **Fig. 1**.
3. Remove the Rockwell relay module.
   - 3.1 Remove the electrical connector from the bottom of the Rockwell relay module.
   - 3.2 Remove the three 6–32 machine screws and kep nuts at the top and sides of the Rockwell relay module.
   - 3.3 Remove the Rockwell relay module from the bracket.
4. Install the new Rockwell relay module.
   - 4.1 Install the three 6–32 machine screws and kep nuts at the top and sides of the ECM. Tighten them 84 lbf·in (940 N·cm).
   - 4.2 Connect the electrical connector in the bottom of the ECM.
5. Connect the batteries and check the keyless security system for correct operation.
6. Remove the chocks from the tires.

Baggage Door Switch Replacement

Replacement

1. Apply the parking brakes and chock the tires. Disconnect the batteries.
2. Open the baggage door with the switch that needs replacing. The alarm switch is aft of the light switch. See **Fig. 1**.



Left-hand switch shown; right-hand opposite

1. Light Switch
2. Alarm Switch
3. Sleeper Cab Security Harness

Fig. 1, Baggage Door Switches Installed

3. Remove the switch. See **Fig. 2**.

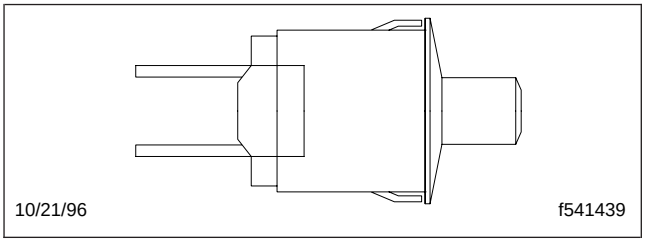


Fig. 2, Baggage Door Switch

   3.1 Remove the electrical connector from the base of the switch.

   3.2 Press in the prongs on the side of the switch and remove it through the front of the bracket.

4. Install the new switch.

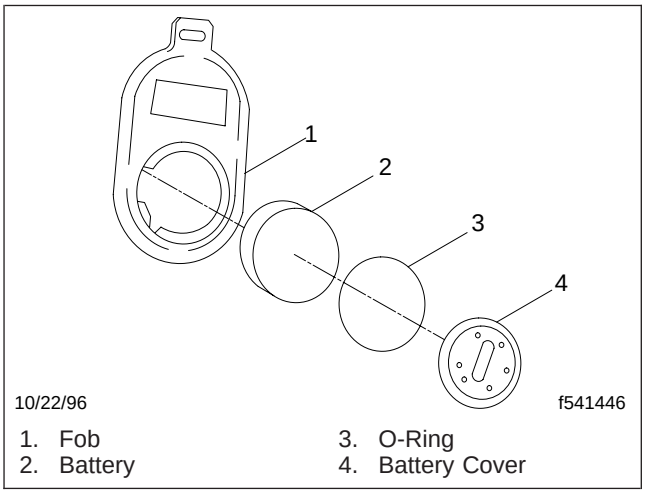
   4.1 Holding in the prongs on the side of the switch, press the switch into the hole in the bracket.

   4.2 Connect the electrical connector to the base of the switch.

5. Connect the batteries and check the switch for correct operation.
6. Remove the chocks from the tires.

Replacement

1. Open the battery cover on the back of the fob with a suitable coin or other thin piece of metal. Twist off the cover. See **Fig. 1**.



1. Fob
2. Battery
3. O-Ring
4. Battery Cover

Fig. 1, Fob Battery

2. Remove the battery and the O-ring installed inside the cover. Save the O-ring for later installation.
3. Install the new battery.
   - 3.1 Insert the new battery into the fob. Make sure the battery is right side up.
   - 3.2 Install the O-ring as removed. If the O-ring is damaged, or there are signs of moisture inside the fob, replace the O-ring.
   - 3.3 Twist on the battery cover and check it to make sure it is tight.
4. Check the fob for correct operation.

Troubleshooting

The keyless security system is mission critical—that is, situations can occur where the engine does not run if the system is not functioning properly. Here are some of the common problems:

- The vehicle doesn't start.
- The key fob doesn't work (doors don't lock or unlock).
- Relays chatter behind the B-pillar.
- The horn sounds, even though the horn button has not been pressed.
- The horn does not sound during an alert or an alarm.
- The marker lights do not flash during an alert or an alarm.
- The LED does not come on when the system is armed, or during an alert or alarm.
- When the vehicle batteries are switched on, the marker lights and/or LED come on, and/or the horn sounds.
- The alarm does not activate when one of the entry points is opened: either cab door, any baggage door, or the sleeper cab access door.

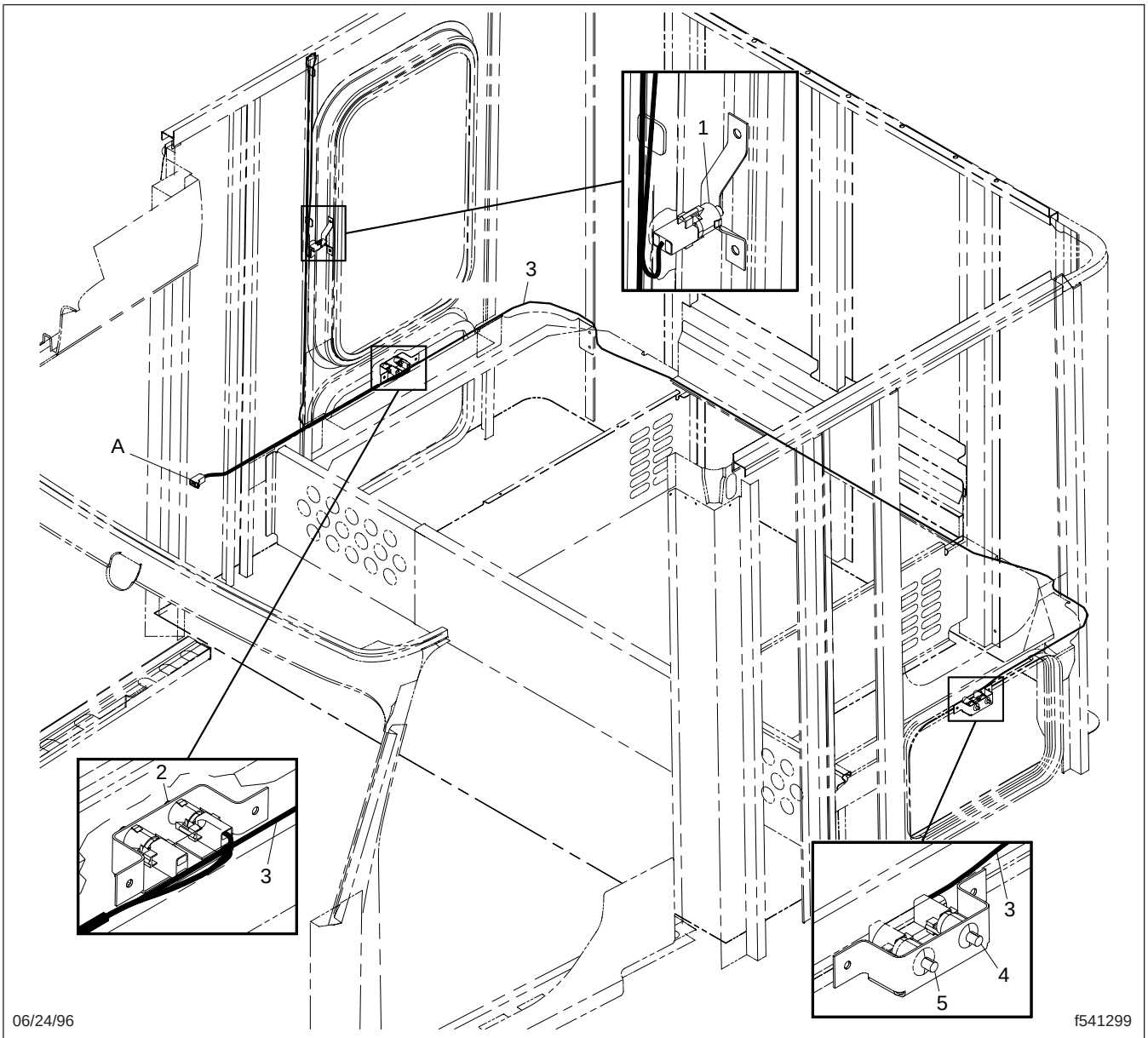
If any of these problems appear, do the following steps in order until the system works correctly. These steps are in a logical sequence, with the most common problems coming first.

1. Program the fob ID into the system, following the instructions under "How To Program the Fobs." When the programming is complete, make sure the program switch is turned OFF.

   If nothing responds, check the batteries in the fob and replace them if necessary. Check the ECM connectors to make sure the security system ECM is receiving power, and fix as necessary. Repeat the fob programming.

   If some components (LED, marker lights, horn, door actuators, ignition) respond but not others, or if the ECM relays click, go to the next step.
2. Check all door closures, including the sleeper cab access door and the baggage doors. See **Fig. 1**. Fix as required.
3. Trace the wiring for each non-working component. See **Table 1**.

Troubleshooting



A. To B-Pillar Harness

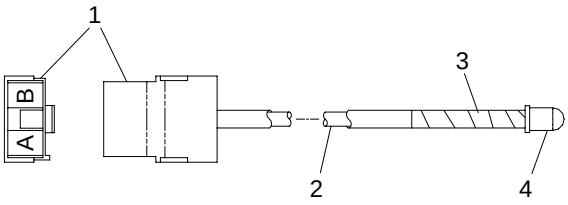
1. Alarm Switch (sleeper cab access door)
2. Alarm Switch (right-hand baggage door)
3. Sleeper Cab Security Harness
4. Alarm Switch (left-hand baggage door)
5. Light Switch (left-hand baggage door)

Fig. 1, Sleeper Cab Security Harness

Keyless Security System Wiring Checks	
Component	**Wiring Check**
Red System Status LED	Check tape connection for security. See **Fig. 2**.
Cab Door Actuator	Remove the kick panel from the cab door (the one with the non-working actuator). See **Fig. 3**. Check the electrical connector for good contact. Reconnect if necessary. Check the wires and pin cavities for continuity, and repair/replace as needed. Remove the electrical cover from the dash to expose the power distribution module (PDM). On the PDM, find connector G. Check wire 443 and pin cavity GA for continuity and repair/replace as needed. See **Fig. 4**.
Door Switch(es): Baggage Door or Sleeper Cab Access Door	Check the door with the non-working switch. Make sure the switch is pressed in when the door is closed. Lift the lower bunk bed, and check the switch wires and grounds for continuity. Repair/replace as needed. See **Fig. 1**. Open the right-hand B-pillar electrical compartment door, and check the sleeper cab harness connector for good contact. Reconnect if necessary. Check wires GND and GND2 and pin cavities A and B for continuity. Repair/replace as needed. See **Fig. 5**.
Horn	Remove the dash panel to expose the horn connector and cannon plug BL (left-hand plug). See **Fig. 6**. Check the horn electrical connector for good contact. Reconnect if necessary. Check pin cavity J4 on the cannon plug for continuity, and repair/replace as needed. Go to the PDM and find connector N on the bottom of the PDM. See **Fig. 7**. Check wire 24A and pin cavity ND8 for continuity. Repair/replace as needed.
Cab Marker Lights	Go to the PDM and find connector N on the bottom of the PDM. See **Fig. 7**. Check wire 46 and pin cavity NC5 for continuity. Repair/replace as needed.
Ignition Keyswitch	Ignition Power: Go to the PDM and find connector A. Check wire 81C and pin cavity AB4 for continuity. Repair/replace as needed. See **Fig. 4**. Battery Power: Go to the PDM and find connector E. Check wires EE and EF, and pin cavities EE and EF for continuity. Repair/replace as needed. Check the Optional Switch 1 (location 44) and Optional Switch 2 (location 47) circuit breakers, and replace if necessary. Discrete ECM Power: Go to the PDM and find connector A. Check wire D439 and pin cavity AC1 for continuity. Repair/replace as needed. Also, go to the B-pillar electrical compartment and check wires D439A and D439B, and pin connectors 14 and 15 on the ECM connector for continuity. Repair/replace as needed.

Table 1, Keyless Security System Wiring Checks

4. Check pin crimp connections. Repair as needed.
5. Check the pin connections on the ECM for good contact, and repair as needed.



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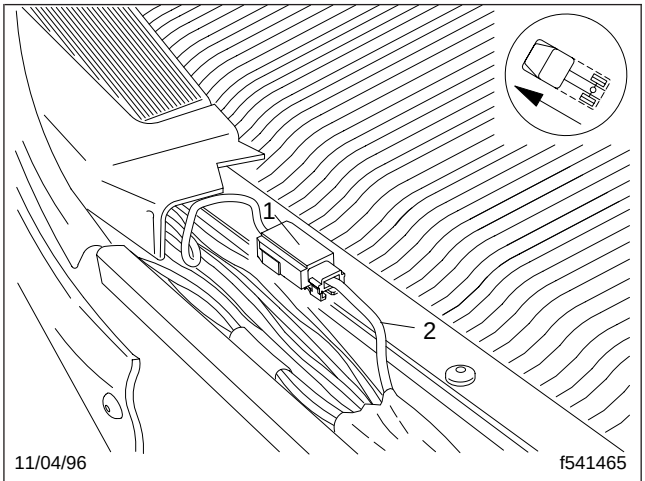
1. Electrical Connectors
2. LED Security Harness
3. Electrical Tape
4. Red System LED

Fig. 2, LED Security Harness



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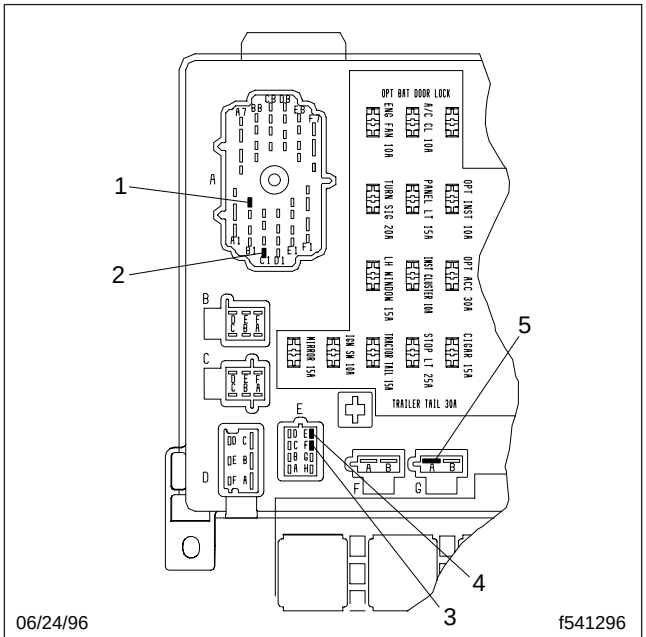
The left-hand door harness is shown.

1. Electrical Connector
2. Door Harness

Fig. 3, Door Harness



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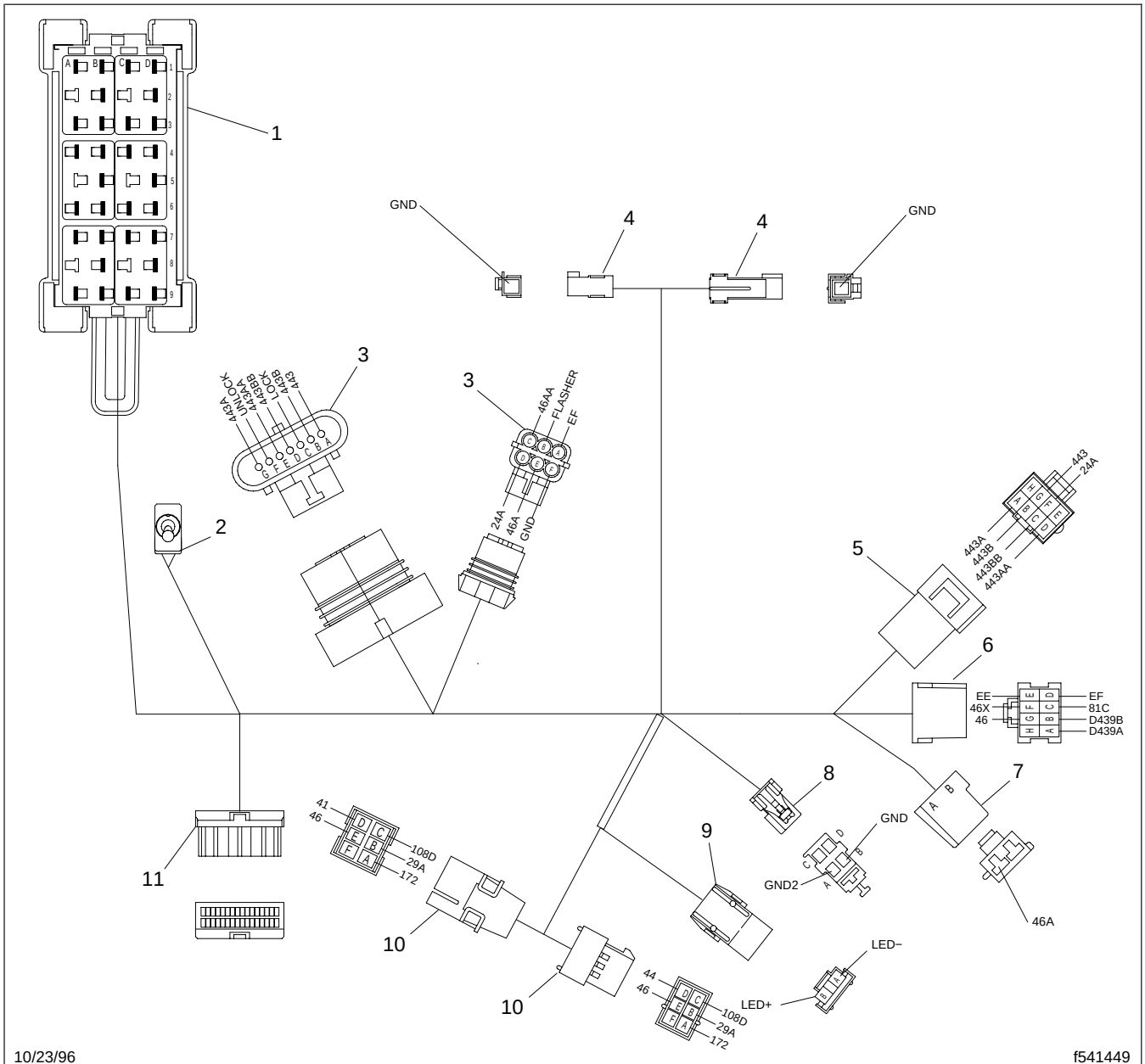
1. Pin Cavity AB4
2. Pin Cavity AC1
3. Pin Cavity EF
4. Pin Cavity EE
5. Pin Cavity GA

Fig. 4, PDM Connectors (top view)



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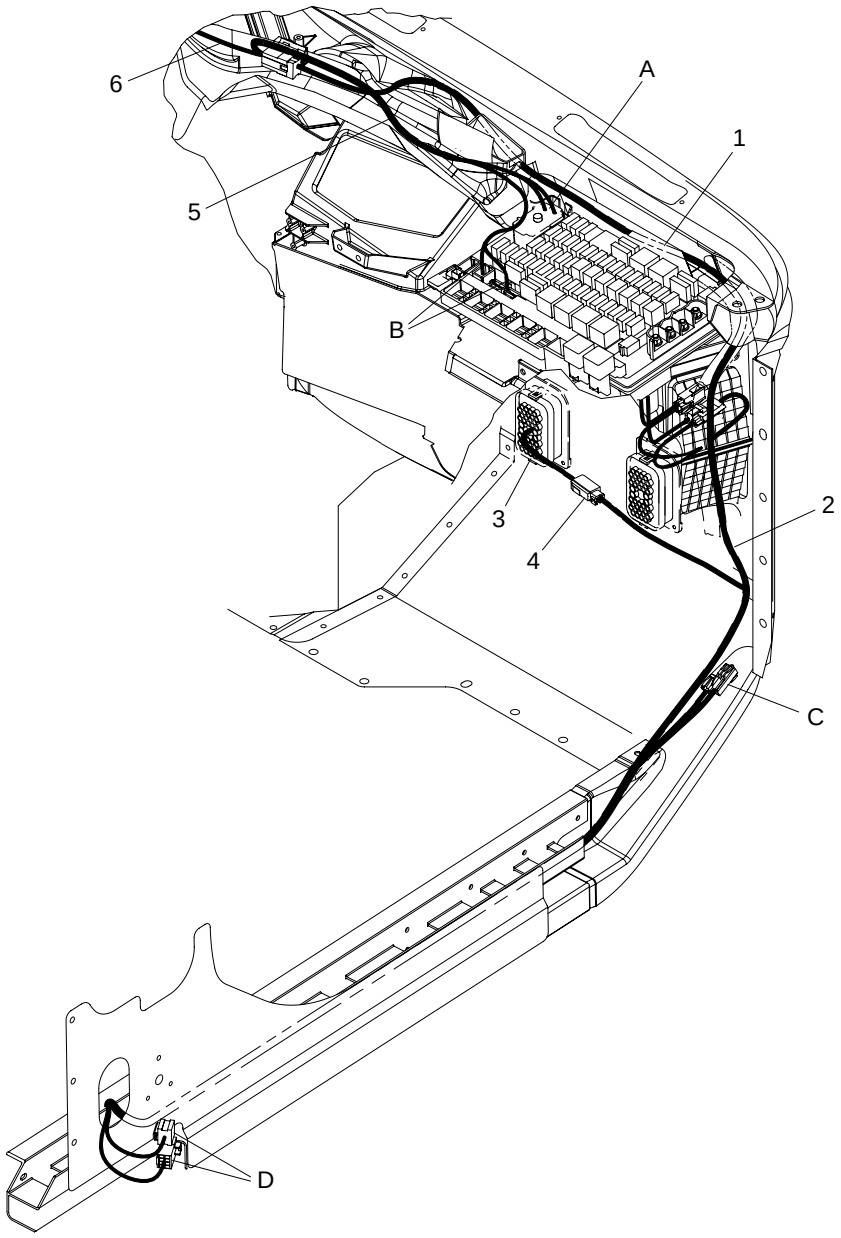
1. Rockwell Relay Module
2. Programming Switch
3. PDM Relay Module Connector
4. To B-Pillar Ground
5. To Door Lock Actuators
6. To Auxiliary PDM Circuits
7. To Marker Lights
8. Sleeper Cab Security Harness Connector
9. LED Security Harness Connector
10. To Door Switch Circuits
11. ECM Connector

Fig. 5, B-Pillar Security Harness

Troubleshooting



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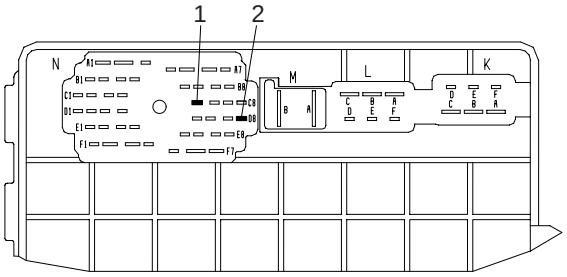
A. To PDM Connector "A"
B. To PDM Connectors "E" and "G"
C. To Right-Hand Door Harness
D. To B-Pillar Security Harness

1. Power Distribution Module (PDM)
2. Main Security Harness
3. Cannon Plug BL
4. Horn Connector
5. PDM Security Harness
6. Bulkhead Security Harness

Fig. 6, Main Security Harness and PDM Security Harness



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1. Pin Cavity NC5
2. Pin Cavity ND8

Fig. 7, PDM Connectors (bottom view)

Specifications

For a drawing of the main security harness, see **Fig. 1**.

For a drawing of the B-pillar security harness, see **Fig. 2**.

For a drawing of the sleeper cab security harness, see **Fig. 3**.

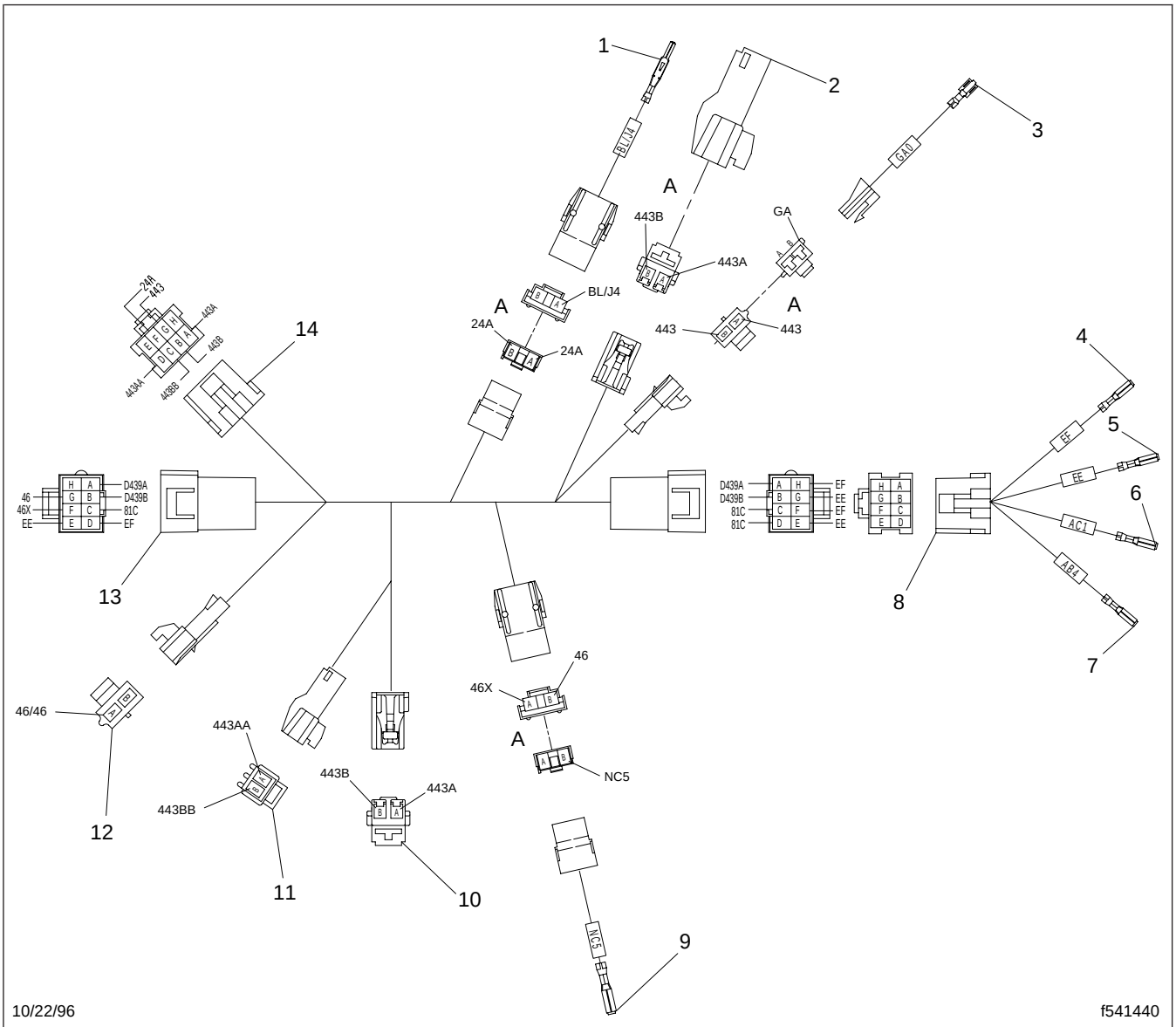
For a system schematic, see **Fig. 4**. For detailed views, see the following drawings:

- For a detailed view of the program switch, ECM, and PDM relay module wiring, see **Fig. 5**.
- For a detailed view of the security system cab wiring, see **Fig. 6**.
- For a detailed view of the security system PDM wiring, see **Fig. 7**.
- For a detailed view of the Rockwell relay module wiring, see **Fig. 8**.

For pin placements in the Rockwell relay module, see **Fig. 9**.

For pin placements in the security system ECM connector, see **Fig. 10**.

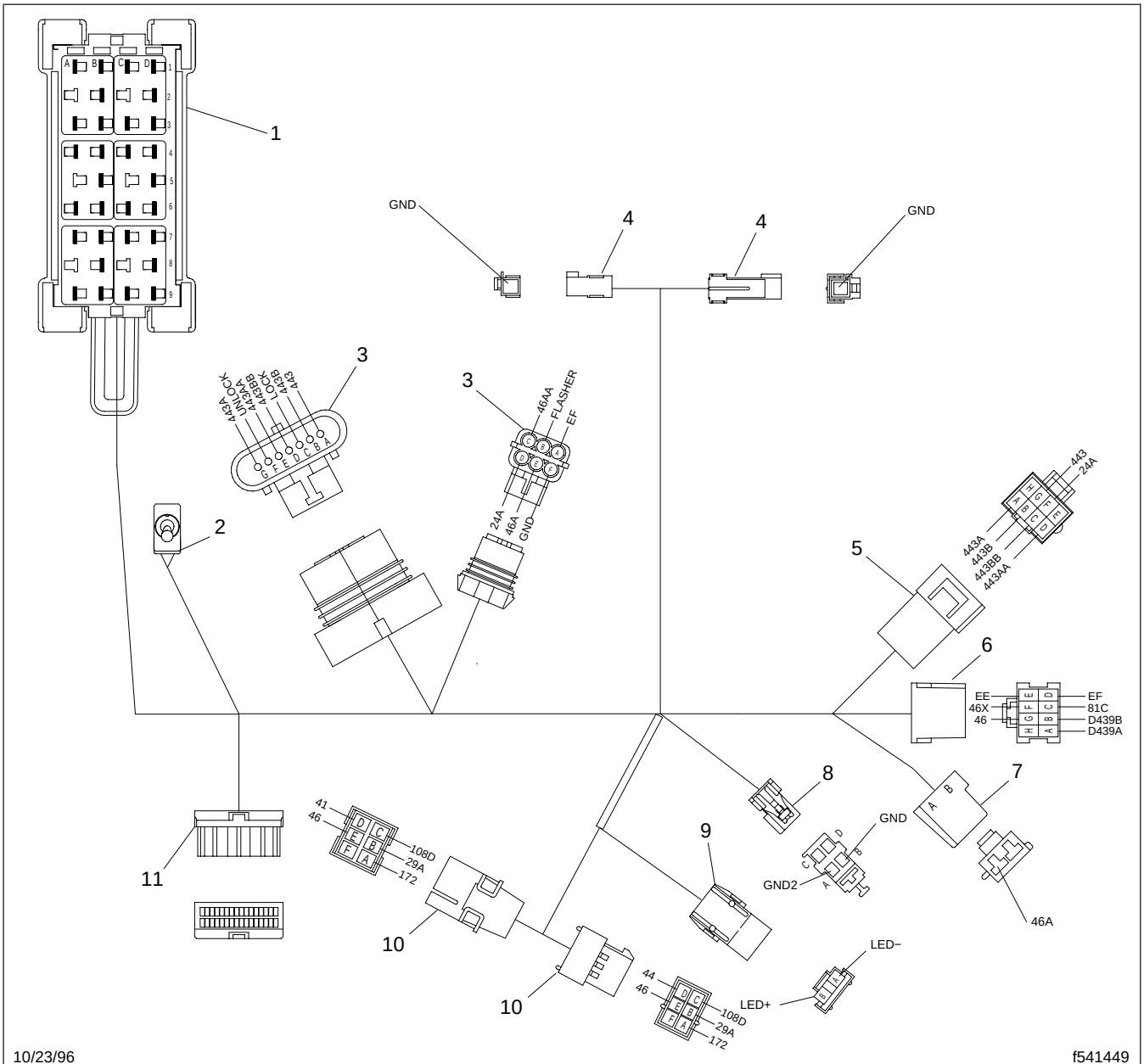
Specifications



A. Vendor supplies these components connected together.

1. Horn Connector
2. To LH Door Harness
3. Door Lock Power
4. 15-Amp C/B (optional switch #1)
5. 15-Amp C/B (optional switch #2)
6. Engine ECU Power
7. 10-Amp C/B (ignition power)
8. PDM Connector
9. Marker Light Power
10. To RH Door Harness
11. From B-Pillar Security Harness
12. To Marker Lights
13. To B-Pillar Security Harness
14. Door Lock Actuator Circuits

Fig. 1, Main Security Harness



10/23/96

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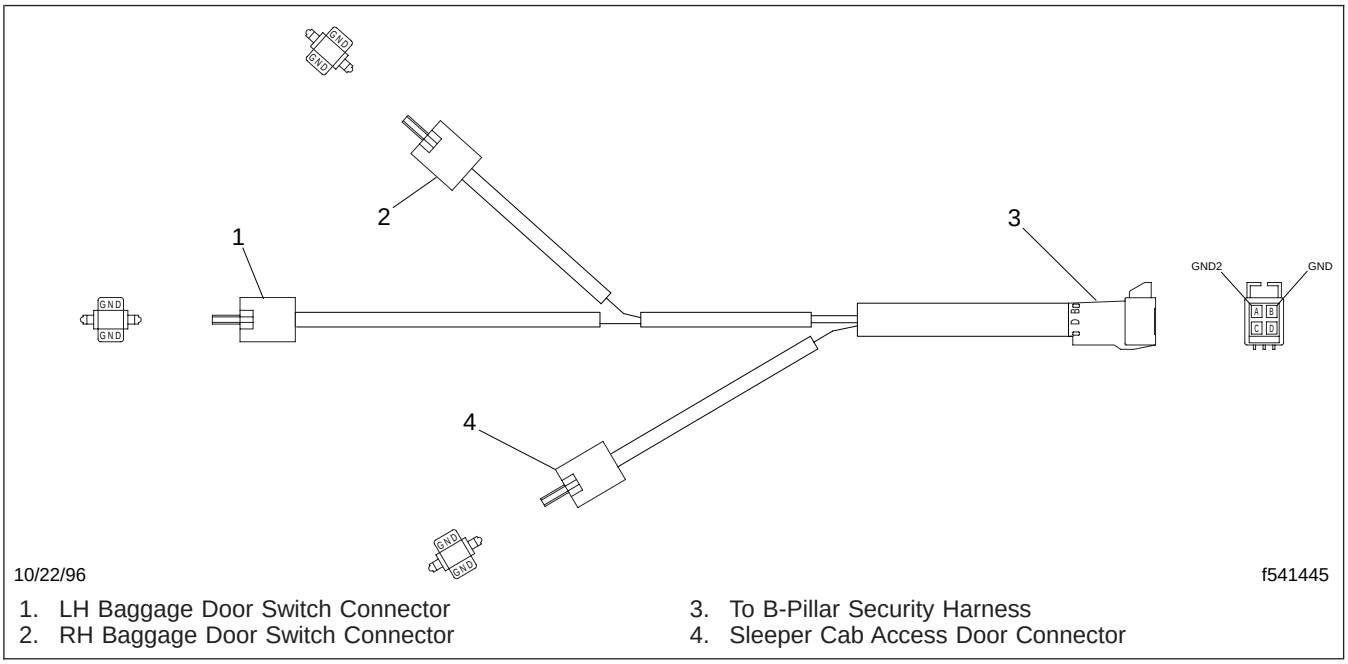
For pin placement in the Rockwell relay module, see **Fig. 9**.

For pin placement in the ECM connector, see **Fig. 10**.

1. Rockwell Relay Module
2. Programming Switch
3. PDM Relay Module Connector
4. To B-Pillar Ground
5. To Door Lock Actuators
6. To Auxiliary PDM Circuits
7. To Marker Lights
8. Sleeper Cab Security Harness Connector
9. LED Security Harness Connector
10. To Door Switch Circuits
11. ECM Connector

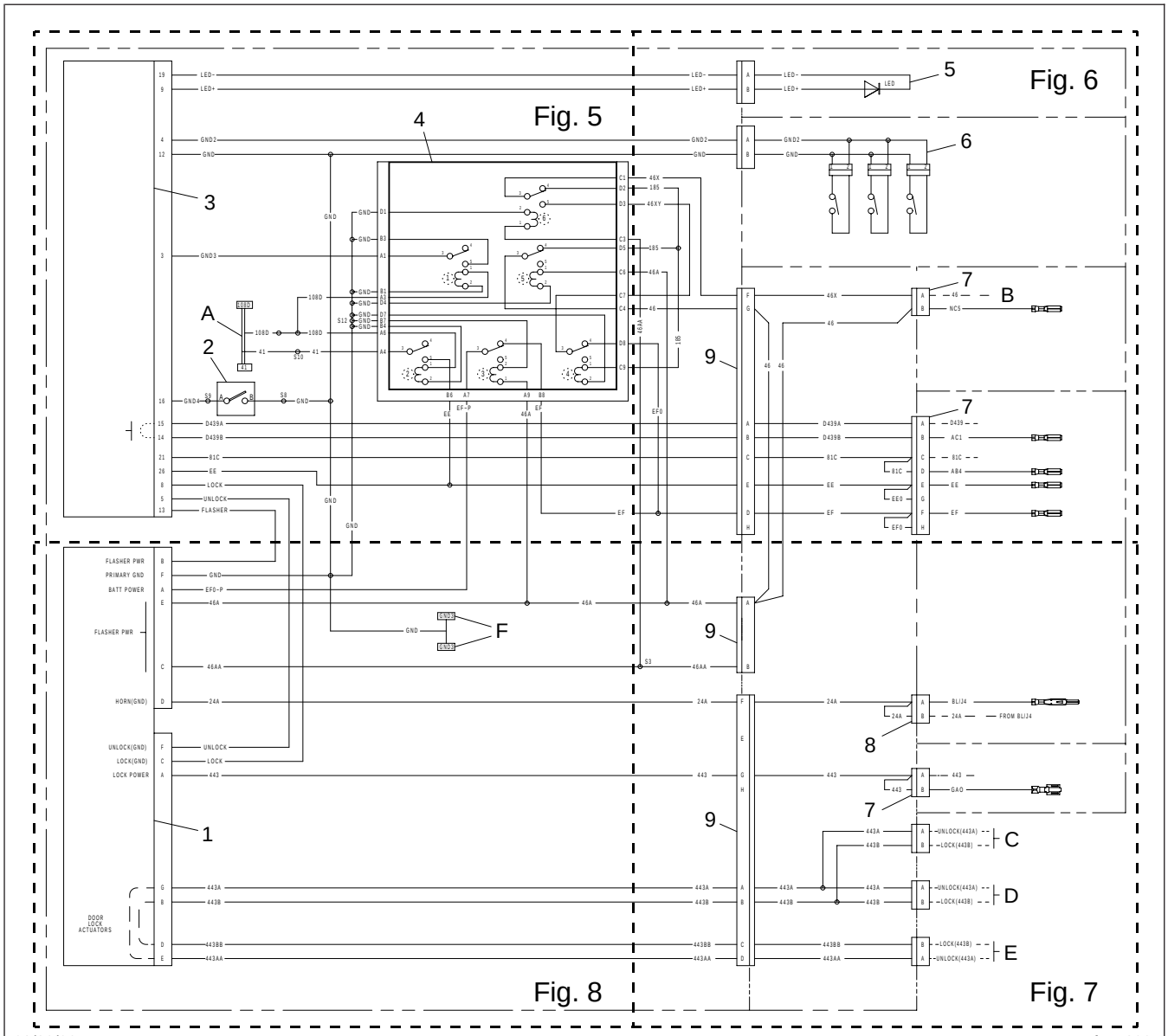
Fig. 2, B-Pillar Security Harness

Specifications



1. LH Baggage Door Switch Connector
2. RH Baggage Door Switch Connector
3. To B-Pillar Security Harness
4. Sleeper Cab Access Door Connector

Fig. 3, Sleeper Cab Security Harness



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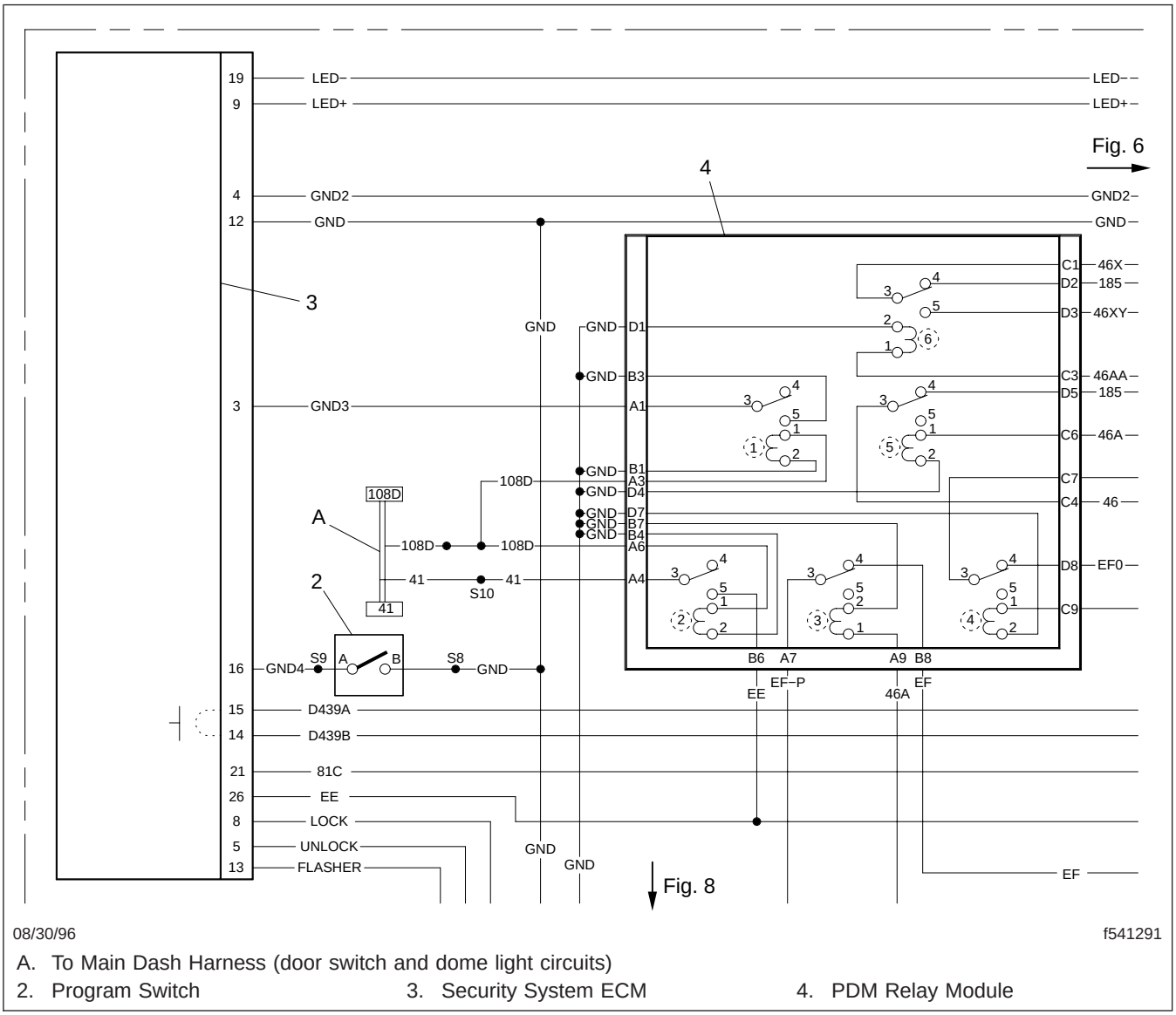
A. To Main Dash Harness (door switch and dome light circuits)
B. To Cab Marker Lights
C. To Left-Hand Door Harness
D. To Right-Hand Door Harness
E. From Main Security Harness
F. To Main Security Harness Ground

1. Rockwell Relay Module
2. Program Switch
3. Electronic Control Module (ECM)
4. PDM Relay Module
5. LED Security Harness
6. Sleeper Cab Security Harness
7. Power Distribution Module (PDM)
8. Bulkhead Security Harness Connector
9. B-Pillar Security Harness Connectors

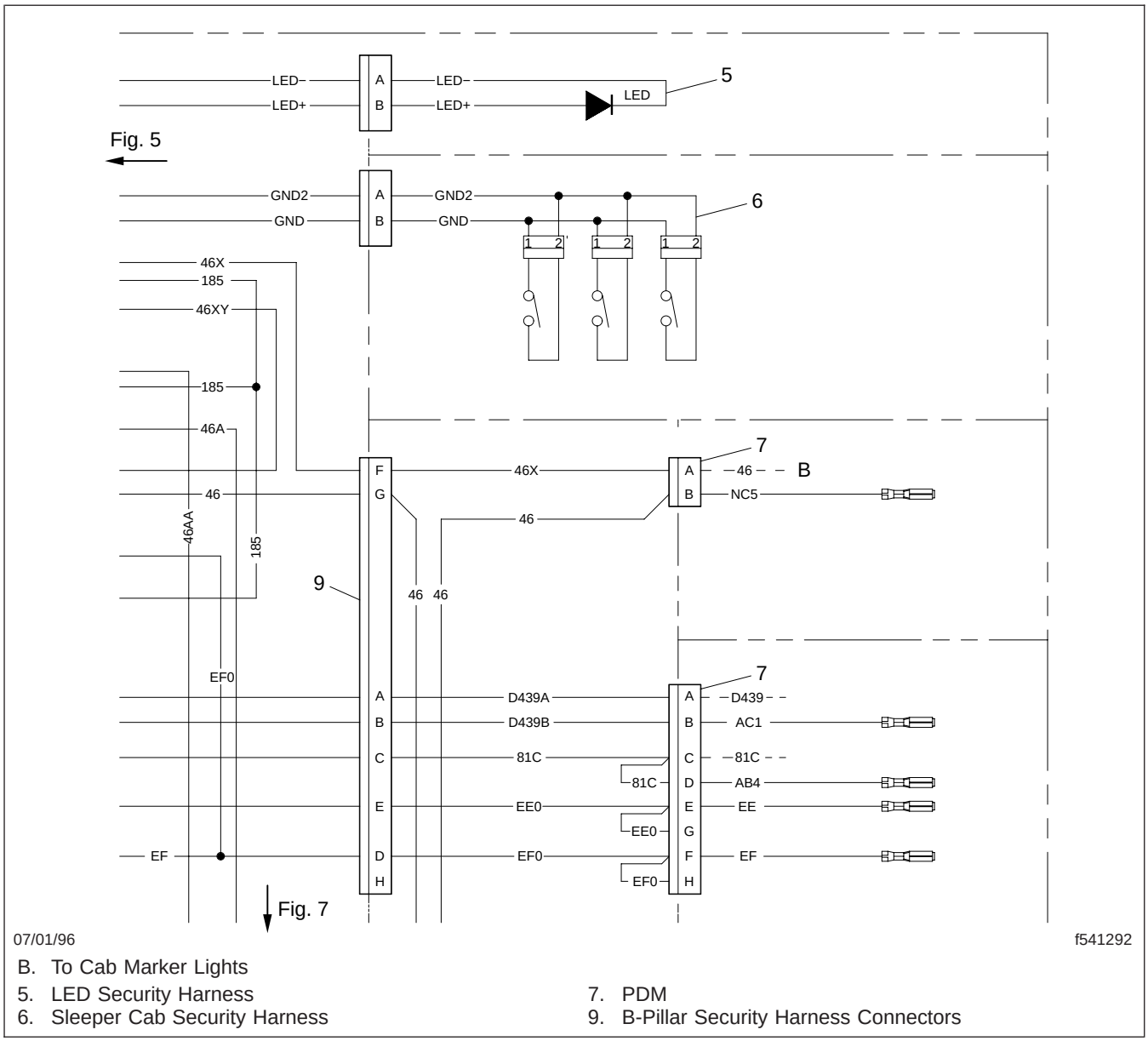
Fig. 4, Keyless Security System Schematic

Specifications



A. To Main Dash Harness (door switch and dome light circuits)
2. Program Switch
3. Security System ECM
4. PDM Relay Module

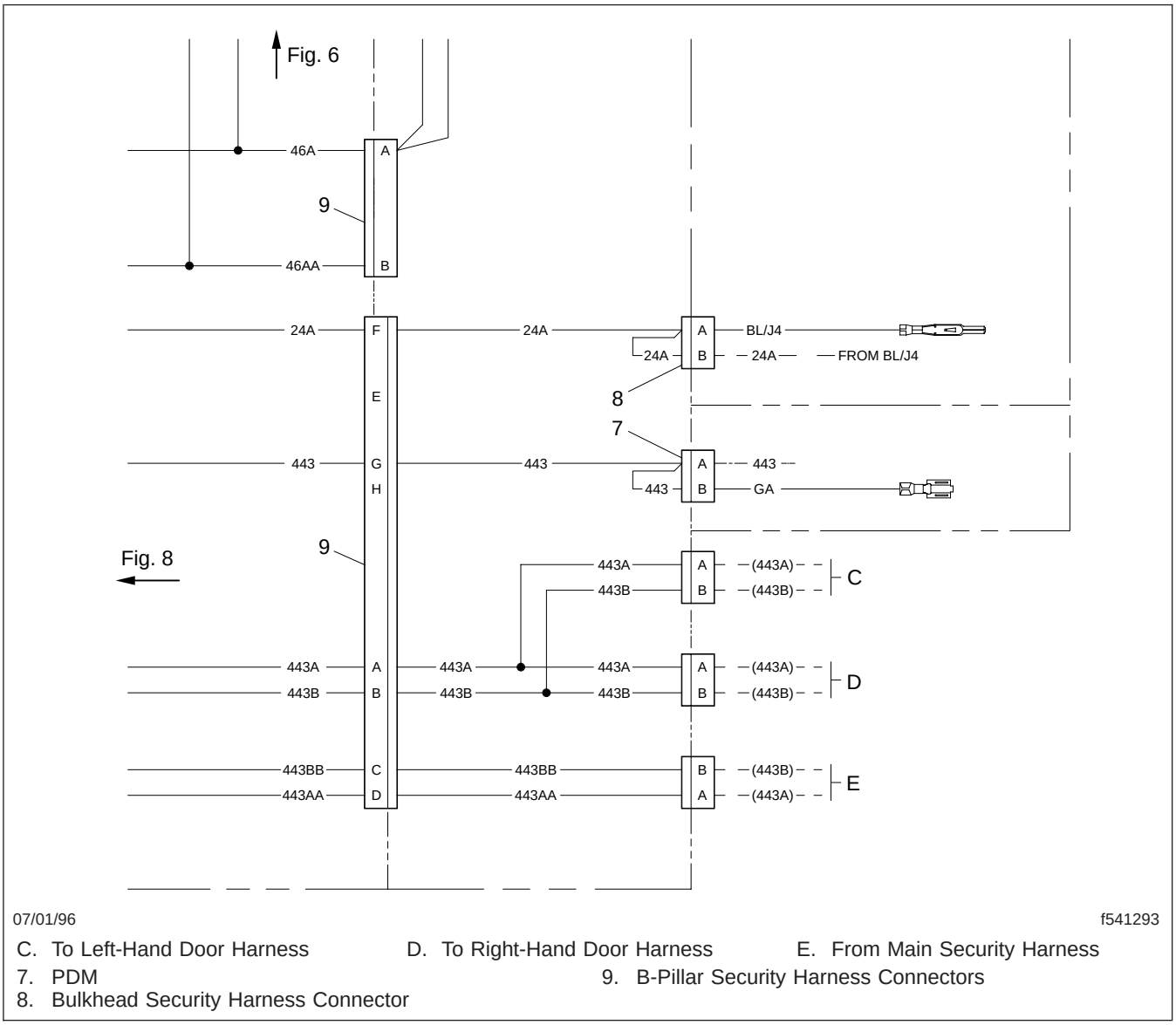
Fig. 5, Keyless Security System Schematic (partial view showing program switch, ECM, and PDM relay module)



B. To Cab Marker Lights
5. LED Security Harness
6. Sleeper Cab Security Harness
7. PDM
9. B-Pillar Security Harness Connectors

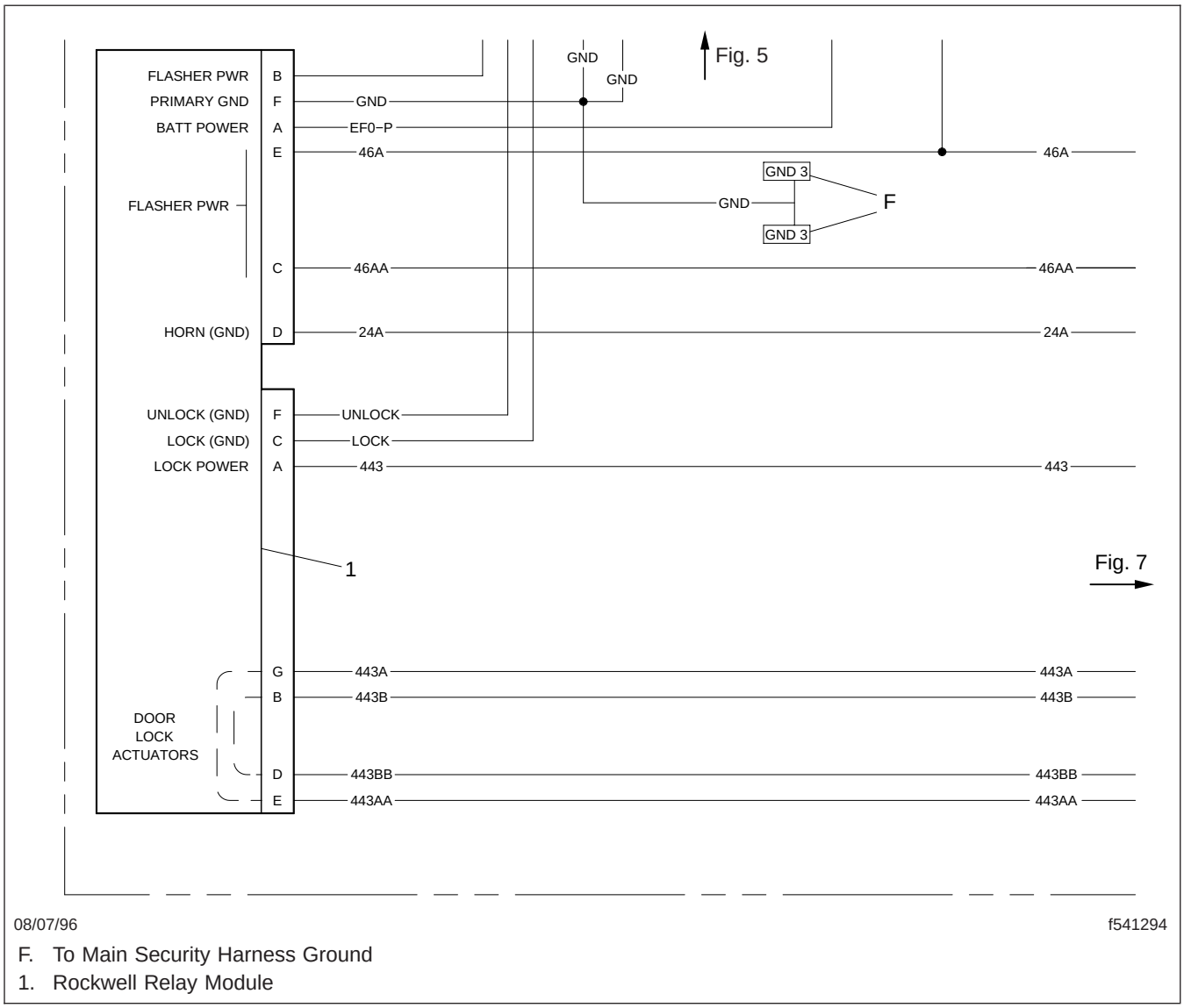
Fig. 6, Keyless Security System Schematic (partial view showing security system cab wiring)

Specifications



C. To Left-Hand Door Harness
D. To Right-Hand Door Harness
E. From Main Security Harness
7. PDM
8. Bulkhead Security Harness Connector
9. B-Pillar Security Harness Connectors

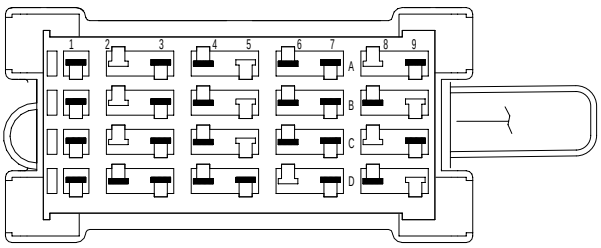
Fig. 7, Keyless Security System Schematic (partial view showing security system PDM wiring)



F. To Main Security Harness Ground
1. Rockwell Relay Module

Fig. 8, Keyless Security System Schematic (partial view showing the Rockwell relay module)

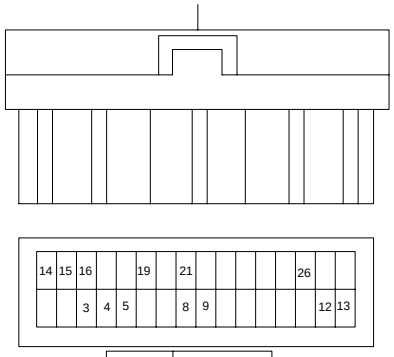
Specifications



PIN #	CIRCUIT	PIN #	CIRCUIT
A1	GND3	C1	46X
A2	-	C2	-
A3	108D	C3	46AA
A4	41	C4	46
A5	-	C5	-
A6	108D	C6	46A
A7	EP-P	C7	46XY
A8	-	C8	-
A9	46A	C9	185
B1	GND	D1	GND
B2	-	D2	185
B3	GND	D3	46XY
B4	GND	D4	GND
B5	-	D5	185
B6	EE	D6	-
B7	GND	D7	GND
B8	EF	D8	EF
B9	-	D9	-

10/23/96 f541437

Fig. 9, Rockwell Relay Module Pin Placements



LOC	CIRCUIT
3	GND3
4	GND2
5	UNLOCK
8	LOCK
9	LED
12	GND
13	FLASHER
14	D439A
15	D439B
16	GND4
17	–
19	LED–
21	81C
22	EE0

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Fig. 10, ECM Connector Pin Placements

Tweeter

Removal

1. Shut down the engine and set the parking brake. Chock the front tires.
2. Remove the Torx®-head screw attaching the tweeter grille to the front of the arm rest cover assembly. See **Fig. 1**.
3. Remove the tweeter grille by gently prying it away from the arm rest cover assembly. Begin prying at the forward end of the grille.
4. At the mirror lower bracket cover on the outside of the vehicle, remove the access tab to uncover the bolt that passes through the door and attaches to the tweeter bracket.
5. Remove the bolt.
6. Remove the two fasteners attaching the tweeter to the inner door panel.
7. Remove the front arm rest cover to access the wires attached to the tweeter. Then, disconnect the speaker wires from the wire harness.

IMPORTANT: Do not remove the heat shrink tube from the speaker wire. Disconnect the wires by pulling the tweeter away from the door, and then disconnecting the wires from the wire harness inside the door.

8. Remove the fastener attaching the tweeter bracket to the tweeter.

Installation

1. Attach the tweeter bracket to the tweeter. Orient the tweeter wires so that they remain in a "6 o'clock" position when the tweeter is installed.
2. Connect the tweeter wires to the speaker wiring harness inside the door.
3. Attach the tweeter speaker assembly to the door inner panel.
4. Install the front arm rest cover.
5. Install the bolt that attaches through the door to the tweeter bracket. Install the access tab on the mirror lower bracket cover.
6. Install the tweeter grille into the door panel by inserting the tab at the aft edge of the grille into the slot in the door panel.
7. Install the Torx-head screw.

5-1/4-inch Midrange

Removal

1. Shut down the engine and set the parking brake. Chock the front tires.
2. Gently pry the midrange speaker grille away from the speaker, prying from the front edge of the grille. See **Fig. 1**.
3. Remove the four Torx-head screws attaching the speaker to the inner door panel.
4. Remove the speaker.
5. Disconnect the speaker wires from the speaker wiring harness.

Installation

1. Connect the speaker wires to the speaker wiring harness inside the inner door panel.
2. Attach the speaker to the door panel using the four Torx-head screws.
3. Install the grille by inserting the tabs on the aft edge of the grille into the slots provided. Snap the forward edge of the grille into position.

6 x 9-inch Full Range

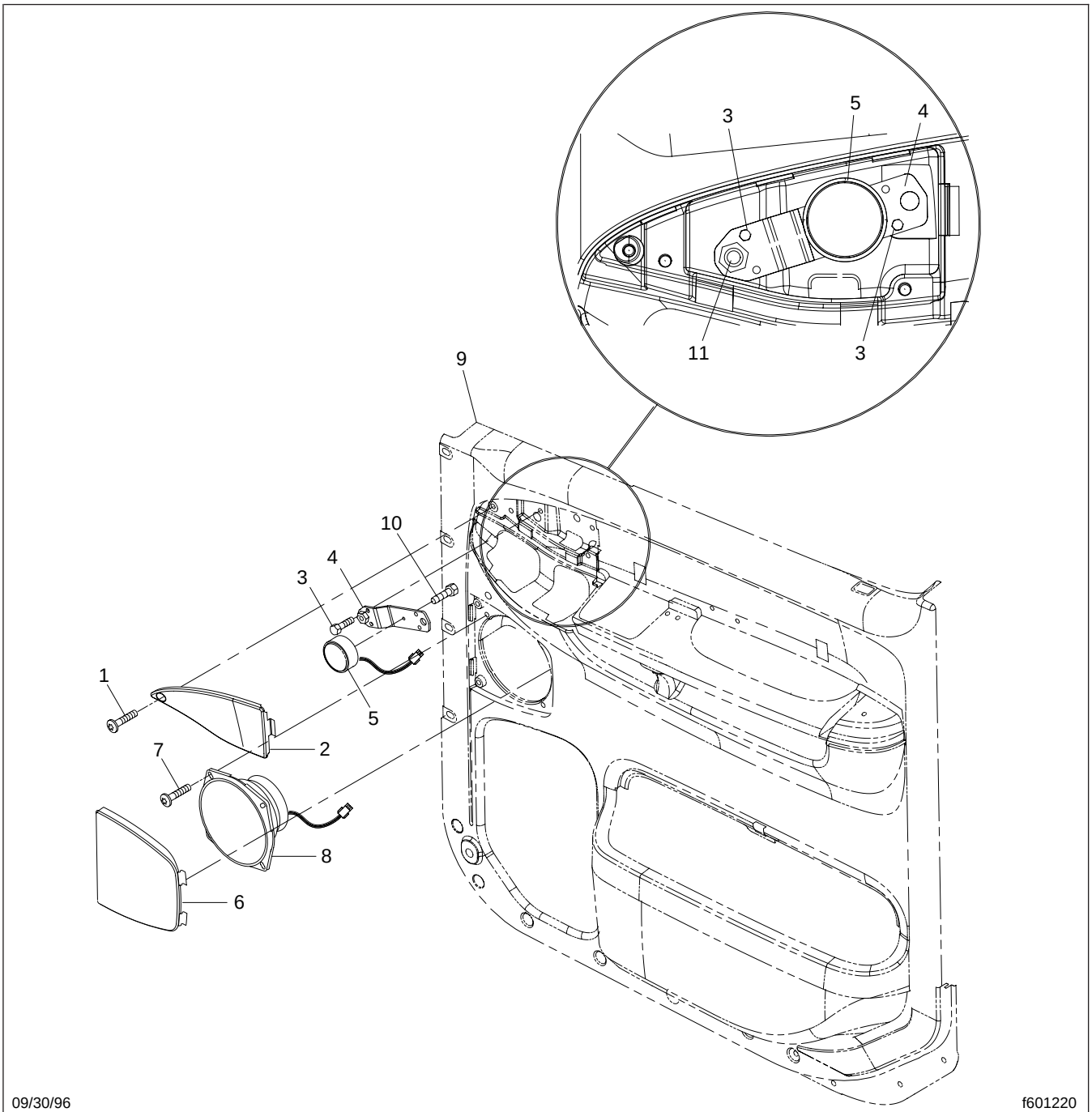
Removal

The location of the full range speakers depends on the type of vehicle. In raised-roof vehicles, the speakers are mounted in the roof cap above the upper bunk. In mid-roof cab vehicles, the speakers are mounted on the underside of the rear overhead shelves in the upper rear sleeper corners.

NOTE: In mid-roof cab vehicles without the rear overhead shelves, the speakers are 5-1/4-inch speakers, and are mounted in the upper rear sleeper corners.

1. Shut down the engine and set the parking brake. Chock the front tires.

Speaker Removal and Installation



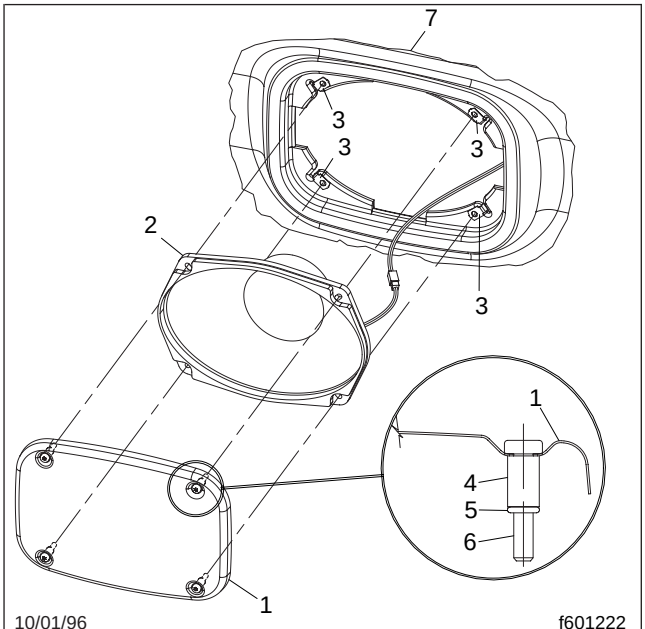
1. Torx-head Screw
2. Tweeter Grille
3. Bracket Fastener
4. Tweeter Bracket
5. Tweeter Speaker
6. Midrange Grille
7. Midrange Fastener
8. Midrange Speaker
9. Door
10. Tweeter-to-Bracket Fastener
11. Weld-nut for Door Bolt

Fig. 1, Tweeter and Midrange Speaker Installations (righthand door)

WARNING

WARNING: Be careful when removing the speaker grille and speaker. The speaker is heavy, and because the speaker is attached with the same fasteners as the speaker grille, the speaker may fall suddenly from the speaker opening during removal, resulting in personal injury or property damage.

2. Remove the four fasteners attaching the grille and the speaker to the cab interior components. Then, remove the grille and the speaker. See **Fig. 2**.



1. Speaker Grille
2. Bass Speaker
3. J-Clip
4. Spacer
5. O-ring
6. Screw
7. Cab Interior Panel

Fig. 2, Bass Speaker Assembly

NOTE: The speaker grille and speaker are held in place by four screw-spacer-O-ring combinations. Be sure to set aside these components for installation.

3. Disconnect the speaker wires from the speaker wire harness.

Installation

1. Build up the speaker grill attachment standoffs as shown in **Fig. 2**, and as follows: Insert the four fastening screws through the four speaker grille mounting holes. Then slip the spacers over the screws and secure with the O-rings.
2. Be sure the four J-clips are in place on the speaker cut-out area to receive the screws.
3. Connect the speaker wires to the speaker wire harness.
4. Install the speaker and speaker grille.

Subwoofer

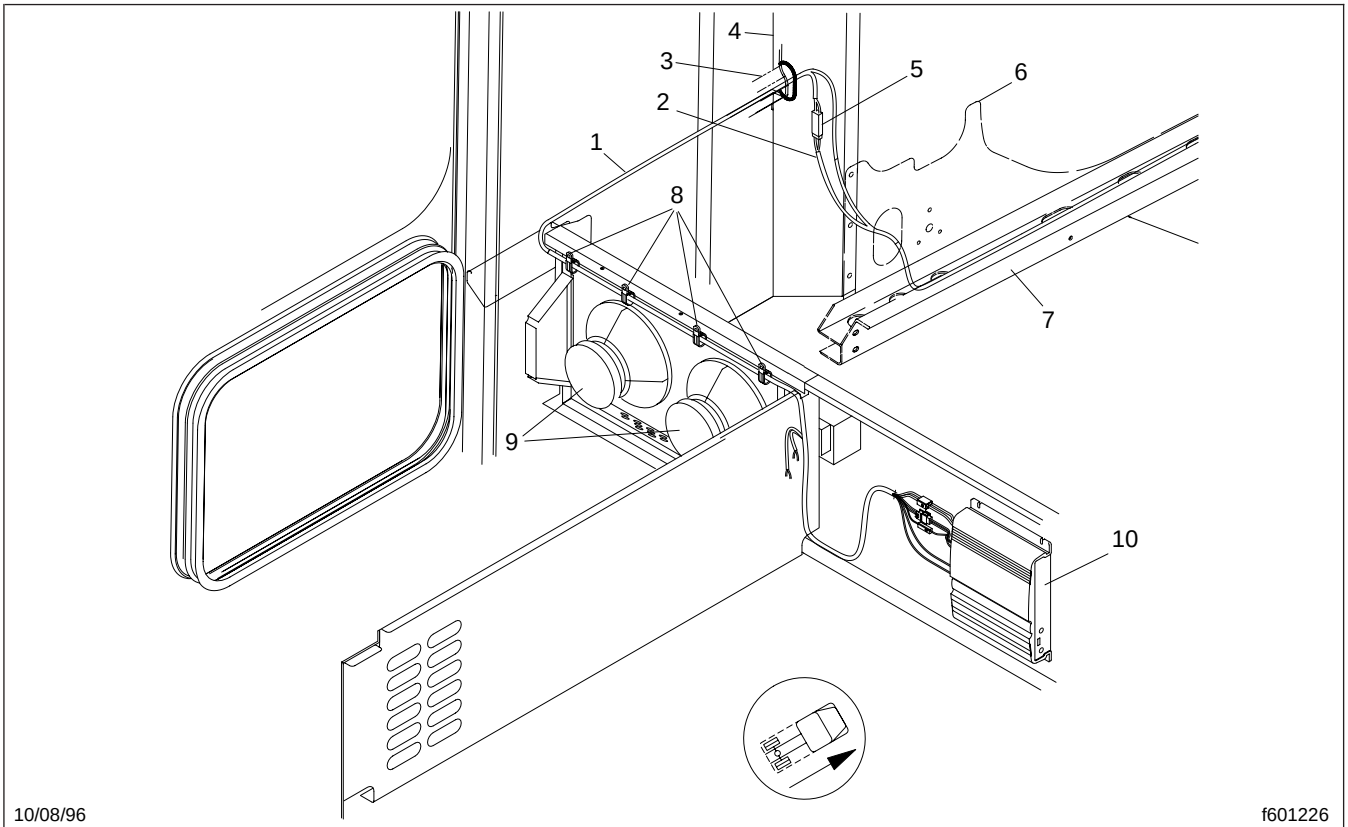
Removal

1. Shut down the engine and set the parking brake. Chock the front tires.
2. Raise the bunk to access the underbunk storage area and the subwoofer assembly. See **Fig. 3**.
3. Disconnect the subwoofer wiring harness from the subwoofer power amplifier.
4. Remove the press-fit grilles from the individual speakers.
5. Remove the nylon locknuts that secure the grille retaining rings.
6. Remove the subwoofer assembly from the underbunk storage area by pulling the assembly away from the bunk partition until all eight screws are free.

NOTE: The subwoofer is installed and removed as an assembly. Proceed to the next step if replacing subwoofer assembly components.

7. Disassemble the subwoofer assembly. See **Fig. 4**.
   - 7.1 Remove the speaker guard from the speaker and panel assembly.
   - 7.2 Remove the nuts and washer securing the speakers to the panel.
   - 7.3 Remove the clamps that secure the speaker wires to the back of the panel.
   - 7.4 Remove the speakers from the panel.

Speaker Removal and Installation



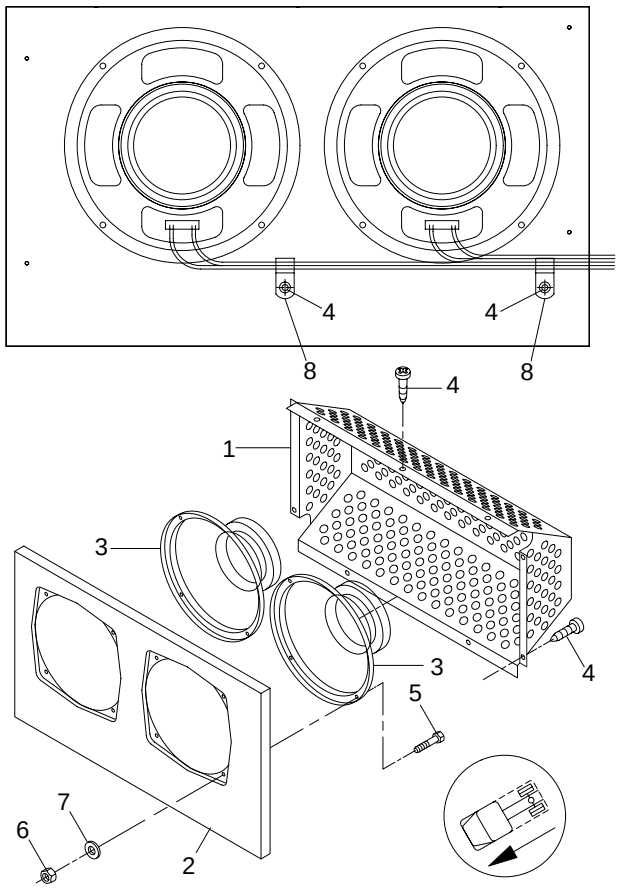
1. Amplifier/Subwoofer Harness, Bunkside
2. Amplifier/Subwoofer Harness, Cabside
3. Sidewall Wirethrough
4. B-pillar
5. Harness Connector
6. B-pillar Lower Reinforcement
7. Outer Underbody Sill
8. Clips
9. Subwoofers
10. Amplifier

Fig. 3, Subwoofer/Amplifier Assembly

Installation

1. Assemble the subwoofer speaker assembly.
   - 1.1 Install each speaker onto the back (flat side) of the panel with four screws. Orient the speakers with the speaker wire terminals facing down in the "6 o'clock" position.
   - 1.2 Secure the wire harness to the back of the panel with clamps as shown in **Fig. 4**.
   - 1.3 Install the nuts and washers onto the screws to secure the speakers to the panel. The nuts and washers should be within the routed-out area of the panel.

     NOTE: The screws are intentionally long for later installation.
   - 1.4 Attach the speaker and panel assembly to the guard. See **Fig. 4**.
   - 1.5 Route the wire harness through the hole in the lower corner of the guard.
2. Position the subwoofer assembly into the under-bunk storage area as shown in **Fig. 3** so that the eight screws protruding from the forward face of the assembly fit the holes in the bunk partition and carpet.
3. Install the grille retaining rings onto the screws. Secure each screw with a nylon locknut.
4. Install the press-fit grilles over the retaining rings.



1. Speaker Guard
2. Speaker Mounting Panel
3. Subwoofer
4. Screw, 10–16-5/8
5. Screw, 10–24-1.75
6. Nut, 10–24
7. Washer
8. Clamp

Fig. 4, Subwoofer Assembly

5. Connect the subwoofer wiring harness to the harness from the subwoofer power amplifier.

Overhead Console Speaker Grille Removal and Installation

Removal and Installation

The triangular-shaped speaker grille mounted to the center bottom of the overhead console does not cover a specific speaker at this location. If a CB radio is installed in the overhead console, however, the speaker grille allows the sound from the CB radio speaker to be heard. Removing the speaker grille also allows access to the center portion of the console for installation purposes.

To remove and install the speaker grille:

1. Using a regular screwdriver, and taking care not to mark or bend the grille itself, gently pry the forward portion of the grille free of the console.

NOTE: The speaker grille has four tabs to keep it in place on the overhead console along the edge of the grille.

2. Install the grille by positioning it onto the console and then gently tapping it into place.

Freightliner supplies two principal wiring harnesses to each engine. The 12-volt (12V) engine harness supplies alternator power to the starter and various appliances. The electronic engine harness communicates data between the electronic control module (ECM), various data-gathering devices, and the cab information systems.

For a view of the harness routing for the C–10/C–12/3176 engines, see **Fig. 1**.

For detailed harness routing for the C–10/C–12/3176 engines, see **Fig. 2**.

For a view of the harness routing for the 3406 engine, see **Fig. 3**.

For detailed harness routing for the 3406 engine, see **Fig. 4**.

For a schematic of the electronic engine wiring, see **Fig. 5**.

For a drawing of the electronic engine harness, see **Fig. 6**. For a detailed diagram and table showing the pin cavities and wire numbers assigned to the 31-pin electronic engine connector at the cab interface, see **Fig. 7**.

NOTE: The cab interface of the electronic engine connector is on the engine side of the frontwall.

For a drawing of the 12V engine harness, see **Fig. 8**.

The circuitry going to the other side of the frontwall passes through the electronic engine connector into the main cab harness as an electronic engine overlay for the Caterpillar engines. For a schematic of the electronic engine overlay for the main cab harness, see **Fig. 9**. For a detailed view of the engine overlay wiring, see **Fig. 10** and **Fig. 11**.

For a drawing of the electronic engine overlay for the main cab harness, see **Fig. 12**. For a detailed diagram and table showing the pin cavities and wire numbers assigned to the 31-pin electronic engine connector at the engine interface, see **Fig. 13**.

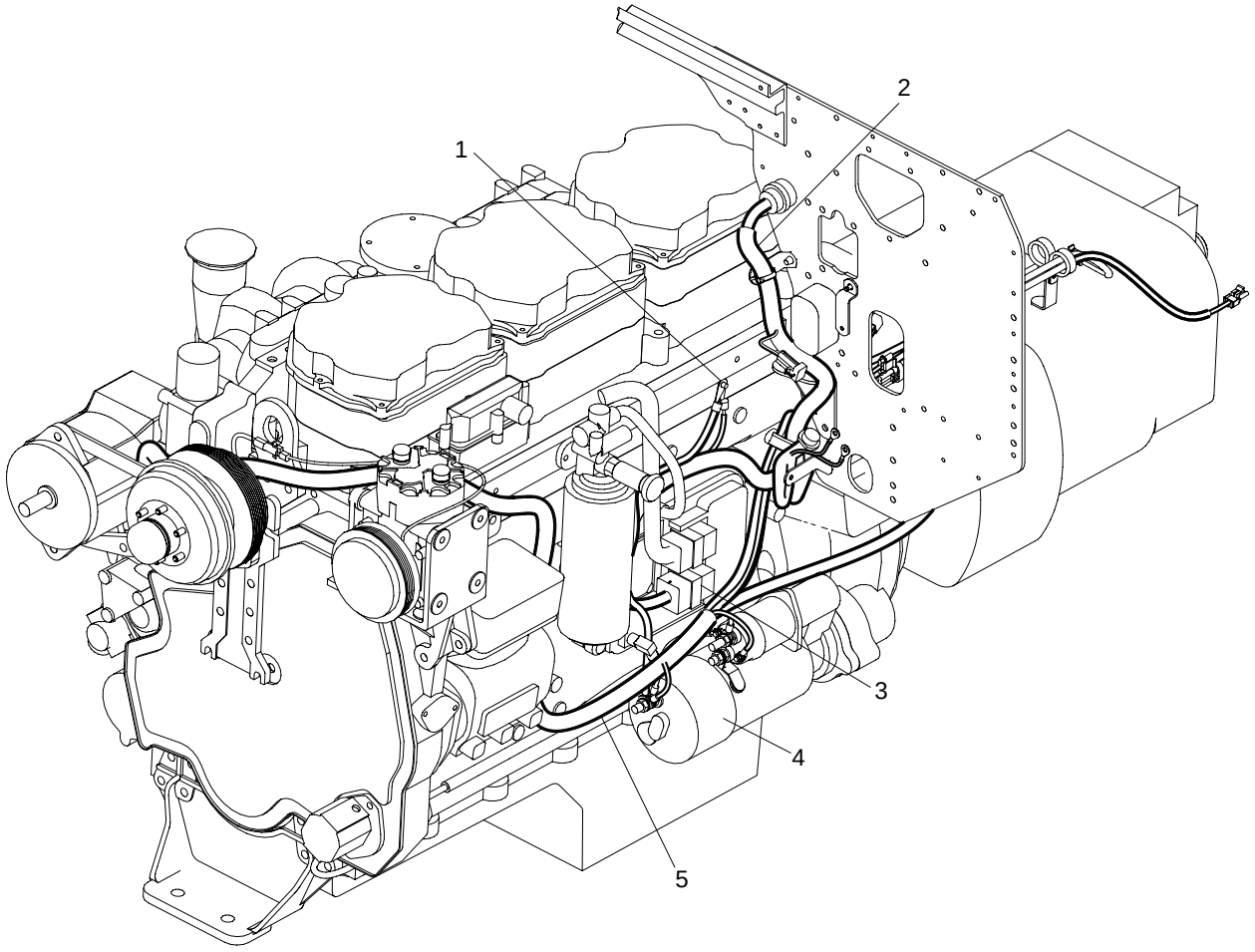
NOTE: The engine interface of the electronic engine connector is on the cab side of the frontwall. Since some of the wiring numbers are different on the cab side, this connector is shown twice, once from each end. For the wiring on the engine side, see **Fig. 7**.

For the engine brake wiring schematic, see **Fig. 14**. For the engine brake harness, see **Fig. 15**.

CAUTION

Before performing any electric welding on a vehicle, disconnect the battery power and ground cables and the engine electronic control module (ECM) connector at the ECM. See Fig. 5 and Fig. 6. Electric currents produced during electric welding can damage various electronic components on the vehicle.

Specifications



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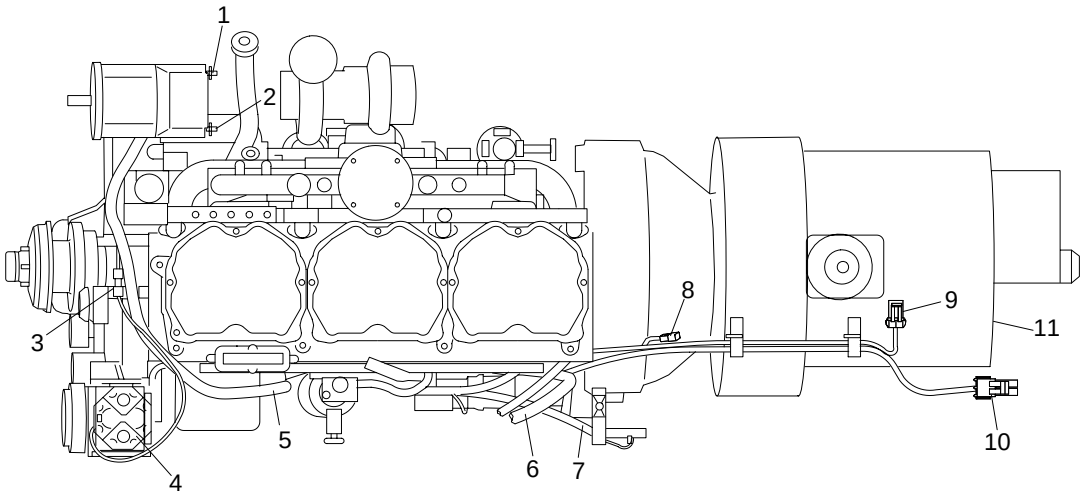
NOTE: Engine shown in isometric view.

1. Cylinder Head Ground Stud
2. Electronic Engine Harness
3. 40-Pin Engine ECM Connector
4. Starter
5. 12V Engine Harness

Fig. 1, C-10/C-12/3176 Engine Harness Routing (isometric view)



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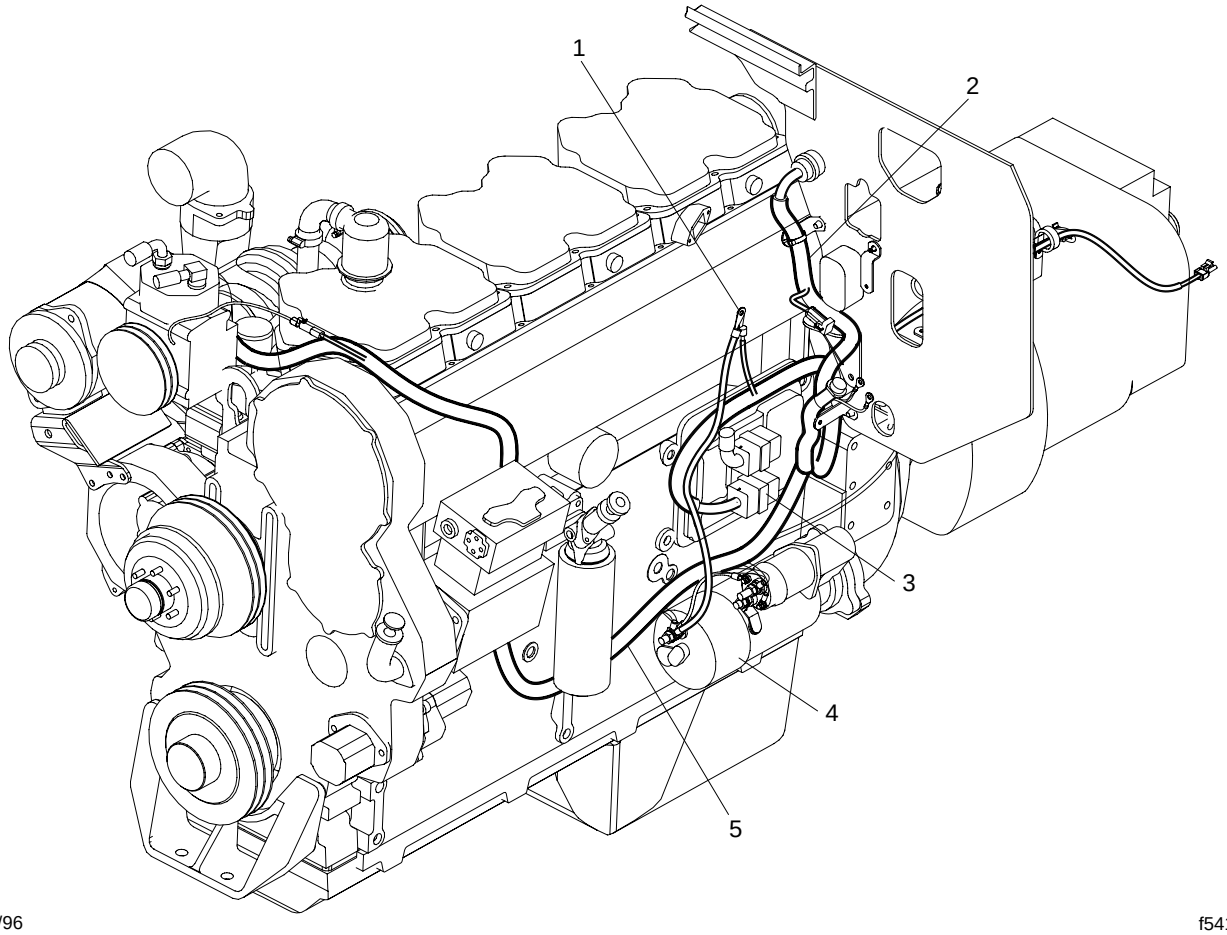
NOTE: Engine shown in top view.

1. Alternator GND Terminal
2. Alternator BAT Terminal
3. Refrigerant Compressor Clutch Connector (circuit 97C)
4. Refrigerant Compressor
5. 12V Engine Harness
6. Electronic Engine Harness
7. Main Power Cable
8. Transmission Temperature Sensor Connector
9. Back-Up Light Connector
10. VSS Connector
11. Transmission

Fig. 2, C-10/C-12/3176 Detailed Engine Harness Routing (top view)

Specifications



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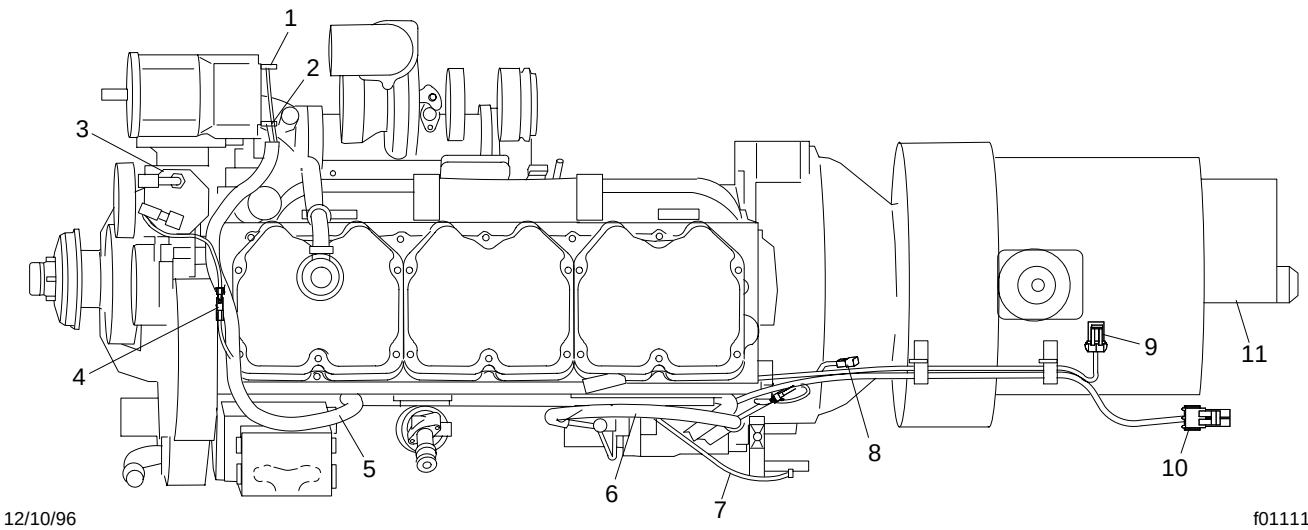
NOTE: Engine shown in isometric view.

1. Cylinder Head Ground Stud
2. Electronic Engine Harness
3. 40-Pin Engine ECM Connector
4. Starter
5. 12V Engine Harness

Fig. 3, 3406 Engine Harness Routing (isometric view)

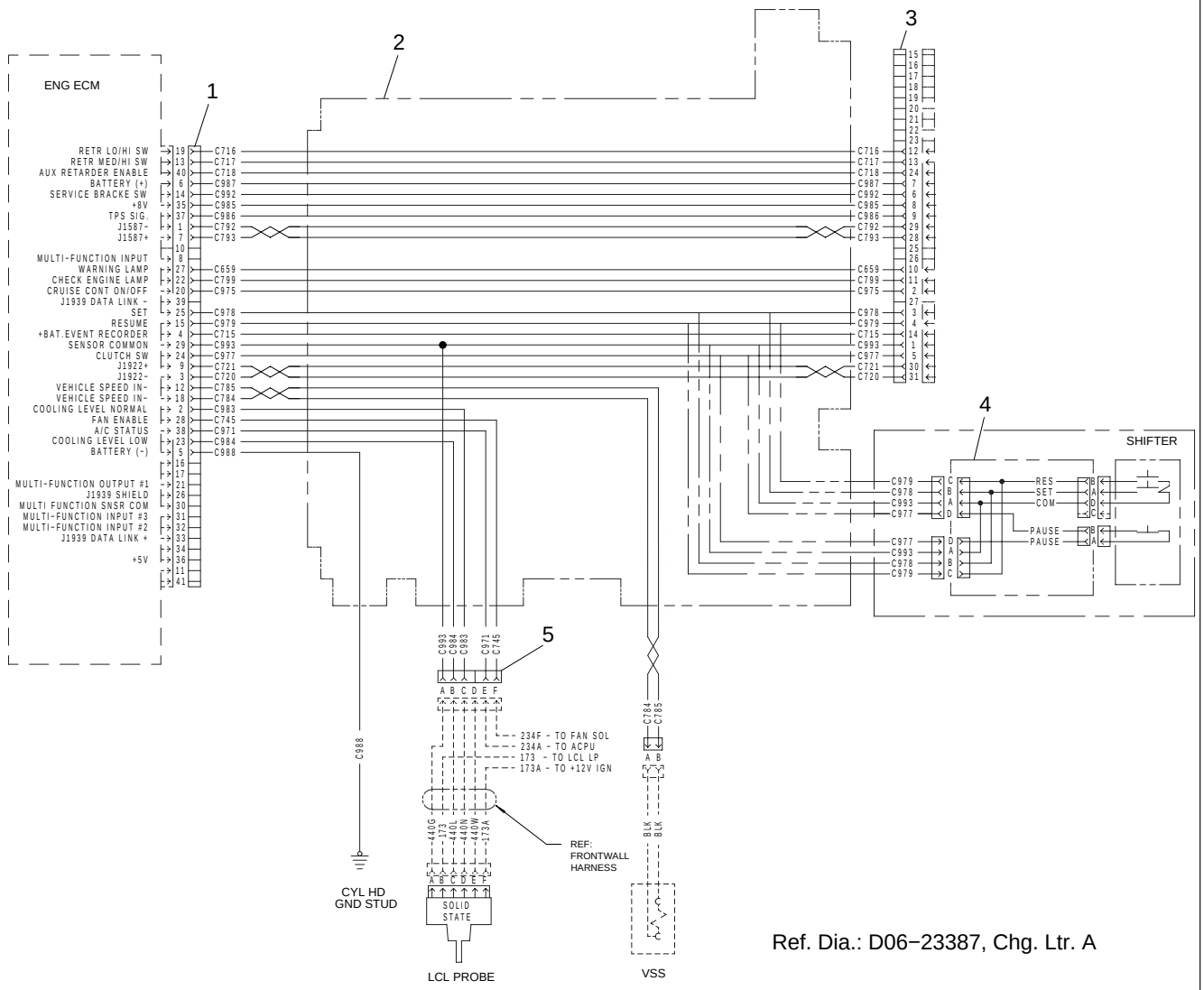


NOTE: Engine shown in top view.

1. Alternator GND Terminal
2. Alternator BAT Terminal
3. Refrigerant Compressor Clutch Connector (circuit 97C)
4. Refrigerant Compressor
5. 12V Engine Harness
6. Electronic Engine Harness
7. Main Power Cable
8. Transmission Temperature Sensor Connector
9. Back-Up Light Connector
10. VSS Connector
11. Transmission

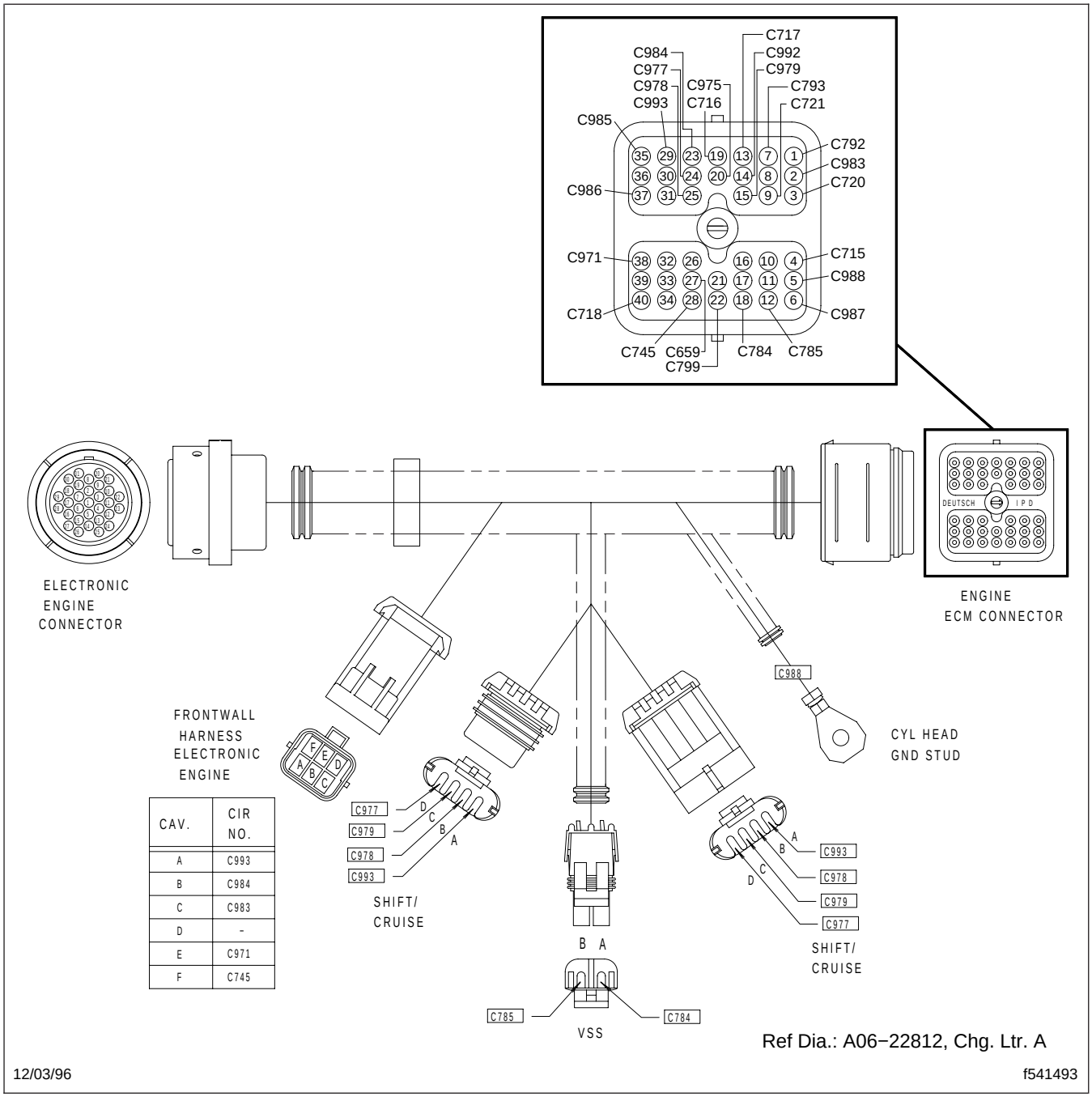
Fig. 4, 3406 Detailed Engine Harness Routing (top view)

Specifications



1. 40-Pin Engine ECM Connector
2. Electronic Engine Harness
3. 31-Pin Electronic Engine Connector
4. Cruise Control Switch (optional—mounted on the shift lever)
5. Frontwall Harness Electronic Engine Connector

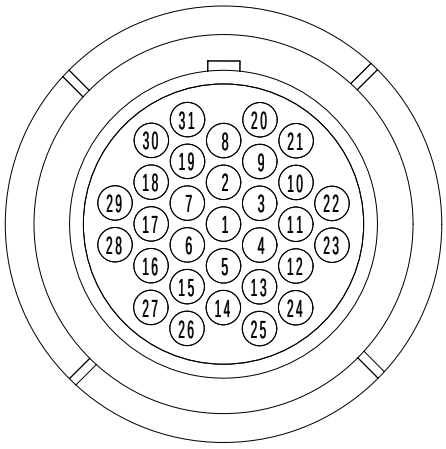
Fig. 5, Electronic Engine Wiring Schematic



CAV.	CIR NO.
A	C993
B	C984
C	C983
D	–
E	C971
F	C745

Fig. 6, Electronic Engine Harness

Specifications



CAV.	WIRE NO.	CAV.	WIRE NO.
1	C993	17	-
2	C975	18	-
3	C978	19	-
4	C979	20	-
5	C977	21	-
6	C992	22	-
7	C987	23	-
8	C985	24	C718
9	C986	25	-
10	C659	26	-
11	C799	27	-
12	C716	28	C793
13	C717	29	C792
14	C715	30	C721
15	-	31	C720
16	-	-	-

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NOTE: The cab interface is on the engine side of the frontwall.

Fig. 7, 31-Pin Electronic Engine Connector (cab interface)

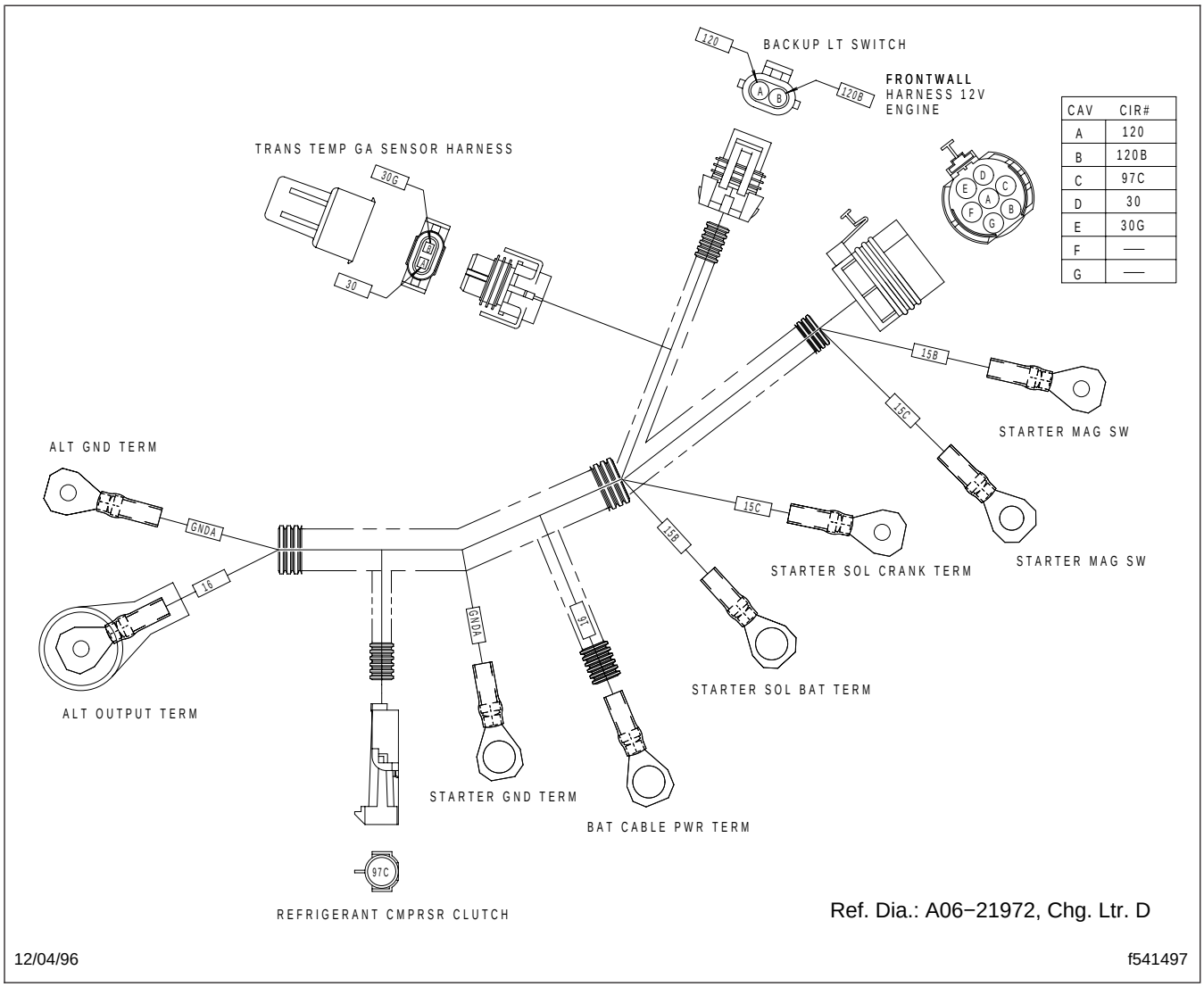
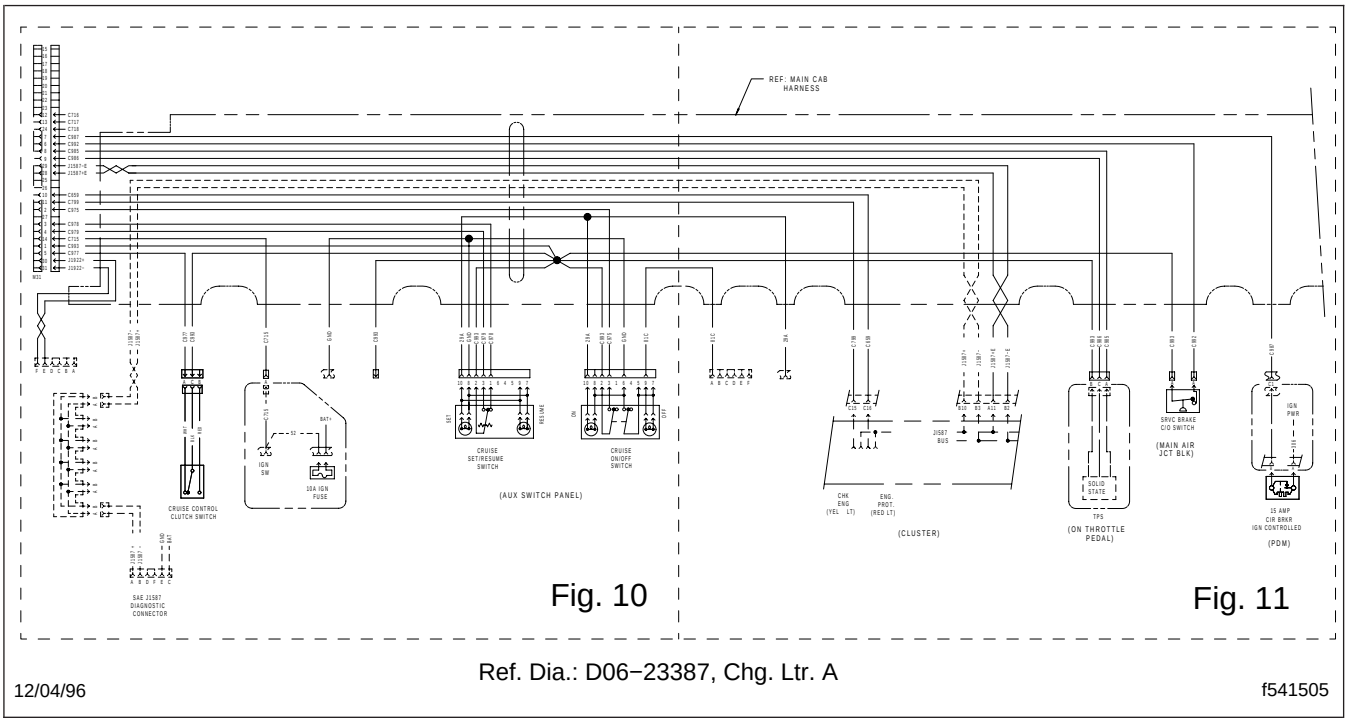


Fig. 8, 12V Engine Harness

Specifications



Ref. Dia.: D06−23387, Chg. Ltr. A

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Fig. 9, Main Cab Harness Wiring Schematic, Electronic Engine Overlay for Caterpillar Engines

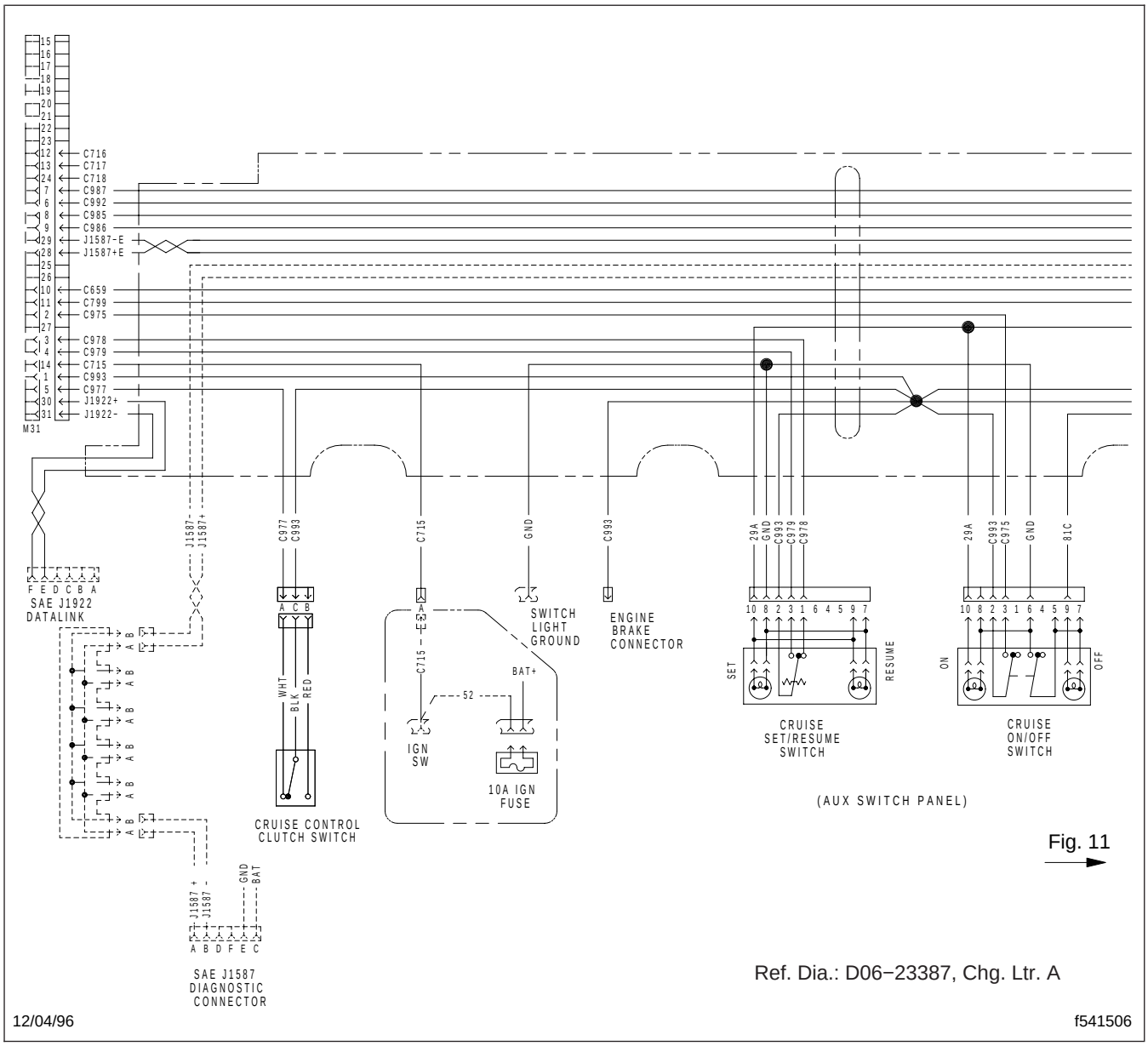


Fig. 10, Main Cab Harness Wiring Schematic, Electronic Engine Overlay for Caterpillar Engines (detailed view)

Specifications

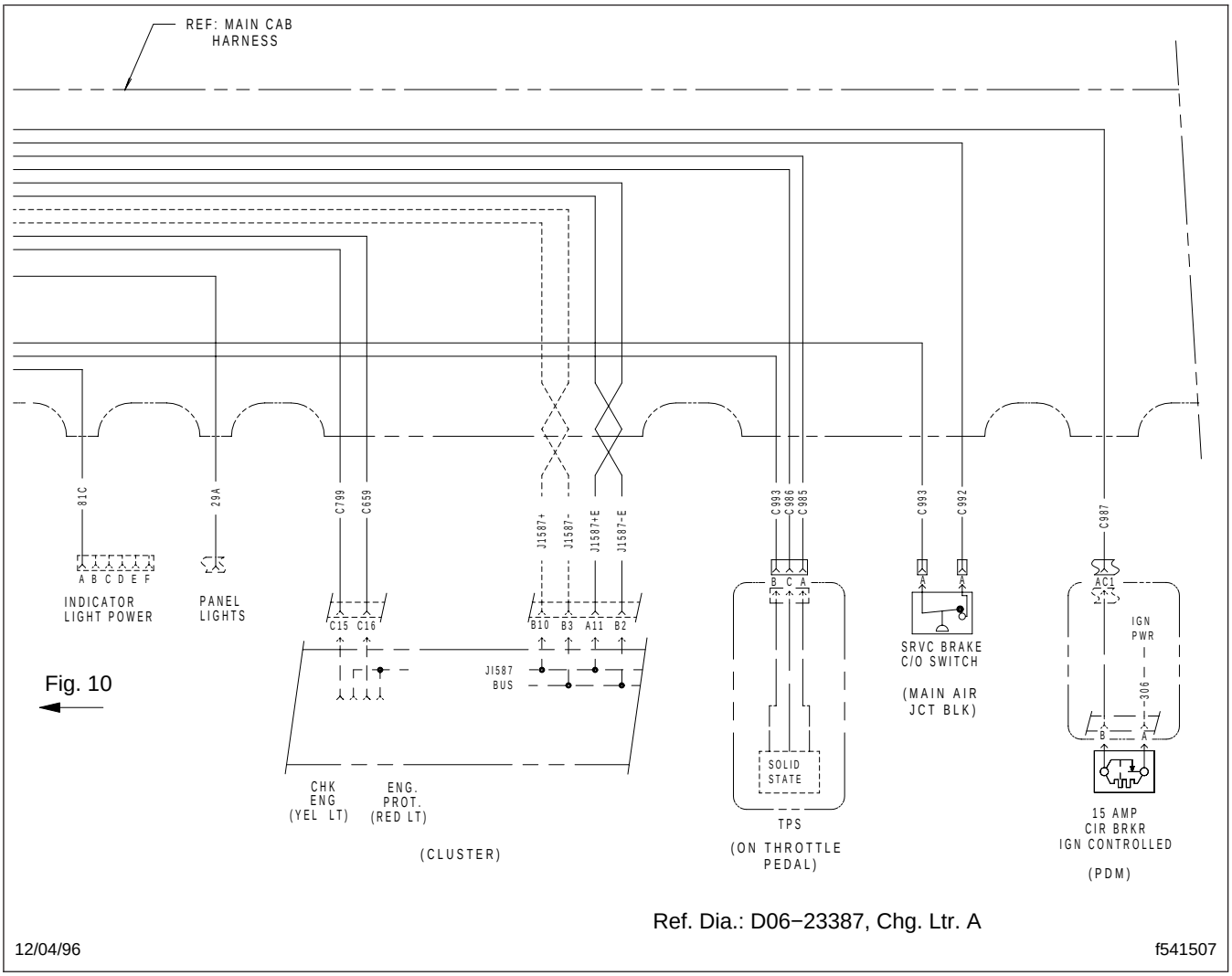
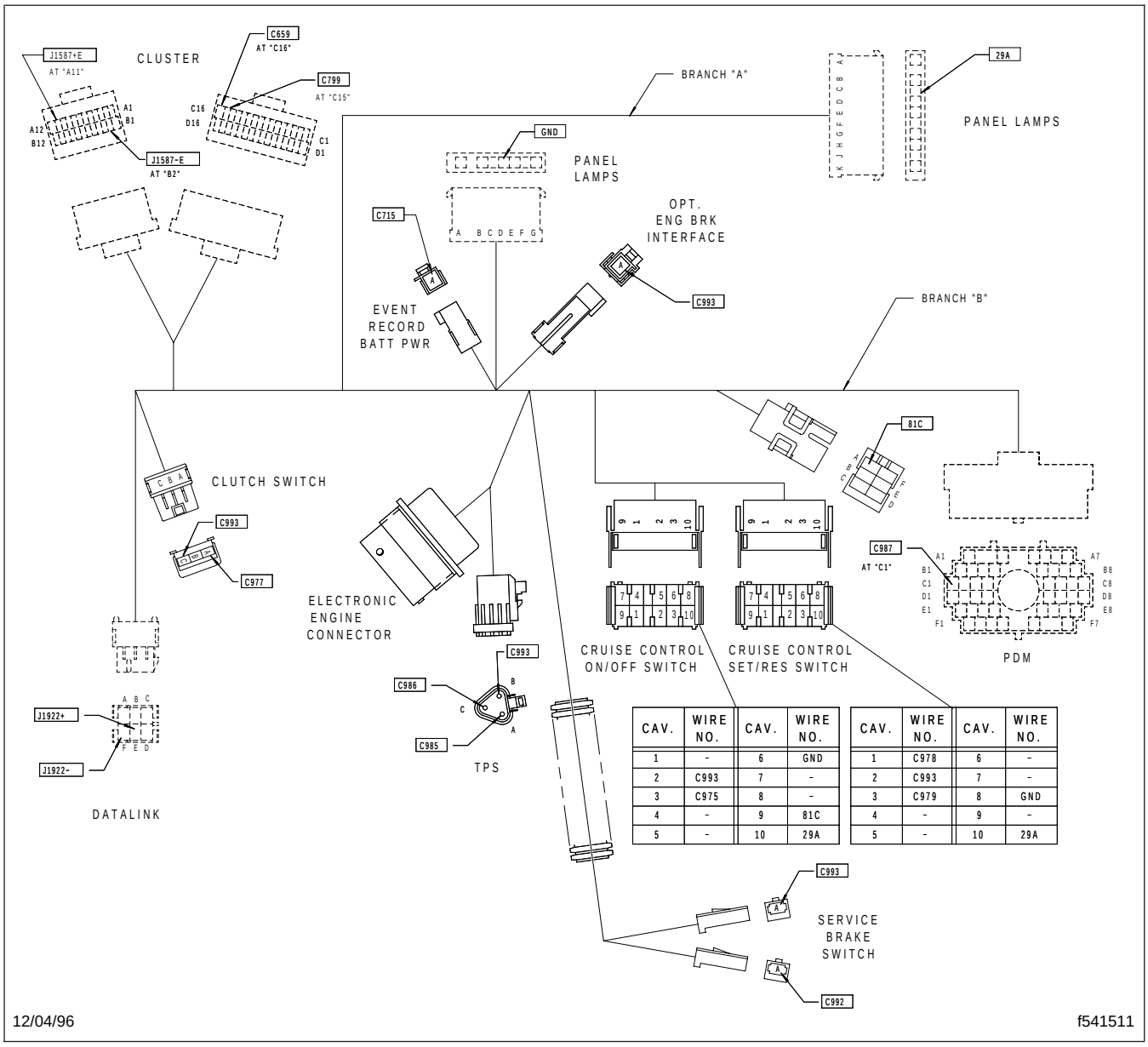


Fig. 11, Main Cab Harness Wiring Schematic, Electronic Engine Overlay for Caterpillar Engines (detailed view)

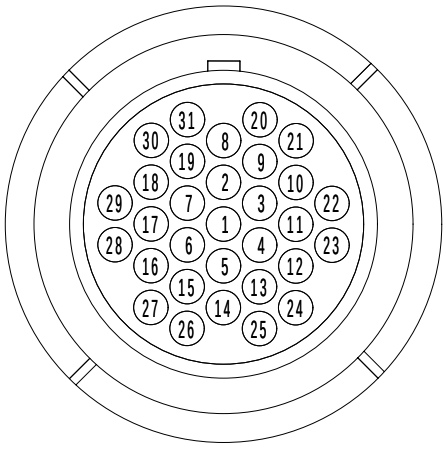


CAV.	WIRE NO.	CAV.	WIRE NO.
1	–	6	GND
2	C993	7	–
3	C975	8	–
4	–	9	81C
5	–	10	29A

CAV.	WIRE NO.	CAV.	WIRE NO.
1	C978	6	–
2	C993	7	–
3	C979	8	GND
4	–	9	–
5	–	10	29A

Fig. 12, Main Cab Harness Drawing, Electronic Engine Overlay for Caterpillar Engines

Specifications



CAV.	WIRE NO.	CAV.	WIRE NO.
1	C993	17	-
2	C975	18	-
3	C978	19	-
4	C979	20	-
5	C977	21	-
6	C992	22	-
7	C987	23	-
8	C985	24	-
9	C986	25	-
10	C659	26	-
11	C799	27	-
12	-	28	J1587+E
13	-	29	J1587-E
14	C715	30	J1922+
15	-	31	J1922-
16	-	-	-

12/03/96 f541522

NOTE: The engine interface is on the cab side of the frontwall.

Fig. 13, 31-Pin Electronic Engine Connector (engine interface)

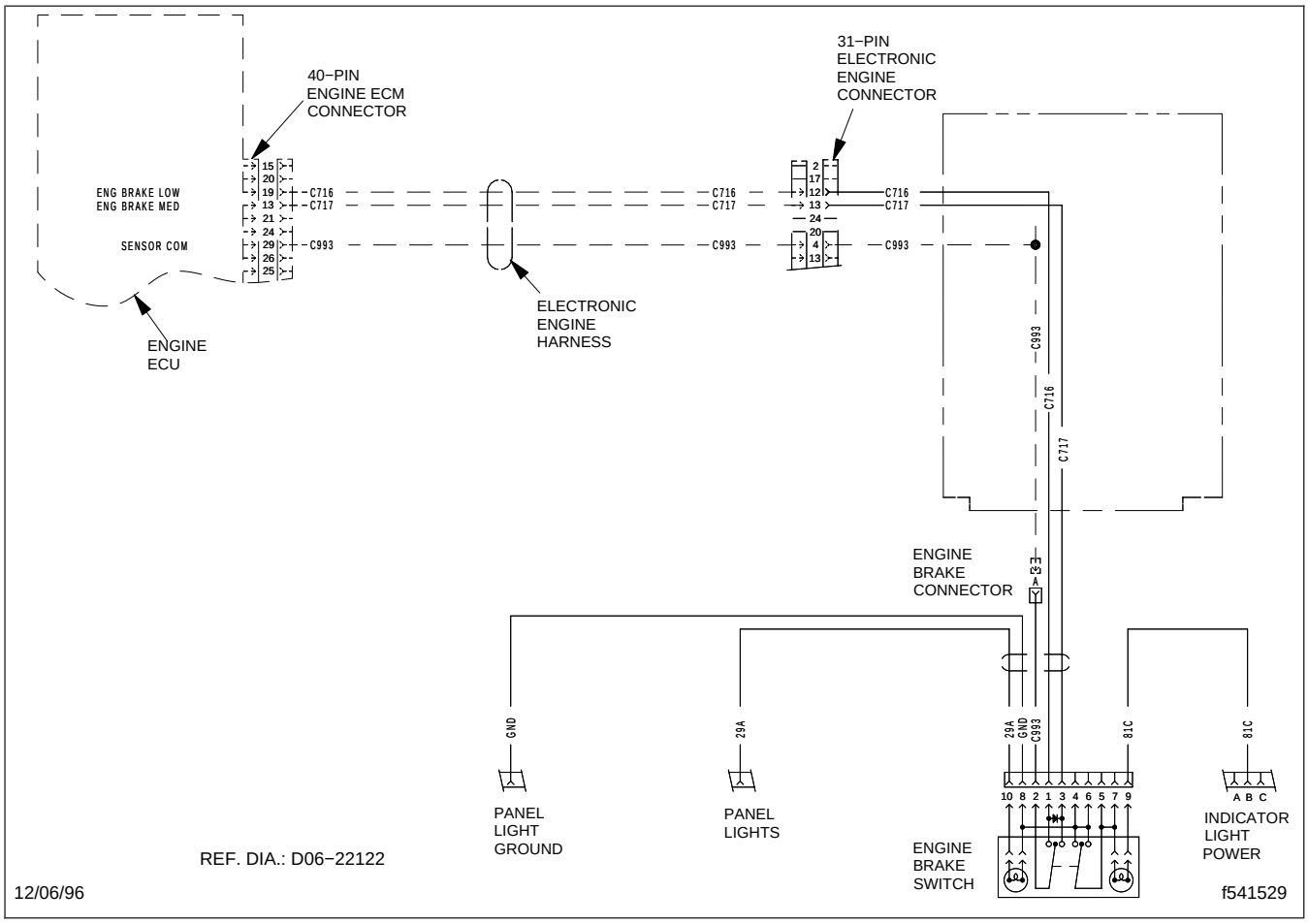
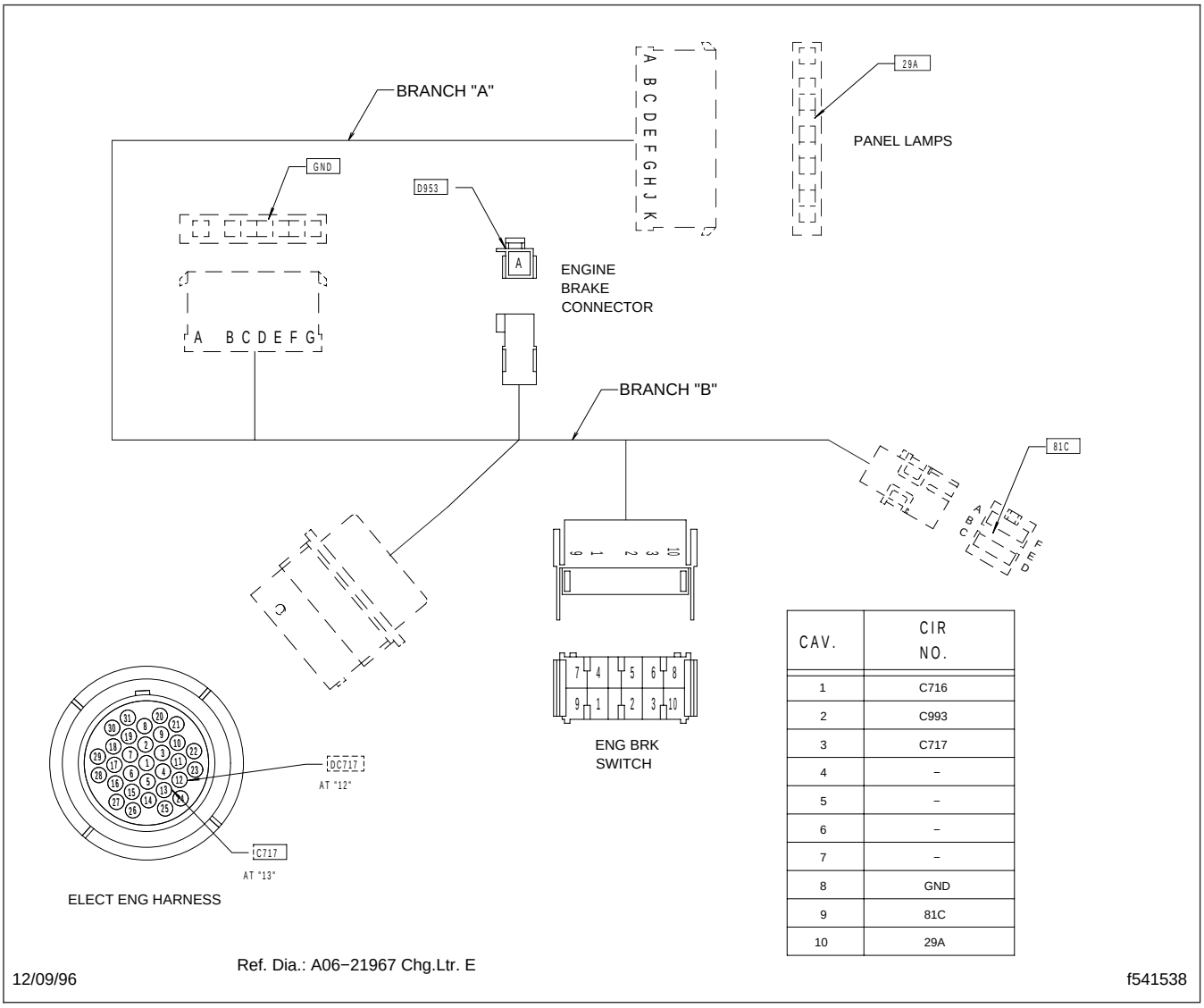


Fig. 14, Engine Brake Wiring Schematic

Specifications



CAV.	CIR NO.
1	C716
2	C993
3	C717
4	–
5	–
6	–
7	–
8	GND
9	81C
10	29A

Fig. 15, Engine Brake Harness Drawing

Specifications

Freightliner supplies two principal wiring harnesses to each engine. The 12-volt (12V) engine harness supplies alternator power to the starter and various appliances. The electronic engine harness communicates data between the electronic control module (ECM), various data-gathering devices, and the cab information systems. In addition, a power harness supplies battery power to the engine ECM.

For a view of the harness routing for the N14 engine, see **Fig. 1**.

For detailed harness routing for the N14 engine, see **Fig. 2**.

For a view of the harness routing for the M11 engine, see **Fig. 3**.

For detailed harness routing for the M11 engine, see **Fig. 4**.

For a schematic of the electronic engine and power harness wiring, see **Fig. 5**. For a detailed view of the power harness and engine ECM end of the electronic engine harness, see **Fig. 6**. For a detailed view of the cab interface (electronic engine connector) end of the electronic engine harness, see **Fig. 7**.

For a drawing of the electronic engine harness, see **Fig. 8**. For a detailed diagram and table showing the pin cavities and wire numbers assigned to the three major multi-pin connectors on this harness, see the following:

- For the 28-pin engine ECM connector, see **Fig. 9**.
- For the 21-pin engine ECM connector, see **Fig. 10**.
- For the 31-pin electronic engine connector at the cab interface, see **Fig. 11**.

NOTE: The cab interface of the electronic engine connector is located on the engine side of the frontwall.

For a drawing of the 12V engine harness, see **Fig. 12**.

For a drawing of the power harness, see **Fig. 13**.

The circuitry going to the other side of the frontwall passes through the electronic engine connector into the main cab harness as an electronic engine overlay for the Cummins engines. For a schematic of the electronic engine overlay for the main cab harness, see **Fig. 14**. For a detailed view of the engine overlay wiring, see **Fig. 15** and **Fig. 16**.

For a drawing of the electronic engine overlay for the main cab harness, see **Fig. 17**. For a detailed diagram and table showing the pin cavities and wire numbers assigned to the 31-pin electronic engine connector at the engine interface, see **Fig. 18**.

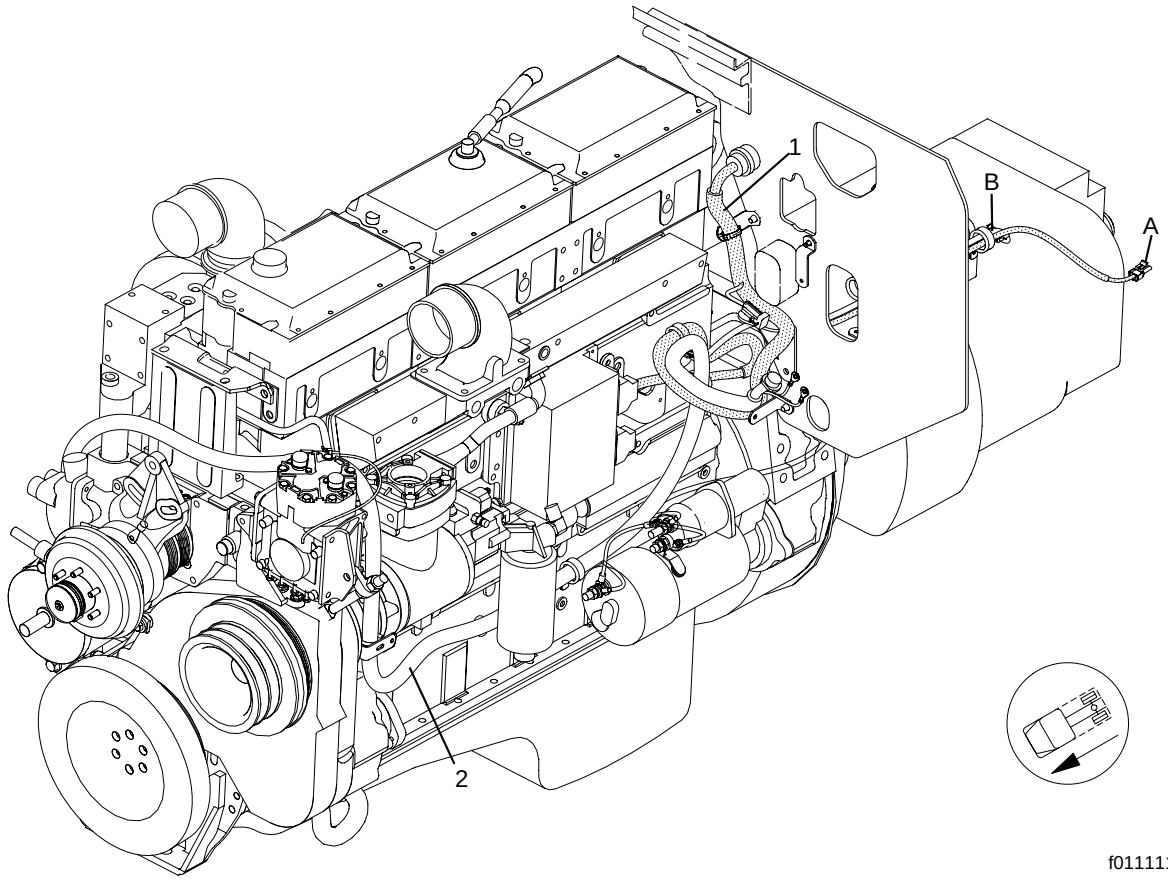
NOTE: The engine interface of the electronic engine connector is located on the cab side of the frontwall. Since some of the wiring numbers are different on the cab side, this connector is shown twice, once from each end. For the wiring on the engine side, see **Fig. 11**.

For engine brake wiring, see **Fig. 15** and **Fig. 16**.

CAUTION

Before performing any electric welding on a vehicle, disconnect the battery power and ground cables and the engine electronic control module (ECM) electrical connector at the ECM. See Fig. 5, Fig. 6, Fig. 9, and Fig. 10. Electric currents produced during electric welding can damage various electronic components on the vehicle.

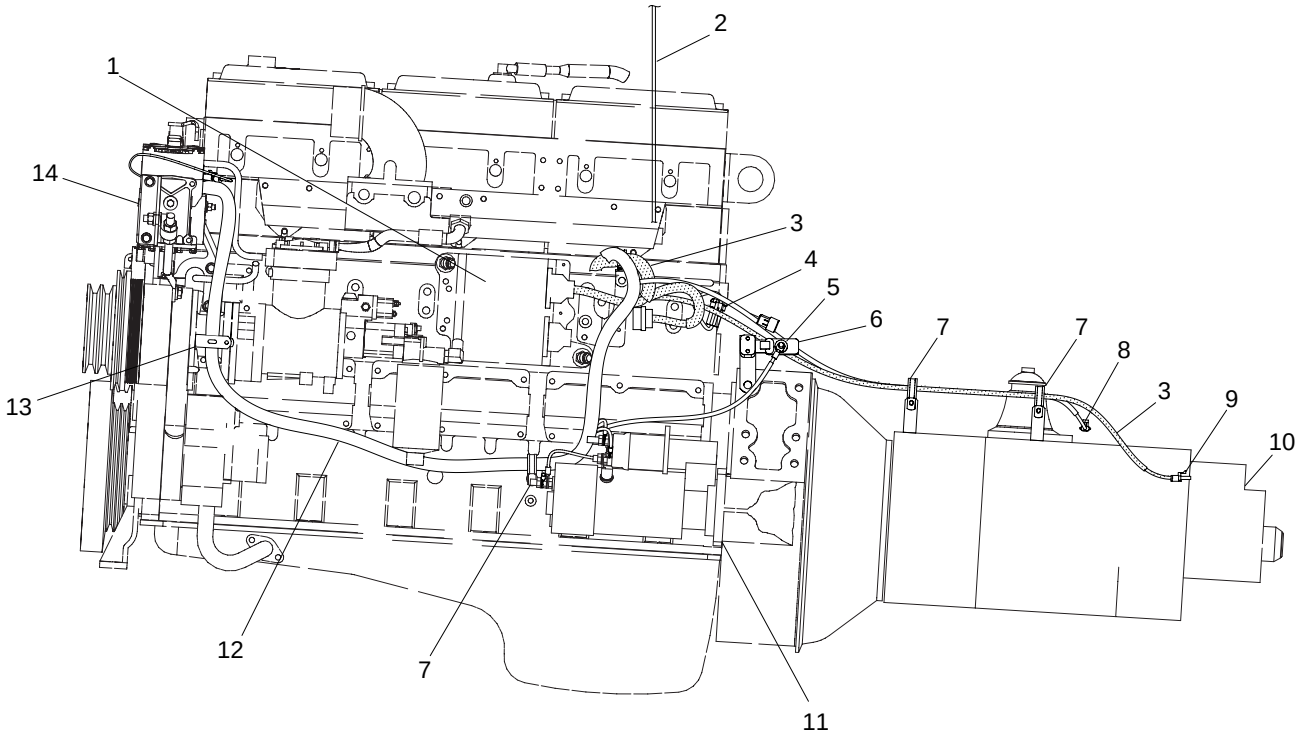
Specifications



NOTE: Engine shown in isometric view.

A. To Vehicle Speed Sensor (VSS)
B. To Back-Up Light Switch
1. Electronic Engine Harness
2. 12V Engine Harness

Fig. 1, N14 Engine Harness Routing



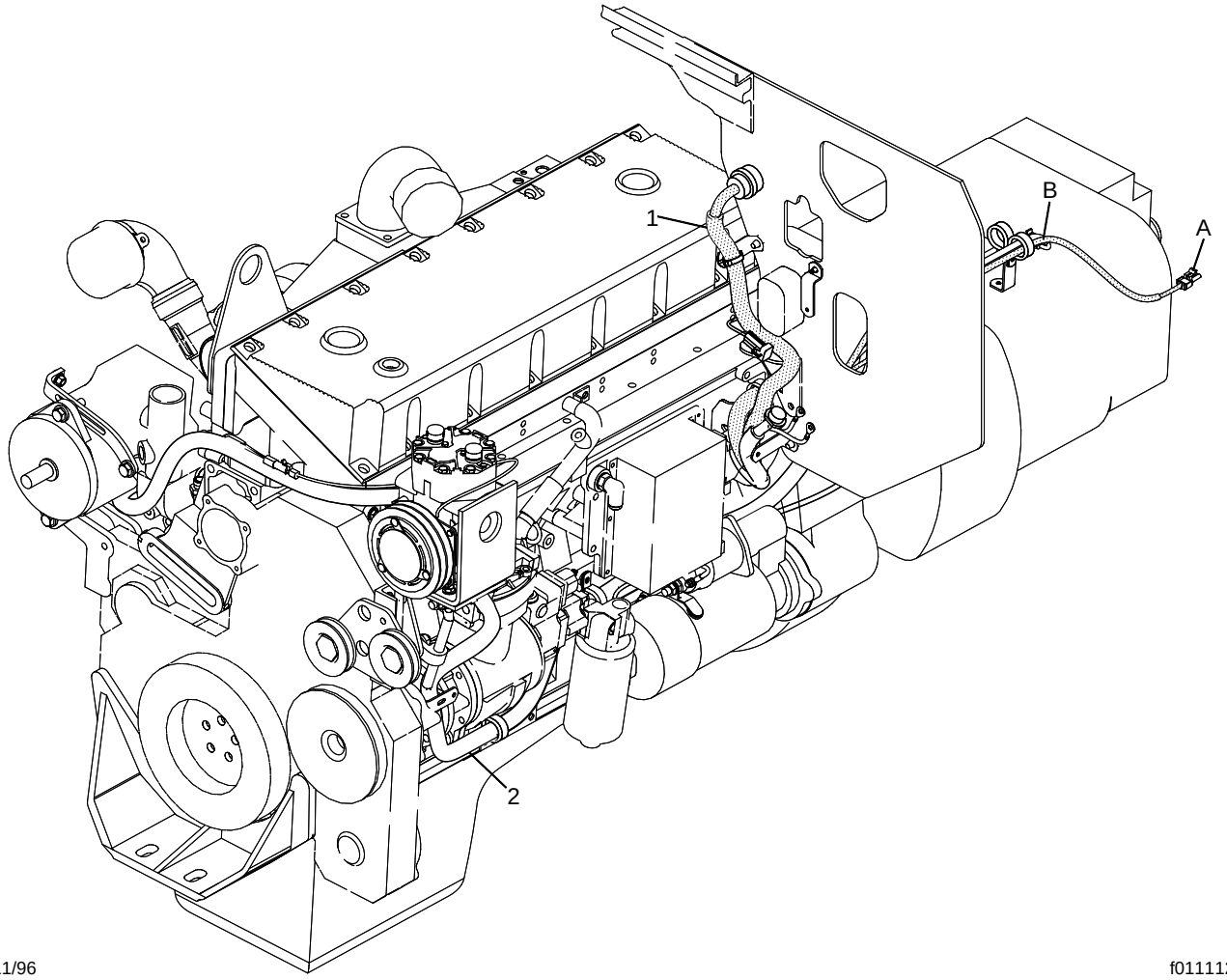
11/26/96 f541521

NOTE: Engine shown in side view.
12V engine harness attaches to alternator (not shown).

1. Engine ECM
2. Location of Frontwall (for reference)
3. Electronic Engine Harness
4. Shift Connector (to shift lever)
5. Main Power Cables (circuit 16)
6. Battery +12V Power Terminal
7. Hose Clamp
8. Back-Up Light Connector
9. VSS Connector
10. Transmission
11. Starter
12. 12V Engine Harness
13. Standoff Bracket
14. Refrigerant Compressor

Fig. 2, Detailed N14 Engine Harness Routing

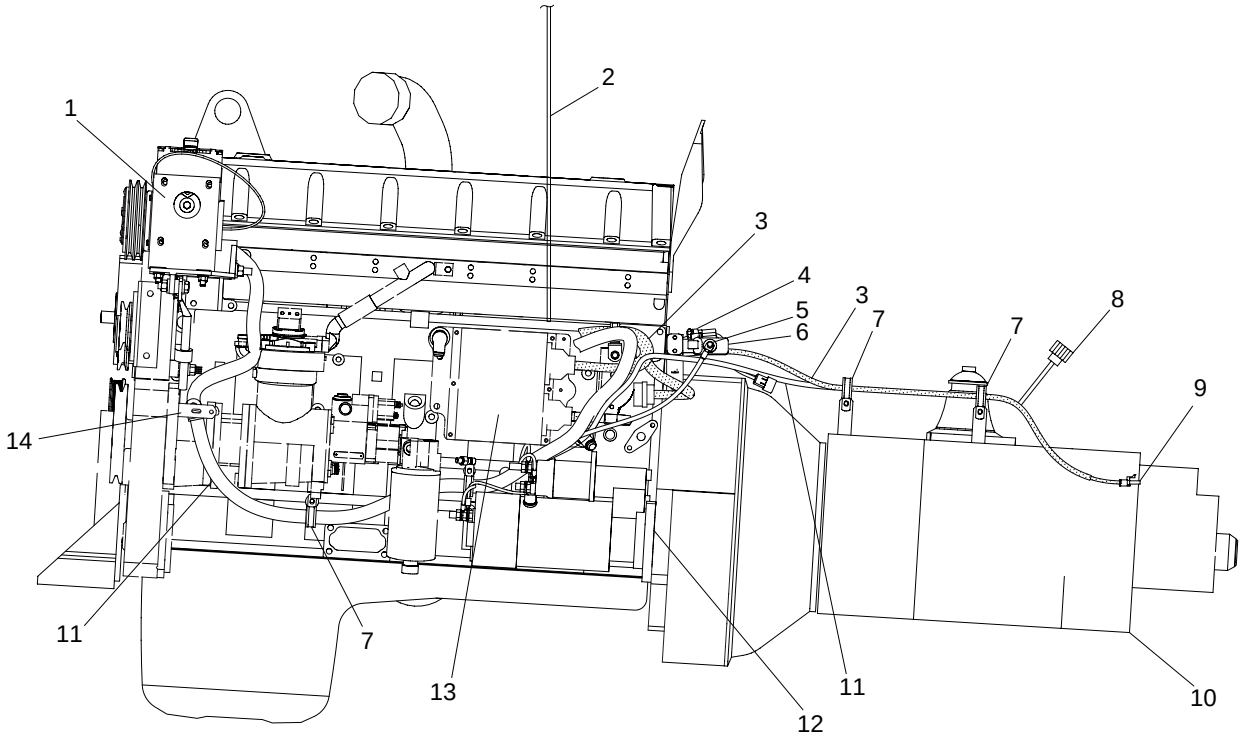
Specifications



NOTE: Engine shown in isometric view.

A. To Vehicle Speed Sensor (VSS)
B. To Back-Up Light Switch
1. Electronic Engine Harness
2. 12V Engine Harness

Fig. 3, M11 Engine Harness Routing



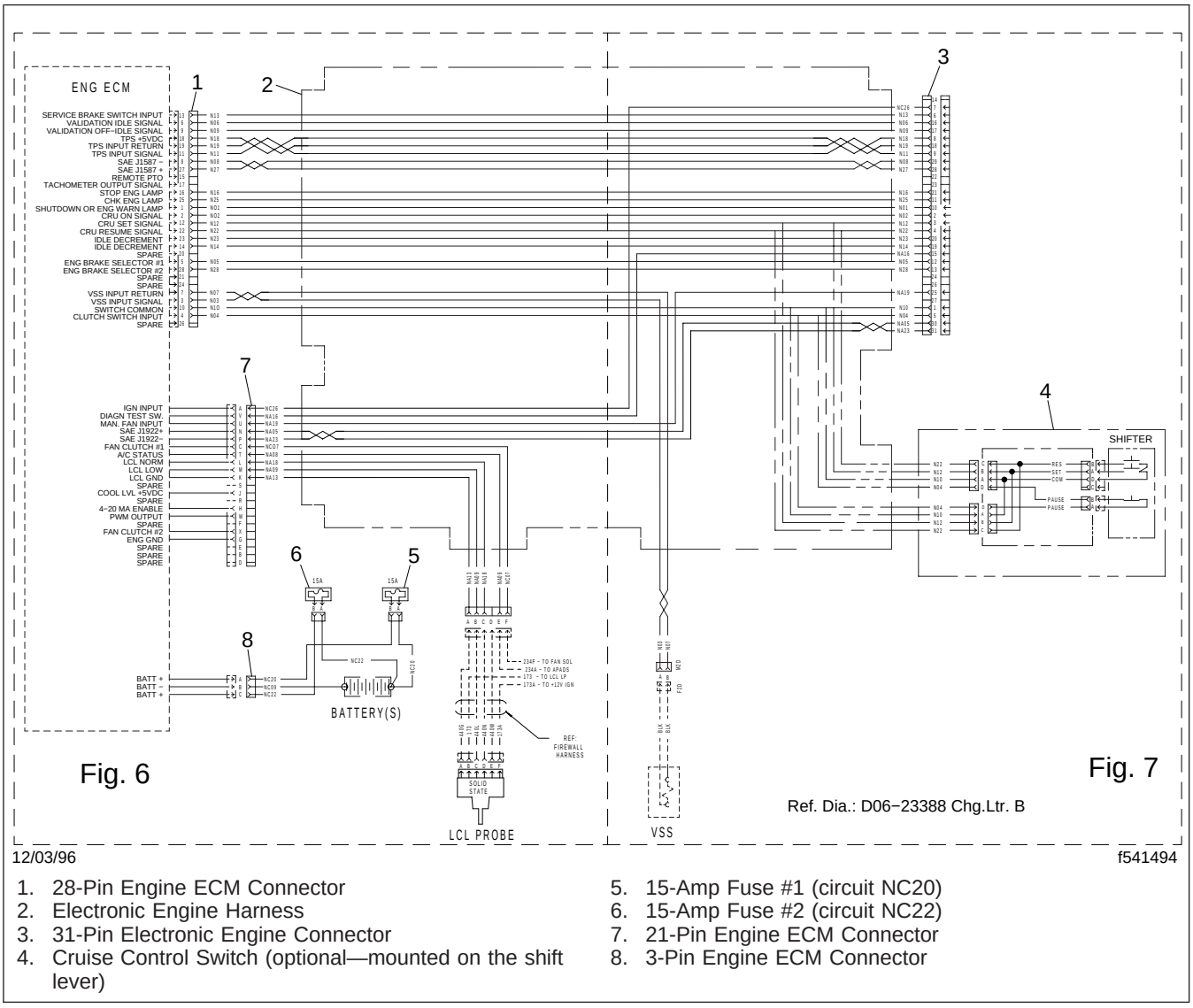
12/03/96 f541520

NOTE: Engine shown in side view.
12V engine harness attaches to alternator (not shown).

1. Refrigerant Compressor
2. Location of Frontwall (for reference)
3. Electronic Engine Harness
4. Shift Connector (to shift lever)
5. Main Power Cables (circuit 16)
6. Battery +12V Power Terminal
7. Hose Clamp
8. Back-Up Light Connector
9. VSS Connector
10. Transmission
11. 12V Engine Harness
12. Starter
13. Engine ECM
14. Standoff Bracket

Fig. 4, Detailed M11 Engine Harness Routing

Specifications



1. 28-Pin Engine ECM Connector
2. Electronic Engine Harness
3. 31-Pin Electronic Engine Connector
4. Cruise Control Switch (optional—mounted on the shift lever)
5. 15-Amp Fuse #1 (circuit NC20)
6. 15-Amp Fuse #2 (circuit NC22)
7. 21-Pin Engine ECM Connector
8. 3-Pin Engine ECM Connector

Fig. 5, Electronic Engine and Power Harness Wiring Schematic

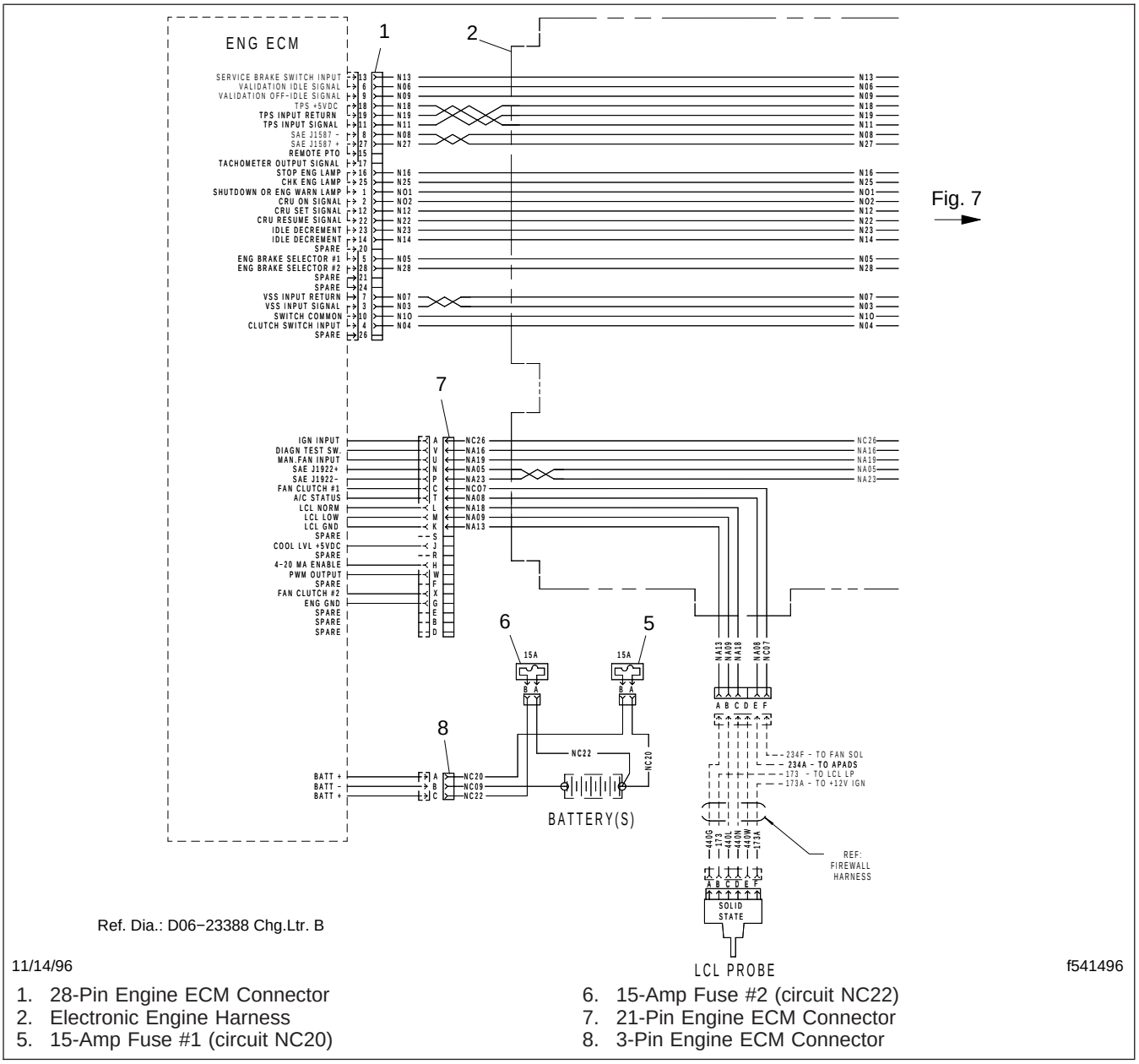


Fig. 7

Ref. Dia.: D06−23388 Chg.Ltr. B

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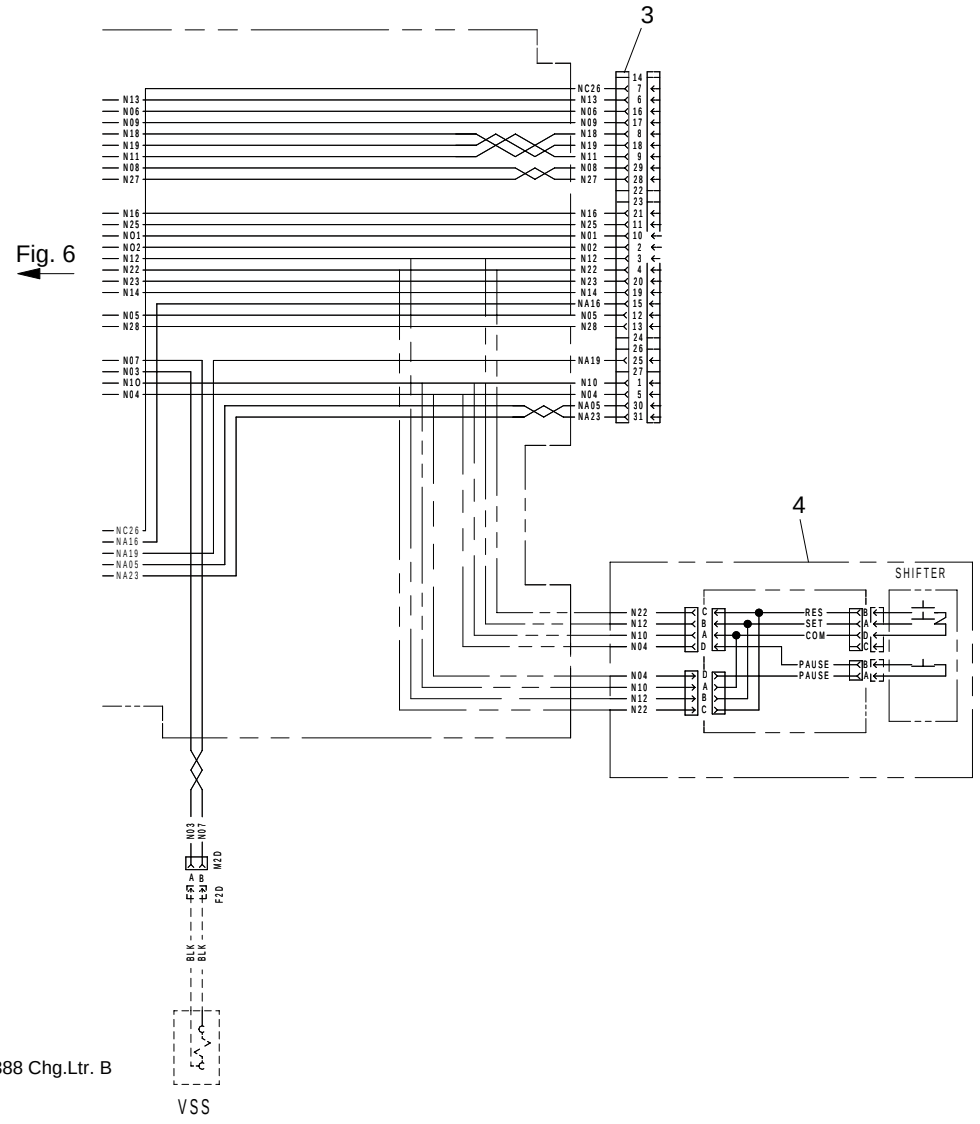
f541496

1. 28-Pin Engine ECM Connector
2. Electronic Engine Harness
5. 15-Amp Fuse #1 (circuit NC20)
6. 15-Amp Fuse #2 (circuit NC22)
7. 21-Pin Engine ECM Connector
8. 3-Pin Engine ECM Connector

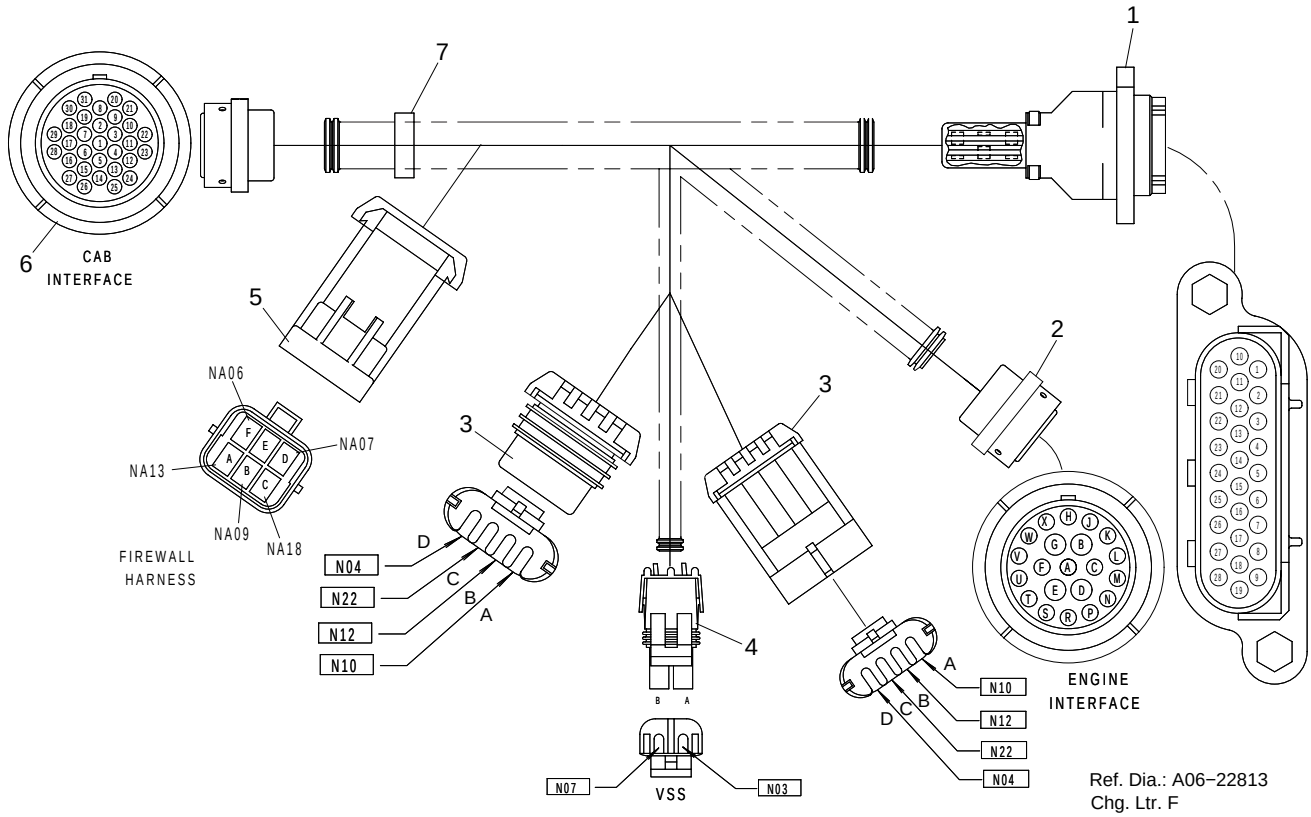
Fig. 6, Electronic Engine and Power Harness Wiring Schematic (detailed view of engine ECM side)

Specifications



3. 31-Pin Electronic Engine Connector
4. Cruise Control Switch (optional—mounted on the shift lever)

Fig. 7, Electronic Engine and Power Harness Wiring Schematic (detailed view of cab interface end)



NOTE: For detail of the 28-pin engine ECM connector, see **Fig. 9**.

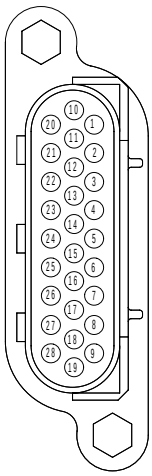
For detail of the 21-pin engine ECM connector, see **Fig. 10**.

For detail of the 31-pin electronic engine connector (cab interface), see **Fig. 11**.

1. 28-Pin Engine ECM Connector
2. 21-Pin Engine ECM Connector
3. Shift/Cruise Connector (optional)
4. VSS
5. Frontwall Harness Connector
6. 31-Pin Electronic Engine Connector (cab interface)
7. Connector Clamp

Fig. 8, Electronic Engine Harness

Specifications



CAV.	CIR NO.	CAV.	CIR NO.	CAV.	CIR NO.
1	N01	11	N11	21	–
2	N02	12	N12	22	N22
3	N03	13	N13	23	N23
4	N04	14	N14	24	–
5	N05	15	–	25	N25
6	N06	16	N16	26	–
7	N07	17	–	27	N27
8	N08	18	N18	28	N28
9	N09	19	N19		
10	N10	20	–		

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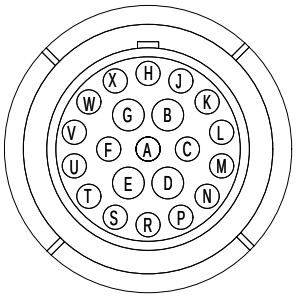
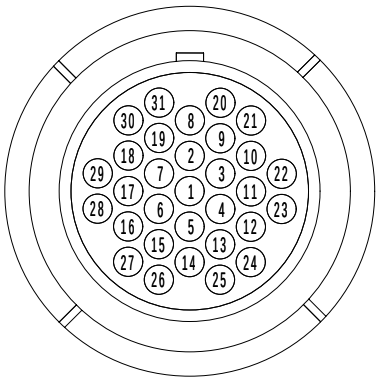
Fig. 9, 28-Pin Engine ECM Connector



CAV.	CIR NO.	CAV.	CIR NO.	CAV.	CIR NO.
A	NC26	H	–	R	–
B	–	J	–	S	–
C	NC07	K	NA13	T	NA08
D	–	L	NA18	U	NA19
E	–	M	NA09	V	NA16
F	–	N	NA23	W	–
G	–	P	NA05	X	–

11/14/96 f541504

Fig. 10, 21-Pin Engine ECM Connector



CAV.	CIR NO.	CAV.	CIR NO.	CAV.	CIR NO.
1	N10	12	N05	23	–
2	N02	13	N28	24	–
3	N12	14	–	25	NA19
4	N22	15	NA16	26	–
5	N04	16	N06	27	–
6	N13	17	N09	28	N27
7	NC26	18	N19	29	N08
8	N18	19	N14	30	NA05
9	N11	20	N23	31	NA23
10	N01	21	N16		
11	N25	22	–		

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NOTE: The cab interface is on the engine side of the frontwall.

Fig. 11, 31-Pin Electronic Engine Connector (cab interface)

Specifications

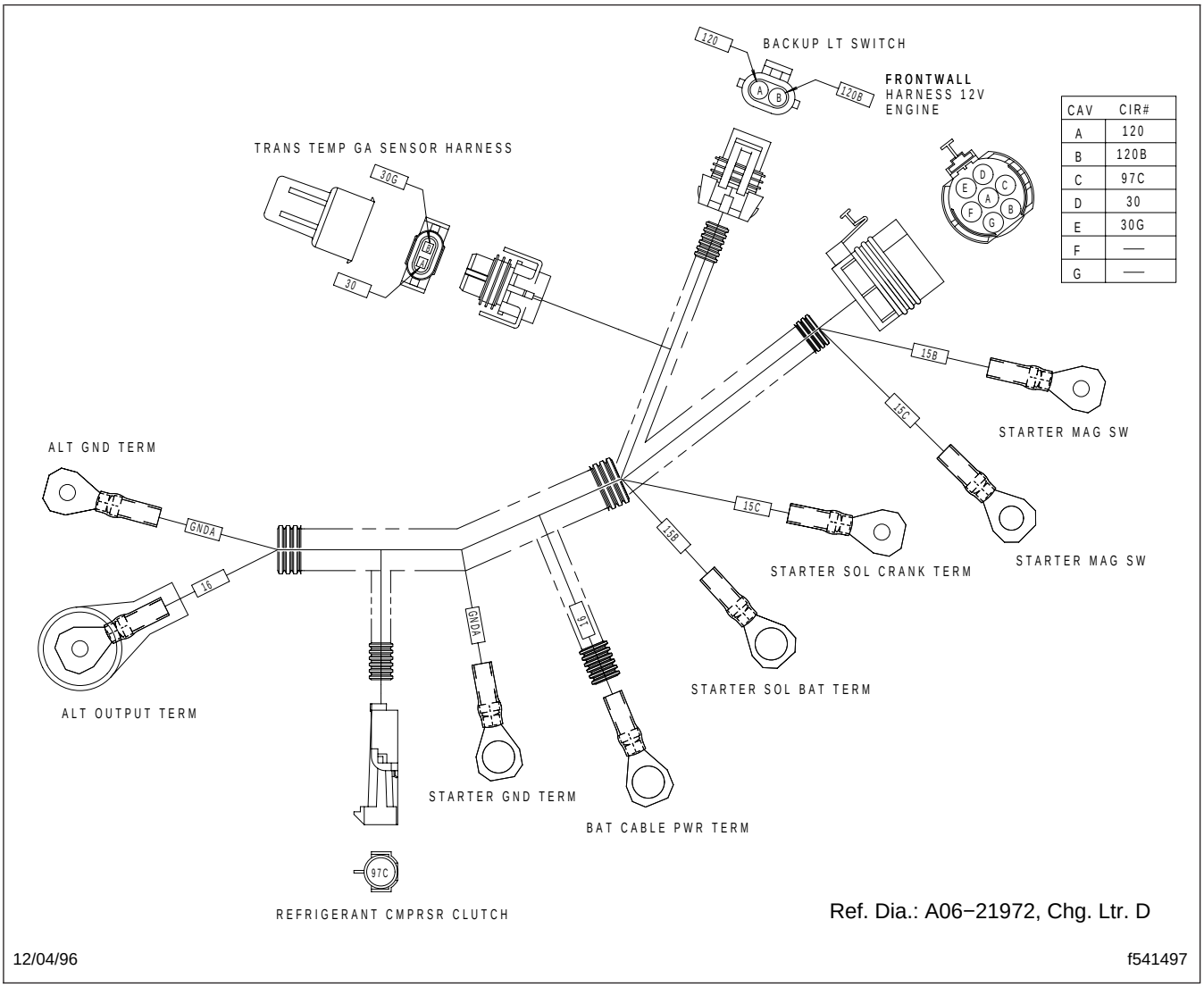
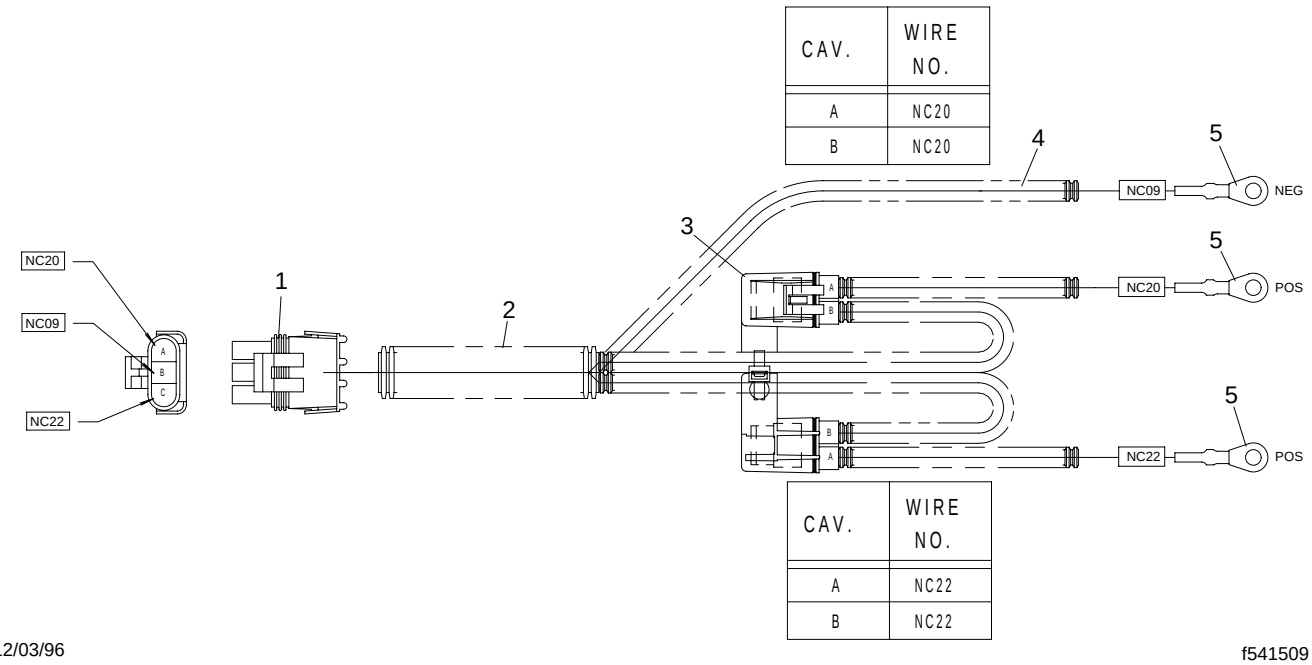


Fig. 12, 12V Engine Harness



1. 3-Pin Engine ECM Connector
2. 3/4-Inch Convoluted Tubing
3. 15-Amp Fuse
4. 1/4-Inch Convoluted Tubing
5. Battery Ring Terminal

Fig. 13, Power Harness

Specifications

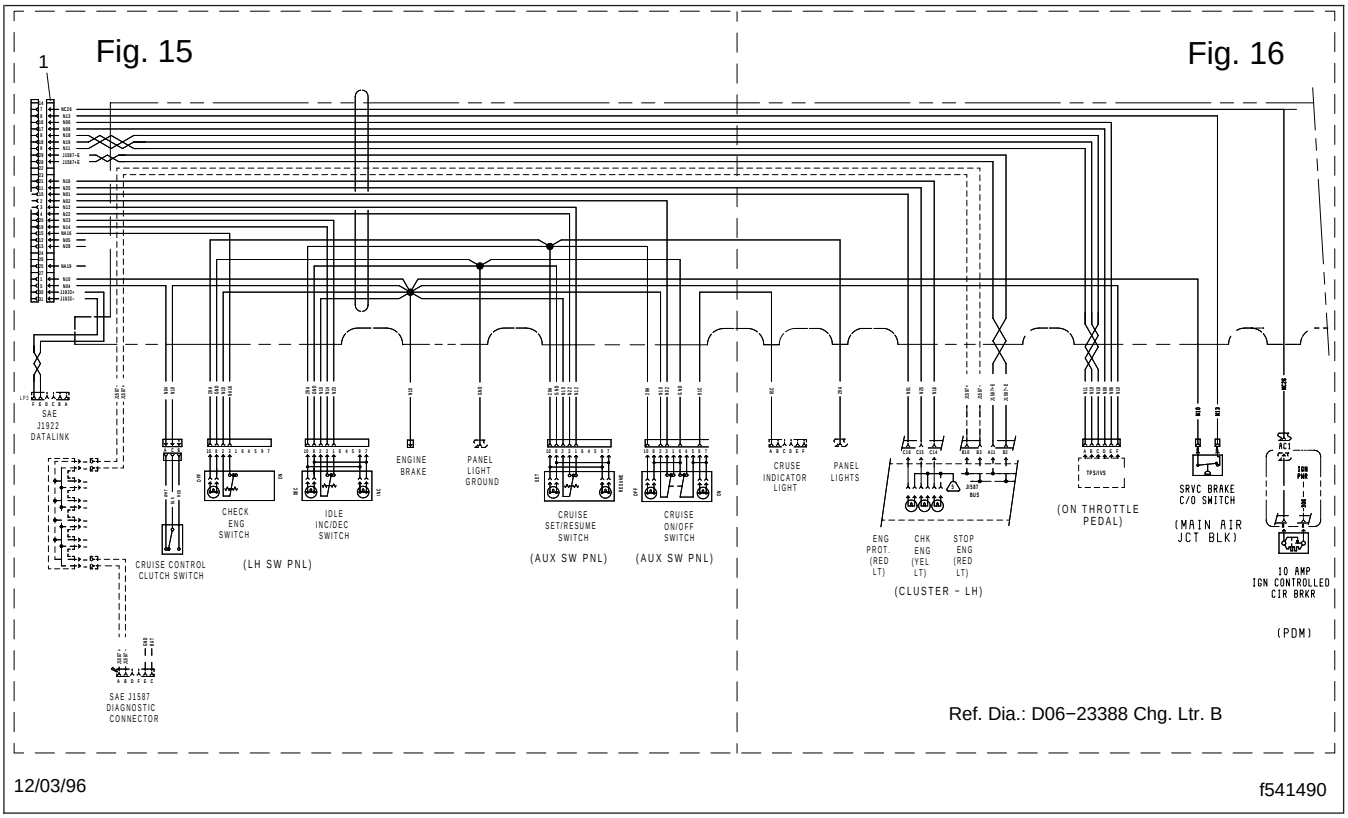


Fig. 14, Main Cab Harness Wiring Schematic, Electronic Engine Overlay for Cummins Engines

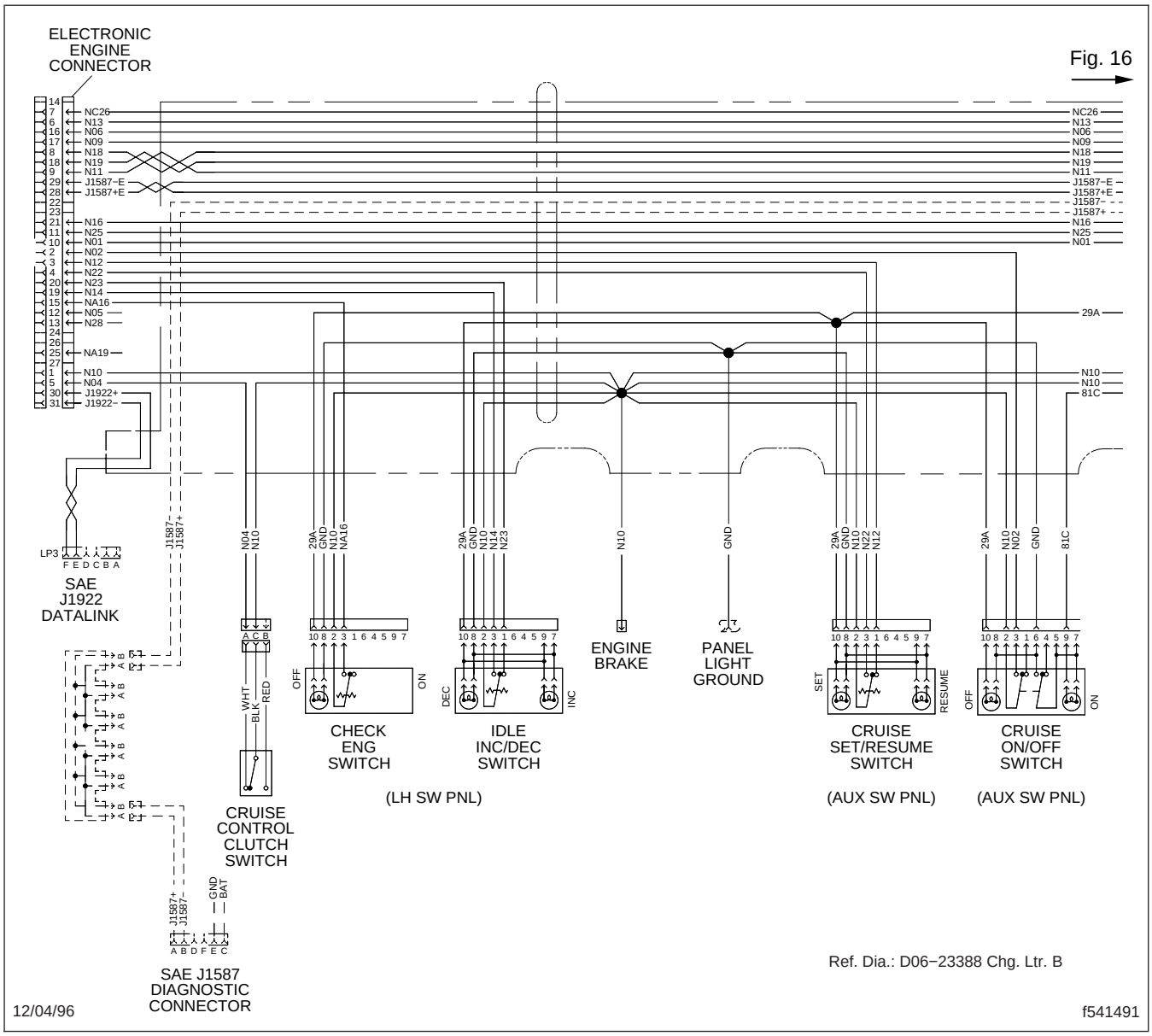


Fig. 15, Main Cab Harness Wiring Schematic, Electronic Engine Overlay for Cummins Engines (detailed view)

Specifications

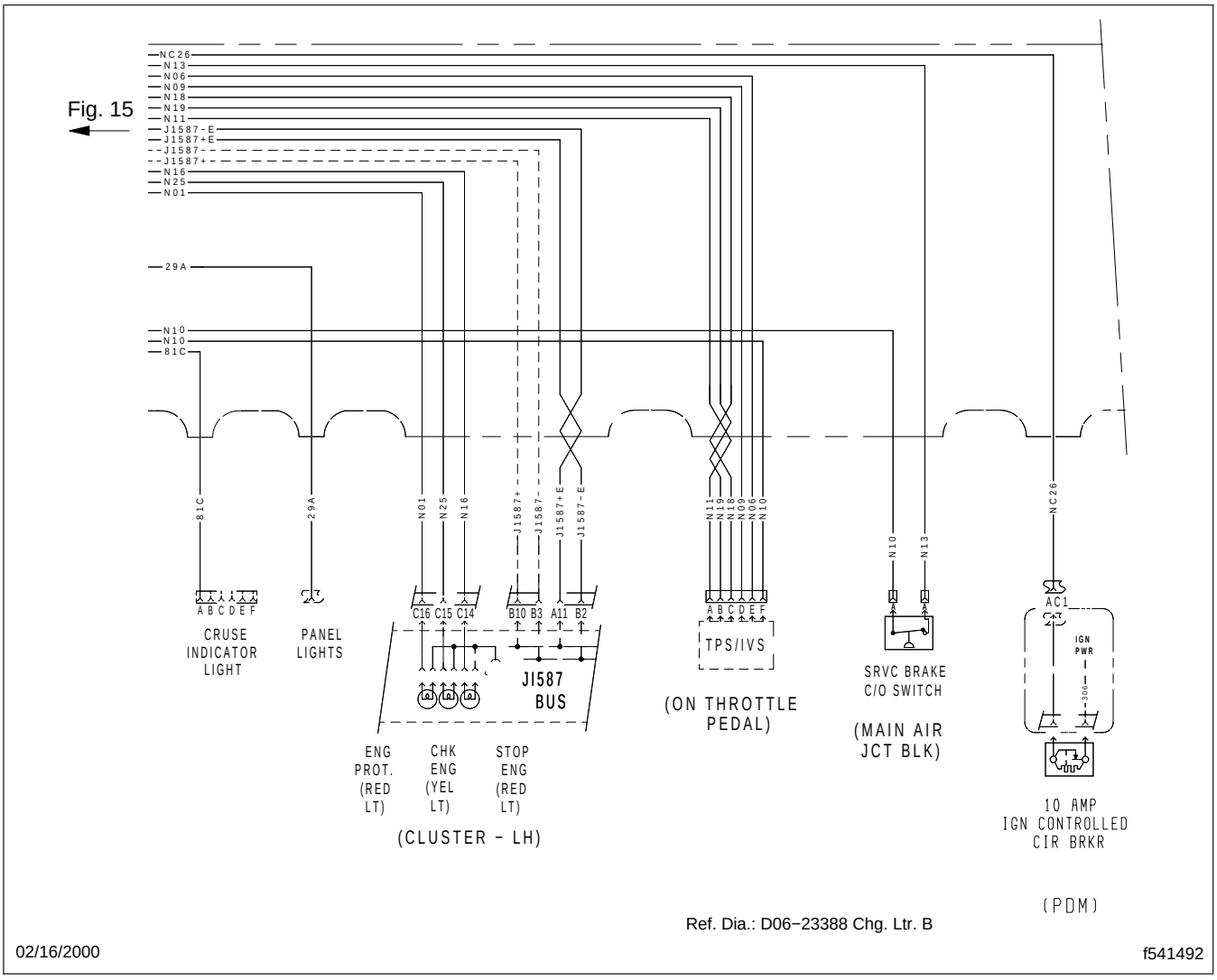
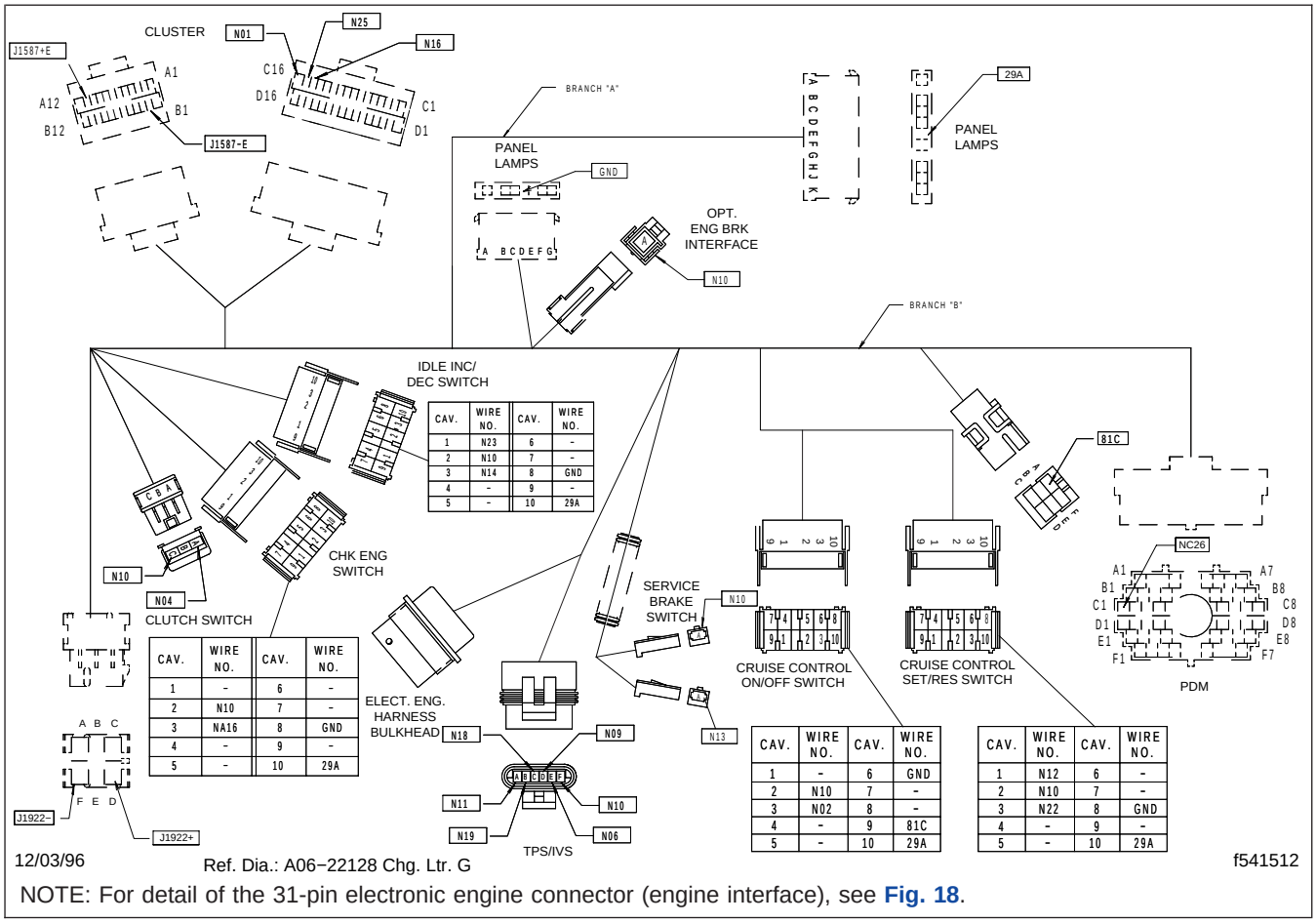


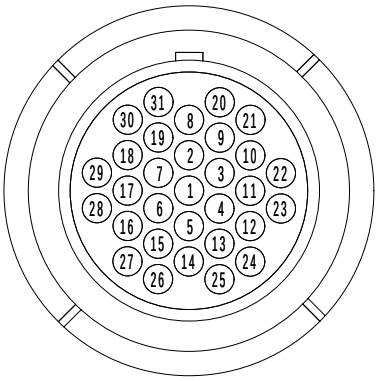
Fig. 16, Main Cab Harness Wiring Schematic, Electronic Engine Overlay for Cummins Engines (detailed view)



NOTE: For detail of the 31-pin electronic engine connector (engine interface), see **Fig. 18**.

Fig. 17, Main Cab Harness Drawing, Electronic Engine Overlay for Cummins Engines

Specifications



CAV.	WIRE NO.	CAV.	WIRE NO.
1	N10	17	N09
2	N02	18	N19
3	N12	19	N14
4	N22	20	N23
5	N04	21	N16
6	N13	22	-
7	NC26	23	-
8	N18	24	-
9	N11	25	-
10	N01	26	-
11	N25	27	-
12	-	28	J1587+E
13	-	29	J1587-E
14	-	30	J1922+
15	NA16	31	J1922-
16	N06	-	-

11/15/96 f541514

NOTE: The engine interface is on the cab side of the frontwall.

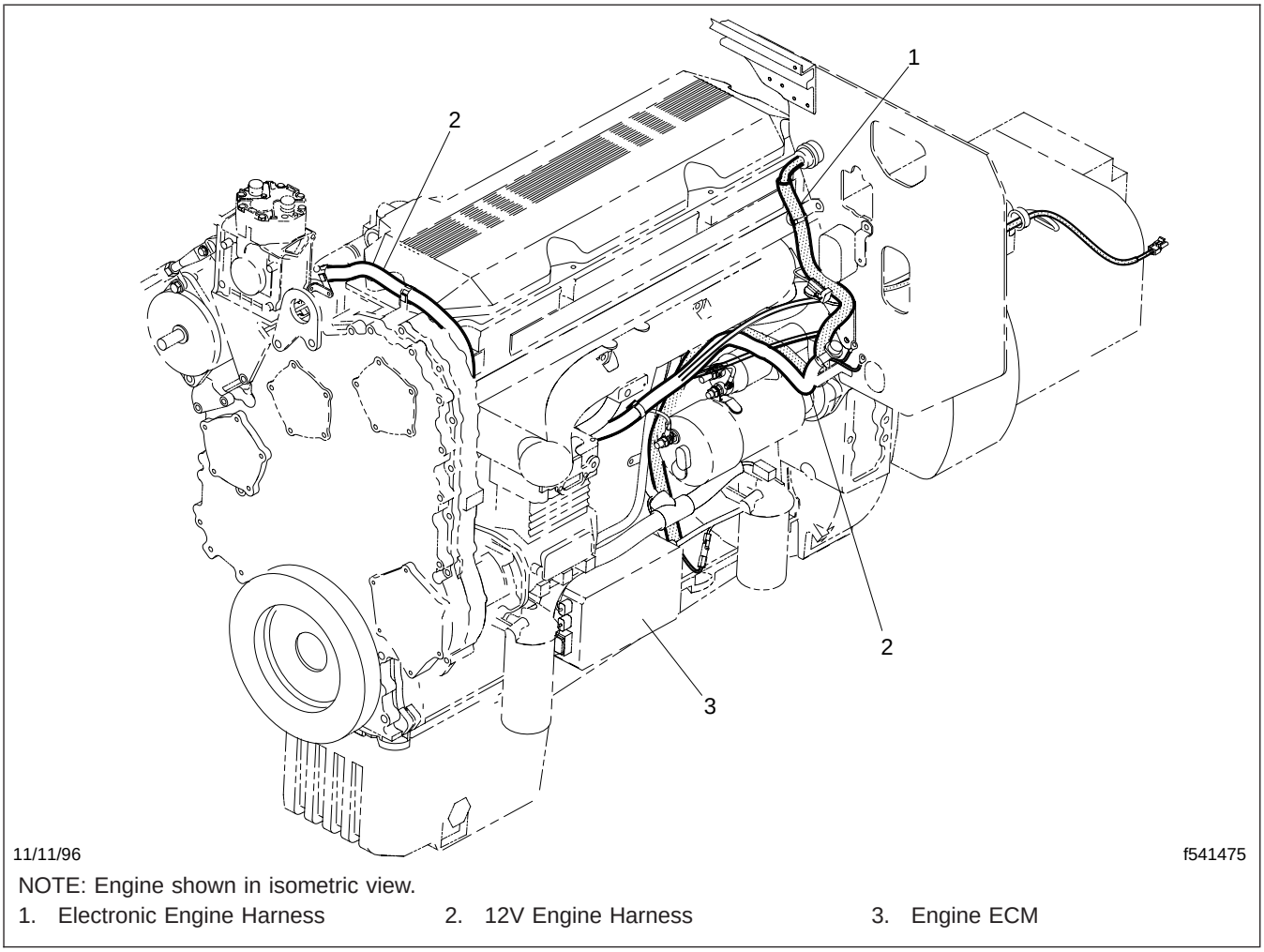
Fig. 18, 31-Pin Electronic Engine Connector (engine interface)

Freightliner supplies two principal wiring harnesses to each engine. The 12-volt (12V) engine harness supplies alternator power to the starter and various appliances. The electronic engine harness communicates data between the electronic control module (ECM), various data-gathering devices, and the cab information systems. In addition, a power harness supplies battery power to the engine ECM.

For a view of the harness routing for the DDC Series 60 engine, see **Fig. 1**.

IMPORTANT: The DDEC III® electronic engine schematics and harness drawings apply to both Series 60 and Series 55 engines. The 12V engine harnesses differ, as described below. The routing diagrams apply only to the Series 60 engine. No routing diagrams are available for the Series 55 engine.

For a schematic of the electronic engine and power harness wiring, see **Fig. 4**. For a detailed view of the power harness and engine ECM end of the electronic engine harness, see **Fig. 5**. For a detailed view of the cab interface (electronic engine connector) end of the electronic engine harness, see **Fig. 6**.



NOTE: Engine shown in isometric view.

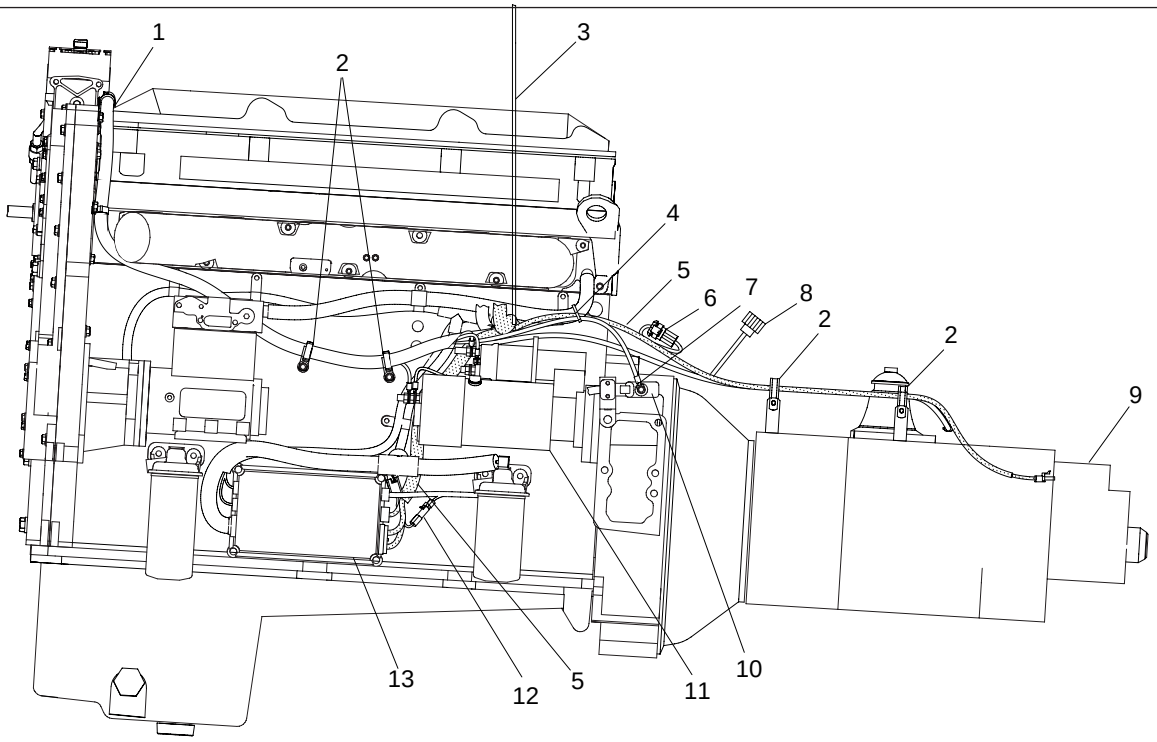
1. Electronic Engine Harness
2. 12V Engine Harness
3. Engine ECM

Fig. 1, Series 60 Engine Harness Routing

For detailed harness routing for the DDC Series 60 engine, see **Fig. 2**.

For a view of the 12V engine harness alternator connections, see **Fig. 3**.

Specifications



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NOTE: Engine shown in side view.
12V engine harness attaches to alternator. See **Fig. 3**.

1. 12V Engine Harness
2. Hose Clamp(s)
3. Location of Frontwall (for reference)
4. Cable Tie Clamp
5. Electronic Engine Harness
6. Shift Connector (to shift lever)
7. Main Power Cables (circuit 16)
8. Transmission Harness Connector
9. Transmission
10. Power Stud
11. Starter
12. Power Harness
13. Engine ECM

Fig. 2, Detailed Series 60 Engine Harness Routing (side view)

For a drawing of the electronic engine harness, see **Fig. 7**. For a detailed diagram and table showing the pin cavities and wire numbers assigned to the two major multi-pin connectors on this harness, see the following:

- For the 30-pin engine ECM connector, see **Fig. 8**.
- For the 31-pin electronic engine connector (cab interface), see **Fig. 9**.

NOTE: The cab interface end of the electronic engine connector is on the engine side of the frontwall.

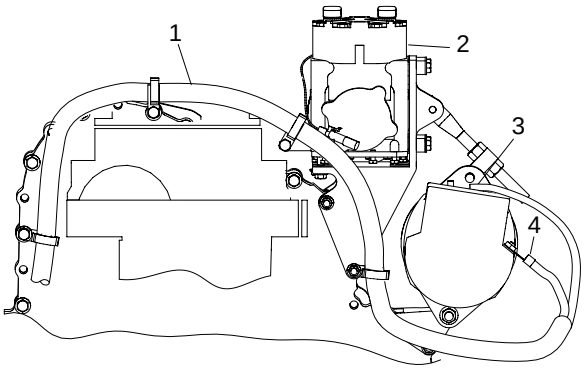
For a drawing of the 12V engine harness for the Series 60 engine, see **Fig. 10**.

For a drawing of the 12V engine harness for the Series 55 engine, see **Fig. 11**.

IMPORTANT: The 12V engine harness on the Series 55 engine is different from the 12V harness on the Series 60 engine. Be sure to use the correct drawing.

For a drawing of the power harness, see **Fig. 12**.

The circuitry going to the other side of the frontwall passes through the electronic engine connector into



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1. 12V Engine Harness
2. Refrigerant Compressor
3. Alternator BAT Terminal Lead
4. Alternator GND Terminal Lead

Fig. 3, Series 60 Engine Harness Alternator Connections

the main cab harness as an electronic engine overlay for the Detroit Diesel engines. For a schematic of the electronic engine overlay for the main cab harness, see **Fig. 13**. For a detailed view of the engine overlay wiring, see **Fig. 14** and **Fig. 15**.

For a drawing of the electronic engine overlay for the main cab harness, see **Fig. 16**. For a detailed view of the engine overlay harness drawing, see **Fig. 17** and **Fig. 18**. For a detailed diagram and table showing the pin cavities and wire numbers assigned to the 31-pin electronic engine connector (engine interface), see **Fig. 19**.

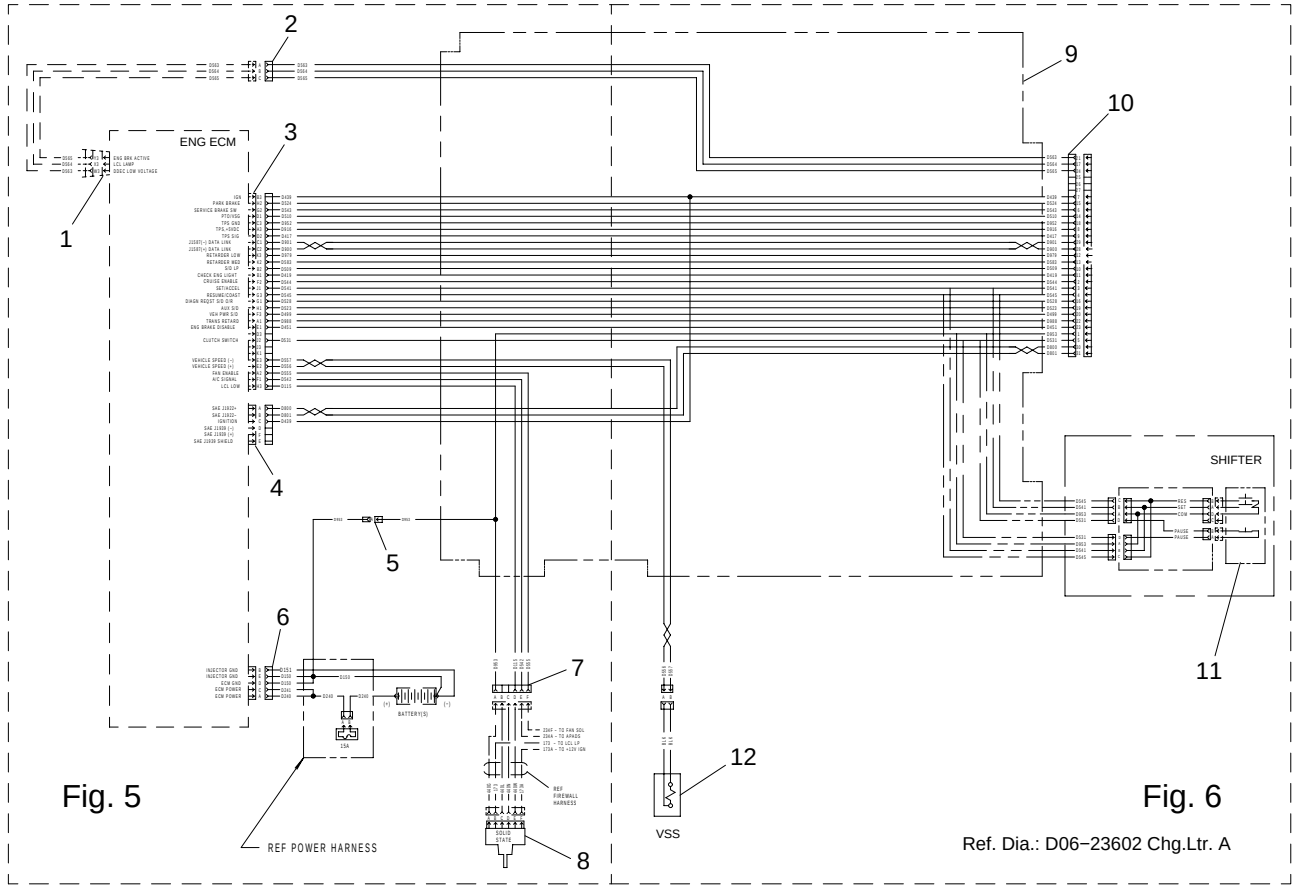
NOTE: The engine interface end of the electronic engine connector is on the cab side of the frontwall. Since some of the wiring numbers are different on the cab side, this connector is shown twice, once from each end. For the wiring on the engine side, see **Fig. 9**.

For engine brake wiring, see **Fig. 20** and **Fig. 21**.

⚠ CAUTION

Before performing any electric welding on a vehicle, disconnect the battery power and ground cables and the engine electronic control module (ECM) electrical connector at the ECM. See Fig. 4, Fig. 5, and Fig. 8. Electric currents produced during electric welding can damage various electronic components on the vehicle.

Specifications



1. 30-Pin DDC ECM Connector (partial—only three pins shown)
2. Option Output Connector
3. 30-Pin Freightliner ECM Connector
4. Communications Connector
5. Power Harness Connector
6. Engine ECM Power Connector
7. Electronic Engine to Frontwall Harness Connector
8. Low Coolant Level Probe
9. Electronic Engine Harness
10. 31-Pin Electronic Engine Connector
11. Cruise Control Switch (optional—mounted on the shift lever)
12. Vehicle Speed Sensor

Fig. 4, Electronic Engine and Power Harness Wiring Schematic

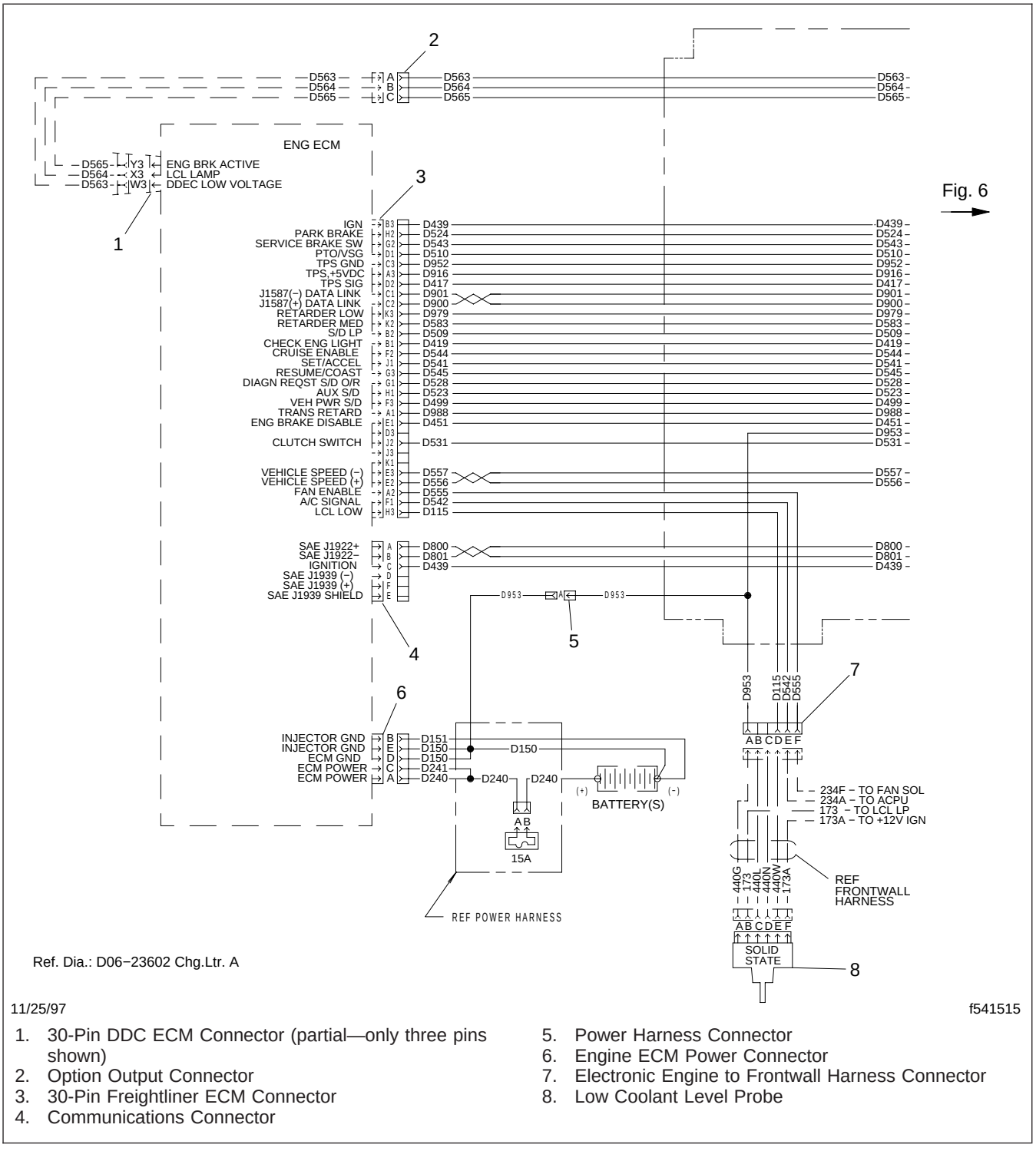


Fig. 6

Ref. Dia.: D06−23602 Chg.Ltr. A

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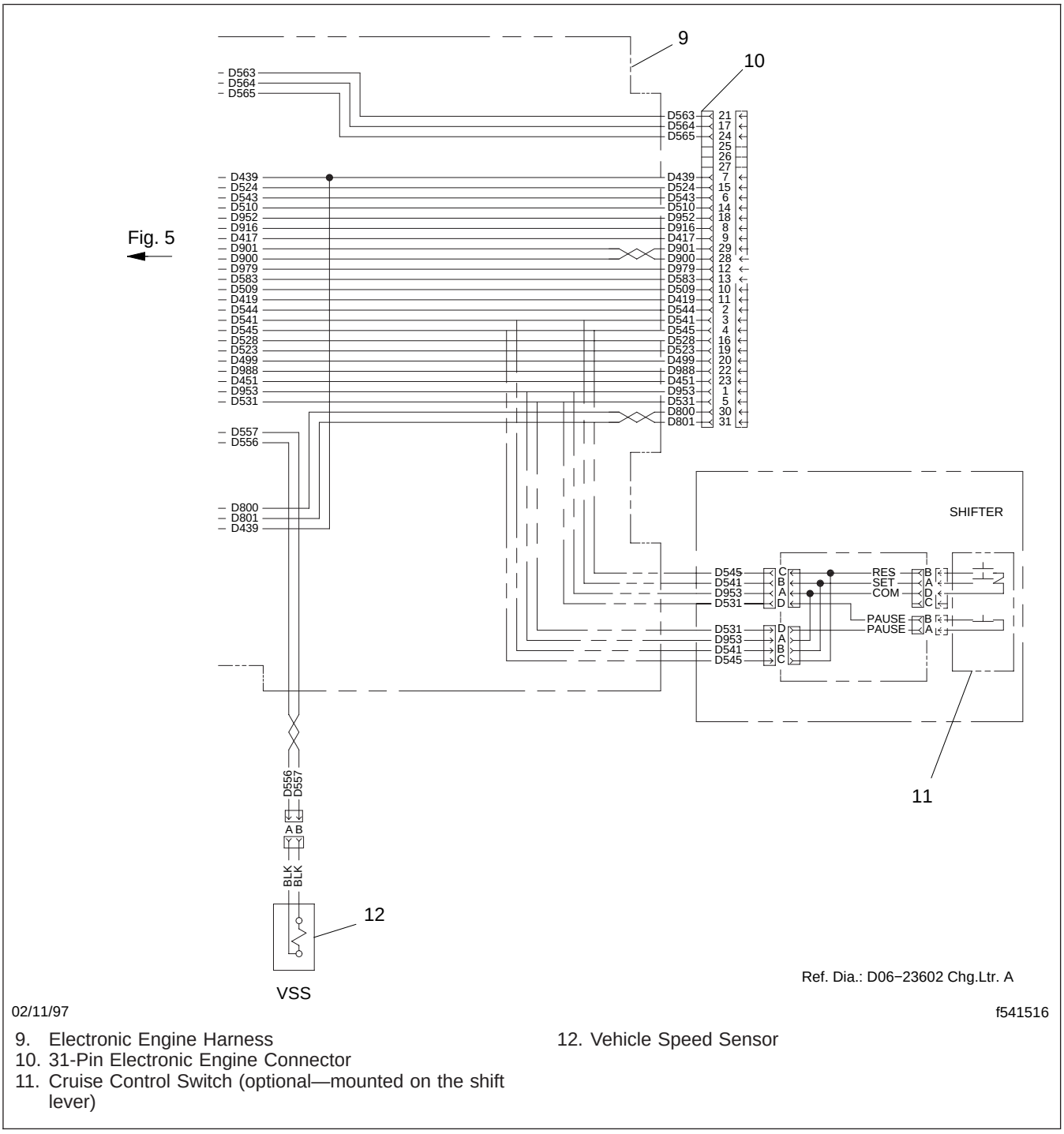
1. 30-Pin DDC ECM Connector (partial—only three pins shown)
2. Option Output Connector
3. 30-Pin Freightliner ECM Connector
4. Communications Connector
5. Power Harness Connector
6. Engine ECM Power Connector
7. Electronic Engine to Frontwall Harness Connector
8. Low Coolant Level Probe

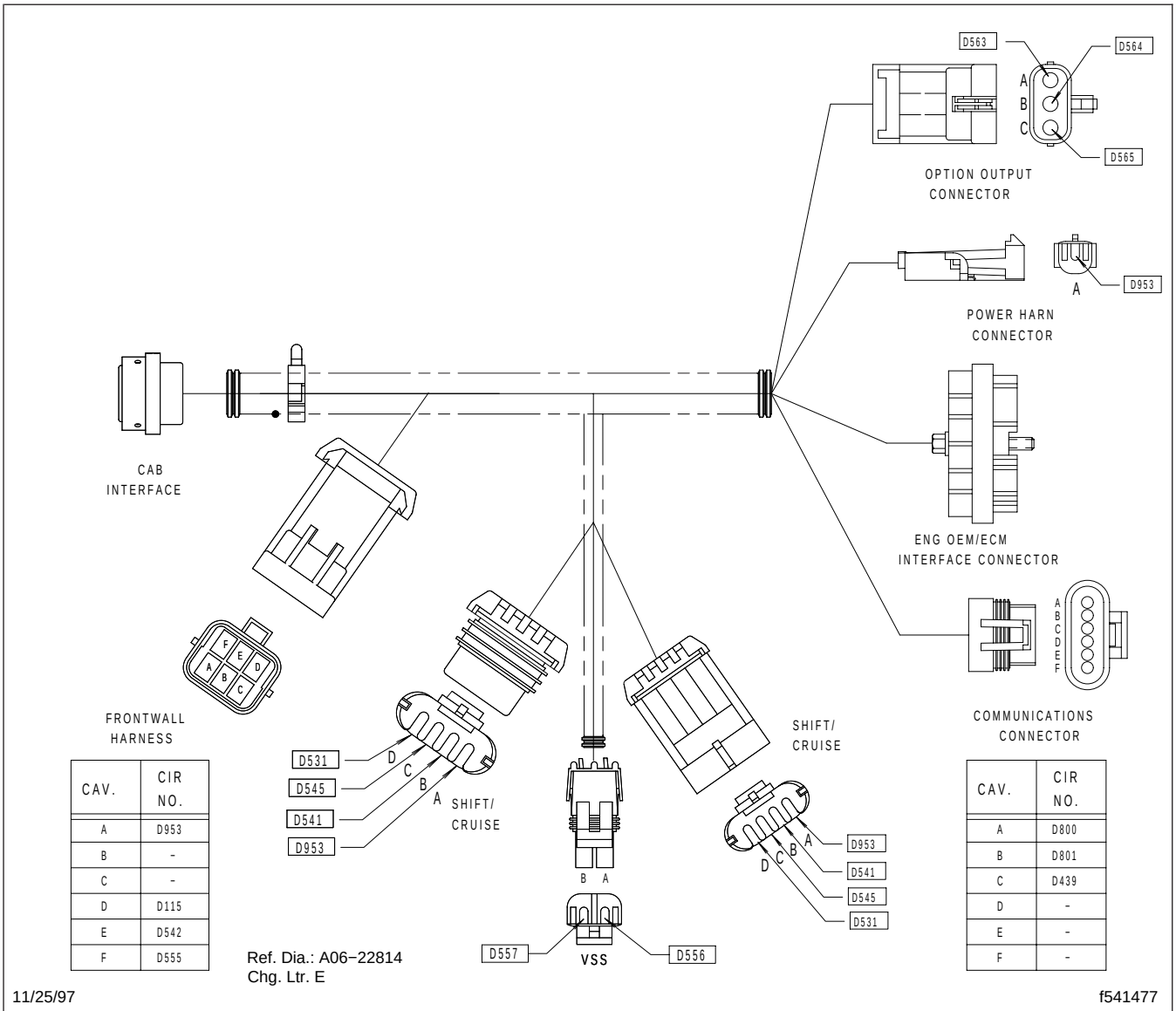
Fig. 5, Electronic Engine and Power Harness Wiring Schematic (detailed view of engine ECM side)

Specifications



9. Electronic Engine Harness
10. 31-Pin Electronic Engine Connector
11. Cruise Control Switch (optional—mounted on the shift lever)
12. Vehicle Speed Sensor

Fig. 6, Electronic Engine and Power Harness Wiring Schematic (detailed view of cab interface end)



CAV.	CIR NO.
A	D953
B	-
C	-
D	D115
E	D542
F	D555

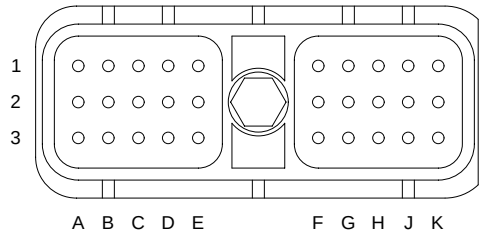
CAV.	CIR NO.
A	D800
B	D801
C	D439
D	-
E	-
F	-

For detail of the 30-pin engine ECM connector, see **Fig. 8**. For detail of the 31-pin electronic engine connector (cab interface), see **Fig. 9**.

NOTE: The shift/cruise connectors are installed only on vehicles with optional shifter-mounted cruise control.

Fig. 7, Electronic Engine Harness

Specifications



CAV.	CIR NO.	CAV.	CIR NO.	CAV.	CIR NO.
A1	D988	D2	D417	G3	D545
A2	D555	D3	–	H1	D523
A3	D916	E1	D451	H2	D524
B1	D419	E2	D556	H3	D115
B2	D509	E3	D557	J1	D541
B3	D439	F1	D542	J2	D531
C1	D901	F2	D544	J3	–
C2	D900	F3	D499	K1	–
C3	D952	G1	D528	K2	D583
D1	D510	G2	D543	K3	D979

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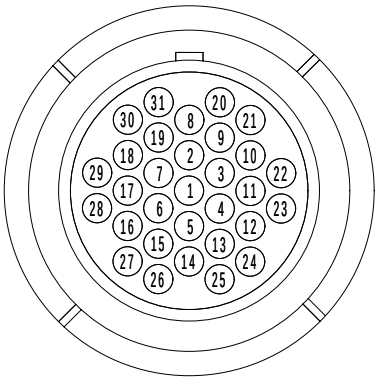
Fig. 8, 30-Pin Engine ECM Connector



CAV.	CIR NO.	CAV.	CIR NO.	CAV.	CIR NO.
1	D953	12	D979	23	D451
2	D544	13	D583	24	D565
3	D541	14	D510	25	–
4	D545	15	D524	26	–
5	D531	16	D528	27	–
6	D543	17	D564	28	D900
7	D439	18	D952	29	D901
8	D916	19	D523	30	D800
9	D417	20	D499	31	D801
10	D509	21	D563		
11	D419	22	D988		

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NOTE: The cab interface is on the engine side of the frontwall.

Fig. 9, 31-Pin Electronic Engine Connector (cab interface)

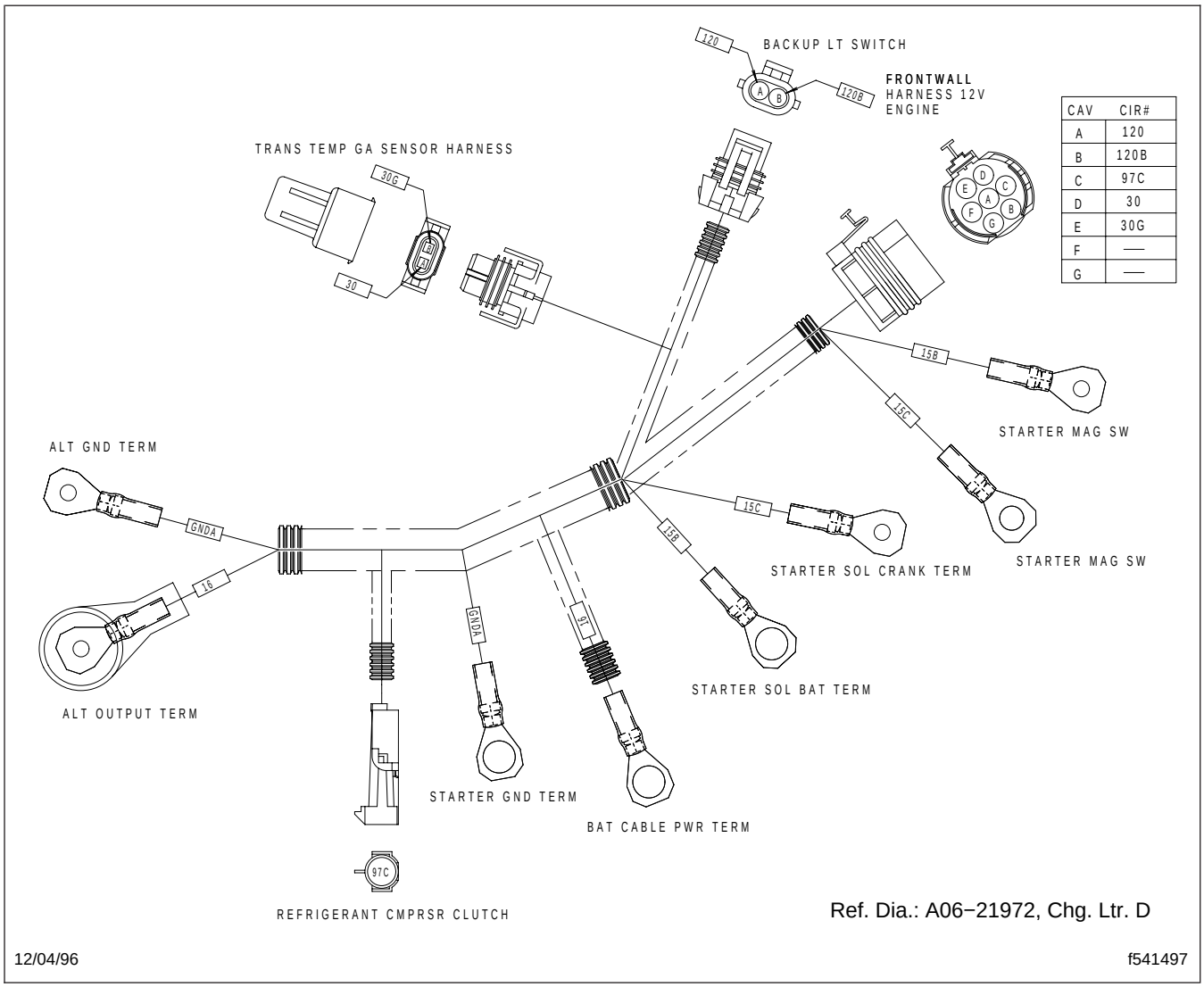


Fig. 10, 12V Engine Harness, Series 60 Engine

Specifications

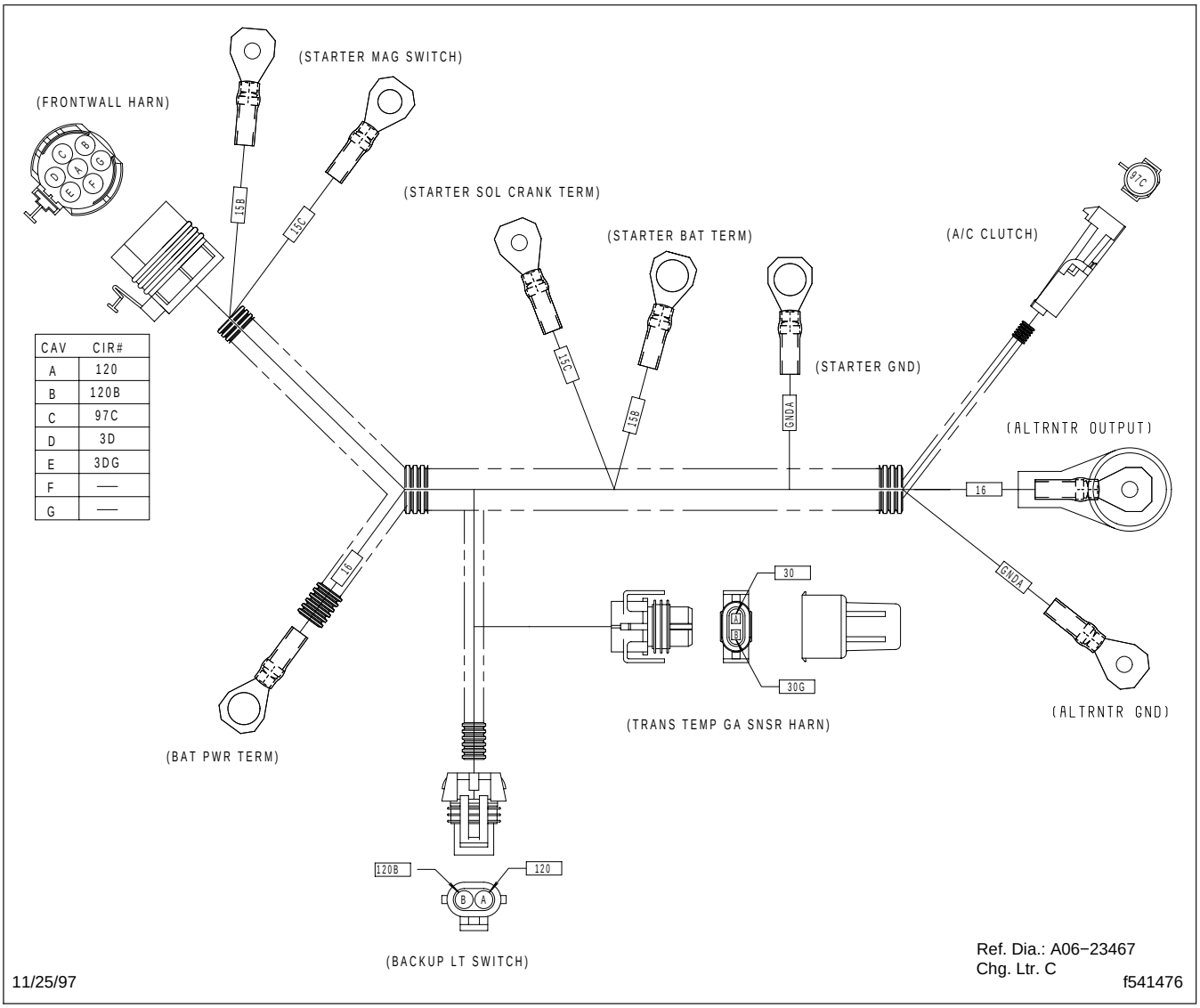
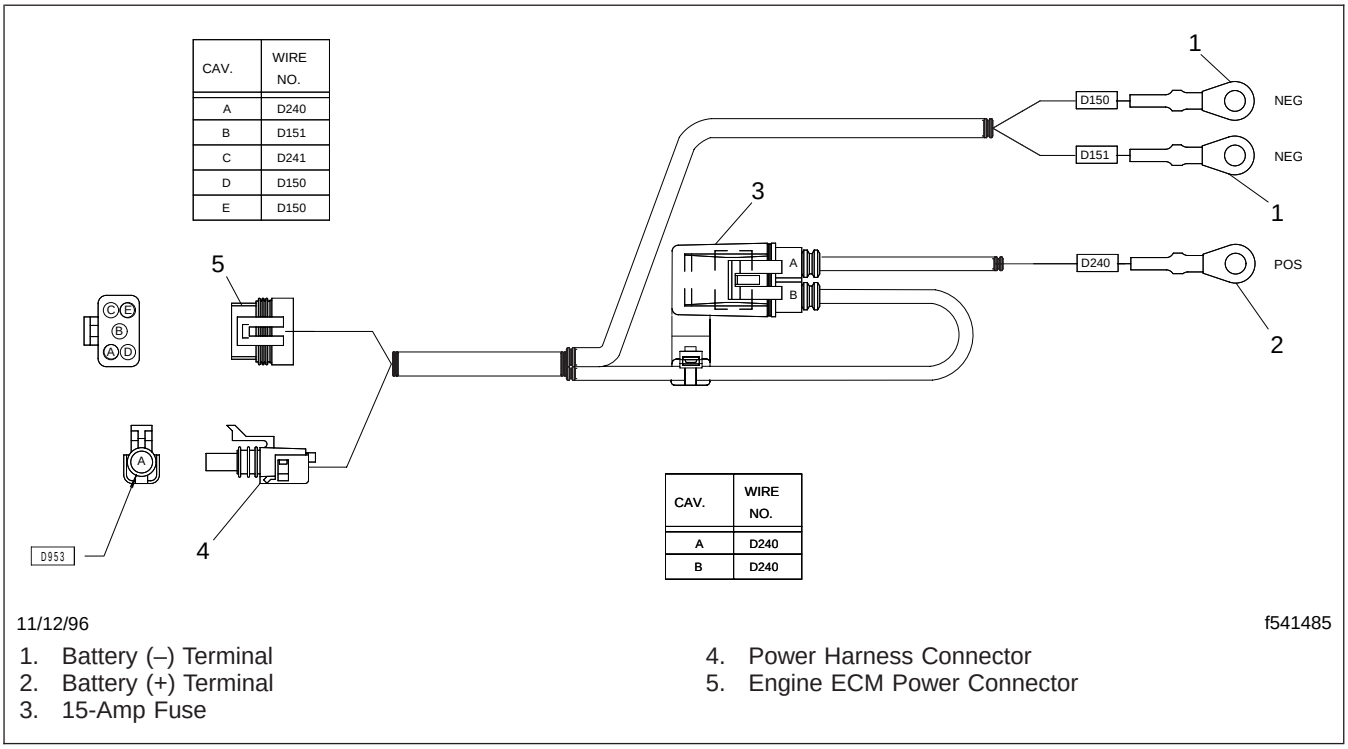


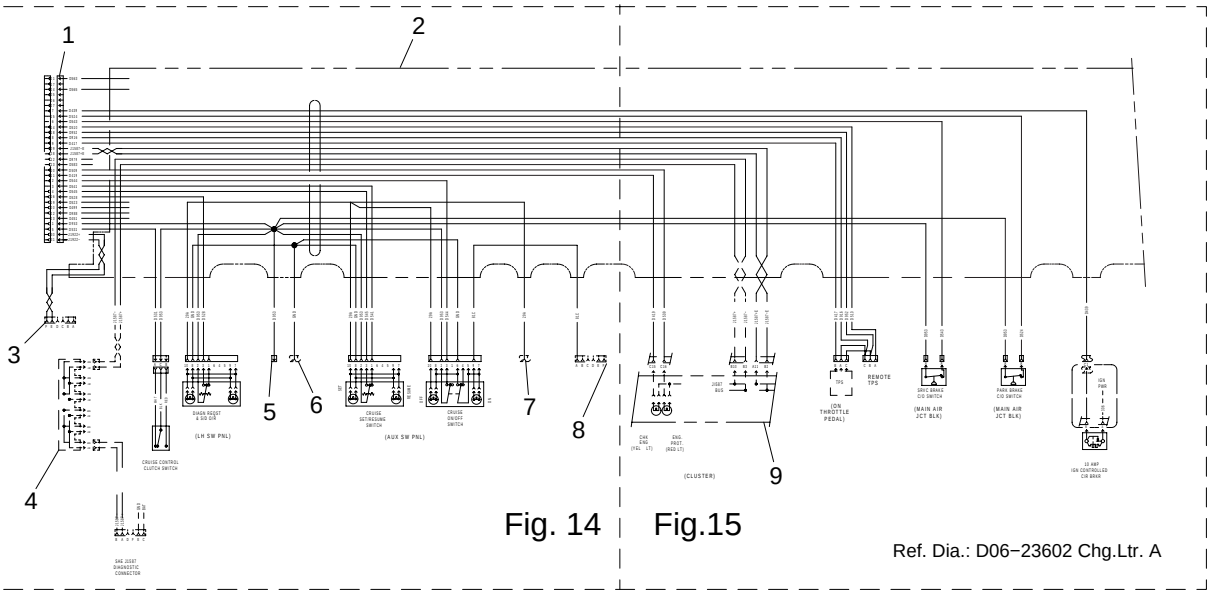
Fig. 11, 12V Engine Harness, Series 55 Engine



1. Battery (–) Terminal
2. Battery (+) Terminal
3. 15-Amp Fuse
4. Power Harness Connector
5. Engine ECM Power Connector

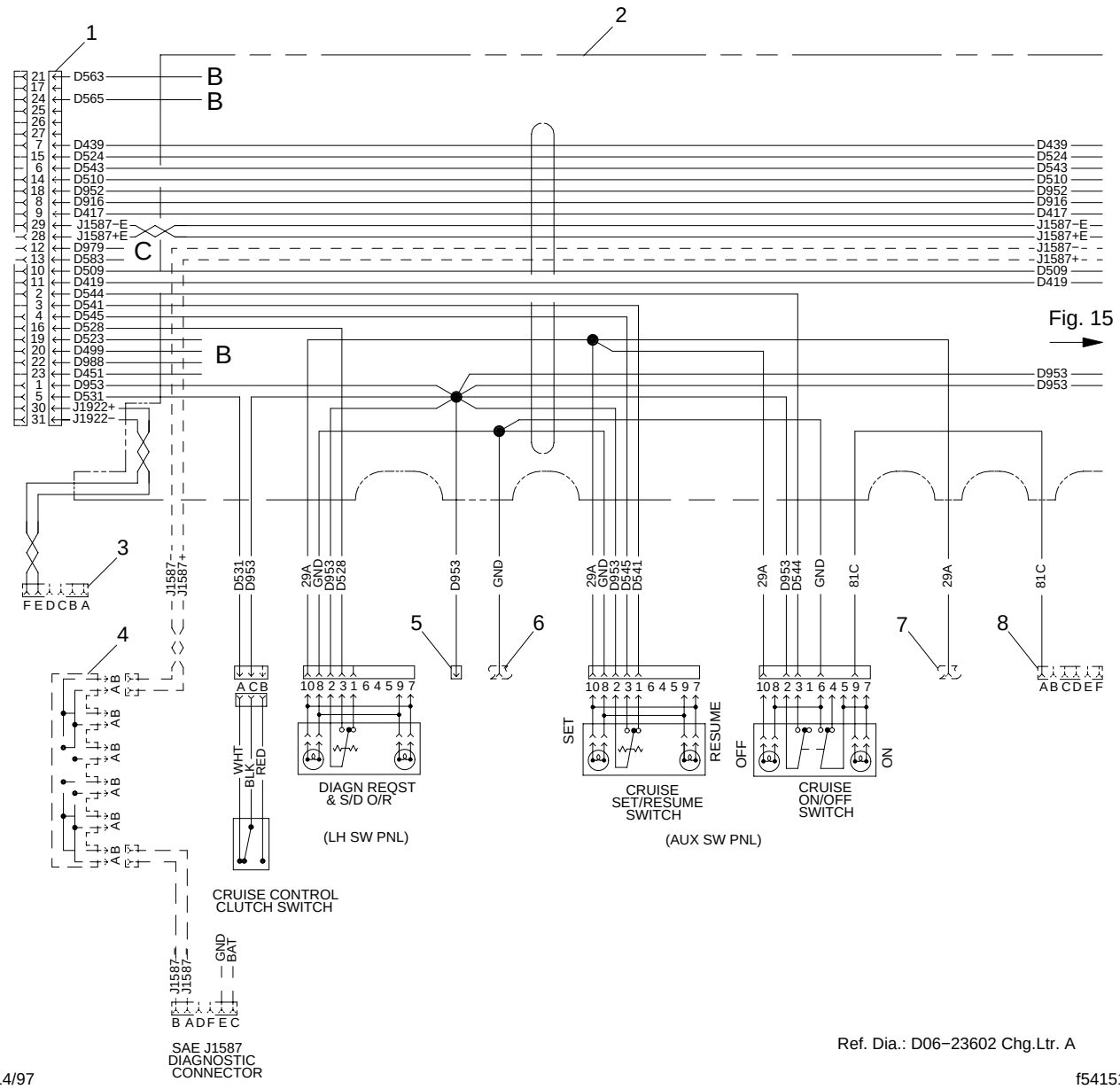
Fig. 12, Power Harness

Specifications



1. 31-Pin Electronic Engine Connector
2. Main Cab Harness
3. J1922 Communications Connector
4. J1587 Junction Block
5. Sensor Common Tap (optional)
6. Switch Ground
7. Panel Light Feed
8. IGN Feed
9. ICU

Fig. 13, Main Cab Harness Wiring Schematic, Electronic Engine Overlay for Detroit Diesel Engines



For engine brake wiring, see **Figure 19**.

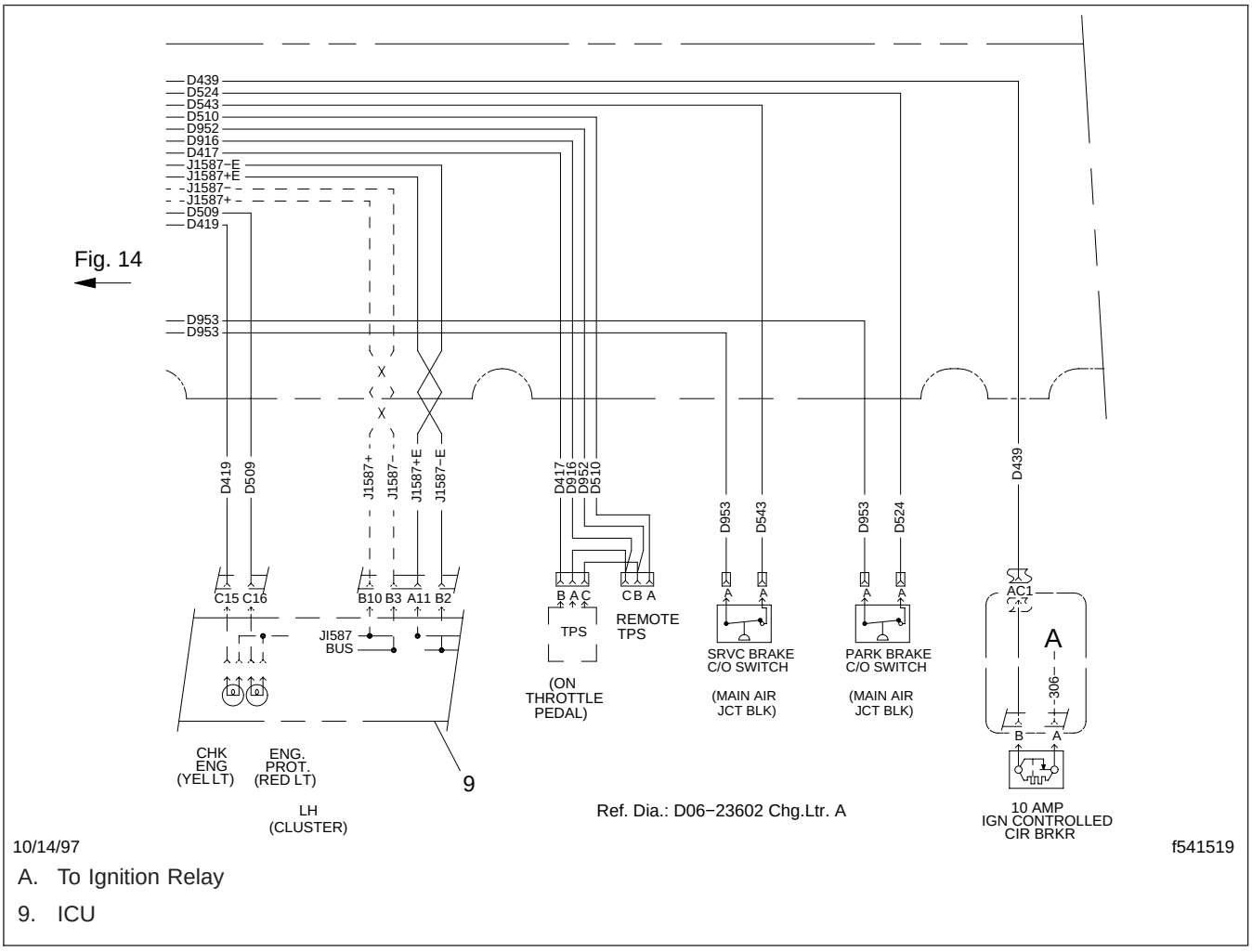
B. Not Shown

C. To Engine Brake

1. 31-Pin Electronic Engine Connector
2. Main Cab Harness
3. J1922 Communications Connector
4. J1587 Junction Block
5. Sensor Common Tap (optional)
6. Switch Ground
7. Panel Light Feed
8. IGN Feed

Fig. 14, Main Cab Harness Wiring Schematic, Electronic Engine Overlay for Detroit Diesel Engines (detailed view)

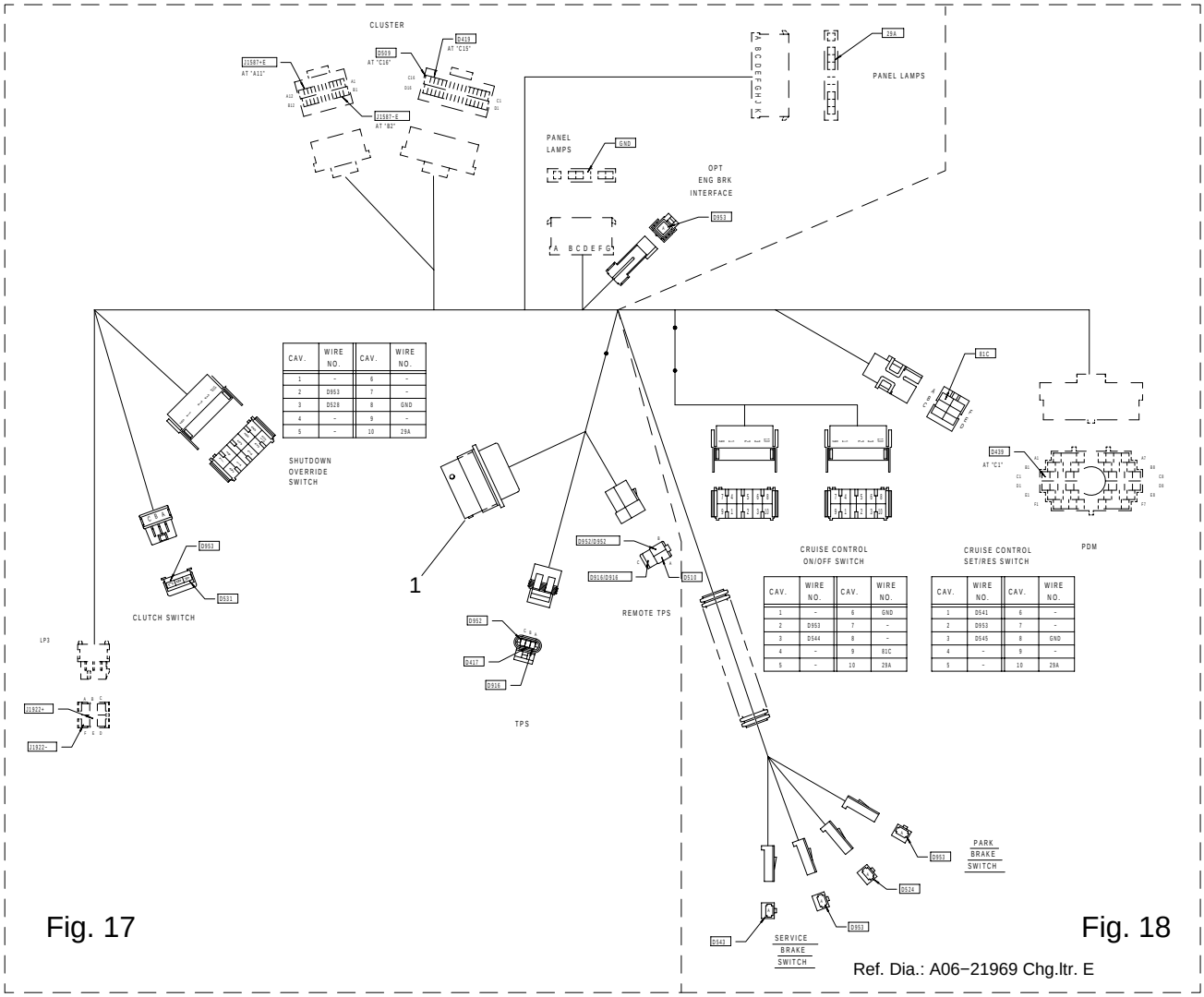
Specifications



A. To Ignition Relay

9. ICU

Fig. 15, Main Cab Harness Wiring Schematic, Electronic Engine Overlay for Detroit Diesel Engines (detailed view)



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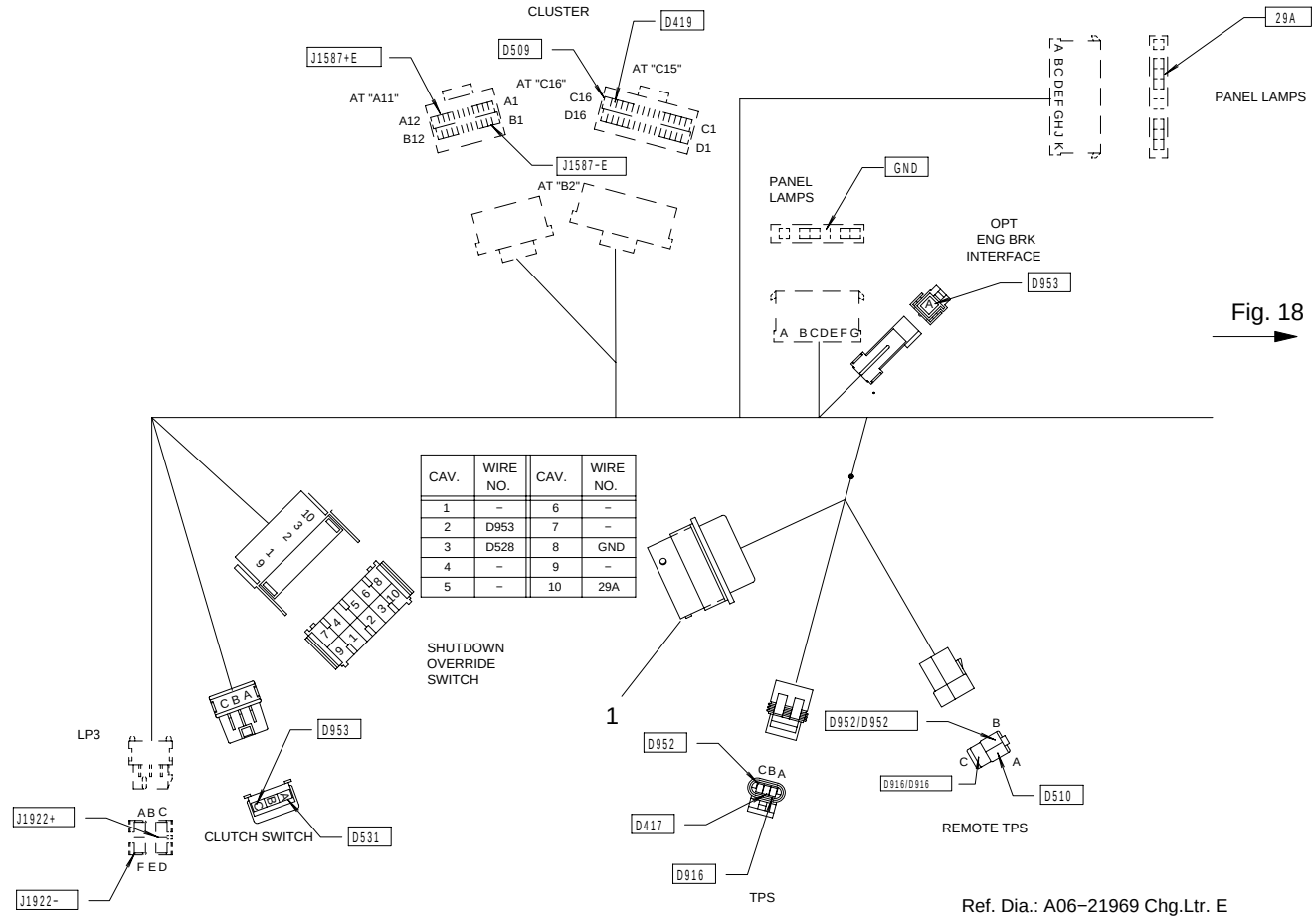
NOTE: For detail of the 31-pin electronic engine connector (engine interface), see **Fig. 18**.

1. Electronic Engine Connector (engine interface)

Fig. 16, Main Cab Harness Drawing, Electronic Engine Overlay for Detroit Diesel Engines

Specifications



CAV.	WIRE NO.	CAV.	WIRE NO.
1	–	6	–
2	D953	7	–
3	D528	8	GND
4	–	9	–
5	–	10	29A

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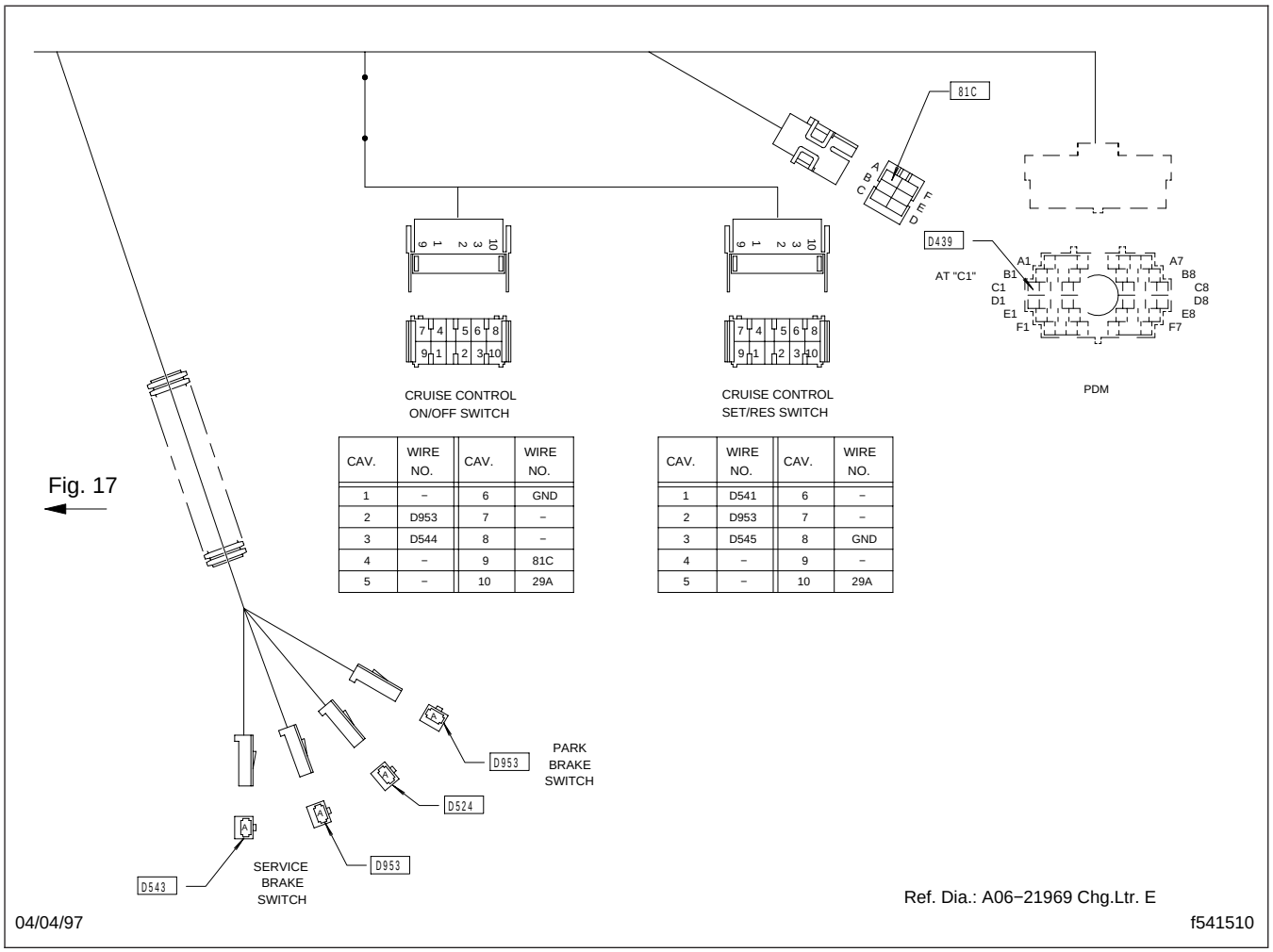
NOTE: For detail of the 31-pin electronic engine connector (engine interface), see **Fig. 18**.

1. Electronic Engine Connector (engine interface)

Fig. 17, Main Cab Harness Drawing, Electronic Engine Overlay for Detroit Diesel Engines (detailed view)

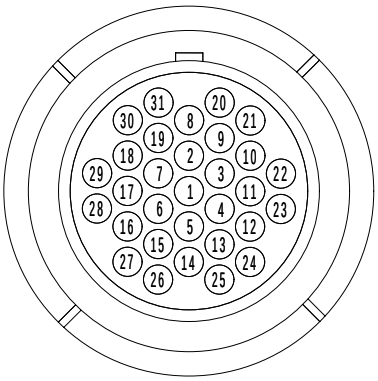


CAV.	WIRE NO.	CAV.	WIRE NO.
1	–	6	GND
2	D953	7	–
3	D544	8	–
4	–	9	81C
5	–	10	29A

CAV.	WIRE NO.	CAV.	WIRE NO.
1	D541	6	–
2	D953	7	–
3	D545	8	GND
4	–	9	–
5	–	10	29A

Fig. 18, Main Cab Harness Drawing, Electronic Engine Overlay for Detroit Diesel Engines (detailed view)

Specifications



CAV.	WIRE NO.	CAV.	WIRE NO.
1	D953	17	-
2	D544	18	D952
3	D541	19	-
4	D545	20	-
5	D531	21	-
6	D543	22	-
7	D439	23	-
8	D916	24	-
9	D417	25	-
10	D509	26	-
11	D419	27	-
12	-	28	J1587+E
13	-	29	J1587-E
14	D510	30	J1922+
15	D524	31	J1922-
16	D528	-	-

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NOTE: The engine interface is on the cab side of the frontwall.

Fig. 19, 31-Pin Electronic Engine Connector (engine interface)

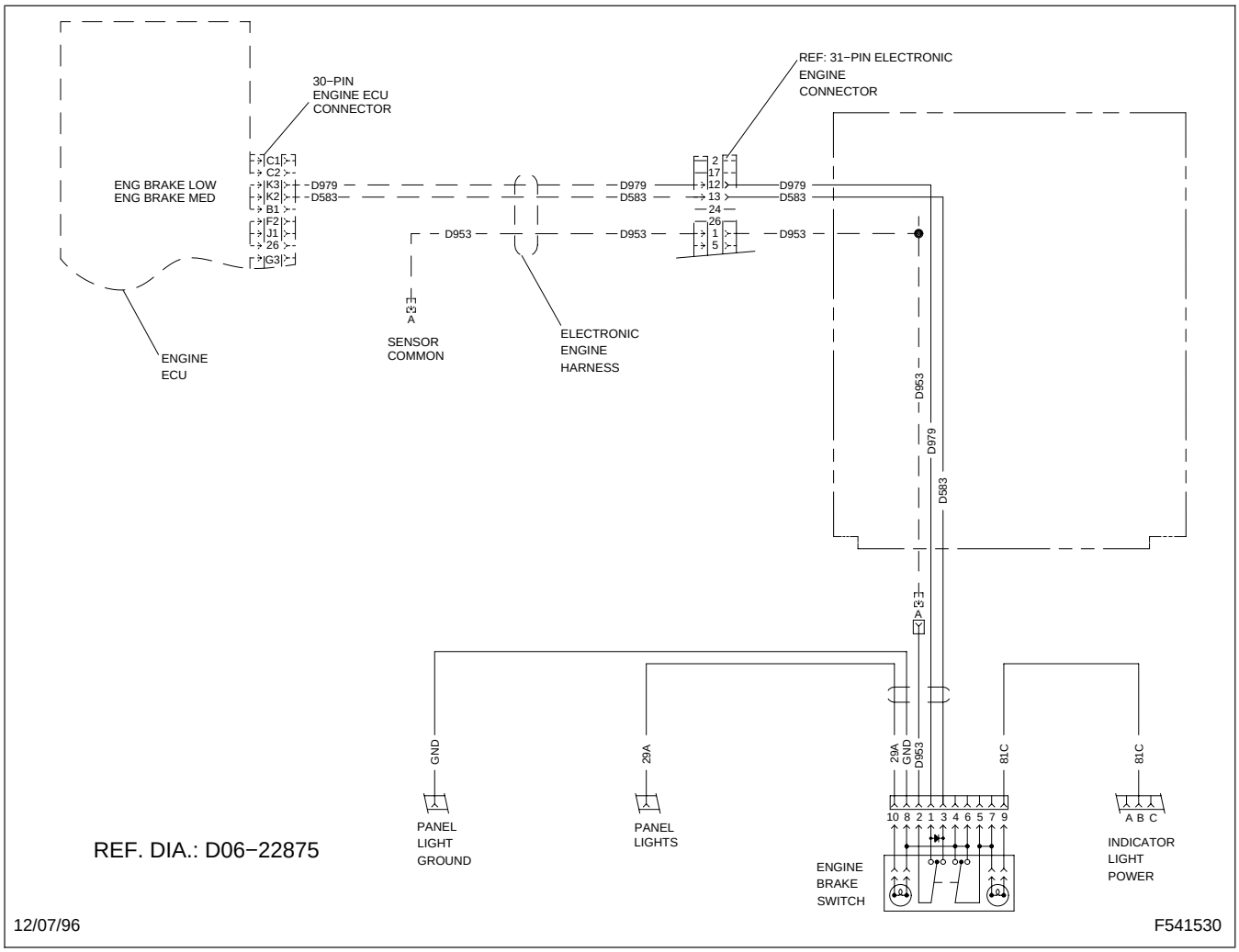
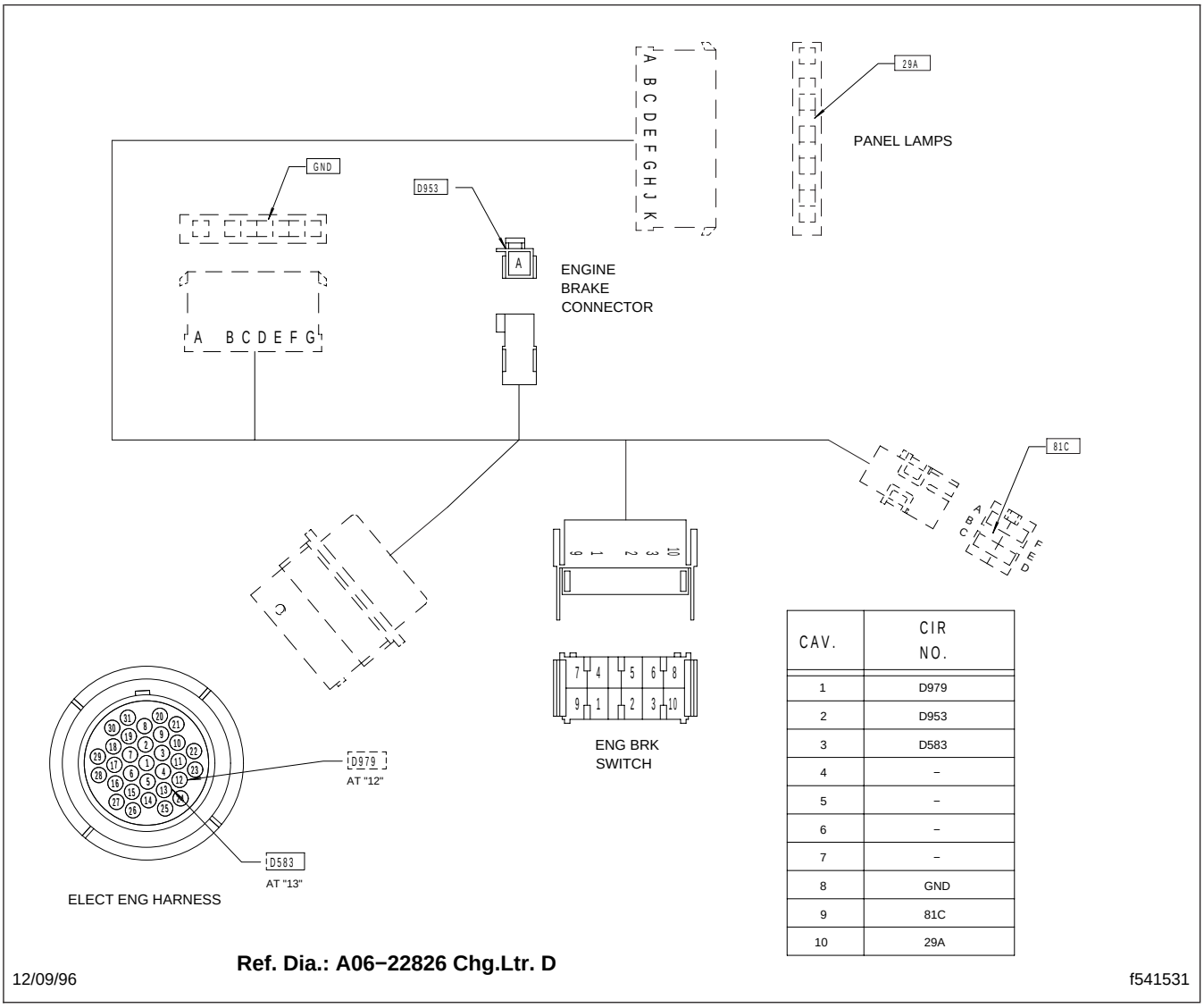


Fig. 20, Engine Brake Wiring Schematic

Specifications



CAV.	CIR NO.
1	D979
2	D953
3	D583
4	–
5	–
6	–
7	–
8	GND
9	81C
10	29A

Fig. 21, Engine Brake Harness Drawing

General Information

The HighwayMaster® mobile communications system combines phone and satellite capabilities. It includes the following components, as shown in **Fig. 1**:

- A control unit for processing all vehicle communications, mounted in the cab (see **Fig. 2**)
- A cellular telephone handset and cradle, mounted on the dash console (see **Fig. 3**)
- A text display unit for satellite communications, mounted on the upper dash panel (see **Fig. 3**)
- A hands-free microphone, mounted on top of the display unit (see **Fig. 3**)
- A speaker, mounted on the cab wall above the driver's seat (see **Fig. 4**)
- A cellular antenna for telephone communications, normally mounted on the passenger's side outside cab wall or on the back of the cab (see **Fig. 5**)
- A GPS (global positioning system) antenna for satellite communications, normally mounted on the back of the cab (see **Fig. 6**)
- The cables necessary to connect the various components together

Each of these components can be replaced separately. See the appropriate subject for replacement procedures.

- For control unit replacement, see **Subject 100**
- For handset replacement, see **Subject 110**
- For display unit replacement, see **Subject 120**
- For microphone replacement, see **Subject 130**
- For speaker replacement, see **Subject 140**
- For cellular antenna replacement, see **Subject 150**
- For GPS antenna replacement, see **Subject 160**

Before use, the control unit must be activated to receive data through the cellular and satellite networks. Also, the system must receive an authorization from Customer Care, HighwayMaster's technical support facility, that a system module has been assigned and that the information about it has been stored in ACUS, a database maintained by AT & T.

NOTE: When replacing a control unit, make sure the new unit has been activated before turning it on for the first time.

To operate successfully, the information must be accurate, and include the following:

1. TIN (Truck Identification Number)—a number generated by HighwayMaster for billing purposes
2. CID (Customer Identification Number)—a number generated by HighwayMaster for customer reporting and tracking
3. MIN (Mobile Identification Number)—the phone number of the cellular modem, which is found on a decal on the side of the control unit
4. ESN (Electronic Serial Number)—an electronically encoded serial number in the control unit, which is also found on the decal on the side of the control unit
5. Tractor Number—the vehicle ID number
6. System Module Serial Number—the serial number of the control unit, which is also found on the decal on the side of the control unit
7. Text Display Serial Number—the serial number of the display unit, which is found on a decal on the back of the display unit
8. Handset Serial Number—the serial number of the handset, which is found on on a metal tag on the back of the handset

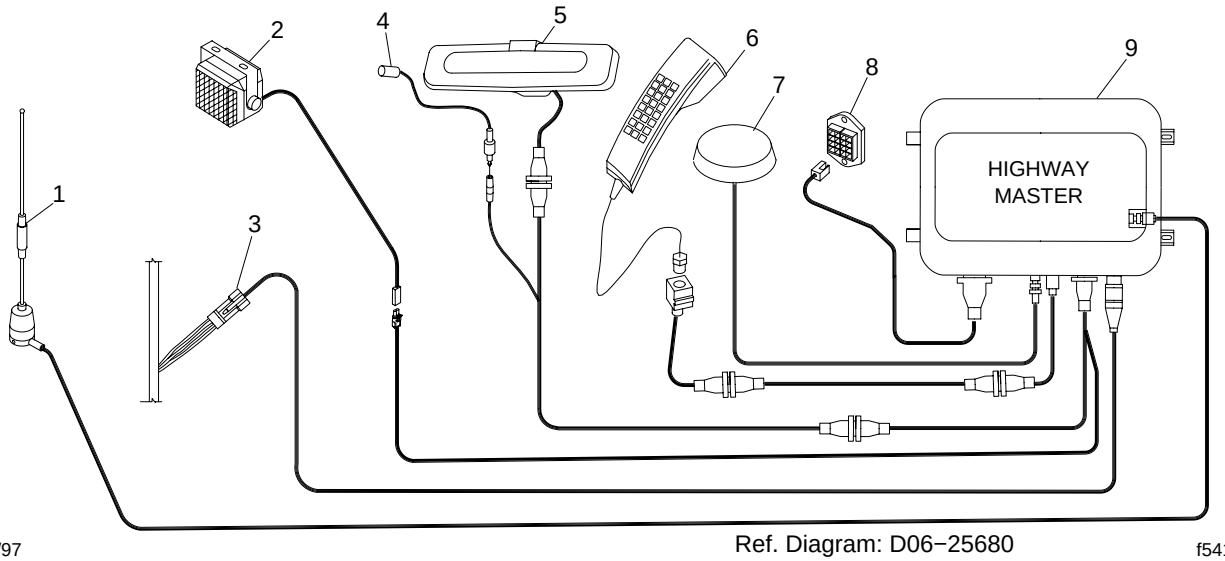
Principles of Operation

START-UP CYCLE

Each time the engine is started, the HighwayMaster system goes into its start-up cycle. When the system is functioning properly, it goes through the following steps:

1. The display shows the underline prompt (_).
2. The display reads "Checking Cellular Service" and then changes to "Registering Unit for Service."
3. Once the unit has been registered, the display reads either "HighwayMaster Service Area" (if you are in an area where HighwayMaster pro-

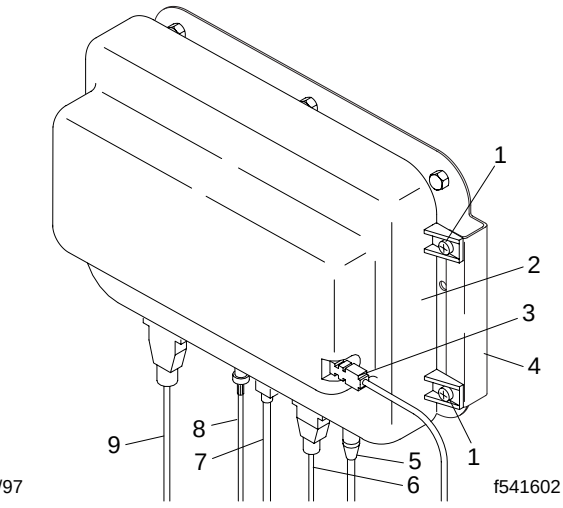
General Information



03/24/97 Ref. Diagram: D06−25680 f541605

1. Cellular Antenna
2. Speaker
3. Power Cable Connection
4. Microphone
5. Display Unit
6. Handset
7. GPS Antenna
8. B-Pillar Datalink Junction Block
9. Control Unit

Fig. 1, HighwayMaster System Components



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1. SEM Screw
2. Control Unit
3. Cellular Antenna Cable
4. Mounting Plate
5. Power Cable
6. Display Cable
7. Phone Cable
8. GPS Antenna Cable
9. Datalink Cable

Fig. 2, Control Unit and Cables

vides cellular coverage) or "HighwayMaster" (if you are out of the coverage area).

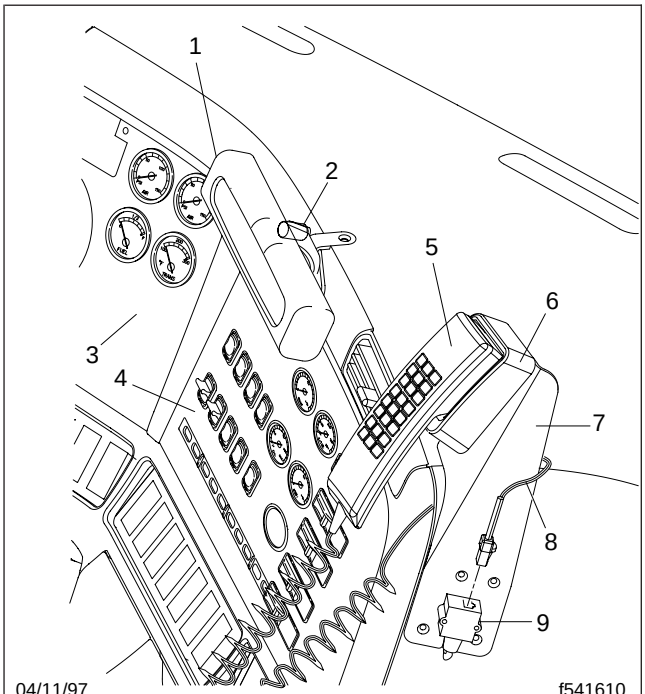
4. When fully operational, the handset is illuminated and the display shows from three to seven bars.

The screen saver timer is a feature that allows the display to go blank if the system has not been used for a programmable number of minutes. The timer can be set to anywhere from 1 to 240 minutes in 1-minute intervals.

HANDSET KEYPAD

In addition to having all the features of a telephone, the handset also functions as a keypad for programming the HighwayMaster system. The function keys on the handset also allow access to the memory functions of the system. The up and down keys allow scrolling through the information stored in memory

- The SND (Send) key is used to start a call and to transmit information. Pressing SND when receiving a call activates the hands-free microphone and the voice recognition system.
- The END key is used to end a hands-free call and get the system ready to receive new information.
- The PWR (Power) key turns the system on and off.



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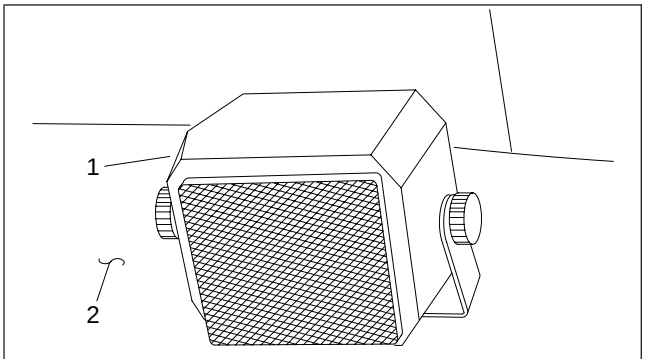
1. Display Unit
2. Microphone
3. Driver's Instrument Panel
4. Auxiliary Instrument Panel
5. Handset
6. Cradle
7. Pedestal
8. Cord
9. Pickup

Fig. 3, HighwayMaster Dash Components



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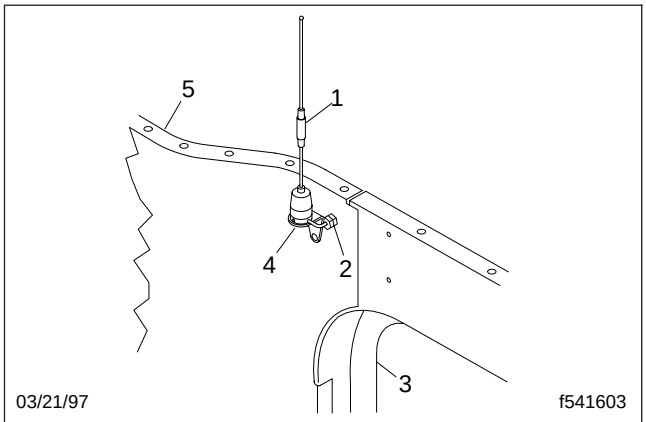
1. Speaker
2. Door Overhead Panel

Fig. 4, Speaker



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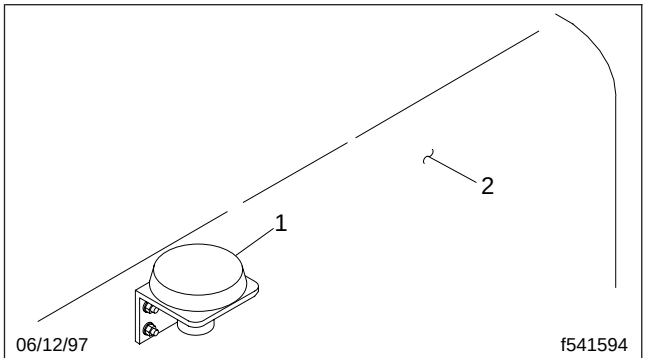
On aftermarket installations, the cellular antenna is installed on the back of the cab, like the GPS antenna.

1. Cellular Antenna
2. Cable Pass-Through Nut
3. RH Door Frame
4. Mounting Bracket
5. Cab Skin, RH Side

Fig. 5, Cellular Antenna



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1. GPS Antenna 2. Back of Cab

Fig. 6, GPS Antenna

- The CHK (Check) key is used to check information, such as NAV status.
- The RCL (Recall) key is used to recall information stored in memory.
- The STO (Store) key is used to store information in memory, including telephone numbers and programming codes.
- The F (Function) key calls up the programming menu, allowing you to set functions such as the screen saver timer.

- The CLR (Clear) key is used to clear information from the display.

VOICE RECOGNITION

For greater driver convenience, the system can be operated by voice commands, using the hands-free microphone and the voice recognition system.

The control unit contains the voice recognition system which allows the speaker to respond to voice commands. To test the voice recognition system, press the END key on the handset. If the speaker says "Ready," the voice recognition system is working.

POWER OFF DELAY

Power off delay is a feature that allows the HighwayMaster system to remain in operation for a programmable number of hours after the vehicle is shut off. The delay can be set to anywhere from 0 to 12 hours in 1-hour intervals.

PERSONAL AND AUTHORIZED CALLING

The personal calling feature allows drivers, at their own expense, to use the HighwayMaster system to make personal calls, providing they have an AT & T TrueChoice ^{SM} calling card.

Both personal and authorized phone numbers can be stored in memory for easier dialing.

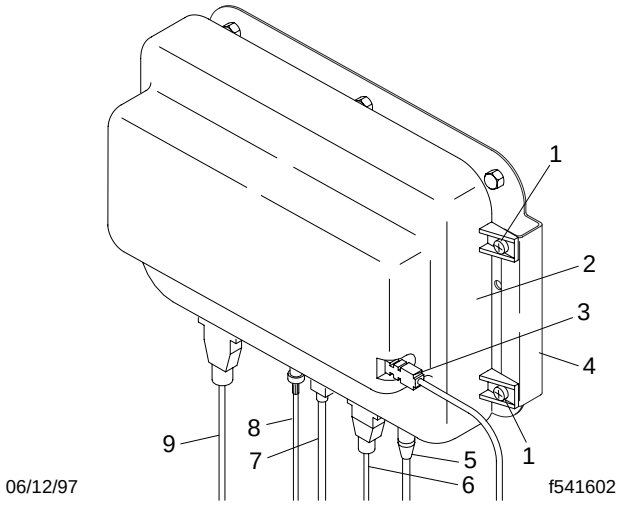
Authorized numbers are used for company business. They are stored in memory by the trucking company using special codes, allowing the driver to call dispatchers, terminals, and customers at company expense.

Replacement

The HighwayMaster® control unit is normally mounted on a mounting tray attached to the wall of the baggage compartment. On day cabs, and in other cases where space does not permit it to be mounted in this location, the control unit is mounted with its mounting plate attached directly to the cab deck.

IMPORTANT: Before attempting to install a new control unit, fax the serial number, electronic serial number, and mobile identification number of the unit to HighwayMaster at 1–214–930–7244. These numbers are found on the decal on the side of the control unit.

1. Set the parking brake, chock the tires, and disconnect the batteries.
2. Gain access to the control unit. Normally it is installed under the bunk on the right-hand side of the cab.
3. Remove the cables attached to the control unit. See **Fig. 1**.



1. SEM Screw
2. Control Unit
3. Cellular Antenna Cable
4. Mounting Plate
5. Power Cable
6. Display Cable
7. Phone Cable
8. GPS Antenna Cable
9. Datalink Cable

Fig. 1, Control Unit and Cables

3.1 Remove the round 1-pin connector on the cellular antenna cable from the plug on the side of the front casing.

3.2 Remove the round 3-pin connector on the power cable from the plug on the bottom of the case.

3.3 Remove the 9-pin connector on the display cable from the plug on the bottom of the case.

3.4 Remove the connector on the phone cable from the phone plug on the bottom of the case.

3.5 Remove the round 1-pin connector on the GPS antenna cable from the plug on the bottom of the case.

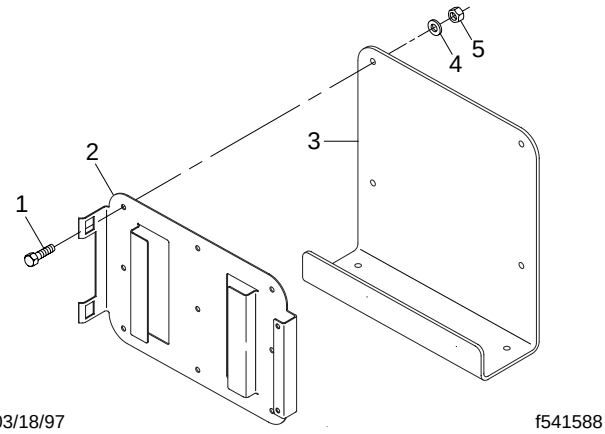
3.6 Remove the 15-pin connector on the datalink cable from the plug on the bottom of the case.

4. Remove the two SEM screws attaching the control unit to the mounting plate and lift the two lugs on the other end of the control unit out of the slots provided on the mounting plate.

NOTE: It is not necessary to remove the mounting plate to replace the control unit. Do the following step only if it is necessary to replace the mounting plate or to change the mounting of the control unit.

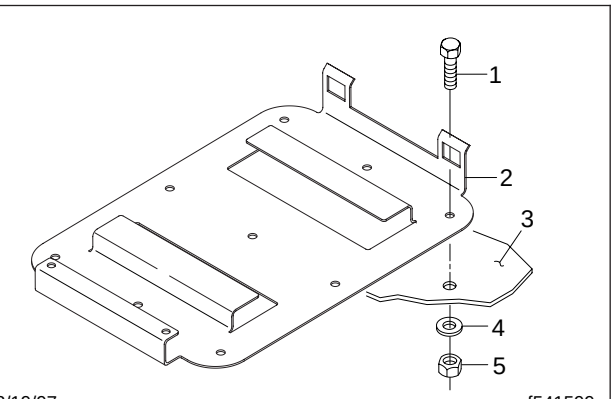
5. Remove the 1/4–20 capscrews (3/4-inch long), washers, and locknuts attaching the mounting plate to the mounting tray. See **Fig. 2** for installations using the mounting tray and **Fig. 3** for installations with the mounting plate attached directly to the cab deck or other cab structure.
6. If removed, attach the mounting plate to the mounting tray or cab structure, as required.
7. Insert the lugs in the control unit into the slots in the mounting plate. Install the SEM screws and tighten them until snug.
8. Connect the batteries.
9. Connect the display, phone, and both antenna cables to the control unit, as removed. Check all cables for good connections at both ends.
10. Connect the datalink cable to the control unit, as removed. Check the cable for good connections at both ends. See **Fig. 4**.

Control Unit Replacement



1. 1/4–20 Capscrew
2. Mounting Plate
3. Mounting Tray
4. 1/4–20 Flatwasher
5. 1/4–20 Locknut

Fig. 2, Removing the Mounting Plate from the Mounting Tray



1. 1/4–20 Capscrew
2. Mounting Plate
3. Cab Deck
4. 1/4–20 Flatwasher
5. 1/4–20 Locknut

Fig. 3, Removing the Mounting Plate from the Cab Rear Deck

IMPORTANT: Do not connect the power cable until battery power has been restored. Before connecting power to the unit, call HighwayMaster Customer Care at 1–800–647–6693 to confirm the unit has been initialized from the host.

11. With battery power restored, connect the power cable to the control unit, as removed. Check the cable for good connections at both ends. See **Fig. 5**.

12. Initialize the control unit.

    12.1 On the handset, press the following sequence of keys:

    - "STO," "9," "9," "SND"
    - "STO," "0," "1," "SND"

    NOTE: If the display does not read "TRANSMISSION SUCCESSFUL," first press the key sequence "STO," "0," "1," "SND" again. If that does not work, call HighwayMaster Customer Care at 1–800–647–6693 and follow their instructions.

    12.2 When the display reads "TRANSMISSION SUCCESSFUL," type in this key sequence:

    - "5," "9," "8," "2," "0," "0," "CHK"

    12.3 When the display reads "GPS HAS REACHED NAV STATUS," the system is ready to operate.

    If the display does not read "GPS HAS REACHED NAV STATUS," see **Troubleshooting, 300**.

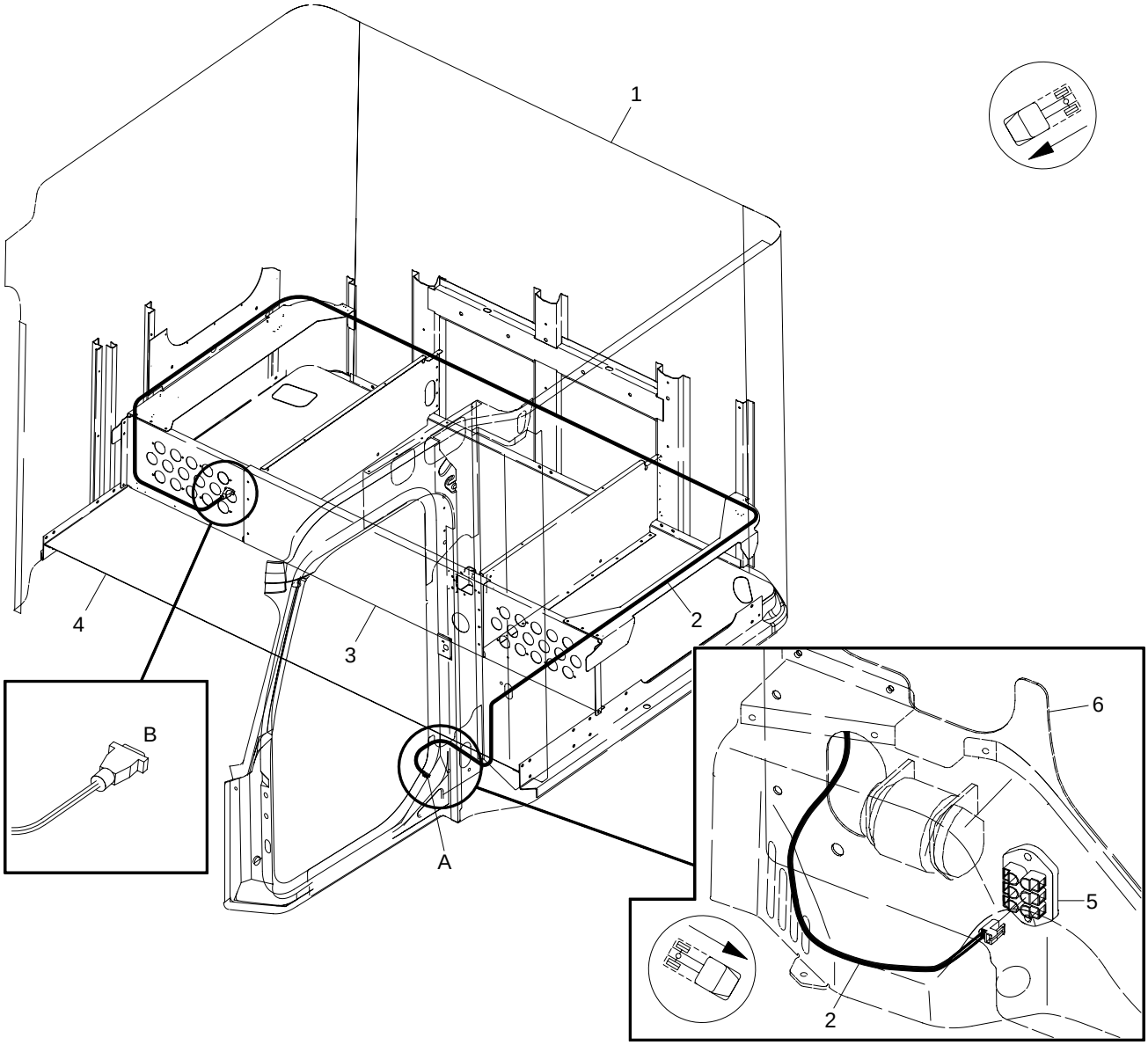
13. Place a voice call. Test the system for correct operation, including the hands-free microphone, volume control, and voice recognition, and make adjustments as needed. For more information, see **Troubleshooting, 300**.

14. Ask Customer Care to issue a returned materials authorization number (RMA). Enter this number on a "Service Record/Installation Acknowledgment" form and send the form back to HighwayMaster along with the old control unit.

15. Return the old control unit to HighwayMaster, using the address label provided. Send it to the following address: HighwayMaster Repair Depot, ATTN: Roy Moultrie, 2300 Highway 79 South, Guntersville AL 35976.

16. Restore the cab to normal operating condition.

17. Remove the chocks from the tires.

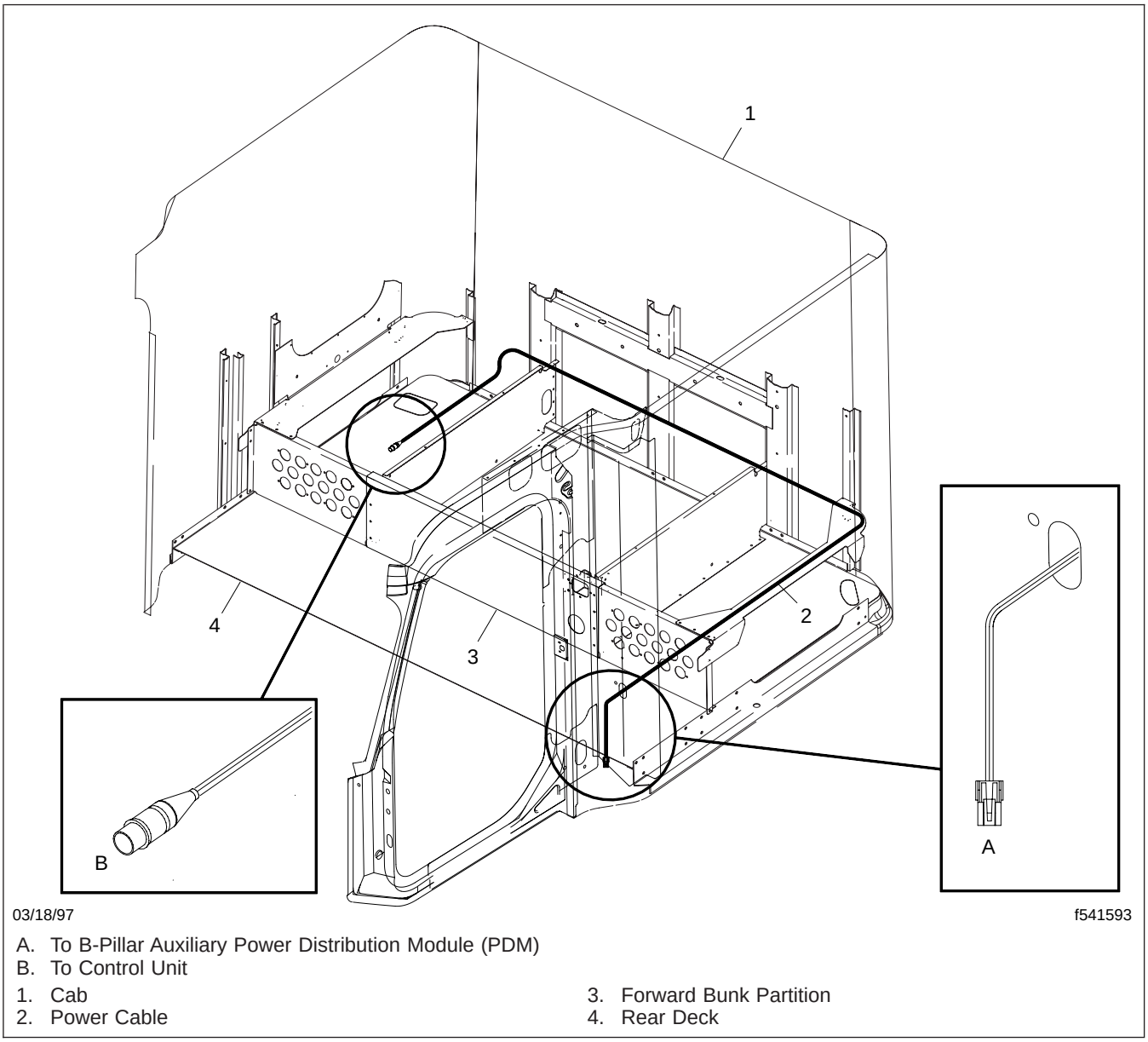


A. To B-Pillar Datalink Junction Block
B. To Control Unit

1. Cab
2. Datalink Cable
3. Forward Bunk Partition
4. Rear Deck
5. Datalink Junction Block
6. B-Pillar

Fig. 4, Datalink Cable Routing

Control Unit Replacement



A. To B-Pillar Auxiliary Power Distribution Module (PDM)
B. To Control Unit

1. Cab
2. Power Cable
3. Forward Bunk Partition
4. Rear Deck

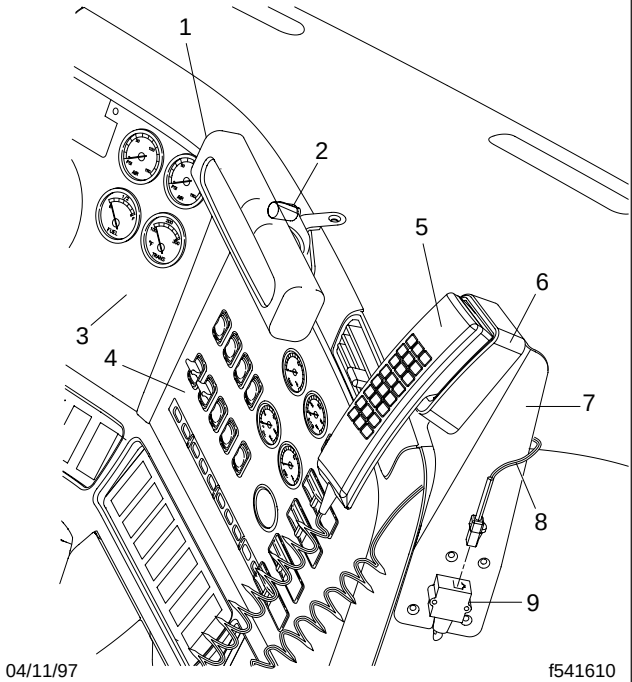
Fig. 5, Power Cable Routing

Replacement

The HighwayMaster® handset and cradle are normally mounted on a pedestal attached to the upper dash assembly (center panel).

IMPORTANT: Before attempting to install a new handset, fax the serial number of the unit to HighwayMaster at 1–214–930–7244. The serial number is found on a metal tag on the back side of the handset.

1. Set the parking brake, chock the tires, and disconnect the batteries.
2. Remove the handset cord from the pickup (mounted on the pedestal). See **Fig. 1**.

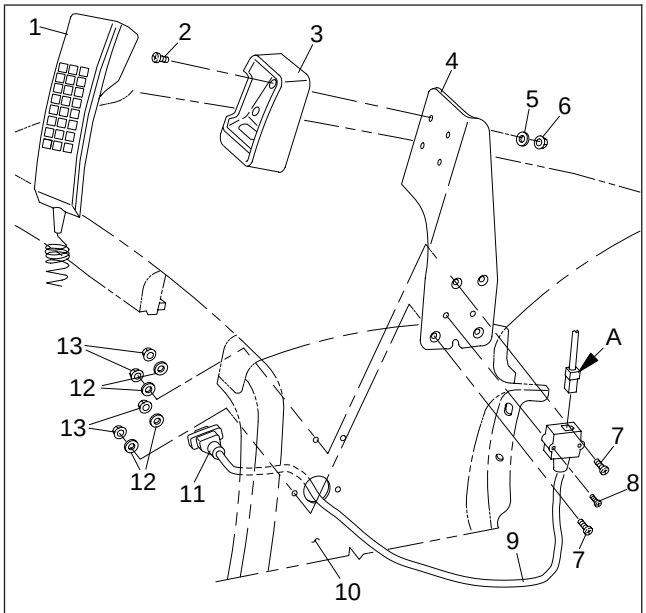


1. Display Unit
2. Microphone
3. Driver's Instrument Panel
4. Auxiliary Instrument Panel
5. Handset
6. Cradle
7. Pedestal
8. Cord
9. Pickup

Fig. 1, Handset and Cord

NOTE: It is not necessary to remove the pedestal to replace the handset. Do the following step only if it is necessary to replace the pedestal or to change the mounting of the handset.

3. Remove the pedestal from the upper dash assembly. See **Fig. 2**.



A. To Handset

1. Handset
2. 6–32 Machine Screw
3. Cradle
4. Pedestal
5. #6 Washer
6. 6–32 Locknut
7. 10–24 Machine Screw
8. 4–40 Machine Screw
9. Phone Cable (dash)
10. Upper Dash Assembly (center panel)
11. Connector
12. #10 Washer
13. 10–32 Locknut

Fig. 2, Handset, Cradle, and Pedestal (exploded view)

3.1 Remove the four 6–32 machine screws, locknuts, and #6 washers, that attach the cradle to the pedestal.

3.2 Remove the two 4–40 machine screws that attach the phone cable pickup to the pedestal.

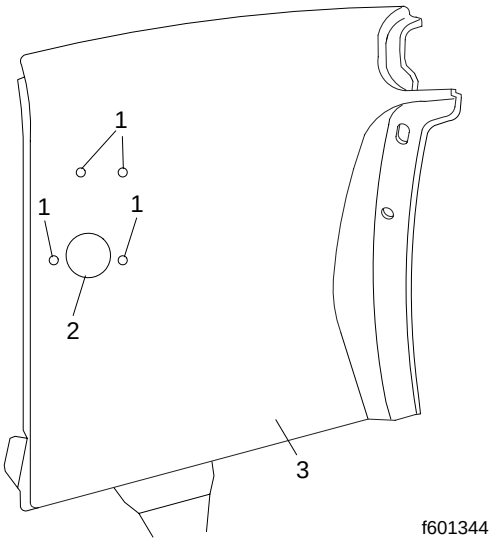
3.3 Remove the four 10–24 machine screws, 10–32 locknuts, and #10 washers that attach the pedestal to the dash.

Handset Replacement

3.4 Remove the phone cable (dash) through the 1-1/4-inch (30 mm) hole in the upper dash assembly.

3.5 Remove the round 1-pin connector on the GPS antenna cable from the plug on the bottom of the case.

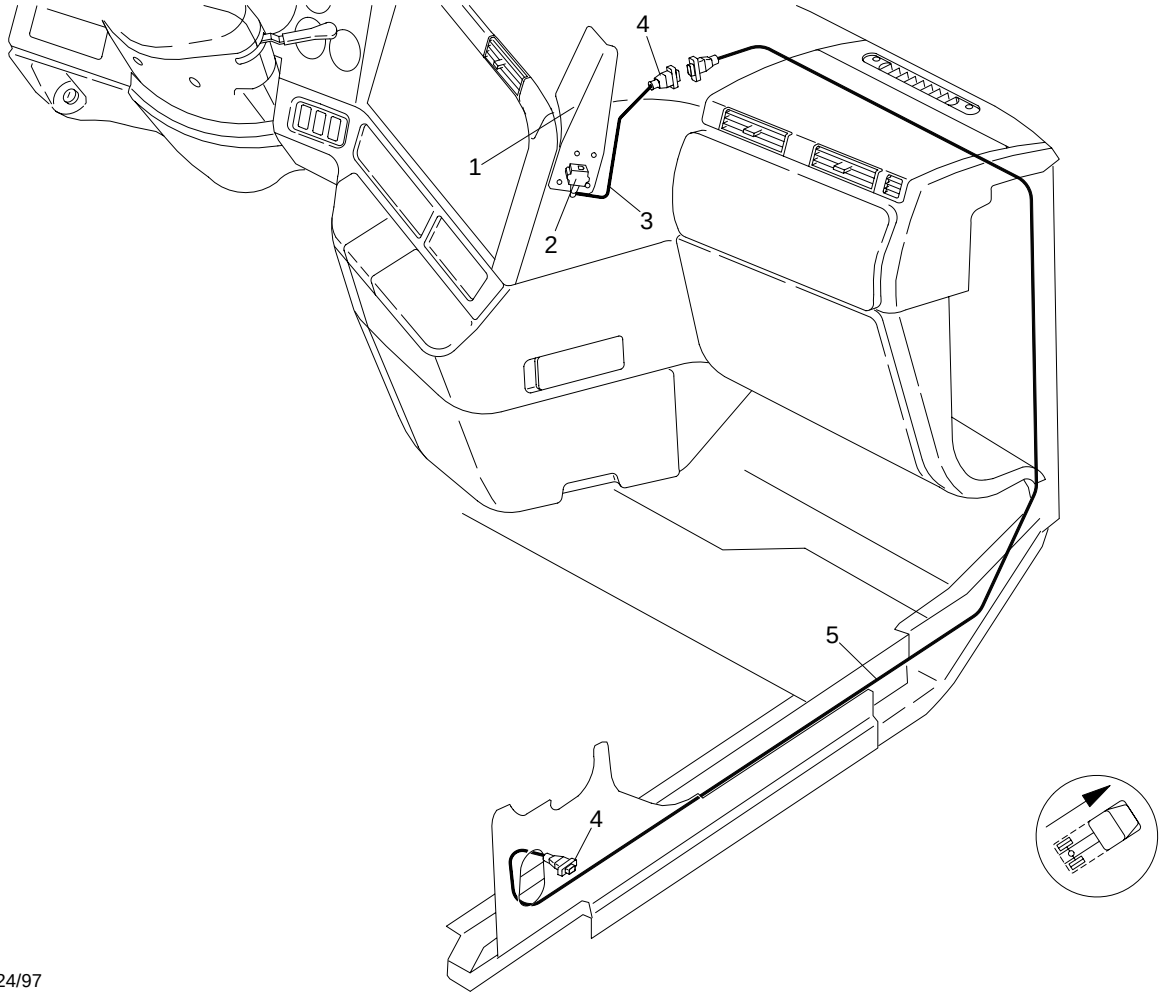
4. Insert the phone cable through the 1-1/4-inch (30 mm) hole in the center panel of the upper dash assembly. Attach the pedestal to the four 1/4-inch (6 mm) holes, as removed. See **Fig. 3**.



1. 1/4-Inch (6 mm) Hole
2. 1-1/4-Inch (30 mm) Hole
3. Upper Dash Assembly (center panel)

Fig. 3, Pedestal Mounting and Phone Cable Holes

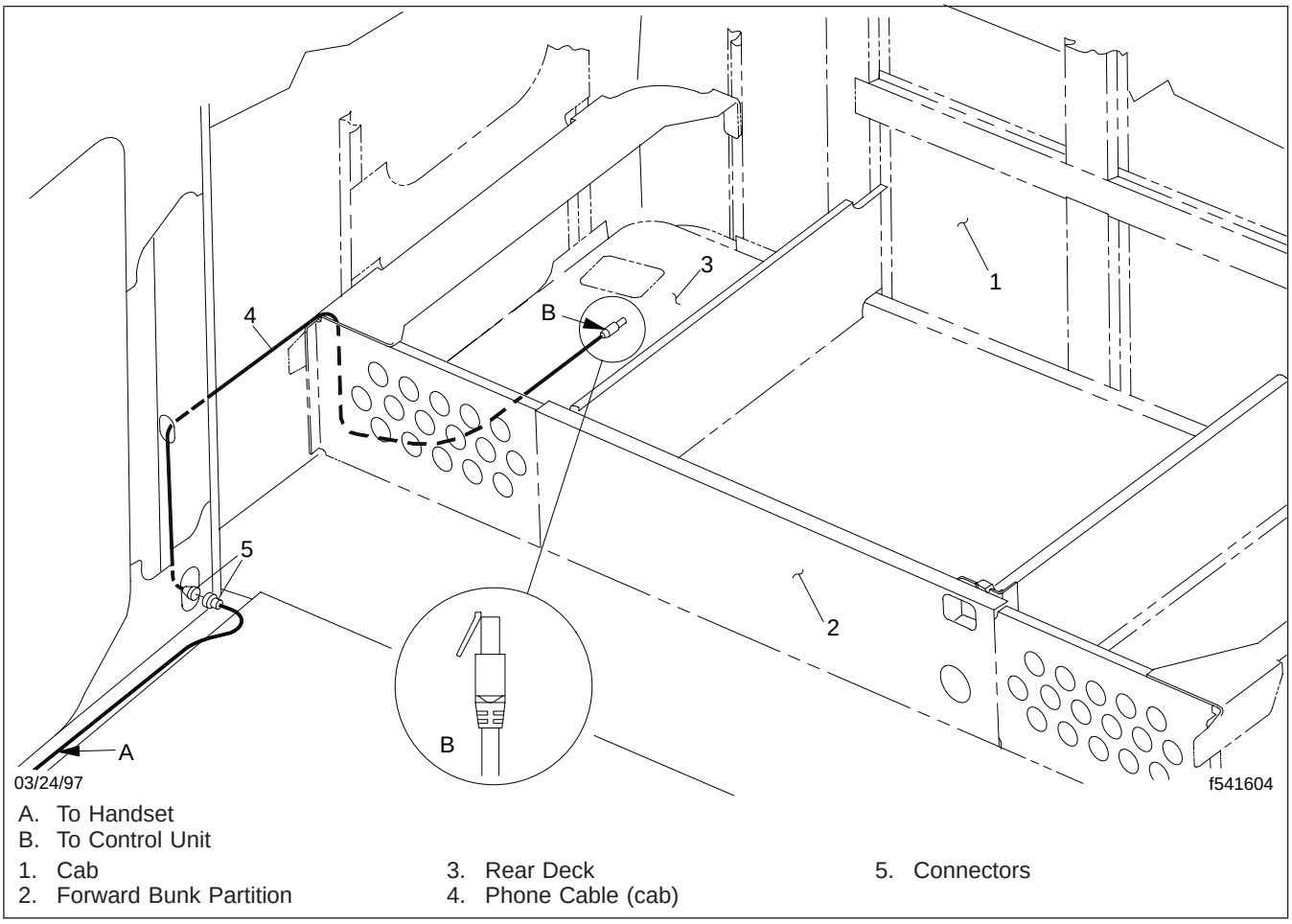
5. If removed, attach the cradle and phone cable pickup.
6. Insert the cord of the new handset into the pickup.
7. Check all the phone cable connections, as shown in **Fig. 4** and **Fig. 5**. Check all three cables, dash, door, and cab, for good connections at both ends.
8. Connect the batteries.
9. Place a voice call. Test the system for correct operation, including the hands-free microphone, volume control, and voice recognition, and make adjustments as needed. For more information, see **Troubleshooting, 300**.
10. Remove the chocks from the tires.



1. Pedestal
2. Pickup
3. Phone Cable (dash)
4. Connector
5. Phone Cable (door)

Fig. 4, Phone Cable Routing (dash)

Handset Replacement



A. To Handset
B. To Control Unit
1. Cab
2. Forward Bunk Partition
3. Rear Deck
4. Phone Cable (cab)
5. Connectors

Fig. 5, Phone Cable Routing (cab)

Display Unit Replacement

Replacement

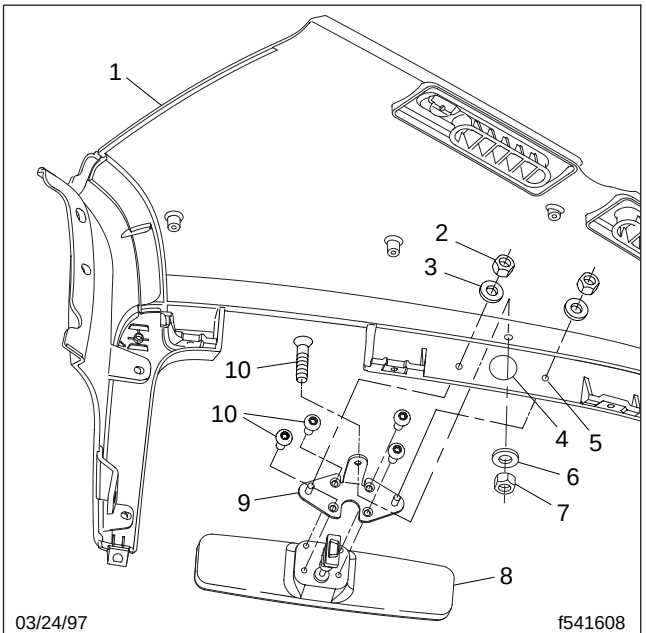
The HighwayMaster® display unit is normally mounted on the auxiliary dash panel.

IMPORTANT: Before attempting to install a new display unit, fax the serial number of the unit to HighwayMaster at 1–214–930–7244. The serial number is found on the decal on the back side of the control unit.

1. Set the parking brake, chock the tires, and disconnect the batteries.
2. Unclip the microphone from the microphone bracket. If the bracket is damaged, remove the two speed clips attaching it to the upper dash assembly and replace the bracket.
3. Remove the 10–32 machine screw from the prong of the display bracket. Remove the locknuts and washers from the studs on the back of the display unit. See **Fig. 1**.
4. Remove the display bracket, with the display unit attached, from the dash. Pull the two wires (display unit and microphone) out of the dash. When the connectors are sufficiently exposed, disconnect the wires and mark them for later assembly. See **Fig. 2**.

NOTE: If necessary, reach under the dash to disconnect the display and microphone wires.

5. Remove the four 10–32 machine screws attaching the display bracket to the display unit.
6. Attach the electrical connectors to the display unit and microphone, as removed.
7. Install the new display unit on the display bracket, using the four 10–32 machine screws.
8. Position the display bracket on the upper dash assembly as shown in **Fig. 3**. Make sure the studs on the back of the display bracket pass through the fastener holes on the front of the upper dash assembly. See **Fig. 4**.
9. Attach the #10 washers and 10–24 locknuts to the studs. Attach the display bracket to the dash with 10–32 machine screw.
10. Install a new microphone bracket, if removed. Clip the microphone to the microphone bracket.



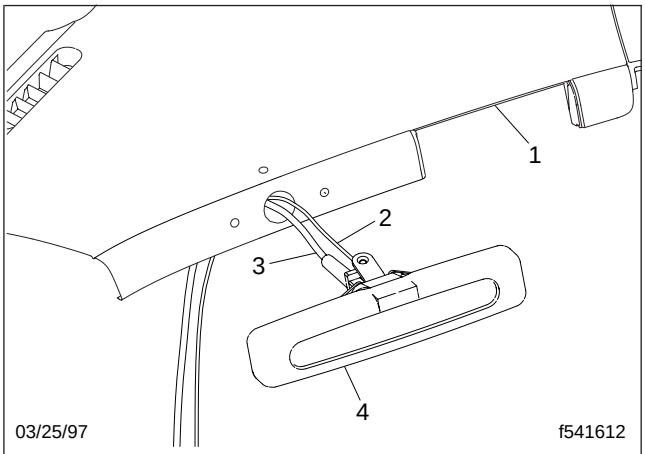
NOTE: The auxiliary dash panel has been removed for clarity.

1. Upper Dash Assembly (LH panel)
2. 1/4–20 Locknut
3. 1/4-Inch Washer
4. 1–1/4-inch (30 mm) Cable Hole
5. 5/16-inch (8 mm) Screw Hole
6. #10 Washer
7. 10–32 Locknut
8. Display Unit
9. Display Bracket
10. 10–32 Machine Screw

Fig. 1, Display Unit Mounting Hardware

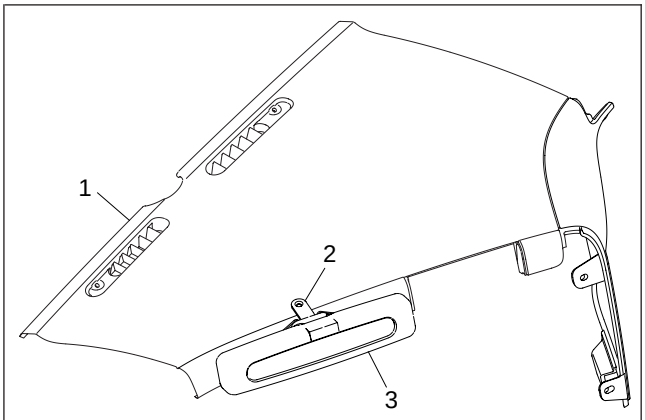
11. Check the door display cable for good connections at both ends. See **Fig. 5**.
12. Check the door display cable for good connections at both ends. See **Fig. 6**.
13. Connect the batteries and restore the cab to normal operating condition.
14. Place a voice call. Test the system for correct operation, including the hands-free microphone, volume control, and voice recognition, and make adjustments as needed. For more information, see **Troubleshooting, 300**.
15. Remove the chocks from the tires.

Display Unit Replacement



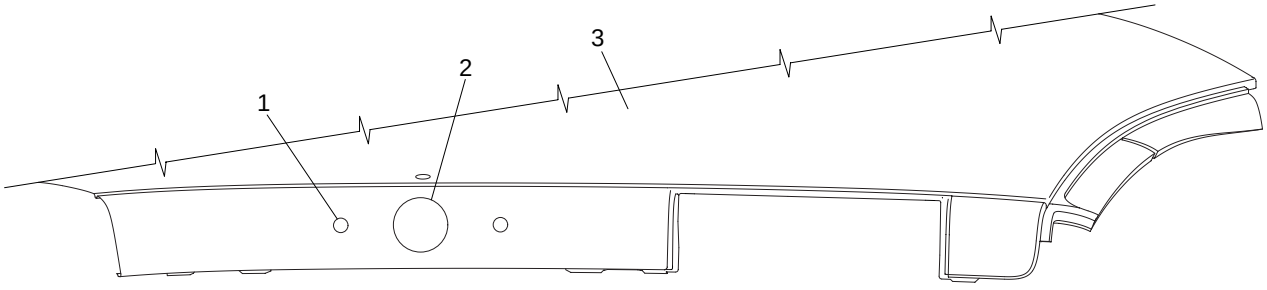
1. Upper Dash Assembly (LH panel)
2. Microphone Wire
3. Display Unit Wire
4. Display Unit

Fig. 2, Wire Removal



1. Upper Dash Assembly (LH panel)
2. Prong of Display Bracket
3. Display Unit

Fig. 3, Display Unit Positioning



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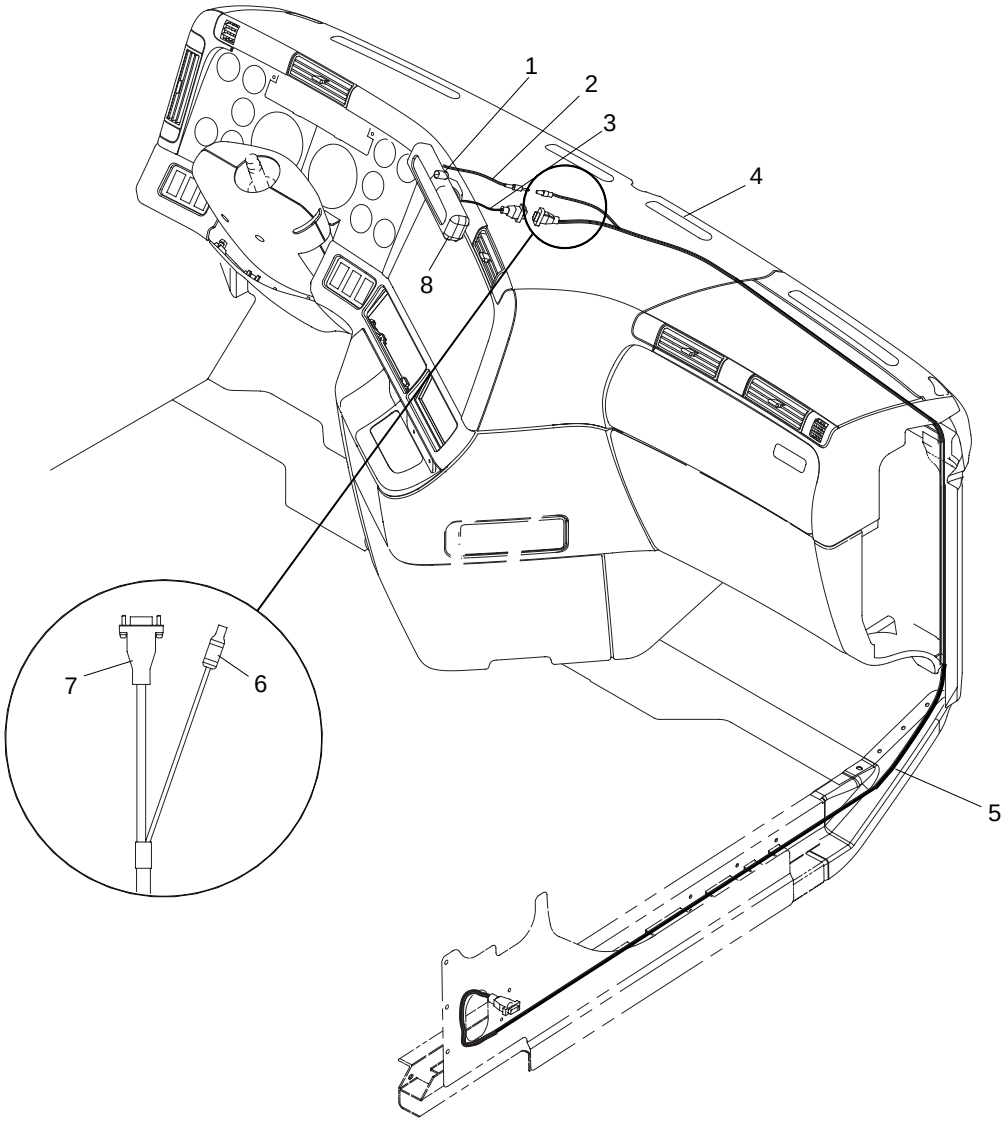
1. 5/16-inch (8 mm) Fastener Hole
2. 1–1/4-inch (30 mm) Cable Hole
3. Upper Dash Assembly (LH panel)

Fig. 4, Hole Location

Display Unit Replacement



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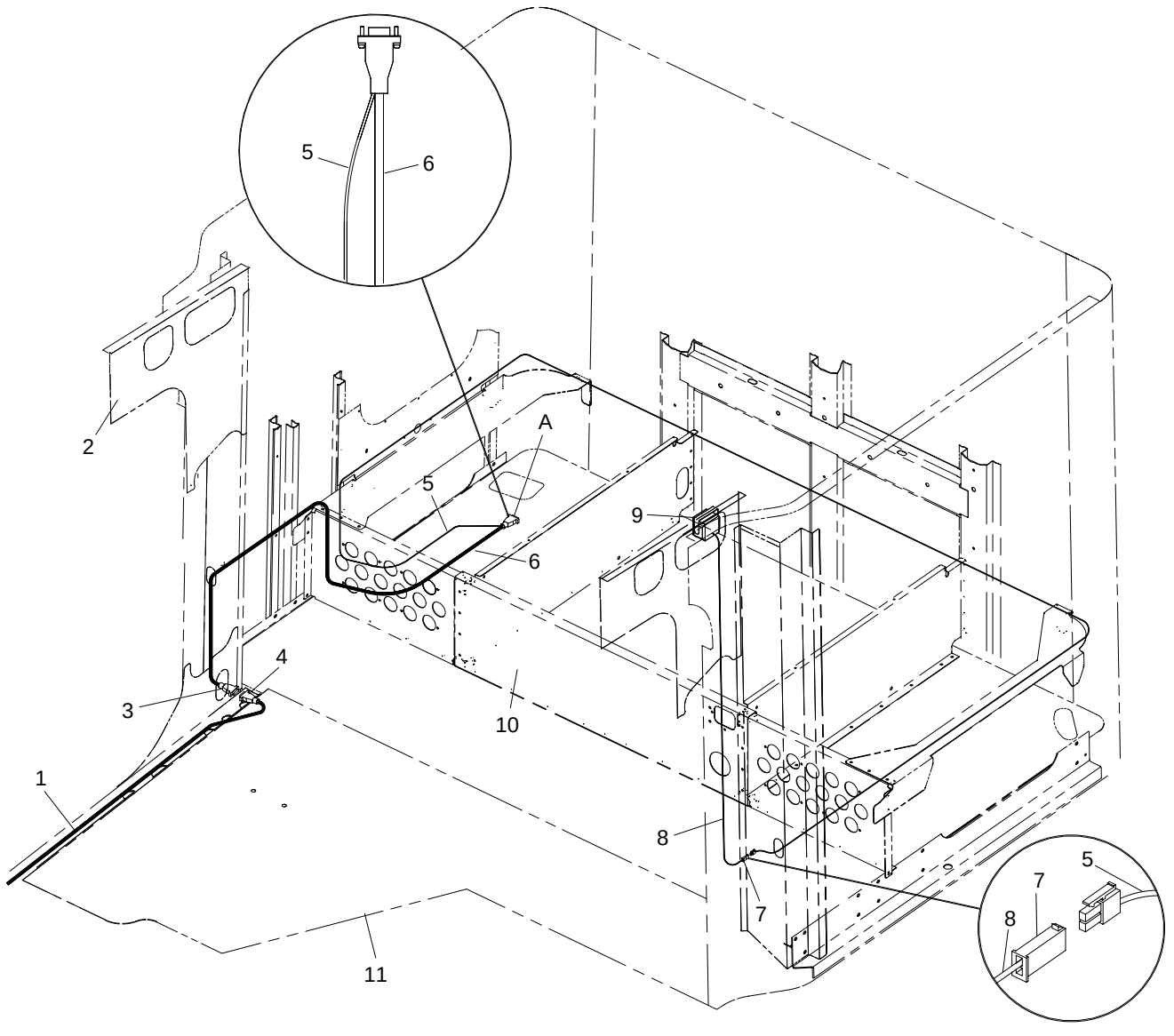
1. Microphone
2. Microphone Wire
3. Display Unit Wire
4. Upper Dash Assembly (LH panel)
5. Display Cable (door)
6. Display Connector
7. Microphone Connector
8. Display Unit

Fig. 5, Display and Microphone Cable Routing (dash)



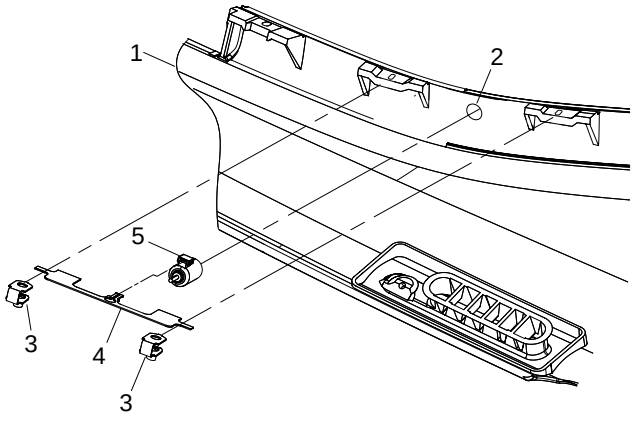
A. To Control Unit
1. Display Cable (door)
2. B-Pillar
3. Display Cable Cab Connector
4. Display Cable Door Connector
5. Speaker Cable (cab)
6. Display Cable (cab)
7. Speaker Connector
8. Speaker Cable (B-pillar)
9. Speaker
10. Forward Bunk Partition
11. Rear Deck

Fig. 6, Display and Speaker Cable Routing (cab)

Replacement

The HighwayMaster® hands-free microphone is normally clipped to a small bracket attached to the upper dash assembly.

1. Set the parking brake, chock the tires, and disconnect the batteries.
2. Unclip the microphone from the microphone bracket. See **Fig. 1**.



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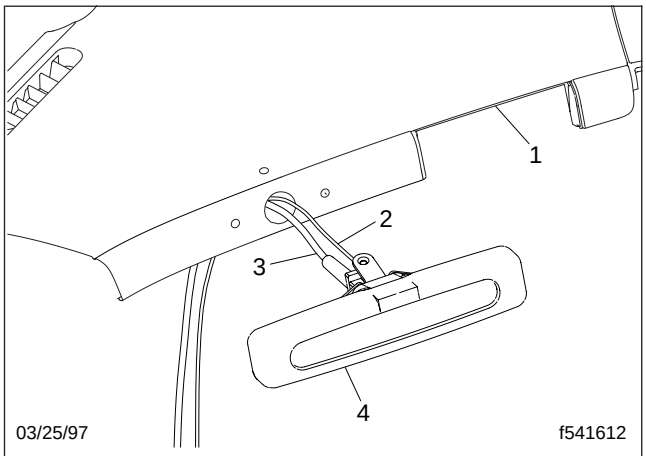
1. Upper Dash Assembly (LH panel)
2. 9/16-Inch (14 mm) Hole
3. Speed Clip
4. Microphone Bracket
5. Microphone

Fig. 1, Microphone Mounting

3. Remove the 10–32 machine screw from the prong of the display bracket. For more information, see **Subject 120**.
4. Remove the display bracket, with the display unit attached, from the dash. Pull the two wires (display unit and microphone) out of the dash. When the microphone connector is sufficiently exposed, disconnect the wire. See **Fig. 2**.

NOTE: If necessary, reach under the dash to disconnect the display and microphone wires.

5. Attach the electrical connector to the new microphone, as removed.
6. Install the display bracket, using the 10–32 machine screw to fasten the prong of the bracket to the upper dash assembly.



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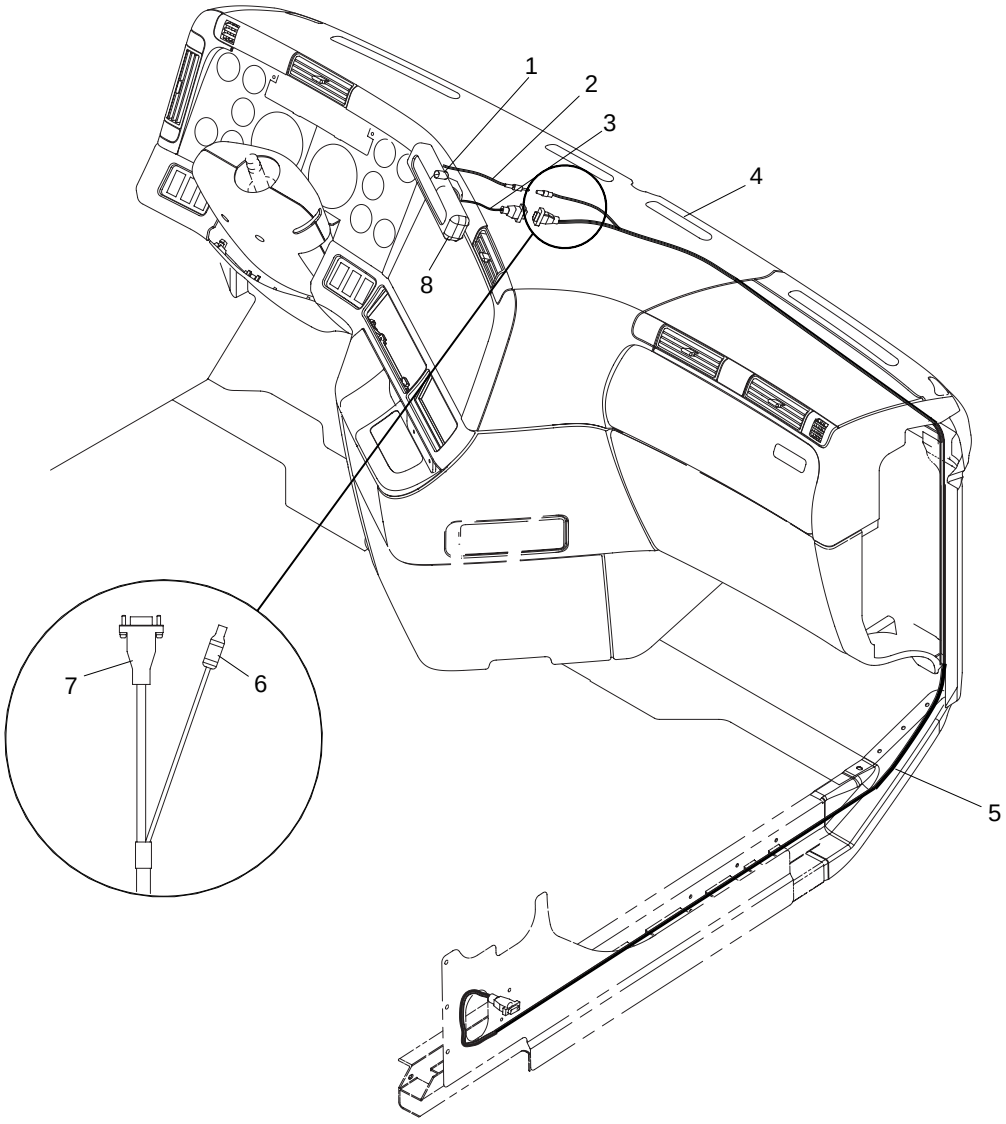
1. Upper Dash Assembly (LH panel)
2. Microphone Wire
3. Display Unit Wire
4. Display Unit

Fig. 2, Wire Removal

7. Clip the new microphone to the microphone bracket.
8. Check the door display cable for good connections at both ends. See **Fig. 3**.
9. Check the cab display cable for good connections at both ends. See **Fig. 4**.
10. Connect the batteries and restore the cab to normal operating condition.
11. Place a voice call. Test the system for correct operation, including the hands-free microphone, volume control, and voice recognition, and make adjustments as needed. For more information, see **Troubleshooting, 300**.
12. Remove the chocks from the tires.

Microphone Replacement



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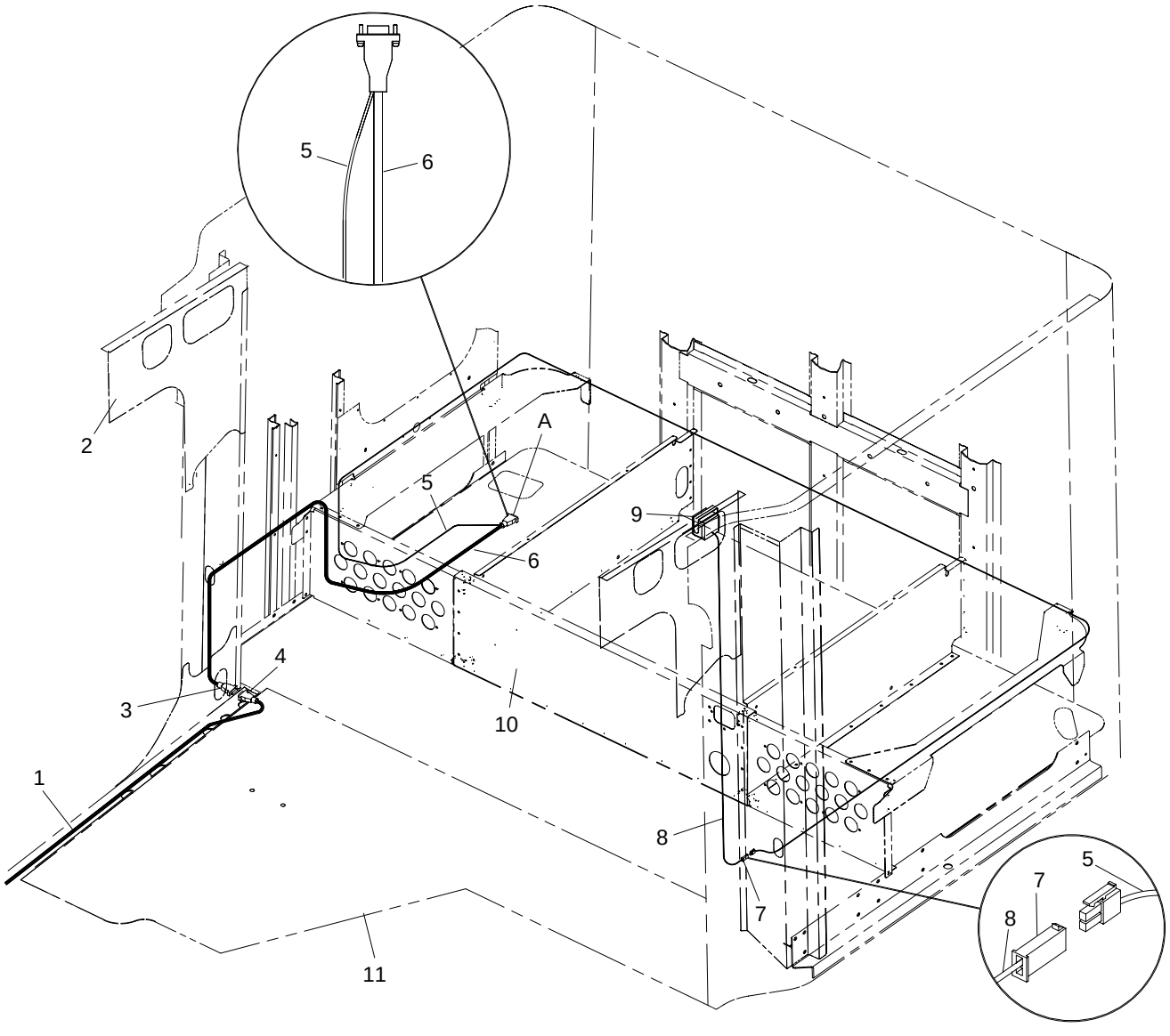
1. Microphone
2. Microphone Wire
3. Display Unit Wire
4. Upper Dash Assembly (LH panel)
5. Display Cable (door)
6. Display Connector
7. Microphone Connector
8. Display Unit

Fig. 3, Display and Microphone Cable Routing (dash)



A. To Control Unit
1. Display Cable (door)
2. B-Pillar
3. Display Cable Cab Connector
4. Display Cable Door Connector
5. Speaker Cable (cab)
6. Display Cable (cab)
7. Speaker Connector
8. Speaker Cable (B-pillar)
9. Speaker
10. Forward Bunk Partition
11. Rear Deck

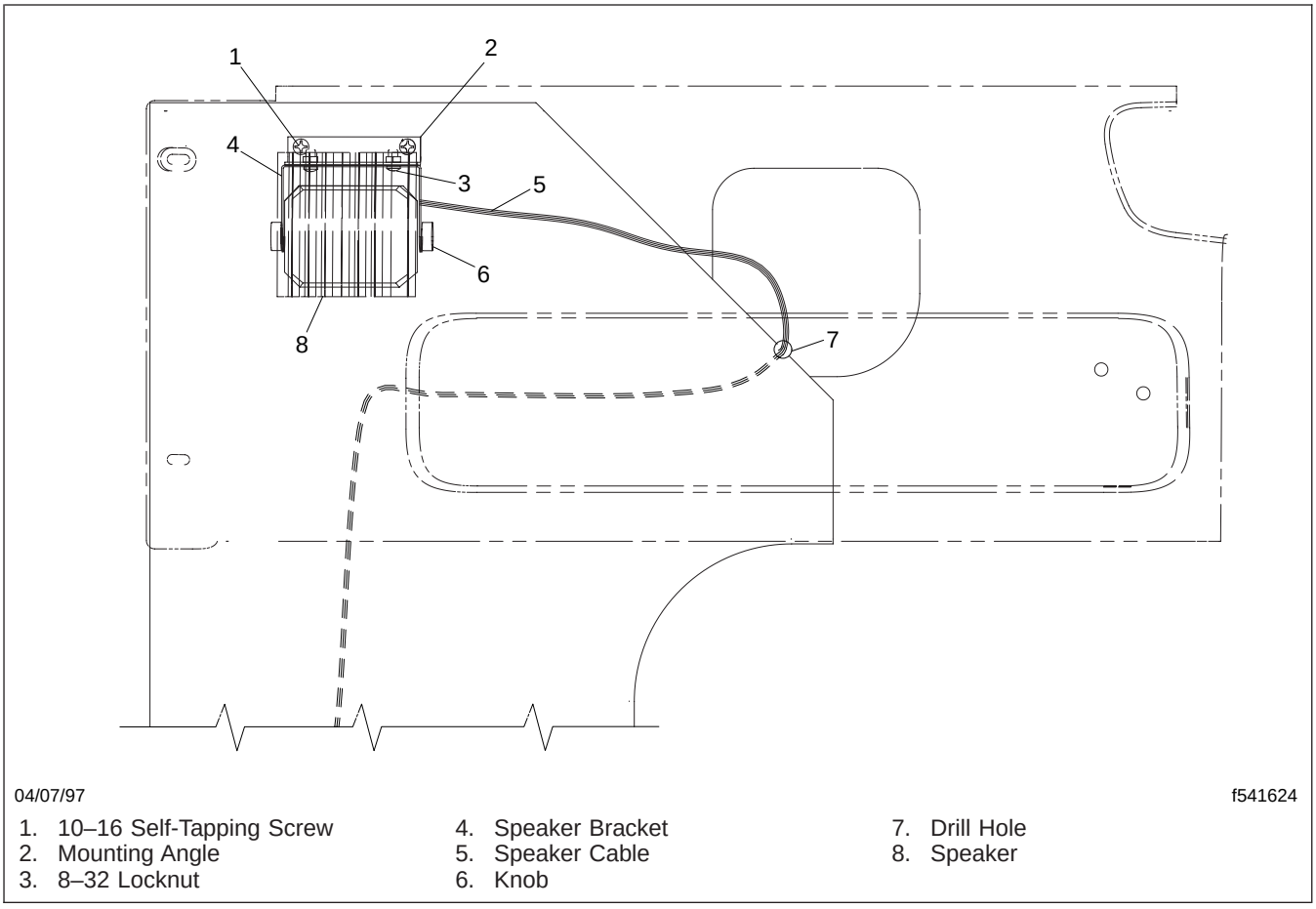
Fig. 4, Display and Speaker Cable Routing (cab)

Replacement

The HighwayMaster® speaker is normally installed on the driver's side of the cab. On factory installations, it is on the B-pillar (see **Fig. 1**); on aftermarket installations, it is on the cab wall above the window (see **Fig. 2**).

3.1 Loosen the knobs on each side of the speaker and remove the speaker from the speaker bracket.

3.2 Pull the speaker cable wire and connector out through the hole in the cab wall. If necessary, remove the upholstery panel.



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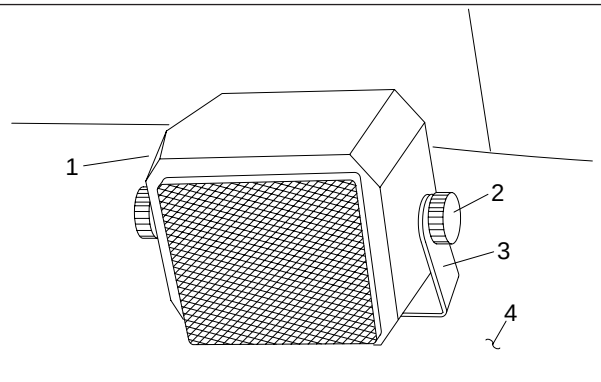
1. 10–16 Self-Tapping Screw
2. Mounting Angle
3. 8–32 Locknut
4. Speaker Bracket
5. Speaker Cable
6. Knob
7. Drill Hole
8. Speaker

Fig. 1, Speaker (factory installation)

1. Set the parking brake, chock the tires, and disconnect the batteries.
2. Open the electrical compartment door on the driver's side B-pillar, behind the seat. Disconnect the speaker electrical connector. See **Fig. 3**.
3. Remove the speaker from the speaker bracket. See **Fig. 1** for the factory installation, and **Fig. 2** for the aftermarket installation.
4. If necessary to change the mounting or replace any of the mounting hardware, remove the speaker mounting. See **Fig. 4** for the factory installation, and **Fig. 5** for the aftermarket installation.

   4.1 Remove the two 8–32 machine screws attaching the speaker bracket to the mounting angle (or cab wall, on aftermarket installations).

Speaker Replacement



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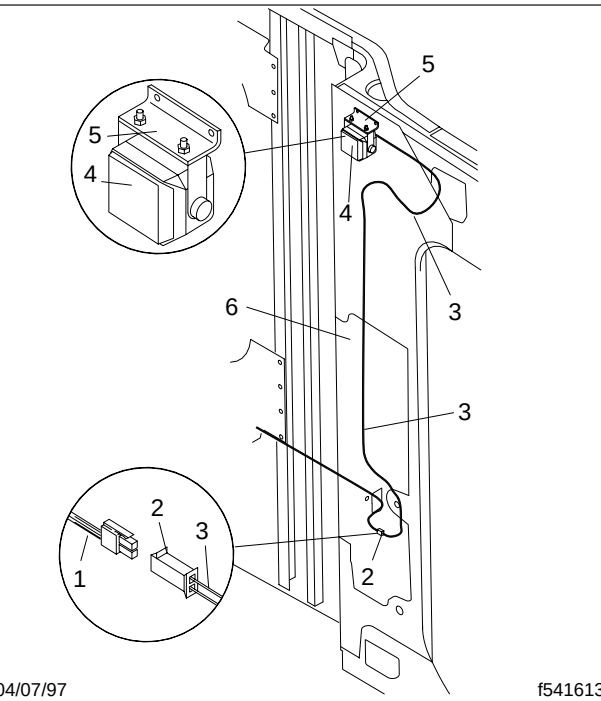
1. Speaker
2. Knob
3. Speaker Bracket
4. Cab Wall

Fig. 2, Speaker (aftermarket installation)



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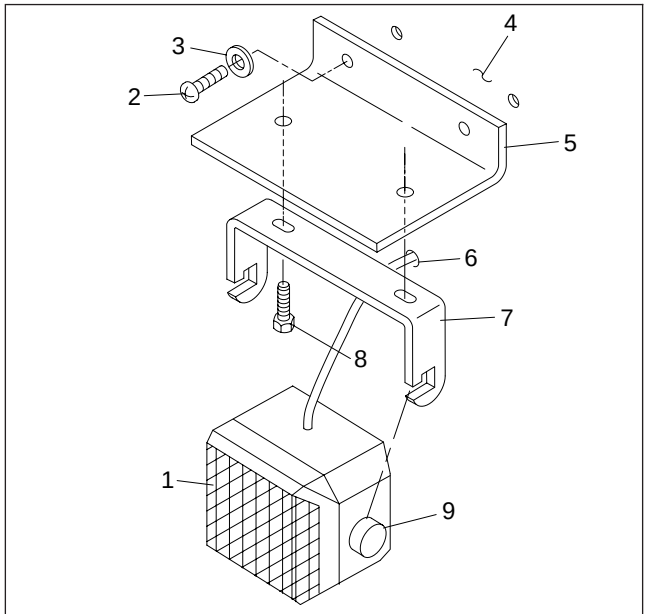
Factory installation is shown. The aftermarket installation is similar.

1. Speaker Cable (cab)
2. Electrical Connector
3. Speaker Cable (B-pillar)
4. Speaker
5. Mounting Angle
6. B-Pillar Electrical Compartment

Fig. 3, Speaker Cable Routing (B-pillar)



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1. Speaker
2. 10–16 Self-Tapping Screw
3. Washer
4. Cab Wall
5. Mounting Angle
6. Drill Hole
7. Speaker Bracket
8. 8–32 Machine Screw
9. Knob

Fig. 4, Speaker Mounting (factory installation)

4.2 If installed, remove the two 10–16 self-tapping screws and washers attaching the mounting angle to the cab wall.

5. If removed, install the mounting angle and speaker bracket. Use the removed fasteners.

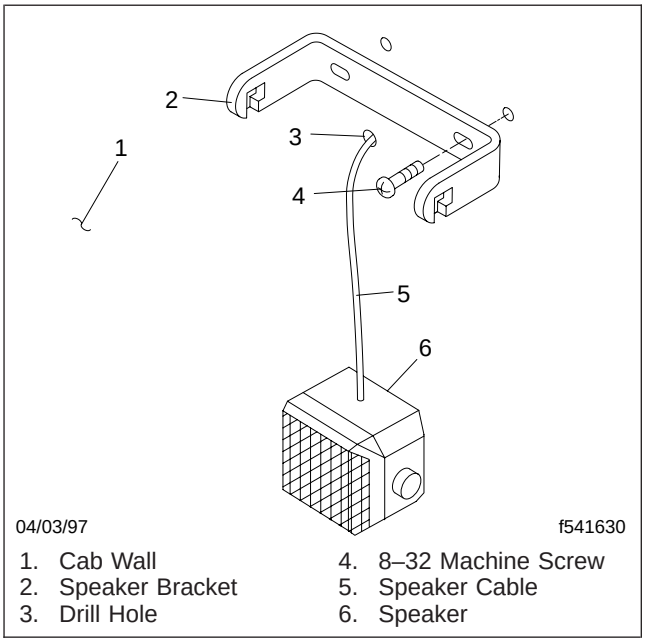
6. Install the speaker.

   6.1 Insert the knobs on each side of the new speaker into the slots in the speaker bracket.

   6.2 Route the new speaker cable through the drill hole and connect it to the electrical connector on the end of the cab speaker cable.

   6.3 When the cable has been properly routed and connected, tighten the knobs on the speaker until firm and tight.

7. Check the B-pillar speaker cable for good connections at both ends. See **Fig. 3**.

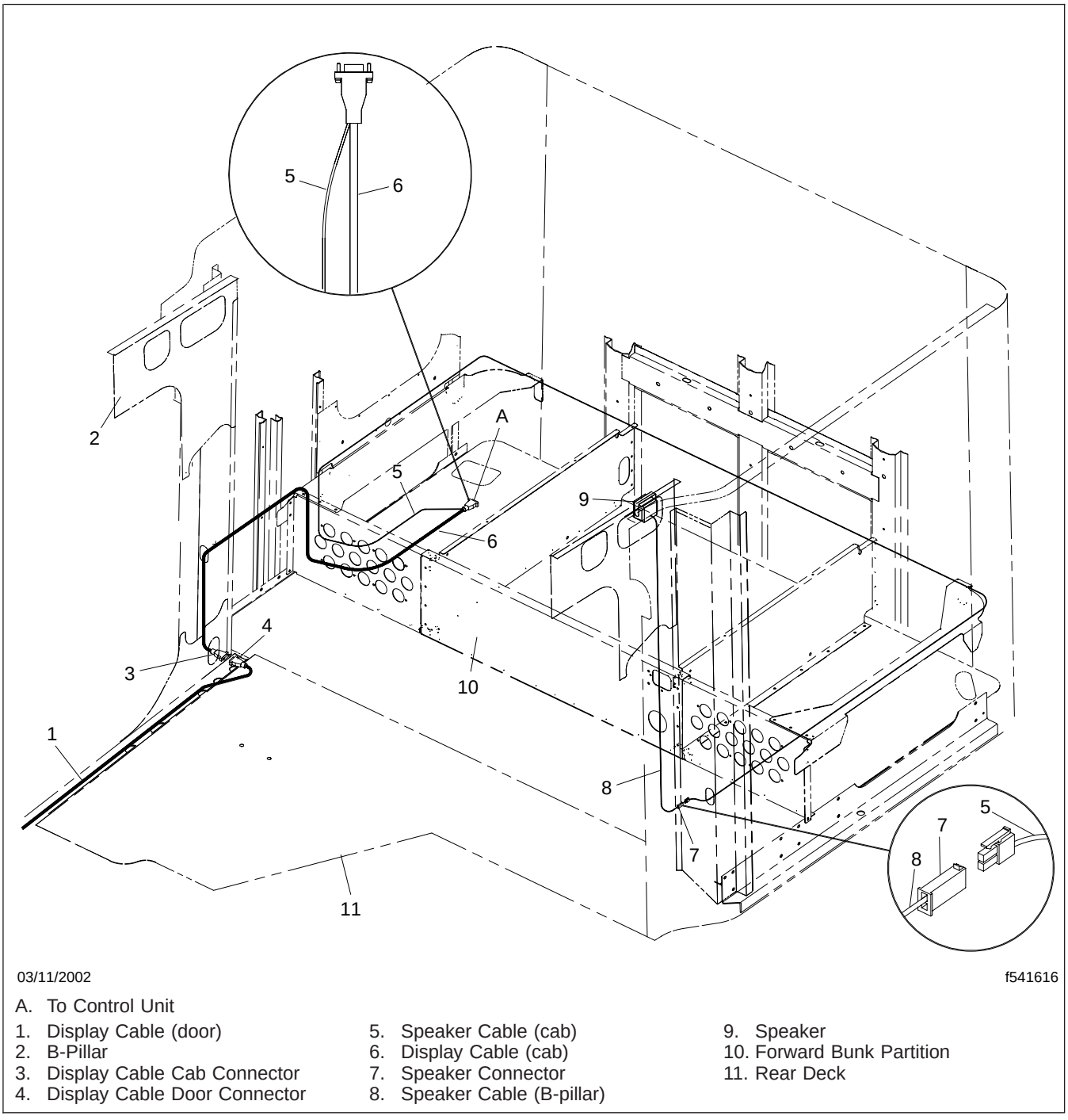


1. Cab Wall
2. Speaker Bracket
3. Drill Hole
4. 8–32 Machine Screw
5. Speaker Cable
6. Speaker

Fig. 5, Speaker Mounting (aftermarket installation)

8. Check the cab speaker cable for good connections at both ends. See **Fig. 6**.
9. Connect the batteries and restore the cab to normal operating condition.
10. Place a voice call. Test the system for correct operation, including the hands-free microphone, volume control, and voice recognition, and make adjustments as needed. For more information, see **Troubleshooting, 300**.
11. Remove the chocks from the tires.

Speaker Replacement

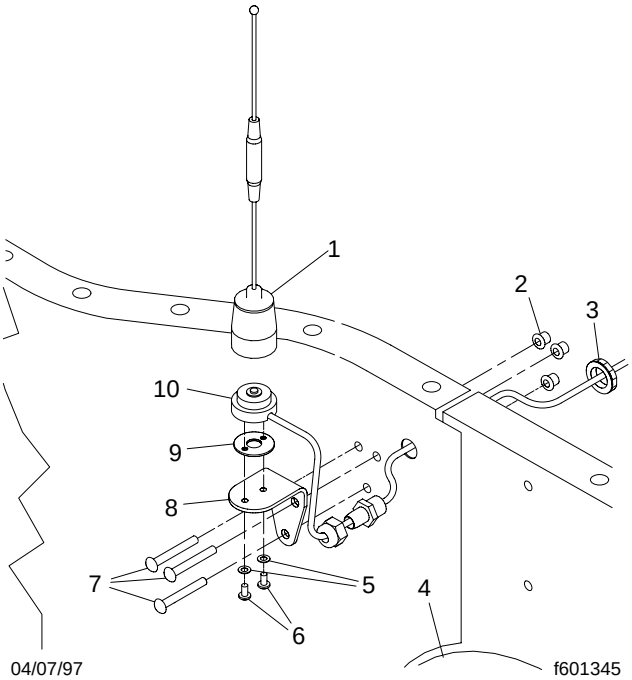


A. To Control Unit
1. Display Cable (door)
2. B-Pillar
3. Display Cable Cab Connector
4. Display Cable Door Connector
5. Speaker Cable (cab)
6. Display Cable (cab)
7. Speaker Connector
8. Speaker Cable (B-pillar)
9. Speaker
10. Forward Bunk Partition
11. Rear Deck

Fig. 6, Display and Speaker Cable Routing (cab)

Replacement

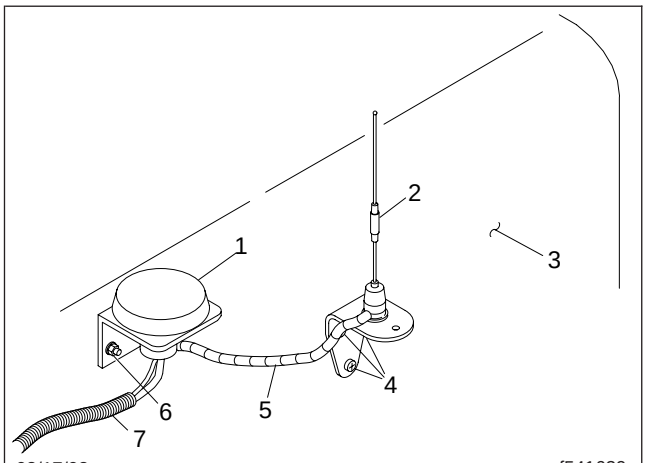
The HighwayMaster® cellular antenna is normally installed on the outside of the cab. On factory installations, it is on the cab wall on the passenger's side just above and behind the door (see **Fig. 1**); on aftermarket installations, it is on the back of the cab (see **Fig. 2**).



1. Cellular Antenna
2. 1/4-Inch Collar
3. Cable Nut
4. Cab Skin (passenger side)
5. #10 Washer
6. 10–32 Machine Screw
7. Brazier HD Lockbolt
8. Cellular Antenna Bracket
9. Spacer
10. Antenna Base

Fig. 1, Cellular Antenna (factory installation)

1. Set the parking brake, chock the tires, and disconnect the batteries.
2. Remove the two 10–32 machine screws and washers from the cellular antenna bracket. Remove the antenna, base and spacer.
3. Install the new antenna, base, and spacer. Use the removed fasteners.

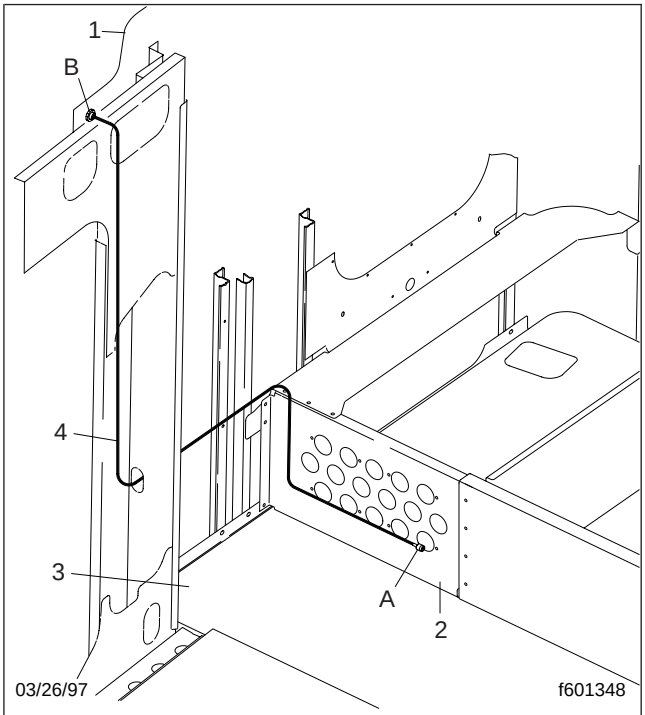


1. GPS Antenna
2. Cellular Antenna
3. Back of Cab
4. Lockbolts
5. Cellular Antenna Cable
6. 5/16-Inch Hexnut
7. Dual Antenna Cable

Fig. 2, Cellular Antenna (aftermarket installation)

4. Check the cellular antenna cable for good connections at both ends. See **Fig. 3**.
5. Connect the batteries and restore the cab to normal operating condition.
6. Place a voice call. Test the system for correct operation, including the hands-free microphone, volume control, and voice recognition, and make adjustments as needed. For more information, see **Troubleshooting, 300**.
7. Remove the chocks from the tires.

Cellular Antenna Replacement



Factory installation is shown.

A. To Control Unit
B. To Cellular Antenna

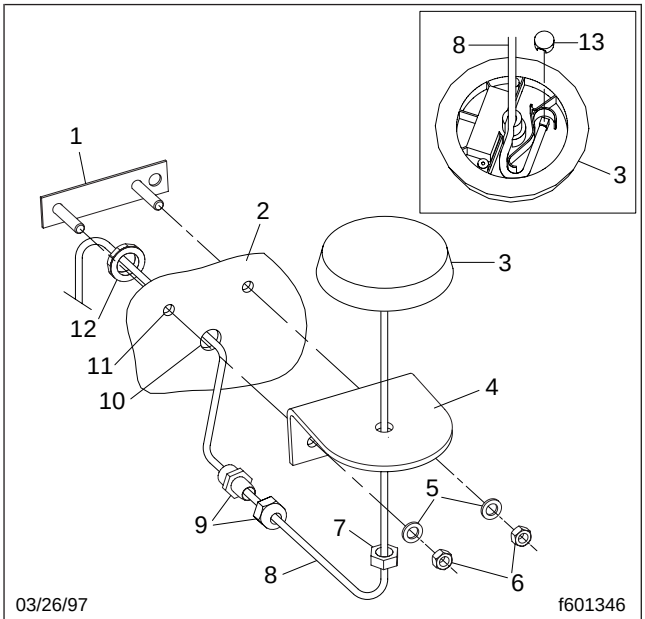
1. Cab Wall
2. Forward Bunk Partition
3. Rear Deck
4. Cellular Antenna Cable

Fig. 3, Cellular Antenna Cable Routing

Replacement

The HighwayMaster® GPS (global positioning system) antenna is normally installed on the back of the cab. On factory installations, it is on the roof cap on the passenger's side; on aftermarket installations, it is on the back of the cab.

1. Set the parking brake, chock the tires, and disconnect the batteries.
2. Loosen the M12 nylon hexnut from the GPS antenna bracket. Remove the antenna. See **Fig. 1** for factory installations and **Fig. 2** for aftermarket installations.



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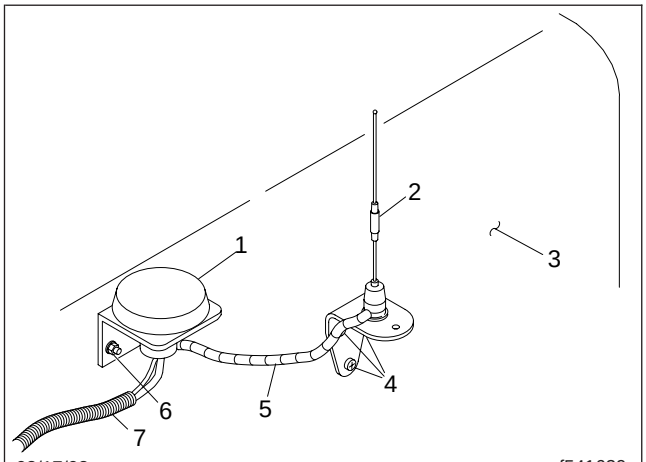
NOTE: The insert shows a bottom view of the antenna.

1. Backing Plate
2. Roof Cap
3. GPS Antenna
4. GPS Antenna Bracket
5. 5/16-Inch Washer
6. 5/16-Inch Locknut
7. M12 Nylon Hexnut
8. GPS Antenna Cable
9. Through-Skin Fittings
10. 21/32-Inch (17 mm) Cable Hole
11. 3/8-Inch (9 mm) Fastener Hole
12. Cable Nut
13. Rubber Cable Cap

Fig. 1, GPS Antenna (factory installation)



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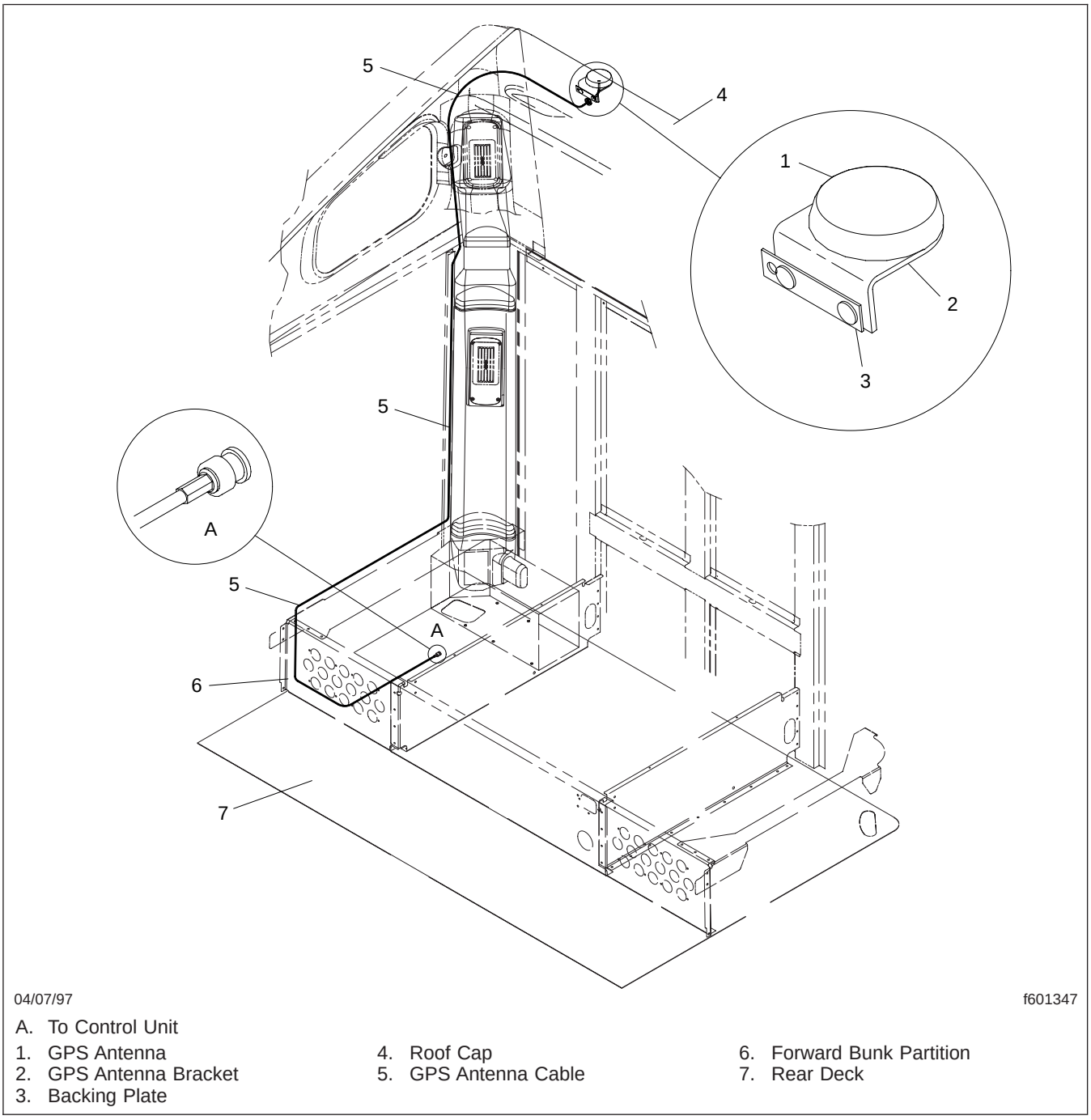
1. GPS Antenna
2. Cellular Antenna
3. Back of Cab
4. Lockbolts
5. Cellular Antenna Cable
6. 5/16-Inch Hexnut
7. Dual Antenna Cable

Fig. 2, GPS Antenna (aftermarket installation)

3. Turn over the new antenna and install the rubber cable cap on end of the GPS antenna cable.
4. Install the new antenna. Make sure the M12 nylon hexnut is firm and tight.
5. Check the GPS antenna cable for good connections at both ends. See **Fig. 3**.
6. Connect the batteries and restore the cab to normal operating condition.
7. Place a voice call. Test the system for correct operation, including the hands-free microphone, volume control, and voice recognition, and make adjustments as needed. For more information, see **Troubleshooting, 300**.
8. Remove the chocks from the tires.

GPS Antenna Replacement



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A. To Control Unit
1. GPS Antenna
2. GPS Antenna Bracket
3. Backing Plate
4. Roof Cap
5. GPS Antenna Cable
6. Forward Bunk Partition
7. Rear Deck

Fig. 3, GPS Antenna Cable Routing

Troubleshooting

When the engine is started, the HighwayMaster system goes into its start-up cycle. When the system is functioning properly, it goes through the following steps:

1. The display shows the underline prompt (_).
2. The display reads "Checking Cellular Service" and then changes to "Registering Unit for Service."
3. Once the unit has been registered, the display reads either "HighwayMaster Service Area" (if you are in an area where HighwayMaster provides cellular coverage) or "HighwayMaster" (if you are out of the coverage area).
4. When fully operational, the handset is illuminated and the display shows from three to seven bars.

Use this cycle as a diagnostic check. If the system does not go through all of these steps, see the appropriate troubleshooting table below.

Problem—The HighwayMaster System Has No Power

Problem—The HighwayMaster System Has No Power	
Possible Cause	**Remedy**
The vehicle is not running.	With the transmission in neutral and the parking brake set, start the engine and check to see if the system goes through the complete start-up cycle.
The circuit breaker is blown or missing.	Check the 10-amp circuit breaker in position #7, Block B3, of the auxiliary power distribution module (PDM) inside the left-hand B-pillar electrical compartment. Replace any damaged components.
There are loose connections.	Carefully check all of the connections on the power, phone, display, speaker, and both antenna cables. Connect as necessary.
The power cable needs replacing.	Disconnect the power cable to the auxiliary PDM. Then disconnect the power cable from the control unit. With the power cable reconnected to the auxiliary PDM, turn the ignition keyswitch on. Now insert the negative lead of a digital voltmeter into the right-hand cavity on the connector. Insert the positive lead into another cavity, and check for voltage. When finished, check the other end of the cable. If the voltage at either end reads less than 11 volts, or more than 13.5 volts, replace the power cable.
The control unit is broken.	Replace the control unit. See **Subject 100** for detailed instructions.

Problem—The HighwayMaster System Has Intermittent Power

Problem—The HighwayMaster System Has Intermittent Power	
Possible Cause	**Remedy**
The circuit breaker is loose or defective.	Check the 10-amp circuit breaker in position #7, Block B3, of the auxiliary power distribution module (PDM) inside the left-hand B-pillar electrical compartment. Replace any damaged components.
There are loose connections.	Carefully check all of the connections on the power, phone, display, speaker, and both antenna cables. Repair/replace as necessary.

Troubleshooting

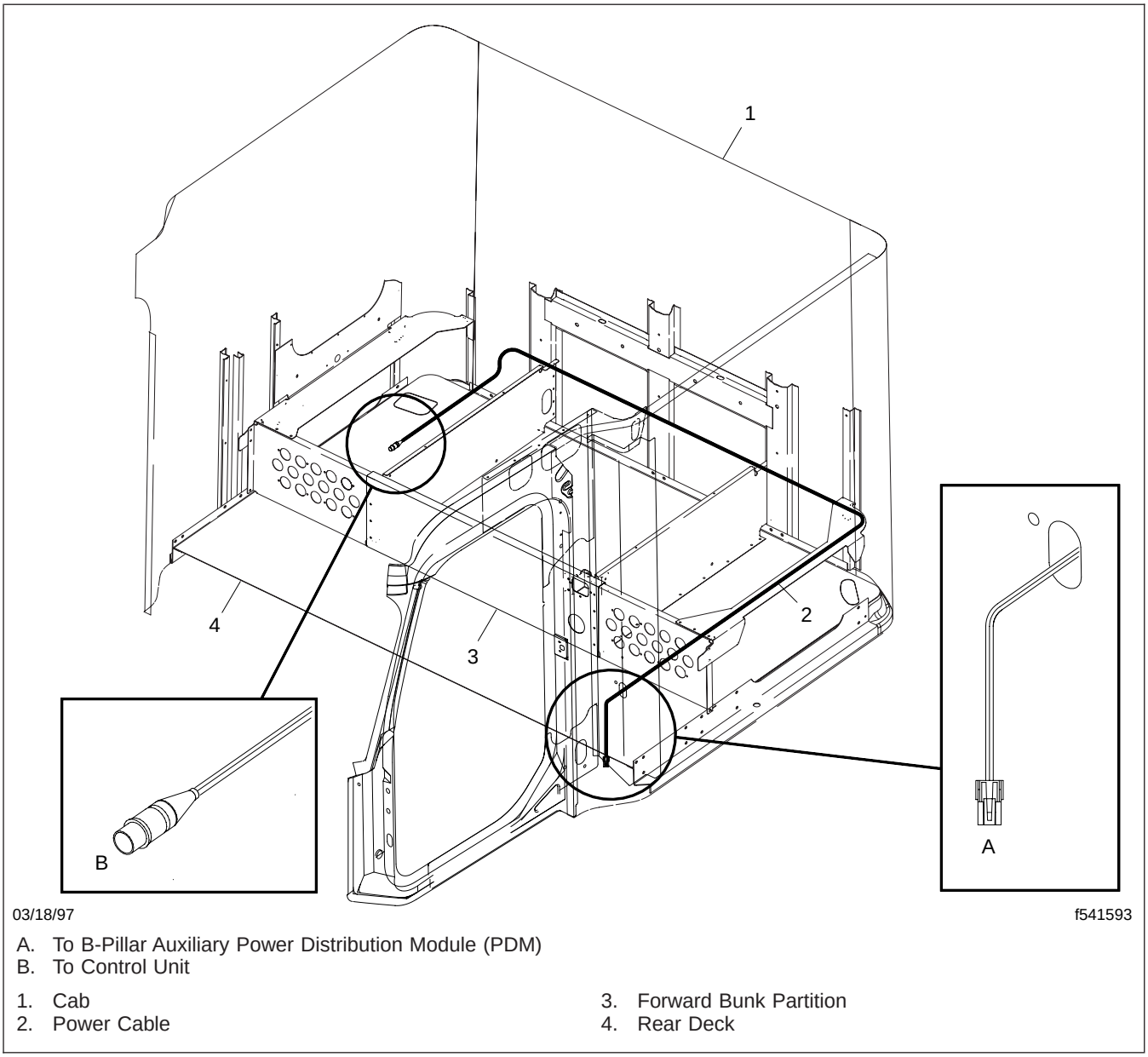
Problem—The HighwayMaster System Has Intermittent Power	
Possible Cause	**Remedy**
The power cable needs replacing.	Disconnect the power cable from the auxiliary PDM. Then disconnect the power cable from the control unit. With the power cable reconnected to the auxiliary PDM, turn the ignition keyswitch on. See **Fig. 1**. Now insert the negative lead of a digital voltmeter into the right-hand cavity on the connector. Insert the positive lead into another cavity, and check for voltage. When finished, check the other end of the cable. If the voltage at either end reads less than 11 volts, or more than 13.5 volts, replace the power cable.
The control unit is broken.	Replace the control unit. See **Subject 100** for detailed instructions.

Problem—When the Ignition Keyswitch Is Turned Off, the HighwayMaster System Also Turns Off

Problem—When the Ignition Keyswitch Is Turned Off, the HighwayMaster System Also Turns Off	
Possible Cause	**Remedy**
The power off delay is not set or is set to 0.	Call the host operator to set the delay to the desired time, from 1 to 12 hours.
There are loose connections in the phone cables.	Disconnect the power cable from the auxiliary PDM. Now disconnect and reconnect the phone cables, making sure the connectors seat properly. See **Fig. 2** and **Fig. 3**. Reconnect the power cable to the auxiliary PDM.
The power plug is installed incorrectly.	Check the installation of the power plug and reposition it if necessary.
The control unit is broken.	Replace the control unit. See **Subject 100** for detailed instructions.

Problem—The Handset Does Not Illuminate

Problem—The Handset Does Not Illuminate	
Possible Cause	**Remedy**
The handset is not correctly connected to the pickup.	Turn the unit off. Check the connection of the handset cord to the pickup and turn the unit back on.
There are loose connections in the phone cables.	Disconnect the power cable from the auxiliary PDM. Now disconnect and reconnect the phone cables, making sure the connectors seat properly. See **Fig. 2** and **Fig. 3**. Reconnect the power cable to the auxiliary PDM.
The handset is broken.	Turn the unit off. Replace the handset with a spare handset and turn the unit back on. If the handset now illuminates, replace the handset. See **Subject 110** for detailed instructions.
The phone cable assembly needs replacing.	Disconnect the power cable from the auxiliary PDM. Now connect a spare phone cable assembly, making sure the connectors seat properly. See **Fig. 2** and **Fig. 3**. Reconnect the power cable to the auxiliary PDM. If the handset now illuminates, replace the phone cable assembly.

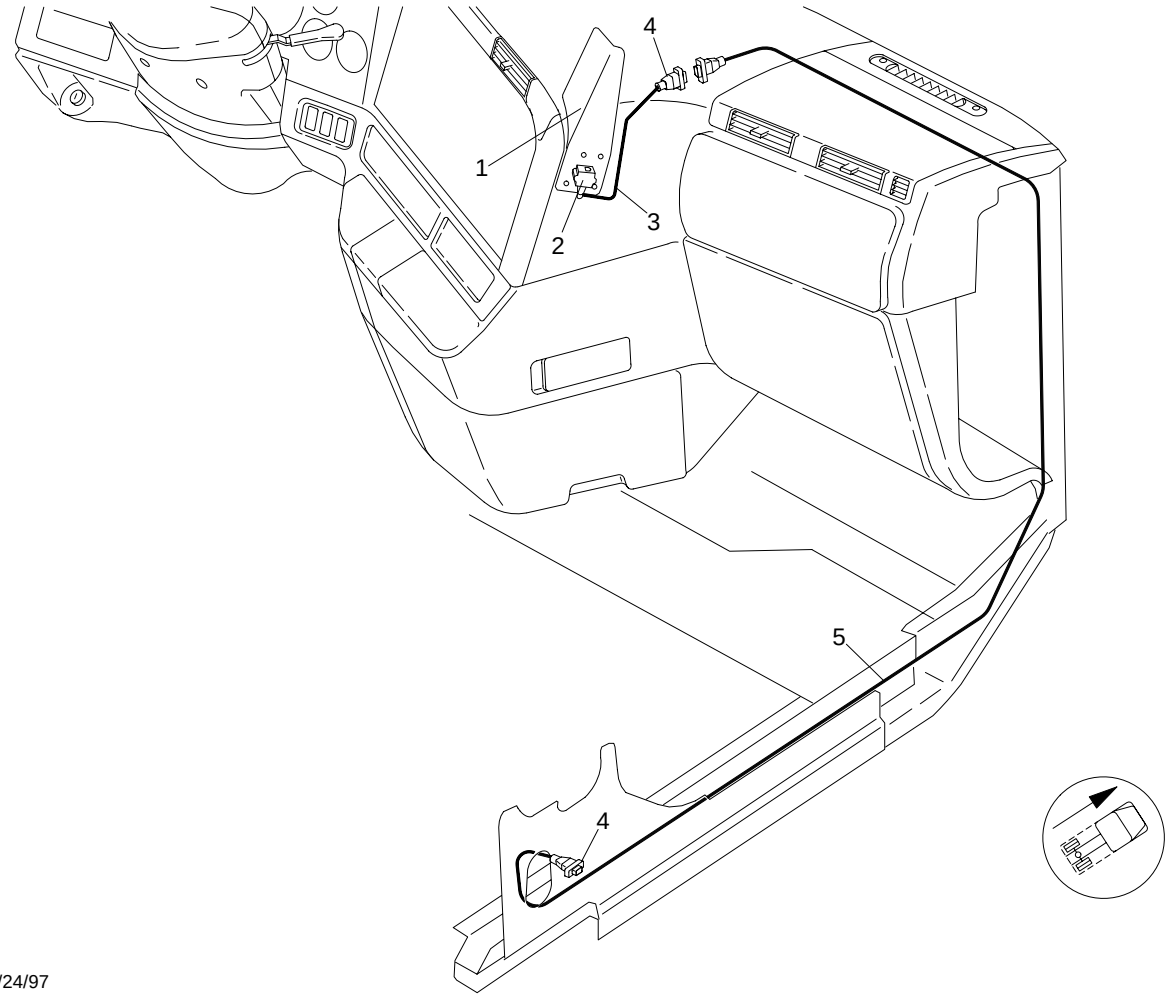


A. To B-Pillar Auxiliary Power Distribution Module (PDM)
B. To Control Unit

1. Cab
2. Power Cable
3. Forward Bunk Partition
4. Rear Deck

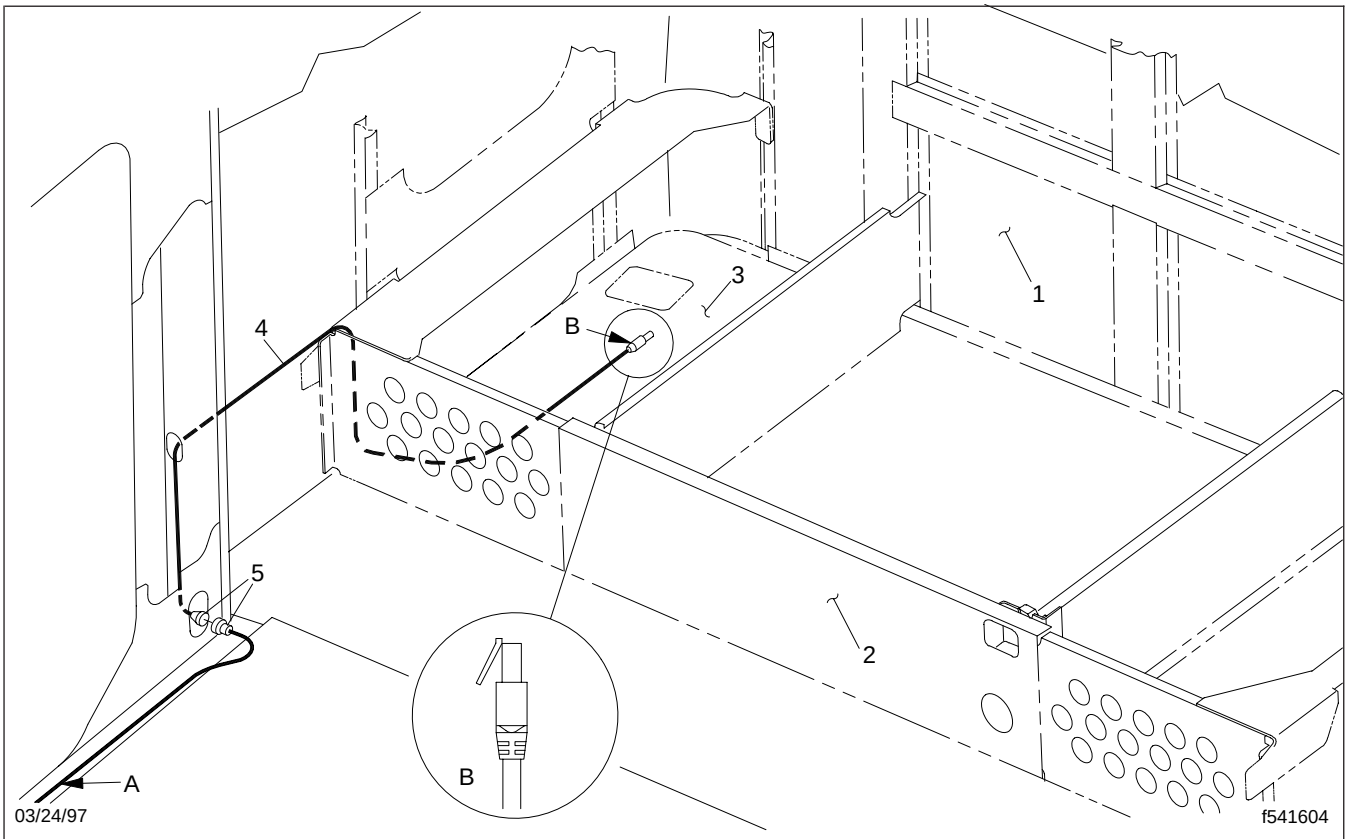
Fig. 1, Power Cable Routing

Troubleshooting



1. Pedestal
2. Pickup
3. Phone Cable (dash)
4. Connector
5. Phone Cable (door)

Fig. 2, Phone Cable Routing (dash)



A. To Handset
B. To Control Unit

1. Cab
2. Forward Bunk Partition
3. Rear Deck
4. Phone Cable (cab)
5. Connectors

Fig. 3, Phone Cable Routing (cab)

Problem—The Keypad on the Handset Does Not Function

Problem—The Keypad on the Handset Does Not Function	
Possible Cause	**Remedy**
The handset is damaged.	Check the handset for physical damage, disconnected wires, and broken seals.
There are sticky keys in the keypad.	Try several keys to see if any key responds. If some keys respond but others do not, clean the keypad. Turn the unit off. Spray on some contact cleaner and wipe off the keypad until it is dry. Turn the unit back on and check the keys again. Repeat if necessary.
The handset is broken.	Turn the power off. Replace the handset with a spare handset and turn the power back on. If the handset now illuminates, replace the handset. See **Subject 110** for detailed instructions.

Troubleshooting

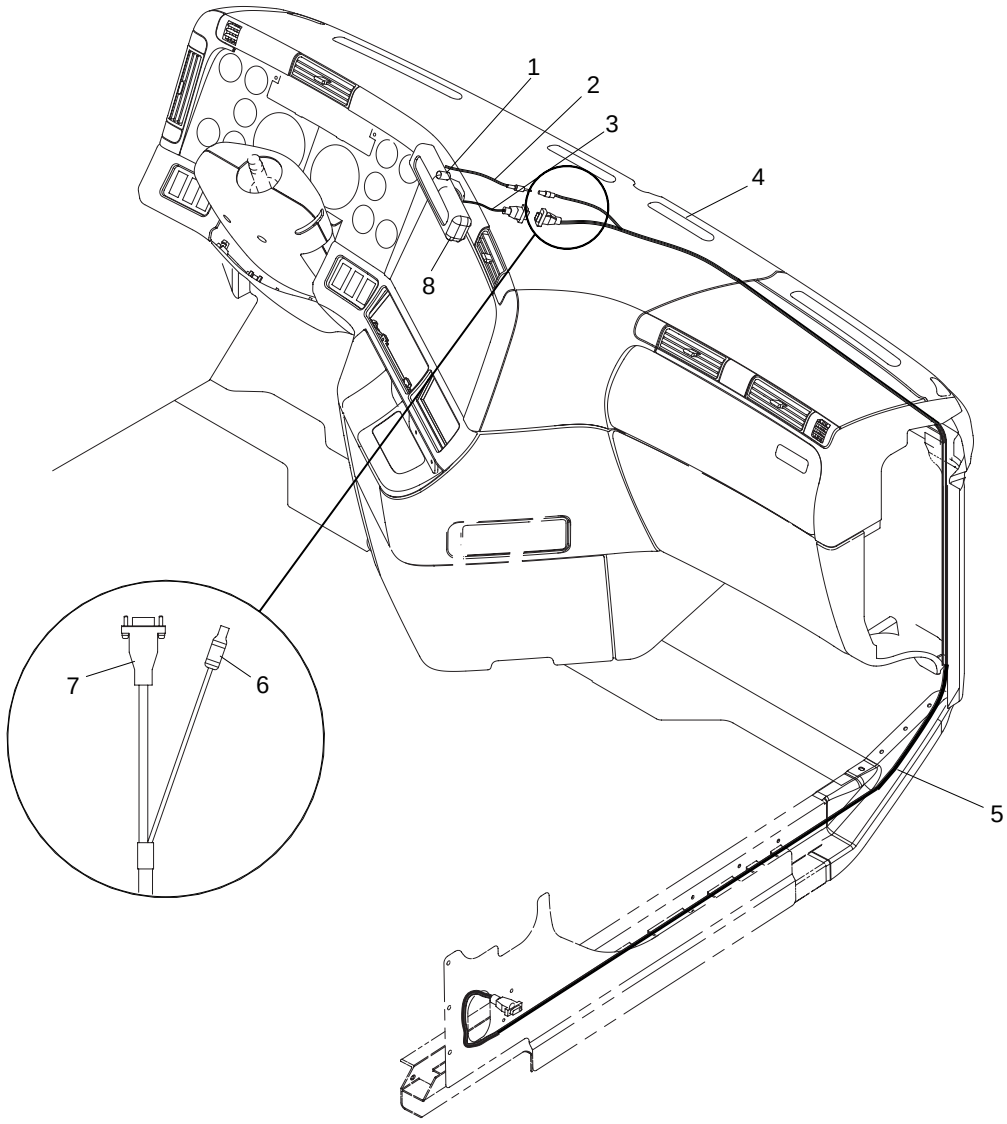
Problem—The Keypad on the Handset Does Not Function	
Possible Cause	**Remedy**
The phone cable assembly needs replacing.	Disconnect the power cable from the auxiliary PDM. Now connect a spare phone cable assembly, making sure the connectors seat properly. See **Fig. 2** and **Fig. 3**. Reconnect the power cable to the auxiliary PDM. If the handset now illuminates, replace the phone cable assembly.

Problem—The Display Is Blank, but the Handset and Control Unit Have Power

Problem—The Display Is Blank, but the Handset and Control Unit Have Power	
Possible Cause	**Remedy**
The screen saver is set to a short period of time.	On the handset, press "F" (function) and "Send." Use the arrow key to move down the menu to get to "Set Screen Saver Timer." Enter any number from 1 to 240 to change the number of minutes before the display goes blank.
There are loose connections in the display cables.	Disconnect the power cable from the auxiliary PDM. Now disconnect and reconnect the display cables, making sure the connectors seat properly. See **Fig. 4** and **Fig. 5**. Reconnect the power cable to the auxiliary PDM.
The display cable assembly needs replacing.	Disconnect the circuit breaker. Now connect a spare display cable, making sure the connectors seat properly. See **Fig. 4** and **Fig. 5**. Reconnect the circuit breaker. If the display now works, replace the display cable assembly.
The display unit is broken.	Replace the display unit. See **Subject 120** for detailed instructions.

Problem—The Display Shows Only the Underline Prompt (_)

Problem—The Display Shows Only the Underline Prompt (_)	
Possible Cause	**Remedy**
The screen saver is set to a short period of time.	On the handset, press "F" (function) and "Send." Use the arrow key to move down the menu to get to "Set Screen Saver Timer." Enter any number from 1 to 240 to change the number of minutes before the display goes blank.
There are loose connections in the display cables.	Disconnect the circuit breaker. Now disconnect and reconnect the display cables, making sure the connectors seat properly. See **Fig. 4** and **Fig. 5**. Reconnect the circuit breaker.
The display unit is broken.	Replace the display unit. See **Subject 120** for detailed instructions.
The display cable assembly needs replacing.	Disconnect the circuit breaker. Now connect a spare display cable, making sure the connectors seat properly. See **Fig. 4** and **Fig. 5**. Reconnect the circuit breaker. If the display now works, replace the display cable assembly.
The control unit is broken.	Replace the control unit. See **Subject 100** for detailed instructions.



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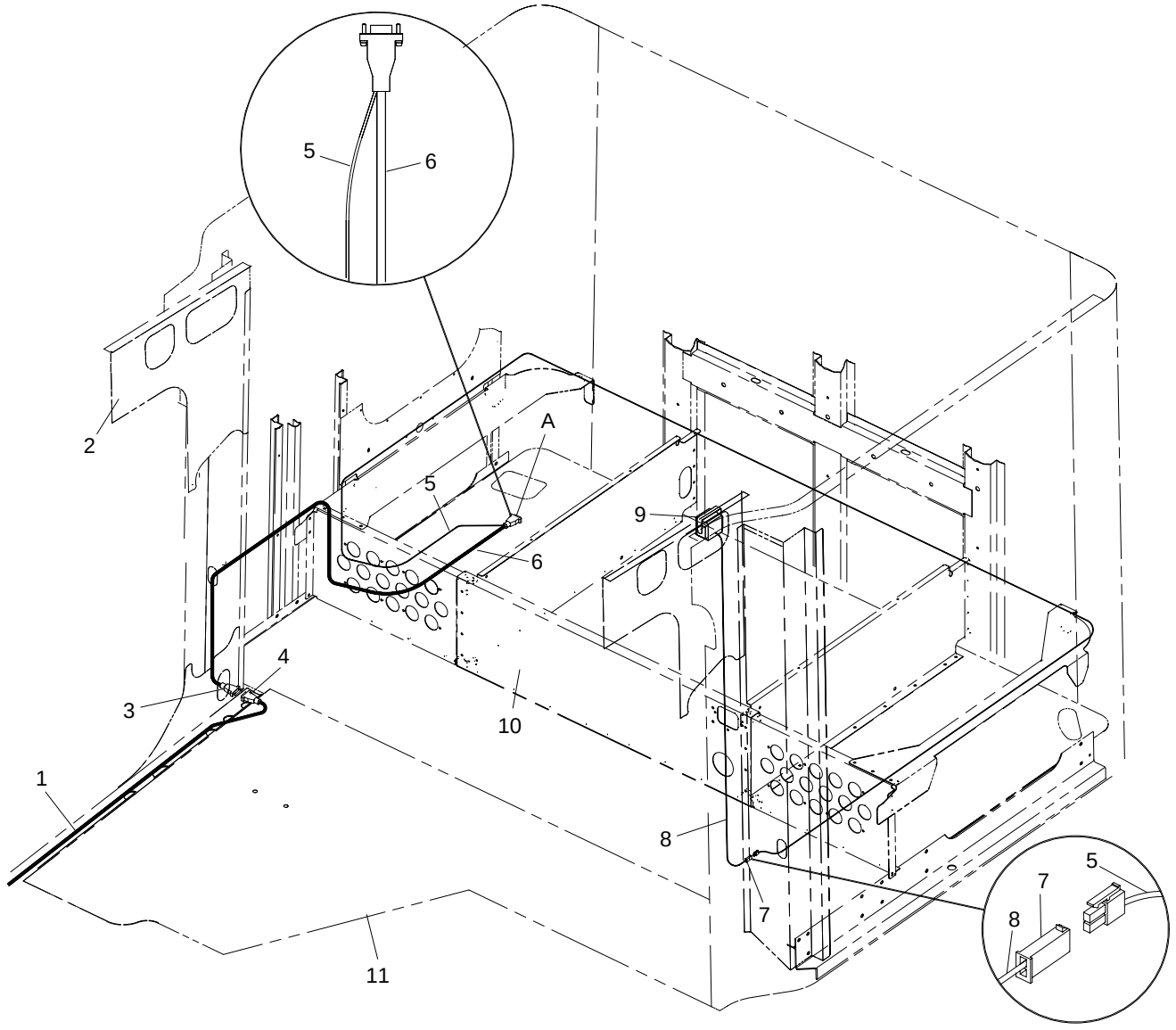
1. Microphone
2. Microphone Wire
3. Display Unit Wire
4. Upper Dash Assembly (LH panel)
5. Display Cable (door)
6. Display Connector
7. Microphone Connector
8. Display Unit

Fig. 4, Display and Microphone Cable Routing (dash)

Troubleshooting



A. To Control Unit

1. Display Cable (door)
2. B-Pillar
3. Display Cable Cab Connector
4. Display Cable Door Connector
5. Speaker Cable (cab)
6. Display Cable (cab)
7. Speaker Connector
8. Speaker Cable (B-pillar)
9. Speaker
10. Forward Bunk Partition
11. Rear Deck

Fig. 5, Display and Speaker Cable Routing (cab)

Problem—The Display Shows Only the "HighwayMaster" Message

Problem—The Display Shows Only the "HighwayMaster" Message	
Possible Cause	**Remedy**
The vehicle is outside the coverage area.	The display is functioning correctly. Move the vehicle to a covered area and the message will change to "HighwayMaster Service Area."
The cellular antenna is missing.	Replace the cellular antenna, making sure the tab is bent down enough to make contact with the antenna base. See **Subject 150** for detailed instructions.
The cellular antenna connector is broken.	Inspect the connector (at the control unit) for damage. Replace the connector, and check the display again. See **Fig. 6**. If the display is still not correct, ask Customer Care (1–800–647–6693) to download a SID table.
The control unit is broken.	Replace the control unit. See **Subject 100** for detailed instructions.

Problem—The Display Gives Scrambled Information

Problem—The Display Gives Scrambled Information	
Possible Cause	**Remedy**
The system needs to be restarted.	Call Customer Care at 1–800–647–6693 and request a remote restart. Remove power from the system for one minute. Reconnect the power and reinitialize the control unit. See **Subject 100** for detailed instructions.

Problem—The Microphone Does Not Work, Or Broadcasts Noise

Problem—The Microphone Does Not Work, Or Broadcasts Noise	
Possible Cause	**Remedy**
There is interference from wind, or other electrical sources.	Check the microphone with the window rolled up and all electrical appliances off.
The connection with the display cable is bad.	Check the connection with the display cable and make sure it is properly connected. For a more secure connection, wrap electrical tape around the connector.
The microphone wire is damaged.	Check the microphone wire for damage. Replace the microphone if any is found. See **Subject 130** for detailed instructions. Test the system again with the new microphone installed.
The display cable assembly needs replacing.	Disconnect the circuit breaker. Now connect a spare display cable, making sure the connectors seat properly. See **Fig. 4** and **Fig. 5**. Reconnect the circuit breaker. If the display now works, replace the display cable assembly.
The control unit is broken.	Replace the control unit. See **Subject 100** for detailed instructions.

Troubleshooting

Problem—The GPS (Satellite) System Does Not Provide Actual Position Data, or Provides It Infrequently

Problem—The GPS (Satellite) System Does Not Provide Actual Position Data, or Provides It Infrequently	
Possible Cause	**Remedy**
The system has not reached "NAV" status.	On the handset keypad, enter "589200," followed by "CHK." When the display reads "GPS HAS REACHED NAV STATUS," call the host operator and ask for an actual position on the vehicle. If the operator still does not have an actual, ask for an immediate data exchange (F2) to download the data.
There are loose connections on the GPS antenna.	Check all of the antenna connections for condition. See **Fig. 7**. Repair/replace as necessary.
The GPS antenna and/or cable is damaged.	Check the GPS antenna and cable for damage. Repair or replace any damaged parts as necessary. On the handset keypad, enter "589200," followed by "CHK." When the display reads "GPS Has Reached NAV Status," call the host operator and ask for an actual position on the vehicle. If the operator still does not have an actual, ask for an **immediate data exchange (F2)** to download the data.
The HighwayMaster system is not registered properly.	Call Customer Care at 1–800–647–6693 to check the registration status of the system.
The control unit is broken.	Replace the control unit. See **Subject 100** for detailed instructions.

Problem—The Speaker Does Not Work

Problem—The Speaker Does Not Work	
Possible Cause	**Remedy**
The handset is not properly seated in the cradle.	Check that the handset is seated properly. Turn the power on, and press the "End" button. If the speaker is operating, it will respond by saying "Ready."
The display unit is broken.	Disconnect the circuit breaker. Now connect a spare display unit. Reconnect the circuit breaker, and press the "End" button. If the speaker now operates, replace the display unit. See **Subject 120** for detailed instructions.
The display cable assembly needs replacing.	Disconnect the circuit breaker. Now connect a spare display cable, making sure the connectors seat properly. See **Fig. 4** and **Fig. 5**. Reconnect the circuit breaker, and press the "End" button. If the speaker now operates, replace the display cable assembly.
The voice recognition system in the control unit is broken.	Replace the control unit. See **Subject 100** for detailed instructions.

Problem—The HighwayMaster System Does Not Receive Status Codes or Authorized Numbers

Problem—The HighwayMaster System Does Not Receive Status Codes or Authorized Numbers	
Possible Cause	**Remedy**
The registration codes were never entered.	On the handset keypad, enter "STO," "99," and "SEND." When the display reads "HighwayMaster Service Area," enter "STO," and "01." Keep repeating this step until the Display reads "Transmission Successful." Check the status codes by entering "STO" "01," and the up arrow (↑) to scroll through the codes. Similarly, check the authorization numbers by entering "RCL," "#," "01," and the up arrow (↑) to scroll through the numbers.
The control unit has not been initialized.	Call the host operator to request initialization and repeat the procedure above.
The HighwayMaster system is not registered properly.	Call Customer Care at 1–800–647–6693 to check the registration status of the system.
The control unit is broken.	Replace the control unit. See **Subject 100** for detailed instructions.

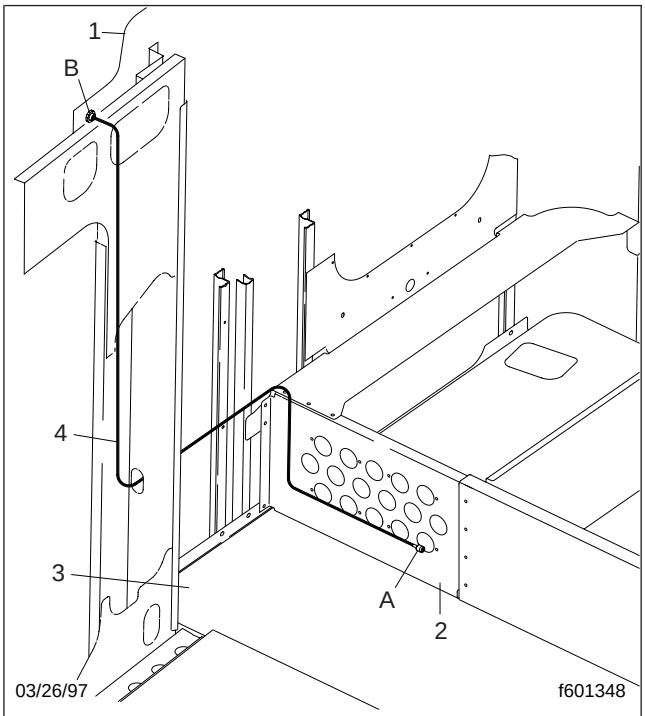
Problem—The HighwayMaster System Will Not Power Off

Problem—The HighwayMaster System Will Not Power Off	
Possible Cause	**Remedy**
The power off delay has been set.	Call the host operator to reset the delay.
The electrical connections are not in the correct place.	Check all the electrical connections from the auxiliary power distribution module to the control unit. Repair/ replace as necessary.
The control unit is broken.	Replace the control unit. See **Subject 100** for detailed instructions.

Problem—The Driver Is Unable To Call Personal Numbers

Problem—The Driver Is Unable To Call Personal Numbers	
Possible Cause	**Remedy**
The driver does not have a valid AT & T calling card.	Ask the driver to call AT & T to obtain a valid calling card.
The personal calling feature is not active.	Call Customer Care at 1–800–647–6693 and ask them to active the personal calling feature.

Troubleshooting

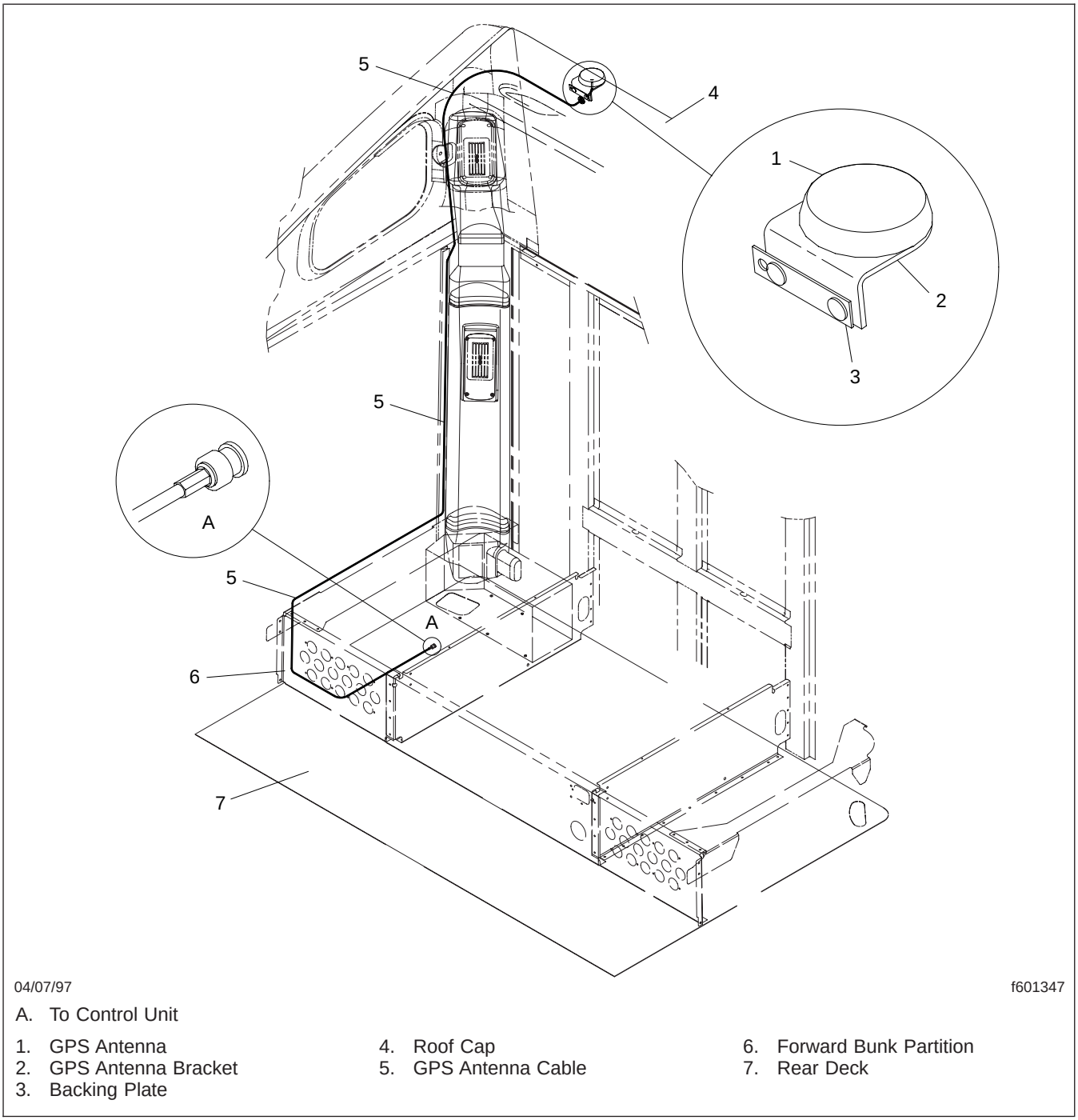


Factory installation is shown.

A. To Control Unit
B. To Cellular Antenna

1. Cab Wall
2. Forward Bunk Partition
3. Rear Deck
4. Cellular Antenna Cable

Fig. 6, Cellular Antenna Cable Routing



A. To Control Unit

1. GPS Antenna
2. GPS Antenna Bracket
3. Backing Plate
4. Roof Cap
5. GPS Antenna Cable
6. Forward Bunk Partition
7. Rear Deck

Fig. 7, GPS Antenna Cable Routing

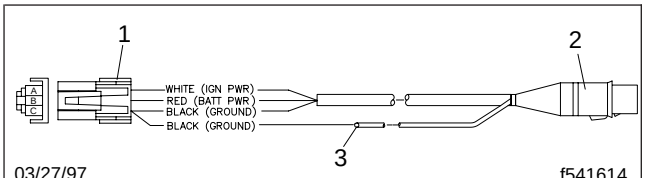
Specifications

For a drawing of the power cable, see **Fig. 1**.

For a drawing of the phone cable, see **Fig. 2**.

For a drawing of the display cable, see **Fig. 3**.

For a schematic of the HighwayMaster system wiring, see **Fig. 4**.



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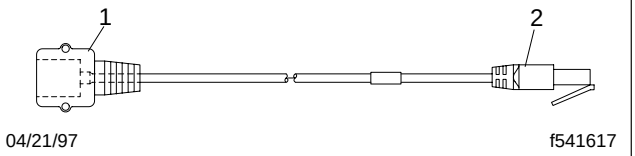
1. Auxiliary PDM Connector
2. Control Unit Connector
3. Splice Clip

Fig. 1, HighwayMaster Power Cable



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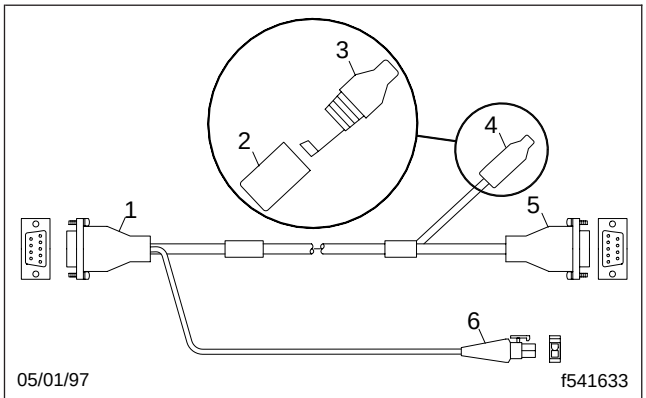
1. Pickup (to handset)
2. Control Unit Connector

Fig. 2, HighwayMaster Phone Cable



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1. Control Unit Connector
2. Sleeve
3. Sleeve Terminal
4. Microphone Connector
5. Display Unit Connector
6. Speaker Connector

Fig. 3, HighwayMaster Display Cable

Specifications

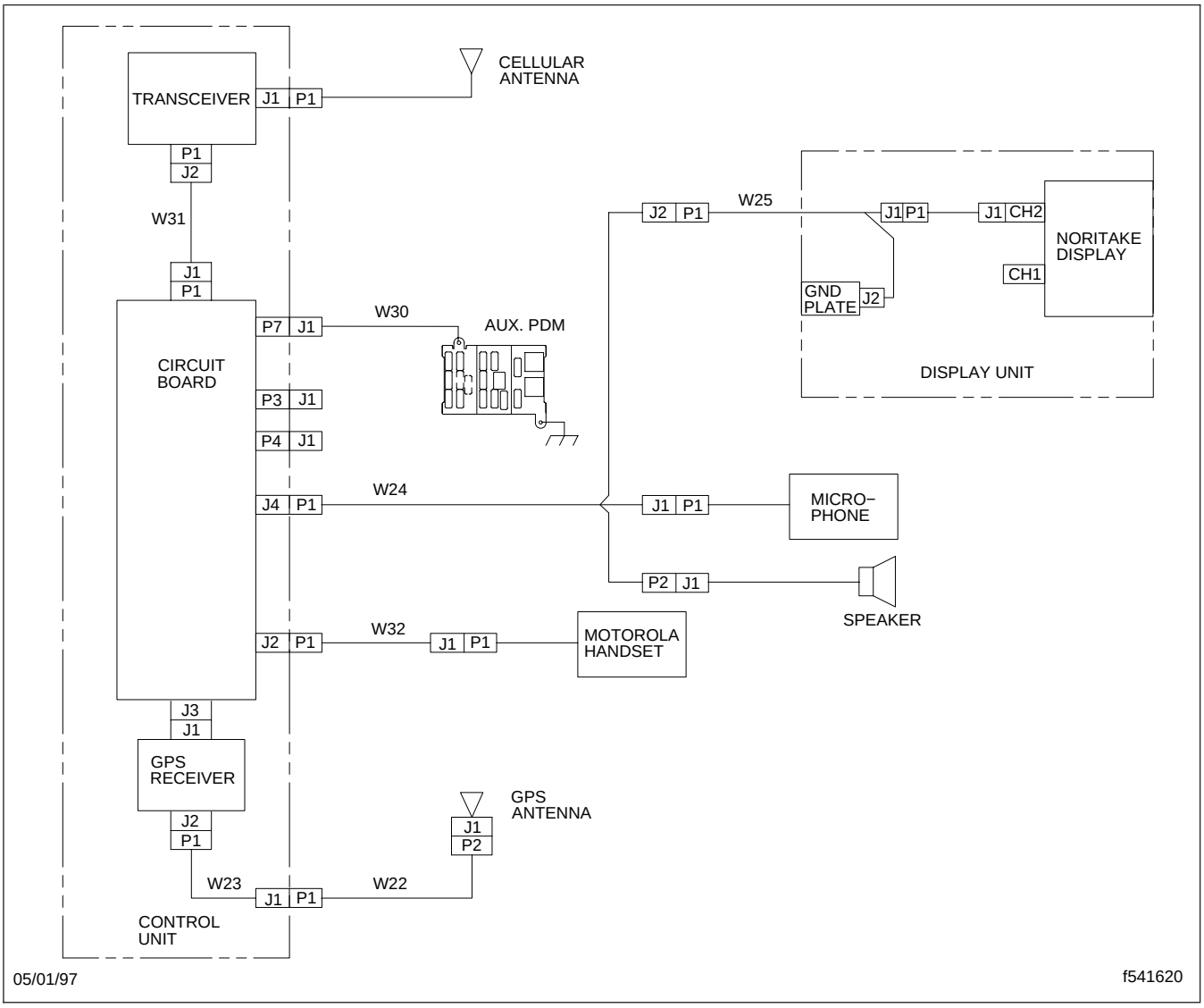


Fig. 4, HighwayMaster Wiring Schematic

IMPORTANT: The level II ICU is also known (on ServiceLink) as the ICU2L.

General Description

This section covers the instrumentation control unit, level II (level II ICU). Since October, 1997, it has been the standard ICU. Before October, 1997, the original version of the ICU (ICU1) was the standard (and only) ICU. For more information about the original version of the ICU, see **Section 54.03**.

NOTE: For information about the optional level III ICU (installed on vehicles since May, 1998), see **Section 54.19**.

LEVEL II ICU (ICU2L)

The level II ICU (ICU2L) is a basic electronic dashboard that accepts input from electrical/magnetic vehicle sensors and converts it into digital output that can be fed to an electronic gauge. Only air gauges operate mechanically.

The level II ICU has only one 16-bit microprocessor. This eliminates the need for the right-hand (blue) connectors found on the original ICU.

There can be up to 14 removable gauges (11 electronic, one electromechanical, and two mechanical) on the driver's instrument panel. The level II ICU can not drive gauges located on the auxiliary instrument panel.

DASH MESSAGE CENTER

The heart of the level II ICU is the dash message center. It has two parts: a set of 18 warning and indicator lights similar to those found on a conventional lightbar, and a dash driver display screen. The dash driver display screen is a 1-line by 6-character vacuum fluorescent display.

The information that can be provided by the message center includes:

- odometer readings
- a listing of active faults
- a "no datalink activity" alert message

Principles of Operation

IGNITION SEQUENCE

When the ignition is turned on, the level II ICU (ICU2L) runs through the ignition sequence. See **Fig. 1** for the standard level II ICU.

If the headlights are turned on, the screen displays the odometer and waits for the ignition to be turned on.

IMPORTANT: When the ignition is first turned on, all the electronic gauges (except the voltmeter) complete a full sweep of their dials, the warning and indicator lights light up, and the buzzer sounds for three seconds.

The following indicator lights go on during the ignition sequence:

- High Coolant Temperature Warning
- Low Engine Oil Pressure Warning
- Low Air Pressure Warning
- Park Brake On Indicator
- All engine warning lights, including Engine Protection, Check Engine, and Stop Engine (Cummins only)
- All ABS warning lights, including Wheel Spin, Tractor ABS, and Trailer ABS (if installed)

NOTE: While the engine and ABS warning lights go on during the ignition sequence, they are not controlled by the level II ICU, but by their own system ECU (electronic control unit).

Once the ignition keyswitch has been turned on, the ICU performs a self-test, looking for active faults. During the first half of the self-test, all segments of the display illuminate. During the second half of the self-test, the software revision level is displayed.

If there are no active faults, the screen displays the odometer.

If the standard level II ICU has received active fault codes from other devices, it displays them, one after the other, until the parking brake is released, or the ignition keyswitch is turned off.

NOTE: The screen displays a code, called the message identifier (MID), indicating the elec-

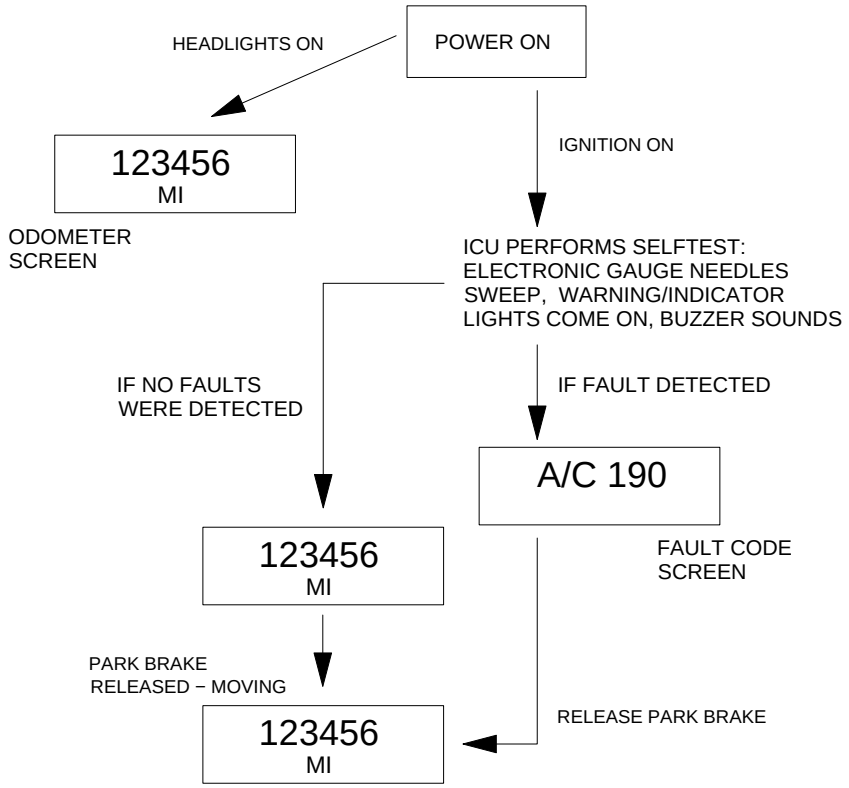
General Information

tronic control unit or system that is not functioning properly.

Example: If the air conditioning system or air conditioning protection unit is not functioning properly, the screen displays "A/C190." For a complete list of possible screen displays, see **Specifications, 400**.

To troubleshoot the Qualcomm system, have an incoming test message sent to the unit in the vehicle and make sure that it is received properly.

To troubleshoot the HighwayMaster system, see Section 54.13, **Troubleshooting, 300**.



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During the first half of the self-test, all segments of the display illuminate. During the second half of the self-test, the software revision level is displayed.

NOTE: If there is more than one fault, the level II ICU displays them, one after another, changing every three seconds, until the park brake is released.

Fig. 1, Ignition Sequence, Standard Level II ICU (ICU2L)

IMPORTANT: The ICU will report a fault for the Qualcomm or HighwayMaster communications systems when the system control unit, or ECU, is connected properly and the system is working correctly.

Once the parking brake is released, the level II ICU displays the odometer again.

ODOMETER

The odometer is a six-digit display with no decimal point. The odometer only displays significant figures (no leading zeros), until the vehicle has traveled one

million miles or kilometers (km). At one million miles (km), the odometer resets itself to 000000, and then continues to display leading zeros.

Example: 456 = 456 miles (km)

000456 = 1,000,456 miles (km)

When first installed, the odometer starts at 0 miles (or km). When the level II ICU is replaced, the odometer does not start with the engine miles (km), but starts again from 0 and cannot be changed, either up or down.

IMPORTANT: Although the odometer uses data supplied by the engine ECM to update its count, it keeps its own mileage starting from the zero point, which marks where it was first installed.

The odometer can be set to display in either miles or kilometers. For procedures, see **Subject 110**.

ALERT SCREEN

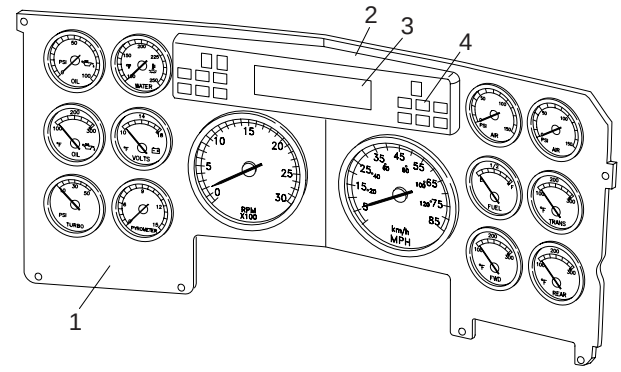
This screen appears when there is no activity on the datalink. The screen displays "NODATA."

Level II Instrumentation Control Unit Replacement

IMPORTANT: The level II ICU is also known (on ServiceLink) as the ICU2L.

Replacement

The instrumentation control unit, level II (level II ICU) includes the driver's instrument panel, the ICU housing, and the dash message center (all installed as one unit). See **Fig. 1**.



1. Driver's Instrument Panel
2. Dash Message Center
3. Dash Driver Display Screen
4. Warning and Indicator Lights

Fig. 1, Driver's Instrument Panel

To replace a complete level II ICU with a new set of gauges, see "Level II ICU (With Gauges)." To replace a level II ICU and reinstall the old set of gauges, see "Level II ICU (Without Gauges)."

To replace individual gauges, switches, or flipper valves, see **Section 54.03, Subject 110**. To replace light bulbs (gauge light, or warning and indicator light), see **Section 54.03, Subject 120**. To replace the warning buzzer, see **Section 54.03, Subject 130**. To replace the dash driver display screen, see **Section 54.03, Subject 140**.

NOTE: For auxiliary instrument panel replacement, see **Section 54.03, Subject 100**.

Level II ICU (With Gauges)

1. Remove the left-hand dash panels. Be sure the screws that attach the dash panel trimtop to the upper dash assembly have been removed. For instructions, see **Section 60.08, Subject 100**.
2. Remove the screw that attaches the dash panel trimtop to the lower dash panel. This screw is located on the far left of the trimtop.

CAUTION

Electronic components of the ICU are vulnerable to damage from static electricity. If available, wear a wrist grounding strap connected to a ground in the cab or workbench. If a grounding strap is not available, touch a grounded component immediately before doing any work which could bring a tool or body part in contact with ICU circuitry.

3. Remove the fasteners from the driver's instrument panel. See **Fig. 2**. Fasteners used on the level II ICU are T25 Torx dog-point screws. See **Fig. 3**.
   - 3.1 Remove the bezel from the dash message center, exposing the two screws underneath it. For more information, see **Section 54.03, Subject 140**.
   - 3.2 Remove the two screws underneath the dash message center bezel.
   - 3.3 Remove the four screws on the bottom of the driver's panel.
   - 3.4 Remove the two screws on the sides of the driver's panel.

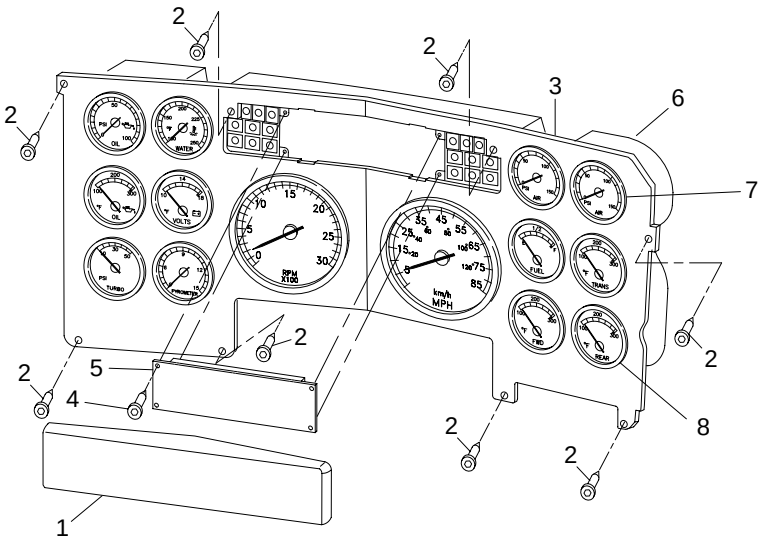
CAUTION

When removing the ICU, the wiring harness may have to be loosened before the driver's panel can be pulled free of the dash. Do not forcibly pull the driver's panel from the dash. This may disconnect wires from the harness electrical connectors on the back of the ICU housing and damage them.

4. Pull the old ICU away from the dash.
   - 4.1 From behind the ICU housing, disconnect the two electrical connectors on the left-hand side.

   IMPORTANT: Bleed off all air before trying to remove the air hoses.

Level II Instrumentation Control Unit Replacement



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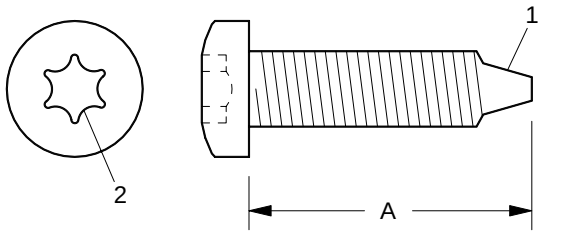
1. Message Center Bezel
2. Dog-Point Screw
3. Driver's Instrument Panel
4. Display Screen Screw
5. Dash Driver Display Screen
6. ICU Housing
7. Mechanical Gauge
8. Electronic Gauge

Fig. 2, Instrumentation Control Unit, Level II (ICU2L)



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A. 3/4 Inch (19 mm)
1. Dog Point
2. Torx Head

Fig. 3, Dog-Point Screw

4.2 Disconnect all air hoses. Using a paint pen, mark the hoses for ease of installation.

5. Remove the old ICU from the dash. See **Fig. 4**.

5.1 Remove the three screws and speed nuts that attach the dash panel trimtop to the old ICU.

5.2 Install the dash panel trimtop on the new level II ICU (ICU2L).

6. Install the level II ICU on the dash.

6.1 Connect the air hoses to the air gauges as marked on removal.

6.2 Connect the two electrical connectors, as removed.

6.3 Place the new level II ICU in the dash and install the fasteners. Be sure to install the fasteners that attach the dash panel trimtop to the upper dash assembly and lower dash panel.

IMPORTANT: A typical warning and indicator light layout is shown in **Fig. 5**.

7. Install the dash message center. See **Fig. 4**.

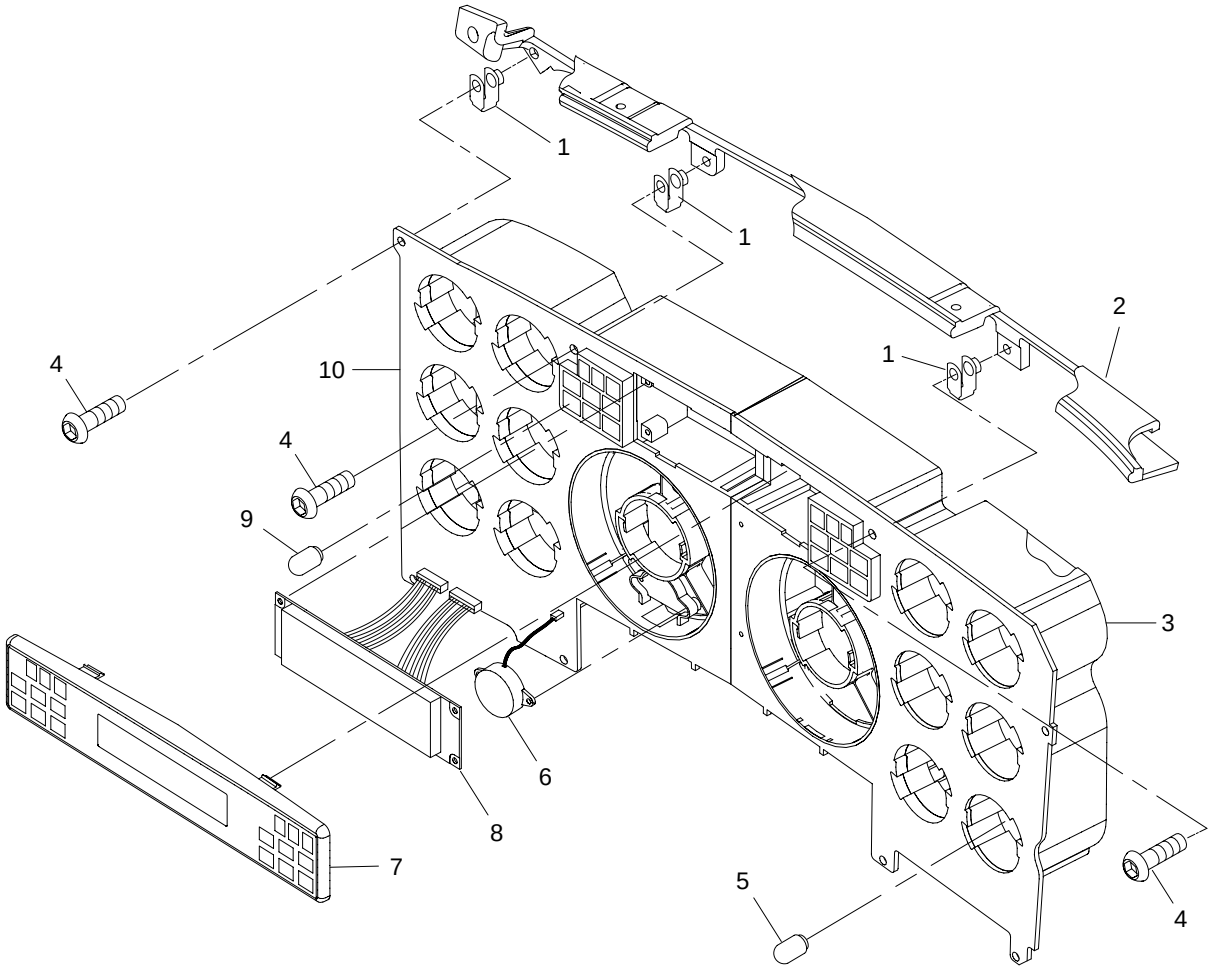
7.1 Remove the bezel from the dash message center on the new level II ICU.

⚠ CAUTION

Be careful not to scratch the new bezel when replacing the lightbar legends. Scratches on the inside of the bezel are visible from the front.

7.2 Take the bezel from the old level II ICU and, using fingers, tweezers, or a small pair of needlenose pliers, gently remove any of the optional plastic legends in-

Level II Instrumentation Control Unit Replacement



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NOTE: Gauges have been removed.

1. Speed Nut
2. Dash Panel Trimtop
3. ICU Housing, RH
4. T25 Dog-Point Screw
5. Gauge Light Bulb
6. Buzzer
7. Message Center Bezel
8. Dash Display Screen
9. Warning and Indicator Light Bulb
10. ICU Housing, LH

Fig. 4, ICU Housing

stalled in the bezel. Install these in the new bezel, being careful not to scratch it.

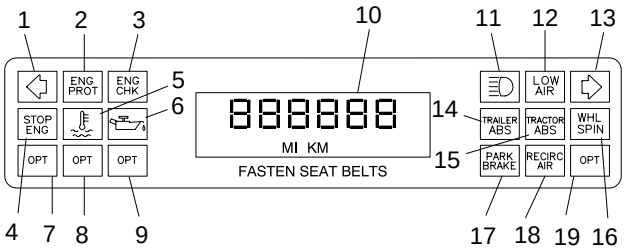
7.3 Snap the bezel into place.

8. Check the gauge layout of the new unit and compare it to the old unit.

IMPORTANT: If any positions are different, replace the gauge for that position with the correct gauge from the old unit. For gauge replacement procedures, see **Section 54.03, Subject 110**.

9. Turn on the ignition and test the operation of the new level II ICU. All the electronic gauges (except the voltmeter) should make one complete sweep and return to their normal indicating positions; the warning and indicator lights should turn on, then off.

Level II Instrumentation Control Unit Replacement



NOTE: Typical installation shown. Location and function of optional lights may vary.

1. Left Turn Indicator
2. Engine Protection Warning & Indicator
3. Check Engine Indicator
4. Stop Engine Warning (Cummins engine only)
5. High Coolant Temperature Warning (optional)
6. Low Oil Pressure Warning (optional)
7. Optional Indicator 3
8. Optional Indicator 2
9. Optional Indicator 1
10. Dash Driver Display Screen
11. High Beam Indicator
12. Low Air Warning
13. Right Turn Indicator
14. Trailer ABS Warning (optional)
15. Tractor ABS Warning
16. Wheel Spin Warning
17. Park Brake On Indicator
18. Recirc Air Warning (optional)
19. Optional Indicator 4

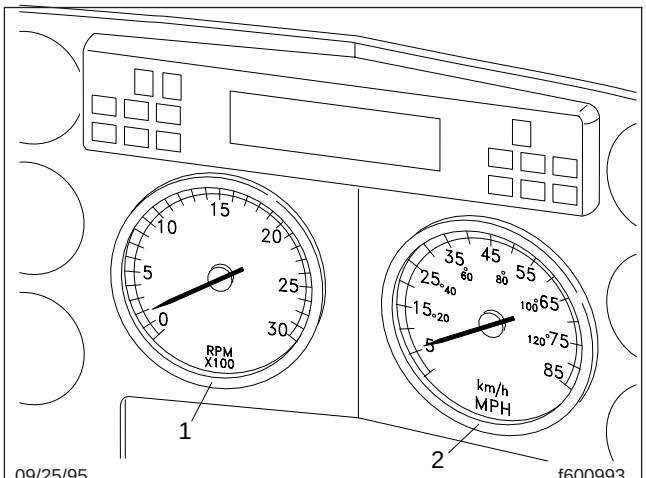
Fig. 5, Dash Message Center, Level II ICU (ICU2L)

If any gauges are not working properly, they will need to be serviced or replaced.

NOTE: Mechanical (air) gauges do not make a sweep.

Level II ICU (Without Gauges)

1. Remove the left-hand dash panels. For instructions, see **Section 60.08, Subject 100**.
2. Remove the fasteners from the driver's instrument panel and dash panel trimtop. See **Fig. 2**. Fasteners used on the level II ICU (ICU2L) are T25 Torx dog-point screws. See **Fig. 3**.
   - 2.1 Remove the bezel from the dash message center, to expose the two screws underneath it. Remove these two screws.
   - 2.2 Remove the four screws on the bottom of the driver's panel.
   - 2.3 Remove the two screws on the sides of the driver's panel.
3. Note the gauge layout for later installation and remove all the gauges. For instructions, see **Section 54.03, Subject 110**. Set aside the gauges for later installation in the new panel.
   - 3.1 Remove the two large-face gauges from the center of the driver's panel. See **Fig. 6**.



1. Tachometer 2. Speedometer

Fig. 6, Driver's Panel Gauge Layout (large-face gauges)

   - 3.2 Remove the small-face gauges (six maximum) from the left-hand side of the driver's panel. See **Fig. 7**.
   - 3.3 Remove the small-face gauges (six maximum) from the right-hand side of the driver's panel. See **Fig. 8**.

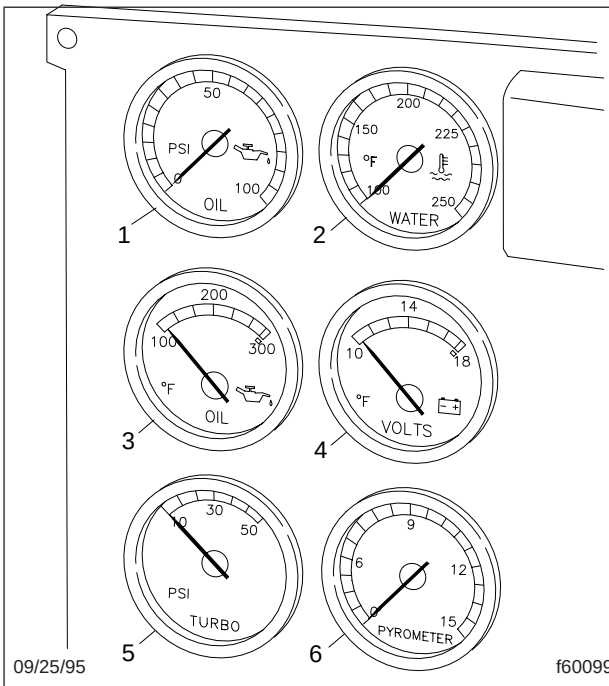
CAUTION

Laying gauges face down for more than one day could allow the oil-dampening fluid to leak out, causing dial movement to become erratic.

4. Pull the old ICU away from the dash.
   - 4.1 From behind the ICU housing, disconnect the two electrical connectors on the left-hand side.

IMPORTANT: Bleed off all air before trying to remove the air hoses.

Level II Instrumentation Control Unit Replacement



NOTE: Gauge layouts may vary. To work properly, gauges must be installed in their correct locations.

1. Oil Pressure Gauge
2. Water Temperature Gauge
3. Oil Temperature Gauge
4. Voltmeter
5. Turbo Air Pressure Gauge
6. Pyrometer

Fig. 7, Driver's Panel Gauge Layout (left-hand side)

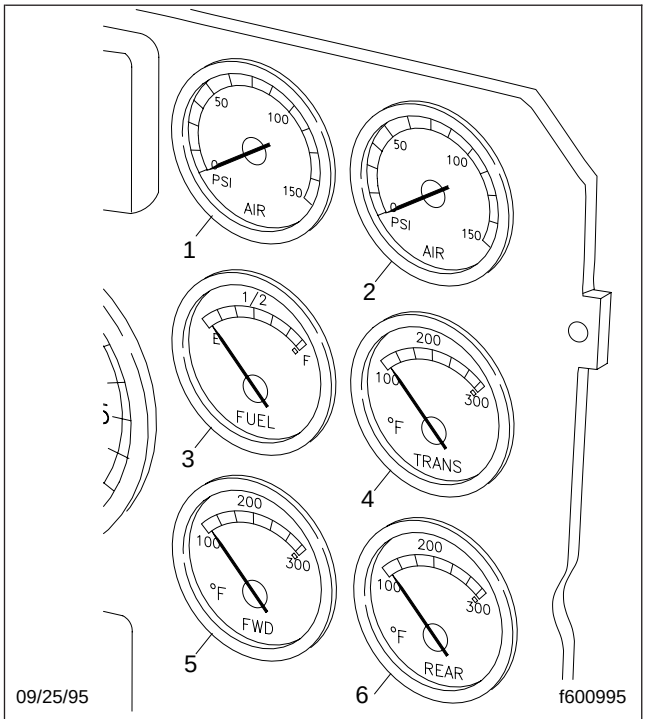
4.2 Disconnect all air hoses. Using a paint pen, mark the hoses for ease of installation.

CAUTION

When removing the old ICU, the wiring harness may have to be loosened before the driver's panel can be pulled free of the dash. Do not forcibly pull the driver's panel from the dash. This may disconnect wires from the harness electrical connectors on the back of the ICU housing and damage them.

5. Remove the old ICU from the dash. See **Fig. 4**.

5.1 Remove the three screws and speed nuts that attach the dash panel trimtop to the old ICU.



NOTE: Gauge layouts may vary. To work properly, gauges must be installed in their correct locations.

1. Primary Air Pressure Gauge
2. Secondary Air Pressure Gauge
3. Fuel Gauge
4. Transmission Fluid Temperature Gauge
5. Forward Axle Temperature Gauge
6. Rear Axle Temperature Gauge

Fig. 8, Driver's Panel Gauge Layout (right-hand side)

5.2 Install the dash panel trimtop on the new level II ICU (ICU2L).

6. Install a new level II ICU in the dash.

6.1 Install all the fasteners as removed, including the fasteners that attach the dash panel trimtop to the upper dash assembly and lower dash panel.

6.2 Connect the two electrical connectors, as removed.

6.3 Install all gauges in the positions from which they were removed. Insert each gauge into its correct hole and twist clockwise about 1/8 turn, until seated.

Level II Instrumentation Control Unit Replacement

7. Snap the dash message center bezel into place, using the four small tabs on the sides of the bezel.
8. Turn on the ignition and test the operation of the gauges. All the electronic gauges (except the voltmeter) should make one complete sweep and return to their normal indicating positions; the warning and indicator lights should turn on, then off.

NOTE: Mechanical (air) gauges do not make a sweep.

IMPORTANT: The level II ICU is also known (on ServiceLink) as the ICU2L.

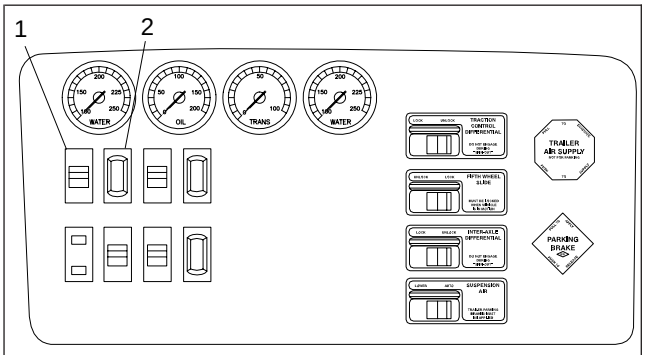
Changing

USING THE CRUISE CONTROL SWITCHES

The odometer can display the distance the vehicle has traveled in either miles or kilometers. The choice of units is selectable using the cruise control switches.

To change the display, do the following steps.

1. Shut down the engine and set the parking brake.
2. Turn the ignition keyswitch ON.
3. Turn the cruise control on (cruise control on/off switch). See **Fig. 1**.



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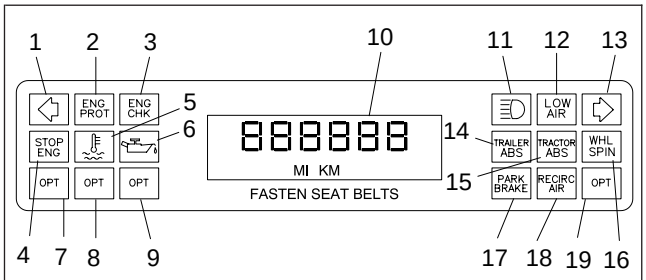
To switch from miles to kilometers, turn the cruise control on. Then press and hold down the set switch until the "MI" display starts to blink.

1. On/Off Switch
2. Set Switch

Fig. 1, Cruise Control Switches

4. With the cruise control on, press and hold down the cruise control set switch until the odometer display begins to blink. After about 5 seconds, the "MI" display at the bottom of the screen will change to "KM" (or "KM" will change to "MI," depending on what units were previously set). See **Fig. 2**.



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NOTE: Typical installation shown. Location and function of optional lights may vary.

1. Left Turn Indicator
2. Engine Protection Warning & Indicator
3. Check Engine Indicator
4. Stop Engine Warning (Cummins engine only)
5. High Coolant Temperature Warning (optional)
6. Low Oil Pressure Warning (optional)
7. Optional Indicator 3
8. Optional Indicator 2
9. Optional Indicator 1
10. Dash Driver Display Screen
11. High Beam Indicator
12. Low Air Warning
13. Right Turn Indicator
14. Trailer ABS Warning (optional)
15. Tractor ABS Warning
16. Wheel Spin Warning
17. Park Brake On Indicator
18. Recirc Air Warning (optional)
19. Optional Indicator 4

Fig. 2, Dash Message Center, Level II ICU

Troubleshooting

The instrumentation control unit (ICU) receives messages and faults transmitted by other ECUs on the J1587 datalink.

NOTE: There are also some warnings that are controlled by sensor inputs to the ICU.

The ICU presents warning information via lamps in the panel. Active fault codes are abbreviated in the driver display.

Ignition Sequence

When the ignition switch is turned ON, the ICU performs an ignition sequence. The electronically driven gauges sweep from zero to full scale and then back to zero. The parking brake, low air pressure, high coolant temperature, and low oil pressure warning/indicator lights also activate for approximately three seconds.

NOTE: The battery voltage, primary air, and secondary air gauges are not electronically driven and do not sweep.

System Fault Analysis

The ICU indicates active fault codes by displaying a three-letter code, which is an abbreviation for the system with the fault.

For lists of MIDs, PIDs, SIDs, and FMIs, see **Section 54.03, Specifications 400**. For more information on these code groups and how to read them, see "Fault Codes" in this subject.

To correct an active fault, see the following sources:

- Engine ECM (MID 128)—use the engine manufacturer's literature.
- ABS ECU (MID 136)—see **Section 42.08, Subject 300** or use the antilock brake system manufacturer's literature.
- ICU (MID 140)—see this section.
- DLU (MID 179)—see **Section 54.06**.
- ACPU (MID 190)—see **Section 83.02, Subject 300**.

IMPORTANT: To begin troubleshooting active fault codes, do not turn the ignition switch OFF and then ON. It is not uncommon for a fault to disappear when ignition power is removed, only to return again when the vehicle has left the shop.

1. Correct the active fault.
2. To verify that the problem is corrected and that the fault code is no longer displayed as active, turn the ignition switch OFF and then ON.
3. Start the vehicle.

NOTE: In some cases, it may be necessary to drive the vehicle to confirm that a fault has been repaired.

Datalink Activity

1. If the alert message "NO DATA" is displayed, check the J1587 datalink wiring (twisted pairs).
2. Verify that all ECUs are connected.
3. Verify that the ECU J1587+ is connected to the datalink J1587+ and that ECU J1587– is connected to datalink J1587–.

Gauges

NOTE: The procedures under the "Gauges" heading apply only to electronic gauges; the air gauges and voltmeter do not sweep.

Gauge Does Not Sweep

If a particular gauge does not sweep during the ignition sequence, there is a problem either with the gauge or the ICU.

1. Turn the gauge counterclockwise and remove it from the ICU housing.
2. Install a gauge known to be good and repeat the ignition sequence.
3. If the test gauge sweeps full scale and back to zero, replace the original gauge with a new one. For replacement instructions, see **Section 54.03, Subject 110**.
4. If the test gauge does not sweep, replace the ICU. For replacement instructions, see **Subject 100** in this section.

NOTE: If the ICU has failed, replace the complete ICU housing. Remove all gauges, the

message center bezel, and the wood grain panel. Install these parts in the new ICU housing.

Gauge Does Sweep

If a gauge malfunctions but sweeps during the ignition sequence, the ICU is not at fault.

1. Check the circuits that supply input signals to the ICU.
2. Check the engine ECM programming.

NOTE: Use the technician diagnostic routine (TDR), provided with ServicePro, to help determine the cause of the problem.

Warning/Indicator Lights

Light Does Not Illuminate

The parking brake, low air pressure, high coolant temperature, and low oil pressure warning/indicator lights should illuminate during the ignition sequence.

IMPORTANT: The following lights do not illuminate during the ignition sequence:

A. ENG PROT indicator light input WL002

B. CHK ENG indicator light input WL003

C. STOP ENG indicator light input WL007 (used on Cummins engines only)

D. TRAC ABS indicator light input WL011

If a warning/indicator light other than those listed above does not illuminate during the ignition sequence, either the light bulb is bad or the ICU is malfunctioning. Replace the light bulb with a test bulb known to be good and repeat the ignition sequence.

1. Remove the message center bezel and replace the bulb with a test bulb. Use the bulb replacement tool provided.
2. If the test bulb lights, replace the original bulb with a new one. For replacement instructions, see **Section 54.03, Subject 120**.

   If the test bulb does not light, replace the ICU. For replacement instructions, see **Subject 100** in this section.

Light Illuminates

If a warning/indicator light malfunctions but illuminates during the ignition sequence, the ICU is not at fault.

Check the circuits that supply input signals to the ICU. These lights are activated by either a 12V power input or a ground input.

NOTE: Use the technician diagnostic routine (TDR), provided with ServicePro, to help determine the cause of the problem.

Buzzer

Buzzer Does Not Operate

If the buzzer does not activate during the ignition sequence, either the buzzer or the ICU is malfunctioning. The buzzer is mounted behind the tachometer.

1. Install a buzzer known to be good and repeat the ignition sequence.
2. If the test buzzer functions, replace the original buzzer with a new one. For replacement instructions, see **Section 54.03, Subject 130**.

   If the test buzzer does not function, replace the ICU. For replacement instructions, see **Subject 100** in this section.

Buzzer Does Operate

If the buzzer operates during the ignition sequence but does not work properly for another function, there is a problem with ICU input circuits.

1. Check the circuits that supply input signals to the ICU.
2. Check the ECU programming corresponding to the buzzer function.

Dash Driver Display Screen

Screen Does Not Activate

If the dash driver display screen does not activate during the ignition sequence, either the display screen itself or the ICU is malfunctioning. The dash driver display screen is mounted behind the message center bezel.

1. Install a dash driver display screen known to be good and repeat the ignition sequence.

2. If the test screen functions, replace the original dash driver display screen with a new one. For replacement instructions, see **Section 54.03, Subject 140**.

   If the test screen does not function, replace the ICU. For replacement instructions, see **Subject 100** in this section.

Screen Does Activate

If the dash driver display screen operates during the ignition sequence, but the odometer does not display properly, the ICU is faulty.

ICU Small Gauges

The oil pressure, coolant temperature, oil temperature, and turbo air pressure gauges are driven electronically by the ICU using data inputs from the engine ECM. The ICU receives digital data from the engine ECM via the J1587 datalink.

1. To determine whether the fault lies in the ICU or the gauge input circuits, use the "Gauges" procedure above.
2. If the problem is found to be in the ICU, replace the ICU. For replacement instructions, see **Subject 100**.

   If the problem is found to be elsewhere, use ServiceLink, or the engine manufacturer's diagnostic software tool, and determine if there is an active engine ECM fault code related to the problem.
3. If an active fault code is displayed, follow the engine manufacturer's instructions to correct the problem.

   If no active fault code is displayed, check the datalink connection from the engine ECM to the ICU.
4. Check the datalink for cross-wired connections from all ECUs.

Voltmeter

The voltmeter is driven by the voltage input to the ICU. The voltmeter should function with the ignition switch in the ON position.

1. Replace a problem gauge with a test gauge known to be good and turn the ignition ON.
2. If the test gauge indicates 11 to 14V, replace the original gauge with a new one.

   If the test gauge indicates lower than 11V or higher than 14V, check input voltages to the ICU as follows:

   2.1 Check the 12V battery circuit: pin D14 and wire 437.

   2.2 Check the 12V ignition circuit: pin D15 and wire 437A.

   2.3 Check the ground circuit: pin D13 and wire GND1.
3. Troubleshoot and repair any of the above circuits that shows a malfunction.

   If all the circuits above are functioning, replace the ICU. For replacement instructions, see **Subject 100**.

Pyrometer

The pyrometer is electronically driven by the ICU. The pyrometer input circuit to the ICU contains a thermocouple mounted on the turbocharger exhaust port and a thermocouple amplifier module (TAM). The thermocouple senses the exhaust temperature and sends a small voltage signal to the TAM. The TAM amplifies this voltage signal by a factor of 100 (typically 0 to 8 VDC) and sends it on to the ICU. The ICU receives the analog voltage signal from the TAM and converts it to the digital signal that drives the pyrometer.

1. To determine whether the fault lies in the ICU or the gauge input circuits, use the "Gauges" procedure above.
2. If the problem is found to be in the ICU, replace the ICU. For replacement instructions, see **Subject 100**.

   If the problem is found to be in the gauge input circuits, check for 12 VDC of ignition power at the vehicle side connector to the TAM (circuit 218). The TAM is located just above the right-hand wheel well. Repair a malfunctioning circuit if necessary.
3. Warm up the engine fully so that the thermocouple reaches operating temperature. Then shut down the engine and turn the ignition back on.

NOTE: Do not measure voltage using chassis ground as a reference.

4. Check the voltage output signal of the TAM.

   Example: 300°F (150°C) = 5.14 VDC (acceptable); 480°F (250°C) = 9.16 VDC (unacceptable).

   NOTE: To measure TAM output voltage, gain access to the circuits at the right-hand wheel well or at the ICU connector pin C6 (218A+) and pin D6 (218A–).

   4.1 Check between circuits 218A+ (positive lead) and 218A– (negative lead). Voltage should be 4 to 8 VDC, depending on temperature.

   4.2 If this measurement is not within the tolerances, then either the TAM or the thermocouple is malfunctioning.

NOTE: The TAM's output should be 100 times greater than the thermocouple output (TAM output = 5.14 VDC, thermocouple output = 0.0514 VDC).

NOTE: Do not measure voltage using chassis ground as a reference.

5. Check the voltage output signal of the thermocouple.

   Example: 300°F (150°C) = 0.0514 VDC (acceptable); 480°F (250°C) = 0.0916 VDC (unacceptable).

   NOTE: To measure thermocouple output voltage, gain access to the circuits at the right-hand wheel well.

   5.1 Check the voltage between circuits. The voltage should be between 0.04 and 0.08 VDC.

   5.2 If this measurement is out of tolerance, the thermocouple is malfunctioning. Replace a malfunctioning thermocouple as required.

   If this measurement is within tolerance, but the measurement in the previous step was out of tolerance, the TAM is malfunctioning. Replace a malfunctioning TAM as required.

6. Check the circuits from the TAM to the ICU.

   6.1 Check for continuity between circuit 218A+ and ICU left-hand connector pin C6.

   6.2 Check for continuity between circuit 218A– and pin D6.

   6.3 Repair a malfunctioning circuit if necessary.

Transmission Temperature Gauge

The transmission temperature gauge is electronically driven by the ICU. The ICU input circuit contains a temperature sensor (thermistor) mounted in the transmission housing. The sensor causes a voltage drop across its leads corresponding to the transmission temperature. The ICU measures the voltage drop and converts it to a digital signal, which drives the electronic transmission temperature gauge.

1. To determine whether the fault lies in the ICU or the gauge input circuits, use the "Gauges" procedure above.

2. If the problem is found to be in the ICU, replace the ICU. For replacement instructions, see **Subject 100**.

   If the problem is found to be in the gauge input circuits, check the resistance of the temperature sensor at the transmission. The resistance between the two sensor pins is typically 5250 ohms to 172 ohms. Replace the sensor if necessary.

   Examples: 32°F (0°C) = 5250 ohms; 77°F (25°C) = 5000 ohms.

3. Check the continuity of the sensor-to-ICU circuits on the ICU connector. Repair a malfunctioning circuit if necessary.

   3.1 Check for continuity between wire 30 and pin C12.

   3.2 Check for continuity between wire 30G and pin C13.

Drive Axle Temperature Gauges

The temperature gauges for the forward-rear and rearmost drive axles are electronically driven by the ICU. The input circuits to the ICU contain temperature sensors (thermistors) mounted in the drive axle housings. The sensor causes a voltage drop across its leads corresponding to the axle temperature. The

ICU measures the voltage drop and converts it to a digital signal, which drives the electronic gauges.

1. To determine whether the fault lies in the ICU or the gauge input circuits, use the "Gauges" procedure above.
2. If the problem is found to be in the ICU, replace the ICU. For replacement instructions, see **Subject 100**.

   If the problem is found to be in the gauge input circuits, check the resistance of the rear axle temperature sensors. The resistance between the two sensor pins is typically 5250 ohms to 172 ohms. Replace the sensor if necessary.

   Examples: 32°F (0°C) = 5250 ohms; 77°F (25°C) = 5000 ohms.
3. Check the continuity of the circuits from the forward-rear drive axle sensors to the ICU connector. Repair a malfunctioning circuit if necessary.

   3.1 Check for continuity between wire 42 and pin A10.

   3.2 Check for continuity between wire 42G and pin A11.
4. Check the continuity of the circuits from the rearmost drive axle sensors to the ICU connector. Repair a malfunctioning circuit if necessary.

   4.1 Check for continuity between wire 43 and pin B2.

   4.2 Check for continuity between wire 43G and pin B4.

Fuel Level Gauge

The fuel level gauge is electronically driven by the ICU. The ICU input circuit contains a resistive fuel level sensor mounted in the fuel tank. The fuel level causes a voltage drop by changing the position of a float, which in turn causes the resistance to change. The ICU detects the voltage drop and converts it to a digital signal, which drives the electronic fuel level gauge.

1. To determine whether the fault lies in the ICU or the gauge input circuits, use the "Gauges" procedure above.
2. If the problem is found to be in the ICU, replace the ICU. For replacement instructions, see **Subject 100**.

   If the problem is found to be in the gauge input circuits, check the resistance of the fuel level sensor at the fuel tank. The resistance between the two sensor pins is typically 29 to 250 ohms. Replace the sensor if necessary.

   Examples: Full tank = 29 to 33.5 ohms; empty tank = 244 to 250 ohms.
3. Check the continuity of the circuits from the fuel level sensor to the ICU connector. Repair a malfunctioning circuit if necessary.

   3.1 Check for continuity between wire 47 and ICU pin D1.

   3.2 Check for continuity between wire 47G and ICU pin D2.

Fault Codes

Since the ICU gathers information via the J1587 datalink, any error message or warning displayed by the ICU can indicate one of two things: a fault in the vehicle system or a fault in the data. If the fault lies in a particular vehicle system, see the troubleshooting subject in the appropriate section of the workshop manual.

Fault Code Screens

Fault code screens provide troubleshooting information in a brief, easy-to-read format.

NOTE: The only fault codes displayed on the Level II ICU (ICU2L) are: ENG 128, ABS 136, and ICU 140.

IMPORTANT: The level II ICU is also known (on ServiceLink) as the ICU2L.

The instrumentation control unit, level II (level II ICU) has only one microprocessor, on the left. The two connectors are pink. Connector #1 has 24 pins, numbered A1 through A12, and B1 through B12. Connector #2 has 32 pins, numbered C1 through C16, and D1 through D16.

See **Fig. 1** for a schematic of the wiring and pinout connections for the level II ICU (ICU2L).

To fully identify fault codes, see **Section 54.03**, Specifications, 400, for a complete list of parameter identifiers (PIDs), sub-system identifiers (SIDs), and failure mode identifiers (FMIs).

Level II ICU Connector #1 Pin Assignments, Pins A1 Through B12		
Number	**Description**	**Wire**
A1	Panel Lights	29A
A3	Low Air Pressure	18
A4	Optional Indicator 3	GND
A5	Optional Indicator 2	GND
A6	Optional Indicator 1	GND
A7	Low Oil Pressure	GND
A8	High Coolant Temperature	GND
A10	Forward-Rear-Axle Oil Temperature Sensor (+)	42
A11	Forward-Rear-Axle Oil Temperature Sensor (–)	42G
A12	Headlights (high beams)	20H
B2	Rearmost-Axle Oil Temperature Sensor (+)	43
B3	J1587 Databus (–)	1587–C
B4	Rearmost-Axle Oil Temperature Sensor (–)	43G
B10	J1587 Databus (+)	1587+C
B11	Tractor ABS	376L

Table 1, Level II ICU Connector #1 Pin Assignments, Pins A1 through B12

Level II ICU Connector #2 Pin Assignments, Pins C1 through D16		
Number	**Pin Assignment**	**Wire**
C1	Recirculation Pressure	98K
C5	Parking Brake	125
C6	Pyrometer (+)	218A+
C8	Left Turn	38L
C11	Wheel Spin	376S
C12	Transmission Fluid Temperature Gauge (–)	30G
C13	Transmission Fluid Temperature Gauge (+)	30
C14	Engine Protection (CUM only)	N16

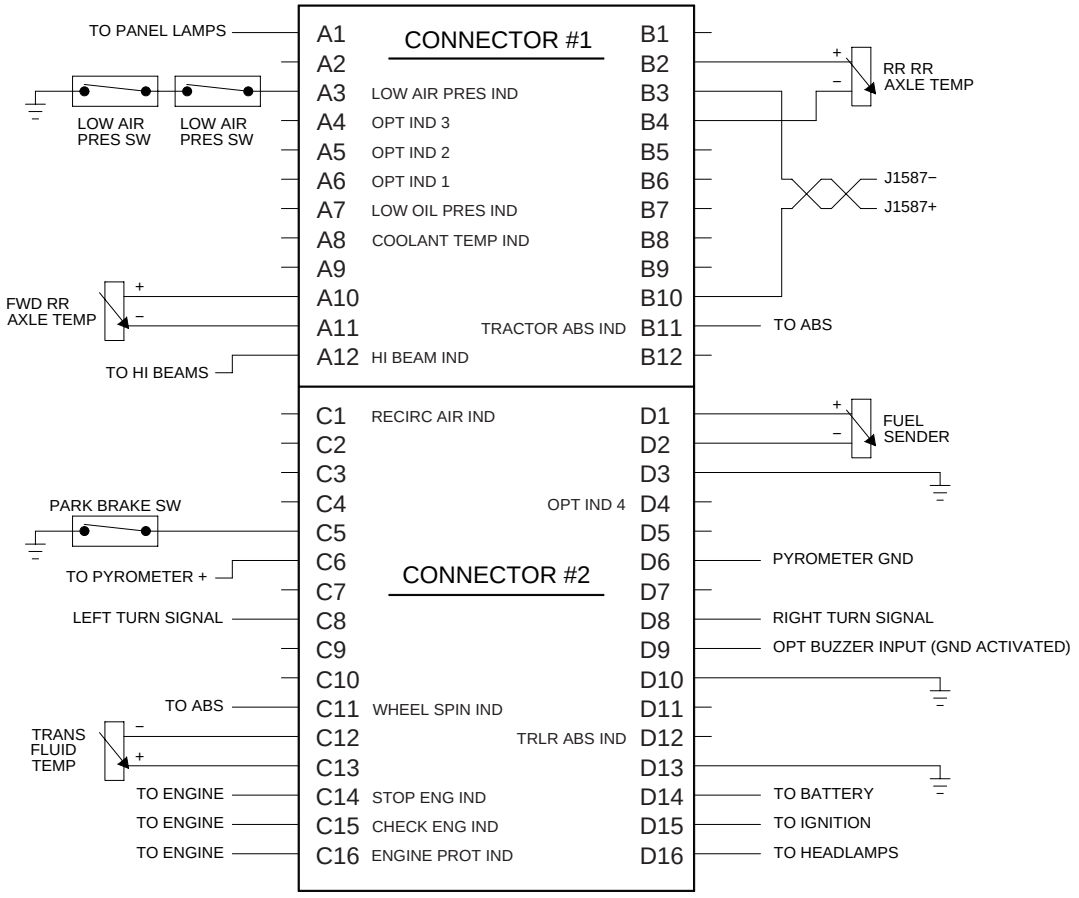
Specifications

Level II ICU Connector #2 Pin Assignments, Pins C1 through D16		
Number	**Pin Assignment**	**Wire**
C15	Check Engine	C799
		D419
		N25
C16	Engine Shutdown	C659
		D509
		N01
D1	Fuel Level (+)	47
D2	Fuel Level (–)	47G
D3	Panel Light Ground	GND
D4	Optional Indicator 4	GND
D6	Pyrometer (–)	218A–
D8	Right Turn	38R
D9	Buzzer Enable	437Z
D10	EMI Ground	GND
D12	Trailer ABS	376F
D13	Ground	GND
D14	Battery	437
D15	Ignition	437A
D16	Headlights	359

Table 2, Level II ICU Connector #2 Pin Assignments, Pins C1 through D16

Message Identifiers (MIDs)		
MID	**Description**	**Text Message**
128	Engine #1	ECU128
136	Anti-Lock Brakes (ABS)	AbS136
140	Instrumentation Control Unit, Left	ICU140
164	B-Panel Unit	bPU164
181	Communications Unit—Satellite	SAT181
190	Air Conditioning Protection Unit	A/C190
219	Collision Detection Radar	CdU219
231	Communications Unit—Cellular	CEL231
232	SPACE (Seat Belt Unit)	SbU232

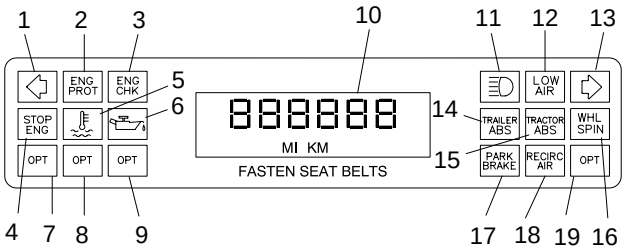
Table 3, Message Identifiers (MIDs)



NOTE: See **Fig. 2** for warning and indicator light positions.

Fig. 1, Level II ICU Pinouts (ICU2L)

Specifications



NOTE: Typical installation shown. Location and function of optional lights may vary.

1. Left Turn Indicator
2. Engine Protection Warning & Indicator
3. Check Engine Indicator
4. Stop Engine Warning (Cummins engine only)
5. High Coolant Temperature Warning (optional)
6. Low Oil Pressure Warning (optional)
7. Optional Indicator 3
8. Optional Indicator 2
9. Optional Indicator 1
10. Dash Driver Display Screen
11. High Beam Indicator
12. Low Air Warning
13. Right Turn Indicator
14. Trailer ABS Warning (optional)
15. Tractor ABS Warning
16. Wheel Spin Warning
17. Park Brake On Indicator
18. Recirc Air Warning (optional)
19. Optional Indicator 4

Fig. 2, Dash Message Center, Level II ICU (ICU2L)

General Description

IMPORTANT NOTIFICATION: Service upon the Eaton VORAD Collision Warning System should be undertaken only by qualified technicians. Special skills and equipment are required to perform these procedures. For assistance, contact Eaton VORAD at (800) 840–7970.

⚠ CAUTION

Before performing any electric welding on a vehicle, disconnect the battery power and ground cables and the CWS Central Processing Unit (CPU) 32-pin connector, ground cable, and antenna cable at the bottom of the CPU. See Subject 170 in this section for instructions. Electric currents produced during electric welding can damage various electronic components on the vehicle.

The Eaton VORAD EVT–200 is a computerized radar collision warning system (CWS) which will alert a driver to objects in front of and to the side of the vehicle. Additional warning time, to prevent potential rear-ending of other vehicles, is provided by alerting the driver to stationary or slow moving objects in front of the vehicle or to objects toward which your vehicle is creeping. The system provides three levels of alerts to indicate the interval to a vehicle ahead travelling at normal speeds. An optional right-side sensor detects objects alongside the vehicle, where they cannot be seen.

The system is able to monitor and maintain data on up to 20 moving or stationary objects within its range. It provides information in fog, rain, or snow conditions, as well as in darkness. A trip recorder option monitors and records the time spent at specific following intervals, driver times, maximum speeds, time spent at various speeds, engine idle time, and average speed. The accident reconstruction option will store two ten minute segments of information on a driver's card and can assist in reconstructing events leading up to an accident. The driver's card can also be programmed as a personal electronic ID card with the driver's name and employee number.

Components consist of one or two in-cab display units, the front mounted antenna assembly, side sensor(s), turn sensor assembly, the central processing unit (CPU), the antenna cable, antenna mounting plate, and associated wiring harnesses.

⚠ WARNING

The collision warning system is intended only as an aid to an alert and conscientious driver. The system may provide little or no warning of pedestrians or animals on the road, head-on collisions, or cross traffic at intersections. Do not rely solely on the system to operate the vehicle; always use the system with the rearview mirrors and other instrumentation. The system will not warn of many possible hazards, is not a substitute for safe driving procedures, and will not compensate for driver impairment. Failure to drive safely and use the system properly could result in personal injury and property damage.

Principles of Operation

The forward-looking CWS operates by transmitting and receiving low power, high frequency, radar (microwave) signals between the vehicle and objects in front of it. These signals determine changes in distance and speed between the vehicle and the object. This information is then used to inform the driver of a potential collision by visual and auditory alerts. To be detected, an object must be within the field of view of the antenna's radar beam. It must also provide a surface that can reflect the radar beam back to the antenna assembly. The side sensor(s) (motion detector) detects objects alongside the vehicle.

The antenna assembly compares the frequencies between the transmitted and received signals. It converts the information to a digital format and outputs it to the CPU for processing. The CPU in turn sends signals to activate the appropriate lights and alarms. The antenna is mounted to aim directly in front of the host vehicle. It has a range of up to 350 feet (107 meters) for moving objects and 220 feet (67 meters) for stationary and slow moving objects.

The side sensor range is set to detect vehicles in the adjacent lane. It also provides information to the CPU for processing.

The turn sensor assembly consists of a magnet, mounted to the steering shaft, which rotates past a sensor, mounted in a fixed position on the steering column. At two to four degrees of steering wheel rotation, the magnet will rotate past the sensor and in-

General Information

dicate to the CPU that a turn is being made. Because the antenna may see objects alongside the road when the vehicle is turning, audible alerts are cancelled by the CPU when the turn sensor indicates a turn in progress.

The CPU processes the information it receives from the antenna assembly, J1587 (vehicle speed), side sensor(s), turn sensor assembly, brake circuit, and turn signal circuit. It sends signals to the driver display unit and side sensor display to illuminate lights and signals the driver display unit to sound alerts over the speaker.

The driver display unit (DDU), if so configured, controls power to the system, speaker volume, and the range threshold of alerts to objects in the road. It also controls the storage of the first ten minute segment of accident reconstruction data onto the driver's card.

The side sensor display (SSD) contains red and yellow alert lights, indicating if an object is detected or not. The red light indicates a detected object. The yellow light indicates no object detected. Both the side sensor display and the driver display unit have a light intensity adjusting light sensor.

Replacement

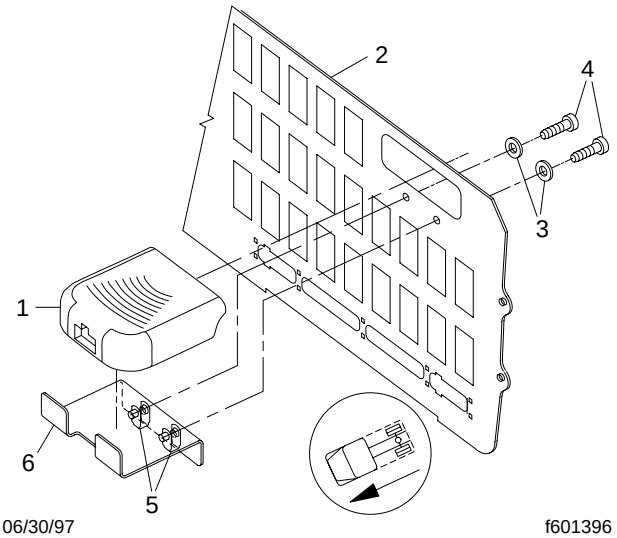
IMPORTANT NOTIFICATION: Service upon the Eaton VORAD Collision Warning System should be undertaken only by qualified technicians. Special skills and equipment are required to perform these procedures. For assistance, contact Eaton VORAD at (800) 840–7970.

NOTE: Removal of the driver display unit requires gaining access to the inside of the auxiliary instrument panel. See **Group 60** of the vehicle workshop manual for specific procedures for removal and installation of the dash panels. See **Subject 190** in this section for DDU test procedures.

1. Park the vehicle on a level surface. Set the parking brake, chock the tires, and disconnect the batteries.
2. Remove the instrument center-panel trim, the HVAC/radio trimplate, and the right-hand dash trimcap.
3. Remove the four Torx®-head screws securing the auxiliary instrument panel to the dash assembly.
4. Gain access to the rear (forward side) of the auxiliary panel by pulling the panel toward you.
5. Remove the two Torx-head screws which attach the driver display unit mounting bracket to the auxiliary panel. See **Fig. 1** .
6. Withdraw the display unit, with its mounting bracket attached, and disconnect the electrical harness.

NOTE: If replacing the display unit or the bracket, carefully separate the unit from the bracket. It is attached with a two-sided adhesive. Remove all of the old adhesive. Install new adhesive and attach the display unit to the bracket.

7. To install the DDU, connect the electrical harness to the display unit.
8. Place the display unit, with bracket attached, behind the auxiliary panel and insert it into the panel.
9. Install and tighten the two bracket mounting Torx-head screws.



1. Driver Display Unit (DDU)
2. Auxiliary Panel (seen from the rear)
3. Washer
4. Torx-Head Screw
5. J-Clip
6. DDU Mounting Bracket

Fig. 1, Driver Display Unit (DDU)

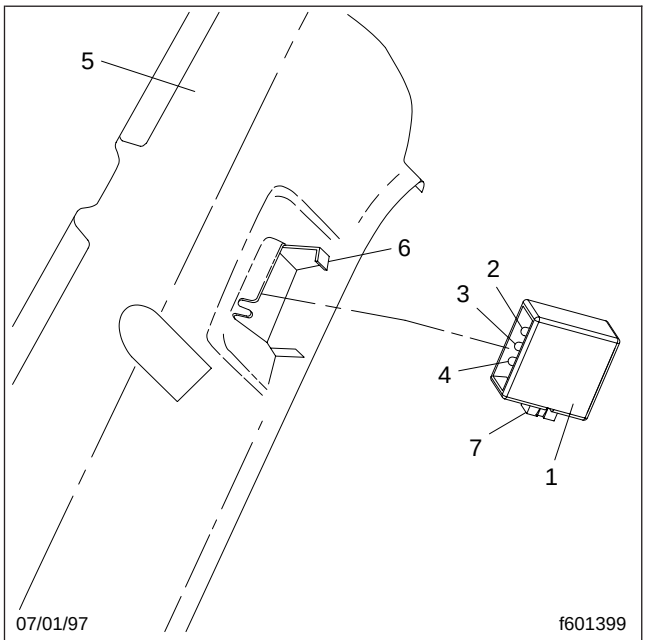
10. Carefully push the auxiliary panel into position, against the dashboard assembly.
11. Install and tighten the four panel Torx-head screws.
12. Install the right-hand trimcap, the HVAC/radio trimplate, and the instrument center-panel trim.
13. Remove the chocks from the tires and connect the batteries.

Replacement

IMPORTANT NOTIFICATION: Service upon the Eaton VORAD Collision Warning System should be undertaken only by qualified technicians. Special skills and equipment are required to perform these procedures. For assistance, contact Eaton VORAD at (800) 840–7970.

NOTE: See **Subject 190** in this section for Side Sensor Display test procedures.

1. Park the vehicle on a level surface. Set the parking brake, chock the tires, and disconnect the batteries.
2. Remove the two Torx®-head screws securing the passenger grab handle to the passenger side A-pillar. Remove the handle.
3. Pull the door trim edging back to expose the edge of the inner A-pillar trim cover. Remove the cover. See **Fig. 1** .
4. Release the plastic retaining clip securing the side sensor display to the A-pillar cover. Remove the display.
5. Disconnect the electrical harness from the display.
6. To install the SSD, connect the harness to the display.
7. Insert the display into the A-pillar cover and ensure it is secured with the plastic retaining clip.
8. Put the A-pillar cover in position on the A-pillar.
9. Press the door trim edging into place.
10. Place the grab handle in position. Install and securely tighten the mounting screws.
11. Remove the chocks from the tires and connect the batteries.



1. Side Sensor Display (SSD)
2. Red Alert Light (vehicle detected)
3. Light Sensor
4. Yellow Alert Light (no vehicle detected)
5. Inner A-Pillar Trim Cover
6. SSD Retaining Clip
7. Electrical Harness Connector

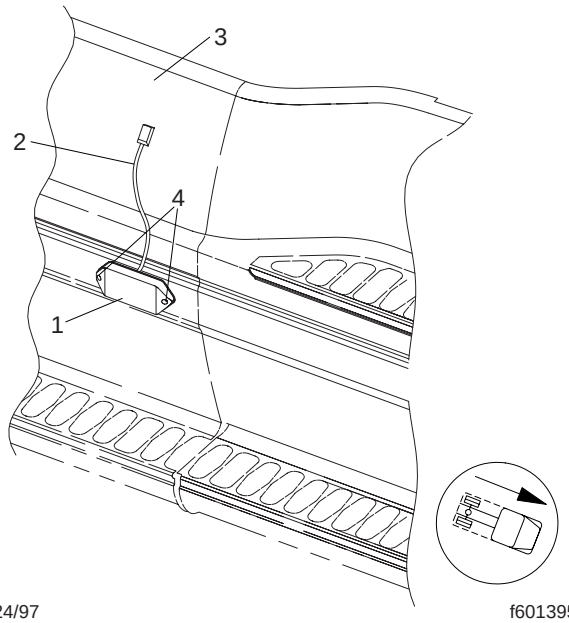
Fig. 1, Side Sensor Display (SSD)

Replacement

IMPORTANT NOTIFICATION: Service upon the Eaton VORAD Collision Warning System should be undertaken only by qualified technicians. Special skills and equipment are required to perform these procedures. For assistance, contact Eaton VORAD at (800) 840–7970.

NOTE: See **Subject 190** in this section for Side Sensor test procedures.

1. Park the vehicle on a level surface. Set the parking brake, chock the tires, and disconnect the batteries.
2. Remove the two Torx®-head screws and nuts securing the side sensor to the center air-fairing panel. See **Fig. 1** .



1. Side Sensor
2. Side Sensor Harness
3. Center Air-Fairing Panel
4. Torx-Head Mounting Screw

Fig. 1, Side Sensor

3. Pull the sensor and gasket away from the panel.
4. Reach through the fuel access door, or up between the side-fairing and fuel tank, and locate the sensor harness. Cut any tie straps securing the sensor harness and pull the mated connectors out through the sensor mounting hole and disconnect them.
5. To install the sensor, place the gasket behind the sensor, locate the two side sensor harness connector ends, and join them together.
6. From the outside, feed the harness through the hole in the fairing panel.
7. Position the sensor gasket against the fairing panel, behind the sensor, and secure the assembly to the fairing panel with the two Torx-head screws and nuts.
8. Reach up between the side-fairing and the fuel tank and make a service loop in the excess side sensor harness. Secure the service loop to the aluminum side-fairing mounting rail with tie straps.
9. Remove the chocks from the tires and connect the batteries.

Replacement

IMPORTANT NOTIFICATION: Service upon the Eaton VORAD Collision Warning System should be undertaken only by qualified technicians. Special skills and equipment are required to perform these procedures. For assistance, contact Eaton VORAD at (800) 840–7970.

NOTE: See **Subject 190** in this section for Turn Sensor Assembly test procedures (Steering Test), **Subject 180** for Initial Adjustments, and **Subject 200** for On-Road Checks and Final Adjustments.

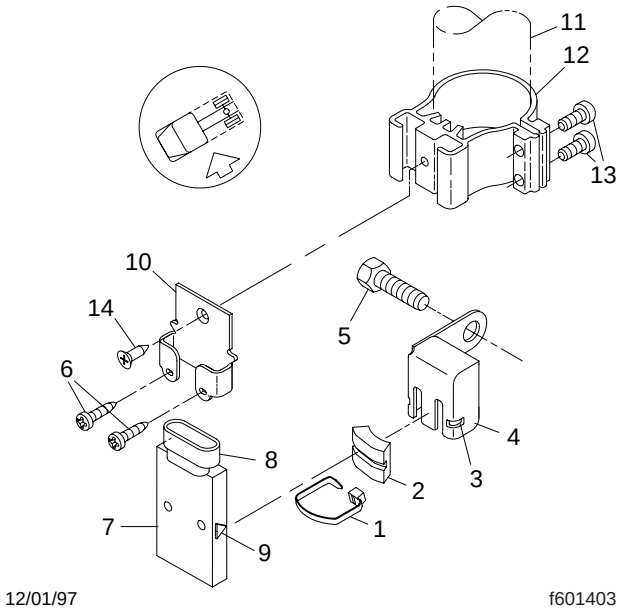
1. Park the vehicle on a level surface. Set the parking brake, chock the tires, and disconnect the batteries.

NOTE: The turn sensor assembly consists of the sensor, the mounting plate, and the sensor mounting collar (attached to the steering column), and the magnet and its bracket, attached to the steering knuckle.

2. Remove the driver's knee bolster at the bottom of the steering column.
3. Remove two mounting nuts and the carpeted cover assembly below the driver's knee bolster.
4. Reach around to the front side of the steering column and disconnect the turn sensor electrical harness from the sensor. See **Fig. 1** .

NOTE: If the sensor mounting collar has not been indexed to the steering column with alignment marks, make alignment marks before moving the collar.

5. Loosen the two Torx®-head screws that secure the sensor mounting collar to the steering column and twist the collar around to gain access to the sensor.
6. Remove the single Phillips-head screw attaching the sensor mounting plate and turn sensor to the sensor mounting collar. Slide the sensor mounting plate and sensor out of the sensor mounting collar.
7. Take note of the position in which the sensor is mounted in the mounting plate and remove the two Phillips-head screws that secure the sensor to the mounting plate. Remove the sensor.



1. Tie Strap
2. Magnet
3. Tie Strap Notch
4. Magnet Bracket
5. Steering Knuckle Pinch Bolt
6. Phillips-Head Screw
7. Turn Sensor
8. Electrical Harness Connector
9. Reference Arrow
10. Sensor Mounting Plate
11. Steering Column
12. Sensor Mounting Collar
13. Torx-Head Screw
14. Phillips-Head Screw

Fig. 1, Turn Sensor Assembly

NOTE: Older versions of the sensor (also used in other applications) may have a spacer plate included with them. An older version will have a stepped area to accommodate the sensor. Do not forget to include the spacer plate when assembling this type. The later type sensor does not have a separate spacer plate. If replacing an older type sensor with a new one, you do not need the spacer plate.

8. Place the new sensor in the mounting plate, in the same position as the old one. Install and tighten the two Phillips-head screws. Then slide the plate with the sensor into the sensor mount-

Turn Sensor Assembly Replacement

ing collar and secure it with the single Phillips-head screw.

9. To remove and replace the sensor mounting collar, remove the two Torx-head screws and expand the collar enough to clear the steering column.

NOTE: If the collar itself is not being replaced with a new one, align the existing collar marks with the existing marks on the steering column. Tighten the Torx-head mounting screws. If the collar is being replaced, ensure that the sensor and magnet are approximately aligned with the front wheels pointing straight ahead. Tighten the mounting screws.

10. To replace the magnet only, cut the tie strap securing it to the bracket.

NOTE: With the wheels pointing straight ahead, access the magnet by turning the steering wheel 180 degrees, in either direction, so that the magnet faces you.

11. Place the new magnet against the bracket, curved side forward, so that the ends fit securely into the bracket slots.
12. Position the magnet firmly at the top of the slots.
13. Secure the magnet to the bracket with a small tie strap. Ensure that the tie strap is retained by the small notches on the sides of the bracket, that it is fully recessed in the slot, and that the knot or block is clear of the magnet face.

IMPORTANT: The steering knuckle pinch bolt and nut must be replaced any time they are removed from the steering knuckle, as when removing or replacing the magnet bracket. Torque the pinch bolt nut to 37 lbf·ft (50 N·m).

NOTE: If the pinch bolt is replaced, secure the magnet bracket while torquing the nut, so that the bracket does not rock or move out of position. Also, the magnet bracket can be mounted in two positions on the steering knuckle. If replacing a bracket, observe the original mounting position and install the new part the same way.

14. Position the sensor mounting collar vertically so that the small arrow on the side of the sensor aligns with the approximate center of the magnet, either above or below the tie strap.

NOTE: Also adjust the collar so that its bottom edge is flush with the bottom edge of the steering column lower bearing housing.

15. Adjust the clearance between the sensor and the magnet by rotating or pivoting the magnet bracket under the pinch bolt. Clearance should be approximately 1/8 inch (3 mm).
16. See **Subject 180** in this section for alignment procedures if the magnet-to-sensor alignment was disturbed.
17. Remove the chocks from the tires and connect the batteries.

Replacement

IMPORTANT NOTIFICATION: Service upon the Eaton VORAD Collision Warning System should be undertaken only by qualified technicians. Special skills and equipment are required to perform these procedures. For assistance, contact Eaton VORAD at (800) 840–7970.

NOTE: See **Subject 190** in this section for Antenna Assembly test procedures, **Subject 180** for Initial Adjustments, and **Subject 200** for On-Road Checks and Final Adjustments.

1. Park the vehicle on a level surface. Set the parking brake, chock the tires, and disconnect the batteries.
2. Remove the four Torx®-head screws which secure the antenna assembly mounting brackets to the antenna mounting plate. See **Fig. 1** .
3. Pull the antenna assembly forward to gain access to the antenna cable attachment.

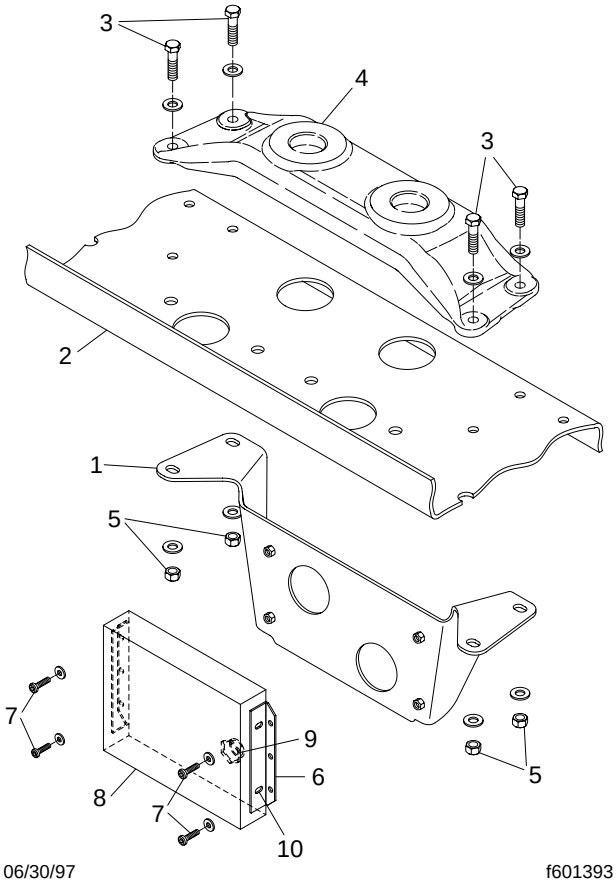
NOTE: It may be necessary to cut tie straps or unfasten harness clamps at the front crossmember, where an antenna cable service loop is provided. Gain a sufficient length of cable to pull the antenna assembly forward and access the cable connection.

4. Unscrew the nylon nut and hold it back against the uniboot to gain access to the knurled nut. See **Fig. 2** .
5. Unscrew the knurled nut and carefully withdraw the cable from the antenna.

⚠ CAUTION

There are two keyways forming part of the inner antenna cable plastic connector end, close to the pins. The cable connector will fit into the antenna assembly in one position only. Use caution when inserting the connector so as not to damage the pins.

6. To install the antenna assembly, carefully insert the cable, correctly aligned, while holding back the uniboot, into the antenna assembly and tighten the knurled nut securely.

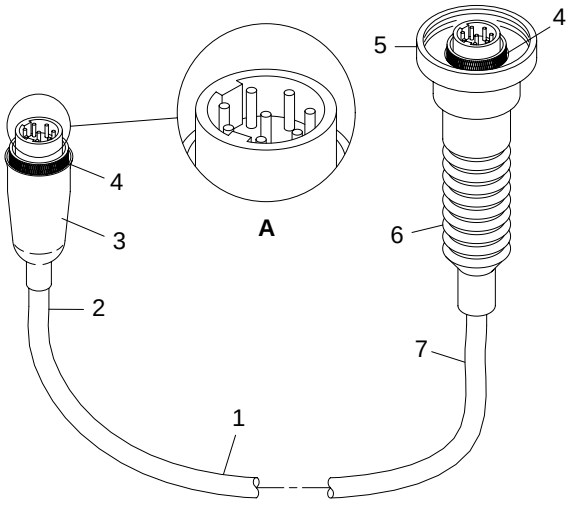


1. Antenna Mounting Plate
2. Front Closing Crossmember
3. Radiator Mounting Bracket/Antenna Mounting Plate Capscrew
4. Radiator Mounting Bracket
5. Nut
6. Antenna Assembly Mounting Bracket
7. Torx-Head Screw
8. Antenna Assembly
9. Antenna Cable Connector
10. Adjustment Slot (location of 5/32-inch Allen setscrew)

Fig. 1, Antenna Assembly

7. Ensure that the O-ring is in position on the antenna and securely tighten the nylon uniboot nut over it.
8. Attach the antenna assembly to the mounting plate with the four Torx-head screws and tighten them securely.

Antenna Assembly Replacement



A. Detail (keyways on both connector ends)
1. Antenna Cable
2. CPU End
3. Boot
4. Knurled Nut
5. Nylon Nut
6. Uniboot
7. Antenna End

Fig. 2, Antenna Cable

9. Position the excess antenna cable length into a service loop at the front crossmember and secure it with tie straps.
10. Remove the chocks from the tires and connect the batteries.

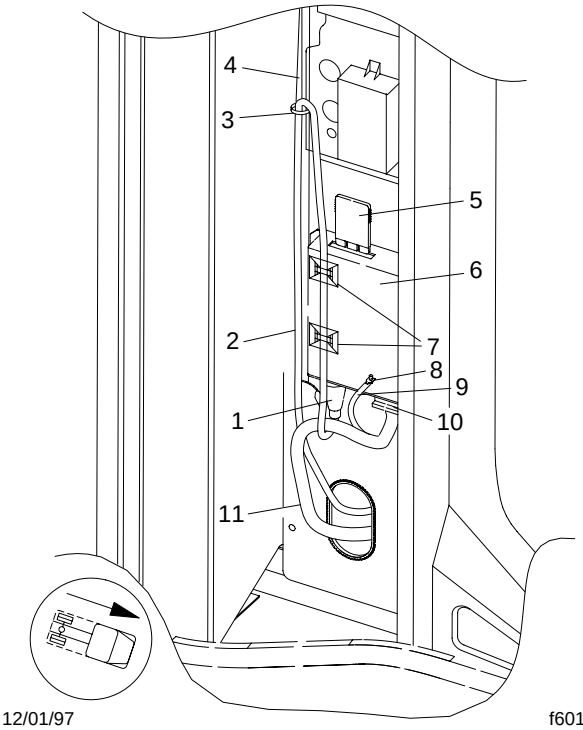
Replacement

IMPORTANT NOTIFICATION: Service upon the Eaton VORAD Collision Warning System should be undertaken only by qualified technicians. Special skills and equipment are required to perform these procedures. For assistance, contact Eaton VORAD at (800) 840–7970.

1. Park the vehicle on a level surface. Set the parking brake, chock the tires, and disconnect the batteries.
2. Inside the cab, use a flat-bladed screwdriver to turn the two camlock fasteners and open the passenger-side B-pillar door.
3. Cut the tie straps holding the antenna cable to the tie strap anchors on the CPU. See **Fig. 1** .
4. Cut the tie straps securing the cable to the other harnesses in the B-pillar cavity.
5. Slide the antenna cable boot, at the CPU connection, back to expose the knurled nut. See **Fig. 2** .
6. Unscrew the knurled nut and carefully withdraw the cable from the CPU.
7. Remove the three screws securing the passenger-side threshold tread plate and remove the plate.
8. Remove the three screws and the plastic trim cover over the seat belt retractor, below the B-pillar door.
9. Remove the rubber grommet surrounding the antenna cable in the floor, and feed the cable through the floor, out of the cab. See **Fig. 3** .
10. Outside the vehicle, open the passenger-side fuel access door to see the cable routing.
11. Cut the tie straps securing the antenna cable to the side sensor cable. Cut tie straps where the cable is routed up and over the HVAC lines and down to the frame rail.

NOTE: It may be helpful to tilt the hood, for better visibility, before attempting to detach the cable from the other harnesses along the frame rail.

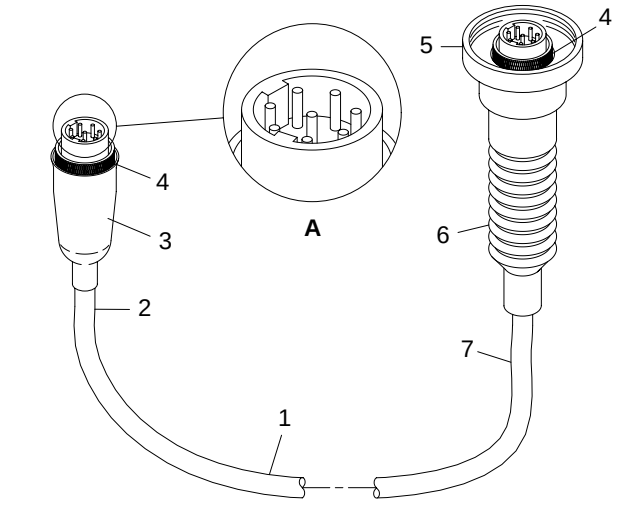
12. Cut the tie straps from the anchor blocks on the frame rail bolts. Release the cable from the other harnesses along the entire length of the antenna cable along the right-hand frame rail, up to the antenna assembly at the front closing crossmember.
13. Remove the antenna assembly from the antenna mounting plate. See **Subject 140** in this section for instructions.
14. Remove the cable from the vehicle.
15. To install the cable, work from underneath the front of the vehicle. Route the antenna connector end of the new cable, with the uniboot, forward, through the air recirculation shield, and through



1. Antenna Cable Boot
2. Antenna Cable
3. Tie Strap
4. Location of Other Harnesses
5. Driver's Card
6. Central Processing Unit (CPU)
7. Tie Strap Anchor
8. Ground Cable Nut
9. Ground Cable
10. 32-Pin Connector
11. 32-Pin Connector Harness

Fig. 1, B-Pillar Cavity

Antenna Cable Replacement



A. Detail (keyways on both connector ends)
1. Antenna Cable
2. CPU End
3. Boot
4. Knurled Nut
5. Nylon Nut
6. Uniboot
7. Antenna End

Fig. 2, Antenna Cable

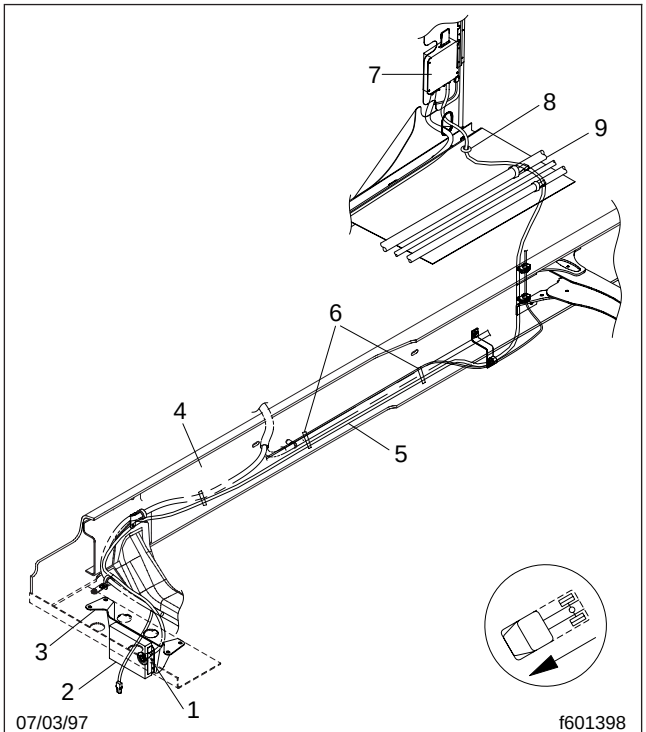
the hole in the mounting plate. Hold the uniboot back and carefully insert the cable, correctly aligned, into the antenna assembly and tighten the knurled nut securely.

⚠ CAUTION

There are two keyways forming part of the inner antenna cable plastic connector end, close to the pins. The cable connector will fit into the antenna assembly in one position only. Use caution when inserting the connector so as not to damage the pins.

16. Ensure that the O-ring is in position on the antenna and securely tighten the nylon nut over it.
17. Install the antenna and securely tighten the four Torx-head screws which attach it to the mounting plate.

NOTE: If the antenna assembly is removed from the mounting plate, even with the mounting brackets left attached, it will be necessary to realign the antenna.



1. Antenna Cable Connector (at antenna)
2. Antenna Assembly
3. Antenna Mounting Plate
4. Right-Side Frame Rail
5. Antenna Cable
6. Tie Strap
7. Central Processing Unit (CPU)
8. Rubber Grommet (in cab floor)
9. HVAC Lines

Fig. 3, Antenna Cable Routing

18. At the point where the cable passes through the mounting plate, make a service loop in the cable approximately 12 inches (30 cm) in length. The entire loop will be 24 inches (60 cm). Route and loop the cable to the left, on top of the front closing crossmember. Secure the cable in the looped position with tie straps to the other harnesses running across the crossmember.
19. Next, route the cable to the right, over the front closing crossmember, and then rearward, along the right-side frame rail. Secure the cable to the wire bundles with tie straps along its full length.

20. At the point where the side sensor is located, route the cable under the frame rail, and up and over the HVAC lines.
21. Secure the cable to the HVAC lines and the side sensor harness with tie straps.
22. Pass the cable into the cab, through the hole in the floor by the B-pillar door, and install the rubber grommet in the floor, around the cable.
23. Route the cable through the lower opening in the B-pillar compartment.
24. Carefully insert the cable, correctly aligned, into the CPU and tighten the knurled nut securely.

⚠ CAUTION

There are two keyways forming part of the inner antenna cable plastic connector end, close to the pins. The cable connector will fit into the CPU in one position only. Use caution when inserting the connector so as not to damage the pins.

25. Slide the boot all the way over the knurled nut.

NOTE: Route the antenna cable beneath the 32-pin connector harness attached to the CPU, to cradle and protect the 32-pin connector harness.

26. Install new tie strap anchors on the CPU and secure the cable to the tie strap anchors.
27. Route the remaining excess cable up along the existing harnesses in the compartment. Secure it to the harnesses in a loop, with tie straps.
28. Install the plastic trim cover over the seat belt retractor and install the three screws.
29. Install the threshold trim plate and the three screws.
30. Close the B-pillar door and secure it with the camlock fasteners.
31. Remove the chocks from the tires and connect the batteries. Lower the hood if it was opened previously.

Replacement

IMPORTANT NOTIFICATION: Service upon the Eaton VORAD Collision Warning System should be undertaken only by qualified technicians. Special skills and equipment are required to perform these procedures. For assistance, contact Eaton VORAD at (800) 840–7970.

1. Park the vehicle on a level surface. Set the parking brake, chock the tires, and disconnect the batteries.
2. Remove the antenna assembly.

NOTE: See **Subject 140** in this section for instructions on replacement of the antenna assembly.

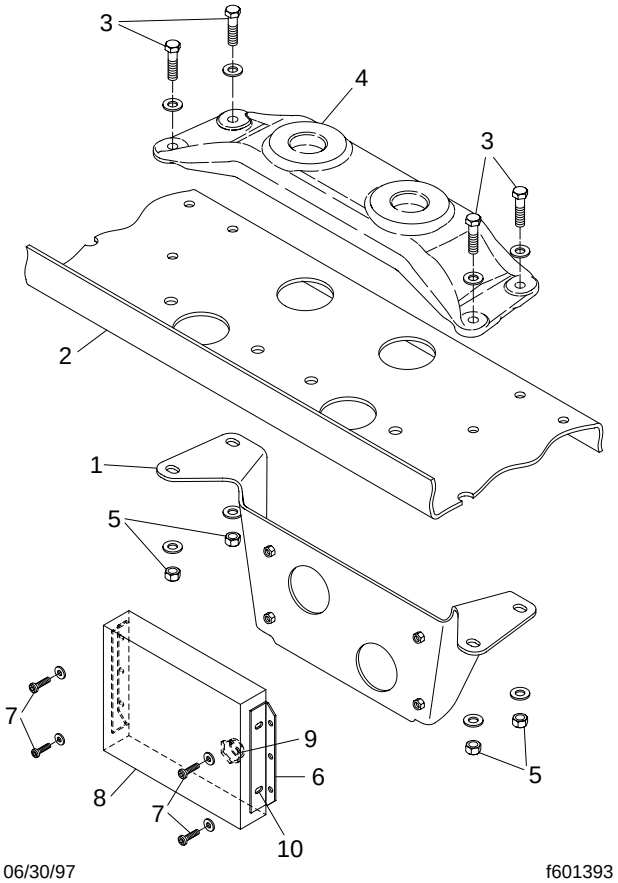
3. With the antenna assembly removed, withdraw the antenna cable through the hole in the mounting plate.
4. Hold the heads of the four radiator mounting bracket/antenna mounting plate capscrews from above and remove the nuts below the mounting plate. See **Fig. 1**.
5. Remove the mounting plate from the vehicle.
6. To install, place the mounting plate in position with the four capscrews extending through the holes in the radiator bracket/mounting plate.
7. Install the four nuts and torque them to 28 lbf·ft (38 N·m).

NOTE: Push the plate back against the mounting capscrews while tightening the nuts. This ensures that the plate is perpendicular to the vehicle's longitudinal axis.

8. Insert the antenna cable through the mounting plate hole, connect the cable to the antenna, and install the antenna assembly onto the mounting plate.

⚠ CAUTION

There are two keyways forming part of the inner antenna cable plastic connector end, close to the pins. The cable connector will fit into the antenna assembly in one position only. Use caution when inserting the connector so as not to damage the pins.



1. Antenna Mounting Plate
2. Front Closing Crossmember
3. Radiator Mounting Bracket/Antenna Mounting Plate Capscrew
4. Radiator Mounting Bracket
5. Nut
6. Antenna Assembly Mounting Bracket
7. Torx-Head Screw
8. Antenna Assembly
9. Antenna Cable Connector
10. Adjustment Slot (location of 5/32-inch Allen setscrew)

Fig. 1, Antenna Mounting Plate

NOTE: If the antenna assembly is removed from the mounting plate, even with the mounting brackets left attached, it will be necessary to realign the antenna.

9. Remove the chocks from the tires and connect the batteries.

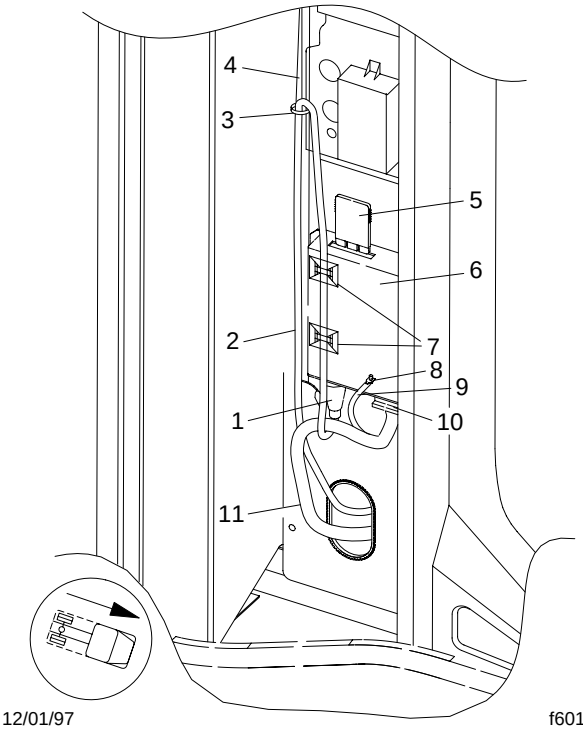
Replacement

IMPORTANT NOTIFICATION: Service upon the Eaton VORAD Collision Warning System should be undertaken only by qualified technicians. Special skills and equipment are required to perform these procedures. For assistance, contact Eaton VORAD at (800) 840–7970.

NOTE: Before replacing a CPU, confirm that there is a problem. Visually inspect the unit and confirm that all connections, power and grounds, are good. Check for a blown fuse or tripped circuit breaker. Check the condition of the pins in all connectors and cavities. Examine the wiring and look for physical damage to the insulation, corrosion, or the effects of heat. See **Subject 300** in this section for CPU fault codes and troubleshooting procedures.

IMPORTANT: It is necessary, if possible, to view the configuration parameters of the old CPU with ProLink and record them before removing the old CPU from the system.

1. Park the vehicle on a level surface. Set the parking brake, chock the tires, and disconnect the batteries.
2. Inside the cab, remove the B-pillar door vinyl trim cover from the passenger side B-pillar door, by pulling it away from its Velcro fasteners.
3. Turn the two camlock fasteners with a flat-bladed screwdriver and open the B-pillar door.
4. Cut the tie straps securing the antenna cable to the tie strap anchors on the CPU. Cut the tie strap securing the uppermost portion of the cable. See **Fig. 1** .
5. Remove the four Torx®-head screws and locknuts attaching the CPU to the B-pillar door. Remove the CPU from the door. See **Fig. 2** .
6. Disengage the push lock connector and carefully withdraw the 32-pin harness connector from the CPU.
7. At the bottom of the CPU, remove the nut from the ground stud and remove the ground wire from the stud.

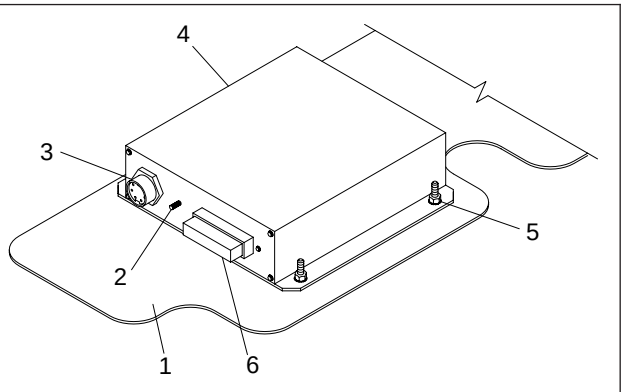


1. Antenna Cable Boot
2. Antenna Cable
3. Tie Strap
4. Location of Other Harnesses
5. Driver's Card
6. Central Processing Unit (CPU)
7. Tie Strap Anchor
8. Ground Cable Nut
9. Ground Cable
10. 32-Pin Connector
11. 32-Pin Connector Harness

Fig. 1, B-Pillar Cavity

8. Slide back the antenna cable boot, unscrew the knurled nut, and carefully withdraw the cable from the CPU.
9. Remove the driver's card, if present, from the old CPU and insert it into the new CPU.
10. To install, place the new CPU in position against the inside of the B-pillar door.
11. Insert the four Torx-head screws, from the outside of the door, through the CPU mounting holes.
12. Install the four locknuts and tighten them securely.

Central Processing Unit (CPU) Replacement



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1. B-Pillar Door
2. Ground Stud
3. Antenna Cable Connector
4. CPU
5. Torx-Head Screw and Locknut
6. 32-Pin Harness Connector

Fig. 2, Central Processing Unit (CPU)

13. Place the ground wire ring terminal over the ground stud on the bottom of the CPU. Install and tighten the nut securely.

NOTE: Route the antenna cable beneath the 32-pin connector harness, attached to the CPU, to cradle and protect the 32-pin harness.

14. Carefully connect the 32-pin harness connector to the CPU.
15. Carefully insert the antenna cable, correctly aligned, into the CPU and tighten the knurled nut securely.

⚠ CAUTION

There are two keyways forming part of the inner antenna cable plastic connector end, close to the pins. The cable connector will fit into the CPU in one position only. Use caution when inserting the connector so as not to damage the pins.

16. Install new tie strap anchors on the CPU and secure the antenna cable to the anchors with tie straps.
17. Secure the excess length of cable to the other harnesses, near the top of the B-pillar compartment, in a loop, with a tie strap.
18. Close the B-pillar door and secure it by turning the two camlock fasteners.
19. Attach the vinyl trim cover to the B-pillar door with the Velcro fasteners.

NOTE: When replacing a CPU with a new unit, it is necessary to verify the system's configuration using ProLink. Follow the steps below to verify that a new CPU is configured identically to the one it is replacing.

20. Access the ProLink SET UP menu.
21. Ensure that the current parameters of the new CPU are identical to those of the CPU it is replacing.
22. Select BIT CONFIGURATION from the SETUP menu.
23. Ensure that the current parameters of the new CPU are identical to those of the CPU it is replacing.
24. Select FLAGS CONFIGURATION from the SETUP menu.
25. Ensure that the current parameters of the new CPU are identical to those of the CPU it is replacing.
26. After you have ensured that the new CPU is configured identically to the old one, press FUNC to return to the SETUP menu and clear all fault codes.
27. Remove the chocks from the tires and connect the batteries.

General Information

IMPORTANT NOTIFICATION: Service upon the Eaton VORAD Collision Warning System should be undertaken only by qualified technicians. Special skills and equipment are required to perform these procedures. For assistance, contact Eaton VORAD at (800) 840–7970.

The two components requiring initial adjustment, after removal and installation, are the turn sensor assembly and the antenna assembly .

No special tools are required to make the initial adjustments to the turn sensor assembly.

For initial adjustments to the antenna assembly, a good quality digital level is recommended.

NOTE: Perform these initial adjustments when the turn sensor, sensor mounting plate, sensor mounting collar, antenna assembly, antenna assembly mounting brackets, or antenna mounting plate are removed or replaced. Perform the initial adjustments before performing the On Road Checks and Final Adjustments.

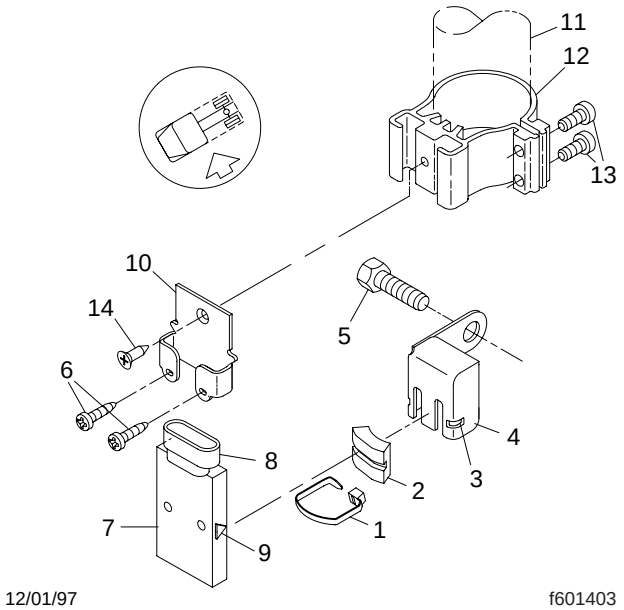
Initial Turn Sensor Assembly Adjustment

1. Park the vehicle on a level surface. Set the parking brake, chock the tires, and disconnect the batteries.
2. Gain access to the turn sensor assembly. See **Subject 130** in this section for instructions.

IMPORTANT: If the steering knuckle pinch bolt and nut are removed (to remove or replace the magnet bracket), they must be replaced with new parts and the nut torqued to 37 lbf·ft (50 N·m). Be sure to secure the magnet bracket when torquing the nut, to prevent the bracket from rocking or moving out of position.

NOTE: If either the magnet, or magnet bracket (or both) is removed or replaced, no initial adjustments are required. Simply install the components as they were previously mounted. However, ensure that 1/8 inch (3 mm) clearance exists between the sensor and the magnet. If the original sensor mounting collar is being reinstalled, align the marks on the collar with the marks on the steering column. If there are no alignment marks, be sure to make them before removing the collar. See **Subject 130** for turn sensor assembly replacement instructions. If a new sensor, sensor mounting plate, or sensor mounting collar is being installed, follow the steps below.

3. Turn the steering wheel so that the front wheels are pointing straight ahead.
4. Expand the new sensor mounting collar (with sensor attached) and place it around the steering column. See **Fig. 1** .



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1. Tie Strap
2. Magnet
3. Tie Strap Notch
4. Magnet Bracket
5. Steering Knuckle Pinch Bolt
6. Phillips-Head Screw
7. Turn Sensor
8. Electrical Harness Connector
9. Reference Arrow
10. Sensor Mounting Plate
11. Steering Column
12. Sensor Mounting Collar
13. Torx-Head Screw
14. Phillips-Head Screw

Fig. 1, Turn Sensor Assembly

Initial Adjustments

5. Install the Torx®-head screws, but do not tighten them fully.
6. Adjust the collar vertically so that the small arrow on the side of the sensor aligns with the approximate center of the magnet, either above or below the tie strap.

NOTE: Also adjust the collar so that its bottom edge is flush with the bottom edge of the steering column lower bearing housing.

7. Roughly align the sensor and magnet horizontally so that they center upon each other when the front wheels are pointed straight ahead.
8. Securely tighten the sensor mounting collar screws.
9. Remove the chocks from the tires and connect the batteries.

Initial Antenna Assembly Adjustment

1. Park the vehicle on a level surface. Set the parking brake, chock the tires, and disconnect the batteries.

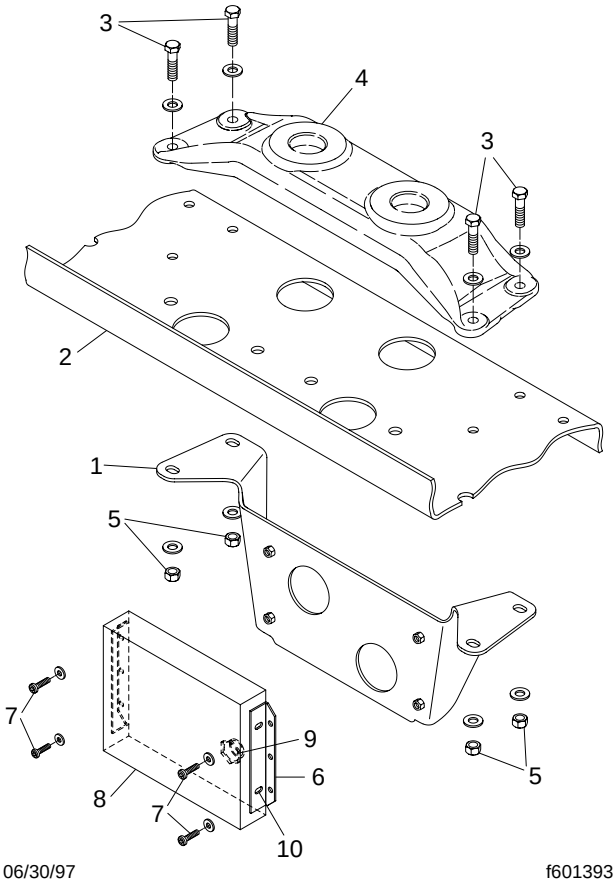
IMPORTANT: The vehicle must be parked on a level surface to properly perform the Initial Antenna Assembly Adjustment procedure.

2. Place the digital level on the frame rail, behind the cab. The vehicle as well as the ground surface needs to be approximately level.

NOTE: Take note of the angle of the vehicle and/or ground surface. You must compensate for any deviation from absolute level.

3. Loosen the four adjusting setscrews (two on each antenna mounting bracket) with a 5/32-inch Allen wrench. See **Fig. 2** .
4. Push the antenna assembly all the way back in the mounting bracket adjustment slots, so that the antenna is flush with the antenna mounting plate, and only snug the setscrews.

NOTE: Push the antenna assembly back, flush with the antenna mounting plate, to accomplish the initial antenna assembly left-to-right adjustment. This adjustment is also dependent upon the proper installation of the mounting plate.



1. Antenna Mounting Plate
2. Front Closing Crossmember
3. Radiator Mounting Bracket/Antenna Mounting Plate Capscrew
4. Radiator Mounting Bracket
5. Nut
6. Antenna Assembly Mounting Bracket
7. Torx-Head Screw
8. Antenna Assembly
9. Antenna Cable Connector
10. Adjustment Slot (location of 5/32-inch Allen setscrew)

Fig. 2, Antenna Assembly

When installing the mounting plate, be sure to push the mounting plate back and hold it against the four mounting plate capscrews as the nuts are being tightened.

5. Place the digital level vertically against the face of the antenna. The initial vertical antenna setting

is one degree down. Look for a reading of 89 degrees (or 91 degrees), depending on level readout.

NOTE: If the vehicle is angled down because it is parked on an unlevel surface, add the number of degrees off from level to the one degree down. If the vehicle is angled up, subtract the number of degrees off from level to the one degree down. For example, if the vehicle is angled down 2.7 degrees the antenna angle must be 3.7 degrees down which will produce a reading of 86.3 degrees (or 93.7 degrees), depending on level readout.

6. Adjust the antenna out from either the top or bottom to obtain the required degree reading on the level.
7. Tighten the setscrews securely.
8. Check the vertical setting to be sure it is still set at the required degree angle.
9. If the vertical setting has changed, repeat the procedure.
10. Remove the chocks from the tires and connect the batteries.

Component Checks

IMPORTANT NOTIFICATION: Service upon the Eaton VORAD Collision Warning System should be undertaken only by qualified technicians. Special skills and equipment are required to perform these procedures. For assistance, contact Eaton VORAD at (800) 840–7970.

MPSI PROLINK® 9000

To properly test and diagnose problems with the Eaton VORAD collision warning system an MPSI ProLink 9000 hand-held tester with an Eaton VORAD diagnostic cartridge is required. The initial or default EVT-200 Diagnostic menu consists of three sub menus: Setup, Checkout, and Error Log. Verify system configuration of the Central Processing Unit (CPU) with the setup menu. Use the checkout menu to test the functions of the various components. Display fault codes using the error log menu.

NOTE: Use only a digital ohmmeter when performing tests to avoid damaging electronic components.

COMPONENT CHECKS USING THE CHECKOUT MENU

NOTE: Before selecting CHECKOUT, select SETUP and verify system configuration. This ensures proper operation of the CHECKOUT menu during component function tests.

The various components of the collision warning system can be activated using this menu. Some checks require assistance from the technician. The technician will be asked, via the ProLink, if the expected event occurred. Use the UP and DOWN arrow keys to scroll the selection arrow. Select the CHECKOUT menu from the initial EVT-200 Diagnostic menu by placing the selection arrow next to CHECKOUT and pressing ENTER.

NOTE: The following component checks are performed with the vehicle stationary.

Side Sensor Display (BSD) Test

1. Select BSD TEST from the CHECKOUT menu.
2. Place the selection arrow next to the side sensor display.

NOTE: If the vehicle has only one side sensor, there will be an N/A value displayed for the other side sensor.

3. Press ENTER to toggle the state of the side sensor display light.
4. The indicator light on the side sensor display will match the RED or YELLOW message shown on the ProLink.
5. Press FUNC to exit the BSD TEST and return to the CHECKOUT menu.

Side Sensor (BSS) Test

1. Select BSS TEST from the CHECKOUT menu.
2. Place the selection arrow next to the side sensor you are testing.

NOTE: If the vehicle has only one side sensor, there will be an N/A value displayed for the other side sensor.

3. Wave your hand in front of the side sensor.
4. As you wave your hand, the message displayed on the ProLink will change from NO to YES.

NOTE: The message OPEN/SHORT will appear if the side sensor power source is disconnected.

5. Press FUNC to exit the BSS TEST and return to the CHECKOUT menu.

Driver Display Unit (DDU) Test

1. Select DDU TEST from the CHECKOUT menu.

NOTE: At the lamp test line, the RED, YELLOW, and ORANGE range control alert lights will toggle automatically. Each will illuminate individually on the display as the ProLink indicates their color.

2. On the DDU, rotate the left knob (volume control) left to right, fully through its range. The percentage value for the LEFT KNOB on the ProLink display will change from 0 to 100 percent.
3. Now rotate the right knob (range control) left to right, fully through its range. The percentage value for the RIGHT KNOB on the ProLink display will change from 0 to 100 percent.
4. Push in the right knob (range control) and hold it until the display indicates PUSH.

Component Checks

5. Press FUNC to exit the DDU TEST and return to the CHECKOUT menu.

Speaker Test

1. Select the SPEAKER TEST from the CHECK-OUT menu.
2. Place the selection arrow next to the particular sound to be tested and press ENTER.

NOTE: When performing this test, sound volume is always at maximum. Adjusting the volume knob (left knob) on the DDU will have no effect.

3. Listen for the specific sound from the DDU speaker.
4. Repeat the procedure to test each of the six different sounds.
5. Press FUNC to exit the SPEAKER TEST and return to the CHECKOUT menu.

Antenna Test

1. Select ANTENNA TEST from the CHECKOUT menu.
2. Have an assistant walk toward the front of the antenna.

NOTE: The antenna will only detect a moving object.

3. Note the RANGE reading on the ProLink.
4. Ensure that the RANGE reading is approximately correct.
5. Press FUNC to exit the ANTENNA TEST and return to the CHECKOUT menu.

Turn Signal Test

1. Select TURN SIGNAL TEST from the CHECK-OUT menu.
2. Place the selection arrow next to the right-side turn signal.

NOTE: There will be an N/A value displayed for the turn signal on the left-hand side.

3. Move the turn signal lever into position to activate the turn signal for the right-hand side.
4. The ProLink display for that turn signal position will change from OFF to ON.
5. Press FUNC to exit the TURN SIGNAL TEST and return to the CHECKOUT menu.

Brake Test

1. Select BRAKE TEST from the CHECKOUT menu.
2. Depress the brake pedal when the ProLink display indicates PRESS BRAKE PEDAL.

NOTE: If the system is not configured for a brake signal BIT test, there will be an N/A value displayed.

3. The BRAKE message on the display will change from OFF to ON when the brake pedal is depressed.
4. Press FUNC to exit the BRAKE TEST and return to the CHECKOUT menu.

Steering Test

1. Ensure that the front wheels of the vehicle are pointed straight ahead.
2. Select STEERING TEST from the CHECKOUT menu.

NOTE: On the ProLink display at the MAG POS line, two characters are displayed to the left and a single character to the right. The two characters on the left indicate left- and right-side activation or non-activation of the sensor. An asterisk (*) indicates that the sensor is being activated by the magnet. A dash (-) indicates that the sensor is not being activated. The single character on the right indicates a count of the magnet position (4 = one full turn of the steering wheel).

3. With the vehicle’s wheels pointed straight ahead, turn the steering wheel clockwise far enough to move the magnet clear of the turn sensor and then back to center. The display will change from ** to -* to - - through this range of motion.
4. With the vehicle’s wheels pointed straight ahead, turn the steering wheel counterclockwise far enough to move the magnet clear of the turn sensor and then back to center. The display will change from ** to *- to - - through this range of motion.

5. After turning the steering wheel in both directions, observe that the ProLink display STATUS line changes from WAITING to PASSED. This indicates that both the left and right sides of the sensor are functioning properly.

NOTE: When the turn sensor and magnet are aligned correctly, the ProLink display will indicate two asterisks (**) at the MAG POS line for a vehicle traveling in a straight line at normal highway speeds.

6. Press FUNC to exit the STEERING TEST and return to the CHECKOUT menu.

Turn Sensor Assembly

IMPORTANT NOTIFICATION: Service upon the Eaton VORAD Collision Warning System should be undertaken only by qualified technicians. Special skills and equipment are required to perform these procedures. For assistance, contact Eaton VORAD at (800) 840–7970.

⚠ WARNING

The following on-highway procedures require two people in the vehicle. A second person is needed to observe the ProLink display and make a note of final adjustments to be made to the turn sensor mounting collar position. Do not attempt these procedures alone as this could result in loss of control of the vehicle and possible physical injury and property damage.

NOTE: These procedures are intended to be performed only on an interstate highway, freeway, or similar roadway. Perform these procedures only after performing the Initial Adjustments, when a turn sensor, sensor mounting plate, or sensor mounting collar has been removed or replaced. See **Subject 180** in this section for instructions.

1. Drive the vehicle straight ahead at normal highway speed.
2. Using ProLink, have the assistant access CHECKOUT, STEERING TEST. Look for two asterisks (**) on the ProLink display.
3. Confirm that the turn sensor assembly is properly aligned by verifying that two asterisks appear while driving the vehicle in a straight line at normal highway speeds of 50 to 55 mph (80 to 88 km/h).

NOTE: In this condition, as slight normal corrections are made with the steering wheel, one or more asterisks may disappear. Broad turns of the steering wheel, greater than 45 degrees, will cause both asterisks to disappear. If two asterisks (**) do not appear while driving in a straight line, adjust the turn sensor assembly.

⚠ WARNING

Only attempt these procedures where at least two lanes are available for use and traffic is light. Improperly performing these procedures could result in loss of control of the vehicle and possible physical injury and property damage.

4. Adjust the turn sensor assembly to the vehicle's traveling centerline by marking the top center position of the steering wheel (12 o'clock position) with tape. Do this as the vehicle is proceeding in a straight line down the highway at normal highway speeds of 50 to 55 mph (80 to 88 km/h).
5. Pull the vehicle off the road in a safe location and shut off the engine. Position the steering wheel with the marker tape at the same top center position (12 o'clock position).
6. Loosen the two Torx®-head screws on the sensor mounting collar and adjust the position of the turn sensor to the centerline of the magnet. See **Subject 180** in this section for instructions. Tighten the collar screws securely.

Antenna Assembly

NOTE: These procedures are intended to be performed only on an interstate highway, freeway, or similar roadway where at least two lanes in your direction are available for use. Perform these procedures only after performing the Initial Adjustments when an antenna assembly, antenna assembly mounting brackets, or antenna mounting plate have been removed or replaced. See **Subject 180** for instructions.

1. Drive the vehicle straight ahead at normal highway speeds of 50 to 55 mph (80 to 88 km/h).

⚠ WARNING

Only attempt these procedures where at least two lanes are available for use and traffic is light. Improperly performing these procedures could result in loss of control of the vehicle and possible physical injury and property damage.

On-Road Checks and Final Adjustments

2. Confirm that the system is monitoring only the vehicle traveling immediately ahead of the host vehicle.

NOTE: The DDU should display following distance information only for the vehicle traveling immediately ahead, by illuminating the number 1 or number 2 alert light. The DDU should not display following distance information for vehicles in the left or right lanes, ahead of the host vehicle, while the host vehicle is traveling in a straight line.

3. If the system is monitoring vehicles in the left or right lane, while traveling in a straight line, adjust the antenna assembly.
4. To adjust the antenna assembly to the vehicle's traveling centerline, first pull the vehicle off the road in a safe location and shut off the engine.
5. Loosen the two Allen setscrews in the antenna mounting bracket only on the side you wish to adjust.
6. Increase the horizontal side mounting angle of the antenna from which the system is monitoring vehicles traveling in the adjacent lane. See **Subject 180** for instructions. Tighten the Allen setscrews securely.

NOTE: Pull the side of the antenna on which vehicles are being detected forward. If the system is detecting vehicles in the adjacent lane on the right-hand side, pull the right-hand side of the antenna forward. If the system is detecting vehicles in the adjacent lane on the left-hand side, pull the left-hand side of the antenna forward.

Troubleshooting

IMPORTANT NOTIFICATION: Service upon the Eaton VORAD Collision Warning System should be undertaken only by qualified technicians. Special skills and equipment are required to perform these procedures. For assistance, contact Eaton VORAD at (800) 840–7970.

COMPONENT TROUBLESHOOTING

When a current active fault is detected by the system, the red fail light on the DDU illuminates until the cause of the condition is corrected. It is possible to read fault codes either on the DDU, by placing it in failure display mode, or with ServiceLink or ProLink.

Active and inactive fault codes may be blinked out over the DDU when the system is placed in failure display mode by holding the volume control knob down upon vehicle start up. Display active codes by turning the range knob to MIN and inactive codes by turning the knob to MAX. Codes will be blinked on the red fail light. The light will blink as many times as the first digit of the fault code number, pause approximately 3/4 of a second, and then blink as many times as the second digit. Additional fault codes are blinked out at intervals of approximately eight seconds. After all the fault codes have been displayed, the sequence repeats. This process continues until the system is turned off. ServiceLink version 1.3 will only allow you to read the codes as MID (message identifier), SID (subsystem identifier), and FMI (failure mode identifier) numbers, which correspond to the specific fault codes.

Beyond simply determining which fault codes are present, it is necessary to use an MPSI ProLink 9000 tester equipped with a VORAD cartridge. Make the various basic checks below before proceeding to the more detailed troubleshooting procedures in the following tables.

1. Confirm that there is a problem.
2. Before replacing any component, make continuity checks with a digital volt/ohm meter.
3. Confirm that all connections, power and grounds, to either the vehicle or components, are good.
4. Check for a blown fuse or tripped circuit breaker.
5. Check the condition of pins in all connectors and cavities.
6. Examine the wiring of the suspect component. Look for physical damage to the insulation, corrosion, and the effects of heat.
7. Examine the external components (antenna assembly, cable, side sensor) for damage or corrosion.

Component Troubleshooting (DDU Green Light-SSD Red Light)		
Symptom	**Cause/Source**	**Remedy**
DDU green ON light blinks eight times.	An event is stored on the driver's card.	NOTE: The ON light will blink rapidly eight times when the system is activated, or when the card is removed and reinserted, indicating an event has been stored on the accident reconstruction segment. There is still one open memory segment available to store accident reconstruction data.

Troubleshooting

Component Troubleshooting (DDU Green Light-SSD Red Light)		
Symptom	**Cause/Source**	**Remedy**
SSD red light illuminates continuously.	CPU not receiving side sensor information/side sensor.	1. — Confirm that the vehicle has a side sensor. If not, verify that the left and right turn signal BIT setting is OFF. * 2. — Check the connection or for damage to the main CPU harness. 3. — Check the connection or for damage to the three-pin extension harness of the main harness pigtail connector and the side sensor. 4. — While performing the BSS test, wave your hand in front of the right side sensor to verify that the correct signal is being received. * 5. — Disconnect the three-pin side sensor and CPU connectors. Check for corrosion or a recessed pin.

* A ProLink diagnostic tool equipped with an EVT–200 cartridge is required for this procedure.

Table 1, Component Troubleshooting (DDU Green Light-SSD Red Light)

Component Troubleshooting (Warning Tones-Volume Knob)		
Symptom	**Cause/Source**	**Remedy**
No warning tones audible.	Speaker not functioning, steering magnet not detected, brake signal incorrect/ DDU, turn sensor assembly, brake input or configuration setting.	1. — Verify that the volume control knob is turned all the way to the right. 2. — Turn the system off and back on. Turn the volume control knob and listen for a tone. 3. — Verify that the DDU connection is good. 4. — Perform the speaker test to verify that a tone is heard from the DDU speaker. 5. — Verify that the magnet is properly aligned with the turn sensor assembly. 6. — Perform the steering test to verify that the sensor correctly detects the magnet position. * 7. — Verify that the brake BIT setting is correctly configured in the CPU. * 8. — Perform the brake test to verify that the correct signal is received when the pedal is depressed. *
Warning tones audible when brakes applied.	Incorrect input signal/ brake input.	NOTE: Stationary, slow-moving, and following distance warning tones are disabled when the brake pedal is depressed. Creep and side sensor alerts are audible when the brake pedal is depressed. 1. — Perform the brake test to confirm receipt of the correct signal when the brake pedal is depressed. * 2. — Verify that the brake BIT setting is correctly configured in the CPU. * 3. — Verify that brake logic is correctly configured in the CPU. *

Component Troubleshooting (Warning Tones-Volume Knob)		
Symptom	**Cause/Source**	**Remedy**
Side sensor warning tones not consistent with condition.	Incorrect input signal/ turn signal input.	1. — Verify that a double tone is not audible when you wave your hand in front of the side sensor with only the brake pedal depressed (turn signal not activated). 2. — Verify that the turn signal BIT setting is correctly configured in the CPU. * 3. — Perform the turn signal test to confirm receipt of the correct signal when the turn signal is applied. *
No system ON/OFF capability.	Hardware configuration.	NOTE: Some models have a non-adjustable feature which prevents the operator from turning off the system. This is a feature requested by the original purchaser.
The volume knob does not reduce the volume.	System configuration/ DDU.	NOTE: System parameters can be configured to limit volume to a minimum level, but only with a ProLink diagnostic tool. If the owner or fleet manager allows full adjustment of the volume level, follow the procedure below. 1. — Verify that the MIN VOL setting is zero. * 2. — Perform the DDU test to confirm proper operation of the left knob. * 3. — Check that the DDU is properly connected and not damaged. 4. — Check that the main harness to the CPU is properly connected and not damaged.

* A ProLink diagnostic tool equipped with an EVT–200 cartridge is required for this procedure.

Table 2, Component Troubleshooting (Warning Tones-Volume Knob)

Component Troubleshooting (Range Knob-Detected Vehicles)		
Symptom	**Cause/Source**	**Remedy**
The range knob does not change the alert levels.	Software configuration/ DDU.	NOTE: System parameters can be configured to prevent the operator from reducing range threshold levels. This configuration can only be changed with a ProLink diagnostic tool. If the owner or fleet manager allows adjustment of the range levels, follow the procedure below. 1. — Verify that the RANGE ENABLE configuration is ON. * 2. — Perform the DDU test to confirm proper operation of the right knob. * 3. — Check that the DDU is properly connected and not damaged. 4. — Check that the main harness to the CPU is properly connected and not damaged.
Front antenna detects vehicles in one adjacent lane with no vehicle in front of host vehicle.	Antenna misaligned/ antenna assembly.	Adjust the antenna horizontal alignment in the direction opposite the detected-side lane to align the antenna assembly to the vehicle's traveling centerline. NOTE: See **Subject 180** and **Subject 200** in this section for antenna alignment procedures.

Troubleshooting

Component Troubleshooting (Range Knob-Detected Vehicles)		
Symptom	**Cause/Source**	**Remedy**
Front antenna detects vehicles in both left and right adjacent lanes with no vehicle in front of host vehicle.	Radar side lobes extended/antenna assembly.	1. — Confirm that the antenna assembly is mounted at the minimum height or above. 2. — Confirm that the antenna assembly is mounted securely. 3. — Confirm that the radar beam's path is unobstructed and that no movement of surrounding body panels is being detected. NOTE: Contact Eaton VORAD at (800) 840–7970 for additional assistance.
Front antenna loses or ignores detected vehicles within 100 feet (30 meters) in front of host vehicle.	Tracking module error/ antenna assembly.	1. — Confirm that the antenna assembly is aligned correctly. 2. — Check the antenna cable connection to the CPU and the antenna assembly. NOTE: Remove the uniboot to check the cable connection at the antenna assembly. 3. — Inspect the antenna assembly, the cable, and the CPU for corrosion or damage. NOTE: If the component listed in the Cause/Source column has been replaced, perform a road test afterward to confirm that the condition has been resolved.

* A ProLink diagnostic tool equipped with an EVT–200 cartridge is required for this procedure.

Table 3, Component Troubleshooting (Range Knob-Detected Vehicles)

FAULT CODE TROUBLESHOOTING USING THE ERROR LOG MENU

1. Select ERROR LOG from the initial EVT-200 Diagnostic menu.

NOTE: ERROR LOG provides a list of all the fault codes detected by the system. A BIT (Built-In Test) is performed every 15 seconds by the system to determine the condition of the components and internal processes. Faults that occur are logged as fault codes in the system's memory. The first line of the ERROR LOG menu displays the code number and the code status, either active or inactive.

2. Place the selection arrow next to the first line of the ERROR LOG menu. The first fault code in the error log is displayed.

NOTE: The second line of the ERROR LOG menu displays the name of the current fault. The third line (CLR CT/MIN) displays the number of occurrences of the current fault and the total number of minutes it has been continuously occurring. The fourth and fifth lines of the menu indicate the date and time of the first and last occurrences, respectively, of the fault.

3. Return the display arrow to the active or inactive code line.
4. Press ENTER and the next fault code with its information is displayed.
5. Continue to press ENTER to display all logged fault codes with their information.

NOTE: It may be helpful in diagnosing or solving a problem to know if some action will remove a fault. Clear the count on a particular fault by following the steps below.

6. Select the fault code for which the count is to be cleared as in steps 2 and 3 above.
7. Place the display arrow on the CLR CT/MIN line.
8. Press ENTER to clear the fault's count.

To get to the Eaton VORAD main menu, press FUNC in the initial EVT-200 Diagnostic menu. The EVT-200 Diagnostic menu is the default menu and comes on initially. Once at the Eaton VORAD main menu screen, you may select active or inactive faults. The name, FMI code, and count for active and inactive faults are displayed here. Failure Mode Identifiers (FMI) numbers describe a specific type of failure detected in a specific system.

9. Press the left or up arrow key to display the previous active or inactive fault.
10. Press the right or down arrow key to display the next active or inactive fault.
11. Press FUNC to return to the Eaton VORAD main menu.

NOTE: At the CLEAR FAULT CODES line, accessed from the Eaton VORAD main menu, you can clear all fault codes from system memory. Be sure this is what you want to do as all BIT data will be reinitialized when all fault codes are cleared.

12. Press ENTER if you want to clear all fault codes and then select DIAGNOSTICS from the Eaton VORAD main menu to return to the EVT-200 Diagnostic menu.

Fault Code Troubleshooting (Codes 11-16)				
Fault Code *	**Cause/Source**	**SID**	**FMI**	**Remedy**
11/RAM	Scratch memory error/CPU	254	12	CPU internal component failure. Cannot be repaired in the field. †
12/FLASH	Program memory error/CPU	254	12	CPU internal component failure. Cannot be repaired in the field. †
13/FPGA	Gate array will not program/CPU	254	12	CPU internal component failure. Cannot be repaired in the field. †
14/DSP	Digital signal processor will not program/CPU	254	12	CPU internal component failure. Cannot be repaired in the field. †
15/BATTERY	Internal battery low/ CPU	254	12	CPU internal component failure. Cannot be repaired in the field. †
16/NVRAM	Internal non-volatile data memory corrupted/CPU	254	12	CPU internal component failure. Cannot be repaired in the field. †

* MID (message identifier) # 219 applies to all the fault codes in this table. This MID has been assigned to collision avoidance radar.

† The CPU must be returned to the manufacturer for repair.

Table 4, Fault Code Troubleshooting (Codes 11-16)

Troubleshooting

Fault Code Troubleshooting (Codes 17-22)				
Fault Code *	**Cause/Source**	**SID**	**FMI**	**Remedy**
17/NO DSP DATA	CPU not receiving antenna data/ antenna cable, antenna assembly, CPU	254	9	1. — Check the antenna cable connection to the CPU and the antenna assembly. NOTE: Remove the uniboot to check the cable connection at the antenna assembly. 2. — Disconnect the antenna cable at both ends and inspect for damage to the connector pins or for pins pushed into the connector. 3. — Inspect the antenna assembly, the cable, and the CPU for corrosion or damage. 4. — Replace the first component listed in the Cause/Source column. Road test the vehicle and determine if the same fault occurs. If it does, replace the next listed component and perform all the preceding elements of the procedure until the fault no longer occurs after road testing.
21/FREQUENCY INJ	Radar frequency test signal error/ CPU, antenna assembly	2	8	1. — Check the antenna cable connection to the CPU and the antenna assembly. NOTE: Remove the uniboot to check the cable connection at the antenna assembly. 2. — Disconnect the antenna cable at both ends and inspect for damage to the connector pins or for pins pushed into the connector. 3. — Inspect the antenna assembly, the cable, and the CPU for corrosion or damage. 4. — Install the software version 106, or higher. Contact Eaton VORAD at (800) 840–7970 for assistance. 5. — Replace the first component listed in the Cause/Source column. Road test the vehicle and determine if the same fault occurs. If it does, replace the next listed component and perform all the preceding elements of the procedure until the fault no longer occurs after road testing.
22/F/E DATA or CLK	Antenna data communication link bad/CPU, antenna assembly, antenna cable	2	2	1. — Check the antenna cable connection to the CPU and the antenna assembly. NOTE: Remove the uniboot to check the cable connection at the antenna assembly. 2. — Disconnect the antenna cable at both ends and inspect for damage to the connector pins or for pins pushed into the connector. 3. — Inspect the antenna assembly, the cable, and the CPU for corrosion or damage. 4. — Replace the first component listed in the Cause/Source column. Road test the vehicle and determine if the same fault occurs. If it does, replace the next listed component and perform all the preceding elements of the procedure until the fault no longer occurs after road testing.

* MID (message identifier) # 219 applies to all the fault codes in this table. This MID has been assigned to collision avoidance radar.

Table 5, Fault Code Troubleshooting (Codes 17-22)

Fault Code Troubleshooting (Codes 23-51)				
Fault Code *	**Cause/Source**	**SID**	**FMI**	**Remedy**
23/MICROWAVE XMIT	Antenna radar not transmitting/antenna assembly, antenna cable	1	2	1. — Check the antenna cable connection to the CPU and the antenna assembly. NOTE: Remove the uniboot to check the cable connection at the antenna assembly. 2. — Disconnect the antenna cable at both ends and inspect for damage to the connector pins or for pins pushed into the connector. 3. — Inspect the antenna assembly, the cable, and the CPU for corrosion or damage.
31/BRAKE	Vehicle brake input connection not detected/brake input	3	5	1. — Confirm that the brake light bulbs are good. 2. — Confirm that the brake switch operates correctly. 3. — Perform the brake test and confirm that the correct signal is received when the pedal is depressed. † 4. — Confirm that brake logic is correctly configured in the CPU. † 5. — Confirm that the brake input wire is connected to the proper source. 6. — Ensure that the main harness to CPU connection is good and that the harness is not damaged. NOTE: If the vehicle is equipped with LED tail lights and the fault code persists, even after confirming steps 1 through 6, contact Eaton VORAD at (800) 840–7970 for assistance.
42	No faults found	–	–	–

Troubleshooting

Fault Code Troubleshooting (Codes 23-51)				
Fault Code *	**Cause/Source**	**SID**	**FMI**	**Remedy**
51/R. STEERING	Right steering sensor input not connected/turn sensor assembly	5	5	1. — Resolve fault codes 17 through 23, if present, before proceeding. 2. — Perform the steering test and confirm that the left and right sides of the sensor correctly detect magnet position. † 3. — Check the turn sensor assembly connection and for damage to the sensor assembly. 4. — Check continuity on all the sensor wires. See **Specifications 400** in this section for a wiring schematic. 5. — Confirm that the value of pin number eight, in the bottom row of the main harness connector, changes from more than five volts to less than two volts when the magnet passes over the right sensor. 6. — Check the main harness to the CPU connection and for damage to the main harness. 7. — Replace the turn sensor assembly, clear all the fault codes, activate the system, and check to see if the fault reappears. 8. — Replace the first component listed in the Cause/Source column. Road test the vehicle and determine if the same fault occurs. If it does, replace the next listed component and perform all the preceding elements of the procedure until the fault no longer occurs after road testing.

* MID (message identifier) # 219 applies to all the fault codes in this table. This MID has been assigned to collision avoidance radar.

† A ProLink diagnostic tool equipped with an EVT–200 cartridge is required for this procedure.

Table 6, Fault Code Troubleshooting (Codes 23-51)

Fault Code Troubleshooting (Codes 52-61)				
Fault Code *	**Cause/Source**	**SID**	**FMI**	**Remedy**
52/L. STEERING	Left steering sensor input not connected/turn sensor assembly	5	5	1. — Resolve fault codes 17 through 23, if present, before proceeding. 2. — Perform the steering test and confirm that the left and right sides of the sensor correctly detect magnet position. † 3. — Check the turn sensor assembly connection and for damage to the sensor assembly. 4. — Check continuity on all the sensor wires. See **Specifications 400** in this section for a wiring schematic. 5. — Confirm that the value of pin number eight, in the top row of the main harness connector, changes from more than five volts to less than two volts when the magnet passes over the left sensor. 6. — Check the main harness to the CPU connection and for damage to the main harness. 7. — Replace the turn sensor assembly, clear all the fault codes, activate the system, and check to see if the fault reappears. 8. — Replace the first component listed in the Cause/Source column. Road test the vehicle and determine if the same fault occurs. If it does, replace the next listed component and perform all the preceding elements of the procedure until the fault no longer occurs after road testing.
53/STR MISALIGNED	Steering sensor misaligned to magnet on column/ turn sensor assembly	5	13	1. — With the vehicle stopped, place the steering wheel in that position (front wheels straight ahead), as when the vehicle was traveling in a straight line at normal highway speeds of 50 to 55 mph. 2. — Perform the steering test to confirm that the left and right sensors correctly detect magnet position. †
61/ SPEEDOMETER	Speed input not detected/speed input, configuration setting	6	5	1. — Confirm that the speed input has the correct source. † 2. — Confirm that the speed mode is correctly configured to the vehicle's electronic speed data line. † 3. — Perform the speedometer test to confirm the speedometer's accuracy against the vehicle speed. † 4. — Check the main harness to the CPU connection and for damage to the main harness. 5. — Twist the system's positive and negative J1587 speed input wires one full turn every 1-1/2 inches (38 mm), to shield against radio frequency interference.

* MID (message identifier) # 219 applies to all the fault codes in this table. This MID has been assigned to collision avoidance radar.

† A ProLink diagnostic tool equipped with an EVT–200 cartridge is required for this procedure.

Table 7, Fault Code Troubleshooting (Codes 52-61)

Troubleshooting

Fault Code Troubleshooting (Codes 71-74)				
Fault Code *	**Cause/Source**	**SID**	**FMI**	**Remedy**
71/RIGHT SIGNAL	Right turn signal input not detected/ turn signal input, configuration setting	7	5	1. — Confirm that the vehicle has a right side sensor. If not, confirm that the right turn signal BIT setting is OFF. † 2. — Confirm that the turn signal bulbs are good. 3. — Confirm that the turn signal switch operates properly. 4. — Confirm that the right turn signal input is connected to the right turn signal lead. 5. — Perform the turn signal test to confirm that the correct input is received when the right turn signal is activated. † 6. — Verify that pin number 2, on the top row of the main harness connector, receives 12 volts when the right signal is activated. 7. — Check the main harness to the CPU connection and for damage to the main harness.
72/RIGHT BSS	Right side sensor not communicating with CPU/right side sensor	10	5	1. — Confirm that the vehicle has a right side sensor. If not, confirm that the right turn signal BIT setting is OFF. † 2. — Perform the BSS test to confirm that the correct signal is received when you wave your hand in front of the right side sensor. † 3. — Check the three-pin extension harness connections at the main harness pigtail connector and at the side sensor. Check the harness for damage. 4. — Unplug the three-pin side sensor and CPU connectors. Inspect for corrosion or a recessed pin. 5. — Check the main harness to the CPU connection and for damage to the main harness.
73/LEFT SIGNAL	Configuration setting	8	5	Confirm that the left turn signal BIT setting is OFF. †
74/LEFT BSS	Second side sensor not communicating with CPU/second side sensor	11	5	1. — Confirm that the vehicle has a second side sensor. 2. — Perform the BSS test to confirm that the correct signal is received when you wave your hand in front of the left side sensor. † 3. — Check the three-pin extension harness connections at the main harness pigtail connector and at the side sensor. Check the harness for damage. 4. — Unplug the three-pin side sensor and CPU connectors. Inspect for corrosion or a recessed pin. 5. — Check the main harness to the CPU connection and for damage to the main harness.

* MID (message identifier) # 219 applies to all the fault codes in this table. This MID has been assigned to collision avoidance radar.

† A ProLink diagnostic tool equipped with an EVT–200 cartridge is required for this procedure.

Table 8, Fault Code Troubleshooting (Codes 71-74)

Fault Code Troubleshooting (Codes 91-93)				
Fault Code *	**Cause/Source**	**SID**	**FMI**	**Remedy**
91/VOLUME	Volume knob not functioning/DDU	9	5	1. — Perform the DDU test to confirm proper operation of the left knob. † 2. — Check the DDU connection and for damage to the DDU. 3. — Check the main harness to the CPU connection and for damage to the main harness.
92/RANGE	Range knob not functioning/DDU	9	5	1. — Perform the DDU test to confirm proper operation of the right knob. † 2. — Check the DDU connection and for damage to the DDU. 3. — Check the main harness to the CPU connection and for damage to the main harness.
93/DRVR DISP UNIT	DDU not communicating with CPU/DDU, CPU, harness	9	5	1. — Perform the DDU test to verify that the DDU operates properly. † 2. — Check the DDU connection and for damage to the DDU. 3. — Verify that the driver is not disconnecting the DDU. 4. — Check the main harness to the CPU connection and for damage to the main harness. 5. — Replace the first component listed in the Cause/Source column. Road test the vehicle and determine if the same fault occurs. If it does, replace the next listed component and perform all the preceding elements of the procedure until the fault no longer occurs after road testing.

* MID (message identifier) # 219 applies to all the fault codes in this table. This MID has been assigned to collision avoidance radar.

† A ProLink diagnostic tool equipped with an EVT–200 cartridge is required for this procedure.

Table 9, Fault Code Troubleshooting (Codes 91-93)

IMPORTANT NOTIFICATION: Servicing of the Eaton VORAD Collision Warning System should be undertaken only by qualified technicians. Special skills and equipment are required to perform these procedures. For assistance, contact Eaton VORAD at (800) 840–7970.

See **Fig. 1** for a schematic of the Collision Warning System wiring and components.

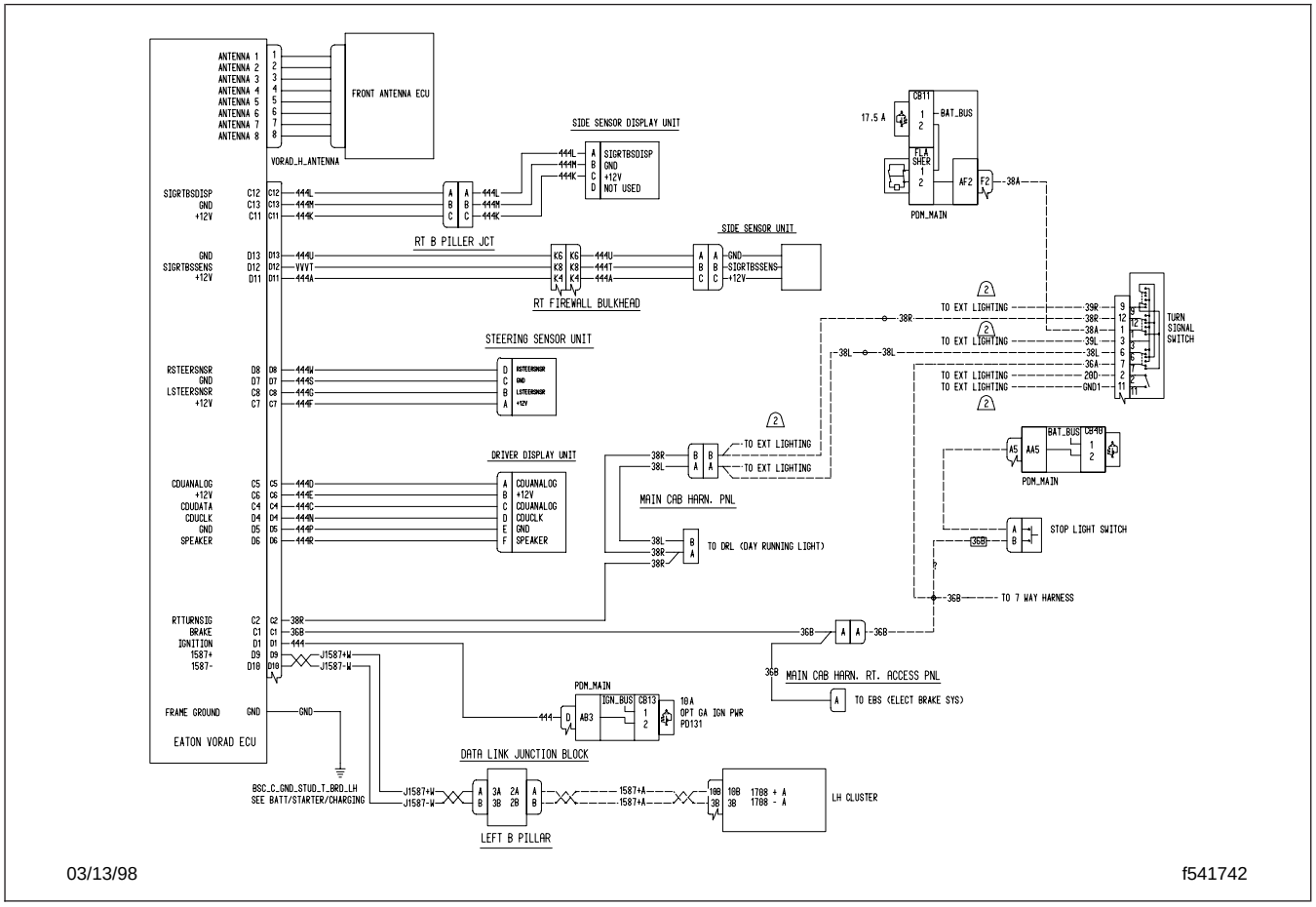


Fig. 1, Wiring Diagram (VORAD EVT-200 collision warning system)

See **Fig. 2** for a schematic of the Collision Warning System overlay harness.

Specifications

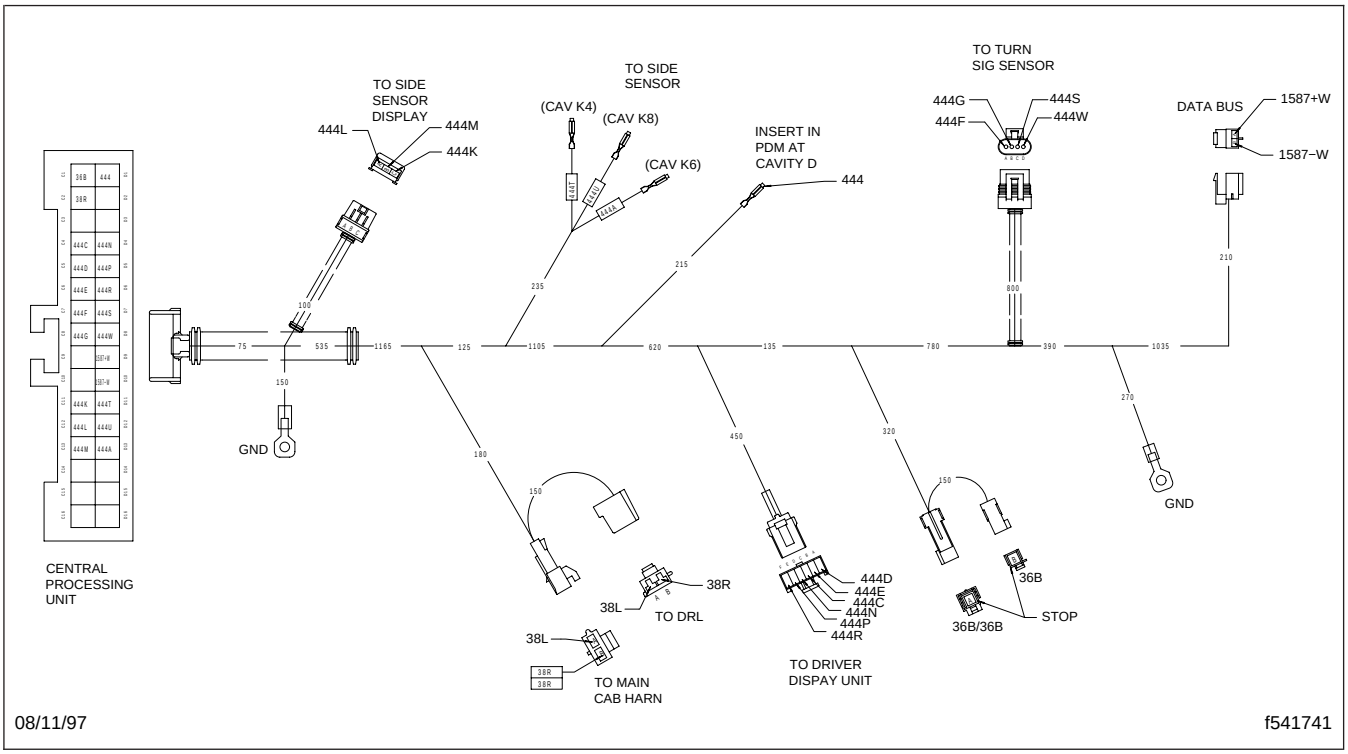


Fig. 2, Harness Assembly (VORAD EVT-200 collision warning system)

Torque Specifications		
Description	**lbf·ft**	**N·m**
Steering Knuckle Pinch Bolt and Nut	37	50
Antenna Mounting Plate Capscrews and Locknuts	28	38

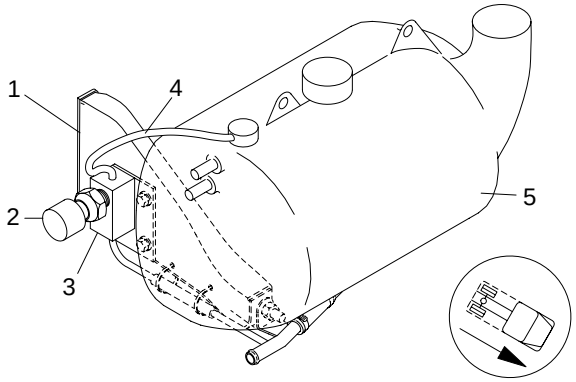
Table 1, Torque Specifications

Component Specifications			
Description	**Inches**	**Millimeters**	**Degrees**
Turn Sensor to Magnet Clearance	1/8	3	—
Antenna Assembly Azimuth Setting	—	—	0
Antenna Assembly Vertical Angle	—	—	1 Down (89 or 91)

Table 2, Component Specifications

General Information

Vehicles built before November 28, 1997 have a low coolant level (LCL) reservoir at the side of the surge tank. The coolant level probe inserts into this reservoir. See **Fig. 1**. The connector on the probe attaches directly to the frontwall harness. For frontwall harness wiring, see **Specifications, 400** in Section 54.00.



12/18/97 f500289a

Other hoses removed for clarity.

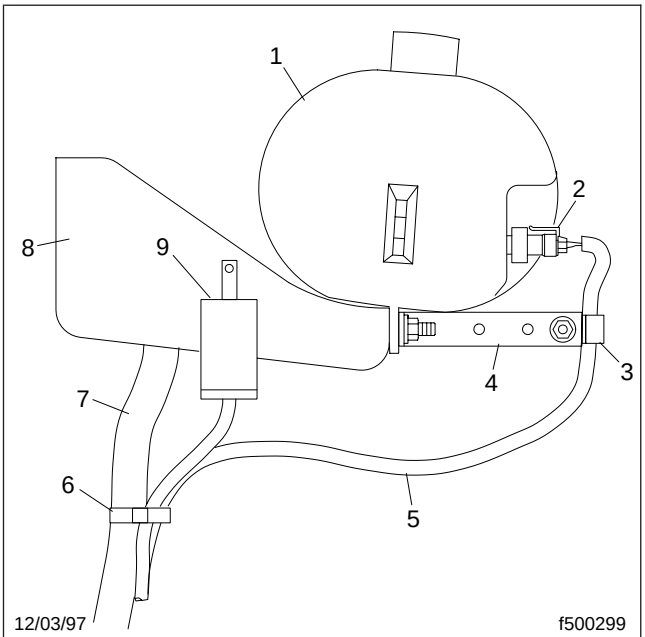
1. Surge Tank Lower Bracket
2. Coolant Level Probe
3. Low Coolant Level Reservoir
4. Return Line
5. Surge Tank

Fig. 1, Probe Mounted In Reservoir

On vehicles built from November 28, 1997, the coolant level probe inserts directly into the surge tank. On these vehicles, the connector on the probe attaches to a special LCL overlay harness which connects between the electronic engine harness and the frontwall harness. For overlay harness wiring, see **Specifications, 400** in this section.

Vehicles with Cummins and Caterpillar engines have a control module installed on the side of the surge tank lower bracket. See **Fig. 2** for these vehicles. On these engines, an electronic engine overlay harness provides 5V power to the control module.

Vehicles with Detroit Diesel engines have no control module. See **Fig. 3** for these vehicles.



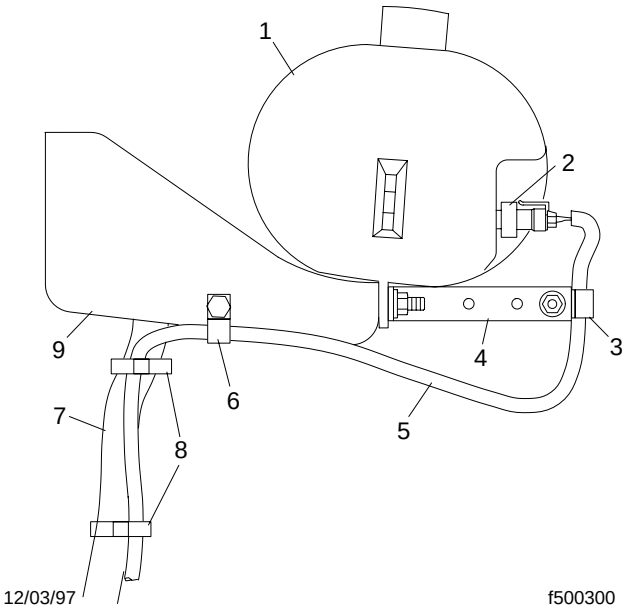
12/03/97 f500299

Hoses removed for clarity.

1. Surge Tank
2. Coolant Level Probe
3. Surge Tank Clamp
4. Overlay Harness Bracket
5. LCL Overlay Harness
6. Tie Strap
7. Electronic Engine Harness
8. Surge Tank Lower Bracket
9. Control Module

Fig. 2, Probe Mounted In Surge Tank, CAT/CUM Engines

General Information



Hoses removed for clarity.

1. Surge Tank
2. Coolant Level Probe
3. Surge Tank Clamp
4. Overlay Harness Bracket
5. LCL Overlay Harness
6. Surge Tank Clamp
7. Electronic Engine Harness
8. Tie Straps
9. Surge Tank Lower Bracket

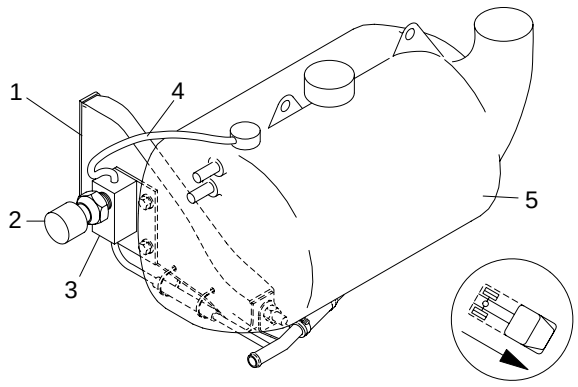
Fig. 3, Probe Mounted In Surge Tank, DDEC Engines

Probe In Reservoir

IMPORTANT: Vehicles built before November 28, 1997 have a low coolant level (LCL) reservoir at the side of the surge tank. The coolant level probe inserts into this reservoir. On vehicles built from November 28, 1997, the coolant level probe inserts directly into the surge tank.

REMOVAL

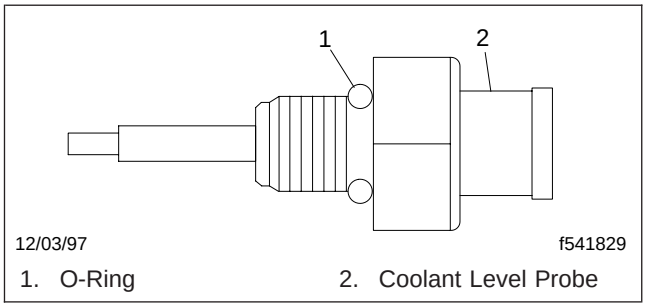
1. Set the parking brake and chock the tires.
2. Clamp off the two lines going to the LCL reservoir. See **Fig. 1**.



Other hoses removed for clarity.
1. Surge Tank Lower Bracket
2. Coolant Level Probe
3. Low Coolant Level Reservoir
4. Return Line
5. Surge Tank

Fig. 1, Probe In Reservoir

3. Disconnect the electrical connector at the rear of the probe.
4. Have a container ready to catch the coolant that runs out. Then slowly unscrew the coolant level probe.
5. Check the O-ring in the base of the probe and replace it if damaged or worn. See **Fig. 2**.
6. Plug the hole in the reservoir with a 3/8-inch pipe plug.



1. O-Ring
2. Coolant Level Probe

Fig. 2, O-Ring, Coolant Level Probe

INSTALLATION

1. Remove the 3/8-inch pipe plug from the hole in the reservoir.
2. Screw the coolant probe into the threaded hole in the reservoir until the threads bottom out and the probe is firmly in place.
3. Attach the electrical connector to the rear of the probe.
4. Remove the clamps from the coolant lines.
5. Check the coolant level in the surge tank and add coolant if necessary.
6. Run the engine and check for leaks around the coolant level reservoir. Make sure there are no kinks in the coolant lines at either the LCL reservoir or the coolant level probe.
7. Remove the chocks from the tires.

Probe In Surge Tank

REMOVAL

1. Set the parking brake and chock the tires.

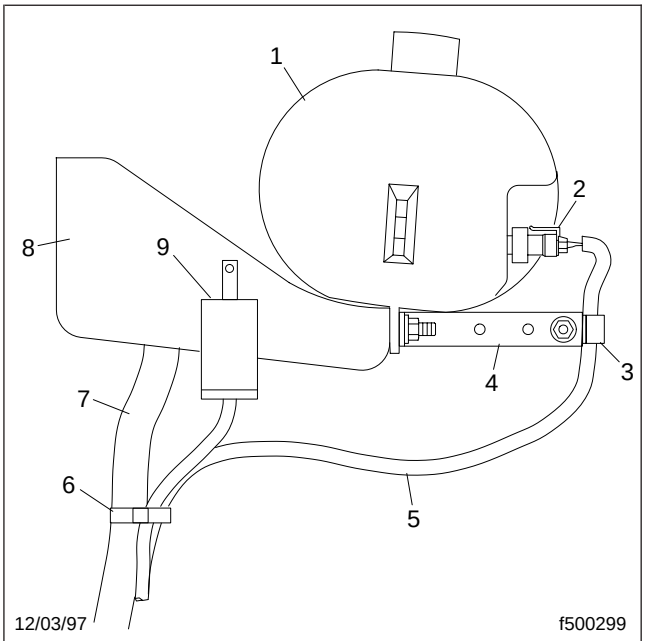
⚠ WARNING

Drain the coolant only when the coolant and engine are cool. Draining it when these are hot could cause severe personal injury due to scalding.

2. Drain the coolant out of the surge tank, at least to the level of the coolant probe. The coolant can be drained by disconnecting the clamps on the makeup line at the bottom of the surge tank and placing the hose in a suitable container.

Coolant Probe Removal and Installation

3. Disconnect the electrical connector at the rear of the probe. See **Fig. 3** for vehicles with Caterpillar (CAT) or Cummins (CUM) engines. See **Fig. 4** for vehicles with Detroit Diesel (DDEC) engines.



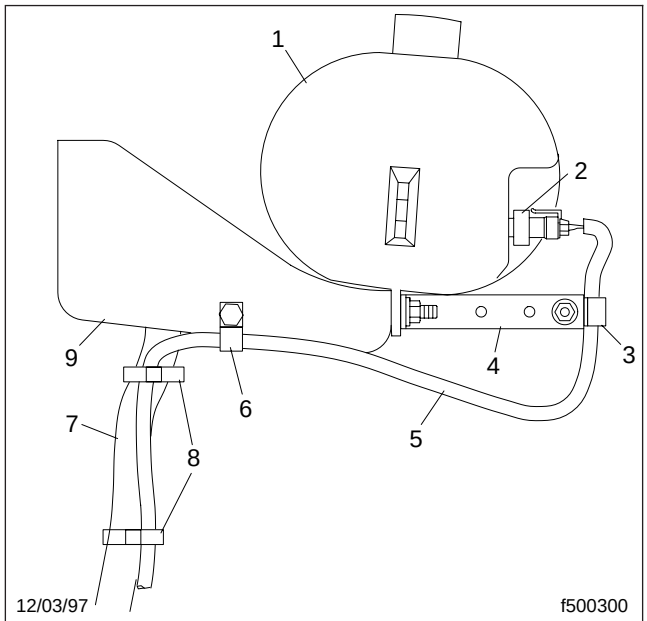
Hoses removed for clarity.
1. Surge Tank
2. Coolant Level Probe
3. Surge Tank Clamp
4. Overlay Harness Bracket
5. LCL Overlay Harness
6. Tie Strap
7. Electronic Engine Harness
8. Surge Tank Lower Bracket
9. Control Module

Fig. 3, Probe In Surge Tank, CAT/CUM Engines

4. Unscrew the coolant level probe and remove it from the surge tank.
5. Check the O-ring in the base of the probe and replace it if damaged or worn. See **Fig. 2**.

INSTALLATION

1. Screw the coolant probe into the threaded hole in the surge tank until the threads bottom out and the probe is firmly in place.
2. Attach the electrical connector to the rear of the probe.



Hoses removed for clarity.
1. Surge Tank
2. Coolant Level Probe
3. Surge Tank Clamp
4. Overlay Harness Bracket
5. LCL Overlay Harness
6. Surge Tank Clamp
7. Electronic Engine Harness
8. Tie Straps
9. Surge Tank Lower Bracket

Fig. 4, Probe In Surge Tank, DDEC Engines

3. Fill the surge tank with coolant. For instructions, see **Subject 100** in Section 20.01.
4. Run the engine and check for leaks around the surge tank.
5. Remove the chocks from the tires.

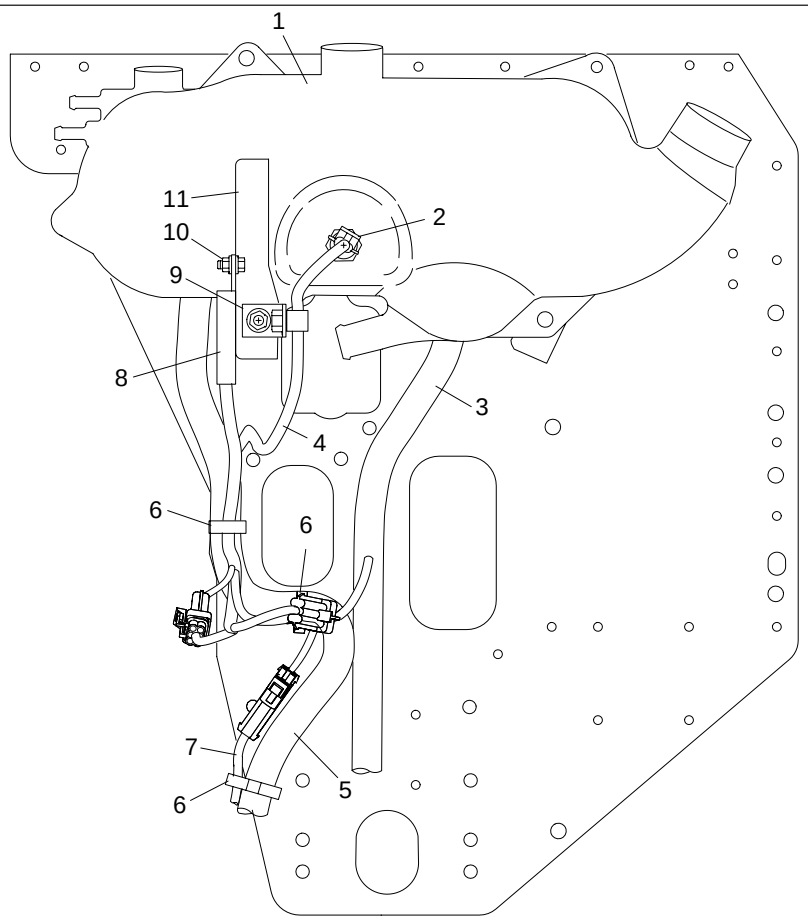
NOTE: Vehicles with Detroit Diesel engines have no control module.

Removal

1. Set the parking brake and chock the tires.
2. Disconnect the electrical connector from the bottom of the control module. See **Fig. 1**.
3. Remove the 1/4–20 locknut from the surge tank lower bracket.
4. Remove the control module from the mounting capscrew.

Installation

1. Position the control module on the mounting capscrew and tighten the locknut 84 lbf·in (940 N·cm).
2. Attach the electrical connector to the base of the module.



12/04/97 f500301

Hoses removed for clarity.

1. Surge Tank
2. Coolant Level Probe
3. Frontwall Harness
4. LCL Overlay Harness
5. Electronic Engine Harness
6. Tie Strap
7. Electronic Engine Overlay Harness
8. Control Module
9. Overlay Harness Bracket
10. Locknut, 1/4–20
11. Surge Tank Lower Bracket

Fig. 1, Control Module

Control Module Removal and Installation

3. Run the engine and check for proper operation of the control module (no false indications of low coolant level).
4. Remove the chocks from the tires.

Cummins CELECT Plus Software

NOTE: The following information applies only to vehicles with a Cummins engine. If the vehicle was built before August 1, 1997, and has a Caterpillar (CAT) or Detroit Diesel (DDC) engine, skip down to "Coolant Sensor Reservoir Inspection."

If the vehicle was built on or after August 1, 1997, and has a Cummins or CAT engine, skip down to "Coolant Level Warning System Test (CAT and Cummins)." For vehicles built on or after August 1, 1997 with Detroit Diesel engines, skip down to "Coolant Level Probe Test (DDC)."

On Cummins CELECT Plus engines, phase 3.6.2 software (or earlier versions) can give a false low coolant level indication on the J1587 databus, even when the engine ECM does not show a problem.

To correct the problem, Cummins has released phase 3.7 software beginning with the following engine serial numbers and build dates listed in **Table 1**. Engines with serial numbers previous to those listed in **Table 1** that have experienced problems of this type need to have the engine ECM recalibrated. Use the phase 3.7 software that was released to the field with the March 1997 CD-ROM to recalibrate the ECM.

Engine Model	Engine Serial Number	Engine Build Date
N14	11839154	06Mar97
M11	34853386	07Mar97

Table 1, Cummins Engine Phase 3.7 Software

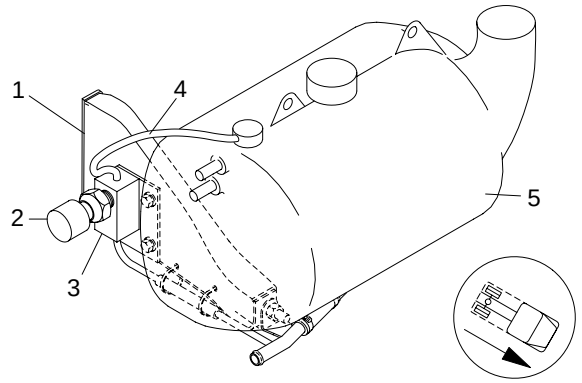
Any Cummins dealer can do this recalibration, and some Freightliner dealers may also be able to do it.

If this does not correct the problem, do the procedure under "Coolant Sensor Reservoir Inspection."

Coolant Sensor Reservoir Inspection

NOTE: The following information applies to vehicles with any type of engine built before August 1, 1997. Do this procedure first on CAT or DDC engines. On Cummins engines, try this procedure only after the software replacement has been done and has failed to correct the problem.

1. Check the coolant level in the surge tank. With the engine cold, there must be coolant at or above the "min" mark.
2. Disconnect the small return line at the top of the surge tank. See **Fig. 1**.



12/18/97 f500289a

Other hoses removed for clarity.

1. Surge Tank Lower Bracket
2. Coolant Level Probe
3. Coolant Sensor Reservoir
4. Return Line
5. Surge Tank

Fig. 1, Coolant Sensor Reservoir

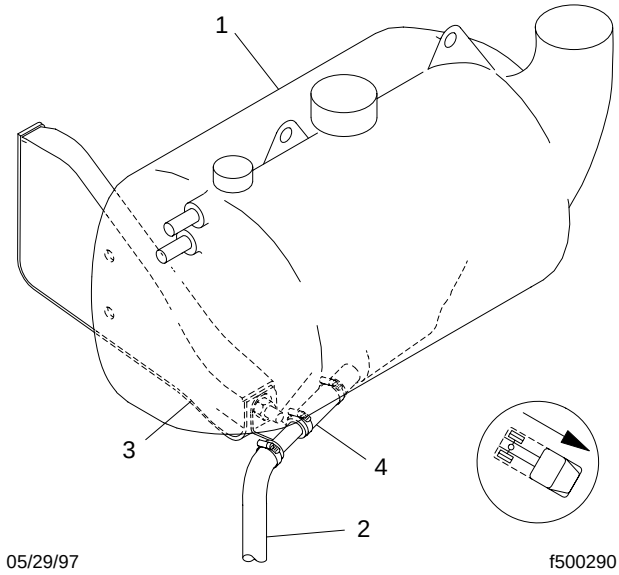
3. Move the open end of this line below the level of the coolant level sensor in the coolant sensor reservoir. The coolant sensor reservoir is the small rectangular metal chamber on the inboard side of the surge tank lower bracket.

   If coolant flows out of the return line, reconnect this line, making sure it is free of kinks.

   If coolant does not flow out of the return line, there is an obstruction in the system.
4. Check the coolant sensor reservoir for fluid. Disconnect the electrical connector and slowly unscrew the coolant level sensor. If no coolant runs out, or very little, there was not enough coolant

in the reservoir to cover the sensor, leading to a low coolant level indication.

5. Remove the obstruction and work coolant back into the reservoir by moving the large makeup line hose back and forth several times. See **Fig. 2**.



05/29/97 f500290

1. Surge Tank
2. Makeup Line
3. Surge Tank Lower Bracket
4. Hose Connector

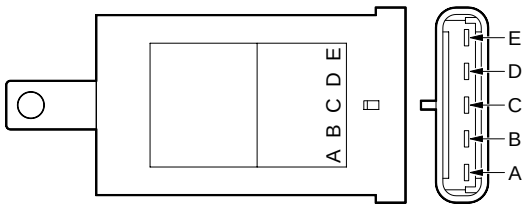
Fig. 2, Makeup Line

Coolant Level Warning System Test (CAT and Cummins)

NOTE: Do this test only on vehicles built after August 1, 1997 with a CAT or Cummins engine. Vehicles with DDC engines do not have a low coolant level module. For these vehicles, skip down to "Coolant Level Probe Test DDC)."

LOW COOLANT LEVEL MODULE

1. Disconnect the low coolant level module from the connector.
2. Connect a 5V power source to the unit.



07/02/98 f542015

A. Circuit PROB (coolant level probe)
B. Circuit LNOR (normal level signal)
C. Circuit LGND (ground)
D. Circuit LLOW (low level signal)
E. Circuit L+5V (5-volt power)

Fig. 3, Low Coolant Level Module

NOTE: For the following steps, see **Fig. 3**.

3. Attach the power supply positive lead to pin E and the negative lead to pin C.
4. Connect a jumper wire between pin A (probe) and pin C (ground) to simulate a normal coolant level sensor reading (probe in coolant).
   - 4.1 Use a digital multimeter to measure the voltage. The digital multimeter should read approximately 5 volts when connected to pin B (positive meter lead) and pin C (negative meter lead).
   - 4.2 The digital multimeter should read approximately 0 volts when connected to pin D (positive meter lead) and pin C (negative meter lead).
5. Disconnect the jumper wire between pin A and pin C to simulate a low coolant level sensor reading.
   - 5.1 The digital multimeter should read approximately 0 volts when connected to pin B (positive meter lead) and to pin C (negative meter lead).
   - 5.2 The digital multimeter should read approximately 5 volts when connected to pin D (positive meter lead) and to pin C (negative meter lead).

COOLANT LEVEL PROBE

1. Check for leaks around the area where the probe attaches to the surge tank. Replace the O-ring if needed. See **Fig. 4**.

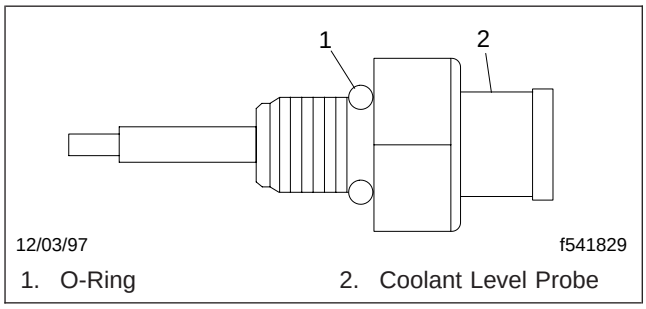


Fig. 4, Coolant Level Probe

2. Disconnect the metri-pack connector from the coolant level probe. Attach a 5V power source to the two pins on the probe. Connect the digital multimeter, still set on the high (20VDC) scale, and measure the voltage across the two pins.

   If the meter shows approximately 5VDC, the coolant level probe is OK.

   If the meter shows low voltage, replace the coolant level probe.

NOTE: Disregard the minus (–) sign on negative voltages.

Coolant Level Probe Test (DDC)

NOTE: Do this test only on vehicles built after August 1, 1997 with a DDC engine. For vehicles with CAT or Cummins engines, see "Coolant Level Warning System Test (CAT and Cummins)."

1. Check for leaks around the area where the probe attaches to the surge tank. Replace the O-ring if needed. See **Fig. 4**.
2. Disconnect the metri-pack connector from the coolant level probe.
3. Set a digital multimeter on high scale (20VDC) and attach it between the cavities in the connector.

   If the meter reads approximately 5 VDC, go to the next step.

   If the meter reads very little or no voltage, check circuits D115 and D953 and repair or replace, as necessary.

NOTE: Disregard the minus (–) sign on negative voltages.

4. With the metri-pack connector still disconnected, attach a 5V power source to the two pins on the probe and measure the voltage across the two pins of the probe.

   If the meter shows approximately 5VDC, the coolant level probe is OK.

   If the meter shows low voltage, replace the coolant level probe.

Specifications

On vehicles built before November 28, 1997, the low coolant probe connects directly to the frontwall harness. For frontwall harness wiring, see **Specifications, 400** in Section 54.00.

On vehicles built from November 28, 1997, the low coolant probe connects to a low coolant level (LCL) overlay harness, which connects in between the electronic engine harness and the frontwall harness. For a schematic of the LCL wiring, see **Fig. 1** for Caterpillar (CAT) and Cummins (CUM) electronic engines and **Fig. 2** for Detroit Diesel (DDEC) electronic engines.

For a drawing of the LCL overlay harness, see **Fig. 3** for CAT and CUM electronic engines and **Fig. 4** for DDEC electronic engines.

On CAT and CUM engines, an electronic control module draws 5V power through the electronic engine overlay harness. For a drawing of the electronic engine overlay harness, see **Fig. 5** for CAT and **Fig. 6** CUM electronic engines.

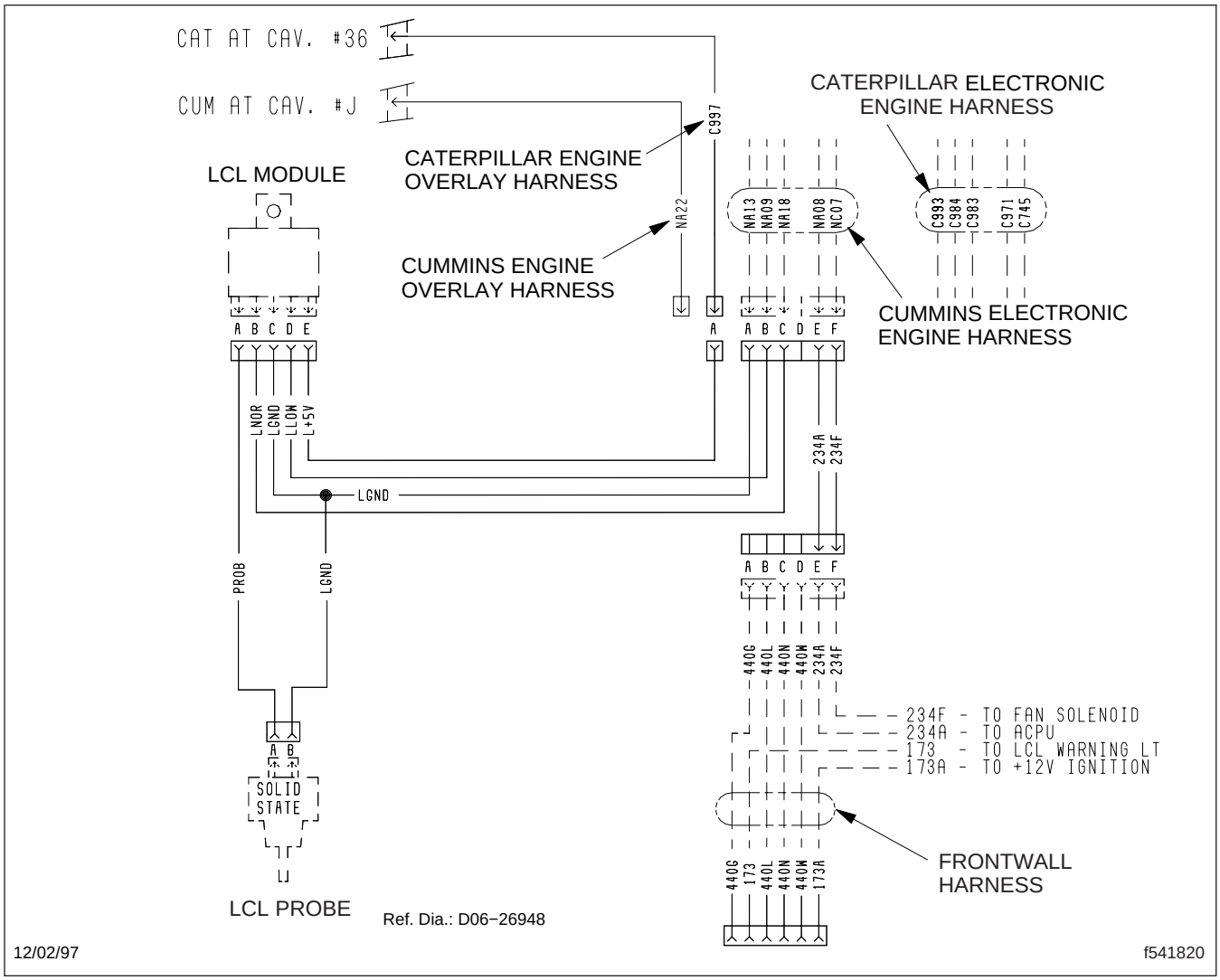


Fig. 1, LCL Wiring Schematic, CAT/CUM Engines

Specifications

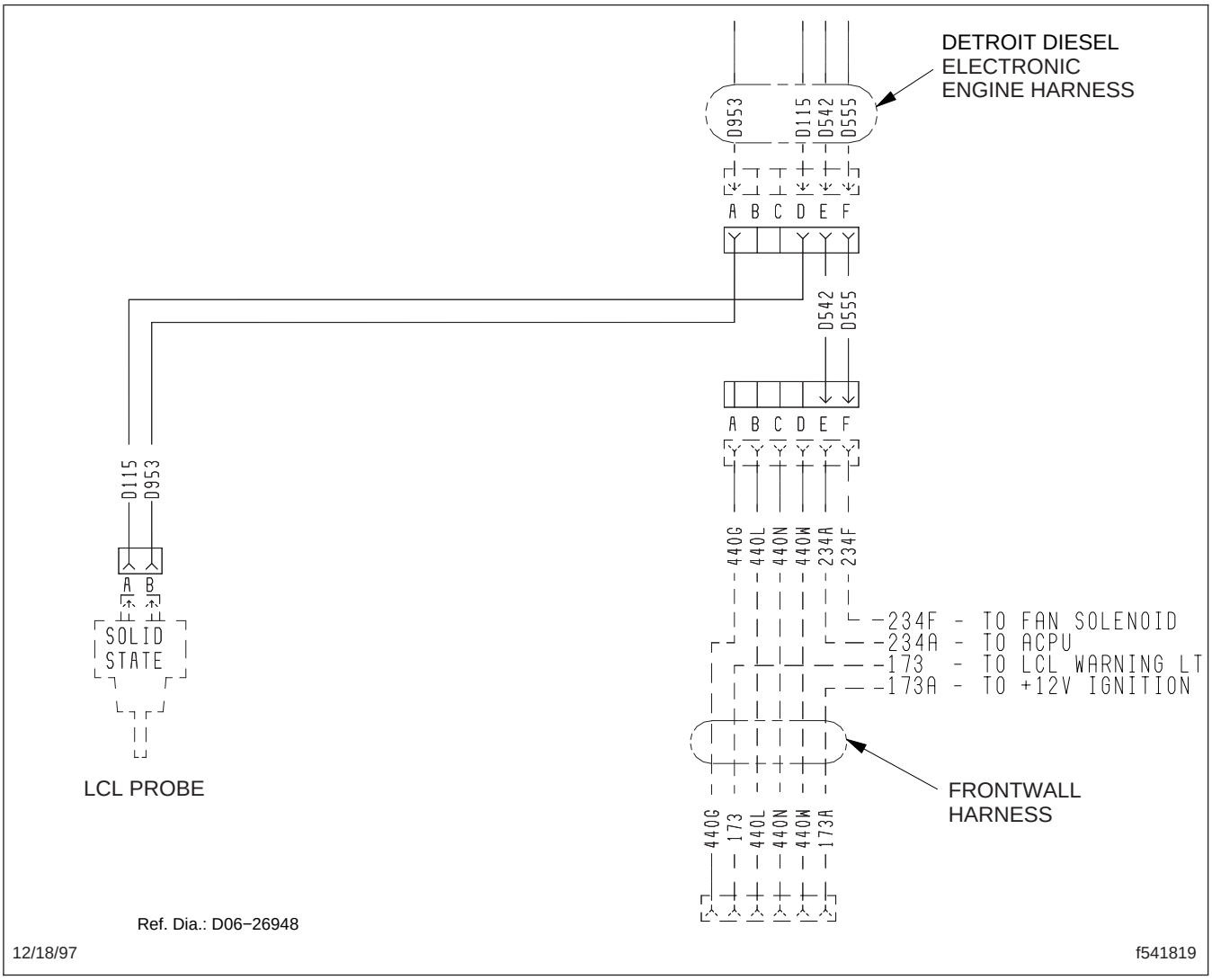
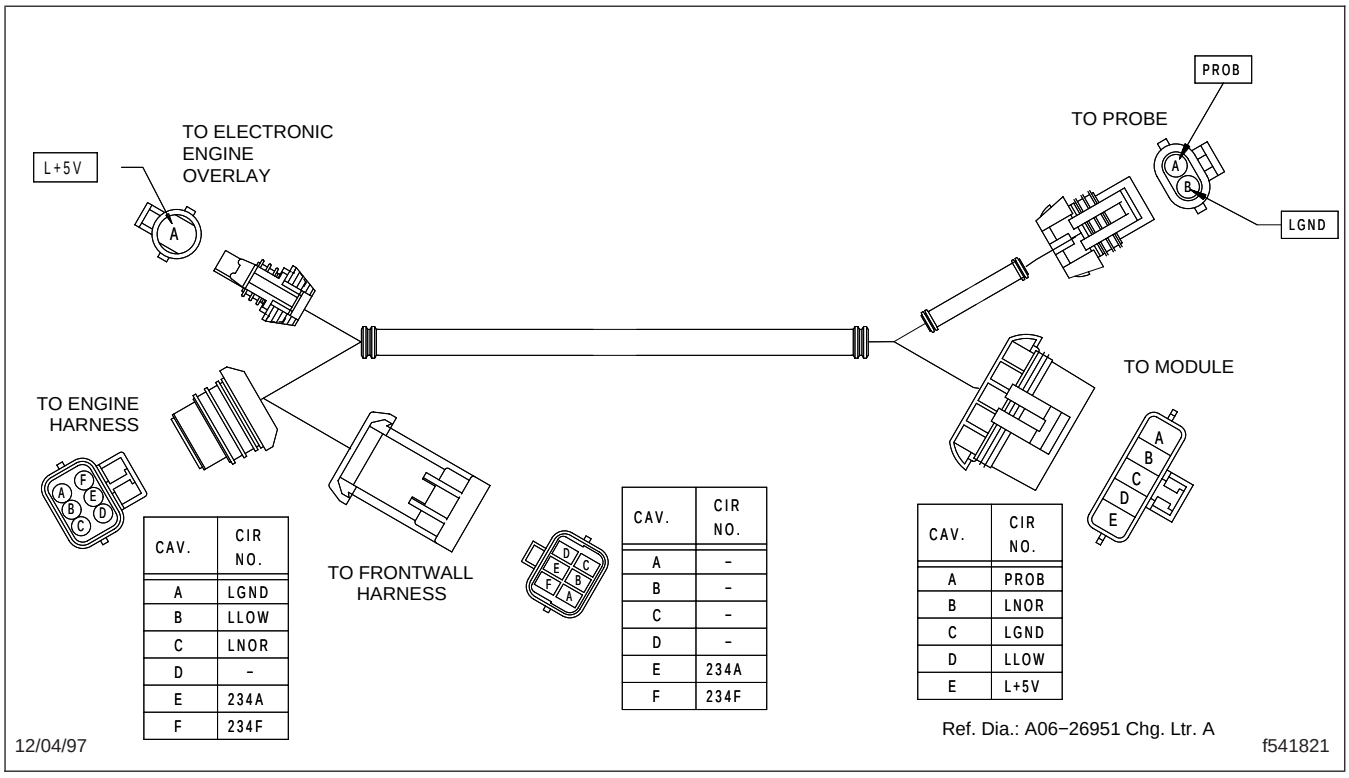


Fig. 2, LCL Wiring Schematic, DDEC Engines

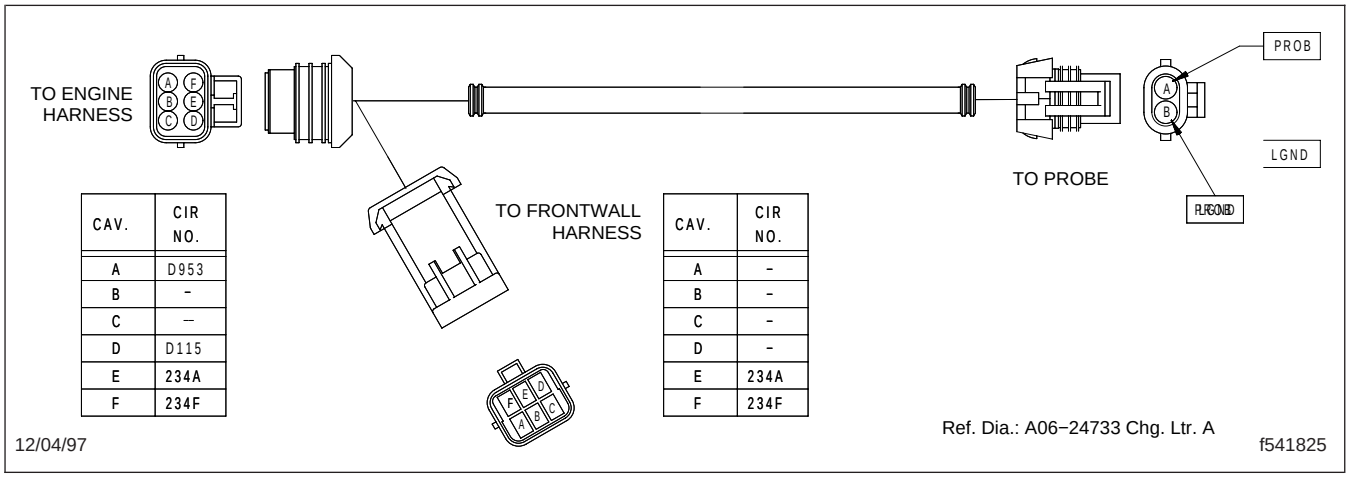


CAV.	CIR NO.
A	LGND
B	LLOW
C	LNOR
D	–
E	234A
F	234F

CAV.	CIR NO.
A	–
B	–
C	–
D	–
E	234A
F	234F

CAV.	CIR NO.
A	PROB
B	LNOR
C	LGND
D	LLOW
E	L+5V

Fig. 3, LCL Overlay Harness, CAT/CUM Engines



CAV.	CIR NO.
A	D953
B	–
C	–
D	D115
E	234A
F	234F

CAV.	CIR NO.
A	–
B	–
C	–
D	–
E	234A
F	234F

Fig. 4, LCL Overlay Harness, DDEC Engines

Specifications

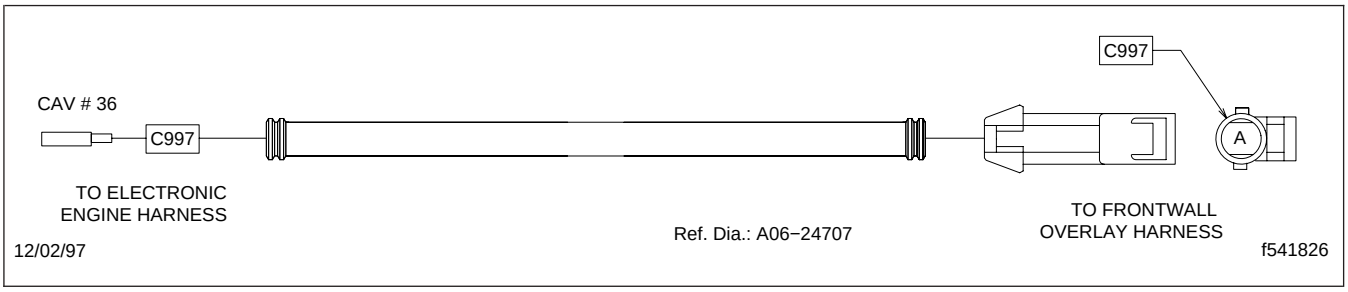


Fig. 5, Electronic Engine Overlay Harness, CAT Engines

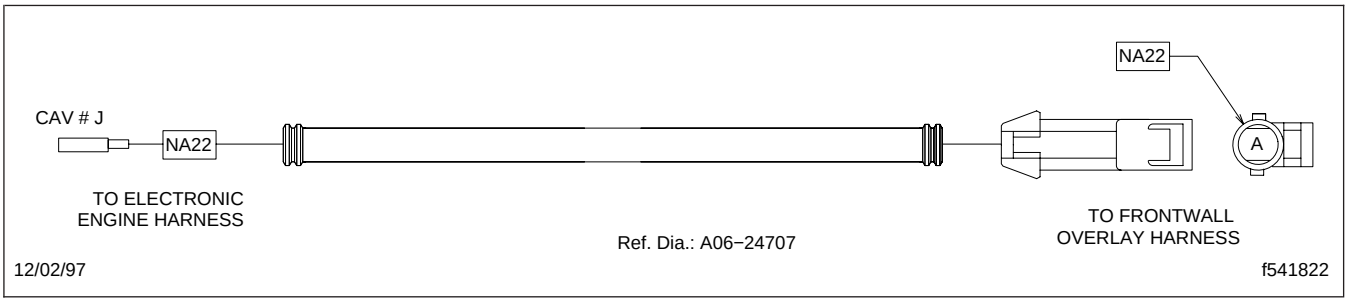


Fig. 6, Electronic Engine Overlay Harness, CUM Engines

General Information

The speedometer and tachometer are controlled by the instrumentation control unit (ICU). Therefore, there are no DIP switches on the back of the speedometer or tachometer.

For speedometers, the magnetic sensor feeds the raw data to the engine electronic control unit (ECU), where the calibration parameters are stored. The engine ECU then transmits the corrected speed information over the J1587 databus to the ICU. The ICU then feeds it to the gauge head.

For tachometers, the engine ECU senses engine rpm internally and transmits a signal directly to the ICU via the J1587 databus. There is no rpm sensor installed on the flywheel, therefore no sensor installation or wiring to check for the tachometer.

Basic Diagnostics

When the ignition keyswitch is turned on, all of the electronic dash gauges on the driver's panel, including the speedometer and tachometer, make one complete sweep and return to their normal indicating positions. This is a diagnostic test of the electronic gauges and the instrumentation control unit (ICU).

NOTE: Non-electronic gauges, such as the voltmeter, or any of the air pressure gauges (primary air, secondary air, application air) do not sweep.

Always start by checking the gauge sweep. If a particular gauge does not sweep normally, but the others do, the fault is in the gauge or the ICU. If the gauge sweeps normally, but does not function properly at other times, the fault lies elsewhere: in the electronic engine programming, in the sensor (speedometer only), or in the wiring.

Potential problems with wiring and the datalink connection can be diagnosed on the ICU by checking the "Datalink Activity" visual display under "Vehicle Information." A large number of arrows pointing both up and down indicates intermittent connections on the datalink. If the datalink connection is missing or bad, the "No Datalink Activity" message appears.

To help define the nature of the problem further, the ICU displays fault codes for certain problems. Bad gauge heads and incorrect engine programming can lead to inaccurate or non-working gauges. ServiceLink displays these engine and dash fault codes also.

Only after checking these sources should it be necessary to check the installation of the magnetic sensor or the wiring itself.

Troubleshooting Step By Step

There are no DIP switches on the back of the speedometer or tachometer. For speedometers, the magnetic sensor feeds the raw data to the engine electronic control unit (ECU), where the calibration parameters are stored. The engine ECU then transmits the corrected speed information over the J1587 databus to the ICU. The ICU then feeds it to the gauge head. For tachometers, the engine ECU senses engine rpm internally and transmits a signal directly to the ICU via the J1587 databus.

NOTE: There is no rpm sensor installed on the flywheel, and therefore no sensor installation or wiring to check for the tachometer.

INACCURATE GAUGE

To recalibrate an inaccurate gauge, use the engine manufacturer's software to reprogram the engine ECU. For instructions, see the appropriate engine manufacturer's service manual.

NEITHER GAUGE WORKING

If neither gauge is working (no gauge deflection at all), and the odometer is also not working, do the following steps in order until the problem is corrected:

1. Turn on the ignition keyswitch and check for a full dial sweep. If neither gauge sweeps, check the engine wiring and the ICU.
2. Check for datalink activity. If there is no datalink activity, check the datalink wiring to the ICU (wires 1708+ and 1708–).
3. Go to the "Datalink Status" screen. If datalink usage reads less than 10%, check the engine wiring to the ICU.
4. Check the ICU and engine faults using ServiceLink. For more information, see "Electronic Troubleshooting."
5. Check the speedometer magnetic sensor for correct installation and proper operation. For more information, see "Troubleshooting the Speedometer Magnetic Sensor."
6. Using a variable multimeter set on ohms, check the wiring for resistance. For more information, see "Troubleshooting the Wiring."

ONE GAUGE NOT WORKING

If only one gauge (speedometer or tachometer) is not working, and the odometer and the other gauges are working OK, do the following steps in order until the problem is corrected:

1. Turn on the ignition keyswitch and check for a full dial sweep. If the gauge does not sweep, replace it with a gauge known to be in good work-

ing order. Check the working gauge for a full dial sweep. If the dial still does not sweep, replace the ICU.

2. If the gauge does sweep, but it still does not work correctly, check for active fault codes, using either the ICU itself, or ServiceLink. For more information, see "Electronic Troubleshooting."

3. On speedometers only, check the magnetic sensor for correct installation and proper operation. For more information, see "Troubleshooting the Speedometer Magnetic Sensor."

   On both tachometers and speedometers, check the engine faults using ServiceLink. For more information, see "Electronic Troubleshooting."

4. Using a variable digital multimeter set on ohms, check the wiring for resistance. For more information, see "Troubleshooting the Wiring."

Electronic Troubleshooting

READING FAULT CODES ON THE DASH DRIVER DISPLAY

The fault codes used to troubleshoot speedometers and tachometers contain three groups of fault numbers, for example: 140 008 06. The fault numbers that are used (MIDs, PIDs, SIDs, and FMIs) are listed in the J1587 specifications. Here is an explanation of these numbers:

- Message Identifiers (MIDs)—The first fault number identifies the electronic control unit that is transmitting the fault. It is called a message identifier, or MID. For tachometers, the MID is 140 (dash left microprocessor); for speedometers, it is 142 (dash right microprocessor).
- Dash Fault Numbers—The second fault number consists of a three-digit dash fault number that identifies the component in which the fault was detected. The coding used for these fault numbers can be either parameter identifiers (PIDs), or sub-system identifiers (SIDs). The fault number for the tachometer is 008, and for the speedometer 022.
- Failure Mode Identifiers (FMIs)—This two-digit fault number at the end of each fault code helps to identify faults in the data being supplied to the component. It is called a Failure Mode Identifier, or FMI. The FMI gives information about where the fault lies. Is the circuit shorted, or open? For a list of FMIs that apply to the speedometer and tachometer, see **Table 1**.

Failure Mode Identifiers (FMIs)	
FMI	**Description and Comments**
00	Above normal operating range
01	Below normal operating range
02	Erratic, intermittent, or incorrect data
05	Current below normal or open circuit
06	Current above normal or circuit shorted to ground
07	Device not responding
08	Abnormal frequency
10	Abnormal rate of change
11	Not identifiable
12	Bad intelligent device or component
13	Out of calibration

Table 1, Failure Mode Identifiers (FMIs)

The ICU displays the fault code on the first line of the dash driver display on the left side of the screen and a short text description of the MID on the right. On the second line of the display, the ICU gives a short text description of the fault number (PID or SID) and FMI. See **Table 2**.

Example: The message screen displays the following fault code: 140 008 06, and the text messages INSTRCLSTR and DR07 COIL – SHORT.

1. The first fault number is the MID. A MID of 140 indicates that the data is coming from the dash left microprocessor (INSTRCLSTR).

2. The second fault number is the dash fault number. A dash fault number of 008 indicates that the data is coming from the tachometer (DR07 COIL).

3. The third fault number is the FMI. An FMI of 06 indicates that there is a short in the tachometer circuit (SHORT).

ICU Fault Message Explanation				
Screen Message	**Description**	**MID**	**Fault No.**	**FMI**
140 008 06 INSTRCLSTR DR07 COIL – SHORT	Tachometer Coil Shorted	140	008	06
140 008 05 INSTRCLSTR DR07 COIL – OPEN	Tachometer Coil Open	140	008	05
142 022 06 INSTRCLSTR DR08 COIL – SHORT	Speedometer Coil Shorted	142	022	06
142 022 05 INSTRCLSTR DR08 COIL – OPEN	Speedometer Coil Open	142	022	05

Table 2, ICU Fault Message Explanation

Therefore, this fault code indicates a short inside the tachometer coil. Replace the faulty gauge with one in good working order.

READING FAULT CODES USING SERVICELINK

On ServiceLink, the same codes appear, but in the form of a table which can be read on the computer monitor. There is a column for each fault number, and following each fault number is a column providing an description. For an example, see **Table 3**.

NOTE: In this table, the dash fault numbers are replaced by PIDs (parameter identifiers) or SIDs (sub-system identifiers). The "type" column identifies the type of fault coding, whether PID or SID. The "ID" column identifies the actual fault number.

ServiceLink can read codes from any electronic control unit installed on the vehicle, including the engine ECU. Whereas the ICU MIDs indicate a bad gauge or a bad ICU, the engine MIDs indicate incorrect engine programming, bad speed/timing circuits, or bad engine rpm sensing.

ServiceLink Fault Messages						
MID	**Description**	**Type**	**ID**	**Description**	**FMI**	**Description**
140	Instrument Cluster, Left	PID	008	Tachometer	06	Ground
140	Instrument Cluster, Left	PID	008	Tachometer	05	Open
142	Instrument Cluster, Right	PID	022	Speedometer	06	Ground
142	Instrument Cluster, Right	PID	022	Speedometer	05	Open
128	Engine #1	SID	031	Tachometer Signal Output	01	Low
128	Engine #1	PID	084	Vehicle Speed Signal	00	High
128	Engine #1	PID	084	Vehicle Speed Signal	01	Low
128	Engine #1	PID	084	Vehicle Speed Signal	02	Erratic
128	Engine #1	PID	084	Vehicle Speed Signal	08	Abnl Freq
128	Engine #1	PID	084	Vehicle Speed Signal	10	Abnl Rate
128	Engine #1	PID	084	Vehicle Speed Signal	11	Not Identifiable
128	Engine #1	PID	084	Vehicle Speed Signal	12	Bad
128	Engine #1	PID	190	Engine RPM Signal	00	High
128	Engine #1	PID	190	Engine RPM Signal	02	Erratic
128	Engine #1	PID	190	Engine RPM Signal	08	Abnl Freq
128	Engine #1	PID	190	Engine RPM Signal	10	Abnl Rate

Table 3, ServiceLink Fault Messages

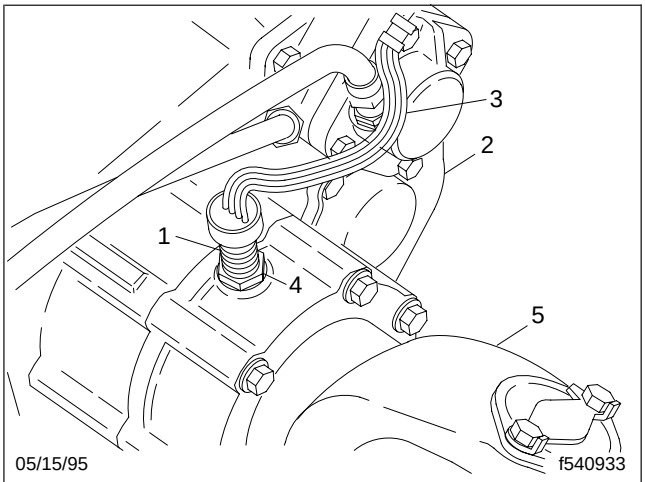
Troubleshooting

For corrective action on engine faults, see the applicable engine manufacturer's manual. If correcting the engine programming still does not solve the problem, check the speedometer magnetic sensor and the wiring.

Troubleshooting the Speedometer Magnetic Sensor

One type of fault that can not be detected by the ICU is a faulty or improperly installed speedometer magnetic sensor. Follow the instructions below to replace or readjust the magnetic sensor.

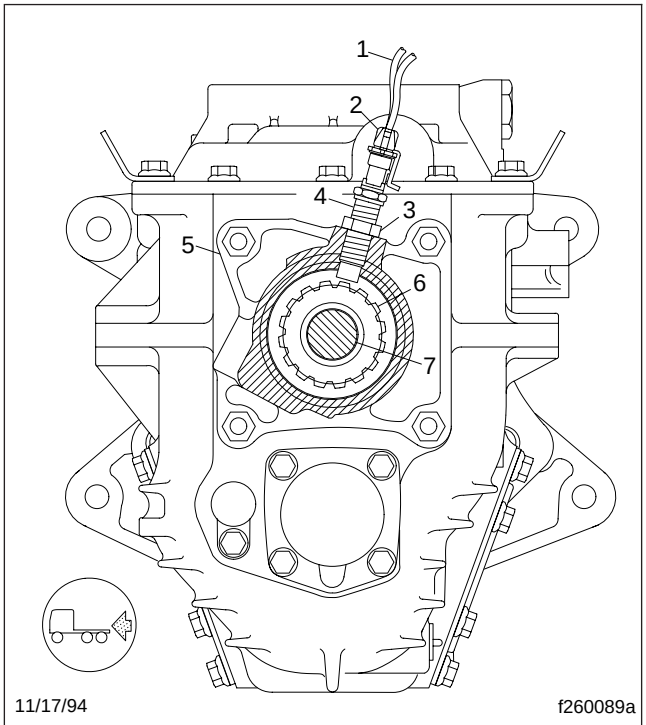
1. Apply the parking brakes, shut down the engine, and chock the tires.
2. Remove the magnetic sensor. See **Fig. 1**.
   - 2.1 Disconnect the electrical connector.



1. Magnetic Sensor
2. Transmission Housing
3. Sensor Wiring
4. Jam Nut
5. Drive Yoke

Fig. 1, Magnetic Sensor Installation

   - 2.2 Loosen the magnetic sensor jam nut. Turn the magnetic sensor until it comes out of the transmission bearing cover.
   - 2.3 On Rockwell transmissions only, check the bearing cover for an O-ring. Remove the O-ring if it did not come off with the sensor.
3. If installing a new sensor, leave the plastic shim on the end of the sensor. This shim serves as a gap gauge. On Rockwell transmissions only, install a new O-ring on the bearing cover.
4. Insert the sensor into the transmission and make sure it is properly adjusted. See **Fig. 2**.



NOTE: Eaton FS4005 series transmission shown

1. Speedometer Wiring
2. Electrical Connector
3. Jam Nut
4. Magnetic Sensor
5. Transmission Bearing Cover
6. Transmission Tailshaft Tone Wheel
7. Transmission Output Shaft

Fig. 2, Magnetic Sensor Installation (cutaway view)

   - 4.1 Back off the jam nut to the outboard end of the sensor.
   - 4.2 Turn the sensor by hand into the transmission bearing cover until it bottoms out inside the transmission.
   - 4.3 If no plastic shim is installed on the sensor, back the sensor out one-half turn.

NOTE: If the plastic shim is installed, do not back out the sensor. The gap has already been set by the plastic shim.

IMPORTANT: Maintain the correct sensor adjustment. Otherwise, the speedometer will not read correctly.

5. With the gap correctly adjusted, tighten the sensor jam nut and attach the electrical connector.
   5.1 Hold the sensor in place to keep it from turning. Tighten the jam nut 18 lbf·ft (25 N·m).
   5.2 Attach the electrical connector and make sure it is securely locked into place.
6. Remove the chocks from the tires.
7. Test drive the vehicle and check that the speedometer is operating correctly. If there is no speedometer reading, it may mean that the magnetic sensor was not adjusted correctly. Readjust the sensor or replace it with a new one, using the installation steps above.

Troubleshooting the Wiring

On the tachometer, the only wiring to troubleshoot is the wiring between the engine ECU and the ICU. On the speedometer, first troubleshoot the wiring from the magnetic sensor.

SPEEDOMETER MAGNETIC SENSOR TO ENGINE ECU

NOTE: Do these checks when troubleshooting the speedometer only.

1. Check the wiring between the magnetic sensor and the engine ECU.
   1.1 Check for an open circuit by connecting the ohmmeter leads to the engine ECU connector. See **Table 4** for sensor wire and pin numbers. Depending on engine type, the resistance measured should fall within 788 to 964 ohms.
   1.2 If the measured resistance is within the acceptable range, go to the next step.

   If the resistance is above the acceptable range, there is an open circuit in the wiring between the magnetic sensor and the engine ECU connector. Repair or replace any damaged wiring.

   If the resistance is below the acceptable range, there is a short circuit in the wiring between the magnetic sensor and the engine ECU connector. Repair or replace any damaged wiring.
2. Check the wiring between the magnetic sensor and the engine ECU for a short circuit to ground.
   2.1 Connect the positive lead from an ohmmeter to each wire and pin terminal, as above, and connect the negative lead to a good ground. If there is no short to ground, the ohmmeter should read infinite ohms. If there is a short to ground, the ohmmeter should read low ohms.
   2.2 If the resistance measured was less than infinite ohms, repair the short to ground in the respective circuit wiring.

ENGINE ECU TO ICU

NOTE: Do these checks when troubleshooting either the tachometer or the speedometer.

1. Check the wiring between the engine ECU connector and the electronic engine connector.
   1.1 Check for an open circuit by connecting the ohmmeter leads to the engine ECU connector. See **Table 5** for datalink wire and pin numbers by engine type. The resistance should measure 400 ohms. Any reading between 360 and 440 ohms is acceptable.
   1.2 If the measured resistance is within the acceptable range, go to the next step.

   If the resistance is above the acceptable range, there is an open circuit in the wiring between the engine ECU connector and the electronic engine connector. Repair or replace any damaged wiring.

   If the resistance is below the acceptable range, there is a short in the wiring between the engine ECU connector and the electronic engine connector. Repair or replace any damaged wiring.
2. Check the wiring between the electronic engine connector and the ICU.
   2.1 Connect the ohmmeter leads to pins 28 and 29 on the electronic engine connector

Troubleshooting

(wiring circuit numbers 1587+ and 1587–, respectively). In each case, the resistance should measure 400 ohms. Any reading between 360 and 440 ohms is acceptable.

2.2 If the measured resistance is within the acceptable range, go to the next step.

If the resistance is above the acceptable range, there is an open circuit in the wiring between the electronic engine connector and the ICU. Repair or replace any damaged wiring.

If the resistance is below the acceptable range, there is a short in the wiring between the electronic engine connector and the ICU. Repair or replace any damaged wiring.

3. Check the ICU pin connectors. Check pins A11 and B2 on the left-hand ICU connector (pink connector) for poor contact and bent or broken pins. Repair the pins or replace the connector as necessary.

Speed Sensor Wire and Pin Numbers in the Engine ECU		
Engine	**Wire Numbers**	**Pin Numbers**
Caterpillar (40-pin engine ECU connector)	C784 (+)	18
	C785 (–)	12
Cummins (28-pin engine ECU connector)	N03 (+)	3
	N07 (–)	7
Detroit Diesel (30-pin engine ECU connector)	D556 (+)	E2
	D557 (–)	E3

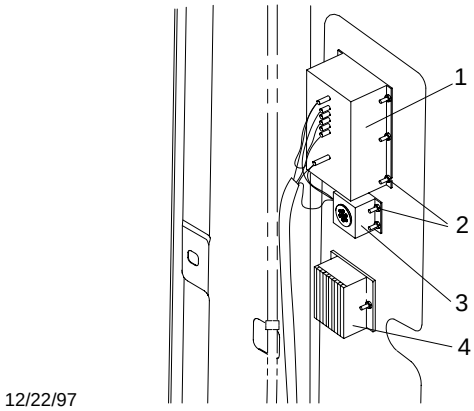
Table 4, Speed Sensor Wire and Pin Numbers in the Engine ECU

J1587 Datalink Wire and Pin Numbers in the Engine ECU		
Engine	**Wire Numbers**	**Pin Numbers**
Caterpillar (40-pin engine ECU connector)	C793 (+)	7
	C792 (–)	9
Cummins (28-pin engine ECU connector)	N27 (+)	27
	N08 (–)	8
Detroit Diesel (30-pin engine ECU connector)	D900 (+)	C2
	D901 (–)	C1

Table 5, Datalink Wire and Pin Numbers in the Engine ECU

General Information

The optional low voltage disconnect module is mounted on the inside of the electrical compartment door located on the right-hand B-pillar behind the seat. See **Fig. 1**.



1. Low Voltage Disconnect Module
2. Mounting Hexnuts
3. Warning Buzzer
4. Daytime Running Light Module

Fig. 1, Right-Hand B-Pillar Electrical Compartment

The low voltage disconnect module monitors battery voltage levels. If battery voltage falls below 12.1 volts, the low voltage disconnect module will sound a warning buzzer for 1 minute. If no action is taken within 60 seconds, the low voltage disconnect module will remove power to predetermined cab and sleeper circuits and a LED indicator on the module will be illuminated.

The low voltage disconnect module controls power to the following cab circuits:

- Optional 1 (circuit 44S)
- Optional 2 (circuit 47S)
- Dome light (circuit 43S)
- Cigarette lighter (circuit 41S)
- Sleeper (E-box) (circuit 10S)
- Utility light (circuit 15S)

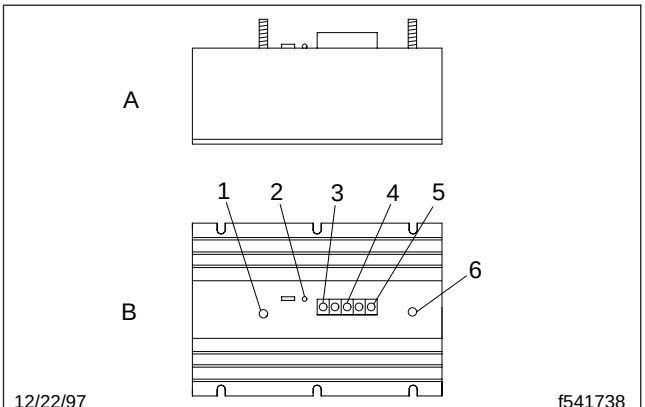
The low voltage disconnect module controls power to the following sleeper circuits:

- Main dome light (circuit 41S)
- Power receptacles #2, and #3 (circuits 57A, 57B, and 57C)
- Read/bag light (circuit 41R)
- Optional battery power (OPT)
- HVAC breaker (circuit 98P)

Once battery voltage reaches 13 volts, or if the vehicle is started, the low voltage disconnect module will automatically reconnect power to the predetermined circuits.

The low voltage disconnect module incorporates a 60 second time delay to prevent false triggering and is equipped with internal short circuit protection, over current protection, transient voltage suppression, and thermal protection.

The low voltage disconnect module has two terminal post connections and five screw type terminal connections. See **Fig. 2** .



A. Side View
B. Front View
1. V-out Terminal
2. LED Indicator
3. Buzzer Control Terminal
4. V-sense Terminal
5. Ground Terminal
6. V-in Terminal

Fig. 2, Low Voltage Disconnect Module

The two terminal post connections are V-in and V-out. The V-in terminal (circuit 14B) is the voltage supply input from the firewall power stud. The V-out terminal (circuit 14BS) is the controlled voltage output from the low voltage disconnect module to the ISO bus power input terminal of the power distribution module (predetermined cab and sleeper circuits). It also supplies power to the warning buzzer.

Three of the five screw type terminals are used on the low voltage disconnect system—V-sense, ground,

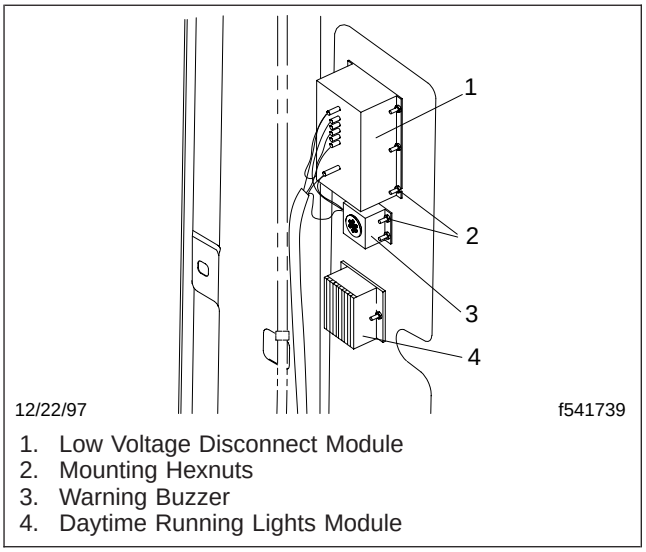
General Information

and warning buzzer control. The V-sense terminal (circuit 447B) is used by the low voltage disconnect module to monitor the level of battery voltage and is connected directly to the battery. The ground terminal (circuit GND) supplies ground for the module and is connected directly to the battery to ensure a good ground. The warning buzzer control terminal (circuit 447J) supplies ground to the warning buzzer, which sounds the warning buzzer, when the low voltage control module detects low voltage.

Low Voltage Disconnect Module Removal and Installation

Removal

1. Apply the parking brakes and chock the tires. Disconnect the batteries.
2. Open the electrical compartment door on the right-hand B-pillar, behind the seat. The low voltage disconnect module is located above the daytime running lights module. See **Fig. 1**.



1. Low Voltage Disconnect Module
2. Mounting Hexnuts
3. Warning Buzzer
4. Daytime Running Lights Module

Fig. 1, Right-Hand B-Pillar Electrical Compartment

3. Remove the low voltage disconnect module.

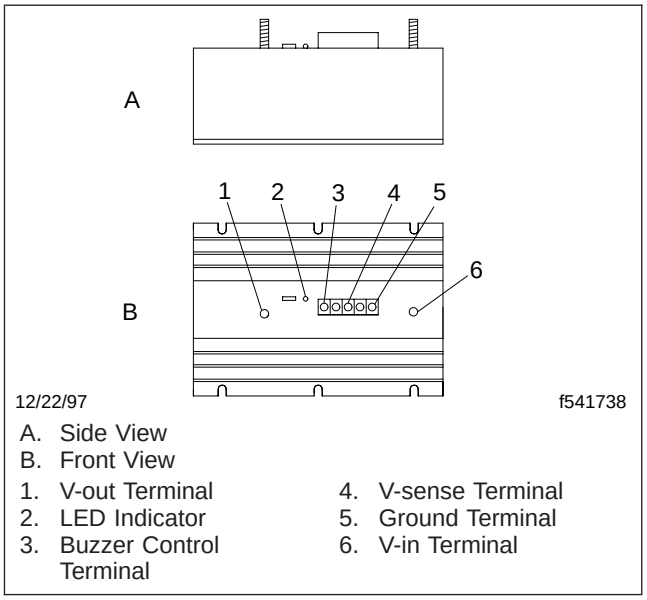
CAUTION

To prevent damage to the low voltage disconnect module, remove the ground wire from the ground terminal last.

3.1 Note the position of the wiring on the terminals and remove the wiring from the screw terminals on the top of the low voltage disconnect module. See **Fig. 2**.

3.2 Remove the six mounting hexnuts, three on each side, from the mounting studs attached to the B-pillar access door.

3.3 Remove the low voltage disconnect module from the electrical compartment door.



A. Side View
B. Front View
1. V-out Terminal
2. LED Indicator
3. Buzzer Control Terminal
4. V-sense Terminal
5. Ground Terminal
6. V-in Terminal

Fig. 2, Low Voltage Disconnect Module

Installation

1. Install the low voltage disconnect module onto the right-hand B-pillar electrical compartment door.

1.1 Position the low voltage disconnect module on the six mounting studs attached to the B-pillar electrical compartment door.

1.2 Install the six mounting hexnuts and tighten them firmly.

CAUTION

To prevent damage to the low voltage disconnect module, connect the ground wire to the ground terminal first.

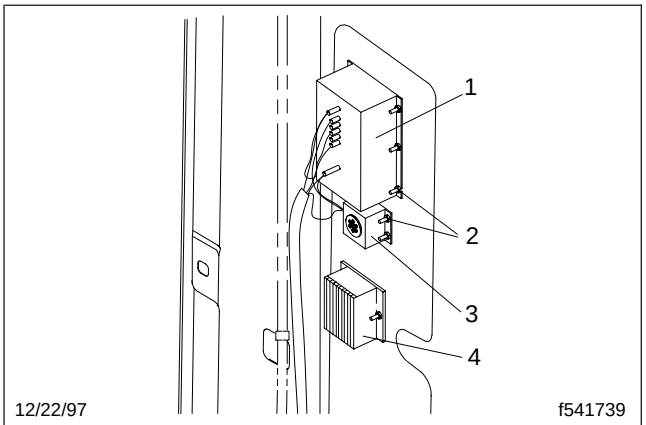
1.3 Install the wiring to the terminals on the top of the low voltage disconnect module. See **Fig. 2**.

2. Close the electrical compartment door.
3. Connect the batteries and remove the chocks from the tires.

Low Voltage Disconnect Warning Buzzer Removal and Installation

Removal

1. Apply the parking brakes and chock the tires. Disconnect the batteries.
2. Open the electrical compartment door on the right-hand B-pillar, behind the seat. The low voltage disconnect warning buzzer is located below the low voltage disconnect module. See **Fig. 1.**



1. Low Voltage Disconnect Module
2. Mounting Hexnuts
3. Warning Buzzer
4. Daytime Running Lights Module

Fig. 1, Right-Hand B-Pillar Electrical Compartment

3. Remove the low voltage disconnect warning buzzer.
   - 3.1 Remove the electrical connector from the low voltage disconnect warning buzzer.
   - 3.2 Remove the two mounting hexnuts from the mounting studs attached to the B-pillar access door.
   - 3.3 Remove the low voltage disconnect warning buzzer from the electrical compartment door.

Installation

1. Install the low voltage disconnect warning buzzer onto the right-hand B-pillar electrical compartment door.
   - 1.1 Position the low voltage disconnect warning buzzer on the two mounting studs attached to the B-pillar electrical compartment door.
   - 1.2 Install the two mounting hexnuts and tighten them firmly.
   - 1.3 Install the electrical connector to the low voltage disconnect warning buzzer.
2. Close the electrical compartment door.
3. Connect the batteries and remove the chocks from the tires.

Functional Test

NOTE: If the LVD deactivates (removes power to the cab/sleeper loads), it needs to be reset prior to performing a functional test. If the batteries are discharged below 12.3 volts, charge the batteries before performing any troubleshooting procedures. The LVD can be reset by starting the engine. Once the LVD senses 13.1 volts or more, it resets automatically.

1. Shut down the engine.
2. Unplug the 10-position connector from the LVD.
3. Remove wire 447B from cavity E on the connector, and wrap a small piece of electrical tape around the exposed wire.
4. Insert the plug into the LVD with wire 447B still removed.

NOTE: The red LED indicator light on the LVD should turn ON when the connector is inserted.

5. Insert a metal conducting probe into cavity E of the connector, making sure contact is made between the metal probe and pin E on the LVD.
6. Connect a jumper wire between the terminal on wire 447B and the test probe inserted in cavity E.

NOTE: The electrical loads such as dome lights will remain OFF even though an electrical connection exists between circuit 447B and pin E. The LVD needs to be reset after removing the plug from the LVD.

7. Reset the LVD by starting the engine. The dome lights should come back ON, and the red LED indicator light on the LVD should turn OFF.
8. Shut down the engine.
9. Remove the metal test probe from cavity E.

NOTE: After removing the test probe, there will be a delay before the LVD disconnects the cab/sleeper loads. If equipped with the optional warning buzzer, it will sound for 60 seconds. After the time delay, the cab/sleeper loads (dome lights, for example) will shut OFF, and the optional warning buzzer will shut OFF.

10. Disconnect the jumper wire from 447B.
11. Remove the 10-position connector from the LVD.
12. Insert wire 447B into cavity E of the connector.
13. Insert the connector into the LVD.
14. Start the engine to reset the LVD.
15. If the LVD does not operate properly after performing the functional test, perform the troubleshooting procedures in this subject.

Troubleshooting Table

Low Voltage Disconnect System

Refer to **Table 1** to troubleshoot the low voltage disconnect system.

Low Voltage Disconnect System Malfunctions	
Problem	**Remedy**
Battery voltage goes below 12.1 (nominal) volts without low voltage disconnect system activation.	Check the low voltage disconnect module and associated wiring. See **Fig. 1**.
Low voltage disconnect system always activated.	Check the low voltage disconnect module and associated wiring. See **Fig. 2**.
The low voltage disconnect system activates without the warning buzzer sounding.	Check the warning buzzer and wires 14BS and 447J. See **Fig. 3**.
The warning buzzer activates without low voltage disconnect system activation.	Check the warning buzzer and wire 447J. See **Fig. 4**.

Table 1, Low Voltage Disconnect System Malfunctions

Troubleshooting

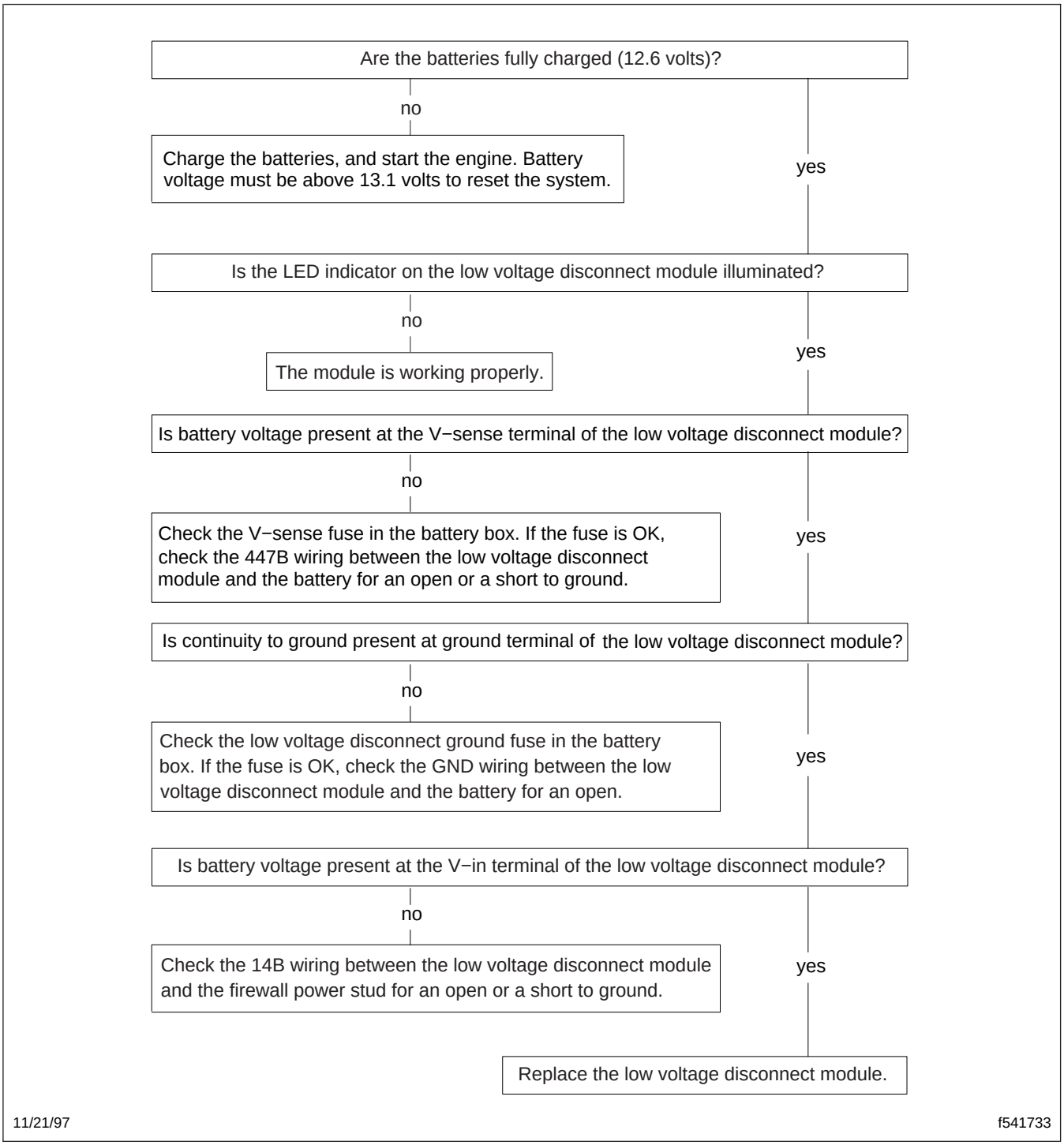


Fig. 1, Battery Voltage Goes Below 12.1 Volts Without Low Voltage Disconnect System Activation

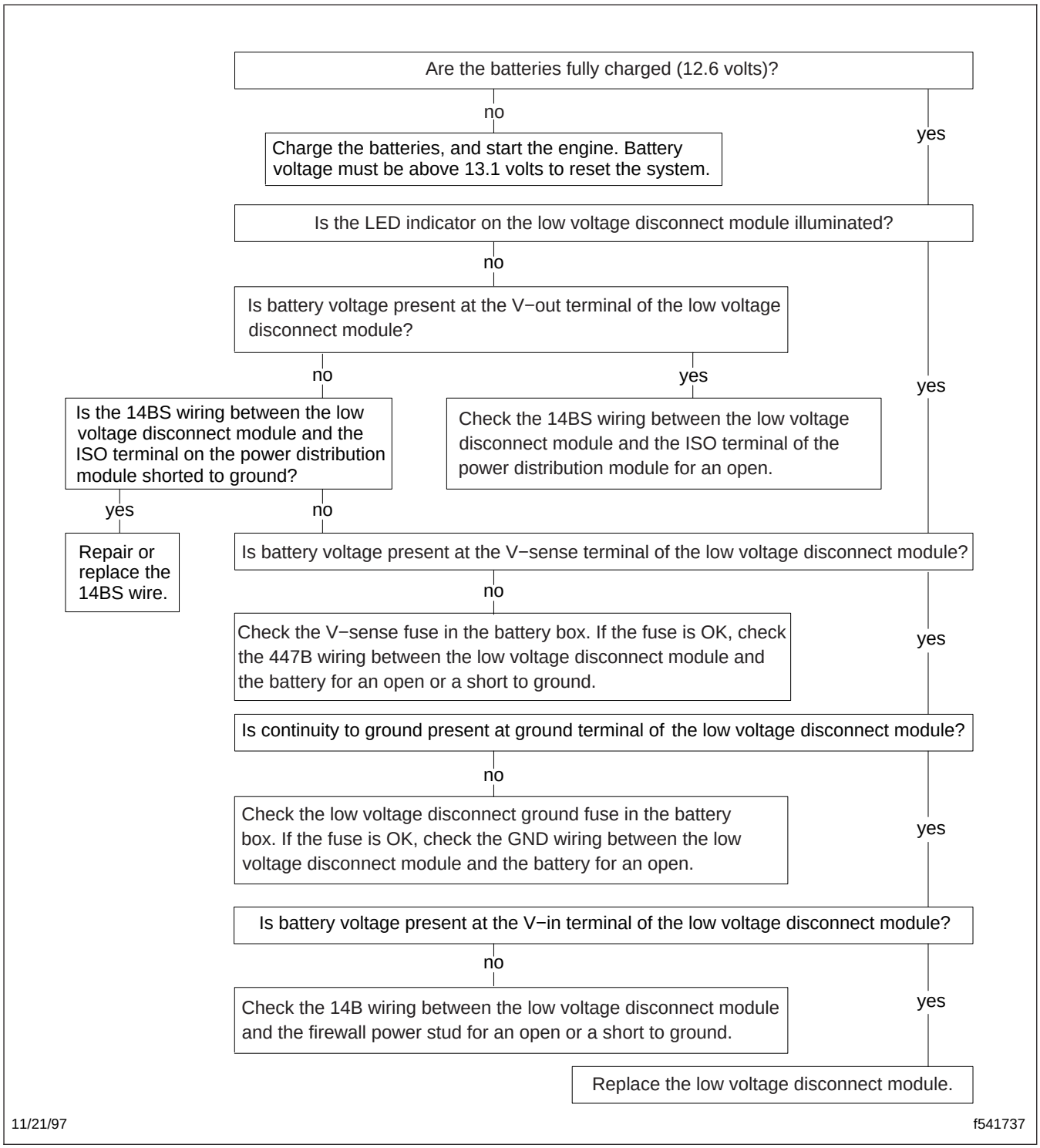
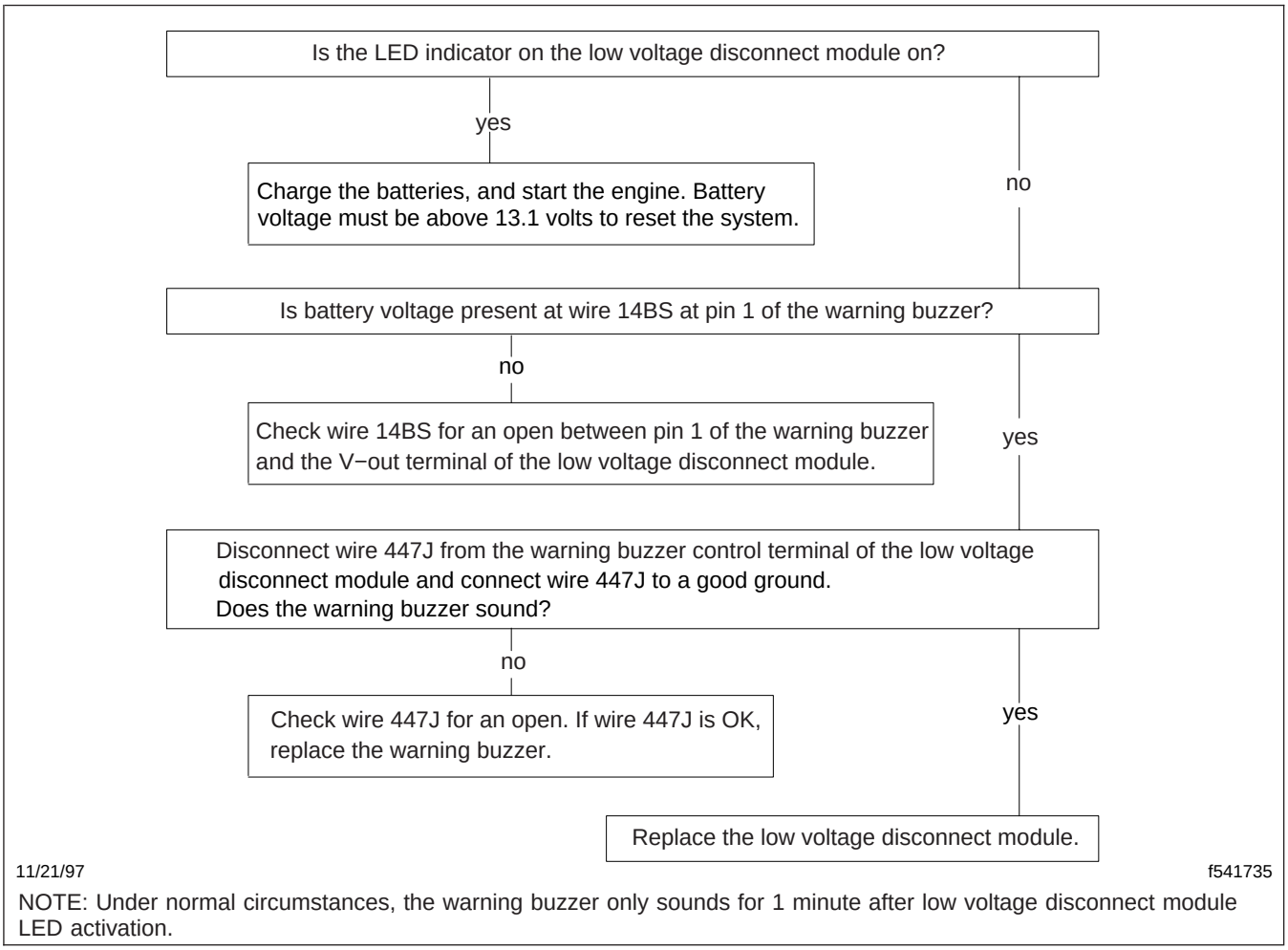


Fig. 2, Low Voltage Disconnect System Always Activated

Troubleshooting



NOTE: Under normal circumstances, the warning buzzer only sounds for 1 minute after low voltage disconnect module LED activation.

Fig. 3, The Low Voltage Disconnect System Activates Without the Warning Buzzer Sounding

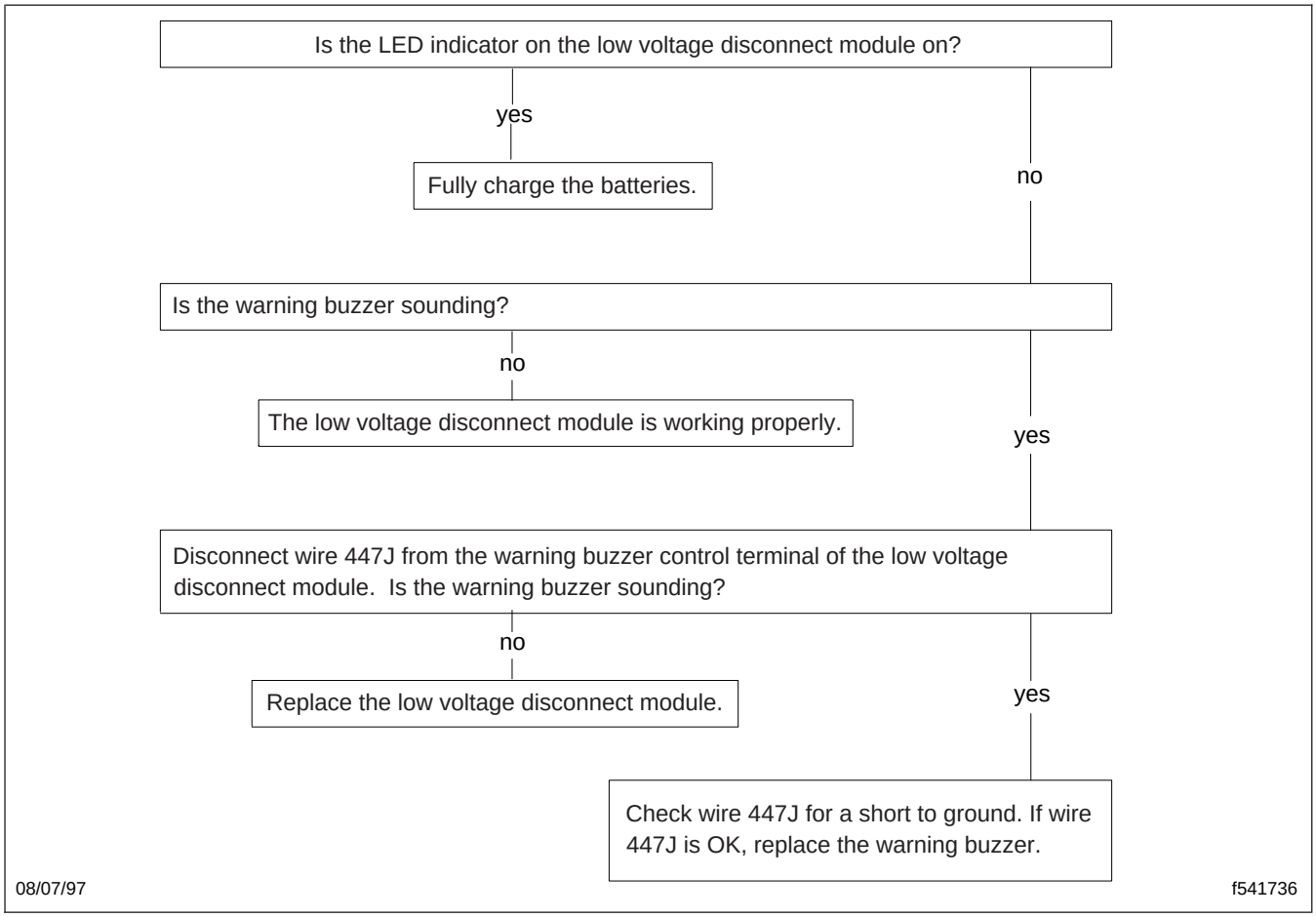


Fig. 4, The Warning Buzzer Activates Without Low Voltage Disconnect System Activation

For a wiring diagram of the low voltage disconnect system, see **Fig. 1**.

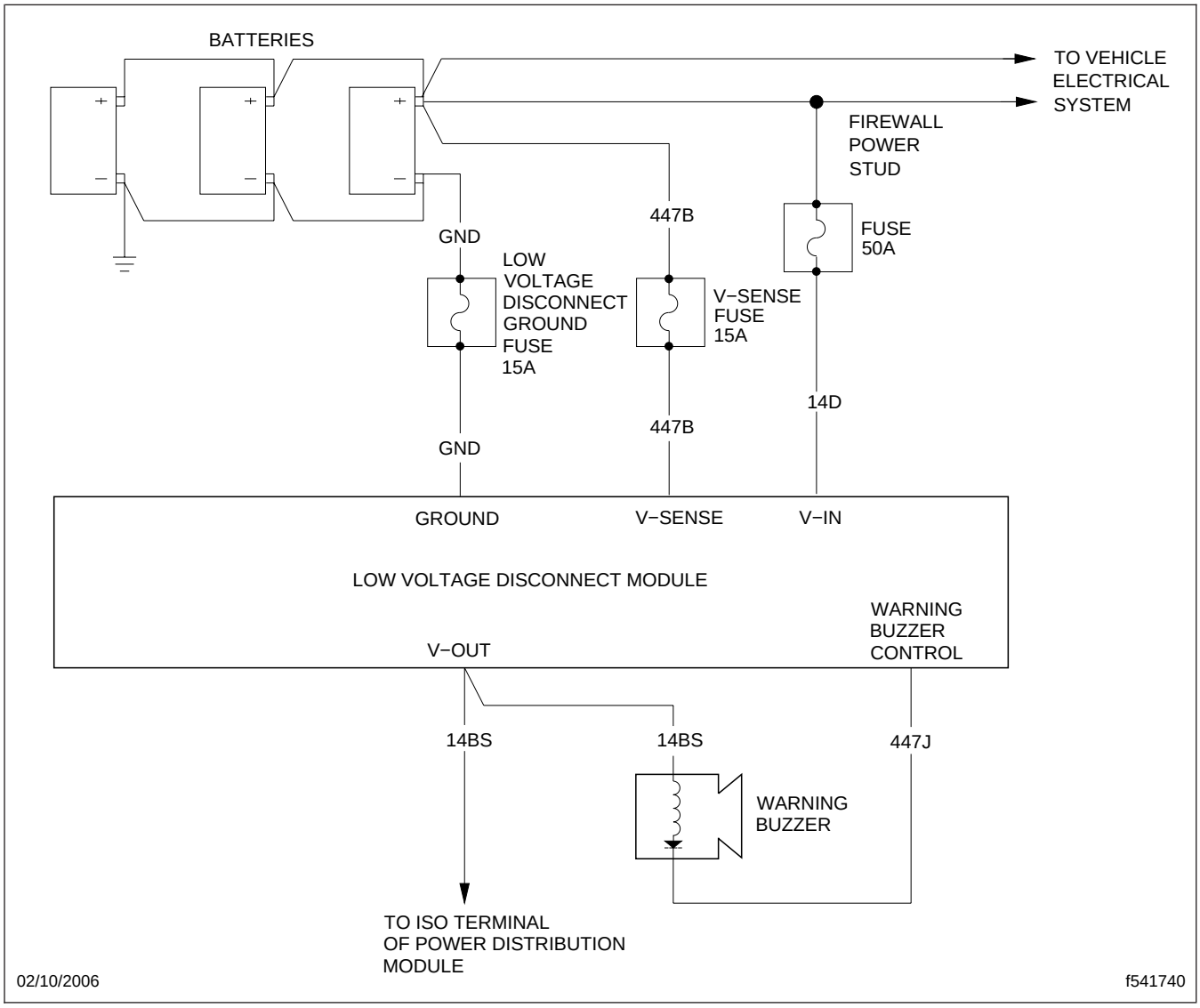


Fig. 1, Wiring Diagram, Sure Power Low Voltage Disconnect System

IMPORTANT: The level III ICU is also known (on ServiceLink) as the ICU2M.

General Description

This section covers the optional instrumentation control unit, level III (level III ICU).

The original version of the ICU (ICU1) was installed on vehicles built until May, 1998 and was replaced by the level III ICU (ICU2M) on that date. For more information about the original version of the ICU, see **Section 54.03**.

NOTE: For information about the standard level II ICU, see **Section 54.14**.

LEVEL III ICU (ICU2M)

The level III ICU is an advanced programmable electronic dashboard that accepts input from electrical/magnetic vehicle sensors and converts it into digital output that can be fed to an electronic gauge. Only air gauges operate mechanically.

The level III ICU has only one 16-bit microprocessor. This eliminates the need for the right-hand (blue) connectors found on the original ICU, and allows enhanced programmability of the parameters that regulate how, and how long, data is displayed on the various alert and data screens.

There can be up to 14 removable gauges (11 electronic, one electromechanical, and two mechanical) on the driver's instrument panel.

Driver Message Center

The heart of the ICU is the Driver Message Center. It has two parts, a set of 18 warning and indicator lights similar to those found on a conventional lightbar, and a dash driver display screen. The dash driver display screen is a 2-line by 20-character vacuum fluorescent display that provides a wide range of information to the driver.

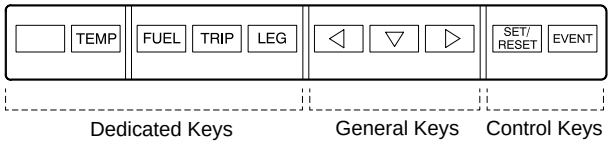
Some of the information that can be provided by the message center includes:

- odometer readings
- outside air temperature
- messages from remote locations such as company docks and offices, shipper's terminals, etc. (if equipped with a communications system, such as Qualcomm)
- trip information, such as trip miles and hours, idle hours, average mph, and leg miles and hours
- fuel information, such as fuel used and miles per gallon, fuel used idling, and PTO fuel used
- engine information, such as miles, hours, gallons of fuel used, and PTO fuel used
- diagnostic information, such as listings of active faults and troubleshooting information
- vehicle information, such as datalink operation and use data, dash part number, and software number

KEYPAD

The ICU is controlled by a keypad located on the auxiliary dash panel. See **Fig. 1**. This keypad, which has 10 keys, can be used to do the following things:

- Call up information onto direct access screens by pressing the appropriate key.
- Move about from screen to screen while the vehicle is stationary.
- Set up the display.
- Record significant data using the EVENT key.



To reset a screen, press the SET/RESET key twice.

Fig. 1, Keypad

NOTE: One key is blank and is not usable at this time.

To set, press the SET/RESET key once. To reset, press the SET/RESET key once. The confirmation screen appears: PUSH RESET AGAIN/TO CONFIRM CLEAR. Now press the SET/RESET key for a second time.

LEVEL III ICU ADVANCEMENTS

The level III ICU is installed, as an option, on vehicles built on or after May, 1998. It provides the features of the original ICU (with one exception), as well as the following advanced features not found on the original version:

- target miles per gallon (MPG), which allows easy comparison of actual fuel mileage to a target mileage.
- brightness control, which allows the brightness of the display to be adjusted independently of the panel lights.

NOTE: Temporarily, the "Faulty Speedo Gauge," or alternate speedometer, screen will not be available on the level III ICU.

Target MPG

The target MPG feature allows quick and easy checking of fuel economy through the "MPG Graph/ Target MPG..Odometer" screen. See **Fig. 2**.

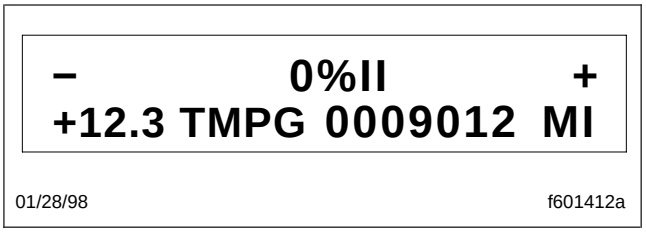


Fig. 2, MPG Graph/Target MPG..Odometer Screen

NOTE: Use the LEFT ARROW key to lower the target MPG, and the RIGHT ARROW key to raise it. Press the SET key to save the target MPG setting. For more information on how to set target MPG, see "Setup Information" later in this subject.

The "Target MPG" area is on the second line of the display, to the left of the odometer.

Example: A reading of "12.3 TMPG" indicates that the target MPG is 12.3 miles per gallon.

The "MPG Graph" on the first line of the display gives the same information in dynamic form. The "0%" mark in the center of the line represents the target MPG. Bars showing to the right of the display indicate that short term fuel economy is above the target; bars showing to the left of the display indicate that short term fuel economy is below the target.

Brightness Control

The panel light dimmer switch normally controls the brightness of all panel and gauge lights, including the level III ICU dash driver display. With the parking brake set, the ICU keypad can control the brightness of the display independently of the other lights. If the panel lights are set to maximum brightness, the display cannot be brightened any further.

NOTE: Use the LEFT ARROW key to dim the display, and the RIGHT ARROW key to brighten it. Press the SET key to save the brightness setting. For more information on how to set the brightness of the display, see "Setup Information" later in this subject.

When the parking brake is released, the arrow keys no longer work to change the brightness of the display, but the settings stay in effect unless the headlights are turned on. With the headlights on, the display dims slightly to adjust to night-time conditions.

Principles of Operation

IGNITION SEQUENCE

When the ignition is turned on, the level III ICU runs through the ignition sequence. See **Fig. 3**. If the headlights are turned on, the screen displays the odometer and waits for the ignition to be turned on.

IMPORTANT: When the ignition is first turned on, all the electronic gauges complete a full sweep of their dials, the warning and indicator lights light up for five seconds, and the alarm sounds for two seconds.

Once the ignition has been turned on, the screen displays the "Freightliner" message. At the same time, the ICU conducts a roll call of all the electronic control units (ECUs) installed on the vehicle, looking for active faults.

If there are no active faults, the screen displays the "Fasten Seat Belts/Odometer" screen.

If, however, the ICU has received active fault codes, or an electronic control unit (ECU) fails to respond to the roll call, it shows the "Active Faults" screen and displays the number of active faults, up to a total of eight. If desired, press RIGHT ARROW to see the active fault codes. Otherwise, press LEFT ARROW,

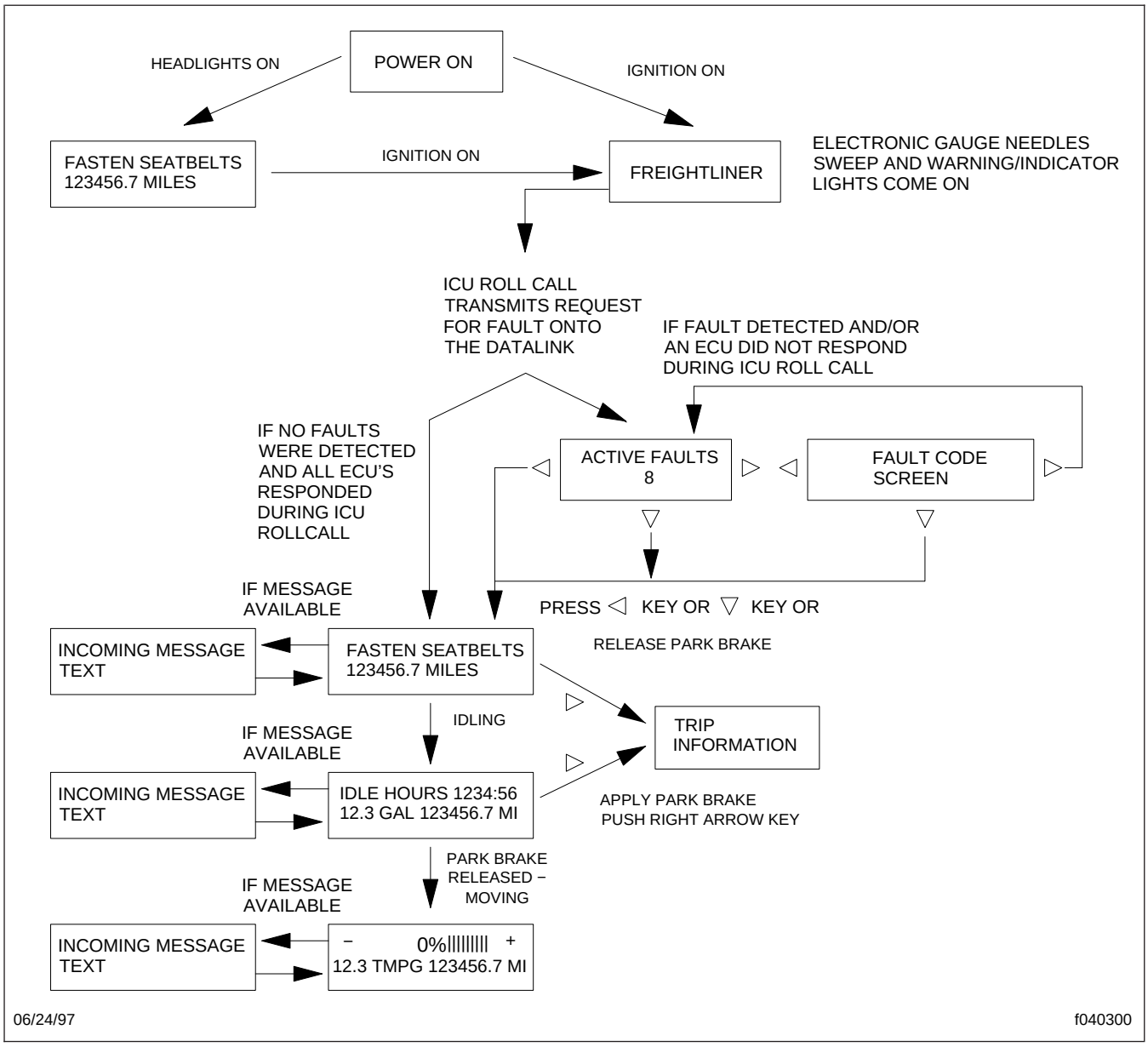


Fig. 3, Level III ICU Ignition Sequence

or, if the engine is on, release the parking brake to go on to the "Fasten Seat Belts/Odometer" screen.

Unless the engine is running, the ignition sequence ends with the "Fasten Seat Belts/Odometer" screen.

NOTE: At this point, if the vehicle has a communications system and an incoming message is available, it will be displayed. To dismiss the incoming message, press any key on the keypad.

With the engine idling (the vehicle not moving), the ignition sequence cycles on, and displays the "Idle Hours/Idle Gallons..Odometer" screen.

NOTE: To understand the information displayed on the message screen, here is an example of

screen layout. On the "Idle Hours/Idle Gallons..Odometer" screen (see **Fig. 4**), idle hours are displayed on the top line with the words "Idle Hours" on the left side of the screen and the number of hours on the right. On the bottom line, the number of idle gallons is on the left and the odometer miles are on the right, with a space in between.

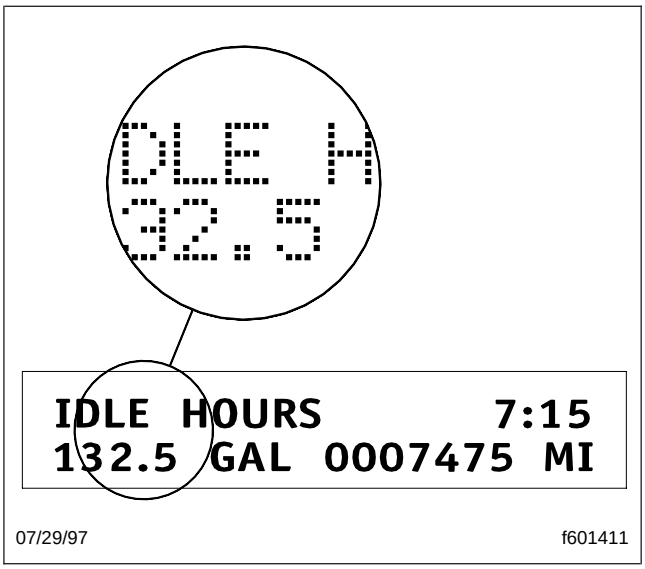


Fig. 4, Idle Hours/Idle Gallons..Odometer Screen

Once the parking brake is released (whether the vehicle is moving or not), the regular message screen display is the "MPG Graph/Target MPG..Odometer" screen. The Target MPG graph compares the actual short term fuel economy with the pre-set target value. The MPG value shows the actual target MPG. See **Fig. 2**.

NOTE: To set the target value, see "Setup Information" later in this subject.

ICU ROLL CALL

Each time the ignition keyswitch is turned on, the ICU roll call function requests data from each ECU on the databus. If the ECU does respond to this request, the databus is communicating with that ECU and no fault code is displayed.

NOTE: Each ICU is configured to receive responses from a list of selected ECUs, as installed on that particular vehicle.

If the ECU does not respond to this request, the ICU displays an active fault code that indicates the databus is not communicating with that ECU. For sample fault codes of this type, see **Table 1**.

If the ICU does not receive a signal on the J1587 datalink from one or more of the active ECUs, it displays a roll call fault. The roll call fault is displayed *only* on the dash driver display screen. It is not broadcast on the datalink; therefore, it cannot be read by ServiceLink.

NOTE: Although the reporting unit for this fault is the ICU, the message identifier (MID) of the non-responding unit is displayed (not broadcast on the datalink). This is not technically correct, but it is more informative, since it identifies the unit that is not responding.

IMPORTANT: The ICU will report a roll call fault for the Qualcomm or HighwayMaster communications systems when the system control unit, or ECU, is connected properly and the system is working correctly. This fault message occurs because the ECU cannot support the roll call function. If this happens, disable the roll call function for this device on the ICU parameter list. See **Table 1**.

To troubleshoot the Qualcomm system, have an incoming test message sent to the unit in the vehicle and make sure that it is received properly.

To troubleshoot the HighwayMaster system, see Section 54.13, **Troubleshooting, 300**.

ODOMETER

The odometer is a seven-digit display with one decimal point after the sixth digit, allowing it to display tenths of miles (or kilometers).

Roll Call Fault Codes	
Fault Code	**Description**
ENG Controller NoRESPONSE128s254 07	The engine ECM did not respond
Trans Controller NoRESPONSE130s254 07	The electronic transmission ECU did not respond
Brake Controller NoRESPONSE136s254 07	The antilock brake system (ABS) ECU did not respond
SUSP Controller NoRESPONSE150s254 07	The electronic suspension (ECAS) did not respond
CMPTR Controller NoRESPONSE179s254 07	The data logging unit (DLU) did not respond
Sat1 Controller NoRESPONSE181s254 07	The Qualcomm® communications system did not respond *
A/C Controller NoRESPONSE190s254 07	The air conditioning protection unit (ACPU) did not respond
Radar Controller NoRESPONSE219s254 07	The VORAD collision warning system did not respond
Sat1 Controller NoRESPONSE231s254 07	The HighwayMaster® communications system did not respond *
SPACE Controller NoRESPONSE232s254 07	The seat belt pre-tensioning system (SPACE) did not respond

* This system control unit cannot support the roll call function.

Table 1, Roll Call Fault Codes

When first installed, the odometer starts at 0.0 miles (or kilometers). When replaced, the odometer does not start with the engine miles, but starts again from 0.0 and cannot be changed, either up or down.

IMPORTANT: Although the odometer uses data supplied by the engine ECM to update its count, it keeps its own mileage starting from the zero point, which marks where it was first installed.

ALERT SCREENS

Alert screens can appear at any time, even when the vehicle is moving; they override the regular screen display. They are warnings, cautions, or other messages that require the driver's attention, but not all of them are critical to the operation of the vehicle.

Alert screens appear whenever the condition occurs. All priority 1 and 2 messages, plus "Turn Signal On" (priority 5) show the word "WARNING," blinking on and off, on the first line of the display.

NOTE: Warning messages always display at full brightness.

There are currently 10 alert screens arranged in six priority levels. See **Table 2**.

Priority 1 Screen

The "Park Brake On" screen overrides any other screen message.

General Information

Alert Screen Priority Levels	
Priority	**Alert Screen Description**
1	Park Brake On
2	Low Oil Pressure
	High Coolant Temp
	Low Coolant Level
	Low Voltage
3	HVAC Recirculation Messages (2)
4	Turn Signal On
5	Incoming Message
6	No Datalink Activity

Table 2, Alert Screen Priority Levels

The "Park Brake On" screen comes on, with the alarm sounding, only when the vehicle is moving at a speed greater than 2.5 miles per hour, or if the clutch is depressed. See **Fig. 5**. It can be dismissed, and the alarm turned off, only by releasing the parking brake.

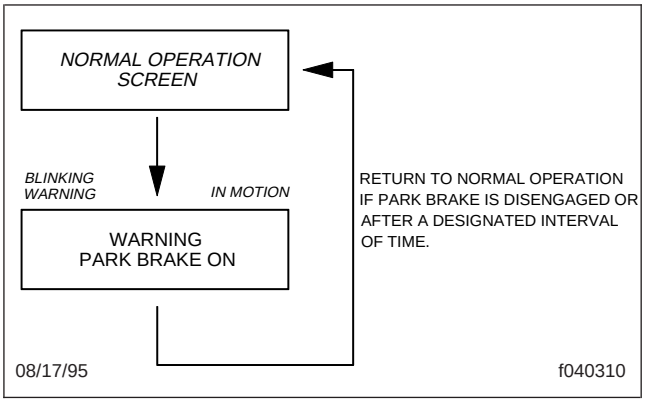


Fig. 5, Park Brake On

If the "Park Brake On" screen remains on after the brake is physically released, check the parking brake switch for proper function.

Priority 2 Screens

The "Low Oil Pressure" screen comes on whether the vehicle is idling or in motion. See **Fig. 6**.

The "High Coolant Temp" screen has the same priority as "Low Oil Pressure." See **Fig. 7**. The same is true of "Low Coolant Level" (see **Fig. 8**) and "Low Voltage" (see **Fig. 9**).

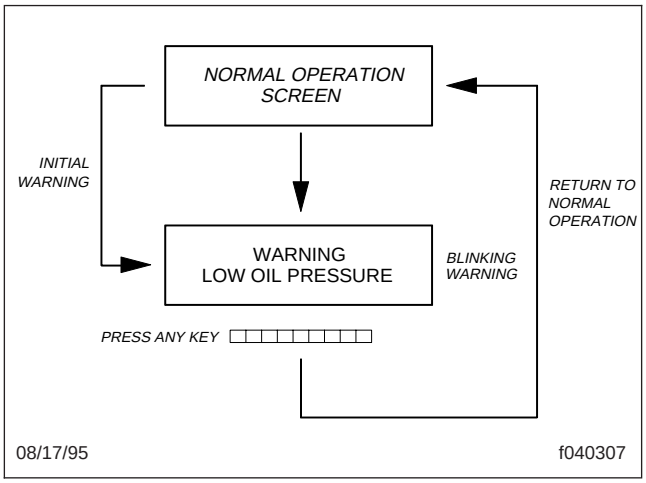


Fig. 6, Low Oil Pressure

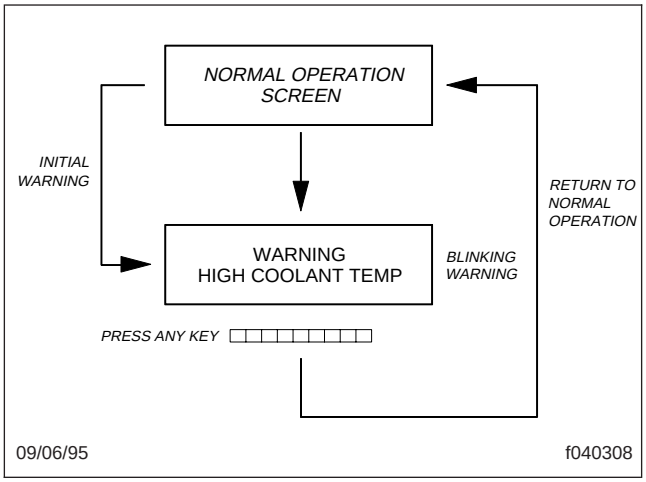


Fig. 7, High Coolant Temperature

Priority 2 screens appear on the dash display as soon as the message is received on the datalink and remain on until any key is pressed. After a key is pressed, the message is dismissed and the dash display returns to the previous screen.

If more than one alert screen message is received, pressing any key dismisses the first message and displays the next, and so on until all the messages have been received.

After 30 seconds, the message is displayed again, and can be dismissed, as before, by pressing any key.

NOTE: Priority 2 screens do not override the ignition sequence (the sequence that runs when

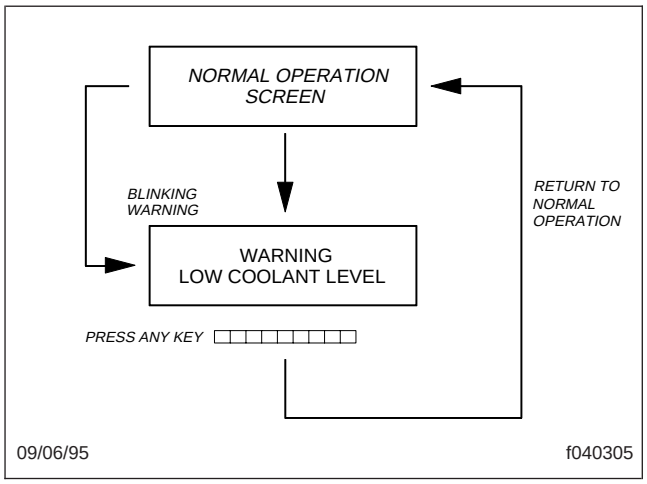


Fig. 8, Low Coolant Level

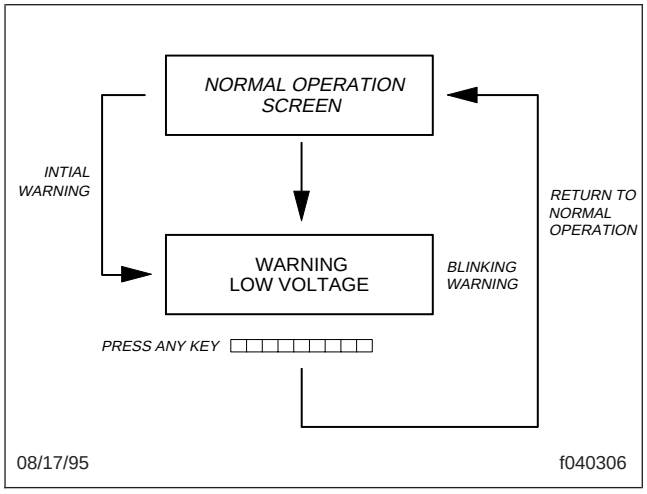


Fig. 9, Low Voltage

the ignition keyswitch is first turned on). Instead, they are displayed as active faults. Press RIGHT ARROW to see the active faults. For more information on the ignition sequence, see "Ignition Sequence" in this subject.

Priority 3 Screens

There are two HVAC (heating, ventilation, and air conditioning) recirculation screens: "Recirc Mode Engaged" and "Provide Fresh Air."

The "Recirc Mode Engaged" screen comes on whenever recirculated air is selected on the fresh/air recirculation switch, or the air circulation switch is rotated to the maximum air conditioning position. See **Fig. 10**. It displays one time only for seven seconds and notifies the driver that recirculated air is being used and that fresh air needs to be provided within at least 20 minutes.

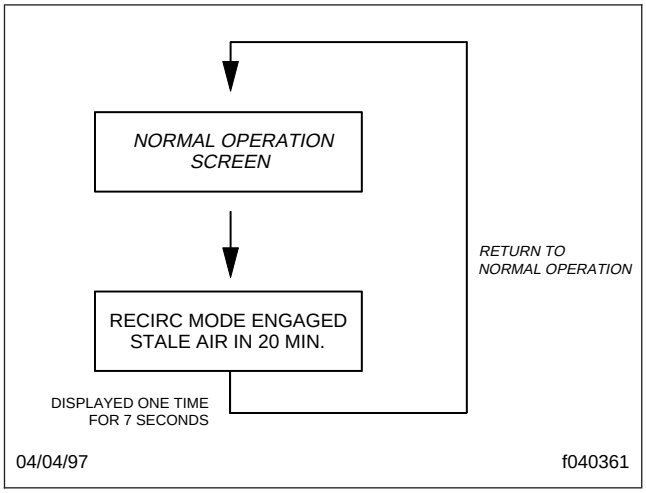


Fig. 10, Recirc Mode Engaged

If fresh air is not provided within that time span, the "Provide Fresh Air Message" is displayed. See **Fig. 11**. It displays for seven seconds every 254 seconds until the driver switches to fresh air, either by selecting fresh air on the fresh/air recirculation switch, or by rotating the air circulation switch away from maximum air conditioning and to one of the other positions.

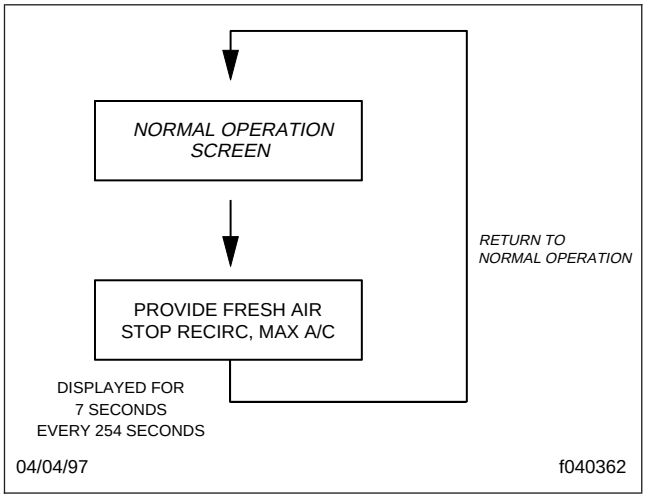


Fig. 11, Provide Fresh Air

Priority 4 Screen

The "Turn Signal On" screen is also connected to the alarm (the alarm connection can be disabled, if desired). See **Fig. 12**. It notifies the driver that the turn signal is on. On vehicles equipped with daytime running lights, the daytime running light is not on when the turn signal is flashing.

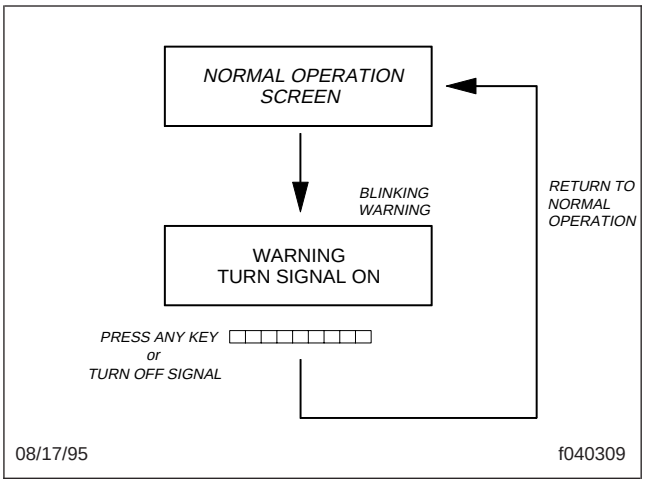


Fig. 12, Turn Signal On

To dismiss this screen, either turn off the turn signal, or press any key.

Priority 5 Screen

The "Incoming Message" screen comes on whenever the communications system receives a message. See **Fig. 13**. It displays one time only and can be dismissed by pressing any key.

NOTE: The "Incoming Message" screen will also display during the ignition sequence, if a message is available.

Priority 6 Screen

The "No Datalink Activity" screen comes on whenever the datalink is not receiving data. See **Fig. 14**.

This screen is a diagnostic tool. For information on how to use this screen to check the datalink wiring, see **Troubleshooting, 300**.

DIRECT ACCESS SCREENS

The driver can also override the regular screen display at any time by pressing the keypad to display

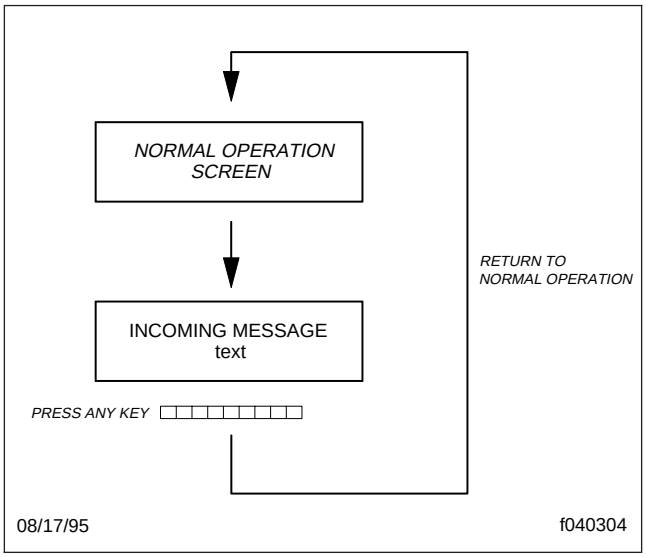


Fig. 13, Incoming Message

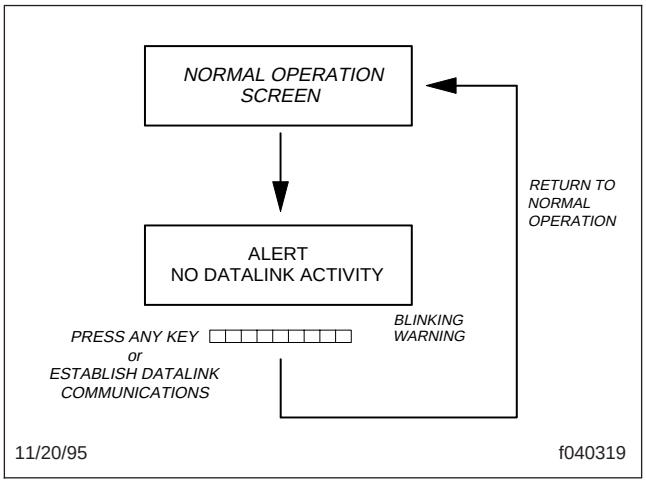


Fig. 14, No Datalink Activity

one of the direct access screens. For a list of the direct access screens, see **Table 3**.

To reset the data displayed on TRIP, FUEL or LEG screens back to zero, press the SET/RESET key twice with the screen displayed.

NOTE: Resetting "Trip Miles and Hours" also resets "Leg Miles and Hours."

Use the EVENT key to record data about a significant driving event (engine problem, driving problem, unusual vehicle operation, etc.). The other keys are used for informational purposes.

Key	Screen Contents	Reset?
TRIP	TRIP MILES 123456.7 TRIP HOURS 1234:56	Yes
FUEL	FUEL USED 12345.6 AVERAGE MPG 12.34	Yes
LEG	LEG MILES 123456.7 LEG HOURS 1234:56	Yes
EVENT	DATA BEING RECORDED	No
TEMP	OUTSIDE AIR TEMPERATURE -12F	No

Table 3, Direct Access Screens

NOTE: Normally, the screen displays DATA BEING RECORDED as shown in **Table 3**. However, if the memory in the data logger is full, the screen instead displays MEMORY FULL/DATA NOT RECORDED. If the data logger is not connected or not responding, the screen displays DATA RECORDER/NOT RESPONDING. If the EVENT key was pressed recently (within the last two minutes), the screen displays STILL RECORDING/LAST EVENT.

All keys display their data for a programmable period of time. This time period is a *resettable parameter* and can be set individually for each direct access screen.

Except for the Event screen, direct access screens can have their display time reset independently of each other, to display for from one to 254 seconds at a time, or to stay on until any key is pressed. Resetting the Trip, Fuel, or Leg screen in direct access also resets the display time for the corresponding screen when the vehicle is not moving. For more information, see "Stationary Access Screens."

The time of display on the Event screen cannot be reset except at the factory.

STATIONARY ACCESS SCREENS

The stationary access screens are a series of informational displays that give driver, maintenance, and setup information.

For reasons of safety, stationary access screens can be seen only when the vehicle is not moving and the parking brake is applied.

There are six sets of stationary access screens:

- Trip Information (see **Fig. 15**)
- Fuel Information (see **Fig. 15**)
- Engine Information (see **Fig. 15**)
- Diagnostic Information (see **Fig. 16**)
- Setup Information (see **Fig. 17**)
- Vehicle Information (see **Fig. 17**)

Each set of stationary access screens has a title screen followed by one or more data screens. To move forward and backward through these screens, use the three arrow keys as shown in **Fig. 15**, **Fig. 16**, and **Fig. 17**.

Trip Information

Trip information provides three data screens: "Trip Miles and Hours," "Idle Hours and Average MPH," and "Leg Miles and Hours." See **Fig. 15**.

"Trip Miles and Hours" displays the number of miles and hours driven since the start of the trip. At the start of a trip, press RESET (SET/RESET twice) to set trip miles and hours back to zero.

NOTE: Resetting "Trip Miles and Hours" also resets "Idle Hours and Average MPH."

"Idle Hours and Average MPH" displays the hours spent idling and the average miles per hour.

"Leg Miles and Hours" records the number of miles and hours driven since the start of the leg. At the start of a new leg, press RESET to set leg miles and hours back to zero.

NOTE: Resetting "Trip Miles and Hours" also resets "Leg Miles and Hours."

Fuel Information

Fuel information provides two data screens: "Fuel Used and Average MPG," and "Idle Gallons and PTO Gallons." See **Fig. 15**.

"Fuel Used and Average MPG" displays the gallons of fuel used since the last reset. At the start of a trip, after refueling, or whenever desired, press RESET (SET/RESET twice) to set fuel used and average miles per gallon back to zero.

General Information

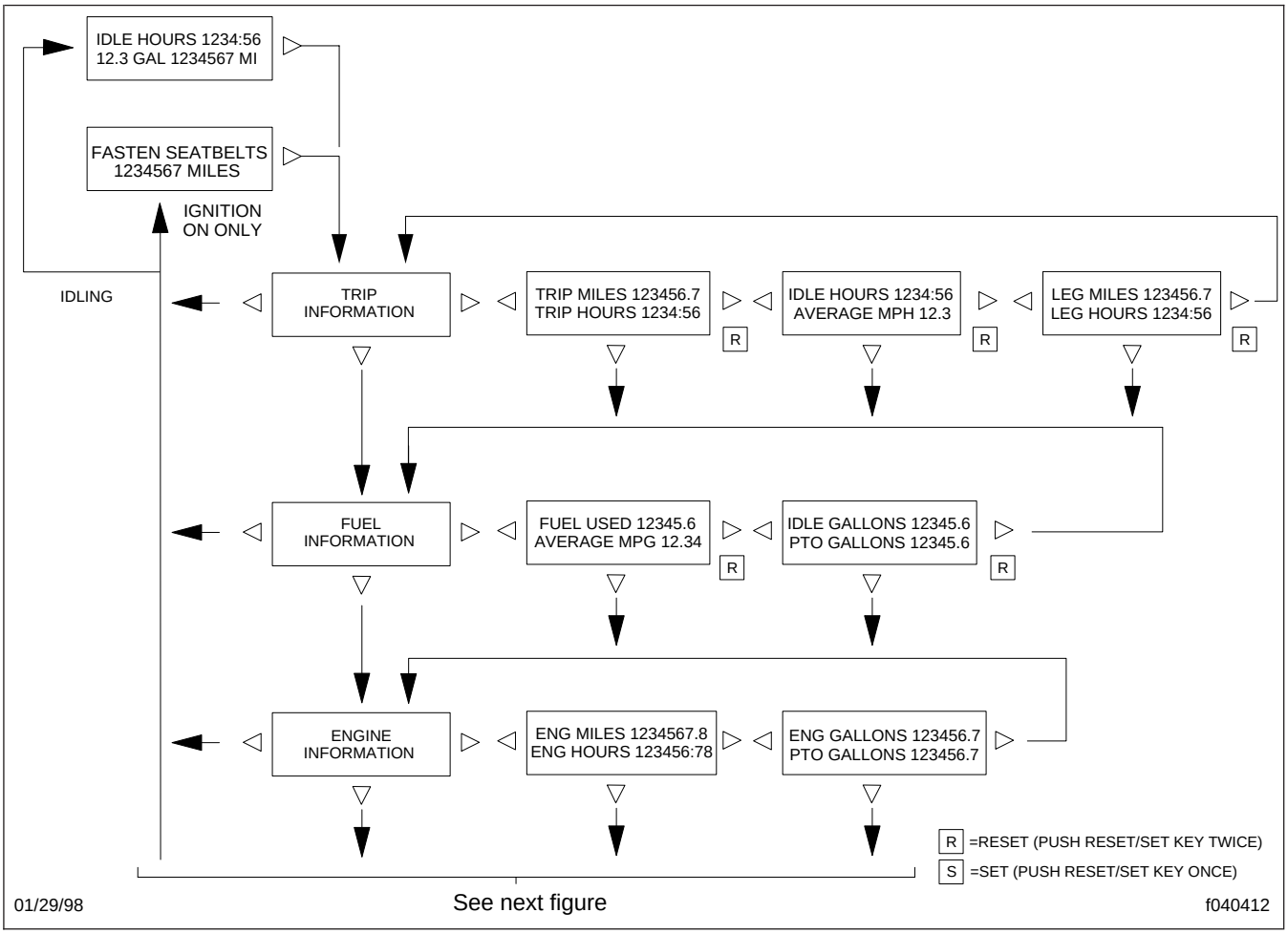


Fig. 15, Trip Information, Fuel Information, and Engine Information

NOTE: Resetting "Trip Miles and Hours" does not also reset "Fuel Used and Average MPG" or "Idle Gallons and PTO Gallons." Fuel Information must be reset separately.

"Idle Gallons and PTO Gallons" displays the gallons of fuel used idling and to operate the Power Take Off unit (if installed). At the start of a trip or whenever desired, press RESET to set idle gallons and PTO gallons back to zero.

Engine Information

Engine information provides two data screens: "Engine Miles and Hours," and "Engine Gallons and PTO Gallons." See **Fig. 15**.

"Engine Miles and Hours" displays the total miles and hours logged by the engine since installation.

NOTE: Engine information is supplied by the engine Electronic Control Module (ECM). It can be reset using engine diagnostic tools. For more information, see the engine manufacturer's manuals.

"Engine Gallons and PTO Gallons" displays the gallons of fuel used by the engine and PTO since installation.

Diagnostic Information

Diagnostic information provides two sets of data screens: "Active Faults," followed by a separate screen for each fault until all have been shown; and

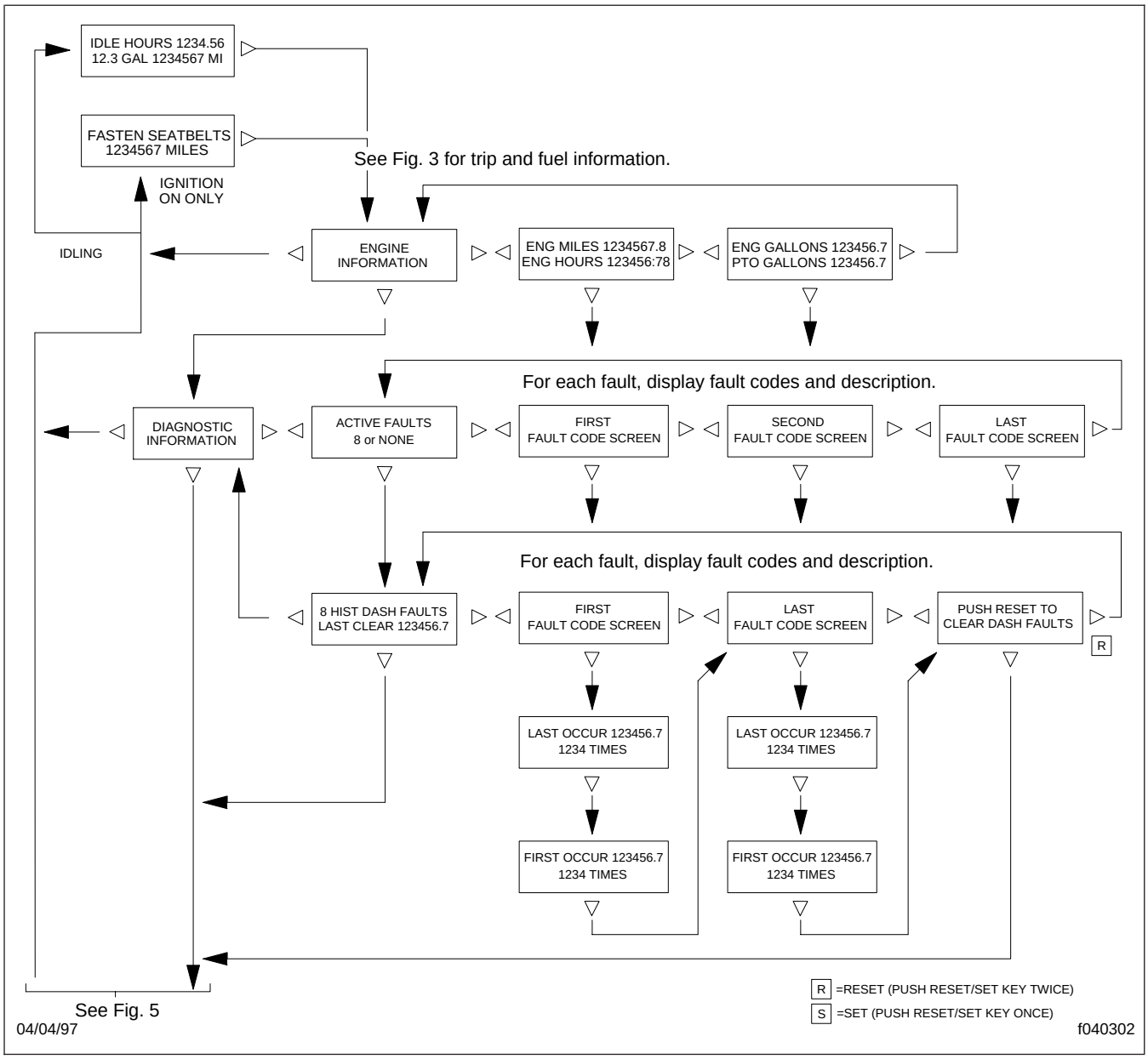


Fig. 16, Engine Information and Diagnostic Information

"Historical Dash Faults," also followed by a separate screen for each fault until all have been shown. See **Fig. 16**.

"Active Faults" cannot be reset. Active faults can be cleared only by correcting the fault.

"Historical Dash Faults" displays all dash faults since the last reset. The second line of the display shows the mileage the last time faults were cleared.

Setup Information

Setup information allows the user to change the target MPG, the brightness of the screen display, the

General Information

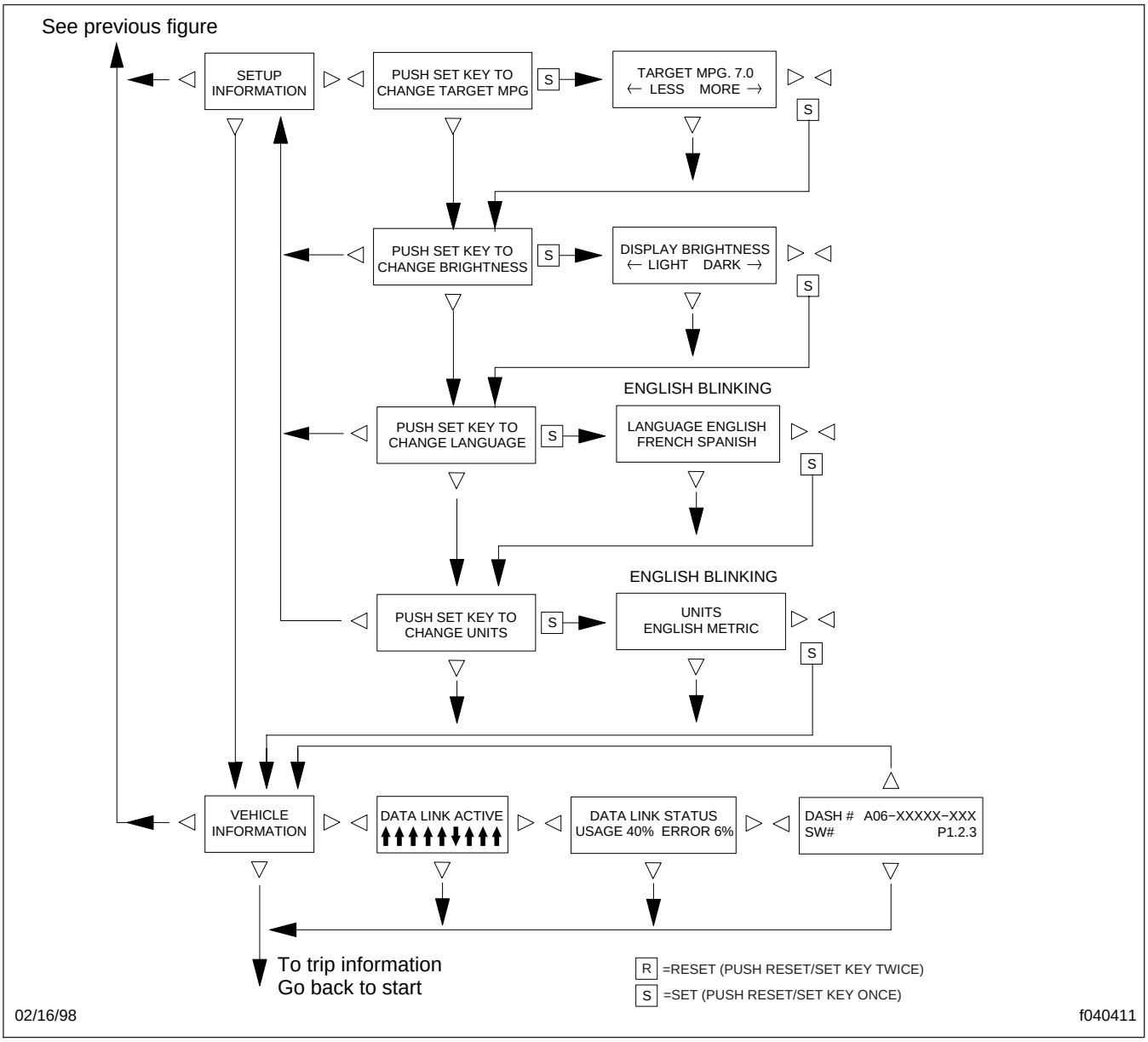


Fig. 17, Setup Information and Vehicle Information

language of the display (English, French, or Spanish), and the units of measurement (English/US conventional or metric).

When prompted by the screen, press SET (push the SET/RESET key once). The units that are settable will be blinking. Use the arrow keys (LEFT, RIGHT, and DOWN) until the display shows the desired setup. Press SET again when finished to save the new settings. See **Fig. 17**.

Vehicle Information

Vehicle information displays important vehicle information, including datalink activity and status, ICU part number, and software identification number.

The "Datalink Active" screen is a dynamic display that shows if the datalink unit is active at the given time. If all the arrows are pointing down, the ICU has not received any information on the datalink since the last time the ignition keyswitch was turned on.

The "Datalink Status" screen is also dynamic, showing current datalink use and error rate. The other screen, which shows the ICU part number and the software identification number, is informational only. See **Fig. 17**.

After vehicle information, pressing the DOWN ARROW takes you back to trip information, and so on.

Level III Instrumentation Control Unit Replacement

IMPORTANT: The level III ICU is also known (on ServiceLink) as the ICU2M.

Instrumentation Control Unit Replacement

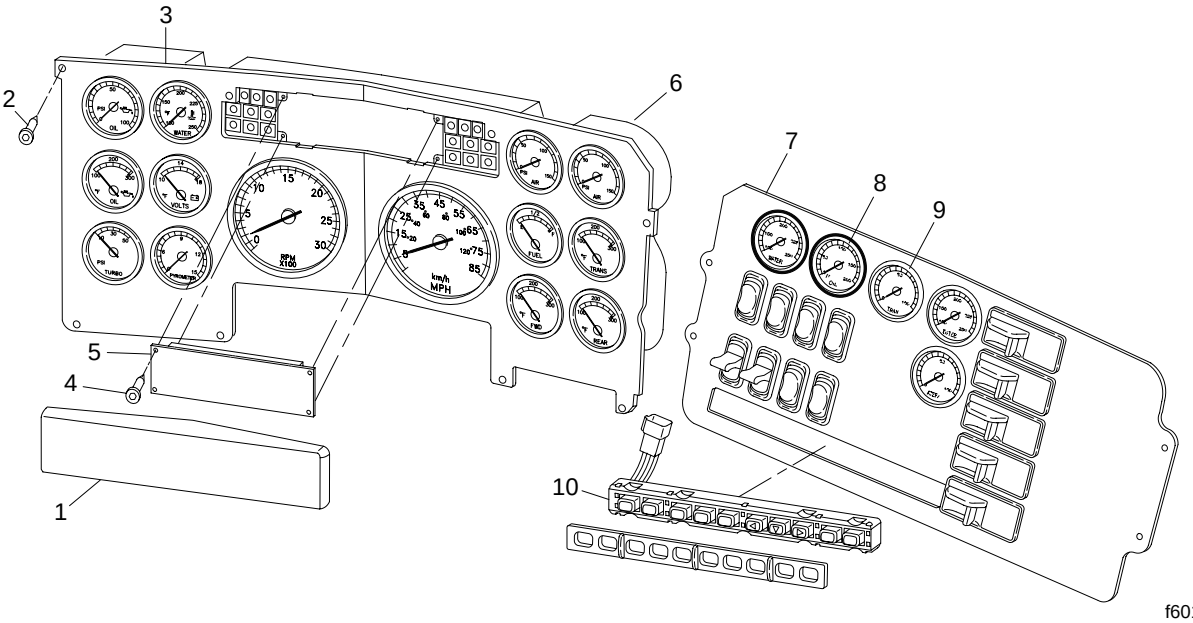
The Level III instrumentation control unit (level III ICU) includes the driver's instrument panel, the ICU housing, and the Driver Message Center (all installed as one unit). Input to the Level III ICU (ICU2M) comes from the keypad and the electronic gauges. See **Fig. 1**.

To replace the dash driver display screen, see Section 54.03, **Subject 140**. To replace the keypad, see Section 54.03, **Subject 150**.

NOTE: To remove the auxiliary instrument panel, see Section 54.03, **Subject 100**.

LEVEL III ICU (WITH GAUGES)

1. Remove the left-hand dash panels. Be sure the screws attaching the dash panel trimtop to the upper dash assembly have been removed. For instructions, see **Section 60.08**.



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1. Message Center Bezel
2. Dog-Point Screw
3. Driver's Instrument Panel
4. Display Screen Screw
5. Dash Driver Display Screen
6. ICU Housing
7. Auxiliary Instrument Panel
8. Electronic Gauge
9. Mechanical Gauge
10. Keypad

Fig. 1, Instrumentation Control Unit, Level III (ICU2M)

To replace a complete ICU with a new set of gauges, see "Level III ICU (With Gauges)." To replace an ICU and reinstall the old set of gauges, see "Level III ICU (Without Gauges)."

To replace individual gauges, switches, or flipper valves, see Section 54.03, **Subject 110**. To replace light bulbs (gauge light, or warning and indicator light), see Section 54.03, **Subject 120**. To replace the warning buzzer, see Section 54.03, **Subject 130**.

2. Remove the screw attaching the dash panel trimtop to the lower dash panel. This screw is located on the far left of the trimtop.

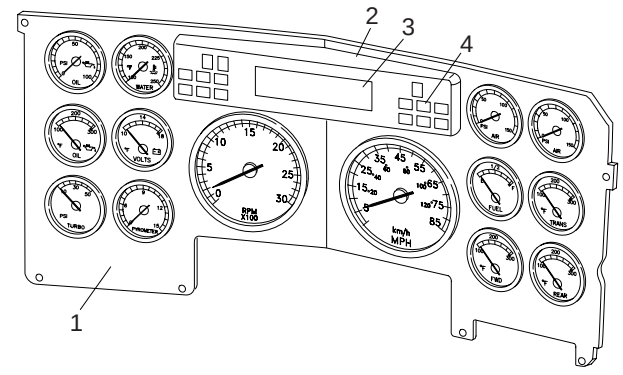
CAUTION

Electronic components of the level III ICU (ICU2M) are vulnerable to damage from static electricity. If available, wear a wrist grounding

Level III Instrumentation Control Unit Replacement

strap connected to a ground in the cab or workbench. If a grounding strap is not available, touch a grounded component immediately before doing any work which could bring a tool or body part in contact with ICU circuitry.

3. Remove the fasteners from the driver's instrument panel. See **Fig. 2**. Fasteners used on the level III ICU are T25 Torx-head dog-point screws. See **Fig. 3**.



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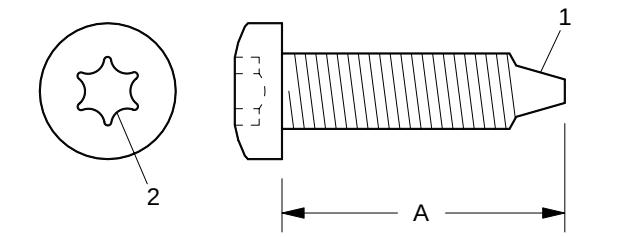
1. Driver's Instrument Panel
2. Driver Message Center
3. Dash Driver Display Screen
4. Warning and Indicator Lights

Fig. 2, Driver's Instrument Panel



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A. 3/4 Inch (19 mm)
1. Dog Point
2. Torx Head

Fig. 3, Dog-Point Screw

3.1 Remove the bezel from the Driver Message Center, exposing the two screws underneath it. For more information, see **Subject 140**.

3.2 Remove the two screws underneath the Driver Message Center bezel.

3.3 Remove the four screws on the bottom of the driver's panel.

3.4 Remove the two screws on the sides of the driver's panel.

4. Pull the old ICU away from the dash.

4.1 From behind the ICU housing, disconnect the two pink connectors on the left-hand side of the housing.

4.2 Disconnect all air hoses. Using a paint pen, mark the hoses for ease of installation.

⚠ CAUTION

When removing the old ICU, the wiring harness may have to be loosened before the driver's panel can be pulled free of the dash. Do not forcibly pull the driver's panel from the dash. This may disconnect wires from the harness electrical connectors on the back of the ICU housing and damage them.

5. Remove the old ICU from the dash. See **Fig. 4**.

5.1 Remove the three screws and speed nuts attaching the dash panel trimtop to the old ICU.

5.2 Install the dash panel trimtop on the new level III ICU (ICU2M).

6. Install the level III ICU on the dash.

6.1 Connect the air hoses to the air gauges as marked on removal.

6.2 Connect the two color-coded electrical connectors, as removed.

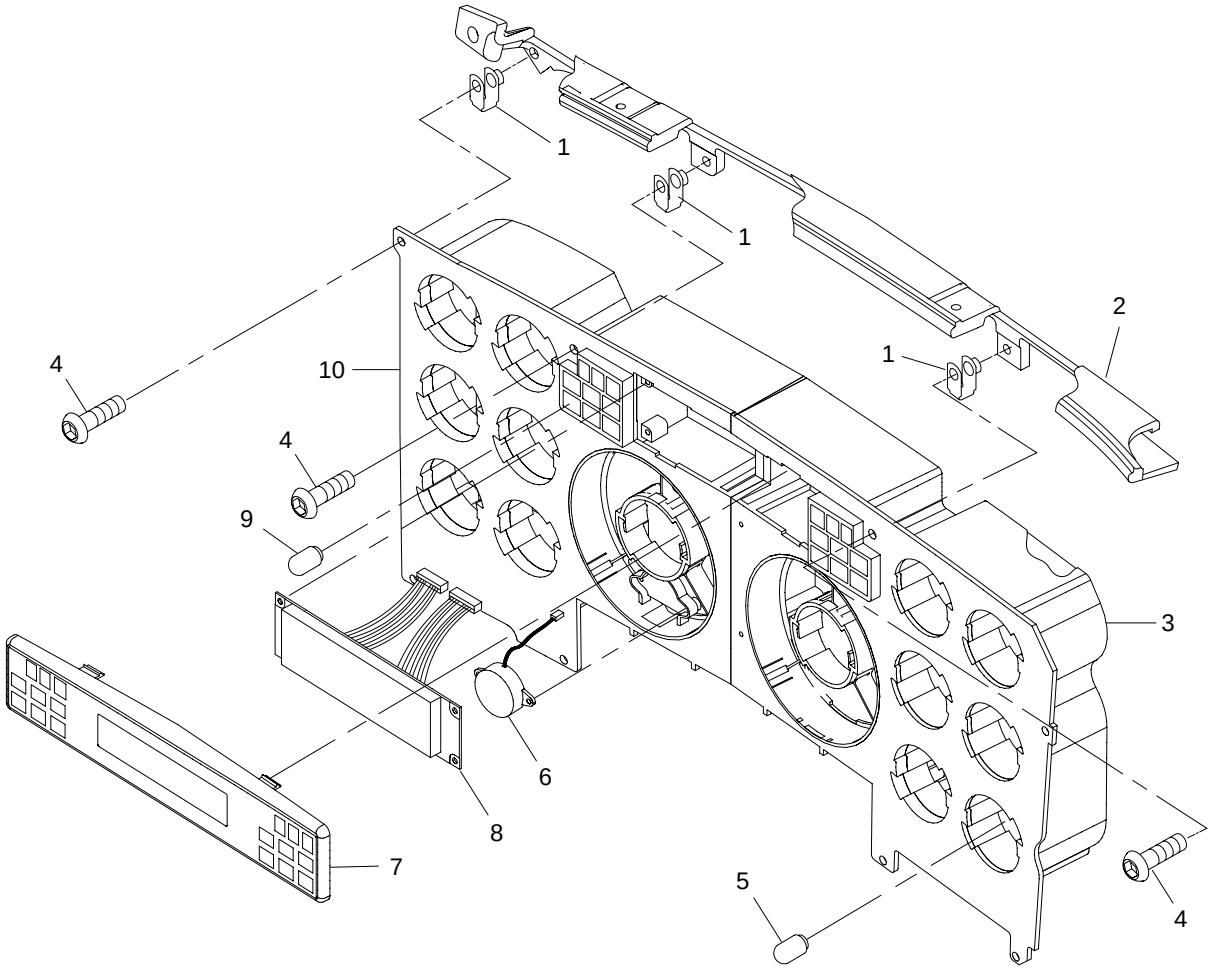
6.3 Place the new level III ICU in the dash and install the fasteners. Be sure to install the fasteners that attach the dash panel trimtop to the upper dash assembly and lower dash panel.

IMPORTANT: A typical warning and indicator light layout is shown in **Fig. 5**.

7. Install the Driver Message Center. See **Fig. 5**.

7.1 Remove the bezel from the Driver Message Center on the new level III ICU.

Level III Instrumentation Control Unit Replacement



04/18/97 f601357

NOTE: Gauges have been removed.

1. Speed Nut
2. Dash Panel Trimtop
3. ICU Housing, RH
4. T25 Dog-Point Screw
5. Gauge Light Bulb
6. Buzzer
7. Message Center Bezel
8. Dash Display Screen
9. Warning and Indicator Light Bulb
10. ICU Housing, LH

Fig. 4, ICU Housing

CAUTION

Be careful not to scratch the new bezel when replacing the lightbar legends. Scratches on the inside of the bezel are visible from the front.

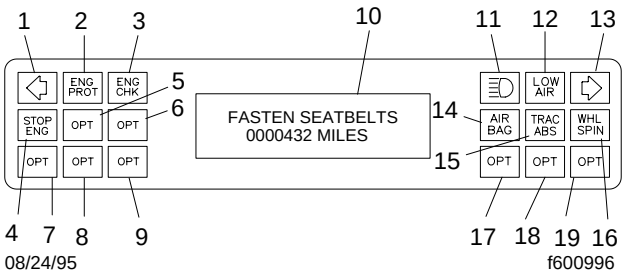
7.2 Take the bezel from the old ICU and, using fingers, tweezers, or a small pair of needle nose pliers, gently remove any of the optional plastic legends installed in the bezel. Install these in the new bezel, being careful not to scratch it.

7.3 Snap the bezel into place.

8. Check the gauge layout of the new unit and compare it to the old unit.

8.1 If any positions are different, replace the gauge for that position with the correct

Level III Instrumentation Control Unit Replacement



Typical installation shown. Location and function of optional lights may vary.

1. Left Turn Indicator
2. Engine Protection Warning & Indicator
3. Check Engine Indicator
4. Stop Engine Warning (Cummins engine only)
5. ECAS Failure Warning (optional)
6. ECAS Transfer Indicator (optional)
7. Trailer ABS Warning (optional)
8. Alternator No Charge Warning (optional)
9. Automatic Transmission Warning (optional)
10. Dash Driver Display Screen
11. High Beam Indicator
12. Low Air Warning
13. Right Turn Indicator
14. Air Bag Warning (optional)
15. Tractor ABS Warning
16. Wheel Spin Warning
17. Optional Indicator 6
18. Low Voltage Warning (optional)
19. Optional Indicator 8

Fig. 5, Driver Message Center, Level III ICU (ICU2M)

gauge from the old unit. For gauge replacement procedures, see **Subject 110**.

8.2 Reconfigure the ICU to its original factory settings. For instructions, see Section 54.03, **Subject 160**.

NOTE: Mechanical (air) gauges do not make a sweep.

9. Turn on the ignition and test the operation of the new level III ICU. All the electronic gauges (except the voltmeter) should make one complete sweep and return to their normal indicating positions; the warning and indicator lights should turn on, then off.

   If any gauges are not working properly, they will need to be serviced or replaced.

LEVEL III ICU (WITHOUT GAUGES)

1. Remove the left-hand dash panels. For instructions, see **Section 60.08**.
2. Remove the fasteners from the driver's instrument panel and dash panel trimtop. See **Fig. 2**. Fasteners used on the level III ICU (ICU2M) are 10-16 Torx-head dog-point screws. See **Fig. 3**.

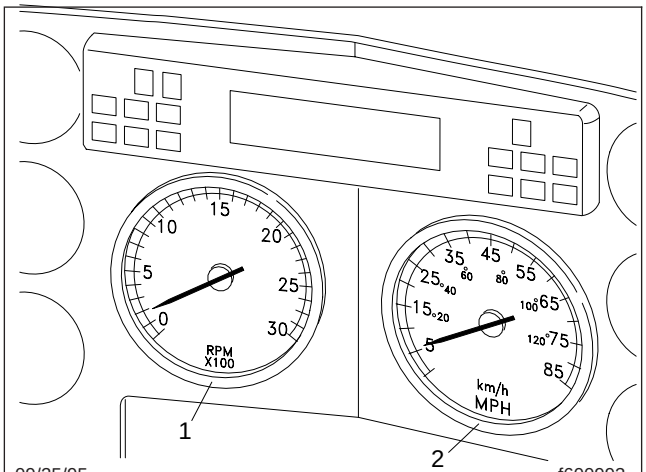
   2.1 Remove the bezel from the Driver Message Center, to expose the two screws underneath it. Remove these two screws.

   2.2 Remove the four screws on the bottom of the driver's panel.

   2.3 Remove the two screws on the sides of the driver's panel.

3. Note the gauge layout for later installation and remove all the gauges. For instructions, see **Subject 110**. Set aside the gauges for later installation in the new panel.

   3.1 Remove the two large-face gauges from the center of the driver's panel. See **Fig. 6**.

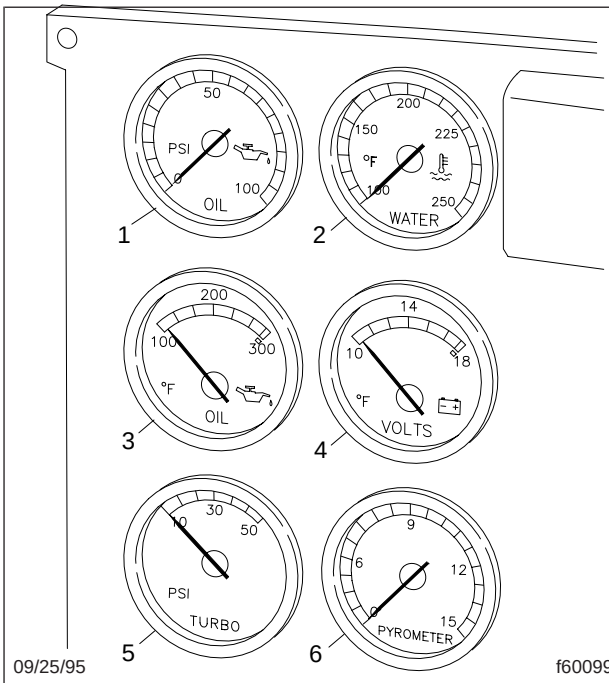


1. Tachometer 2. Speedometer

Fig. 6, Driver's Panel Gauge Layout (large-face gauges)

3.2 Remove the small-face gauges (six maximum) from the left-hand side of the driver's panel. See **Fig. 7**.

Level III Instrumentation Control Unit Replacement



Gauge layouts may vary. To work properly, gauges must be installed in their correct locations.

1. Oil Pressure Gauge
2. Water Temperature Gauge
3. Oil Temperature Gauge
4. Voltmeter
5. Turbo Air Pressure Gauge
6. Pyrometer

Fig. 7, Driver's Panel Gauge Layout (left-hand side)

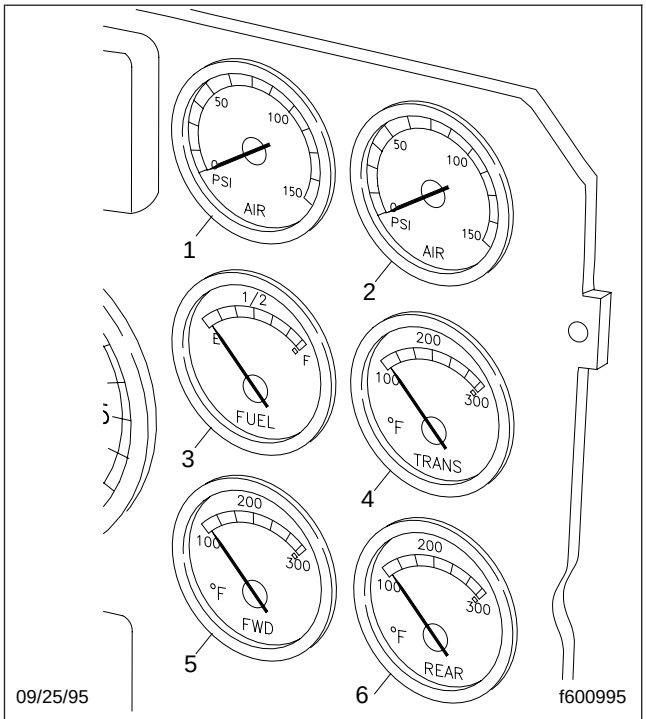
3.3 Remove the small-face gauges (six maximum) from the right-hand side of the driver's panel. See **Fig. 8**.

CAUTION

Do not lay gauges face down for long periods of time. The electronic gauges use an oil-dampening fluid that leaks out when the gauge is face down, causing dial movement to become erratic.

4. Pull the old ICU away from the dash.

4.1 From behind the ICU housing, disconnect the two pink connectors on the left-hand side of the housing.



Gauge layouts may vary. To work properly, gauges must be installed in their correct locations.

1. Primary Air Pressure Gauge
2. Secondary Air Pressure Gauge
3. Fuel Gauge
4. Transmission Fluid Temperature Gauge
5. Forward Axle Temperature Gauge
6. Rear Axle Temperature Gauge

Fig. 8, Driver's Panel Gauge Layout (right-hand side)

4.2 Disconnect all air hoses. Using a paint pen, mark the hoses for ease of installation.

CAUTION

When removing the old ICU, the wiring harness may have to be loosened before the driver's panel can be pulled free of the dash. Do not forcibly pull the driver's panel from the dash. This may disconnect wires from the harness electrical connectors on the back of the ICU housing and damage them.

5. Remove the old ICU from the dash. See **Fig. 4**.

5.1 Remove the three screws and speed nuts attaching the dash panel trimtop to the old ICU.

Level III Instrumentation Control Unit Replacement

5.2 Install the dash panel trimtop on the new level III ICU (ICU2M).

6. Install a new level III ICU in the dash.

6.1 Install all the fasteners as removed, including the fasteners attaching the dash panel trimtop to the upper dash assembly and lower dash panel.

6.2 Connect the two color-coded electrical connectors, as removed.

6.3 Install all gauges in the positions from which they were removed. Insert each gauge into its correct hole and twist clockwise about 1/8 turn, until seated.

7. Snap the Driver Message Center bezel into place, using the four small tabs on the sides of the bezel.

NOTE: Mechanical (air) gauges do not make a sweep.

8. Turn on the ignition and test the operation of the gauges. All the electronic gauges (except the voltmeter) should make one complete sweep and return to their normal indicating positions; the warning and indicator lights should turn on, then off.

9. Reconfigure the ICU to its original factory settings. For instructions, see Section 54.03, **Subject 160**.

Ignition Sequence Screen Parameter Changing, Level III ICU

IMPORTANT: The level III ICU is also known (on ServiceLink) as the ICU2M.

The parameters in this subject are used to control the display of screens that appear during the ignition sequence.

To change ignition sequence screen parameters (parms), display the parameter table in ServiceLink. Using one of the tables listed below, enter the desired range setting in the "Value" column in the parameter table.

NOTE: Not all parameters can be changed by every user. Some cannot be changed by users at all. Others require authorization. These files display in different colors on the ServiceLink screen and are designated by footnotes in the text.

Ignition Sequence Screen Parameters *			
Parm	**Units**	**Range**	**Description and Explanation of Screen**
1 *	Sec	0–15	**Freightliner Screen:** Controls the length of time that the "Freightliner" screen shows on the dash driver display during the "Ignition ON" sequence.
		0=Off	Enter "0" (zero). The screen display is disabled (it does not display at all).
		7–15	Enter any number between "7" and "15." The screen displays for that number of seconds.
2 *	Sec	0–15	**Monitored Systems OK Screen:** Controls the enabling of this screen and the length of time that it shows on the dash driver display during the "Ignition ON" sequence.
		0=Off	Enter "0" (zero). The screen display is disabled (it does not display at all).
		1–15	Enter any number between "1" and "15." The screen displays for that number of seconds.
3 †	Sec	0–15	**Service Interval, Miles:** Controls the enabling of this screen and the length of time that it shows on the dash driver display during the ignition sequence.
		0=Off	Enter "0" (zero). The screen display is disabled (it does not display at all).
		1–15	Enter any number between "1" and "15." The screen displays for that number of seconds.
4 †	Sec	0–15	**Service Interval, Hours:** Controls the enabling of this screen and the length of time that it shows on the dash driver display during the ignition sequence.
		0=Off	Enter "0" (zero). The screen display is disabled (it does not display at all).
		1–15	Enter any number between "1" and "15." The screen displays for that number of seconds.
5	None	0 or 1	**Idle Hours and Gallons Screen:** Controls the enabling of this screen in the ignition sequence and in stationary access (accessed from the keypad).
		0=Off	Enter "0" (zero). The screen display is disabled (it does not display on the ignition sequence or when requested).
		1=On	Enter "1." The screen display is enabled (it displays on the ignition sequence or when requested).
6 †	None	1 or 2	**MPG Display Screen:** Controls the enabling of this screen. This is the basic display screen, showing the mpg bar graph (dynamic display), current mpg value and the odometer reading.
		1	Enter "1." The screen displays with bargraph.
		2	Enter "2." The screen displays without bargraph.

* No access by users to parms #1 and #2

† Authorization required

Table 1, Ignition Sequence Screen Parameters (parms #1-6)

Ignition Sequence Screen Parameter Changing, Level III ICU

Ignition Sequence Screen Parameters *			
Parm	**Units**	**Range**	**Description and Explanation of Screen**
7	Sec	0–63	**Incoming Message Screen:** Controls the length of time that the "Incoming Message" screen shows on the dash driver display whenever the ICU receives a message from the data link.
		0=Off	Enter "0" (zero). The screen never displays at all.
		1–62	Enter any number between "1" and "62." The screen displays for that number of seconds.
		63	Enter "63." The screen displays until the operator dismisses it by pressing any key.

* All parameters in this table are accessible to users

Table 2, Ignition Sequence Screen Parameters (parm #7)

Stationary Access Screen Parameter Changing, Level III ICU

IMPORTANT: The level III ICU is also known (on ServiceLink) as the ICU2M.

The parameters in this subject are used to control the display of stationary access screens.

To change stationary access screen parameters (parms), display the parameter table in ServiceLink. Using one of the tables listed below, enter the desired range setting in the "Value" column in the parameter table.

NOTE: Not all parameters can be changed by every user. Some cannot be changed by users at all. Others require authorization. These files display in different colors on the ServiceLink screen and are designated by footnotes in the text.

Stationary Access Screen Parameters *			
Parm	**Units**	**Range**	**Description and Explanation of Screen**
101	None	0 or 1	**Trip Information Screen:** Controls the enabling of this title screen (accessed from the keypad).
		0=Off	Enter "0" (zero). The screen display is disabled (it does not display when requested).
		1=On	Enter "1." The screen display is enabled (it does display when requested).
102	None	0 or 1	**Trip Miles and Trip Hours Screen:** Controls the enabling of this data screen (accessed from the keypad). For programming instructions, see parm #101.
103	None	0 or 1	**Idle Hours and Average MPG Screen:** Controls the enabling of this screen (accessed from the keypad). For programming instructions, see parm #101.
104	None	0 or 1	**Leg Miles and Leg Hours Screen:** Controls the enabling of this data screen (accessed from the keypad). For programming instructions, see parm #101.
105	None	0 or 1	**Fuel Information Screen:** Controls the enabling of this title screen (accessed from the keypad). For programming instructions, see parm #101.
106	None	0 or 1	**Fuel Used and Average MPG Screen:** Controls the enabling of this data screen (accessed from the keypad). For programming instructions, see parm #101.
107	None	0 or 1	**Idle Gallons and PTO Gallons Screen:** Controls the enabling of this screen (accessed from the keypad). For programming instructions, see parm #101.
108	None	0 or 1	**Engine Information Screen:** Controls the enabling of this title screen (accessed from the keypad). For programming instructions, see parm #101.
109	None	0 or 1	**Engine Miles and Engine Hours Screen:** Controls the enabling of this screen (accessed from the keypad). For programming instructions, see parm #101.
110	None	0 or 1	**Engine Gallons and PTO Gallons Screen:** Controls the enabling of this screen (accessed from the keypad). For programming instructions, see parm #101.

* All parameters in this table are accessible to users

Table 1, Stationary Access Screen Parameters (parms #101-110)

Stationary Access Screen Parameter Changing, Level III ICU

Stationary Access Screen Parameters *			
Parm	**Units**	**Range**	**Description and Explanation of Screen**
111	None	0 or 1	**Diagnostic Information Screen:** Controls the enabling of this title screen.
		0=Off	Enter "0" (zero). The screen display is disabled (it does not display at all).
		1=On	Enter "1." The screen display is enabled (it displays when requested).
112 †	None	0 or 1	**Active Faults Screen:** Controls the enabling of this screen (accessed from the keypad), alerting the driver that faults are present. This screen displays all vehicle active faults in the memory of the ICU, as received on the J1587 datalink.
			For programming instructions, see parm #111.
113 †	None	0 or 1	**Historical Faults Screen:** Controls the enabling of this screen (accessed from the keypad). This screen shows how many historic dash faults (both active and inactive) since the last reset, and the odometer reading at last reset.
			For programming instructions, see parm #111.
114	None	0 or 1	**Service Information Screen:** Controls the enabling of this title screen.
			For programming instructions, see parm #111.
115	None	0 or 1	**Miles to Service Screen:** Controls the enabling of this data screen (accessed from the keypad).
			For programming instructions, see parm #111.
116	None	0 or 1	**Hours to Service Screen:** Controls the enabling of this data screen (accessed from the keypad).
			For programming instructions, see parm #111.
118	None	0 or 1	**Service Due Hours Ago Screen:** Controls the enabling of this data screen (accessed from the keypad).
			For programming instructions, see parm #111.
119	None	0 or 1	**Setup Information Screen:** Controls the enabling of this title screen.
			For programming instructions, see parm #111.
120	None	0 or 1	**Target MPG Screen:** Controls the enabling of this screen (accessed from the keypad). This screen allows the driver to set a target fuel mileage for use by the bar graph.
			For programming instructions, see parm #111.
121	None	0 or 1	**Set Language Screen:** Controls the enabling of this screen (accessed from the keypad). This screen allows the driver to change the language of the display (English, French, Spanish).
			For programming instructions, see parm #111.
122	None	0 or 1	**Set Units Screen:** Controls the enabling of this screen (accessed from the keypad). This screen allows the driver to choose between U.S. Customary (feet, pounds) and metric units of measurement.
			For programming instructions, see parm #111.

* All parameters in this table are accessible to users

† Authorization required

Table 2, Stationary Access Screen Parameters (parms #111-122)

Stationary Access Screen Parameters *			
Parm	**Units**	**Range**	**Description and Explanation of Screen**
123	None	0 or 1	**Vehicle Information Screen:** Controls the enabling of this title screen.
		0=Off	Enter "0" (zero). The screen display is disabled (it does not display when requested).

Stationary Access Screen Parameter Changing, Level III ICU

Stationary Access Screen Parameters *			
Parm	**Units**	**Range**	**Description and Explanation of Screen**
		1=On	Enter "1." The screen display is enabled (it does display when requested).
124	None	0 or 1	**Data Link Active Screen:** Controls the enabling of this dynamic display screen. For programming instructions, see parm #123.
125	None	0 or 1	**Data Link Status Screen:** Controls the enabling of this dynamic display screen. For programming instructions, see parm #123.
126 *	Sec	0–254	**No Data Link Activity Alert Screen:** Controls the enabling of this alert screen, how often the display repeats, and whether the screen can be dismissed by the driver. This screen appears when the ICU cannot detect any response from the J1587 databus through the data link.
		0=Off	Enter "0" (zero). The screen display is disabled (it does not display at all).
		1	Enter "1." The screen displays one time only for seven seconds.
		2	Enter "2." The screen displays for seven seconds, dismisses itself, and returns every 254 seconds until the fault is corrected.
		3–253	Enter any number between "3" and "253." The screen display repeats after that number of seconds. It continues its repeat cycle until the fault is corrected. Each time, it can be dismissed by the driver pushing any key.
		254	Enter "254." The screen displays continuously until the condition returns to normal. It can not be dismissed.
127 *	None	0 or 1	**Part No. and Software Screen:** Controls the enabling of this screen (accessed from the keypad). This screen displays the ICU part number (see parm #400) and software version number (see parm #402). For programming instructions, see parm #123.
128 †	None	0 or 1	**Vehicle ID Number Screen:** Controls the enabling of this screen (accessed from the keypad). This screen displays vehicle ID number (see parm #401). For programming instructions, see parm #123.
129 †	Miles	0–254	**Reset Faults Screen:** Controls the enabling of this screen, whose purpose is to delete all the accumulated historical faults.
		0=Off	Enter "0" (zero). The screen display is disabled (it does not display when requested).
		1–254	Enter any number between "1" and "254." The screen function is enabled for from 1 to 254 odometer miles. NOTE: This function is used by the production plants only.

* No access by users to parms #126 or #127

† Authorization required

Table 3, Stationary Access Screen Parameters (parms #123-129)

Stationary Access Screen Parameters *			
Parm	**Units**	**Range**	**Description and Explanation of Screen**
130 *	Sec	0–15	**Reset Key Valid Time:** When the "Reset Confirmation" screen is enabled (see parm #131), controls the number of seconds allowed to confirm a reset (prevents accidental resets).
		0=Off	Enter "0" (zero). This function is disabled (resets are not confirmed).

Stationary Access Screen Parameter Changing, Level III ICU

Stationary Access Screen Parameters *			
Parm	**Units**	**Range**	**Description and Explanation of Screen**
		1-15	Enter any number between "1" and "15." The reset is confirmed if the reset key is pressed within that number of seconds. If the reset key is not pressed within the allotted time, the screen being reset continues to report its old values.
131 *	None	0 or 1	**Reset Confirmation Screen:** Controls the enabling of this screen, which appears when the reset button on the keypad is pressed.
		0=Off	Enter "0" (zero). The screen is disabled (it does not display when the reset button is pressed).
		1=On	Enter "1." The screen display is enabled (it displays when the reset button is pressed).
			NOTE: See parm #130, which sets the number of seconds required for confirmation.

* No access by users to parms #130 or #131

Table 4, Stationary Access Screen Parameters (parms #130-131)

Direct Access Screen Parameter Changing, Level III ICU

IMPORTANT: The level III ICU is also known (on ServiceLink) as the ICU2M.

The parameters in this subject are used to control the display of direct access screens.

To change direct access screen parameters (parms), display the parameter table in ServiceLink. Using one of the tables listed below, enter the desired range setting in the "Value" column in the parameter table.

NOTE: Not all parameters can be changed by every user. Some cannot be changed by users at all. Others require authorization. These files display in different colors on the ServiceLink screen and are designated by footnotes in the text.

Direct Access Screen Parameters *			
Parm	**Units**	**Range**	**Description and Explanation of Screen**
200	Sec	0–254	**Trip Miles and Trip Hours Screen Display Time:** Controls the enabling of this direct access screen and the length of time that it shows on the dash driver display after pressing the TRIP key.
		0=Off	Enter "0" (zero). The screen display is disabled (it does not display at all).
		1–253	Enter any number between "1" and "253." The screen displays for that number of seconds.
		254	Enter "254." The screen displays continuously until dismissed. It can be dismissed by pressing any key.
201	Sec	0–254	**Fuel Used and Average MPG Screen Display Time:** Controls the enabling of this direct access screen and the length of time that it shows on the dash driver display after pressing the FUEL key.
			For programming instructions, see parm #200.
202	Sec	0–254	**Leg Miles and Leg Hours Screen Display Time:** Controls the enabling of this direct access screen and the length of time that it shows on the dash driver display after pressing the LEG key.
			For programming instructions, see parm #200.
203 †	Sec	0–254	**Outside Temperature Screen:** Controls the enabling of this screen, and how long it remains on. This screen is accessed by pressing the TEMP key.
			For programming instructions, see parm #200.

* All parameters in this table are accessible to users

† Authorization required

Table 1, Direct Access Screen Parameters (parms #200-203)

Alert Screen and Alarm Parameter Changing, Level III ICU

IMPORTANT: The level III ICU is also known (on ServiceLink) as the ICU2M.

The parameters in this subject are used to control the display of alert screens and the sounding of the audible alarm.

To change alert screen and/or alarm parameters (parms), display the parameter table in ServiceLink. Using one of the tables listed below, enter the desired range setting in the "Value" column in the parameter table.

NOTE: Not all parameters can be changed by every user. Some cannot be changed by users at all. Others require authorization. These files display in different colors on the ServiceLink screen and are designated by footnotes in the text.

Alert Screen and Alarm Parameters *			
Parm	**Units**	**Range**	**Description**
300 *	Sec	0–254	**Low Coolant Level Warning Screen:** Controls the enabling of this alert screen, how often the display repeats, and whether the screen can be dismissed by the driver. This screen appears when the engine ECU reports a low coolant level fault.
		0=Off	Enter "0" (zero). The screen display is disabled (it does not display at all).
		1	Enter "1." The screen displays one time only for seven seconds.
		2	Enter "2." The screen displays for seven seconds, dismisses itself, and returns every 254 seconds until the fault is corrected.
		3–253	Enter any number between "3" and "253." The screen display repeats after that number of seconds. It continues its repeat cycle until the fault is corrected. Each time, it can be dismissed by the driver pushing any key.
		254	Enter "254." The screen displays continuously until the condition returns to normal. It can not be dismissed.
301 †	None	0–3	**Low Coolant Level Alarm:** Controls the enabling of this alarm, and the type of sound. This alarm sounds when the coolant level is too low.
		0=Off	Enter "0" (zero). The alarm function is disabled (it does not sound).
		1	Enter "1." The alarm sounds continuously until the problem is corrected.
		2	Enter "2." The alarm pulses steadily until the problem is corrected.
		3	Enter "3." The alarm pulses according to a programmed pattern until the problem is corrected. NOTE: To change the programmable pulsing function, see parm #325.
302 †	Sec	0–254	**Low Voltage Warning Screen:** Controls the enabling of this alert screen, how often the display repeats, and whether the screen can be dismissed by the driver. See parm #300 for programming instructions.
303 †	None	0–3	**Low Voltage Alarm:** Controls the enabling of this alarm, and the type of sound. This is an optional alarm function. See parm #301 for programming instructions.
304 †	Sec	0–254	**Low Oil Pressure Warning Screen:** Controls the enabling of this alert screen, how often the display repeats, and whether the screen can be dismissed by the driver. See parm #300 for programming instructions.

* No access by users to parm #300

† Authorization required

Table 1, Alert Screen and Alarm Parameters (parms #300-304)

Alert Screen and Alarm Parameter Changing, Level III ICU

Alert Screen and Alarm Parameters *			
Parm	**Units**	**Range**	**Description**
305 †	None	0–3	**Low Oil Pressure Alarm:** Controls the enabling of this alarm, and the type of sound. This alarm sounds when the oil pressure is too low.
		0=Off	Enter "0" (zero). The alarm function is disabled (it does not sound).
		1	Enter "1." The alarm sounds continuously until the problem is corrected.
		2	Enter "2." The alarm pulses steadily until the problem is corrected.
		3	Enter "3." The alarm pulses according to a programmed pattern until the problem is corrected. NOTE: To change the programmable pulsing function, see parm #325.
306 †	Sec	0–254	**High Coolant Temperature Warning Screen:** Controls the enabling of this alert screen, how often the display repeats, and whether the screen can be dismissed by the driver.
		0=Off	Enter "0" (zero). The screen display is disabled (it does not display at all).
		1	Enter "1." The screen displays one time only for seven seconds.
		2	Enter "2." The screen displays for seven seconds, dismisses itself, and returns every 254 seconds until the fault is corrected.
		3–253	Enter any number between "3" and "253." The screen display repeats after that number of seconds. It continues its repeat cycle until the fault is corrected. Each time, it can be dismissed by the driver pushing any key.
		254	Enter "254." The screen displays continuously until the condition returns to normal. It can not be dismissed.
307 †	None	0–3	**High Coolant Temperature Alarm:** Controls the enabling of this alarm, and the type of sound. This alarm sounds when the coolant temperature is too high. See parm #305 for programming instructions.
308 †	Mph	1–15	**Parking Brake Warning Screen (Vehicle MPH):** Controls the vehicle speed required to activate this alert screen (vehicle moving, parking brake on). Enter any number between "1" and "15." The alert screen displays when the vehicle is traveling at one-half that speed. For example, if the vehicle mph value is set to "5," the screen displays when the vehicle is traveling at a speed of 2.5 mph with the parking brake on.
309 †	Sec	60–254	**Parking Brake Warning Screen (Time On):** Controls the number of seconds this alert screen displays (vehicle moving, parking brake on). Enter any number between "60" and "254." The alert screen displays for that number of seconds, then turns itself off.
310 †	None	0–3	**Parking Brake On and Vehicle Moving Alarm:** Controls the enabling of this alarm, and the type of sound. This alarm sounds when the vehicle is moving and the parking brake is on. For programming instructions, see parm #305.
311 †	Sec	60–254	**Parking Brake Warning Alarm (Time On):** Controls the number of seconds this alarm sounds (vehicle moving, parking brake on). Enter any number between "60" and "254." The alarm sounds for that number of seconds, then turns itself off.

* All parameters in this table are accessible to users

† Authorization required

Table 2, Alert Screen and Alarm Parameters (parms #305-311)

Alert Screen and Alarm Parameter Changing, Level III ICU

Alert Screen and Alarm Parameters *			
Parm	**Units**	**Range**	**Description**
312 †	None	60-254	**Door Open and Parking Brake Off Alert Screen:** Controls the enabling of this alert screen, which comes on when the parking brake is off and the door open and/or the ignition keyswitch turned on. Enter any number between "60" and "254." The alert screen displays for that number of seconds, then turns itself off.
313 *	None	0–3	**Door Open and Parking Brake Off Alarm:** Controls the enabling of this alarm, and the type of sound. This alarm sounds when the door is open and the parking brake is off.
		0=Off	Enter "0" (zero). The alarm function is disabled (it does not sound).
		1	Enter "1." The alarm sounds continuously until the problem is corrected.
		2	Enter "2." The alarm pulses steadily until the problem is corrected.
		3	Enter "3." The alarm pulses according to a programmed pattern until the problem is corrected. NOTE: To change the programmable pulsing function, see parm #325.
314	None	0 or 1	**Turn Signal Warning Screen:** Controls the enabling of this alert screen, how often the display repeats, and whether the screen can be dismissed by the driver. This screen appears when the turn signals have been left on.
		0=Off	Enter "0" (zero). The screen display is disabled (it does not display at all).
		1	Enter "1." The screen displays one time only for seven seconds.
		2	Enter "2." The screen displays for seven seconds, dismisses itself, and returns every 254 seconds until the fault is corrected.
		3–253	Enter any number between "3" and "253." The screen display repeats after that number of seconds. It continues its repeat cycle until the fault is corrected. Each time, it can be dismissed by the driver pushing any key.
		254	Enter "254." The screen displays continuously until the condition returns to normal. It can not be dismissed. NOTE: See parm #443, which controls the number of seconds the turn signals have to remain on before the alert screen activates, and parm #444, which controls the distance in miles the vehicle has to travel.
315	None	0–3	**Turn Signal ON Alarm:** Controls the enabling of this alarm, and the type of sound: continuous buzzing (type 1), steady pulsing (type 2), or programmable pulsing (type 3). This alarm sounds when the turn signals are left on too long, as defined by time (see parm #443), distance (see parm #444), or both. For programming instructions, see parm #313.
316 *	None	0–254	**Low Windshield Wiper Water Level Screen:** Controls the enabling of this alert screen, which appears when the water level in the washer reservoir gets low.
		0=Off	Enter "0" (zero). The screen is disabled (it does not display at all).
		1=On	Enter "1." The screen display is enabled (it displays when the turn signals have been left on).

* No access by users to parms #313 or #316

† Authorization required

Table 3, Alert Screen and Alarm Parameters (parms #312-316)

Alert Screen and Alarm Parameter Changing, Level III ICU

Alert Screen and Alarm Parameters *			
Parm	**Units**	**Range**	**Description and Explanation of Screen**
317 *	None	0–3	**Low Windshield Wiper Water Level Alarm:** Controls the enabling of this alarm, and the type of sound. This alarm comes on when the windshield washer water level gets too low.
		0=Off	Enter "0" (zero). The alarm function is disabled (it does not sound).
		1	Enter "1." The alarm sounds continuously until the problem is corrected.
		2	Enter "2." The alarm pulses steadily until the problem is corrected.
		3	Enter "3." The alarm pulses according to a programmed pattern until the problem is corrected. NOTE: To change the programmable pulsing function, see parm #325.
318 †	None	0–254	**Recirc Mode Engaged Screen:** Controls the enabling of this alert screen, how often the display repeats, and whether the screen can be dismissed by the driver. This screen appears when the HVAC unit has been switched to recirculated air.
		0=Off	Enter "0" (zero). The screen display is disabled (it does not display at all).
		1	Enter "1." The screen displays one time only for seven seconds.
		2	Enter "2." The screen displays for seven seconds, dismisses itself, and returns every 254 seconds until the fault is corrected.
		3–253	Enter any number between "3" and "253." The screen display repeats after that number of seconds. It continues its repeat cycle until the fault is corrected. Each time, it can be dismissed by the driver pushing any key.
		254	Enter "254." The screen displays continuously until the condition returns to normal. It can not be dismissed.
319 *	None	0–254	**Provide Fresh Air Screen:** Controls the enabling of this alert screen, how often the display repeats, and whether the screen can be dismissed by the driver. This screen appears when the HVAC unit has been operating for 20 minutes on recirculated air. See parm #318 for programming instructions. NOTE: To change the alarm function, see parm #320.
320 *	None	0–3	**HVAC Input Alarm:** Controls the enabling of this alarm, and the type of sound. This alarm sounds when either the Recirc Mode Engaged (parm #318) or Provide Fresh Air (parm #319) alert screens come on. For programming instructions, see parm #317.
321 *	None	0–3	**Door Open, Headlights On, Ignition Off Alarm:** Controls the enabling of this alarm, and the type of sound: continuous buzzing (type 1), steady pulsing (type 2), or programmable pulsing (type 3). This alarm sounds when the door is open or the headlights are on, but the ignition keyswitch is turned OFF. See parm #320 for programming instructions.
322 †	None	0–3	**Engine Protection Alarm:** Controls the enabling of this alarm, and the type of sound. This alarm sounds when the engine protection light comes on. For programming instructions, see parm #317.

* No access by users to parms #317, 319, #320, or #321

† Authorization required

Table 4, Alert Screen and Alarm Parameters (parms #317-322)

Alert Screen and Alarm Parameter Changing, Level III ICU

Alert Screen and Alarm Parameters *			
Parm	**Units**	**Range**	**Description and Explanation of Screen**
323 *	None	0–3	**Low Air Alarm:** Controls the enabling of this alarm, and the type of sound. This alarm sounds when the air pressure drops below the minimum.
		0=Off	Enter "0" (zero). The alarm function is disabled (it does not sound).
		1	Enter "1." The alarm sounds continuously until the problem is corrected.
		2	Enter "2." The alarm pulses steadily until the problem is corrected.
		3	Enter "3." The alarm pulses according to a programmed pattern until the problem is corrected. NOTE: To change the programmable pulsing function, see parm #325.
324	None	0–3	**Alarm Enable:** Controls the enabling of this alarm, and the type of sound: continuous buzzing (type 1), steady pulsing (type 2), or programmable pulsing (type 3). This is an optional alarm function. For programming instructions, see parm #323.
325	Sec	0–15	**Alarm Pulsing:** Controls the number of seconds each alarm pulse lasts when the type 3 alarm is selected.
		0=Off	Enter "0" (zero). The type 3 (programmable) alarm function is disabled (this does not affect the other two types of alarm function).
		1–15	Enter any number between "1" and "15." The alarm remains ON for that number of seconds during each pulse.
326 *	Sec	0–15	**Set Screen Blinking Time:** Controls the blinking rate of screen displays.
		0=Off	Enter "0" (zero). Blinking is disabled (no screen displays blink).
		1–15	Enter any number between "1" and "15." The screen displays for one-half that number of seconds. For example, if the blinking time is set to "3," blinking displays will blink every 1.5 seconds.

* No access by users to parm #323 or #326

Table 5, Alert Screen and Alarm Parameters (parms #323-326)

Configuration Parameter Changing, Level III ICU

IMPORTANT: The level III ICU is also known (on ServiceLink) as the ICU2M.

The parameters in this subject are used to control the configuration of the screens as they are displayed by the level III ICU.

To change configuration parameters (parms), display the parameter table in ServiceLink. Using one of the tables listed below, enter the desired range setting in the "Value" column in the parameter table.

NOTE: Not all parameters can be changed by every user. Some cannot be changed by users at all. Others require authorization. These files display in different colors on the ServiceLink screen and are designated by footnotes in the text.

Configuration Parameters *			
Parm	**Units**	**Range**	**Description**
400 *	None	12 bits	**Input Software Version Number:** Allows the input of the software version number installed in the ICU. This is a data input parameter. Enter the software version number.
401 †	None	17 bits	**Input Vehicle ID Number:** Allows the input of the vehicle identification number. This is a data input parameter. Enter the vehicle identification number.
402 *	None	21 bits	**Input Century Class ICU Part Number:** Allows the input of the ICU part number. This is a data input parameter. Enter the ICU part number.
403 *	None	64 bits	**Input ICU Password:** Allows the input of the ICU password. This is a data input parameter. Enter the ICU password.
404	None	0 or 128 *0=Off* *128*	**Engine:** Enables the ICU to look for an electronic engine control module (ECM) installed on the vehicle and responding to the data link. Enter "0" (zero) if no ECM is installed. Enter "128" if an ECM is installed.
405	None	0 or 232 *0=Off* *232*	**SPACE:** Enables the ICU to look for a seat-belt pre-tensioning system (SPACE) installed on the vehicle and responding to the data link. Enter "0" (zero) if no SPACE system is installed. Enter "232" if a SPACE system is installed.
406	None	0 or 219 *0=Off* *219*	**VORAD®:** Enables the ICU to look for an Eaton® VORAD collision avoidance system installed on the vehicle and responding to the data link. Enter "0" (zero) if no collision avoidance system is installed. Enter "219" if a collision avoidance system is installed.
407	None	0 or 136 *0=Off* *136*	**ABS:** Enables the ICU to look for an antilock brake system installed on the vehicle and responding to the data link. Enter "0" (zero) if no antilock brake system is installed. Enter "136" if an antilock brake system is installed.
408	None	0 or 150 *0=Off*	**ECAS:** Enables the ICU to look for an electronic suspension installed on the vehicle and responding to the data link. Enter "0" (zero) if no electronic suspension is installed.

Configuration Parameter Changing, Level III ICU

Configuration Parameters *			
Parm	**Units**	**Range**	**Description**
		150	Enter "150" if an electronic suspension is installed.

* No access by users to parms #400, #402, or #403

† Authorization required

Table 1, Configuration Parameters (parms #400-408)

Configuration Parameters *			
Parm	**Units**	**Range**	**Description**
409	None	0 or 190	**ACPU:** Enables the ICU to look for an air conditioning protection unit installed on the vehicle and responding to the data link.
		0=Off	Enter "0" (zero) if no air conditioning protection unit is installed.
		190	Enter "190" if an air conditioning protection unit is installed.
410	None	0 or 130	**Transmission:** Enables the ICU to look for an electronic transmission installed on the vehicle and responding to the data link.
		0=Off	Enter "0" (zero) if no electronic transmission is installed.
		130	Enter "130" if an electronic transmission is installed.
411	None	0,181 or 231	**Communications:** Enables the ICU to look for a communications system installed on the vehicle and responding to the data link.
		0=Off	Enter "0" (zero) if no communications system is installed.
		181	Enter "181" if a Qualcomm® satellite communications system is installed.
		231	Enter "231" if a HighwayMaster® communications system is installed.
413	None	0 or 179	**Data Logging Unit:** Enables the ICU to look for a data logging unit installed on the vehicle and responding to the data link.
		0=Off	Enter "0" (zero) if no data logging unit is installed.
		179	Enter "179" if a data logging unit is installed.
415 †	None	0–866	**Gauge Function DR001:** Specifies a gauge function at this location.
		0=Off	Enter "0" (zero) if no gauge is installed at gauge location DR001.
		810–866	Enter any number between "810" and "866" that corresponds to the assignment number of the gauge installed at this location. For example, if the engine oil pressure gauge is installed here, enter "852."
416 †	None	0–866	**Gauge Function DR002:** Specifies a gauge function at this location.
		0=Off	Enter "0" (zero) if no gauge is installed at gauge location DR002.
		810–866	Enter any number between "810" and "866" that corresponds to the assignment number of the gauge installed at this location. For example, if the coolant temperature gauge is installed here, enter "856."
417 †	None	0–866	**Gauge Function DR003:** Specifies a gauge function at this location.
		0=Off	Enter "0" (zero) if no gauge is installed at gauge location DR003.
		810–866	Enter any number between "810" and "866" that corresponds to the assignment number of the gauge installed at this location. For example, if the engine oil temperature gauge is installed here, enter "854."
418 †	None	0–866	**Gauge Function DR004:** Specifies a gauge function at this location.

Configuration Parameters *			
Parm	**Units**	**Range**	**Description**
		0=Off	Enter "0" (zero) if no gauge is installed at gauge location DR004.
		810–866	Enter any number between "810" and "866" that corresponds to the assignment number of the gauge installed at this location. For example, if the voltmeter is installed here, enter "836."

* All parameters in this table are accessible to users

† Authorization required

Table 2, Configuration Parameters (parms #409-418)

Configuration Parameters *			
Parm	**Units**	**Range**	**Description**
419 †	None	0–866	**Gauge Function DR005:** Specifies a gauge function at this location.
		0=Off	Enter "0" (zero) if no gauge is installed at gauge location DR005.
		810–866	Enter any number between "810" and "866" that corresponds to the assignment number of the gauge installed at this location. For example, if the turbo air pressure gauge is installed here, enter "842."
420 †	None	0–866	**Gauge Function DR006:** Specifies a gauge function at this location.
		0=Off	Enter "0" (zero) if no gauge is installed at gauge location DR006.
		810–866	Enter any number between "810" and "866" that corresponds to the assignment number of the gauge installed at this location. For example, if the pyrometer is installed here, enter "858."
421 †	None	0–866	**Gauge Function DR007:** Specifies a gauge function at this location.
		0=Off	Enter "0" (zero) if no gauge is installed at gauge location DR007.
		810–866	Enter any number between "810" and "866" that corresponds to the assignment number of the gauge installed at this location. For example, if the tachometer is installed here, enter "812."
422 †	None	0–866	**Gauge Function DR008:** Specifies a gauge function at this location.
		0=Off	Enter "0" (zero) if no gauge is installed at gauge location DR008.
		810–866	Enter any number between "810" and "866" that corresponds to the assignment number of the gauge installed at this location. For example, if the speedometer is installed here, enter "810."
423 †	None	0–866	**Gauge Function DR009:** Specifies a gauge function at this location.
		0=Off	Enter "0" (zero) if no gauge is installed at gauge location DR009.
		810–866	Enter any number between "810" and "866" that corresponds to the assignment number of the gauge installed at this location. For example, if the primary air system pressure gauge is installed here, enter "840."
424 †	None	0–866	**Gauge Function DR010:** Specifies a gauge function at this location.
		0=Off	Enter "0" (zero) if no gauge is installed at gauge location DR010.
		810–866	Enter any number between "810" and "866" that corresponds to the assignment number of the gauge installed at this location. For example, if the secondary air system pressure gauge is installed here, enter "840."
425 †	None	0–866	**Gauge Function DR011:** Specifies a gauge function at this location.
		0=Off	Enter "0" (zero) if no gauge is installed at gauge location DR011.
		810–866	Enter any number between "810" and "866" that corresponds to the assignment number of the gauge installed at this location. For example, if the fuel level gauge is installed here, enter "844."

Configuration Parameter Changing, Level III ICU

Configuration Parameters *			
Parm	**Units**	**Range**	**Description**
426 †	None	0–866	**Gauge Function DR012:** Specifies a gauge function at this location.
		0=Off	Enter "0" (zero) if no gauge is installed at gauge location DR012.
		810–866	Enter any number between "810" and "866" that corresponds to the assignment number of the gauge installed at this location. For example, if the transmission fluid temperature gauge is installed here, enter "864."

* All parameters in this table are accessible to users

† Authorization required

Table 3, Configuration Parameters (parms #419-426)

Configuration Parameters *			
Parm	**Units**	**Range**	**Description**
427 †	None	0–866	**Gauge Function DR013:** Specifies a gauge function at this location.
		0=Off	Enter "0" (zero) if no gauge is installed at gauge location DR013.
		810–866	Enter any number between "810" and "866" that corresponds to the assignment number of the gauge installed at this location. For example, if the forward (or rear) axle temperature gauge is installed here, enter "866."
428 †	None	0–866	**Gauge Function DR014:** Specifies a gauge function at this location.
		0=Off	Enter "0" (zero) if no gauge is installed at gauge location DR014.
		810–866	Enter any number between "810" and "866" that corresponds to the assignment number of the gauge installed at this location. For example, if the rear (or forward) axle temperature gauge is installed here, enter "866."
429 †	rpm	0–999	**Starter Lockout Rpm:** Specifies the engine speed in revolutions per minute (rpm) required to lock out the starter.
		0=Off	Enter "0" (zero) if no starter lock-out is desired.
		1–999	Enter any number between "1" and "999" that corresponds to the engine rpm required to lock out the starter. For example, if the starter is to be locked out at 500 rpm, enter "500."
430 †	sec	0–254	**Starter Lockout Time:** Specifies the number of seconds that engine speed must remain above the rpm value specified in parm #429 before the starter is locked out.
		0=Off	Enter "0" (zero) if no starter lock-out is desired.
		1–254	Enter any number between "1" and "254" that corresponds to the number of seconds that the engine rpm must remain above the value required to lock out the starter. For example, if the starter is to be locked out five seconds after engine rpm has remained above the specified value, say 500 rpm, enter "5."
431 †	sec	0–180	**Ignition Keyswitch Illumination:** Specifies the length of time the ignition keyswitch remains lit after the driver's door is opened or the switch is turned OFF.
		0=Off	Enter "0" (zero) if no ignition keyswitch illumination is desired.
		1–180	Enter any number between "1" and "180" that corresponds to the number of seconds that the ignition keyswitch remains lit. For example, if the switch is to be remain lit for 30 seconds, enter "30."
432 *	Sec	0–15	**Bulb Check Time On:** Controls the number of seconds that the bulbs illuminate during the "Ignition ON" sequence.
		0=Off	Enter "0" (zero). This function is disabled (the bulbs do not illuminate).

Configuration Parameters *			
Parm	**Units**	**Range**	**Description**
		1-15	Enter any number between "1" and "15." The bulbs illuminate for that number of seconds.
433 *	Min	0–254	**Dash Active After Ignition Off:** Controls the number of minutes that the dash continues to remain active after the ignition keyswitch is turned OFF.
		0	Enter "0" (zero). When the ignition keyswitch is turned off, the dash turns inactive immediately.
		1–254	Enter any number between "1" and "254." After the ignition keyswitch has been turned off, the dash continues to remain active for that number of minutes.
			NOTE: The dash will appear to be turned off, even though the microprocessor remains active to perform these functions: door open, parking brake off (as enabled by parm #211); alarm (as enabled by various parms).

* No access by users to parms #432 or #433

† Authorization required

Table 4, Configuration Parameters (parms #427-433)

Configuration Parameters *			
Parm	**Units**	**Range**	**Description**
434 *	Sec	0–7	**Alarm Check On Time:** Controls the number of seconds that the alarm sounds during the "Ignition ON" sequence.
		0=Off	Enter "0" (zero). The alarm does not sound at all.
		1–7	Enter any number between "1" and "7." The alarm sounds for that number of seconds.
435 †	Volts	5–135	**Low Voltage Warning Threshold:** Controls the voltage required to trigger the display of the "Warning–Low Voltage" screen.
			Enter any number between "5" and "135." The low voltage warning comes on when the voltage equals one-tenth that amount. For example, if this parameter is set to "115," the warning comes on at 11.5 volts.
436 †	Miles	0–254	**Maintenance Interval, Miles:** Controls the spacing of service intervals, in units of 50 miles, for tracking by the ICU in the event that the service interval screens are activated.
		0=Off	Enter "0" (zero). This function is disabled (the service intervals are not tracked by the ICU).
		1-254	Enter any number between "1" and "254." The service intervals are tracked at a spacing of 50 times that number of miles.
437 †	Miles	0–254	**Maintenance Screen Activation, Miles:** Controls the distance in miles from the next service at which the service information screens activate.
		0=Off	Enter "0" (zero). This function is disabled (the service information screens do not activate).
		1-254	Enter any number between "1" and "254." The service information screens activate at that number of miles. For example, to activate the service information screens 100 miles before the next service, enter "100."
438 †	Hours	0–254	**Maintenance Interval, Hours:** Controls the spacing of service intervals, in units of 150 hours, for tracking by the ICU in the event that the service interval screens are activated.
		0=Off	Enter "0" (zero). This function is disabled (the service intervals are not tracked by the ICU).
		1-254	Enter any number between "1" and "254." The service intervals are tracked at a spacing of 10 times that number of hours.
439 †	Hours	0–254	**Maintenance Screen Activation, Hours:** Controls the time in hours from the next service at which the service information screens activate.

Configuration Parameter Changing, Level III ICU

Configuration Parameters *			
Parm	**Units**	**Range**	**Description**
		0=Off	Enter "0" (zero). This function is disabled (the service information screens do not activate).
		1-254	Enter any number between "1" and "254." The service information screens activate at that number of hours. For example, to activate the service information screens 20 hours before the next service, enter "20."
440 *	None	1–254	**Short Term Fuel Economy Average Coefficient:** On the mpg bar graph display (see parm #6), controls the amount of filtering done to the fuel economy data. Enter any number between "1" and "254." A lower number provides more filtering (a less responsive, slower to change graph). A higher number provides less filtering (a more responsive, faster to change graph).

* No access by users to parms #434 or #440

† Authorization required

Table 5, Configuration Parameters (parms #434-440)

Configuration Parameters *			
Parm	**Units**	**Range**	**Description**
441 *	None	1–254	**Fuel Economy Rate of Change Coefficient:** On the mpg bar graph display (see parm #6), controls the amount of filtering done to the rate of change calculated by comparing current fuel usage to previous usage. Enter any number between "1" and "254." A lower number provides more filtering (a less responsive, slower moving graph). A higher number provides less filtering (a more responsive, faster moving graph).
442 *	Mpg	1–254	**Target Miles Per Gallon (Mpg):** On the mpg bar graph display (see parm #6), controls the value used for the target mpg. Enter any number between "1" and "254." The target mpg equals one-tenth (0.1) of that number. For example, to set the target mpg at 10.5, enter "105."
443 †	Min	0–15	**Turn Signal Warning Activation Time:** Controls how long the turn signals have to remain ON before the buzzer warning activates and the dash driver display shows the "Warning–Turn Signal ON" screen.
		0=Off	Enter "0" (zero). The warning does not activate (it does not come on at all).
		1–15	Enter any number between "1" and "15." The warning activates, but only after that number of minutes has elapsed. NOTE: If both parm #113, turn signal activation time, and parm #114, turn signal activation distance, are turned on, the turn signal warning is activated by whichever condition becomes active first.
444 †	Miles	0–15	**Turn Signal Warning Activation Distance:** Controls how far the vehicle has to travel with the turn signals ON before the buzzer warning activates and the dash driver display shows the "Warning–Turn Signal ON" screen.
		0=Off	Enter "0" (zero). The warning does not activate (it does not come on at all).

Configuration Parameters *			
Parm	**Units**	**Range**	**Description**
		1–15	Enter any number between "1" and "15." The warning activates, but only after the vehicle has traveled one-tenth that number of miles. For example, if "5" is entered, the turn signal warning activates after the vehicle has traveled 0.5 (one-half) mile. NOTE: If both parm #113, turn signal activation time, and parm #114, turn signal activation distance, are turned on, the turn signal warning is activated by whichever condition becomes active first.

* No access by users to parms #441 or #442

† Authorization required

Table 6, Configuration Parameters (parms #441-444)

Gauge Assignment Numbers		
Value	**Function**	**Default Location**
0	Gauge Off	—
810	Speedometer	DR008
812	Tachometer	DR007
836	Voltmeter	DR004
838	Application Air Pressure	None
840	Primary Air System Pressure	DR009
	Secondary Air System Pressure	DR010
842	Turbo Air Pressure	DR005
843	Fuel Pressure	None
844	Fuel Level	DR011
	Second Fuel Level	None
852	Engine Oil Pressure	DR001
854	Engine Oil Temperature	DR003
856	Engine Coolant Temperature	DR002
858	Pyrometer	DR006
864	Transmission Fluid Temperature	DR012
866	Forward-Rear Axle Temperature	DR013
	Rearmost Axle Temperature	DR014

Table 7, Gauge Assignment Numbers

Troubleshooting

The instrumentation control unit (ICU) receives messages and faults transmitted by other ECUs on the J1587 datalink.

NOTE: There are also some warnings that are controlled by sensor inputs to the ICU.

The ICU presents this information to the operator or service technician in the form of alert screens (when the vehicle is moving), diagnostic information data screens (when the vehicle is not moving), or active fault screens.

IGNITION SEQUENCE

When the ignition switch is turned ON, the ICU performs an ignition sequence. The electronically driven gauges sweep from zero to full scale and then back to zero. The parking brake and low air pressure warning/indicator lights also activate for a certain number of seconds (the number of seconds can be programmed).

NOTE: The battery voltage, primary air, and secondary air gauges are not electronically driven and do not sweep.

During the ignition sequence, the ICU monitors and records any active vehicle electronic system fault codes transmitted on the datalink by other Electronic Control Units (ECUs). The ICU stores a maximum of 16 active fault codes (eight each for the ICU and for other vehicle systems). The ICU will store these active faults in memory until one of the following happens:

- The ignition switch is turned OFF or;
- The ICU receives a "DIAGNOSTIC CLEAR" message and the ECU stops transmitting the fault code.

The ICU can store eight ICU system historic, or inactive, fault codes. Clear ICU system historic fault codes with the SET/RESET keypad key or with ServiceLink.

SYSTEM FAULT ANALYSIS

When displaying fault codes, the ICU uses four kinds of code groups:

- Module Identifiers (MIDs)
- Parameter Identifiers (PIDs)
- Sub-System Identifiers (SIDs)
- Failure Mode Identifiers (FMIs)

For lists of MIDs, PIDs, SIDs, and FMIs, see Section 54.03, **Specifications 400**. For more information on these code groups and how to read them, see "Fault Codes" in this subject.

To correct an active fault, see the following sources:

- Engine ECM (MID 128)—use the engine manufacturer's literature.
- ABS ECU (MID 136)—see **Section 42.08** or use the antilock brake system manufacturer's literature.
- ICU (MIDs 140, 142, and 234)—see this section.
- DLU (MID 179)—see **Section 54.06**.
- ACPU (MID 190)—see **Section 83.02**.

IMPORTANT: To begin troubleshooting active fault codes, do not turn the ignition switch OFF and then ON. It is not uncommon for a fault to disappear when ignition power is removed, only to return again when the vehicle has left the shop.

1. Correct the active fault.
2. To verify that the problem is corrected and that the fault code is no longer displayed as active, turn the ignition switch OFF and then ON.
3. Start the vehicle.

NOTE: In some cases, it may be necessary to drive the vehicle to confirm that a fault has been repaired.

DATALINK ACTIVITY

1. If the alert message "NO DATALINK ACTIVITY" is displayed, check the J1587 datalink wiring (twisted pairs).
2. Verify that all ECUs are connected.
3. Verify that the ECU J1587+ is connected to the datalink J1587+ and that ECU J1587– is connected to datalink J1587–.

GAUGES

Gauge Does Not Sweep

NOTE: This section applies only to electronic gauges; the air gauges and voltmeter do not sweep.

If a particular gauge does not sweep during the ignition sequence, there is a problem either with the gauge or the ICU.

1. Turn the gauge counterclockwise and remove it from the ICU housing.
2. Install a gauge known to be good and repeat the ignition sequence.
3. If the test gauge sweeps full scale and back to zero, replace the original gauge with a new one. For replacement instructions, see Section 54.03, **Subject 110**.
4. If the test gauge does not sweep, replace the ICU. For replacement instructions, see **Subject 100**.

NOTE: If the ICU has failed, replace the complete ICU housing. Remove all gauges, the message center bezel, and the wood grain panel. Install these parts in the new ICU housing.

Gauge Does Sweep

If a gauge malfunctions but sweeps during the ignition sequence, the ICU is not at fault.

1. Check the circuits that supply input signals to the ICU.
2. Check the engine ECM programming.

NOTE: Use the technician diagnostic routine (TDR), provided with ServicePro, to help determine the cause of the problem.

WARNING/INDICATOR LIGHTS

Light Does Not Illuminate

The parking brake and low air pressure warning/indicator lights should illuminate during the ignition sequence.

IMPORTANT: The following lights do not illuminate during the ignition sequence:

A. ENG PROT indicator light input WL002

B. CHK ENG indicator light input WL003

C. STOP ENG indicator light input WL007 (used on Cummins engines only)

D. TRAC ABS indicator light input WL011

If a warning/indicator light other than those listed above does not illuminate during the ignition sequence, either the light bulb is bad or the ICU is malfunctioning. Replace the light bulb with a test bulb known to be good and repeat the ignition sequence.

1. Remove the message center bezel and replace the bulb with a test bulb. Use the bulb replacement tool provided.
2. If the test bulb lights, replace the original bulb with a new one. For replacement instructions, see Section 54.03, **Subject 120**.

   If the test bulb does not light, replace the ICU. For replacement instructions, see **Subject 100**.

Light Illuminates

If a warning/indicator light malfunctions but illuminates during the ignition sequence, the ICU is not at fault.

1. Check the circuits that supply input signals to the ICU. These lights are activated by either a 12V power input or a ground input.
2. Check the ECU programming corresponding to the light.

NOTE: Use the technician diagnostic routine (TDR), provided with ServicePro, to help determine the cause of the problem.

BUZZER

Buzzer Does Not Operate

If the buzzer does not activate during the ignition sequence, either the buzzer or the ICU is malfunctioning. The buzzer is mounted behind the tachometer.

1. Install a buzzer known to be good and repeat the ignition sequence.
2. If the test buzzer functions, replace the original buzzer with a new one. For replacement instructions, see Section 54.03, **Subject 130**.

If the test buzzer does not function, replace the ICU. For replacement instructions, see **Subject 100**.

Buzzer Does Operate

If the buzzer operates during the ignition sequence but does not work properly for another function, there is a problem with the ICU configuration or with ICU input circuits.

1. Check the ICU parameter (buzzer functions) configuration with ServiceLink. For more information, see Section 54.03, **Subject 180**.
2. Check the circuits that supply input signals to the ICU.
3. Check the ECU programming corresponding to the buzzer function.

DASH DRIVER DISPLAY SCREEN

Screen Does Not Activate

If the dash driver display screen does not activate during the ignition sequence, either the display screen itself or the ICU is malfunctioning. The dash driver display screen is mounted behind the message center bezel.

1. Install a dash driver display screen known to be good and repeat the ignition sequence.
2. If the test screen functions, replace the original dash driver display screen with a new one. For replacement instructions, see Section 54.03, **Subject 140**.

   If the test screen does not function, replace the ICU. For replacement instructions, see **Subject 100**.

Screen Does Activate

If the dash driver display screen operates during the ignition sequence, but does not work properly for another function, then there is a problem in the ICU configuration or the keypad, or the ICU is faulty.

1. Check the ICU parameter configuration (screen display functions) with ServiceLink.
2. Verify that the ICU parameter that controls the screen function which is having the problem is configured correctly.
3. If the parameter value is incorrect, change the parameter value and enable the screen function. For more information, see Section 54.03, **Subject 170** or **Subject 200**. For screen functions controlled by the right-hand ICU microprocessor, see Section 54.03, **Subject 220**.
4. Check the keypad connection to the wiring harness and repair the circuit if necessary.
5. If the keypad to wiring harness connection is good, replace the keypad. For replacement instructions, see Section 54.03, **Subject 150**.

ICU SMALL GAUGES

The oil pressure, coolant temperature, oil temperature, and turbo air pressure gauges are driven electronically by the ICU using data inputs from the engine ECM. The ICU receives digital data from the engine ECM via the J1587 datalink.

1. To determine whether the fault lies in the ICU or the gauge input circuits, use the "Gauges" procedure above.
2. If the problem is found to be in the ICU, replace the ICU. For replacement instructions, see **Subject 100**.

   If the problem is found to be elsewhere, use ServiceLink, or the engine manufacturer's diagnostic software tool, and determine if there is an active engine ECM fault code related to the problem.
3. If an active fault code is displayed, follow the engine manufacturer's instructions to correct the problem.

   If no active fault code is displayed, check the datalink connection from the engine ECM to the ICU.
4. Check the datalink for cross-wired connections from all ECUs.

VOLTMETER

The voltmeter is driven by the voltage input to the ICU. The voltmeter should function with the ignition switch in the ON position.

1. Replace a problem gauge with a test gauge known to be good and turn the ignition ON.
2. If the test gauge indicates 11 to 14V, replace the original gauge with a new one.

If the test gauge indicates lower than 11V or higher than 14V, check input voltages to the ICU connector as follows:

2.1 Check the 12V battery circuit: pin D14 and wire 437.

2.2 Check the 12V ignition circuit: pin D15 and wire 437A.

2.3 Check the ground circuit: pin D13 and wire GND1.

3. Troubleshoot and repair any of the above circuits that shows a malfunction.

   If all the circuits above are functioning, replace the ICU. For replacement instructions, see **Subject 100**.

PYROMETER

The pyrometer is electronically driven by the ICU. The pyrometer input circuit to the ICU contains a thermocouple mounted on the turbocharger exhaust port and a thermocouple amplifier module (TAM). The thermocouple senses the exhaust temperature and sends a small voltage signal to the TAM. The TAM amplifies this voltage signal by a factor of 100 (typically 0 to 8 VDC) and sends it on to the ICU. The ICU receives the analog voltage signal from the TAM and converts it to the digital signal that drives the pyrometer.

1. To determine whether the fault lies in the ICU or the gauge input circuits, use the "Gauges" procedure above.

2. If the problem is found to be in the ICU, replace the ICU. For replacement instructions, see **Subject 100**.

   If the problem is found to be in the gauge input circuits, check for 12 VDC of ignition power at the vehicle side connector to the TAM (circuit 218). The TAM is located just above the right-hand wheel well. Repair a malfunctioning circuit if necessary.

3. Warm up the engine fully so that the thermocouple reaches operating temperature. Then shut down the engine and turn the ignition back on.

NOTE: Do not measure voltage using chassis ground as a reference.

4. Check the voltage output signal of the TAM.

   Example: At 300°F (150°C) = 5.14 VDC (acceptable); at 480°F (250°C) = 9.16 VDC (unacceptable).

   NOTE: To measure TAM output voltage, gain access the circuits at the right-hand wheel well or at the ICU connector pin C6 (218A+) and pin D6 (218A–).

   4.1 Check between circuits 218A+ (positive lead) and 218A– (negative lead). Voltage should be 4 to 8 VDC, depending on temperature.

   4.2 If this measurement is not within the tolerances, then either the TAM or the thermocouple is malfunctioning.

NOTE: The TAM's output should be 100 times greater than the thermocouple output (TAM output = 5.14 VDC, thermocouple output = .0514 VDC).

NOTE: Do not measure voltage using chassis ground as a reference.

5. Check the voltage output signal of the thermocouple.

   Example: At 300°F (150°C) = 0.0514 VDC (acceptable); at 480°F (250°C) = 0.0916 VDC (unacceptable).

   NOTE: To measure thermocouple output voltage, gain access to the circuits at the right-hand wheel well.

   5.1 Check the voltage between circuits. The voltage should be between 0.04 and 0.08 VDC.

   5.2 If this measurement is out of tolerance, the thermocouple is malfunctioning. Replace a malfunctioning thermocouple as required.

   If this measurement is within tolerance, but the measurement in the previous step was out of tolerance, the TAM is malfunctioning. Replace a malfunctioning TAM as required.

6. Check the circuits from the TAM to the ICU.

   6.1 Check for continuity between circuit 218A+ and ICU left-hand connector pin C6.

6.2 Check for continuity between circuit 218A– and pin D6.

6.3 Repair a malfunctioning circuit if necessary.

TRANSMISSION TEMPERATURE GAUGE

The transmission temperature gauge is electronically driven by the ICU. The ICU input circuit contains a temperature sensor (thermistor) mounted in the transmission housing. The sensor causes a voltage drop across its leads corresponding to the transmission temperature. The ICU measures the voltage drop and converts it to a digital signal, which drives the electronic transmission temperature gauge.

1. To determine whether the fault lies in the ICU or the gauge input circuits, use the "Gauges" procedure above.
2. If the problem is found to be in the ICU, replace the ICU. For replacement instructions, see **Subject 100**.

   If the problem is found to be in the gauge input circuits, check the resistance of the temperature sensor at the transmission. The resistance between the two sensor pins is typically 5250 ohms to 172 ohms. Replace the sensor if necessary.

   Examples: At 32°F (0°C) = 5250 ohms; at 77°F (25°C) = 5000 ohms.
3. Check the continuity of the sensor-to-ICU circuits on the ICU connector. Repair a malfunctioning circuit if necessary.

   3.1 Check for continuity between wire 30 and pin C12.

   3.2 Check for continuity between wire 30G and pin C13.

DRIVE AXLE TEMPERATURE GAUGES

The temperature gauges for the forward-rear and rearmost drive axles are electronically driven by the ICU. The input circuits to the ICU contain temperature sensors (thermistors) mounted in the drive axle housings. The sensor causes a voltage drop across its leads corresponding to the axle temperature. The ICU measures the voltage drop and converts it to a digital signal, which drives the electronic gauges.

1. To determine whether the fault lies in the ICU or the gauge input circuits, use the "Gauges" procedure above.
2. If the problem is found to be in the ICU, replace the ICU. For replacement instructions, see **Subject 100**.

   If the problem is found to be in the gauge input circuits, check the resistance of the rear axle temperature sensors. The resistance between the two sensor pins is typically 5250 ohms to 172 ohms. Replace the sensor if necessary.

   Examples: At 32°F (0°C) = 5250 ohms; at 77°F (25°C) = 5000 ohms.
3. Check the continuity of the circuits from the forward-rear drive axle sensors to the ICU connector. Repair a malfunctioning circuit if necessary.

   3.1 Check for continuity between wire 42 and pin A10.

   3.2 Check for continuity between wire 42G and pin A11.
4. Check the continuity of the circuits from the rearmost drive axle sensors to the ICU connector. Repair a malfunctioning circuit if necessary.

   4.1 Check for continuity between wire 43 and pin B2.

   4.2 Check for continuity between wire 43G and pin B4.

OUTSIDE AMBIENT AIR TEMPERATURE CIRCUIT

A temperature sensor (thermistor) is mounted under the front bumper step. The sensor sends a resistance value corresponding to the outside air temperature to the ICU, which converts it to a digital signal. The ICU uses this digital signal to display the outside ambient air temperature on the dash driver display, when the TEMP key is pressed on the keypad.

1. Turn the ignition switch to the ON position and push the TEMP key on the keypad to troubleshoot the outside ambient air temperature circuit.

2. If there is an open circuit, the display will read +00. Verify that the sensor is connected.
3. Check the continuity of circuit 299 (Air Temp+) from the front bumper step to the chassis connector, and from there to the ICU connector. Repair a malfunctioning circuit if necessary.
   - 3.1 Check for continuity between the front bumper step and chassis connector pin D7.
   - 3.2 Check for continuity between chassis connector pin D7 and ICU pin C7.
4. Check the continuity of circuit 299A (Air Temp GND) from the front bumper step to the chassis connector, and from there to the ICU connector. Repair a malfunctioning circuit if necessary.
   - 4.1 Check for continuity between the front bumper step and chassis connector pin D9.
   - 4.2 Check for continuity between chassis connector pin D9 and ICU pin D7.
5. If the temperature displayed does not correspond to the air temperature, check the resistance of the temperature sensor. The resistance between the two sensor pins is typically 0.25 to 34 kilo ohms. Replace the sensor if necessary.

   Examples: At 59°F (15°C) = 1.5 to 1.6 kilo ohms; at 68°F (20°C) = 1.2 to 1.3 kilo ohms; and at 77°F (25°C) = 0.9 to 1.1 kilo ohms.

FUEL LEVEL GAUGE

The fuel level gauge is electronically driven by the ICU. The ICU input circuit contains a resistive fuel level sensor mounted in the fuel tank. The fuel level causes a voltage drop by changing the position of a float, which in turn causes the resistance to change. The ICU detects the voltage drop and converts it to a digital signal, which drives the electronic fuel level gauge.

1. To determine whether the fault lies in the ICU or the gauge input circuits, use the "Gauges" procedure above.
2. If the problem is found to be in the ICU, replace the ICU. For replacement instructions, see **Subject 100**.

   If the problem is found to be in the gauge input circuits, check the resistance of the fuel level sensor at the fuel tank. The resistance between the two sensor pins is typically 29 to 250 ohms. Replace the sensor if necessary.

   Examples: Full tank = 29 to 33.5 ohms; empty tank = 244 to 250 ohms.
3. Check the continuity of the circuits from the fuel level sensor to the ICU connector. Repair a malfunctioning circuit if necessary.
   - 3.1 Check for continuity between wire 47 and ICU pin D1.
   - 3.2 Check for continuity between wire 47G and ICU pin D2.

FAULT CODES

The ICU displays four kinds of numerical code groups for reporting faults, accompanied by a text message which describes both the failed component and the failure mode, or cause of failure.

Each fault code displayed consists of three code groups. The first code group identifies the fault transmitter. It is referred to as the module identifier (MID). For a complete list of MIDs, see Section 54.03, **Specifications 400**.

The next code group consists of three digits also. This code identifies the system in which the fault was detected. It is either the parameter identifier (PID), or the sub-system identifier (SID). For lists of PIDs and SIDs, see Section 54.03, **Specifications 400**.

Since the ICU gathers information via the J1587 datalink, any error message or warning displayed by the ICU can indicate one of two things: a fault in the vehicle system or a fault in the data. If the fault lies in a particular vehicle system, see the troubleshooting subject in the appropriate section of the workshop manual.

To help identify faults in the data, the ICU displays a two-digit code at the end of each fault message called the Failure Mode Identifier (FMI). The FMI gives information about where the fault lies. Is the circuit shorted, or open? Is the vehicle low on coolant, or is the coolant level sensor bad? For a complete list of FMIs, see Section 54.03, **Specifications 400**.

See **Table 1** for a list of Level III (ICU2M) fault codes.

Level III (ICU2M) Fault Codes			
Parameter	**Additional Information**	**J 1587 Spec.**	**MID (transmitter)**
Diagnostic Faults	Broadcast Every 15 sec. (Active)	PID 194	140
Software ID	On Request (PID 0 and 128)	PID 234	140
Component ID	On Request (PID 0 and 128)	PID 243	140
Park Brake Status	Broadcast 1.0 per sec.	PID 70	140
Brake Switch Status	Broadcast 1.0 per sec.	PID 65	140
Low Air Pressure	Broadcast 1.0 per sec.	PID 254	142
Fuel Level	Broadcast every 10 sec.	PID 96	140
Battery Voltage	Broadcast 1.0 per sec.	PID 168	140
Transmission Oil Temperature	Broadcast 1.0 per sec. *	PID 177	140
FWD Rear Axle Temperature	Broadcast 1.0 per sec. *	PID 77	140
RR Rear Axle Temperature	Broadcast 1.0 per sec. *	PID 78	140
Exhaust Gas Temperature	Broadcast 1.0 per sec. *	PID 173	140
Ambient Air Temperature	Broadcast 10.0 per sec.	PID 171	140
Odometer	Broadcast Every 10 sec.	PID 245	140
VIN	On Request (PID 0 and 128)	PID 237	140
Requests, Specific	Broadcast 1.0 per sec.	PID 128	140

* Fault messages should not be transmitted if the parameter for the gauge is not enabled.

Table 1, Level III (ICU2M) Fault Codes

Fault Code Screens

Fault code screens provide troubleshooting information in a brief, easy-to-read format. See the example in **Table 2**.

Screen Contents
ENG Coolant TEMP
Low 128x110 01 *

* x is blank for a PID, "s" for a SID.

Table 2, Level III (ICU 2M) Fault Code Screen

NOTE: The second code group in the fault code can be either a PID or a SID. To tell them apart, all SIDs are preceded by an "s" in the space between the first code group (the MID) and the second code group. If the second code group is a PID, the space is blank.

Specifications

IMPORTANT: The level III ICU is also known (on ServiceLink) as the ICU2M.

The instrumentation control unit, level III (level III ICU) has only one microprocessor, on the left. The two connectors are pink. Connector #1 has 24 pins, numbered A1 through A12, and B1 through B12. Connector #2 has 32 pins, numbered C1 through C16, and D1 through D16.

See **Fig. 1** for a schematic of the wiring and pinout connections for the level III ICU (ICU2M).

The original version of the ICU (ICU1) was installed on vehicles built before May, 1998. The level III ICU (ICU2M) is installed on vehicles built later than May, 1998.

To fully identify fault codes, see Section 54.03, **Specifications, 400**, for a complete list of parameter identifiers (PIDs), sub-system identifiers (SIDs), and failure mode identifiers (FMIs).

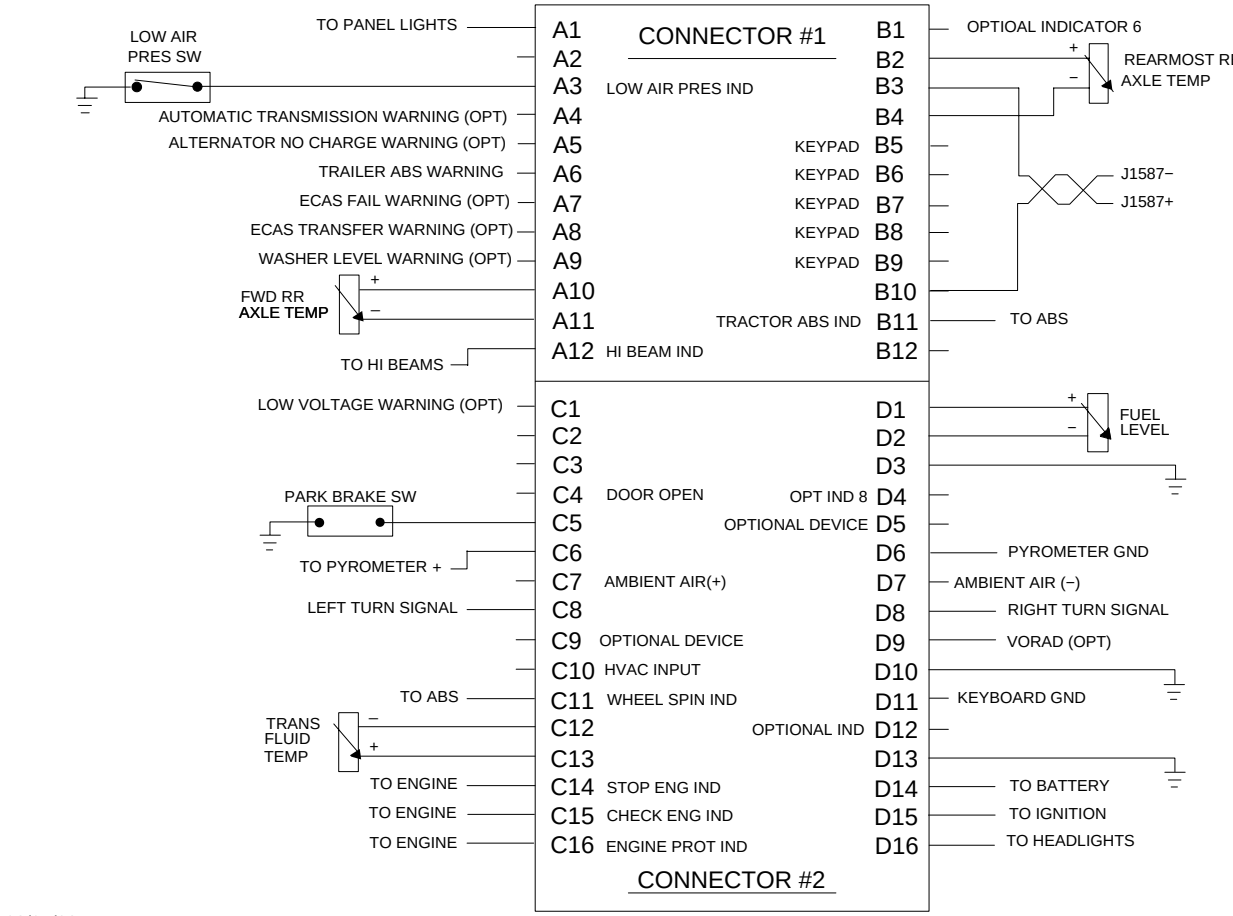
Level III ICU Connector #1 Pin Assignments, Pins A1 Through B12		
Number	**Description**	**Wire**
A1	Panel Lights	29A
A2	Event Key	442B
A3	Low Air Pressure Warning	18
A4	Automatic Transmission Temperature Warning (optional)	31
A5	Alternator No Charge Warning (optional)	137
A6	Trailer ABS Indicator (optional)	376F
A7	ECAS Failure Warning (optional)	434B
A8	ECAS Transfer Indicator (optional)	434P
A9	Washer Level Warning	320A
A10	Forward-Rear-Axle Oil Temperature Sensor (+)	42
A11	Forward-Rear-Axle Oil Temperature Sensor (–)	42G
A12	High Beam Indicator	20H
B1	Optional Indicator 6	GND
B2	Rearmost-Axle Oil Temperature Sensor (+)	43
B3	J1587 Databus (–)	1587–C
B4	Rearmost-Axle Oil Temperature Sensor (–)	43G
B5	Wire 3 (keypad)	437D
B6	Wire 2 (keypad)	437C
B7	Wire 5 (keypad)	437F
B8	Wire 1 (keypad)	437B
B9	Wire 4 (keypad)	437E
B10	J1587 Databus (+)	1587+C
B11	Tractor ABS Warning	376L

Table 1, Level III ICU Connector #1 Pin Assignments, Pins A1 through B12

Specifications

Level III ICU Connector #2 Pin Assignments, Pins C1 through D16		
Number	**Pin Assignment**	**Wire**
C1	Low Voltage Warning (optional)	19B
C4	Door Open Indicator	437W
C5	Parking Brake Switch	125
C6	Pyrometer (+)	218A+
C7	Ambient Air Sensor (+)	299
C8	Left Turn Indicator	38L
C9	Optional Device	GND
C11	Wheel Spin Indicator	376S
C12	Transmission Fluid Temperature Sensor (–)	30G
C13	Transmission Fluid Temperature Sensor (+)	30
C14	Engine Protection (CUM only)	N16
C15	Check Engine	C799
		D419
		N25
C16	Engine Shutdown	C659
		D509
		N01
D1	Fuel Level Sensor (+)	47
D2	Fuel Level Sensor (–)	47G
D3	Panel Light Ground	GND
D4	Optional Indicator 8	GND
D6	Pyrometer (–)	218A–
D7	Ambient Air Sensor (–)	299A
D8	Right Turn Signal	38R
D9	VORAD (optional)	444K
D10	EMI Ground	GND
D11	Keypad Panel GND	437G
D12	Trailer ABS Warning	376F
D13	Ground	GND
D14	Battery	437
D15	Ignition	437A
D16	Headlights	359

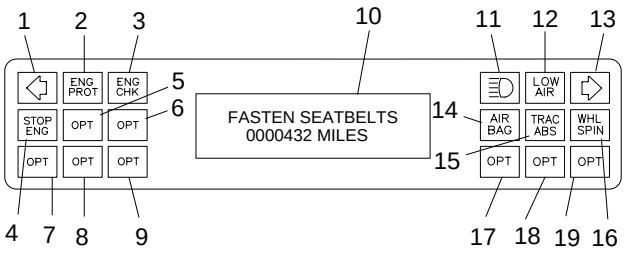
Table 2, Level III ICU Connector #2 Pin Assignments, Pins C1 through D16



NOTE: See **Fig. 2** for warning and indicator light positions.

Fig. 1, Level III ICU Pinouts (ICU2M)

Specifications



Typical installation shown. Location and function of optional lights may vary.

1. Left Turn Indicator
2. Engine Protection Warning & Indicator
3. Check Engine Indicator
4. Stop Engine Warning (Cummins engine only)
5. ECAS Failure Warning (optional)
6. ECAS Transfer Indicator (optional)
7. Trailer ABS Indicator (optional)
8. Alternator No Charge Warning (optional)
9. Transmission Temperature Warning (optional)
10. Dash Driver Display Screen
11. High Beam Indicator
12. Low Air Pressure Warning
13. Right Turn Indicator
14. Air Bag Warning (optional)
15. Tractor ABS Warning
16. Wheel Spin Indicator
17. Optional Indicator 6
18. Low Voltage Warning (optional)
19. Optional Indicator 8

Fig. 2, Driver Message Center, Level III ICU (ICU2M)

General Description

This section covers the instrumentation control unit model 3 (ICU3). It is optional on both the Argosy COE and the Century Class Conventional.

ICU3

The ICU3 is a basic electronic dashboard that accepts input from the fuel level sensor, the transmission temperature sensor (if installed), and the J1587 datalink. The information is processed by a microcomputer and displayed on electronic gauges driven by stepper motors. Only air gauges operate mechanically.

The following gauges are standard:

- Speedometer
- Tachometer
- Engine Oil Pressure Gauge
- Coolant Temperature Gauge
- Fuel Level Gauge
- Primary Air System Pressure Gauge
- Secondary Air System Pressure Gauge

The transmission fluid temperature gauge is optional, but it is required on vehicles with automatic transmissions.

The speedometer and tachometer are large-faced electronic gauges located below the driver information center. See **Fig. 1**.

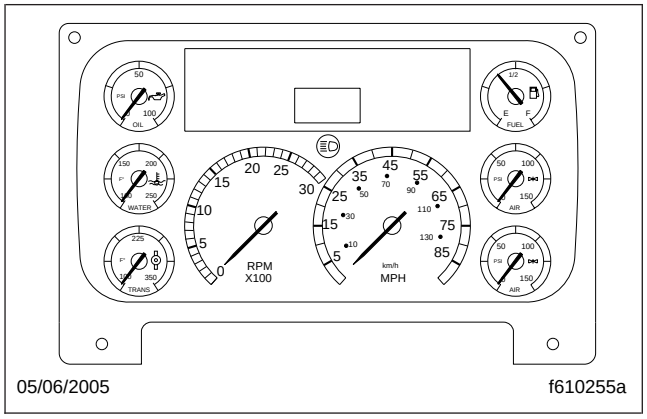


Fig. 1, ICU3

The other gauges are small-faced gauges on the driver's instrument panel, to either side of the speedometer and tachometer. The engine oil pressure, coolant temperature, transmission fluid temperature, and fuel level gauges are electronic; the two system air gauges, primary and secondary, are mechanical.

Only the air pressure gauges are replaceable in the field. The ICU3 can not drive gauges located on the auxiliary instrument panel.

Dash Message Center

The heart of the ICU3 is the dash message center. It has two parts: a set of 26 warning and indicator lights similar to those found on a conventional lightbar, and a dash driver display screen. The dash driver display screen is a 1-line by 7-character liquid crystal display (LCD) which is normally used to display the odometer reading. In addition, there is a separate voltmeter display underneath the odometer display.

The information that can be provided by the message center includes:

- odometer readings
- a listing of active faults

Mode/Reset Switch

The mode/reset switch is located on the right-hand side of the instrument cluster, if installed. See **Fig. 2**.

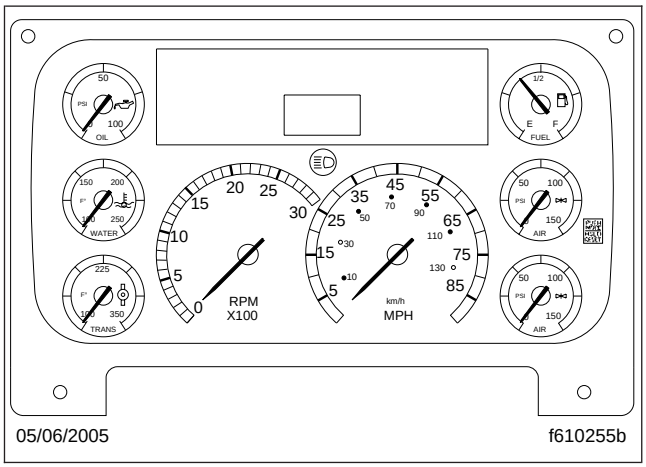


Fig. 2, ICU3 with Mode/Reset Switch

General Information

The mode/reset switch is used to scroll through the displays on the driver display screen, and to reset the trip distance and trip hours values to zero.

When the odometer reading is displayed and the parking brake is applied:

- Press the mode/reset switch once to display trip distance.
- Press the mode/reset switch a second time to display trip hours (engine hours).
- Press the mode/reset switch a third time and the SELECT screen and the current units, MI or KM, will display.
- Release the parking brake to return to the diagnostic screen.

To reset trip miles and/or trip hours to zero, press and hold the mode/reset switch for 1 second or longer. To toggle between MI (miles) or KM (kilometers), press and hold the mode/reset switch while in the SELECT screen.

The mode/reset switch can also be used to display complete fault codes for diagnostic purposes. For more information, see **Specifications, 410**.

Warning and Indicator Lights

There are spaces on the ICU3 for 26 warning and indicator lights. See **Fig. 3** for a typical installation.

There are four rows of lights. The lights in the top row are all optional and may be installed in any order, except for two lights which are typically installed at a fixed position.

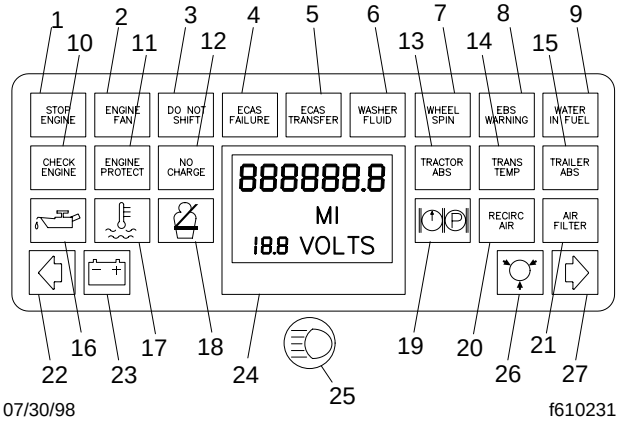
- Position 1: Stop Engine Warning (Red)—installed on vehicles with Cummins engines only
- Position 7: Wheel Spin Indicator (Amber)

NOTE: Positions 1 through 8 are ground-activated circuits; position 9 is power-activated.

On the other three rows, the lights are installed at fixed positions that do not vary. Some lights are optional; if an optional light is not requested, the position is blank (does not light up).

The following fixed-position lights are standard:

- Check Engine Indicator (Amber)
- Low Engine Oil Pressure Warning (Red)
- High Coolant Temperature Warning (Red)



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Typical installation shown. Location of legends installed in the top row may vary, and other legends may be specified.

1. Stop Engine Warning (Cummins engine only)
2. Engine Fan On Indicator (optional)
3. Do Not Shift Indicator (optional)
4. ECAS Failure Warning (optional)
5. ECAS Transfer Indicator (optional)
6. Low Washer Fluid Indicator (optional)
7. Wheel Spin Indicator (optional)
8. EBS Warning (optional)
9. Water In Fuel Indicator (optional)
10. Check Engine Indicator
11. Engine Protection Warning (optional)
12. Alternator No Charge Indicator (optional)
13. Tractor ABS Warning
14. Transmission Temperature Warning (optional)
15. Trailer ABS Warning (optional)
16. Low Engine Oil Pressure Warning
17. High Coolant Temperature Warning
18. Fasten Seat Belt Warning
19. Parking Brake On Warning
20. Recirculated Air Indicator
21. Air Restriction Indicator
22. Left Turn Signal
23. Low Battery Voltage Warning
24. Dash Driver Display Screen
25. High Beams On Indicator
26. Low Air Pressure Warning
27. Right Turn Signal

Fig. 3, Dash Message Center, ICU3

- Fasten Seat Belt Warning (Red)
- Left Turn Signal (Green)
- Low Battery Voltage Warning (Red)
- Tractor ABS Indicator (Amber)
- Parking Brake On Warning (Red)

- Recirculated Air Indicator (Amber)
- Low Air Pressure Warning (Red)
- Right Turn Signal (Green)
- High Beams On Indicator (Blue)

The following fixed-position lights are optional:

- Engine Protection Warning (Red)
- Alternator No Charge Indicator (Amber)
- High Transmission Temperature Indicator (Amber)—installed on vehicles with automatic transmissions
- Trailer ABS Indicator (Amber)—installed on vehicles designed to be used with a trailer
- Air Restriction Indicator (Amber)

The following lights are optional and their installed location may vary anywhere in the top row:

- Engine Fan On Indicator (Amber)
- Do Not Shift Indicator (Amber)
- ECAS Failure Warning (Red)
- ECAS Transfer Indicator (Amber)
- Low Washer Fluid Indicator (Amber)
- EBS (Electronic Braking System) Warning (Red)
- Water In Fuel Indicator (Amber)

All light bulbs are replaceable in the field, including gauge light bulbs and warning/indicator light bulbs.

Principles of Operation

Ignition Sequence

When the ignition keyswitch is turned on, the ICU3 runs through the ignition sequence. See **Fig. 4**. If the headlights are turned on, the screen displays the odometer and waits for the ignition to be turned on.

IMPORTANT: When the ignition keyswitch is first turned on, all the electronic gauges complete a full sweep of their dials, the warning and indicator lights light up, and the buzzer sounds for three seconds.

The following warning and indicator lights go on during the ignition sequence:

- Low Engine Oil Pressure Warning
- High Coolant Temperature Warning
- Low Air Pressure Warning
- Parking Brake On Warning
- Low Battery Voltage Indicator
- Fasten Seat Belt Warning
- All engine warning lights, including Engine Protection, Check Engine, and Stop Engine (on Cummins only)
- All ABS warning lights, including Wheel Spin, Tractor ABS, and Trailer ABS (if installed)

NOTE: Even though the engine and ABS warning lights go on during the ignition sequence, they are not controlled by the ICU3, but by their own system ECU (electronic control unit).

Once the ignition keyswitch has been turned on, the ICU performs a self-test, looking for active faults. During the first half of the self-test, all segments of the display illuminate as follows: "888888.8." During the second half of the self-test, the software revision level is displayed.

If there are no active faults, the screen displays the odometer.

If, however, the ICU3 has received active fault codes from other devices, it displays them, one after the other, until the parking brake is released or the ignition keyswitch is turned off.

The screen displays a code, called the message identifier (MID), indicating the ECU or system that is not functioning properly.

Example: If the engine or engine control unit is not functioning properly, the screen displays "ECU 128." For a complete list of possible screen displays, see **Specifications, 400**.

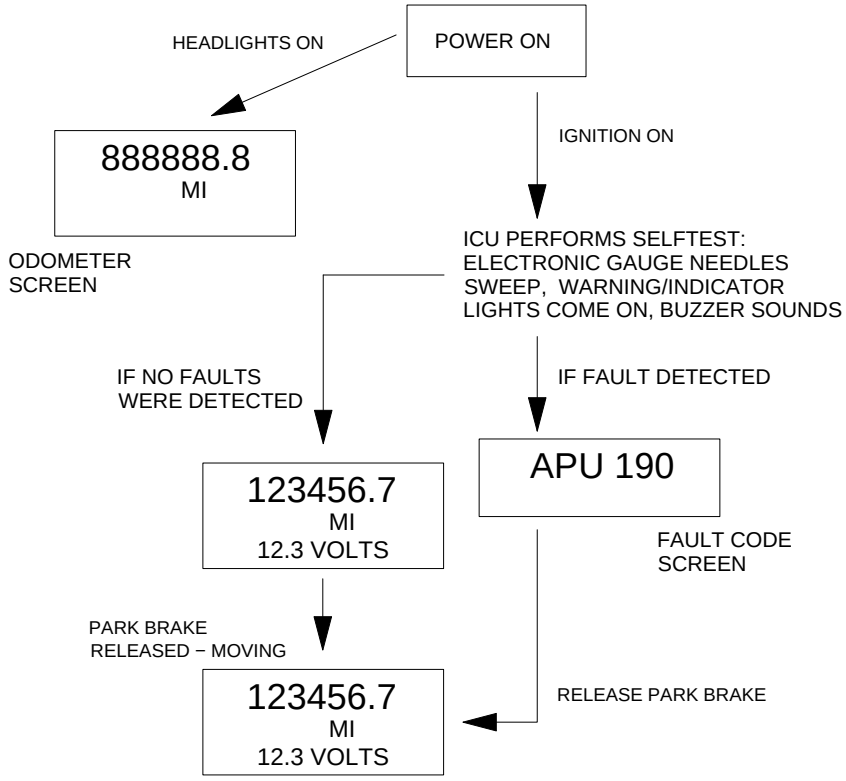
NOTE: If the ICU3 receives a message from an ECU that has not been pre-programmed into the ICU's memory, it displays "SYS MID" instead.

Once the parking brake is released, the ICU3 displays the odometer again.

Odometer

The odometer is set to display in either miles or kilometers, depending on the primary scale of the speedometer. The legend, either "MI" or "KM," illumi-

General Information



During the first half of the self-test, all segments of the display illuminate. During the second half of the self-test, the software revision level is displayed.

NOTE: If there is more than one fault, the ICU3 displays them, one after another, changing every three seconds, until the park brake is released.

Fig. 4, ICU3 Ignition Sequence

nates between the odometer and the volts display when the engine is running or the headlights are turned on.

The odometer is a seven-digit display with a decimal point, until the vehicle has traveled 999,999.9 miles or kilometers (km). At one million miles (km), the odometer resets itself to "1000000," without the decimal point, and can continue up to 9,999,999. The odometer only displays significant figures (no leading zeros).

IMPORTANT: Although the odometer uses data supplied by the engine ECU to update its count, it keeps its own mileage starting from the zero point, which marks where it was first installed.

Buzzer

The buzzer sounds during the ignition sequence and whenever one of the following conditions exists:

- The engine oil pressure falls below the preset level, which is 5 to 9 psi (35 to 60 kPa) on most engines.
- The coolant temperature rises above the preset level, which is 215°F (101°C) on Caterpillar and Detroit Diesel engines; 221°F (105°C) on Mercedes-Benz engines; and 220°F (104°C) on Cummins engines.
- The air pressure falls below the preset level, which is 44 psi (300 kPa).

- The parking brake is set with the vehicle moving at a speed greater than 2 miles per hour (3 km/h).

An optional ground-activated buzzer can be controlled by another ECU on the vehicle.

Replacement

The instrumentation control unit model 3 (ICU3) is a self-contained one-piece unit, including housing, gauges, and the dash message center. It is attached to wing panels that are fastened to the dash. See **Fig. 1**.

Air pressure gauges and light bulbs are the only components that are replaceable in the field. For air pressure gauge replacement, see **Subject 110**. For light bulb replacement, see **Subject 120**.

To replace individual switches or flipper valves, see **Section 54.03, Subject 110**.

NOTE: To remove the auxiliary instrument panel, see **Section 54.03, Subject 100**.

IMPORTANT: Before draining the air, it can be helpful to move the adjustable steering column to the lowest possible position.

1. Drain both air systems, primary and secondary.

CAUTION

Electronic components of the ICU3 are vulnerable to damage from static electricity. If available, wear a wrist grounding strap connected to a ground in the cab or workbench. If a grounding strap is not available, touch a grounded component immediately before doing any work which could bring a tool or body part in contact with ICU3 circuitry.

2. Remove the four fasteners from the corners of the bezel attached to the front of the ICU housing. See **Fig. 2**. Fasteners used on the ICU3 are Torx® T25 dog-point screws. See **Fig. 3**.

CAUTION

Do not forcibly pull the driver's panel from the dash. This may dislodge wires from the harness electrical connectors on the back of the ICU housing and damage the wires, the ICU, or the dash.

3. Pull the old ICU away from the dash. When removing the old ICU from an Argosy COE, carefully work the ICU housing free of the wing panels. Do not remove the wing panels unless they are damaged. Pull the top of the unit towards you until the back of the housing is free, then pull up to remove the rest of the unit.
4. Remove the connectors from the back of the housing.

   4.1 From behind the ICU housing, disconnect the two electrical connectors in the center of the housing.

   IMPORTANT: Bleed off all air before trying to remove the air hoses.

   4.2 Disconnect all air hoses. Using a paint pen, mark the hoses for ease of installation.
5. Remove the old ICU from the vehicle. See **Fig. 2**.
6. Install the new ICU3 on the dash. See **Fig. 2**.

   6.1 Connect the air hoses to the air gauges as marked during removal.

   6.2 Connect the two electrical connectors, as removed.

   6.3 Install the wing panels, if removed.

   6.4 Place the ICU3 in the dash and install the fasteners.
7. Turn on the ignition and test the operation of the new ICU3. All the electronic gauges should make one complete sweep and return to their normal indicating positions; the warning and indicator lights should turn on, then off. Mechanical (air) gauges do not make a sweep.

   If any gauges are not working properly, the ICU3 will need to be serviced or replaced.

Instrumentation Control Unit 3 Replacement

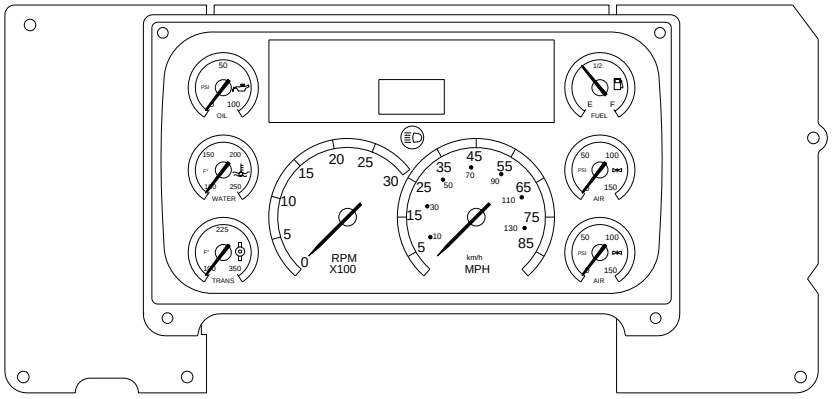


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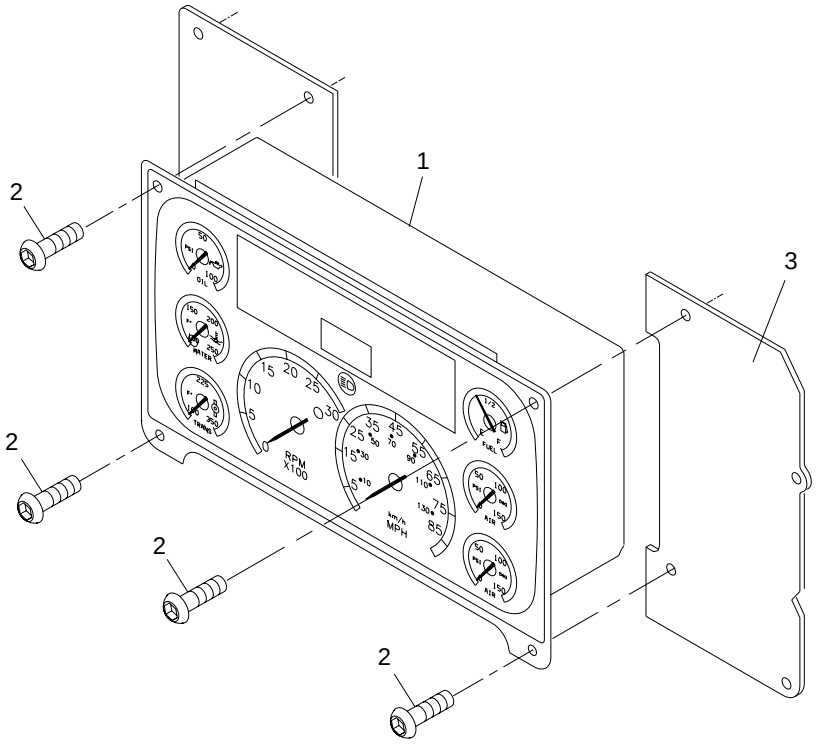
Fig. 1, ICU3 With Wing Panels



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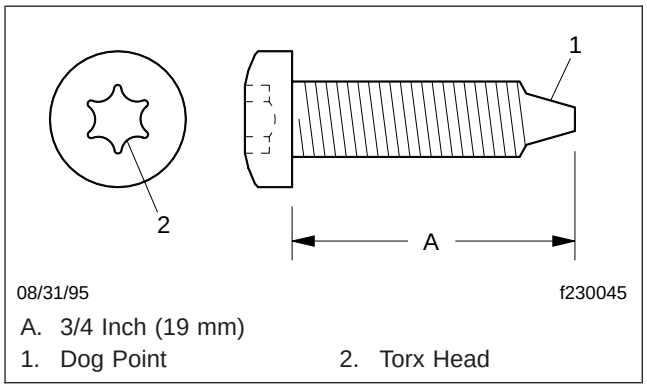
1. ICU Housing
2. T25 Dog-Point Screw
3. Wing Panel

Fig. 2, ICU3 Installation



A. 3/4 Inch (19 mm)
1. Dog Point
2. Torx Head

Fig. 3, Dog-Point Screw

Replacement

IMPORTANT: Before draining the air, it can be helpful to move the adjustable steering column to the lowest possible position. This makes it easier to remove the ICU.

1. Drain both air systems, primary and secondary.

CAUTION

To avoid damaging the ICU, please read and follow the cautions in Subject 100 regarding grounding the ICU and forcibly pulling it from the dash.

2. Remove the ICU3. See **Fig. 1**. For detailed instructions, see **Subject 100**.

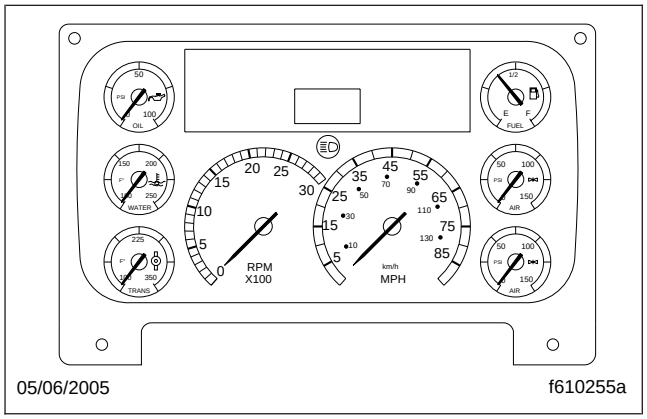


Fig. 1, ICU3

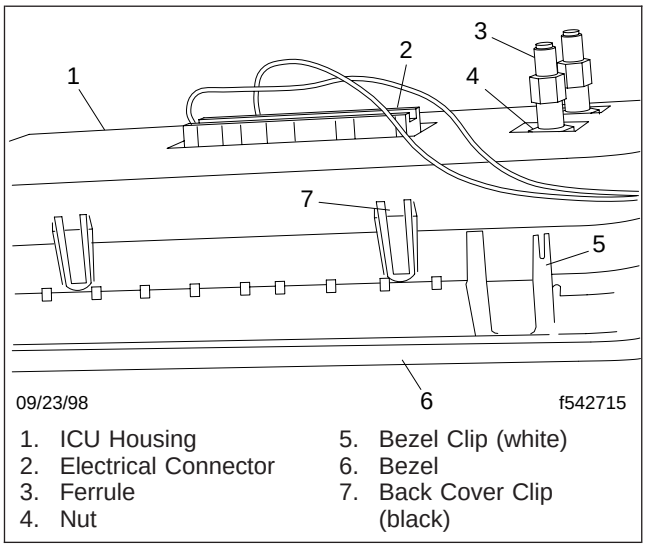
3. Remove the reset button from the front of the ICU housing, if installed.

CAUTION

Use extreme care to avoid breaking the clips when prying them off the ICU housing. The clips are under tension and are easy to damage.

4. Using a thin-bladed screwdriver, very carefully pry off the nine large white clips from the sides of the ICU housing. Remove the bezel from the ICU housing. See **Fig. 2**.

   4.1 From the back of the ICU housing, remove the ferrule from the threaded tube coming out the back of the air gauge.



1. ICU Housing
2. Electrical Connector
3. Ferrule
4. Nut
5. Bezel Clip (white)
6. Bezel
7. Back Cover Clip (black)

Fig. 2, Air Pressure Gauge Installation

   4.2 Remove the nut from the threaded air tube.

5. Remove the old air gauge from the ICU.

6. Install the new air gauge.

   6.1 Insert the new gauge into the hole in the ICU housing.

   6.2 Tighten the nut on the threaded tube.

   6.3 Install the ferrule.

7. Position the bezel on the ICU housing. Fasten the nine white clips to the sides of the ICU housing.

8. Install the reset button on the ICU housing, if removed.

9. Install the ICU3. For detailed instructions, see **Subject 100**.

10. Start the engine and wait for the air pressure to build up. When it has, test the operation of the new gauge.

Replacement

IMPORTANT: Before draining the air, it can be helpful to move the adjustable steering column to the lowest possible position. This makes it easier to remove the ICU.

1. Drain both air systems, primary and secondary.

CAUTION

To avoid damaging the ICU, please read and follow the cautions in Subject 100 regarding grounding the ICU and forcibly pulling it from the dash.

2. Remove the ICU3. See **Fig. 1**. For detailed instructions, see **Subject 100**.

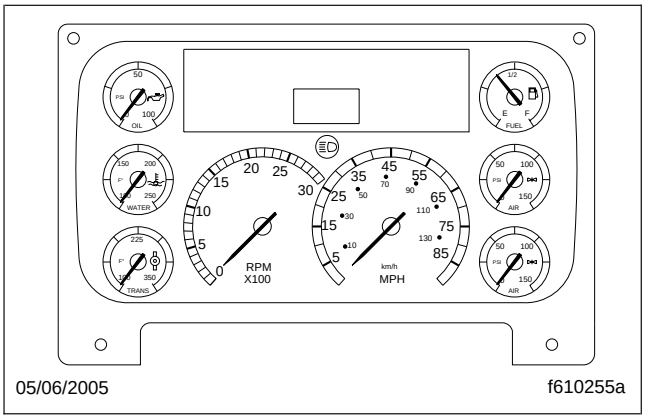


Fig. 1, ICU3

CAUTION

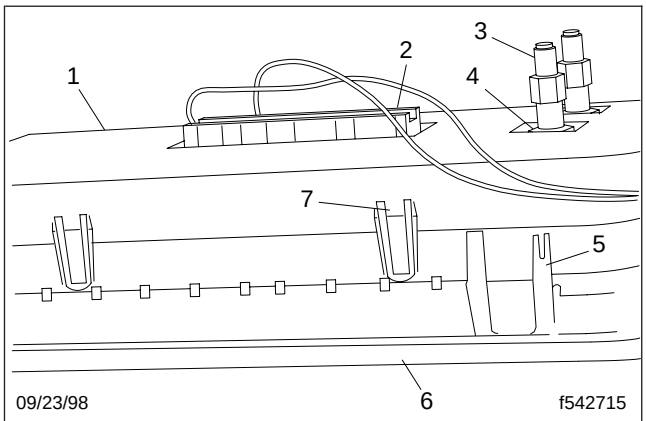
Use extreme care to avoid breaking the clips when prying them off the ICU housing. The clips are under tension and are easy to damage.

3. Pry off the five small black clips from the sides of the ICU housing. Remove the back cover from the ICU housing. See **Fig. 2**.

4. Remove the burnt-out light bulb(s). See **Fig. 3**.

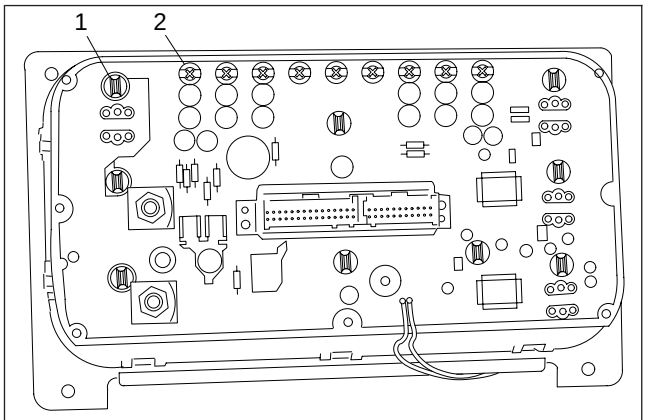
   4.1 To remove gauge light bulbs, twist the bulb holder behind the affected gauge until the bulb comes out.

   4.2 To remove warning/indicator light bulbs, use a small screwdriver to twist out the bulb base behind the affected light.



1. ICU Housing
2. Electrical Connector
3. Ferrule
4. Nut
5. Bezel Clip (white)
6. Bezel
7. Back Cover Clip (black)

Fig. 2, Back Cover Installation



1. Gauge Light Bulb Holder
2. Warning and Indicator Light Bulb Base

Fig. 3, Light Bulb Installation

5. Install the new light bulb(s).

   5.1 To install gauge light bulbs, twist the bulb holder into the slot from which the old one was removed.

   5.2 To install warning/indicator light bulbs, insert the new bulb base into the proper slot and use a small screwdriver to tighten it.

6. Position the back cover on the ICU housing. Fasten the five black clips to the sides of the ICU housing.

Light Bulb Replacement

7. Install the ICU3. For detailed instructions, see **Subject 100**.
8. Turn on the ignition keyswitch. Check all bulbs for correct operation.

The instrumentation control unit model 3 (ICU3) has two pink connectors that plug into pins located in the center of the unit, on the back. Connector #1 has 24 cavities, numbered A1 through A12, and B1 through B12. Connector #2 has 32 cavities, numbered C1 through C16, and D1 through D16.

See **Fig. 1** for a schematic of the wiring and pinout connections for the ICU3.

To fully identify fault codes, see **Section 54.03, Specifications 400**, for a complete list of parameter identifiers (PIDs), sub-system identifiers (SIDs), and failure mode identifiers (FMIs).

Wire numbers for optional indicators depend on the option installed. The wire number given applies only to the option listed and will change if a different option is installed at that location. Optional indicator #9 is 12V power-activated; all other optional indicators are ground-activated.

NOTE: Do not use reserved pins for testing or programming.

ICU3 Connector #1 Pin Assignments, Pins A1 Through B12		
Number	**Description**	**Wire**
A1	Panel Lights	29A
A2	Reserved	—
A3	Low Air Pressure	18
A4	Transmission Temperature (optional; automatic transmission)	30G
A5	Air Restriction	183A
A6	Engine Fan On (Optional Indicator 2)	To GND*
A7	Do Not Shift (Optional Indicator 3)	To GND*
A8	ECAS Failure (Optional Indicator 4)	To GND*
A9	No Charge (optional)	137
A10	Reserved	—
A11	Reserved	—
A12	Headlights (high beams)	20H
B1	ECAS Transfer (Optional Indicator 5)	To GND*
B2	Reserved	—
B3	J1587 Datalink (–)	1587–C
B4	Reserved	—
B5	Reserved	—
B6	Reserved	—
B7	Reserved	—
B8	Low Washer Fluid (Optional Indicator 6)	320A
B9	Reserved	—
B10	J1587 Datalink (+)	1587+C
B11	Tractor ABS	376L
B12	Ground-Activated Buzzer (optional)	437Z

* Depends on option installed.

Table 1, ICU3 Connector #1 Pin Assignments, Pins A1 through B12

Specifications

ICU3 Connector #2 Pin Assignments, Pins C1 through D16		
Number	**Pin Assignment**	**Wire**
C1	EBS Warning (Optional Indicator 8)	To GND*
C2	Reserved	—
C3	Reserved	—
C4	Reserved	—
C5	Parking Brake	125
C6	Reserved	—
C7	Reserved	—
C8	Left Turn	38L
C9	Reserved	—
C10	Recirculated Air	98K
C11	Wheel Spin (optional indicator 7)	376S
C12	Transmission Fluid Temperature Gauge (–)	30G
C13	Transmission Fluid Temperature Gauge (+)	30
C14	Stop Engine—CUM only (optional indicator 1)	N16
C15	Check Engine	C799
		D419
		N25
C16	Engine Protection (optional; shutdown warning)	C659
		D509
		N01
D1	Fuel Level (+)	47
D2	Fuel Level (–)	47G
D3	Panel Light Ground	GND1
D4	Water In Fuel (Optional Indicator 9)	To Power*
D5	Reserved for J1939 Datalink (+)	1939+C
D6	Reserved	—
D7	Reserved	—
D8	Right Turn	38R
D9	Reserved for J1939 Datalink (–)	1939–C
D10	EMI Ground	GNDC
D11	Reserved for J1939 (shield)	1939
D12	Trailer ABS (optional; trailer only)	376F
D13	Printed Circuit (PC) Board Ground	GND1
D14	Battery Power	437
D15	Ignition Power	437A

ICU3 Connector #2 Pin Assignments, Pins C1 through D16		
Number	**Pin Assignment**	**Wire**
D16	Headlight Power (odometer illumination)	359

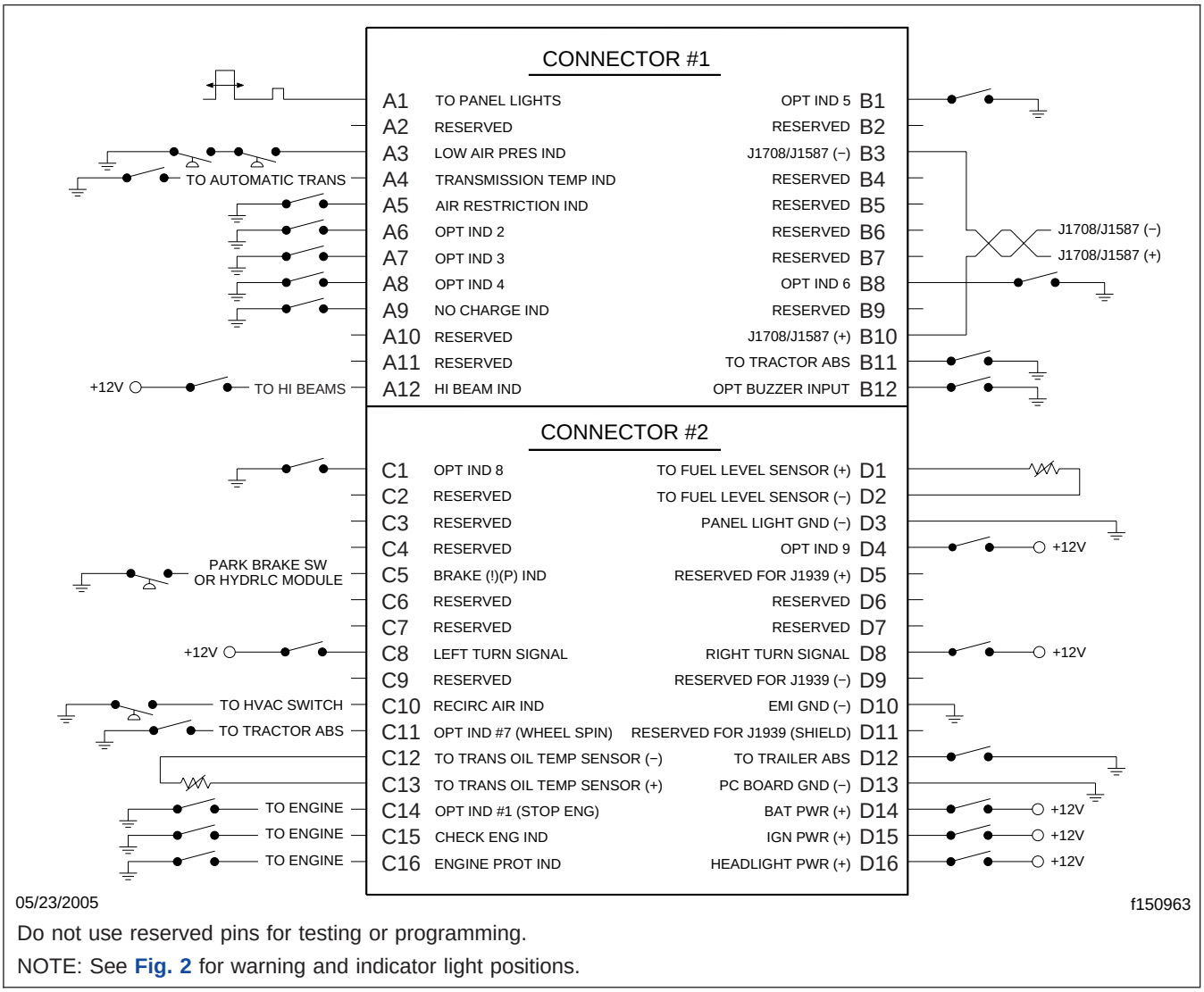
* Depends on option installed.

Table 2, ICU3 Connector #2 Pin Assignments, Pins C1 through D16

Message Identifiers (MIDs)		
MID	**Description**	**Text Message**
128	Engine Control Unit	ECU 128
136	Anti-Lock Brakes (ABS)	AbS 136
140	Instrumentation Control Unit	ICU 140
164	B-Panel Unit	bPU 164
181	Communications Unit—Satellite	SAT 181
190	Air Conditioning Protection Unit	APU 190
219	Collision Detection Radar	CdU 219
231	Communications Unit—Cellular	CEL 231
232	SPACE (Seat Belt Unit)	SbU 232

Table 3, Message Identifiers (MIDs)

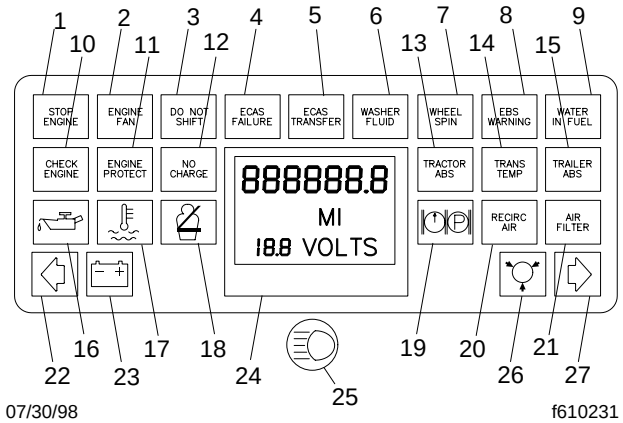
Specifications



Do not use reserved pins for testing or programming.

NOTE: See **Fig. 2** for warning and indicator light positions.

Fig. 1, ICU3 Pinouts



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Typical installation shown. Location of legends installed in the top row may vary, and other legends may be specified.

1. Stop Engine Warning (Cummins engine only)
2. Engine Fan On Indicator (optional)
3. Do Not Shift Indicator (optional)
4. ECAS Failure Warning (optional)
5. ECAS Transfer Indicator (optional)
6. Low Washer Fluid Indicator (optional)
7. Wheel Spin Indicator (optional)
8. EBS Warning (optional)
9. Water In Fuel Indicator (optional)
10. Check Engine Indicator
11. Engine Protection Warning (optional)
12. Alternator No Charge Indicator (optional)
13. Tractor ABS Warning
14. Transmission Temperature Warning (optional)
15. Trailer ABS Warning (optional)
16. Low Engine Oil Pressure Warning
17. High Coolant Temperature Warning
18. Fasten Seat Belt Warning
19. Parking Brake On Warning
20. Recirculated Air Indicator
21. Air Restriction Indicator
22. Left Turn Signal
23. Low Battery Voltage Warning
24. Dash Driver Display Screen
25. High Beams On Indicator
26. Low Air Pressure Warning
27. Right Turn Signal

Fig. 2, Dash Message Center, ICU3

Mode/Reset Switch Functions

The mode/reset switch has two functions, push and hold. (1) To scroll between screens, push the switch in and release it. (2) To reset screen data, press the switch and hold it in for at least one second.

Use the following flow charts to cycle through the Mode/Reset switch functions and screens.

See **Fig. 1** for Mode/Reset Switch Start Sequence.

See **Fig. 2** for Mode/Reset Switch Trip Screens.

See **Fig. 3** for Mode/Reset Switch Engine Miles and Service Screens.

See **Fig. 4** for Mode/Reset Switch Fault Screens.

See **Fig. 5** for Mode/Reset Switch Service Screens.

See **Fig. 6** for Mode/Reset Switch Oil Level Screens.

See **Fig. 7** for Mode/Reset Switch Reset and Toggle Screens.

Service Interval Tables

For service interval miles look-up values, see **Table 1**.

For service interval hours look-up values, see **Table 2**.

Service Interval Distance Settings		
Number	**Miles**	**Kilometers**
1	1000	1610
2	1500	2415
3	2000	3220
4	2500	4025
5	3000	4830
6	3500	5635
7	4000	6440
8	4500	7245
9	5000	8050
10	5500	8855
11	6000	9660
12	6500	10465
13	7000	11270
14	7500	12075
15	8000	12880
16	8500	13685
17	9000	14490
18	9500	15295
19	10000	16100
20	11000	17710
21	12000	19320
22	13000	20930
23	14000	22540
24	15000	24150
25	16000	25760
26	17000	27370
27	18000	28980
28	19000	30590
29	20000	32200
30	21000	33810
31	22000	35420
32	23000	37030
33	24000	38640
34	25000	40250

Table 1, Service Interval Distance Settings

Mode/Reset Switch Functions

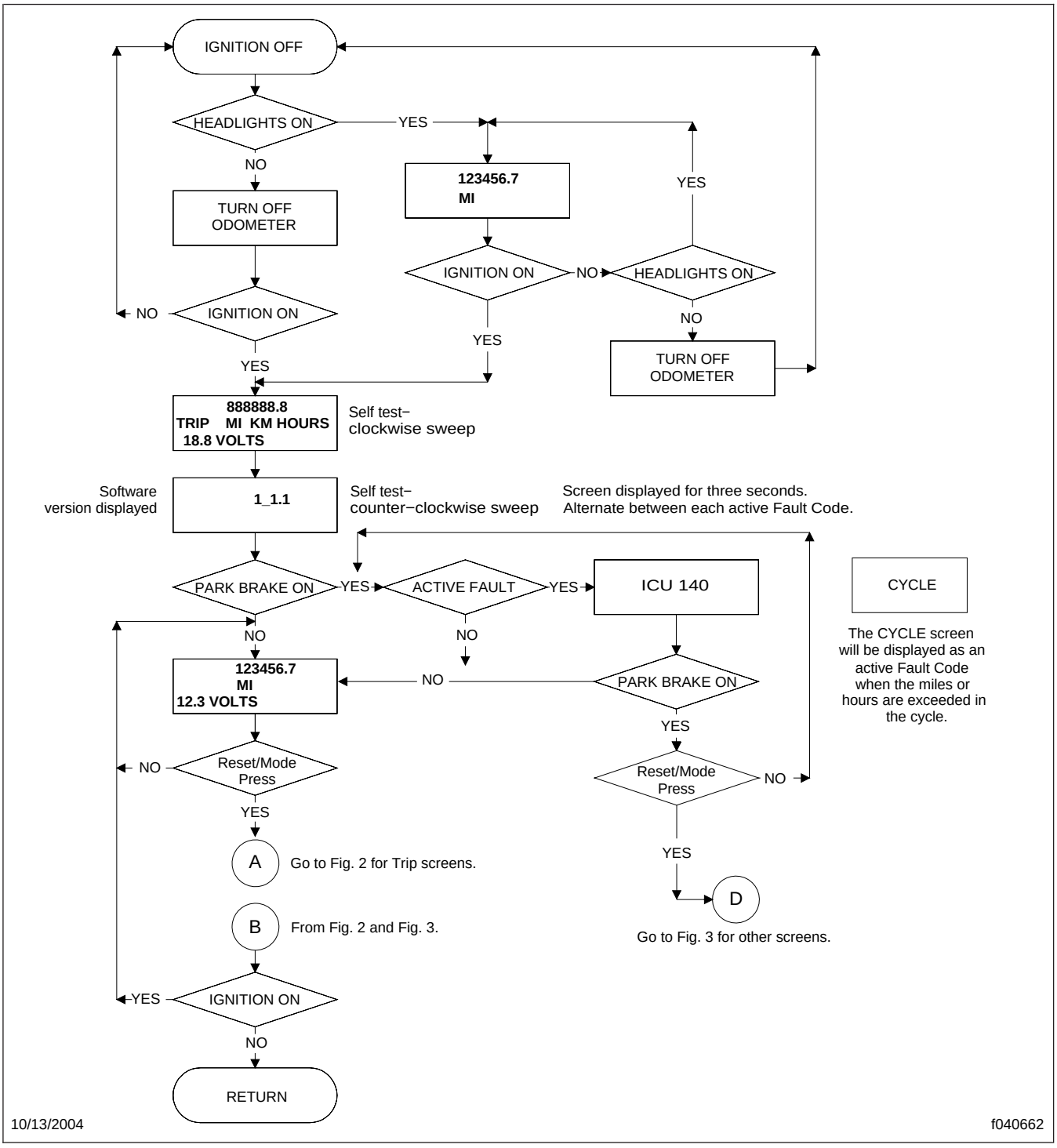


Fig. 1, Mode/Reset Switch Start Sequence

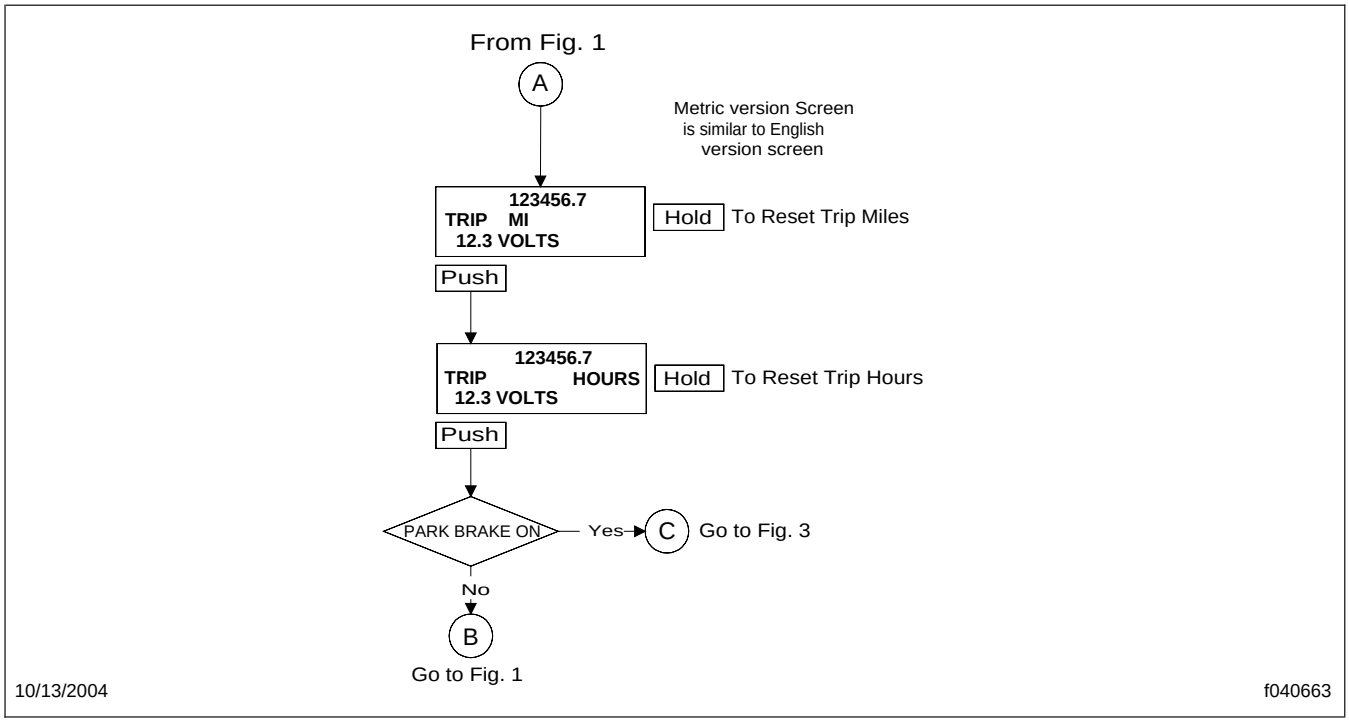


Fig. 2, Mode/Reset Switch Trip Screens

Mode/Reset Switch Functions

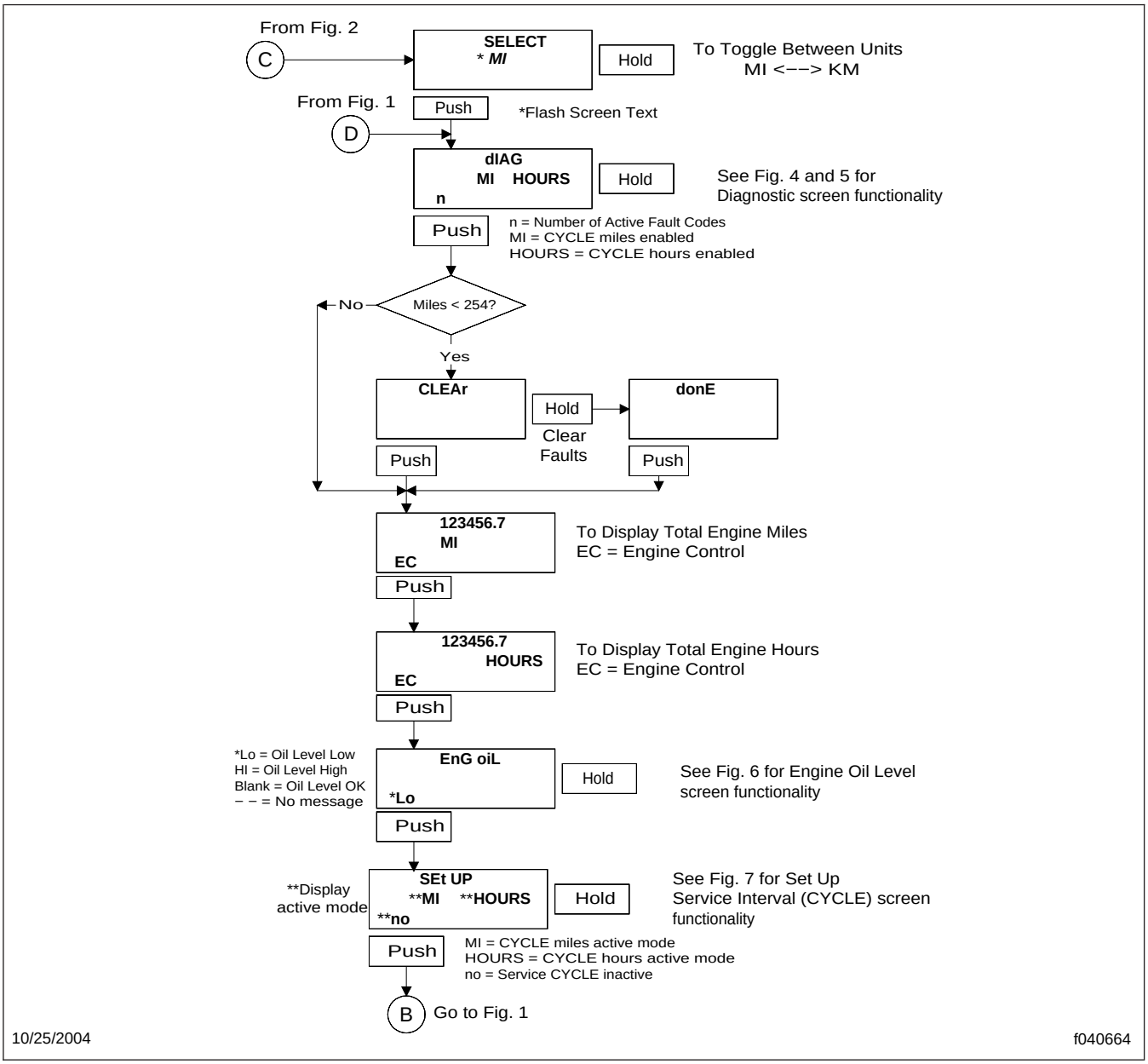


Fig. 3, Mode/Reset Switch Engine Miles and Service Screens

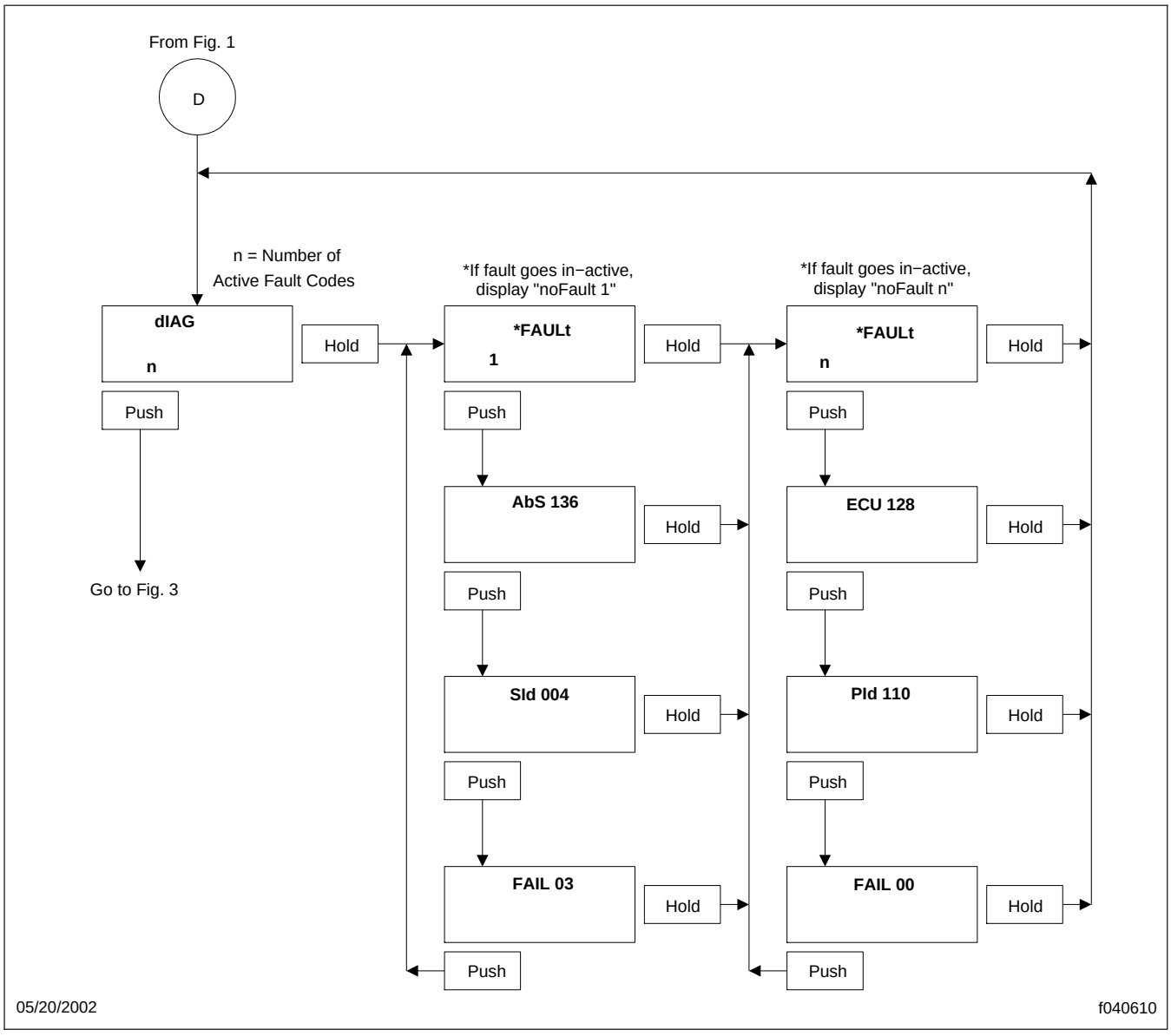


Fig. 4, Mode/Reset Switch Fault Screens

Mode/Reset Switch Functions

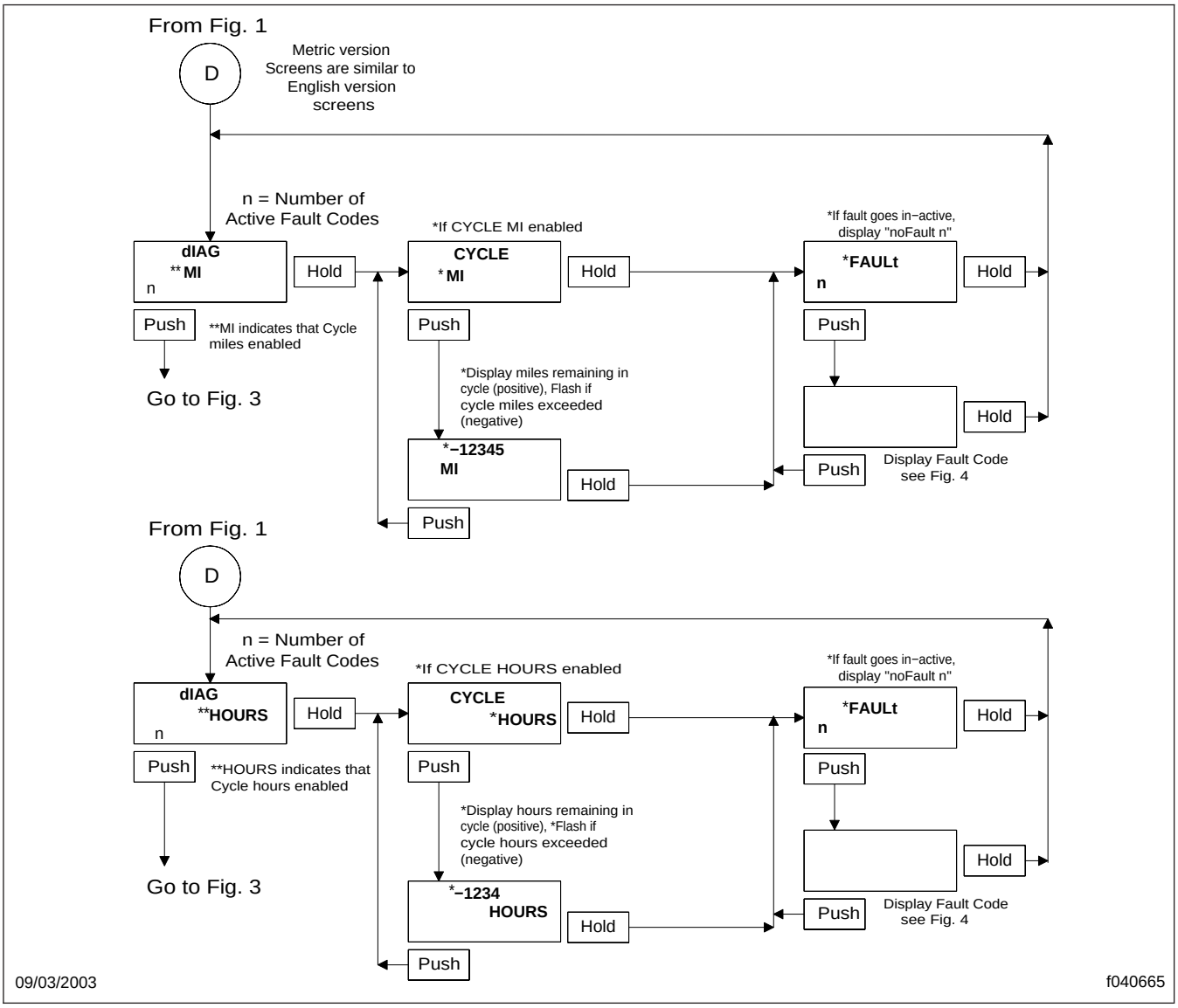


Fig. 5, Mode/Reset Switch Service Screens

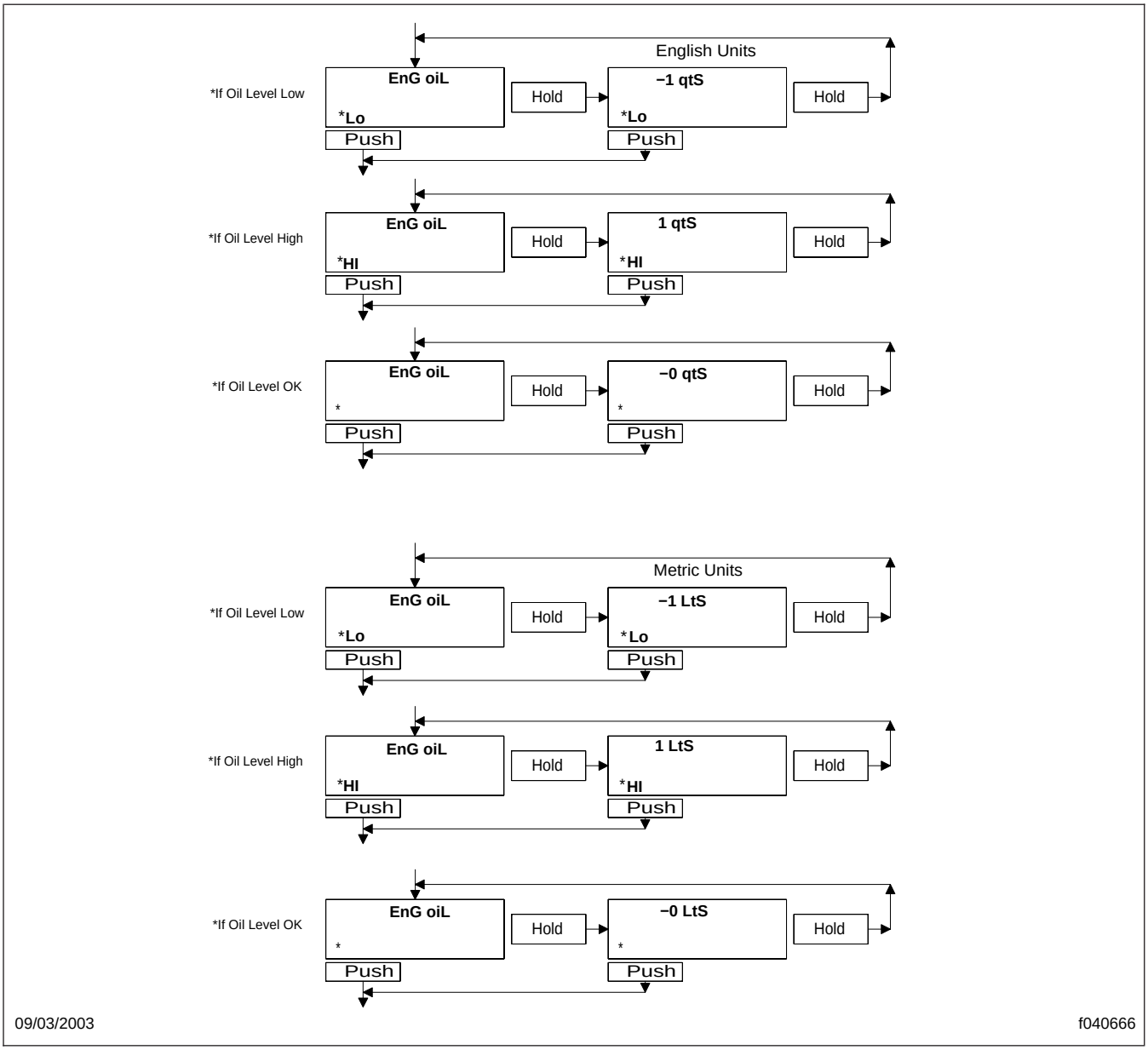


Fig. 6, Mode/Reset Switch Oil Level Screens

Mode/Reset Switch Functions

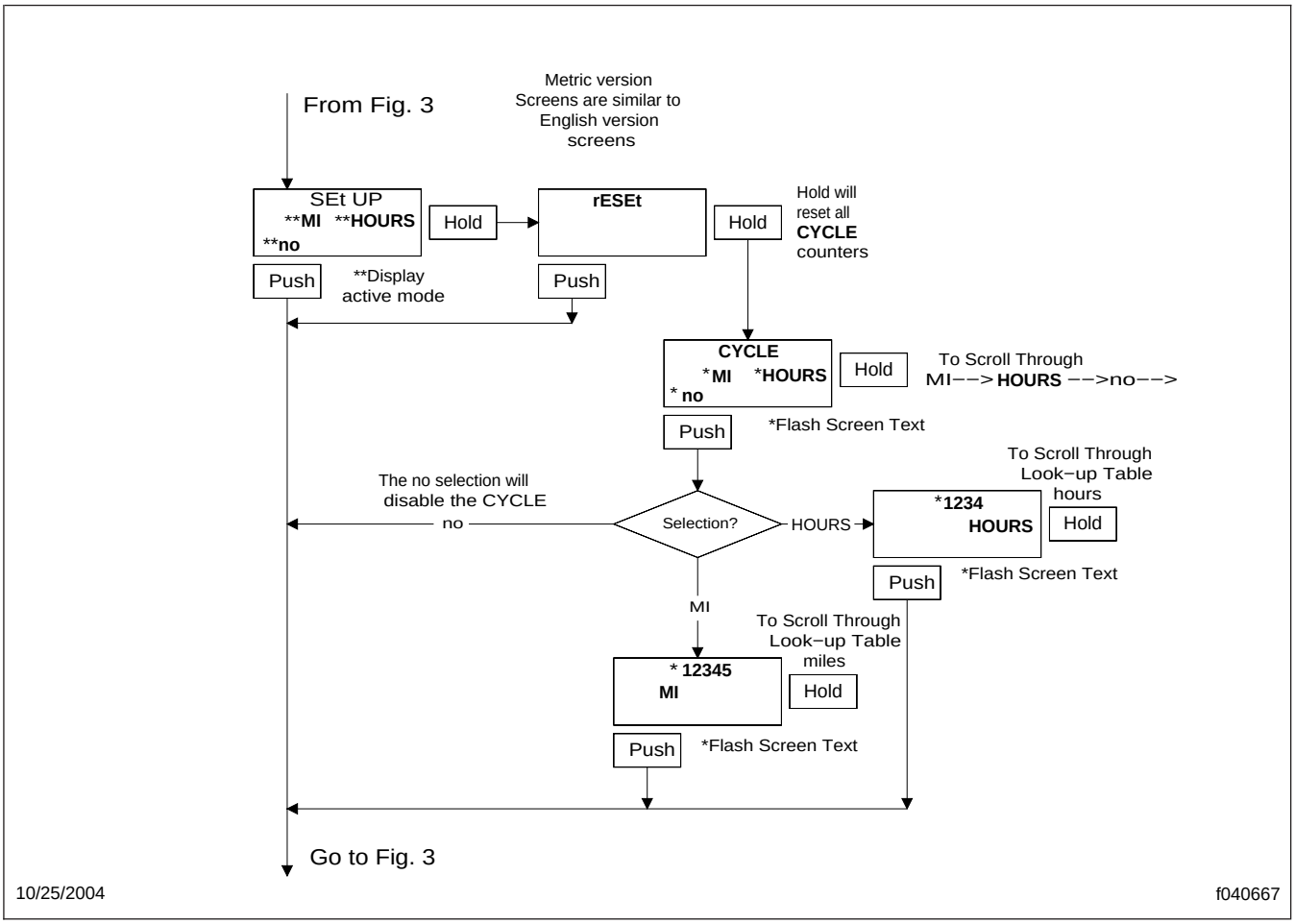


Fig. 7, Mode/Reset Switch Reset and Toggle Screens

Service Interval Hours Settings	
Number	**Hours**
1	50
2	75
3	100
4	125
5	150
6	175
7	200
8	225
9	250
10	300
11	350

Service Interval Hours Settings	
Number	**Hours**
12	400
13	450
14	500
15	550
16	600
17	650
18	700
19	750
20	800
21	850
22	900

Service Interval Hours Settings	
Number	**Hours**
23	950
24	1000

Table 2, Service Interval Hours Settings

General Description

IMPORTANT NOTIFICATION: Servicing of the Eaton VORAD EVT–300 Collision Warning System should be undertaken only by qualified technicians. Special skills and equipment are required to perform these procedures. For assistance, contact Eaton VORAD at (800) 840–7970.

⚠ CAUTION

Before performing any electric welding on a vehicle, disconnect the battery power and ground cables, and the CWS Central Processing Unit (CPU) 32-pin connector and ground cables. See Subject 150 for instructions. Electric currents produced during electric welding can damage various electronic components on the vehicle.

The Eaton VORAD EVT–300 is a computerized collision warning system (CWS) that uses front-mounted and side-mounted (optional) radar to continuously monitor vehicles ahead and alongside the vehicle. Additional warning time, to prevent potential rear-ending of other vehicles, is provided by alerting the driver to stationary or slow moving objects in front of the vehicle or to objects toward which the vehicle is creeping. The system provides three levels of alerts to indicate the interval to a vehicle ahead travelling at normal speeds.

The system warns of potentially dangerous situations by means of visual and audible alerts. The system performs in fog, rain, snow, dust, smoke, and darkness. To be detected, objects must be within the radar beam's field of view and provide a surface area that can reflect back the radar beam.

Components consist of one, two, or three in-cab display units, the front-mounted antenna assembly, side sensor(s), the central processing unit (CPU), antenna mounting plate, and associated wiring harnesses.

Forward-Looking Antenna Assembly

The forward-looking antenna assembly transmits radar signals to, and receives them back from, vehicles and objects ahead. This allows the determination of the distance to, relative speed of, and angle to the target of vehicles and objects ahead. The system uses this information to warn the driver of potentially dangerous situations.

The forward-looking antenna assembly will simultaneously monitor up to 20 vehicles within a 350-foot (107-meter) range. Much information processing is done by the antenna itself. A four-wire twisted pair attaches via a Deutsch connector to the rear of the antenna. The antenna wires are built into the 32-pin connector going to the CPU.

The forward-looking azimuth measurement system (monopulse technology) provides a 12 degree beam. It is able to track targets in a curve (up to 20 targets at one time) but reports only those within the vehicle's lane. Road curvature information is provided by the CPU's yaw rate sensor, which shapes the radar detection zone to the curve.

The detection range is reduced during a sharp turn.

Optional Side Sensors

An optional side sensor(s), mounted on the side of the vehicle, also transmits and receives radar signals for a distance of 2 to 10 feet (0.5 to 3 meters), alongside the vehicle. It has a 15 degree beam angle. The side sensor can detect unseen vehicles and objects, moving and stationary, adjacent to the vehicle.

CPU Internal Gyroscope

The B-pillar door must be closed and secured when the vehicle is in operation. Unintended motion of the B-pillar door will affect the CPU's internal gyroscope. The system may provide an incorrect or unnecessary warning or no warning when one is required.

The CPU's internal gyroscope is sensitive to orientation. The CPU must be mounted with the uppermost surface within ±3 degrees of true horizontal and vertical planes. Ensure that the directional arrow on the CPU points up. A separate power ground, as well as a ground strap, is provided on the CPU.

Driver Display Unit

The driver display unit (DDU) contains the controls and indicators relating to system operation. See Fig. 1. A slot is provided at the front lower edge to insert an optional driver's identification card. An optional, configurable light and audible alarm indicate

General Information

whether or not the driver's identification card has been inserted. At startup, a power-on LED test takes place and all of the lights illuminate.

The "first alert detection range" is adjusted by rotating the range knob. See **Fig. 1**, Ref. 5.

NOTE: The system may be configured so that range control is not adjustable by the driver.

Accident reconstruction data can be saved by pushing and holding the range knob for five seconds. This will save the most recent data in half of the allocated memory.

A green SC indicator light (see **Fig. 1**, Ref. 6) will flash eight times when the range knob is depressed for five seconds to store accident reconstruction information. It will also flash eight times after the power-on LED test is finished if accident reconstruction data was previously stored.

A yellow alert light (see **Fig. 1**, Ref. 11) will illuminate when an object is detected within the 350-foot (107-meter) maximum detection range. The yellow light also illuminates when the proximity alarm threshold is crossed.

NOTE: The maximum detection range on straight roads is 350 feet (107 meters). On curved roads, the range is reduced by the road's turn radius.

An orange alert light (see **Fig. 1**, Ref. 10) illuminates along with the yellow alert light when the vehicle is within a three-second following interval behind another vehicle in the same lane. If within a 2-second following interval, and closing on the vehicle ahead, a warning tone will also sound.

A red alert light (see **Fig. 1**, Ref. 9) illuminates along with the yellow and orange alert lights when the vehicle is less than one second behind another vehicle. If the vehicle ahead is opening the interval, no tone will sound. If the interval is closing, double tones will sound. Within a 1/2-second or less following interval, opening or closing, the tones will repeat twice per second.

If a stationary vehicle or object, or an object moving at least 20 percent slower than the CWS-equipped vehicle, is detected within 220 feet (67 meters), and within three seconds, all three alert lights will illuminate and the double tones will sound. This warning overrides all others and is not affected by the range control knob setting.

If the CWS-equipped vehicle is traveling less than 5 mph (8 km/h) and an object is detected less than 15 feet (4.5 meters) in front of the vehicle, and the closing rate is less than 2 mph (3 km/h) but more than 1/2 mph (1 km/h), the yellow alert light will illuminate and a low-frequency double tone will sound.

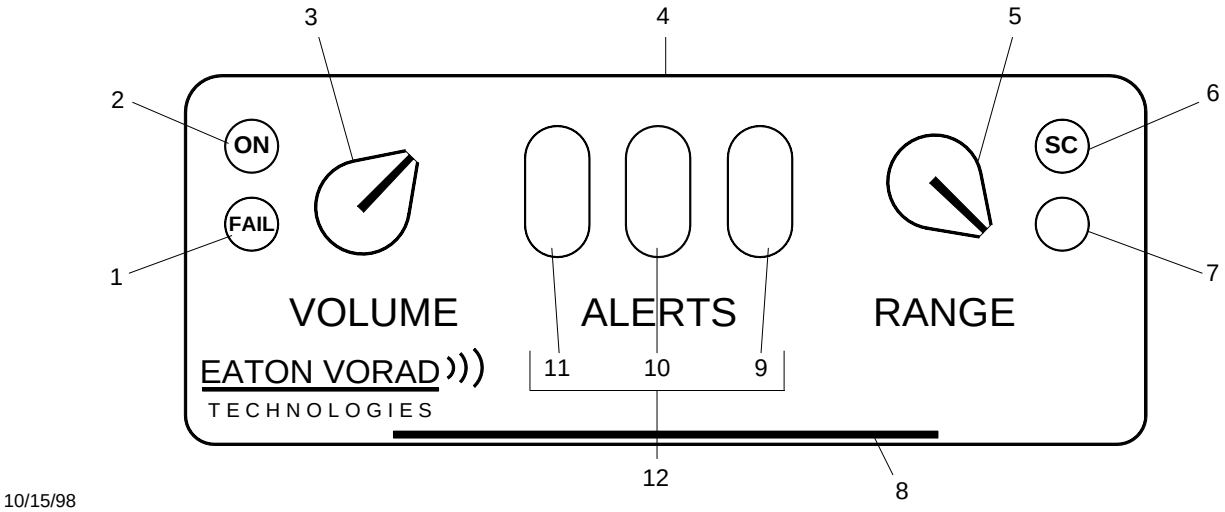
All warnings apply only to objects within the maximum detection range and in the CWS-equipped vehicle's lane. Proximity alert tones and 2-second following interval tones are configured items. All tones are disabled in sharp turns or when the brakes are applied. If the configuration permits, the 3-second alert level may be adjusted with the range control knob.

A low-frequency tone sounds when a system failure is detected. A medium-frequency tone sounds when the volume control level is changed. Only if the system is configured to require a driver's identification card (optional) does the following information apply. A high-frequency tone sounds when the driver's identification card has been successfully read. A low-frequency tone sounds when the driver's card has been unsuccessfully read. The system can be configured so that if the system is on and the requested driver's card has not been inserted: no alert is given, or a visual alert only is given, or both a visual and an audible alert are given.

The side sensor is an optional part of the system. One side sensor may be mounted on one side of the vehicle, or one may be mounted on each side of the vehicle, or two may be mounted on one side to increase the monitored area on that side. The red side sensor light will illuminate and stay on if a failure is detected. If objects are temporarily unable to be detected during heavy rain, both the red and yellow lights will illuminate.

The optional accident reconstruction capability provides two segments of system data, one of which can be stored in system memory. Pushing and holding the DDU range knob for about 5 seconds will store the first segment. Within 6 seconds, the green SC indicator light will blink rapidly eight times, confirming that the data has been saved. If the range knob is pushed again, a fail tone will sound. After the first segment is saved, the second segment runs continuously, but only contains the last 10 minutes (approximately) of system data.

If the first memory segment has been frozen, then the other segment cannot be frozen. Only by disconnecting the main CPU connector can the second memory segment be preserved. The CPU must be



1. Red, System Failure Indicator Light
2. Green, Power On/Driver's Card Status Indicator Light
3. Volume Control and Power On/Off Knob
4. Speaker (on top of unit)
5. Range Knob
6. Green, SC Indicator Light
7. Light Sensor
8. Driver's Card Slot
9. Red, Alert Light
10. Orange, Alert Light
11. Yellow, Alert Light
12. Distance/Danger Alert Lights

Fig. 1, Driver Display Unit (DDU)

returned to Eaton VORAD for downloading and interpretation of accident reconstruction data.

Pressing and holding the DDU volume knob (see **Fig. 1**, Ref. 3) for at least five seconds will activate the failure display mode. The system may turn off if the knob is released before five seconds. After five seconds, the DDU FAIL light will begin blinking out fault codes. After an eight-second interval additional fault codes, if present, will be blinked out. A code 10 will be displayed if either no faults are found or when all fault codes have been displayed.

NOTE: Vehicles equipped with an instrument cluster with a message center (ICU–2M only), will automatically display MID, SID, and FMI codes when a CWS fault is detected. An abbreviated text description of the fault, in English, will also display. The Eaton VORAD assigned fault code numbers (10 through 94) will not display.

Fault codes are cleared by pushing and holding the range knob, but only when the system is in failure display mode, otherwise one segment of accident reconstruction data will be frozen.

Principles of Operation

The collision warning system (CWS) operates by transmitting and receiving low power, high frequency, radar (microwave) signals between the vehicle and objects in front of and to the side(s) of it. These signals determine changes in distance and speed between the vehicle and the object. This information is then used to inform the driver of a potential collision by visual and auditory alerts. To be detected, an object must be within the field of view of the antenna's radar beam. It must also provide a surface that can reflect the radar beam back to the antenna assembly. The side sensor(s) detects objects alongside the vehicle.

The antenna assembly compares the frequencies between the transmitted and received signals. It converts the information to a digital format and outputs it to the central processing unit (CPU) for processing. The CPU in turn sends signals to activate the appropriate lights and alarms. The antenna is mounted to aim directly in front of the vehicle. It has a range of up to 350 feet (107 meters) for moving objects and 220 feet (67 meters) for stationary and slow-moving objects.

General Information

The side sensor range is set to detect vehicles in the adjacent lane. It also provides information to the CPU for processing.

The CPU processes the information it receives from the antenna assembly, J1587 (vehicle speed), side sensor(s), brake circuit, and turn signal circuit. It sends signals to the driver display unit and the side sensor display to illuminate lights. It also signals the driver display unit to sound alerts over the speaker.

The driver display unit (DDU), if so configured, controls power to the system, speaker volume, and the range threshold of alerts to objects in the road. It also controls the storage of the first 10-minute segment of accident reconstruction data onto the driver's card.

The side sensor display (SSD) contains red and yellow alert lights, indicating if an object is detected or not. The red light indicates a detected object. The yellow light indicates no object detected. Both the side sensor display and the driver display unit have a light-intensity adjusting light sensor.

SmartCruise

System Overview

SmartCruise is an optional Adaptive Cruise Control (ACC) system that uses the EVT-300 hardware and SmartCruise software to maintain the vehicle's headway by interacting with the engine and requesting that the engine either de-fuel, or de-fuel and apply the engine brake. Since SmartCruise does not apply the service brake or steer the vehicle, the driver needs to be in control of the vehicle at all times. Also, because of the limitations of the EVT-300 system in distinguishing real targets from false targets when these targets are stationary and present in or near the vehicle's path (road signs in a curve or near the lane of travel, overpasses, parked vehicles on the side of the road, center dividers, retaining walls, etc.), SmartCruise ignores stationary targets when maintaining the headway, but the EVT-300 Collision Warning System (CWS) does not alert the driver of a target in the vehicles path.

SmartCruise works in conjunction with the engine cruise control functions so that all functions of the cruise control (called Conventional Cruise Control, which is contained in the engine ECU) operate as usual when no targets are present in front of the vehicle. When a valid target is present and SmartCruise determines that the headway is less than the driver's set headway, it will request the engine to de-fuel, or to de-fuel and apply the engine brake. Once the correct headway is achieved, SmartCruise maintains the headway until the the speed of the target exceeds the driver's set speed. At that moment, SmartCruise allows the engine to continue with Conventional Cruise Control functions.

System Requirements

Using the data gathered by the forward looking antenna assembly, SmartCruise is capable of controlling the headway of the vehicle. SmartCruise interacts with the Engine Control Module (ECM) over the SAE J1939 data bus. When the driver activates the Conventional Cruise Control (CCC), vehicle speed is controlled by the engine cruise control system (CCC) until SmartCruise determines that a target is being approached. If a target is approaching, SmartCruise sends a message over the J1939 data bus to the engine to reduce power or also apply the engine brake. Once the correct headway is achieved, SmartCruise will maintain that headway until the speed of the target exceeds the driver's set speed. SmartCruise then allows the engine to resume Conventional Cruise Control functions.

Operating Parameters

The operating parameters of the SmartCruise system are as follows:

- The minimum operating speed of the vehicle is the same as the minimum operating Conventional Cruise Control speed.
- The minimum set speed of the vehicle is 30 MPH.
- The minimum following headway is no less than 2.0 seconds when the range of adjustment is enabled.
- The maximum range of adjustment is at least 2.75 seconds when the range of adjustment is enabled.
- If the system loses its target in a curve, the system will not accelerate or resume to set speed while in a curve with a radius less than 2200 feet.

System Heartbeat on SAE J1939

The Adaptive Cruise Control Heartbeat is enabled when specific components are installed on the vehicle, and when specific requirements are met by the EVT-300.

Vehicle Requirements

SmartCruise is available on heavy-duty trucks with an engine brake, a Vehicle Cruise Control system, and an electronically controlled engine. Engine speed and engine brake application is controllable over the SAE J1939 data bus. The current operating state of the Vehicle Cruise Control is available over either the J1939 or the SAE J1587 data bus. Although not mandatory, for optimal performance the truck should have an electronically controllable transmission that allows the selection of the transmission gear over the J1939 bus.

The vehicle equipped with EVT-300 CWS and SmartCruise will only offer SmartCruise as a standard Cruise Control feature. Conventional Cruise Control can only be enabled by toggling the Headway Control (HDWY CNTL) On/Off switch twice within 10 seconds.

Eaton VORAD Requirements

The EVT-300 CWS with SmartCruise will send a J1939 “heartbeat” message (ACC1 message every 100 ms) continuously from Power On to Power Off to indicate to the engine that the EVT-300 is operating properly. If the "SmartCruise Enable" configuration option is "NO," no ACC1 messages will be transmitted.

The EVT-300 system will be powered when the ignition is switched ON. After the self-check the system will start transmitting the heartbeat. Fifteen seconds after the engine has been started and reached a steady state (idle), if the heartbeat is not on the data bus, the engine should disable SmartCruise mode and return to throttle mode. If the Ignition is ON, but the engine was not started, the engine will disregard the presence or absence of the ‘heartbeat’ (ACC1) on the J1939 data bus.

SmartCruise will always be in one of the following eight states and will transmit its current state in the ACC1 message:

- "000—Off (stand by, enabled, ready for activation)" - Indicates SmartCruise is enabled in the EVT-300 configuration setup and there are no EVT-300 faults that prevent SmartCruise from operating and the Conventional Cruise Control is not active.
- "001—Speed control active" - SmartCruise is on, but not currently sending control messages. In other words, no target is ahead and the Conventional Cruise Control is controlling road speed to the driver’s set speed.
- "010—Distance control active" - SmartCruise is on, the target is ahead, and SmartCruise actively sending control messages to maintain following interval.
- "011—Overtake mode" - SmartCruise is on, but temporarily disabled because the driver is manually overriding cruise control by using either the throttle pedal or the cruise control "accel" switch.
- "100—Not defined" - Not used.
- "101—Finish mode" - SmartCruise is on, no target is ahead, and SmartCruise is sending control messages to return to the driver’s set speed. This occurs when the target SmartCruise is tracking moves out of the way and SmartCruise returns the vehicle to the driver’s set speed.
- "110—Disabled or error" - SmartCruise is in an error state and cannot operate.
- "111—Not available" The operator has pressed the EVT-300 OFF switch.

Engine Requirements

The Adaptive Cruise Control (SmartCruise) system will continuously send a heartbeat message (ACC1) on the J1939 data bus. If there is no heartbeat present on the J1939 data bus, the engine should assume that the ACC system is no longer functioning properly and should disable Cruise Control functions and return to throttle control. The engine will have one memory flag that will be programmed at the vehicle manufacturing plant to indicate that an ACC system will be installed on the vehicle. The memory flag in the engine ECM shall be set to ‘1’ by a programming tool if the vehicle has ACC or it should be left unchanged, defaulted to ‘0’ (by the engine manufacturer) for no ACC.

The EVT-300 system will be powered when the ignition is switched ON. The system will start transmit-

General Information

ting the heartbeat in less than 15 seconds after the engine has been started and reached a steady state (idle). If the heartbeat is not on the data bus after 15 seconds, the engine should disable ACC mode and return to throttle mode. If the Ignition is ON, but the engine was not started, the engine disregards the presence or absence of the 'heartbeat' (ACC1) on the J1939 data bus.

When ACC has failed, Conventional Cruise Control can be enabled by toggling the Headway Control On/Off switch twice within 10 seconds.

If the ACC heartbeat comes back on the data bus, the engine ECM shall again allow ACC operation, but only at the next engine ignition key-on cycle. This is to avoid the possibility of the engine being in Conventional Cruise Control and SmartCruise taking over without driver notification and acknowledgement, in the event of intermittent data bus message or wiring connections.

If the SmartCruise is disabled on a vehicle, the memory flag in the engine ECM needs to be set to 0 by a programming tool to allow normal operation of Conventional Cruise Control functions.

Faults

SmartCruise should report faults if SmartCruise operation is not allowed. The fault will remain active until the ignition power is cycled (Off/On) or the fault is cleared using a service tool (ProLink or ServiceLink). An active fault will cause the "110 -Disabled or error" state to be sent in the ACC1 message, and the HDWY FAIL light will illuminate. It will also send a fault message via J1587 to the ICU for the driver display.

If the EVT-300 has a fault that prevents it from operating SmartCruise properly, it will discontinue sending the heartbeat or will send an ACC1 message of "110" to indicate that the engine should change from cruise control to throttle control.

For certain faults reported by the CWS, SmartCruise operation will not be allowed. If a SmartCruise fault occurs, the ignition power must be recycled to re-enable SmartCruise operation. Faults for which SmartCruise operation will *not* be allowed, and faults for which SmartCruise operation is allowed are shown in **Table 1**.

SmartCruise Response to CWS Faults	
Faults that do not Disable SmartCruise	**Faults that Disable SmartCruise**
NVRAM RAM	CRUISE
NVRAM BATTERY	BRAKE
EEPROM	SPEED
CYBERCARD	GYRO
RT or LT TURN SIGNAL	VBUS RX or TX
RT or LT SIDE SENSOR	J1939 H/W
RTC	J1939 ADDRESS
J1587 RX or TX (if there is no critical data coming from J1587 for SmartCruise)	J1939 EEC1 or ERC1 UPDATE
	NO DDU PWR-ON or ID MSG
	DDU VBUS TIMEOUT
J1939 ETC2 or CCVS UPDATE	FE VBUS TIMEOUT
	FE ADC INTERRUPT
DDU RESET MSG	FE NOISE FLOOR
	FE MODULATION
DDU VBUS	FE FREQ INJ
	FE PROGRAM CRC
FE RESET MSG	FE AZ DATA
VEHICLE BATTERY	FE FREQ DATA
HEAVY RAIN	DDU VOLUME, RANGE, SPEAKER, or DRIVER
SOFTWARE	SOFTWARE
VBUS QUEUE	INCOMPATIBLE CPU/FE SOFTWARE
	SMARTCRUISE/ENGINE COMPATIBILITY

Table 1, SmartCruise Response to CWS Faults

Accident Reconstruction

The EVT-300 has the capability to store data that can be used for accident reconstruction purposes.

The Accident Recorder can store two segments of system data in the system's non-volatile memory. The Central Processing Unit must be returned to Eaton VORAD Corporation to download and interpret the recorded data in the non-volatile memory. This must be done before 30 days have elapsed, or the event will be removed from the system memory.

Replacement

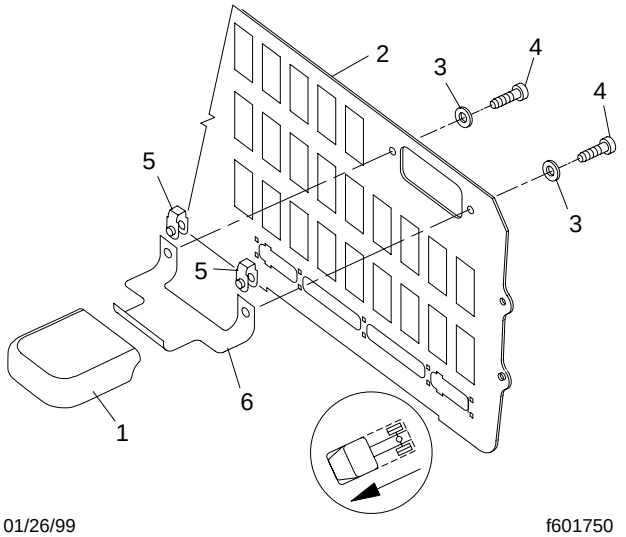
IMPORTANT NOTIFICATION: Servicing of the Eaton VORAD Collision Warning System should be undertaken only by qualified technicians. Special skills and equipment are required to perform these procedures. For assistance, contact Eaton VORAD at (800) 840–7970.

NOTE: Removal of the driver display unit (DDU) requires gaining access to the inside of the auxiliary instrument panel. See **Group 60** for specific procedures for removal and installation of the dash panels. See **Subject 170** for DDU test procedures.

1. Park the vehicle on a level surface. Set the parking brake, chock the tires, and disconnect the batteries.
2. Remove the instrument center-panel trim, the HVAC/radio trimplate, and the right-hand dash trimcap.
3. Remove the four Torx®-head screws securing the auxiliary instrument panel to the dash assembly.
4. Gain access to the rear (forward side) of the auxiliary panel by pulling the panel toward you.
5. Remove the two Torx-head screws which attach the DDU mounting bracket to the auxiliary panel. See **Fig. 1** .
6. Withdraw the DDU, with its mounting bracket attached, and disconnect the electrical harness.

NOTE: If replacing the DDU or the bracket, carefully separate the unit from the bracket. It is attached with a two-sided adhesive. Remove all of the old adhesive. Install new adhesive and attach the DDU to the bracket.

7. To install the DDU, first connect the electrical harness.
8. Place the DDU, with bracket attached, behind the auxiliary panel and insert it into the panel.
9. Install and tighten the two bracket mounting Torx-head screws.
10. Carefully push the auxiliary panel into position, against the dashboard assembly.



1. Driver Display Unit (DDU)
2. Auxiliary Panel (seen from the rear)
3. Washer
4. Torx-head Screw
5. J-Clip
6. DDU Mounting Bracket

Fig. 1, Driver Display Unit (DDU)

11. Install the four Torx-head screws which secure the panel to the dashboard assembly and tighten them securely.
12. Install the right-hand trimcap, the HVAC/radio trimplate, and the instrument center-panel trim.
13. Remove the chocks from the tires and connect the batteries.

Replacement

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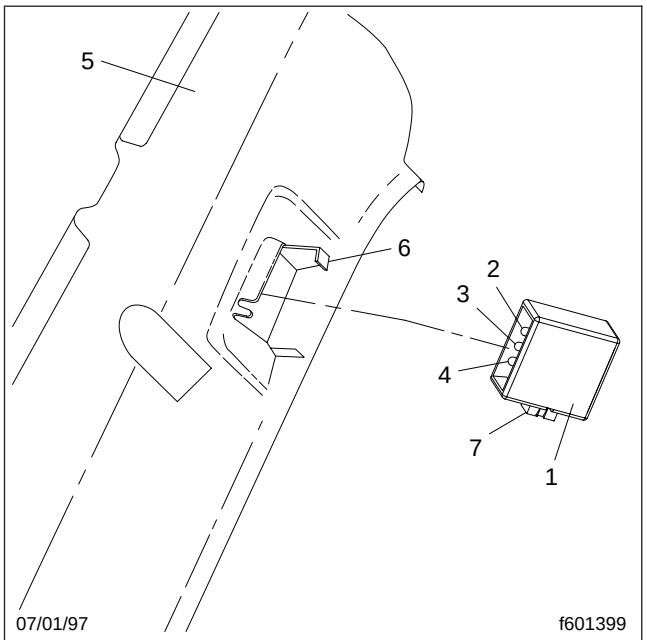
NOTE: See **Subject 170** for side sensor display (SSD) test procedures.

1. Park the vehicle on a level surface. Set the parking brake, chock the tires, and disconnect the batteries.
2. Remove the two Torx®-head screws securing the passenger grab handle to the passenger side A-pillar. Remove the handle.
3. Pull the door trim edging back to expose the edge of the inner A-pillar trim cover. Remove the cover. See **Fig. 1** .
4. Release the plastic retaining clip securing the SSD to the A-pillar cover. Remove the SSD.
5. Disconnect the electrical harness.
6. To install, connect the harness to the SSD.
7. Insert the SSD into the A-pillar cover and ensure it is secured with the plastic retaining clip.
8. Put the A-pillar cover in position on the A-pillar.
9. Press the door trim edging into place.
10. Place the grab handle in position. Install and securely tighten the mounting screws.
11. Remove the chocks from the tires and connect the batteries.



1. Side Sensor Display (SSD)
2. Red Alert Light (vehicle detected)
3. Light Sensor
4. Yellow Alert Light (no vehicle detected)
5. Inner A-Pillar Trim Cover
6. SSD Retaining Clip
7. Electrical Harness Connector

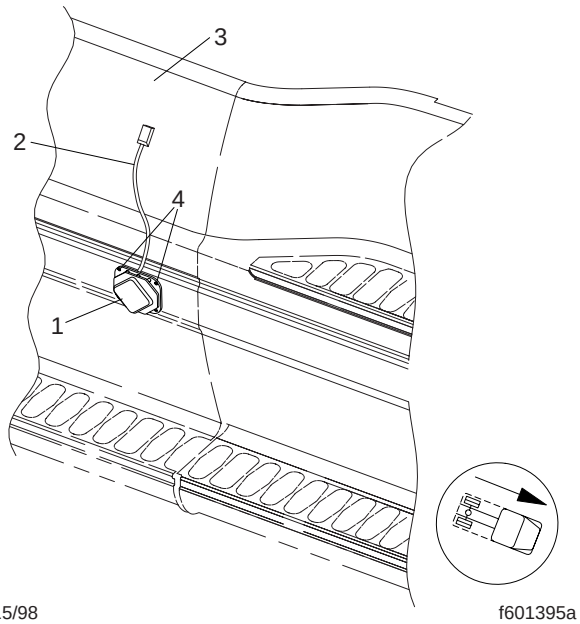
Fig. 1, Side Sensor Display (SSD)

Replacement

IMPORTANT NOTIFICATION: Servicing of the Eaton VORAD Collision Warning System should be undertaken only by qualified technicians. Special skills and equipment are required to perform these procedures. For assistance, contact Eaton VORAD at (800) 840–7970.

NOTE: See **Subject 170** for side sensor test procedures.

1. Park the vehicle on a level surface. Set the parking brake, chock the tires, and disconnect the batteries.
2. Remove the four fasteners and nuts securing the side sensor to the center air-fairing panel. See **Fig. 1** .



1. Side Sensor
2. Side Sensor Harness
3. Center Air-Fairing Panel
4. Mounting Fastener

Fig. 1, Side Sensor

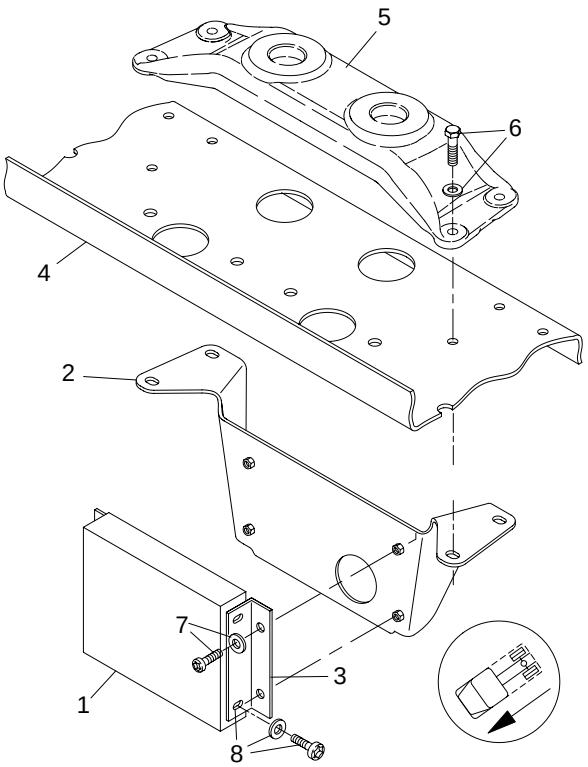
3. Pull the sensor away from the panel.
4. Reach through the fuel access door, or up between the side-fairing and fuel tank, and locate the sensor harness. Cut any tie straps securing the sensor harness and pull the mated connectors out through the sensor mounting hole and disconnect them.
5. To install, locate the two side sensor harness connector ends and join them together.
6. From the outside, feed the harness through the hole in the fairing panel.
7. Secure the assembly to the fairing panel with the four fasteners and nuts.
8. Reach up between the side-fairing and the fuel tank and make a service loop in the excess side sensor harness. Secure the service loop to the aluminum side-fairing mounting rail with tie straps.
9. Remove the chocks from the tires and connect the batteries.

Replacement

IMPORTANT NOTIFICATION: Servicing of the Eaton VORAD Collision Warning System should be undertaken only by qualified technicians. Special skills and equipment are required to perform these procedures. For assistance, contact Eaton VORAD at (800) 840–7970.

NOTE: See **Subject 170** for antenna assembly test procedures, **Subject 160** for initial adjustments, and **Subject 180** for on-road checks and final adjustments.

1. Park the vehicle on a level surface. Set the parking brake, chock the tires, and disconnect the batteries.
2. Remove the four fasteners which secure the antenna assembly mounting brackets to the antenna mounting plate. See **Fig. 1** or **Fig. 2** .
3. Pull the antenna assembly forward to gain access to the four-wire twisted pair and the Deutsch connector.
4. Disconnect the Deutsch connector from the rear of the antenna assembly.
5. To install the antenna assembly, connect the Deutsch connector to the rear of the antenna assembly.
6. Attach the antenna assembly to the mounting plate with the four fasteners and tighten them securely.
7. Realign the antenna.
8. Remove the chocks from the tires and connect the batteries.



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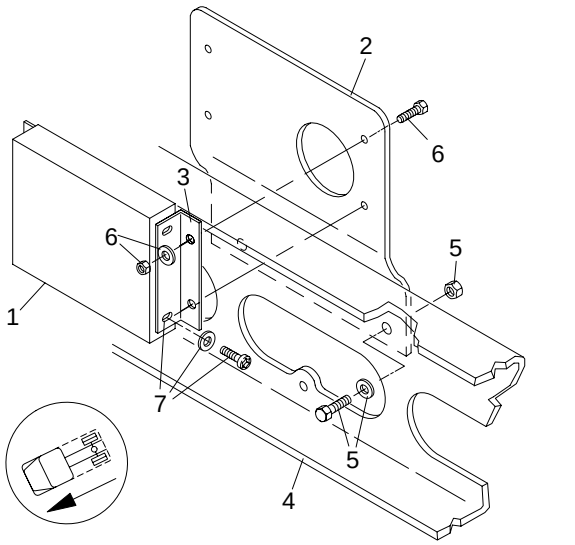
1. Antenna Assembly
2. Antenna Mounting Plate
3. Antenna Bracket
4. Front Closing Crossmember
5. Lower Radiator Support
6. Fastener (mounting plate/radiator support)
7. Fastener (mounting plate/antenna bracket)
8. Adjusting Slot/Fastener

Fig. 1, Antenna Assembly (Conventional)

Antenna Assembly Replacement



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1. Antenna Assembly
2. Antenna Mounting Plate
3. Antenna Bracket
4. Front Crossmember
5. Fastener (mounting plate/crossmember)
6. Fastener (mounting plate/antenna bracket)
7. Adjusting Slot/Fastener

Fig. 2, Antenna Assembly (Argosy)

Replacement

IMPORTANT NOTIFICATION: Servicing of the Eaton VORAD Collision Warning System should be undertaken only by qualified technicians. Special skills and equipment are required to perform these procedures. For assistance, contact Eaton VORAD at (800) 840–7970.

1. Park the vehicle on a level surface. Set the parking brake, chock the tires, and disconnect the batteries.
2. On both Conventionals and Argosy COEs, remove the antenna assembly.

NOTE: See **Subject 130** for instructions on replacement of the antenna assembly.

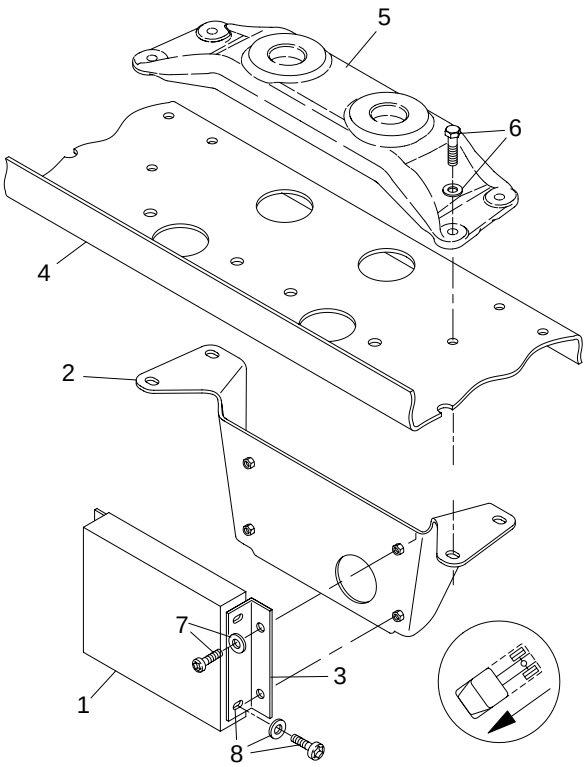
3. With the antenna assembly removed, disconnect the Deutsch connector from the rear of the antenna assembly.
4. On Conventionals, hold the heads of the four mounting plate/radiator support fasteners from above and remove the nuts below the mounting plate. See **Fig. 1** .
5. Remove the mounting plate from the vehicle.
6. To install, place the mounting plate in position with the four fasteners extending through the holes in the radiator support/mounting plate.
7. Install the four nuts and torque them 28 lbf·ft (38 N·m).

NOTE: Push the plate back against the mounting fasteners while tightening the nuts. This ensures that the plate is perpendicular to the vehicle's longitudinal axis.

8. On Argosy COEs, remove the two mounting plate/crossmember fasteners and remove the mounting plate from the vehicle. See **Fig. 2** .
9. To install, place the mounting plate in position behind the crossmember, install the two fasteners, and tighten them 8 lbf·ft (11 N·m).
10. On both Conventionals and Argosy COEs, connect the Deutsch connector to the rear of the antenna assembly, and install the antenna assembly onto the mounting plate.

NOTE: If the antenna assembly is removed from the mounting plate, even with the mounting brackets left attached, it will be necessary to realign the antenna.

11. Remove the chocks from the tires and connect the batteries.

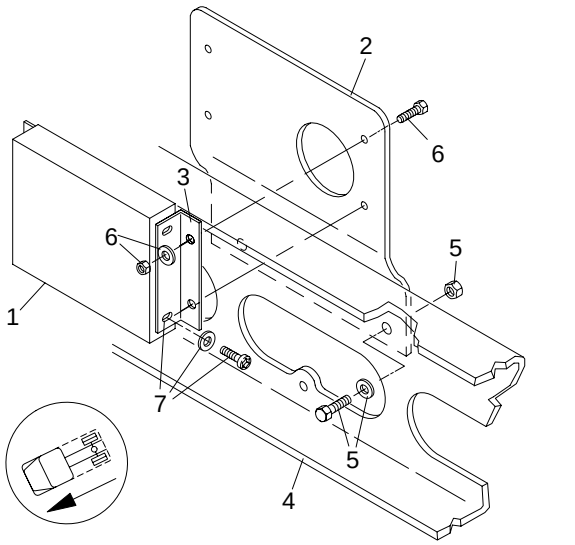


05/05/99 f601748

1. Antenna Assembly
2. Antenna Mounting Plate
3. Antenna Bracket
4. Front Closing Crossmember
5. Lower Radiator Support
6. Fastener (mounting plate/radiator support)
7. Fastener (mounting plate/antenna bracket)
8. Adjusting Slot/Fastener

Fig. 1, Antenna Mounting Plate (Conventional)

Antenna Mounting Plate Replacement



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1. Antenna Assembly
2. Antenna Mounting Plate
3. Antenna Bracket
4. Front Crossmember
5. Fastener (mounting plate/crossmember)
6. Fastener (mounting plate/antenna bracket)
7. Adjusting Slot/Fastener

Fig. 2, Antenna Mounting Plate (Argosy)

Replacement

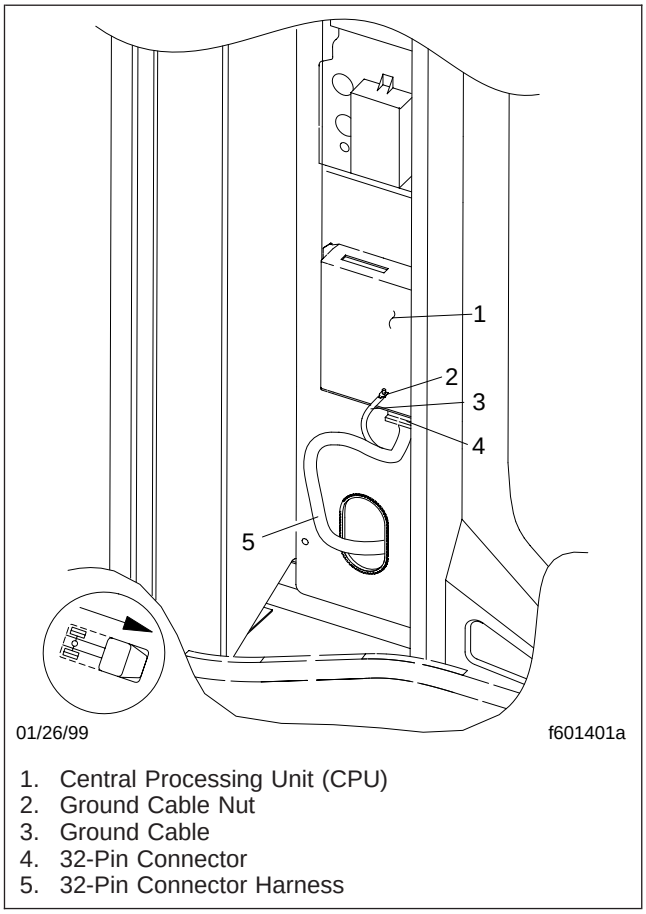
IMPORTANT NOTIFICATION: Servicing of the Eaton VORAD Collision Warning System should be undertaken only by qualified technicians. Special skills and equipment are required to perform these procedures. For assistance, contact Eaton VORAD at (800) 840–7970.

NOTE: Before replacing a central processing unit (CPU), confirm that there is a problem. Visually inspect the CPU and confirm that all connections, power and grounds, are good. Check for a blown fuse or tripped circuit breaker. Check the condition of the pins in all connectors and cavities. Examine the wiring and look for physical damage to the insulation, corrosion, or the effects of heat. See **Subject 300** for CPU fault codes and troubleshooting procedures.

IMPORTANT: If possible, view the configuration parameters of the old CPU with ProLink and record them before removing the old CPU from the system.

1. Park the vehicle on a level surface. Set the parking brake, chock the tires, and disconnect the batteries.
2. Inside the cab, turn the two camlock fasteners on the B-pillar door with a flat-bladed screwdriver and open the B-pillar door. See **Fig. 1** .
3. Remove the four locknuts attaching the CPU to the mounting studs on the inside of the B-pillar door. Remove the CPU from the door. See **Fig. 2** .
4. Disengage the push lock connector and carefully withdraw the 32-pin harness connector from the CPU.
5. At the bottom of the CPU, remove the nut from the ground stud and remove the ground wire from the stud.

IMPORTANT: The CPU's internal gyroscope is sensitive to orientation. The CPU must be mounted with the uppermost surface within ±3° of true horizontal and vertical planes. Also, ensure that the directional arrow on the CPU points up.



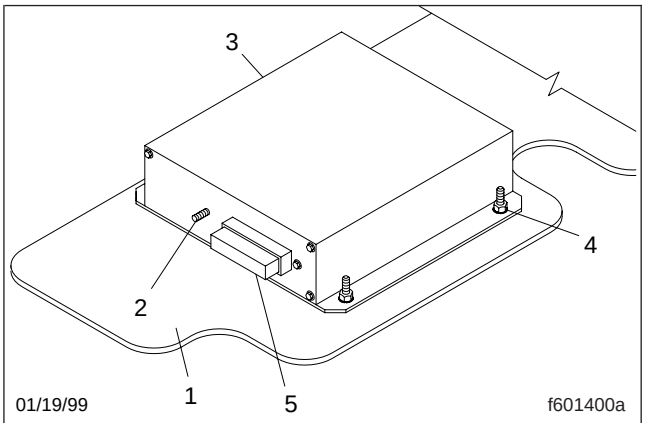
1. Central Processing Unit (CPU)
2. Ground Cable Nut
3. Ground Cable
4. 32-Pin Connector
5. 32-Pin Connector Harness

Fig. 1, B-Pillar Cavity (showing CPU)

6. To install, place the new CPU in position against the mounting studs, inside the B-pillar door.
7. Install the four locknuts and tighten them securely.
8. Place the ground wire ring terminal over the ground stud on the bottom of the CPU. Install and tighten the nut securely.
9. Carefully connect the 32-pin harness connector to the CPU.
10. Close the B-pillar door and secure it by turning the two camlock fasteners.

NOTE: When replacing a CPU with a new unit, it is necessary to verify the system's configuration using ProLink. Follow the steps below to verify that a new CPU is configured identically to the one it is replacing.

Central Processing Unit (CPU) Replacement



1. B-Pillar Door
2. Ground Stud
3. Central Processing Unit (CPU)
4. Mounting Stud and Locknut
5. 32-Pin Harness Connector

Fig. 2, Central Processing Unit (CPU)

11. Access the ProLink SET UP menu.
12. Verify that the vehicle ID number and the odometer reading are correct.
13. Select H/W (hardware) CONFIGURATION from the SETUP menu and confirm that the current parameters of the new CPU are identical to those of the CPU it is replacing.
14. Select S/W (software) CONFIGURATION from the SETUP menu and confirm that the current parameters of the new CPU are identical to those of the CPU it is replacing.
15. Select TRIP PARAMETERS from the S/W (software) CONFIGURATION menu and confirm that the current parameters of the new CPU are identical to those of the CPU it is replacing.
16. Select PERFORMANCE OPTIONS from the S/W (software) CONFIGURATION menu and confirm that the current parameters of the new CPU are identical to those of the CPU it is replacing.
17. Select PRODUCT OPTIONS from the S/W (software) CONFIGURATION menu and confirm that the current parameters of the new CPU are identical to those of the CPU it is replacing.
18. After you have ensured that the new CPU is configured identically to the old one, press FUNC to return to the SETUP menu and clear all fault codes.
19. Remove the chocks from the tires and connect the batteries.

General Information

IMPORTANT NOTIFICATION: Service on the Eaton VORAD Collision Warning System should be undertaken only by qualified technicians. Special skills and equipment are required to perform these procedures. For assistance, contact Eaton VORAD at (800) 840–7970.

The only component requiring an initial adjustment, after removal and installation, is the antenna assembly.

For initial adjustments to the antenna assembly, a good quality digital level is recommended.

NOTE: Perform these initial adjustments when the antenna assembly, antenna assembly mounting brackets, or antenna mounting plate are removed or replaced. Perform the initial adjustments before performing the on-road checks and final adjustments.

Initial Antenna Assembly Adjustment

1. Park the vehicle on a level surface. Set the parking brake, chock the tires, and disconnect the batteries.

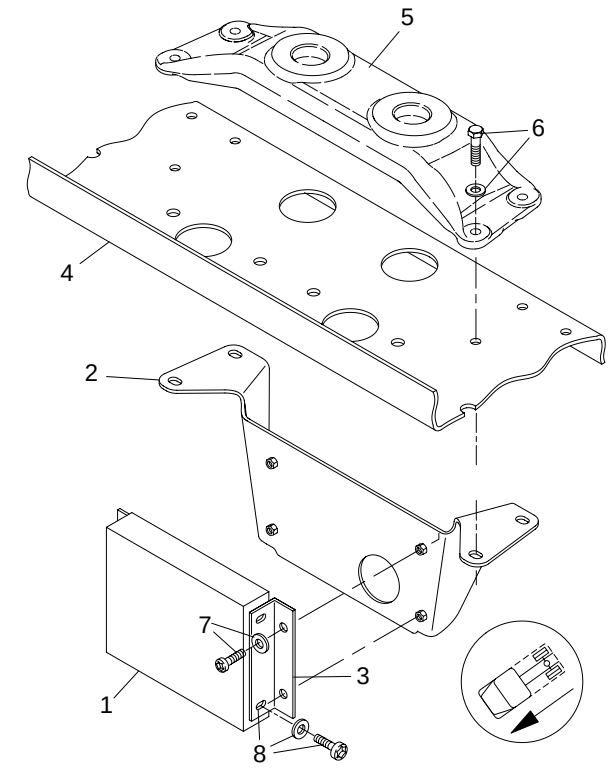
IMPORTANT: The vehicle must be parked on a level surface, with the suspension aired up to the normal ride height and ride attitude, to properly perform the initial antenna assembly adjustment procedure.

2. Place the digital level on the frame rail, behind the cab. The vehicle as well as the ground surface needs to be approximately level.

NOTE: Take note of the angle of the vehicle and/or ground surface. You must compensate for any deviation from absolute level.

3. Loosen the four adjusting setscrews (two on each antenna mounting bracket) with a 5/32-inch Allen wrench. See **Fig. 1** or **Fig. 2**.

4. Push the antenna assembly all the way back in the mounting bracket adjustment slots, so that the antenna is flush with the antenna mounting plate, and only snug the setscrews.



05/05/99 f601748

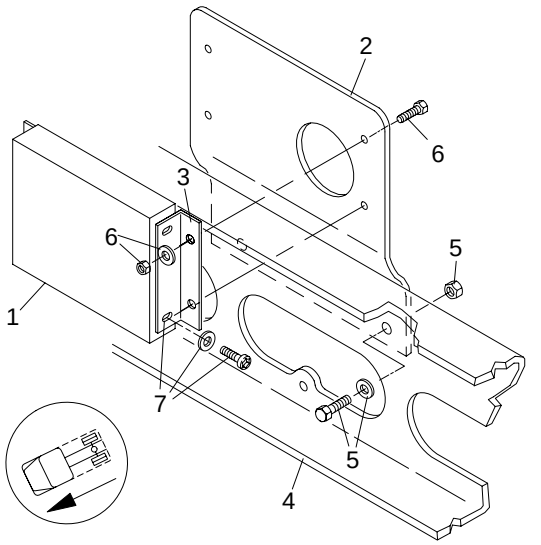
1. Antenna Assembly
2. Antenna Mounting Plate
3. Antenna Bracket
4. Front Closing Crossmember
5. Lower Radiator Support
6. Fastener (mounting plate/radiator support)
7. Fastener (mounting plate/antenna bracket)
8. Adjusting Slot/Fastener

Fig. 1, Antenna Assembly (Conventional)

NOTE: Push the antenna assembly back, flush with the antenna mounting plate, to accomplish the initial antenna assembly left-to-right adjustment. This adjustment is also dependent upon the proper installation of the mounting plate. When installing the mounting plate on Conventional vehicles, be sure to push the mounting plate back and hold it against the four mounting plate/radiator support fasteners as the nuts are being tightened.

5. Place the digital level vertically against the face of the antenna. The initial vertical antenna setting is one degree down. Look for a reading of 89

Initial Adjustments



05/05/99 f601749

1. Antenna Assembly
2. Antenna Mounting Plate
3. Antenna Bracket
4. Front Crossmember
5. Fastener (mounting plate/crossmember)
6. Fastener (mounting plate/antenna bracket)
7. Adjusting Slot/Fastener

Fig. 2, Antenna Assembly (Argosy)

degrees (or 91 degrees), depending on level readout. Ensure that the top of the antenna is tilted toward the front by one degree.

NOTE: If the vehicle is angled down because it is parked on an unlevel surface, add the number of degrees off from level to the one degree down. If the vehicle is angled up, subtract the number of degrees off from level to the one degree down. For example, if the vehicle is angled down 2.7 degrees the antenna angle must be 3.7 degrees down which will produce a reading of 86.3 degrees (or 93.7 degrees), depending on level readout.

6. Adjust the antenna out from either the top or bottom to obtain the required degree reading on the level.
7. Tighten the setscrews securely.
8. Check the vertical setting to be sure it is still set at the required degree angle.
9. If the vertical setting has changed, repeat the procedure.
10. Proceed to **Subject 180** for instructions on performing the on-road checks and final adjustments.
11. Connect the batteries and remove the chocks from the tires.

Component Checks

IMPORTANT NOTIFICATION: Servicing of the Eaton VORAD Collision Warning System should be undertaken only by qualified technicians. Special skills and equipment are required to perform these procedures. For assistance, contact Eaton VORAD at (800) 840–7970.

MPSI PROLINK® 9000

To properly test and diagnose problems with the Eaton VORAD EVT–300 collision warning system, an MPSI ProLink 9000 diagnostic tool equipped with an Eaton VORAD cartridge, or a multi-protocol cartridge with the Eaton applications PCMCIA card, is required. The initial or default EVT–300 diagnostic menu consists of three sub menus: setup, checkout, and error log. Verify system configuration of the central processing unit (CPU) with the setup menu. Use the checkout menu to test the functions of the various components. Display fault codes using the error log menu.

NOTE: Use only a digital ohmmeter when performing tests to avoid damaging electronic components.

COMPONENT CHECKS USING THE CHECKOUT MENU

NOTE: Before selecting CHECKOUT, select SETUP and verify system configuration. This ensures proper operation of the CHECKOUT menu during component function tests.

The various components of the collision warning system can be activated using this menu. Some checks require assistance from the technician. The technician will be asked, via the ProLink, if the expected event occurred. Use the UP and DOWN arrow keys to scroll the selection arrow. Select the CHECKOUT menu from the initial EVT–300 diagnostic menu by placing the selection arrow next to CHECKOUT and pressing ENTER.

NOTE: The following component checks are performed with the vehicle stationary.

Side Sensor Display (SSD) Test

1. Select SSD TEST from the CHECKOUT menu.
2. Place the selection arrow next to the side sensor display.

NOTE: If the vehicle has only one side sensor, there will be an N/A value displayed for the other side sensor.

3. Press ENTER to toggle the state of the side sensor display light.
4. The indicator light on the side sensor display will match the RED or YELLOW message shown on the ProLink.
5. Press FUNC to exit the SSD TEST and return to the CHECKOUT menu.

Side Sensor (SS) Test

1. Select SS TEST from the CHECKOUT menu.
2. Place the selection arrow next to the side sensor you are testing.

NOTE: If the vehicle has only one side sensor, there will be an N/A value displayed for the other side sensor.

3. Wave your hand in front of the side sensor.
4. As you wave your hand, the message displayed on the ProLink will change from NO to YES.

NOTE: The message OPEN/SHORT will appear if the side sensor power source is disconnected.

5. Press FUNC to exit the SS TEST and return to the CHECKOUT menu.

Driver Display Unit (DDU) Test

1. Select DDU TEST from the CHECKOUT menu.

NOTE: At the lamp test line, the RED, YELLOW, and ORANGE range control alert lights will toggle automatically. Each will illuminate individually on the display as the ProLink indicates their color.

2. On the DDU, rotate the left knob (volume control) left to right fully through its range. The percentage value for the LEFT KNOB on the ProLink display will change from 0 to 100 percent.
3. Then, rotate the right knob (range control) left to right fully through its range. The percentage value for the RIGHT KNOB on the ProLink display will change from 0 to 100 percent.

Component Checks

4. Push in the right knob (range control). The display will indicate PUSH.
5. Press FUNC to exit the DDU TEST and return to the CHECKOUT menu.

Speaker Test

1. Select the SPEAKER TEST from the CHECKOUT menu.
2. Place the selection arrow next to the particular sound to be tested and press ENTER.

NOTE: When performing this test, sound volume is always at maximum. Adjusting the volume knob (left knob) on the DDU will have no effect.

3. Listen for the specific sound from the DDU speaker.
4. Repeat the procedure to test each of the six different sounds.
5. Press FUNC to exit the SPEAKER TEST and return to the CHECKOUT menu.

Antenna Test

1. Select ANTENNA TEST from the CHECKOUT menu.
2. Have an assistant walk toward the front of the antenna.

NOTE: The antenna will only detect a moving object.

3. Note the RANGE reading on the ProLink.
4. Ensure that the RANGE reading is approximately correct.
5. Press FUNC to exit the ANTENNA TEST and return to the CHECKOUT menu.

Turn Signal Test

1. Select TURN SIGNAL TEST from the CHECKOUT menu.
2. Place the selection arrow next to the right-side turn signal.

NOTE: There will be an N/A value displayed for the turn signal on the left-hand side.

3. Move the turn signal lever into position to activate the turn signal for the right-hand side.
4. The ProLink display for that turn signal position will change from OFF to ON.
5. Press FUNC to exit the TURN SIGNAL TEST and return to the CHECKOUT menu.

Brake Test

1. Select BRAKE TEST from the CHECKOUT menu.
2. Depress the brake pedal when the ProLink display indicates PRESS BRAKE PEDAL.

NOTE: If the system is not configured for a brake signal BIT test, there will be an N/A value displayed.

3. The BRAKE message on the display will change from OFF to ON when the brake pedal is depressed.
4. Press FUNC to exit the BRAKE TEST and return to the CHECKOUT menu.

Antenna Assembly

IMPORTANT NOTIFICATION: Service on the Eaton VORAD Collision Warning System should be undertaken only by qualified technicians. Special skills and equipment are required to perform these procedures. For assistance, contact Eaton VORAD at (800) 840–7970.

NOTE: These procedures are intended to be performed only on an interstate highway, freeway, or similar roadway where at least two lanes in your direction are available for use. Perform these procedures only after performing the initial adjustments when an antenna assembly, antenna assembly mounting brackets, or antenna mounting plate have been removed or replaced. See **Subject 160** for instructions.

1. Drive the vehicle straight ahead at normal highway speeds of 50 to 55 mph (80 to 88 km/h).

⚠ WARNING

Only attempt these procedures where at least two lanes are available for use and traffic is light. Improperly performing these procedures could result in loss of control of the vehicle and possible physical injury and property damage.

2. Confirm that the system is monitoring only the vehicle traveling immediately ahead of your vehicle.
3. Using ProLink, select the CHECKOUT menu, then scroll to and select ANTENNA.

NOTE: The driver display unit (DDU) should display following distance information only for the vehicle traveling immediately ahead, by illuminating the number 1 or number 2 alert light. The DDU should not display following distance information for vehicles in the left or right lanes, ahead of the your vehicle, while your vehicle is traveling in a straight line.

4. Monitor the azimuth reading on ProLink. Look for a 0.0 reading.

NOTE: The vehicle you are tracking must be traveling directly ahead in your lane, in the same position (center) of the lane as your vehicle, and both vehicles must be traveling on a straight roadway.

When the above conditions are met and a negative value is indicated, the antenna is "seeing" the target in its own left field of view (antenna facing to the right too much). When a positive value is indicated, the antenna is "seeing" the target in its own right field of view (antenna facing to the left too much). Look for a reading that will "bounce around" 0.0 in equal values, positive to negative (equal values produced left to right).

5. To adjust the antenna assembly, first pull the vehicle off the road in a safe location and shut off the engine.
6. Loosen the two adjusting setscrews in the antenna mounting bracket only on the side you wish to adjust.
7. If negative values were read, point the antenna to the left by pulling out the passenger's side of the antenna.
8. If positive values were read, point the antenna to the right by pulling out the driver's side of the antenna.
9. Tighten the antenna-adjusting setscrews securely.
10. Drive the vehicle again and monitor the azimuth reading on ProLink. Look for a 0.0 reading.
11. If necessary, repeat the procedure from the beginning until the reading "bounces around" 0.0 in equal values, positive to negative (equal values produced left to right).

Troubleshooting

IMPORTANT NOTIFICATION: Servicing of the Eaton VORAD Collision Warning System should be undertaken only by qualified technicians. Special skills and equipment are required to perform these procedures. For assistance, contact Eaton VORAD at (800) 840–7970.

COMPONENT TROUBLESHOOTING

When an active fault is detected by the system, the red failure light on the driver display unit (DDU) illuminates until the cause of the condition is corrected. It is possible to read fault codes either on the DDU, by placing it in failure display mode, or with a ProLink® 9000 diagnostic tool.

NOTE: Vehicles equipped with an instrument cluster with a message center (ICU-2M only), will automatically display MID, SID, and FMI codes when a CWS fault is detected. An abbreviated text description of the fault, in English, will also display. The Eaton-VORAD assigned fault code numbers (10 through 94) will not display.

Active and inactive fault codes may be blinked out over the DDU when the system is placed in failure display mode. Press and hold the DDU volume knob for at least 5 seconds. The system may turn off if you release the knob before 5 seconds. After 5 seconds, the DDU red failure light will begin blinking out fault codes. After an 8-second interval additional fault codes, if present, will be blinked out. A code 10 will be displayed if either no faults are found or when all fault codes have been displayed. Display active codes by turning the range knob to the left of center.

Display inactive codes by turning the knob to the right of center. The failure light will blink as many times as the first digit of the fault code number, pause approximately 3/4 of a second, and then blink as many times as the second digit. After all of the active or inactive fault codes have been displayed, the sequence repeats. This process continues until the system is turned off. To clear all fault codes from system memory while in failure display mode, press and hold the range knob for approximately 30 seconds.

Make the various basic checks below before proceeding to the more detailed troubleshooting procedures in the following tables.

NOTE: Certain tests, as noted in the following table require the use of a ProLink 9000 diagnostic tool, equipped with an Eaton VORAD cartridge or a multi-protocol cartridge with the Eaton applications PCMCIA card.

1. Confirm that there is a problem.
2. Before replacing any component, make continuity checks with a DVOM (digital volt/ohm meter).
3. Confirm that all connections, power and grounds, to either the vehicle or components, are good.
4. Check for a blown fuse or tripped circuit breaker.
5. Check the condition of pins in all connectors and cavities.
6. Examine the wiring of the suspect component. Look for physical damage to the insulation, corrosion, and the effects of heat.
7. Examine the external components (antenna assembly, wire harness, side sensor) for damage or corrosion.

Component Troubleshooting		
Symptom	**Cause/Source**	**Remedy**
DDU green ON light blinks continuously.	Driver ID card not inserted/driver ID card.	1. — Verify that the card alarm is correctly configured in the CPU. * 2. — Insert a new driver identification card.
DDU green SC light blinks eight times at power up.	An event is stored in the CPU's memory.	NOTE: When the system is turned on, the SC light will blink eight times after the self-test has been completed, if an event has been saved. Return the CPU to the factory to have the event uploaded and/or cleared.

Troubleshooting

Component Troubleshooting		
Symptom	**Cause/Source**	**Remedy**
Red FAIL light on side sensor display illuminates continuously.	CPU not receiving side sensor information/side sensor.	1. — Confirm that the vehicle has a side sensor. If not, verify in the H/W configuration menu that the RSS, LSS, and 2SS 1SSD setting is NO. * 2. — Check the connection and for damage to the side sensor wiring harness to the CPU. 3. — While performing the SS test, wave your hand in front of the side sensor and verify that the correct signal is received. * 4. — Verify a 5-volt output at the side sensor signal wire at the side sensor connector, using a DVOM (digital volt/ohm meter) with a target present. 5. — Disconnect the three-pin side sensor, pigtail, and CPU connectors. Check for corrosion or a recessed pin. 6. — Replace the side sensor.
No warning tones audible.	Speaker not functioning, incorrect brake signal, gyro malfunction, speed input signal inoperative/ DDU, brake input or configuration setting, CPU, speed input or source.	1. — Verify that the volume control knob is turned all the way to the right. 2. — Turn the system off and back on. Turn the volume control knob and listen for a tone. 3. — Verify that the DDU connection is good. 4. — Perform the speaker test and verify that an audible tone is heard from the DDU speaker. 5. — Verify that the CPU is oriented and mounted correctly for its type. 6. — Verify speed input. 7. — Perform the brake test and verify that the correct signal is received when the brake pedal is depressed. *
Warning tones audible when brakes applied.	Incorrect input signal/ brake input.	NOTE: The forward following distance warning tones are disabled when the brake pedal is depressed. Creep (proximity) and side sensor alerts are not disabled when the brake pedal is depressed. 1. — Perform the brake test and confirm receipt of the correct signal when the brake pedal is depressed. * 2. — Verify that the brake mode setting is correctly configured in the CPU. * 3. — Verify that the brake logic is correctly configured in the CPU. *
Side sensor warning tone audible when brakes are applied.	Incorrect input signal/ turn signal input.	1. — Verify that a tone is not audible when you wave your hand in front of the side sensor, with only the brake pedal depressed (turn signal not activated). 2. — Verify that the turn signal setting is correctly configured in the CPU. * 3. — Perform the turn signal test and confirm receipt of the correct signal when the turn signal is applied. *
No system ON/OFF capability.	Software/system configuration.	NOTE: System parameters may be configured to enable or disable the on/off capability. This requires use of a ProLink 9000 diagnostic tool.

Component Troubleshooting		
Symptom	**Cause/Source**	**Remedy**
The volume knob does not reduce the volume.	System configuration/ DDU.	NOTE: System parameters can be configured to limit volume to a minimum level, but only with a ProLink diagnostic tool. If the owner or fleet manager allows full adjustment of the volume level, follow the procedure below. 1. — Verify that the MIN VOL setting is zero. * 2. — Perform the DDU test and confirm proper operation of the volume knob. * 3. — Check that the DDU is properly connected and not damaged. 4. — Check that the main harness to the CPU is properly connected and not damaged.
The range knob does not change the alert levels.	Software configuration/ DDU.	NOTE: System parameters do not always allow the operator to reduce the range threshold level. This configuration can only be changed with a ProLink diagnostic tool. If the owner or fleet manager allows adjustment of the range level, follow the procedure below. 1. — Verify that the RANGE ENABLE configuration is ON. * 2. — Perform the DDU test and confirm proper operation of the range knob. * 3. — Check that the DDU is properly connected and not damaged. 4. — Check that the main harness to the CPU is properly connected and not damaged.
Front antenna detects vehicles in an adjacent lane with no vehicle in front of your vehicle.	Antenna misaligned/ antenna assembly.	1. — Walk a measured path in front of the vehicle and cross from side to side in front of the antenna. Verify that the reported target distance and azimuth angle are correct. * 2. — Confirm that the antenna face angle is properly adjusted to 1 degree down. 3. — Adjust the antenna in the direction opposite the detected side lane. Then, confirm that the antenna azimuth angle is correct left to right.
Front antenna detects vehicles in both left and right adjacent lanes, with no vehicle in front of your vehicle.	Radar side lobes extended/antenna assembly.	1. — Confirm that the antenna assembly is mounted at the minimum height, or above. 2. — Confirm that the antenna assembly is mounted securely. 3. — Confirm that the antenna beam's path is unobstructed and that no movement of surrounding body panels is being detected. 4. — Walk a measured path in front of the vehicle and cross from side to side in front of the antenna. Verify that the reported target distance and azimuth angle are correct. * 5. — Confirm that the antenna face angle is properly adjusted to 1 degree down. NOTE: Contact Eaton VORAD at (800) 840–7970 for additional assistance.

Troubleshooting

Component Troubleshooting		
Symptom	**Cause/Source**	**Remedy**
Front antenna loses or ignores detected vehicles within 100 feet (30 meters) in front of your vehicle.	Tracking module error/ antenna assembly.	1. — Confirm that the antenna assembly is correctly aligned. 2. — Check the antenna harness connection to the CPU and the antenna assembly. 3. — Inspect the antenna assembly, the harness, and the CPU for corrosion or damage. 4. — Confirm that the antenna assembly is mounted at the minimum height or above. 5. — Confirm that the antenna assembly is securely mounted. 6. — Confirm that the antenna beam's path is unobstructed and that no movement of surrounding body panels is being detected. 7. — Walk a measured path in front of the vehicle and cross from side to side in front of the antenna. Verify that the reported target distance and azimuth angle are correct. * 8. — Confirm that the antenna face angle is properly adjusted to 1 degree down. NOTE: If the component listed in the Cause/Source column has been replaced, perform a road test afterward to confirm that the condition has been resolved.
Side sensor display does not indicate power, or a detected object.	Side sensor display, wiring, CPU/side sensor display, wire harness, CPU.	1. — Check the side sensor display with ProLink and verify its operation. * 2. — Check that the side sensor display wire harness is properly connected and not damaged. 3. — Check for correct continuity and supplied voltage readings at the connector. 4. — Replace the side sensor display, then check its operation. 5. — Replace the CPU, reconfigure settings, then check its operation. *

* A ProLink 9000 diagnostic tool, equipped with an Eaton VORAD cartridge or a multi-protocol cartridge with the Eaton applications PCMCIA card, is required to perform checkout and configuration procedures.

Table 1, Component Troubleshooting

FAULT CODE TROUBLESHOOTING USING THE ERROR LOG MENU

1. Select ERROR LOG from the initial EVT–300 diagnostic menu.

NOTE: ERROR LOG provides a list of all the fault codes detected by the system. A BIT (Built-In Test) is performed every 15 seconds by the system to determine the condition of the components and internal processes. Faults that occur are logged as fault codes in the system's memory. The first line of the ERROR LOG menu displays the code number and the code status, either active or inactive.

2. Place the selection arrow next to the first line of the ERROR LOG menu. The first fault code in the error log is displayed.

NOTE: The second line of the ERROR LOG menu displays the name of the current fault. The third line (CLR CT/MIN) displays the number of occurrences of the current fault and the

total number of minutes it has been continuously occurring. The fourth and fifth lines of the menu indicate the date and time of the first and last occurrences, respectively, of the fault.

3. Return the display arrow to the active or inactive code line.
4. Press ENTER and the next fault code with its information is displayed.
5. Continue to press ENTER to display all logged fault codes with their information.

NOTE: It may be helpful in diagnosing or solving a problem to know if some action will remove a fault. Clear the count on a particular fault by following the steps below.

6. Select the fault code for which the count is to be cleared as in steps 2 and 3 above.
7. Place the display arrow on the CLR CT/MIN line.
8. Press ENTER to clear the fault's count.

NOTE: To get to the Eaton VORAD main menu, press FUNC in the initial EVT–300 diagnostic menu. The EVT–300 diagnostic menu is the default menu and comes on initially. Once at the Eaton VORAD main menu screen, you may select active or inactive faults. The name, FMI code, and count for active and inactive faults are displayed here. Failure Mode Identifiers (FMI) numbers describe a specific type of failure detected in a specific system.

9. Press the left or up arrow key to display the previous active or inactive fault.
10. Press the right or down arrow key to display the next active or inactive fault.
11. Press FUNC to return to the Eaton VORAD main menu.

NOTE: At the CLEAR FAULT CODES line, accessed from the Eaton VORAD main menu, you can clear all fault codes from system memory. Be sure this is what you want to do as all BIT data will be reinitialized when all fault codes are cleared.

12. Press ENTER if you want to clear all fault codes and then select DIAGNOSTICS from the Eaton VORAD main menu to return to the EVT–300 diagnostic menu.

Fault Code Troubleshooting

Fault Code *	Cause/Source	SID	FMI	Remedy
11/CONTROLLER	Controller/CPU.	254	12	CPU cruise control input error. Cannot be repaired in the field. †
12/CONTROLLER	Controller/CPU.	254	4	CPU NVRAM memory error. Cannot be repaired in the field. †
13/CONTROLLER	Controller/CPU.	254	4	CPU NVRAM internal battery voltage low. Cannot be repaired in the field. †
14/CONTROLLER	Controller/CPU.	254	12	CPU EEPROM error. Unable to write to memory storage device. Cannot be repaired in the field. †
15/CONTROLLER	Controller/ CyberCard.	254	12	1. — The system is unable to read the CyberCard or the card slot is damaged. Ensure that the card slot is clean and that no dirt, dust, or debris is present. 2. — CPU internal component failure. Cannot be repaired in the field. †

Troubleshooting

Fault Code Troubleshooting				
Fault Code *	**Cause/Source**	**SID**	**FMI**	**Remedy**
21/BRAKE	Vehicle brake input connection not detected/brake input.	3	2	1. — Confirm that the brake source is correctly configured in the CPU. ‡ 2. — Confirm that the exterior brake light bulbs are good. 3. — Confirm that the brake switch operates correctly. 4. — Perform the brake test and confirm that the correct signal is received when the pedal is depressed. ‡ 5. — Confirm that the brake logic is correctly configured in the CPU. ‡ 6. — Confirm that the brake input wire is connected to the proper source. 7. — Ensure that the main harness to CPU connection is good and that the harness is not damaged. 8. — Verify that pin number 9, on the top row of the main harness connector, receives 12 volts when the brake is applied.
22/SPEED MONITOR	Speed input is not detected/speed input, configuration setting.	6	2	1. — Confirm that the SPEEDO BIT setting is correctly configured in the CPU. ‡ 2. — Confirm that the speed mode is correctly configured. ‡ 3. — Perform the speedometer test to confirm the speedometer's accuracy against the vehicle speed. ‡ 4. — Check the main harness to the CPU connection and for damage to the main harness.
23/RIGHT TURN SIGNAL	Right turn signal input not detected/ turn signal input, configuration setting.	7	2	1. — Confirm that the vehicle has a right side sensor. If not, confirm that the right turn signal setting, in the H/W configuration menu, is NO. ‡ 2. — Confirm that the exterior turn signal bulbs are good. 3. — Confirm that the turn signal switch operates properly. 4. — Confirm that the right turn signal input is connected to the right turn signal lead. 5. — Perform the turn signal test to confirm that the correct input is received when the right turn signal is activated. ‡ 6. — Verify that pin number 15, on the top row of the main harness connector, receives 12 volts when the right turn signal is activated. 7. — Check the main harness to the CPU connection and for damage to the main harness.

Fault Code Troubleshooting				
Fault Code *	**Cause/Source**	**SID**	**FMI**	**Remedy**
24/RIGHT SIDE SENSOR	Right side sensor not communicating with CPU/right side sensor.	10	2	1. — Confirm that the vehicle has a right side sensor. If not, verify in the H/W configuration menu that the RSS setting is NO. ‡ 2. — Check the connection and for damage to the right side sensor wiring harness to the CPU. 3. — While performing the SS test, wave your hand in front of the right side sensor and verify that the correct signal is received. ‡ 4. — Disconnect the three-pin right side sensor, CPU pigtail, and CPU connectors. Check for corrosion or a recessed pin.
25/LEFT TURN SIGNAL	Left turn signal input not detected/ turn signal input, configuration setting.	8	2	1. — Confirm that the vehicle has a left side sensor. If not, confirm that the left turn signal setting is NO. ‡ 2. — Confirm that the exterior turn signal bulbs are good. 3. — Confirm that the turn signal switch operates properly. 4. — Confirm that the left turn signal input is connected to the left turn signal lead. 5. — Perform the turn signal test to confirm that the correct input is received when the left turn signal is activated. ‡ 6. — Verify that pin number 15, on the bottom row of the main harness connector, receives 12 volts when the left turn signal is activated. 7. — Check the main harness to the CPU connection and for damage to the main harness.
26/LEFT SIDE SENSOR	Left side sensor not communicating with CPU/left side sensor.	11	2	1. — Confirm that the vehicle has a left side sensor. If not, verify in the H/W configuration menu that the LSS setting is NO. ‡ 2. — Check the connection and for damage to the left side sensor wiring harness to the CPU. 3. — While performing the SS test, wave your hand in front of the left side sensor and verify that the correct signal is received. ‡ 4. — Disconnect the three-pin left side sensor, CPU pigtail, and CPU connectors. Check for corrosion or a recessed pin.
31/CONTROLLER	Controller/CPU.	254	12	CPU real time clock error. Cannot be repaired in the field. †
32/CONTROLLER	CPU gyroscope error/CPU.	254	12	1. — Confirm that the CPU is oriented and mounted correctly for its type. 2. — While performing the GYRO test, confirm that the voltage is stable when the vehicle is stationary, but begins to vary when a turn is simulated by tilting the CPU left to right. ‡ 3. — CPU internal component failure. Cannot be repaired in the field. †

Troubleshooting

Fault Code Troubleshooting				
Fault Code *	**Cause/Source**	**SID**	**FMI**	**Remedy**
33/CONTROLLER	VBUS communications reception/wire integrity, connectors.	254	12	1. — Check the main harness to CPU connection and for damage to the pins and harness. 2. — Check the connection of the J1587 wires and for damage to the pins and wires.
34/CONTROLLER	VBUS communications transmission/wire integrity, connectors.	254	12	1. — Check the main harness to CPU connection and for damage to the pins and harness. 2. — Check the connection of the J1587 wires and for damage to the pins and wires.
41/CONTROLLER	J1587 communications reception/CPU, wire integrity, connectors.	254	12	1. — In the S/W configuration menu, confirm that J1587 is correctly configured and enabled. ‡ 2. — Check the connection of the J1587 wires to the vehicle harness and for damage to the wires. 3. — Check the connection of the J1587 wires at pin number 7 positive and pin number 8 negative, on the top row of the CPU connector.
42/CONTROLLER	J1587 communications transmission/CPU, wire integrity, connectors.	254	12	1. — In the S/W configuration menu, confirm that J1587 is correctly configured and enabled. ‡ 2. — Check the connection of the J1587 wires to the vehicle harness and for damage to the wires. 3. — Check the connection of the J1587 wires at pin number 7 positive and pin number 8 negative, on the top row of the CPU connector.
43/CONTROLLER	J1939 H/W communications/ CPU, wire integrity, connectors.	254	12	1. — In the S/W configuration or product options menu, confirm that J1939 is activated through SPEED mode or BRAKE mode. ‡ 2. — Check the connection of the J1939 harness to the vehicle J1939 backbone and for damage to the harness. 3. — Check the connection of the J1939 wires at pin number 7 positive, pin number 8 negative, and pin number 9 shield on the bottom row of the CPU connector. NOTE: Special instructions are necessary to clear this error. Contact Eaton VORAD at (800) 840–7970.
44/CONTROLLER	J1939 address communications/ CPU, wire integrity, connectors.	254	12	1. — In the S/W configuration or product options menu, confirm that J1939 is activated through SPEED mode or BRAKE mode. ‡ 2. — Check the connection of the J1939 harness to the vehicle J1939 backbone and for damage to the harness. 3. — Check the connection of the J1939 wires at pin number 7 positive, pin number 8 negative, and pin number 9 shield on the bottom row of the CPU connector. NOTE: Special instructions are necessary to clear this error. Contact Eaton VORAD at (800) 840–7970.

Fault Code Troubleshooting				
Fault Code *	**Cause/Source**	**SID**	**FMI**	**Remedy**
45/CONTROLLER	J1939 ERC 1 communications/ wire integrity, connectors, engine retarder, engine retarder switch.	254	12	1. — Check the connection of the J1939 harness to the vehicle J1939 backbone and for damage to the harness. 2. — Check the connection of the J1939 wires at pin number 7 positive, pin number 8 negative, and pin number 9 shield on the bottom row of the CPU connector. 3. — Confirm that the engine retarder and the engine retarder switch function properly. NOTE: Special instructions are necessary to clear this error. Contact Eaton VORAD at (800) 840–7970.
46/CONTROLLER	J1939 EEC 1 communications/ wire integrity, connectors, engine ECM software.	254	12	1. — Check the connection of the J1939 harness to the vehicle J1939 backbone and for damage to the harness. 2. — Check the connection of the J1939 wires at pin number 7 positive, pin number 8 negative, and pin number 9 shield on the bottom row of the CPU connector. 3. — Confirm that the engine ECM software is compatible with EVT–300.
47/CONTROLLER	J1939 ETC2 communications/ wire integrity, connectors, transmission, transmission software.	254	12	1. — Check the connection of the J1939 harness to the vehicle J1939 backbone and for damage to the harness. 2. — Check the connection of the J1939 wires at pin number 7 positive, pin number 8 negative, and pin number 9 shield on the bottom row of the CPU connector. 3. — Confirm that the transmission and/or transmission software is compatible with EVT–300. NOTE: Contact Eaton VORAD at (800) 840–7970 for additional assistance.
48/CONTROLLER	J1939 CCVS communications/ wire integrity, connectors, cruise control switch(es).	254	12	1. — Check the connection of the J1939 harness to the vehicle J1939 backbone and for damage to the harness. 2. — Check the connection of the J1939 wires at pin number 7 positive, pin number 8 negative, and pin number 9 shield on the bottom row of the CPU connector. 3. — Confirm that the cruise control switch(es) operates properly. NOTE: Contact Eaton VORAD at (800) 840–7970 for additional assistance.
51/CONTROL DISPLAY UNIT	No DDU power message/DDU, wire integrity, connectors.	9	12	1. — Confirm that the DDU indicator lights, speaker, and knobs function properly. ‡ 2. — Check the connection of the DDU wires in the main harness to the CPU and for damage to the wires. 3. — Check the J1587 wire connections and for damage to the wires.

Troubleshooting

Fault Code Troubleshooting				
Fault Code *	**Cause/Source**	**SID**	**FMI**	**Remedy**
52/CONTROL DISPLAY UNIT	No DDU ID message/DDU, wire integrity, connectors, driver ID card.	9	12	1. — Confirm that the DDU indicator lights, speaker, and knobs function properly. ‡ 2. — Check the connection of the DDU wires in the main harness to the CPU and for damage to the wires. 3. — Check the J1587 wire connections and for damage to the wires. 4. — Insert the driver ID card and confirm that it is identified.
53/CONTROL DISPLAY UNIT	DDU reset message error/DDU, wire integrity, connectors.	9	12	1. — Confirm that the DDU indicator lights, speaker, and knobs function properly. ‡ 2. — Check the connection of the DDU wires in the main harness to the CPU and for damage to the wires. 3. — Check the J1587 wire connections and for damage to the wires.
54/CONTROL DISPLAY UNIT DDU VBUS TIMEOUT	No VBUS communications/ wire integrity, connectors.	9	12	1. — Check the connection of the DDU wires in the main harness to the CPU and for damage to the wires. 2. — Check the J1587 wire connections and for damage to the wires.
61/CONTROL DISPLAY UNIT DDU VBUS	No VBUS communications/ wire integrity, connectors.	9	12	1. — Check the connection of the DDU wires in the main harness to the CPU and for damage to the wires. 2. — Check the J1587 wire connections and for damage to the wires.
62/CONTROL DISPLAY UNIT	DDU volume input error/DDU, wire integrity, connectors.	9	5	1. — Confirm that the DDU indicator lights, speaker, and knobs function properly. ‡ 2. — Check the connection of the DDU wires in the main harness to the CPU and for damage to the wires.
63/CONTROL DISPLAY UNIT	DDU range input error/DDU, wire integrity, connector.	9	5	1. — Confirm that the DDU indicator lights, speaker, and knobs function properly. ‡ 2. — Check the connection of the DDU wires in the main harness to the CPU and for damage to the wires.
64/CONTROL DISPLAY UNIT	DDU speaker error/ DDU, wire integrity, connector.	4	5	1. — Confirm that the DDU indicator lights, speaker, and knobs function properly. ‡ 2. — Check the connection of the DDU wires in the main harness to the CPU and for damage to the wires.
65/CONTROL DISPLAY UNIT DDU SPEAKER DRIVER	No DDU speaker output/DDU, wire integrity, connector.	4	5	1. — Confirm that the DDU indicator lights, speaker, and knobs function properly. ‡ 2. — Check the connection of the DDU wires in the main harness to the CPU and for damage to the wires.

Fault Code Troubleshooting				
Fault Code *	**Cause/Source**	**SID**	**FMI**	**Remedy**
71/FORWARD ANTENNA NO FE POWER MESSAGE	No FE power message/antenna assembly, wire integrity, connector.	1	12	1. — Walk in front of the antenna and verify that the reported target distance and azimuth angle are correct. ‡ 2. — Check the connection of the antenna assembly wires in the main harness to the CPU and for damage to the wires and connector pins. 3. — Check the condition of the J1587 wires and for damage to the wires.
72/FORWARD ANTENNA NO FE ID MESSAGE	No FE ID message/ antenna assembly, wire integrity, connector.	1	12	1. — Walk in front of the antenna and verify that the reported target distance and azimuth angle are correct. ‡ 2. — Check the connection of the antenna assembly wires in the main harness to the CPU and for damage to the wires and connector pins. 3. — Check the condition of the J1587 wires and for damage to the wires.
73/FORWARD ANTENNA FE RESET MESSAGE	FE reset message/ antenna assembly, wire integrity, connector.	1	12	1. — Walk in front of the antenna and verify that the reported target distance and azimuth angle are correct. ‡ 2. — Check the connection of the antenna assembly wires in the main harness to the CPU and for damage to the wires and connector pins. 3. — Check the condition of the J1587 wires and for damage to the wires.
74/FORWARD ANTENNA FE VBUS TIMEOUT	FE VBUS timeout/ antenna assembly, wire integrity, connector.	1	12	1. — Walk in front of the antenna and verify that the reported target distance and azimuth angle are correct. ‡ 2. — Check the connection of the antenna assembly wires in the main harness to the CPU and for damage to the wires and connector pins. 3. — Check the condition of the J1587 wires and for damage to the wires.
81/FORWARD ANTENNA FE ADC INTERRUPT	FE ADC interrupt/ antenna assembly, wire integrity, connector.	2	12	1. — Walk in front of the antenna and verify that the reported target distance and azimuth angle are correct. ‡ 2. — Check the connection of the antenna assembly wires in the main harness to the CPU and for damage to the wires and connector pins. 3. — Check the condition of the J1587 wires and for damage to the wires.
83/FORWARD ANTENNA FE NOISE FLOOR	FE noise floor/ antenna assembly, wire integrity, connector.	1	12	1. — Walk in front of the antenna and verify that the reported target distance and azimuth angle are correct. ‡ 2. — Check the connection of the antenna assembly wires in the main harness to the CPU and for damage to the wires and connector pins. 3. — Check the condition of the J1587 wires and for damage to the wires.

Troubleshooting

Fault Code Troubleshooting				
Fault Code *	**Cause/Source**	**SID**	**FMI**	**Remedy**
84/FORWARD ANTENNA FE MODULATION	FE modulation/ antenna assembly, wire integrity, connector.	1	12	1. — Walk in front of the antenna and verify that the reported target distance and azimuth angle are correct. ‡ 2. — Check the connection of the antenna assembly wires in the main harness to the CPU and for damage to the wires and connector pins. 3. — Check the condition of the J1587 wires and for damage to the wires.
85/FORWARD ANTENNA FE FREQUENCY INJECTION	FE frequency injection/antenna assembly, wire integrity, connector.	1	12	1. — Walk in front of the antenna and verify that the reported target distance and azimuth angle are correct. ‡ 2. — Check the connection of the antenna assembly wires in the main harness to the CPU and for damage to the wires and connector pins. 3. — Check the condition of the J1587 wires and for damage to the wires.
86/FORWARD ANTENNA FE PROGRAM CRC	FE program CRC/ antenna assembly, wire integrity, connector.	1	12	1. — Walk in front of the antenna and verify that the reported target distance and azimuth angle are correct. ‡ 2. — Check the connection of the antenna assembly wires in the main harness to the CPU and for damage to the wires and connector pins. 3. — Check the condition of the J1587 wires and for damage to the wires.
87/FORWARD ANTENNA	Forward antenna communications/ antenna assembly, wire integrity, connector.	2	12	1. — Walk in front of the antenna and verify that the reported target distance and azimuth angle are correct. ‡ 2. — Check the connection of the antenna assembly wires in the main harness to the CPU and for damage to the wires and connector pins. 3. — Check the condition of the J1587 wires and for damage to the wires.
88/FORWARD ANTENNA	Forward antenna communications/ antenna assembly, wire integrity, connector.	2	12	1. — Walk in front of the antenna and verify that the reported target distance and azimuth angle are correct. ‡ 2. — Check the connection of the antenna assembly wires in the main harness to the CPU and for damage to the wires and connector pins. 3. — Check the condition of the J1587 wires and for damage to the wires.
91/VEHICLE BATTERY	Vehicle battery/ vehicle battery problem.	0	0	1. — Inspect the vehicle batteries and determine the problem. 2. — Charge or replace the vehicle batteries.

Fault Code Troubleshooting				
Fault Code *	**Cause/Source**	**SID**	**FMI**	**Remedy**
92/HEAVY RAIN	Heavy rain/side sensor, wire integrity, connectors.	0	0	1. — In heavy rain conditions, this is not an error. 2. — Confirm that the vehicle has a side sensor. 3. — Check the side sensor to CPU connection and for damage to the wire harness. 4. — While performing the SS test, wave your hand in front of the side sensor and confirm that the correct signal is received. ‡ 5. — Disconnect the three-pin side sensor and CPU connectors. Check for corrosion or a recessed pin.
93/SOFTWARE	Software error/ software, CPU, antenna assembly, DDU, side sensor.	0	0	1. — The software detects a J1587 transmit or receive buffer overflow. 2. — Internal component failure. Cannot be repaired in the field. †
94/VBUS Q	VBUS queue error/ software.	0	0	1. — The software detects a VBUS transmit or receive buffer overflow. 2. — Internal component failure. Cannot be repaired in the field. †
10/END	No faults found, or end of fault codes.	0	0	1. — No faults found. 2. — End of fault codes.

* MID (message identifier) # 219 applies to all the fault codes in this table. This MID has been assigned to collision avoidance radar.

† Return the CPU to the manufacturer for repair and/or replace it.

‡ A ProLink 9000 diagnostic tool, equipped with an Eaton VORAD cartridge or a multi-protocol cartridge with the Eaton applications PCMCIA card, is required to perform checkout and configuration procedures.

Table 2, Fault Code Troubleshooting

Specifications

IMPORTANT NOTIFICATION: Servicing of the Eaton VORAD Collision Warning System should be undertaken only by qualified technicians. Special skills and equipment are required to perform these procedures. For assistance, contact Eaton VORAD at (800) 840–7970.

See **Fig. 1** or **Fig. 2** for a diagram of the collision warning system wiring and components.

See **Fig. 3** or **Fig. 4** for a diagram of the collision warning system dash overlay harness.

Torque Specifications		
Fastener Description	**lbf·ft**	**N·m**
Antenna Mounting Plate Capscrews and Locknuts (Conventional)	28	38
Antenna Mounting Plate Capscrews and Locknuts (Argosy)	8	11

Table 1, Torque Specifications

Component Specifications	
Description	**Degrees**
Antenna Assembly Azimuth Setting	0
Antenna Assembly Vertical Angle	1 Down (89 or 91)

Table 2, Component Specifications

Specifications

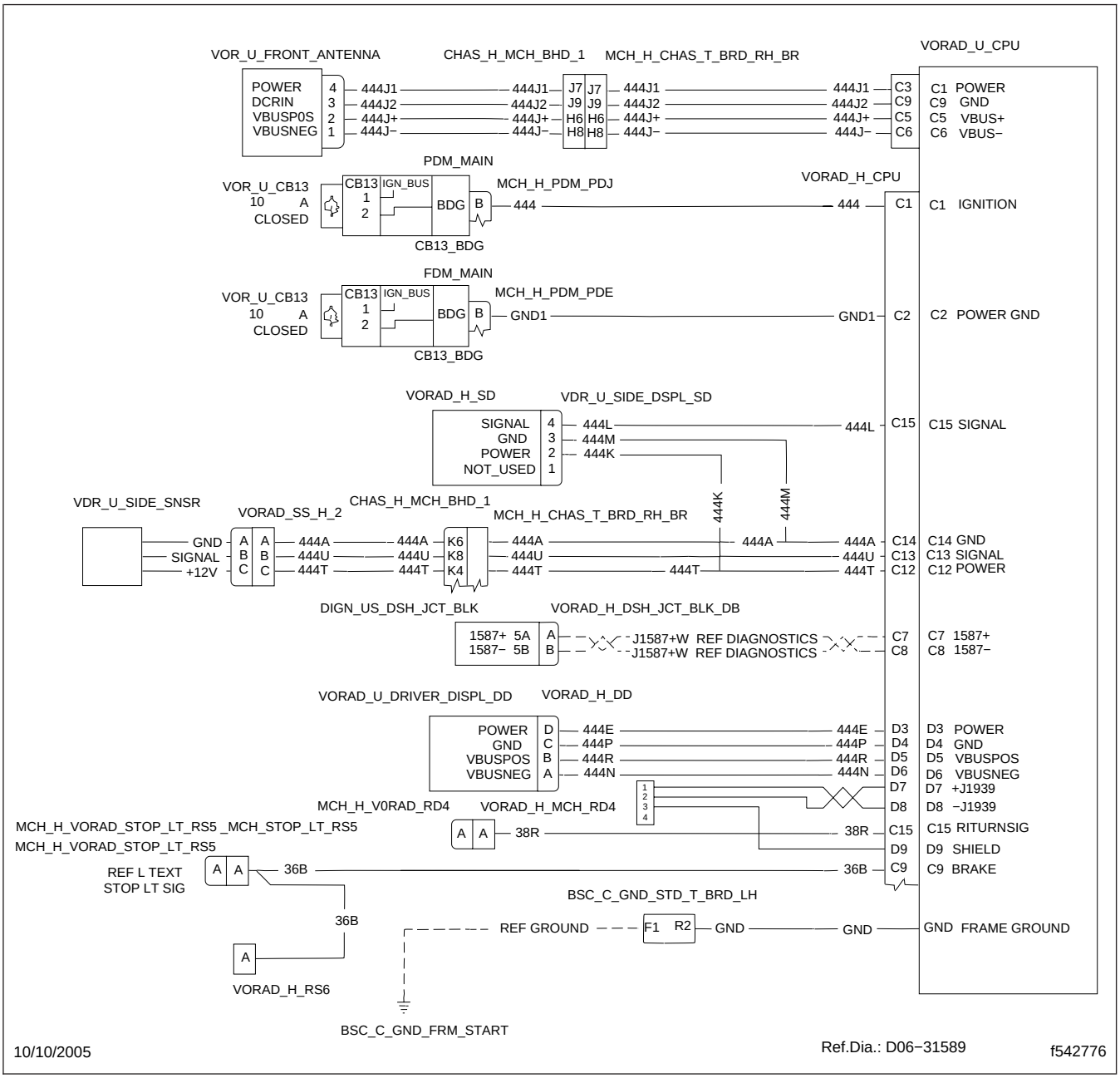


Fig. 1, Wiring Diagram (Conventional)

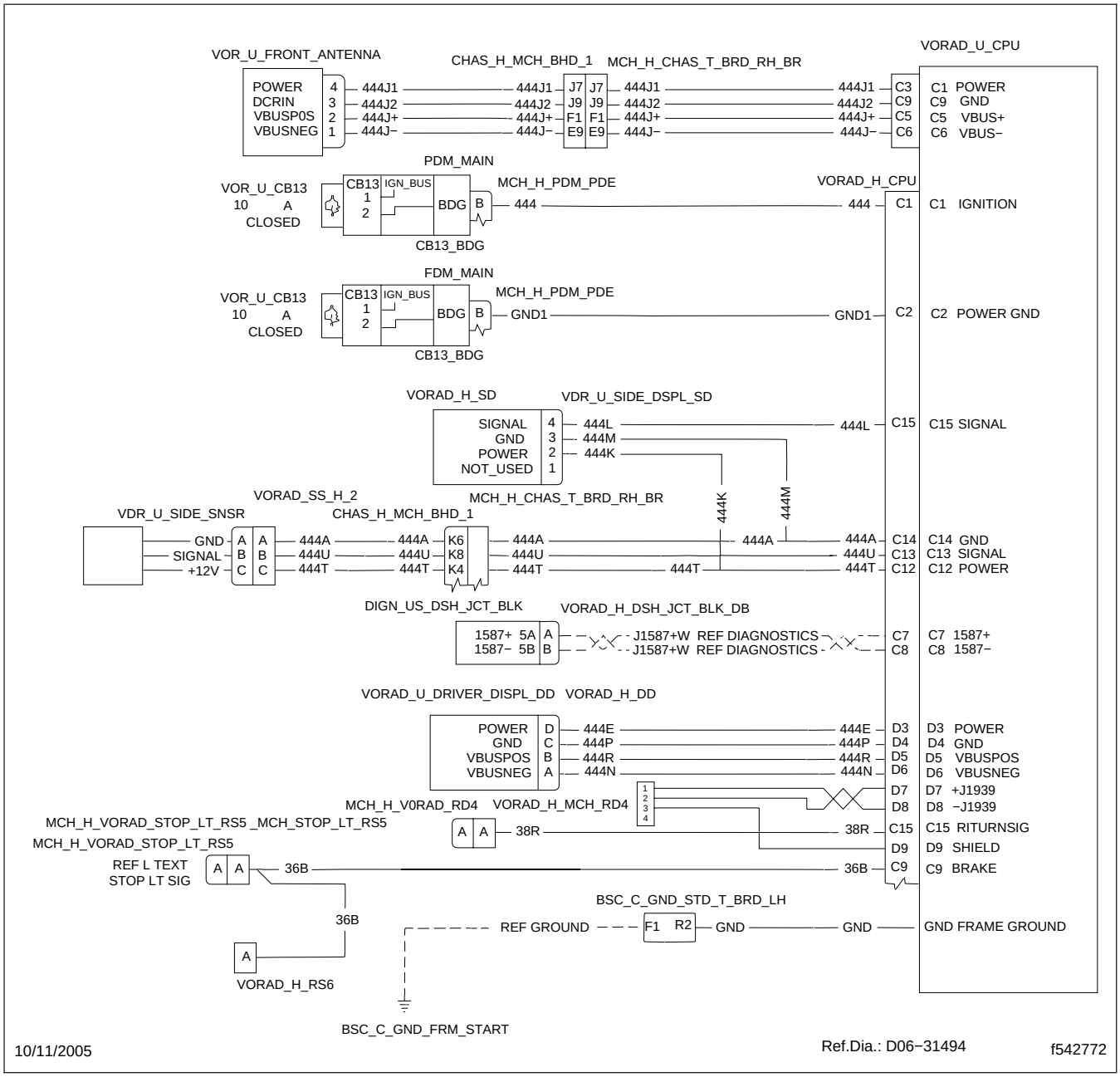


Fig. 2, Wiring Diagram (Argosy)

Specifications

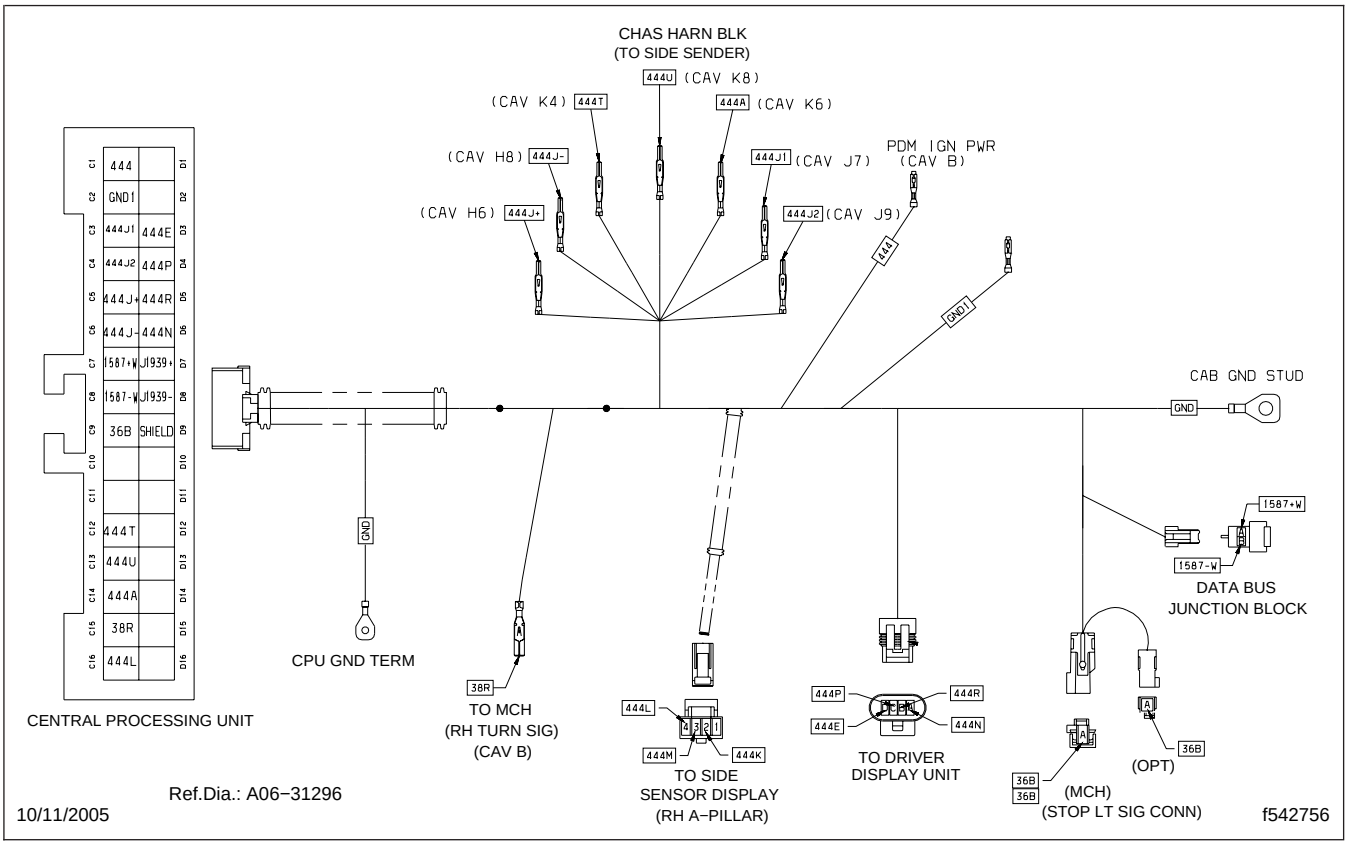


Fig. 3, Dash Harness Assembly (Conventional)

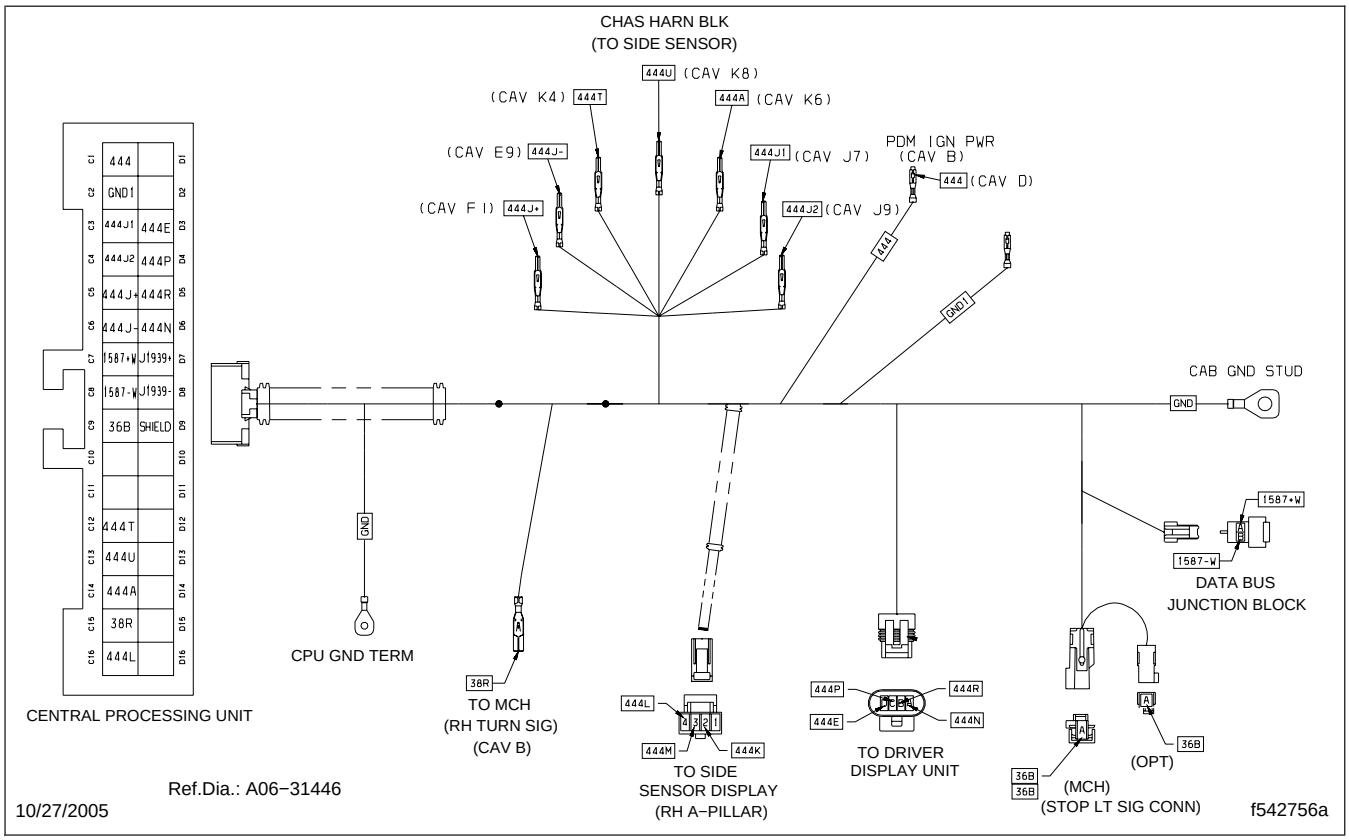


Fig. 4, Dash Harness Assembly (Argosy)

Datalink Repairs

If the datalink wires or cables are damaged, they can be repaired as follows:

J1587 and J1922 REPAIRS

Use the same methods of repair for the twisted-pair datalink wiring as are used for the other wires on the vehicle. However, the datalink wires must be twisted at a rate of a minimum one turn per inch (25 mm) of length.

J1939 REPAIRS

A special cable must be used for repairs to the J1939 datalink wiring. The two types of J1939 cable ("heavy" and "lite") can be spliced together as long as the pass-through connectors are the "heavy" type. The "lite" cable (because of its lower cost) is recommended for repairs on both types of J1939 cable. Refer to Appendix C of SAE J1939-11 for the special procedures for repairing the "heavy" J1939 datalink cable.

General Information

A "datalink" is an electrical network that connects two or more computers to exchange data. The simplest datalink is a pair of wires between two computers. Freightliner uses datalinks to connect the Electronic Control Units (ECUs) for the electronically controlled vehicle systems with each other and with the Instrumentation Control Unit (ICU). A personal computer using Freightliner's ServiceLink diagnostic software can also be connected to the network via a datalink.

Different types of datalinks are used to connect certain ECUs. A Century Class vehicle may have any of the following datalinks:

- J1587: A general-purpose, low-speed datalink for all ECU data exchange. See **Fig. 1**. The J1587 datalink uses a twisted pair of wires to reduce interference from the digital messages being sent on the wires. Most Century Class vehicles have a J1587 datalink.
- J1922: A special-purpose, low-speed datalink for engine, ABS, and transmission ECU communication. See **Fig. 2**. Most vehicles with ABS and traction control have a J1922 datalink. ServiceLink and other diagnostic tools cannot be connected to a J1922 datalink. However, faults are still reported by the ECU on the J1922 datalink through the warning lights in the ICU or fault codes reported on the J1587 datalink or both.
- J1939: A high-speed, general-purpose datalink. See **Fig. 3**. The J1939 datalink uses special cabling: either "heavy," which has two data conductors, a drain conductor and a foil shield in a heavy jacket, or "lite," which has the two data conductors in a plastic jacket. The "heavy" and "lite" J1939 datalinks can be intermixed as long as a "heavy" connector is used between the two. An ECU can be connected anywhere along the length of the datalink, but a terminating resistor is required on each end of a J1939 datalink, within a maximum distance of 3 feet (1 m) from the last ECU or diagnostics connector. Certain configurations require J1939 datalinks, but they are not widely used on Century Class vehicles.

On the datalink, the ECUs send and receive the following types of data:

- Vehicle operating parameters like engine speed, oil temperature, etc.
- ECU-to-ECU control and common messages
- Diagnostic data, such as fault codes
- ECU status information

For more information, see **Section 54.03, Specifications 400**, Tables 3 through 9.

On Century Class vehicles, the typically factory-installed ECUs shown in **Table 1** connect to the datalink.

ECUs Connected to the Datalink	
ECU	**Status**
Engine ECU	Always connected
Instrumentation Control Unit	Always connected
Electronic Transmission ECU	Optional
Antilock Brakes (ABS) ECU	Standard
Electronic Suspension ECU	Optional
Data Logging Unit	Optional
Qualcomm® Communications System Control Unit	Optional
Air Conditioning Protection Unit (ACPU)	Standard*
HighwayMaster® Communications System Control Unit	Optional

* Not available on vehicles built after April 1999.

Table 1, ECUs Connected to the Datalink

The Roll Call

To check the readiness of the ECUs on the datalink, the ICU sends a signal to other ECUs and expects a response from each. This "Roll Call" procedure tells the ICU which ECUs are functioning correctly. When the list of functioning ECUs is compared against the parameter list of factory-installed ECUs that are supposed to respond, the technician can determine which ECUs or datalinks are bad.

The roll call procedure was not included in the software of the ICU2L, and is not found in some early versions of ICU1. The list of ECUs that are polled can be changed using Freightliner ServiceLink software for ICU1 and ICU2M only. The following ICUs will conduct a roll call when the ignition is first turned on:

- ICU1 with software versions 8.4.0 and greater (any ECU, subject to parameter settings)
- ICU2M (any ECU, subject to parameter settings)
- ICU3 (limited to engine ECU and ABS ECU)
- ICU2L (limited to engine ECU and ABS ECU) after March 1999 release

See **Table 2** for the ICU parameters.

If the ICU does not receive a signal on the datalink from one or more of the active ECUs, it displays a roll call fault. The roll call fault is displayed *only* on the dash driver display screen. It is not broadcast on the datalink; therefore, it cannot be read by ServiceLink. However, Servicelink 2.0 can be used to determine if an ECU is not responding because it polls all ECUs on the datalink when it first connects to the vehicle datalink.

Datalink Junction Blocks

For datalink wiring diagrams, see **Specifications 400**. For the J1587 datalink, the wires routed through the vehicle cab have the following junction block connectors:

- The vehicles built through August 1996 have one datalink junction block. The ICU connector serves as the dash junction block.
- The vehicles built from August 1996 to June 1997 have two datalink junction blocks but only one datalink connection to the ICU, with an internal jumper to the right-hand side.
- The vehicles built from June 1997 have two datalink junction blocks and two datalink connections (one to each ICU microprocessor). Vehicles with an ICU2M, ICU2L, or ICU3 use only one connection to the ICU.

ServiceLink Roll Call Parameters				
ECU	ICU Parameter No.		Roll Call	
	ICU1	ICU2M	ON	OFF
Engine ECU	N/A*	404	128	0
Electronic Transmission ECU	193	410	130	0
Antilock Brakes (ABS) ECU	190	407	136	0
Electronic Suspension ECU	191	408	150	0
Data Logging Unit	195	413	179	0
Qualcomm® Communications System Control Unit	194	411	181†	0
Air Conditioning Protection Unit (ACPU)	192	409	190	0
HighwayMaster® Communications System Control Unit	194	411	231†	0
VORAD ECU	189	406	219	0

* Always enabled

† Do not use this parameter.

Table 2, ServiceLink Roll Call Parameters

Century Class vehicles have at least one datalink junction block located under the B-pillar base cover. See **Fig. 4**. Those built since August, 1996, have a second datalink junction block located behind the waste bin on the wall of the driver's console support. The location of the junction block at the dash is shown in **Fig. 5**.

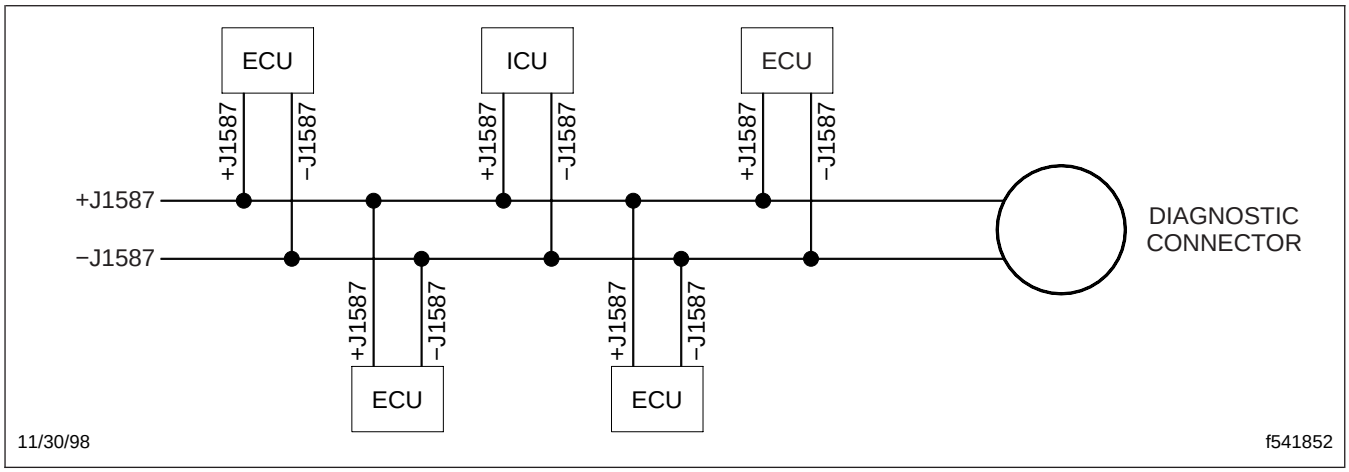
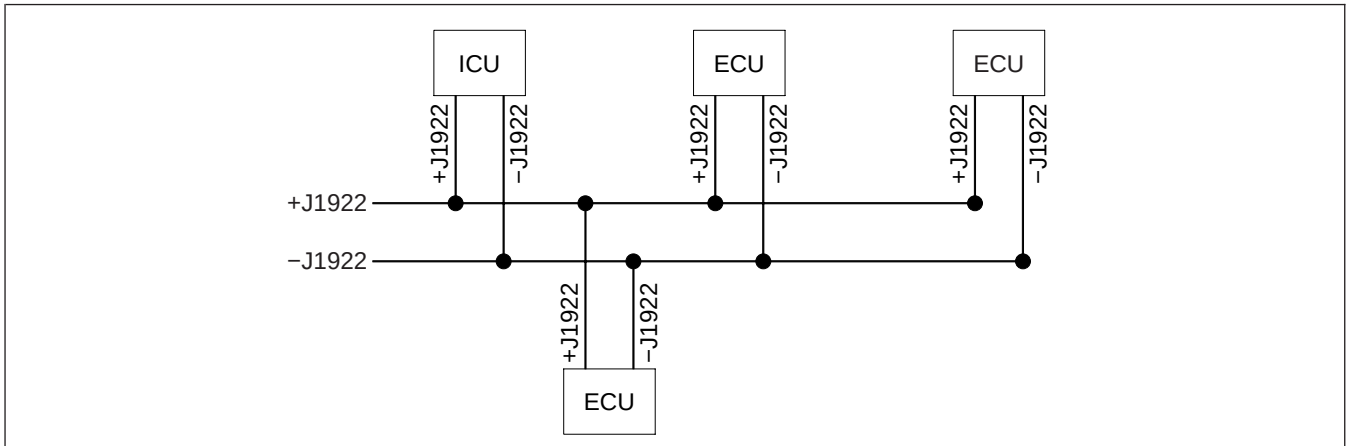


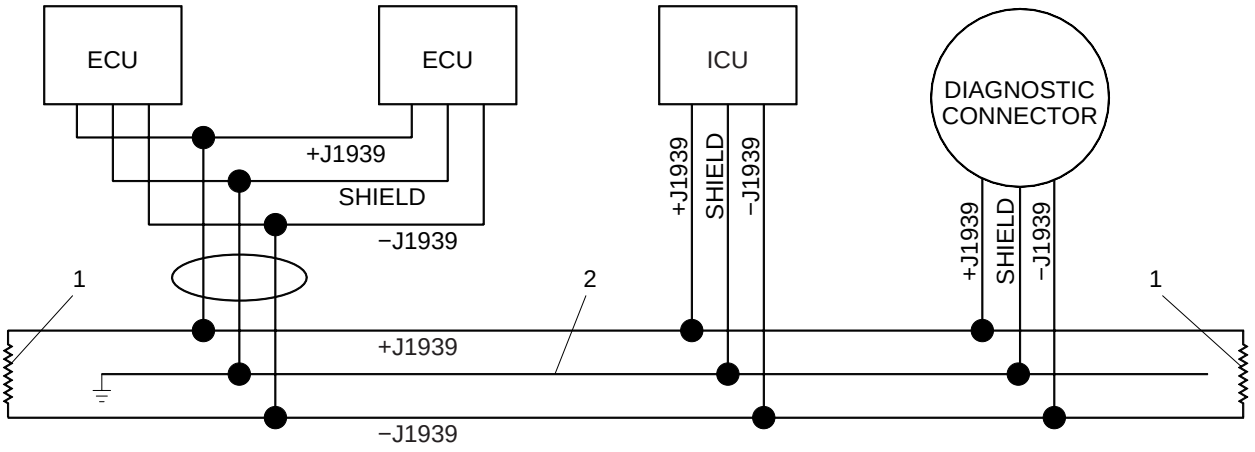
Fig. 1, Basic J1587 Datalink



Note: The J1922 datalink has no diagnostics connector and a maximum of one ECU each for the engine, transmission, and ABS.

Fig. 2, J1922 Datalink Example

General Information



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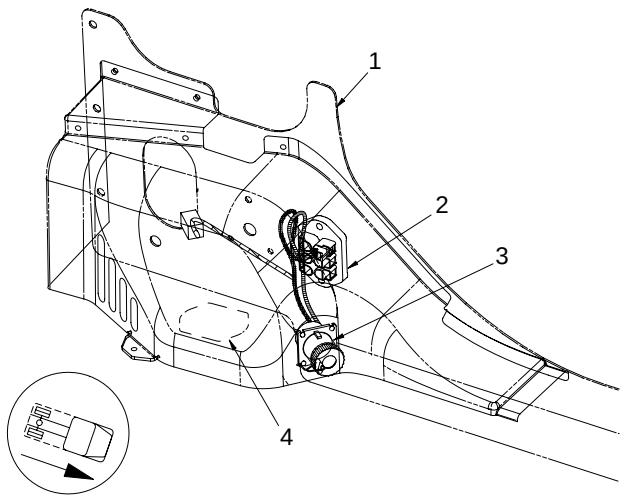
Note: The J1939 "Lite" datalink has no grounded shield (Item 2).

1. Terminating Resistors (120 Ohm)
2. Grounded Shield (J1939 "Heavy" only)

Fig. 3, Sample J1939 Datalink with Terminating Resistors



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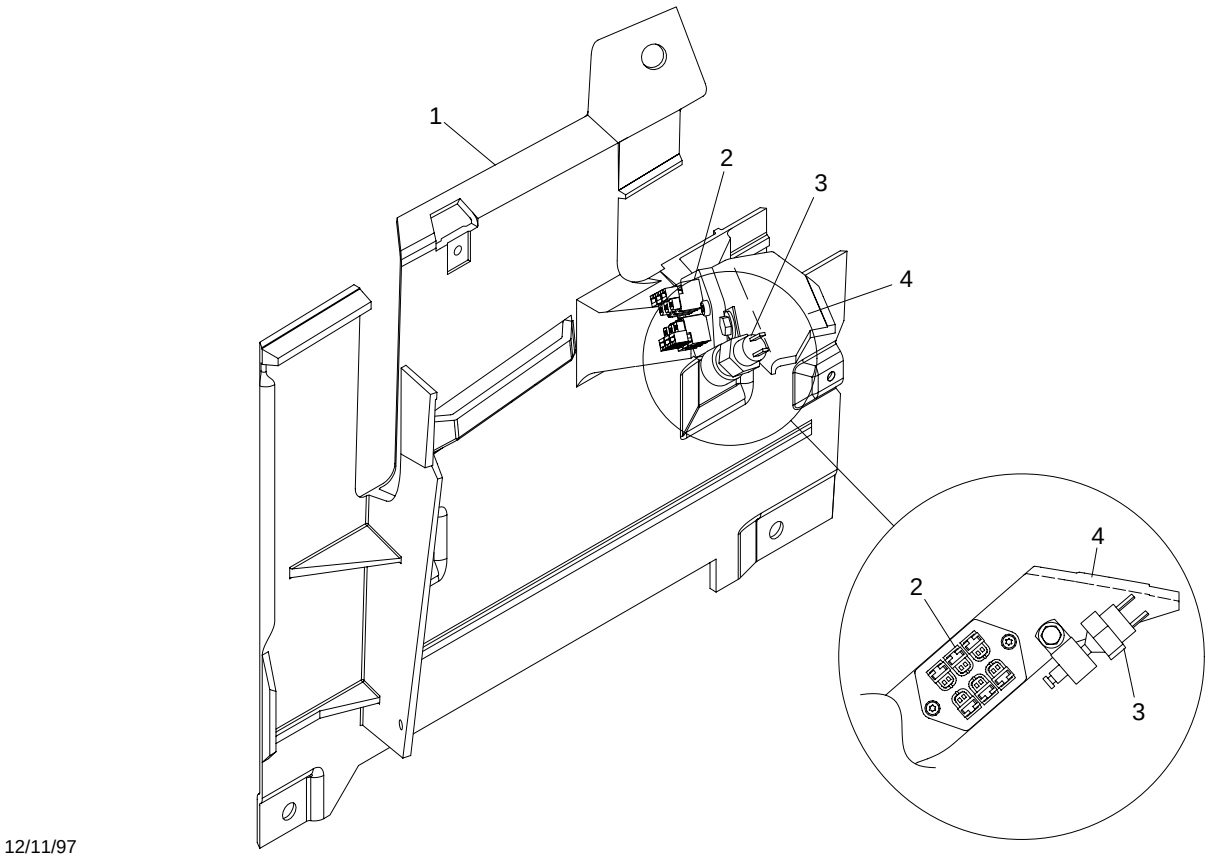
1. LH B-Pillar Structure
2. Datalink Junction Block
3. Diagnostics Connector
4. Optional Datalink Junction Block

Fig. 4, B-Pillar Datalink Junction Block



1. Driver's Console Support
2. Datalink Junction Block
3. HVAC Recirc Air Switch
4. Dash Support Arm

Fig. 5, Dash Datalink Junction Block

General Information

This Troubleshooting subject has three main parts:

- Troubleshooting Tables

  Use the Troubleshooting Tables to get ideas on what could be causing the problem and the possible remedies to that problem.

- Troubleshooting Procedures

  Follow the Troubleshooting Procedures section to isolate the areas that have faults and to know which tests to perform.

- Testing Procedures

  The Testing Procedures section has the individual tests and specifications needed to determine whether a part must be repaired or replaced.

Troubleshooting Tables

Use the following troubleshooting tables to find remedies to possible causes of datalink problems.

Problem—Power-On Roll Call Reports Fault

Problem—Power-On Roll Call Reports Fault	
Possible Cause	**Remedy**
ECU does not support roll call function (ICU1/2M only).	Reset ECU parameter to disable roll call.
Datalink wiring has fault.	Repair or replace.
Wrong power supply voltage or ground to ECU.	Replace fuse or circuit breaker, charge battery, check connections.
Connector has fault - (Pass-through, Stub, Diagnostic)	Repair or replace wiring.
ECU has fault.	Replace ECU.
ICU has fault.	Replace ICU.
Terminating resistor for J1939 datalink is missing or has a fault.	Replace terminating resistor.
Stub length is too long on J1939 datalink.	Shorten "lite" stub to less than 10 feet (3 m).
Battery is discharged or is bad.	Charge or replace battery.

Problem—ServiceLink Will Not Connect

Problem—ServiceLink Will Not Connect	
Possible Cause	**Remedy**
ICU is older series that does not support roll call.	Use ICU for display of active fault codes only.
One or more ECUs has a fault.	Remove suspected ECUs one at a time until ServiceLink can be connected.
ServiceLink computer is not configured or connected correctly.	Make sure that the cable is connected to the correct port on the computer. Try to connect ServiceLink to another vehicle.
Connector types are different.	The J1939 datalink and new J1587 datalinks have 9-pin connectors. Connect an adapter or use the ICU for the diagnostics information display.
J1922 datalink is installed.	Use ICU for diagnostics information display.
Battery is discharged, has a bad connection, or has a fault.	Charge, clean terminals, or replace battery.

Troubleshooting

Problem—Missing Data on Datalink-Driven Gauges

Problem—Missing Data on Datalink-Driven Gauges *	
Possible Cause	**Remedy**
ICU or engine ECU is not communicating on datalink.	Test wiring and ICU or engine ECU.
Datalink wiring has a fault.	Test and repair wiring.
Connector or junction block has a fault.	Repair or replace connector.
Incorrect voltage to ECUs	Test datalink and vehicle wiring.

* Datalink-driven gauges include: engine oil pressure,coolant temperature, engine oil temperature, turbo air pressure, tachometer, speedometer

Troubleshooting Procedures

To find the part of the datalink system that is causing a problem, follow the Troubleshooting Procedures and refer to the appropriate Troubleshooting Tests for the test points and specifications. Perform the steps of the Troubleshooting Procedures in sequence until you locate the fault.

The seven steps to diagnosing a datalink problem are:

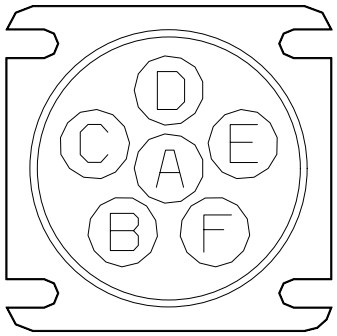
1. Determine which types of datalink are installed on the vehicle.

   1.1 Check the diagnostic connector. A 6-pin connector (or a 9-pin connector without pins C and D installed) is used for J1587 datalinks. See **Fig. 1** and **Fig. 2**. J1939 datalinks have pins C and D installed in the 9-pin diagnostics connector. The J1922 datalink wiring is used only for the engine, ABS and automatic transmission ECUs and has no diagnostic connector.

   1.2 Check the wires. J1939 cable has a heavy jacket. Note that some non-Freightliner ECUs have their J1587 wires inside a jacket as well. If all the wiring has a jacket, the datalink is a J1939 datalink.

   If the J1939 cable has a drain wire inside the shielding, it is a "heavy" cable. The J1939 "lite" cable (with no drain wire) can be spliced into a section of "heavy" cable.

   1.3 Determine whether a Cummins IS Series, Caterpillar CFE, or a Mercedes-Benz engine is installed with an ABS system that has traction control. These systems use a J1939 datalink.



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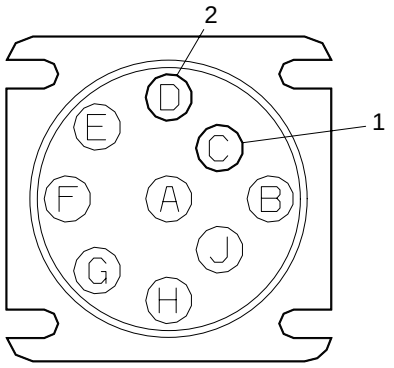
1. Pin A (J1587+)
2. Pin B (J1587–)
3. Pin C (12V+)
4. Pin E (Ground)

Fig. 1, J1587 6-Pin Diagnostics Connector



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NOTE: Pins C and D are not installed in the J1587 diagnostics connector.

1. Pin C (J1939+)
2. Pin D (J1939–)

Fig. 2, J1939/J1587 9-Pin Diagnostics Connector

1.4 A J1939 datalink is used when an Eaton® Fuller® AutoShift transmission is installed. The WABCO EBS (brake-by-wire) system and certain Eaton VORAD EVT-300 systems also require J1939 datalinks. Certain other ECUs may require a J1939 datalink.

2. Determine which ECUs are not communicating either with the ICU or Servicelink 2.0.

2.1 Identify the missing ECU from the code on the ICU display or on ServiceLink. See the *Century Class Trucks Workshop Manual, Section 54.03,* **Specifications 400**, for the complete list of codes.

2.2 Compare the ICU (late ICU1, ICU2M, ICU2L after March 1999, and ICU3) roll call list with ServiceLink ECU list.

Note: Some ECUs cannot communicate with the ICU, but will appear on the ServiceLink parameter list. The ICU2L and ICU3 rollcall function is limited to the engine ECU and the ABS ECU.

2.3 If an ECU is not communicating on the datalink, disconnect all the generic ECUs, one at a time, until no faults are displayed on the ICU screen or until ServiceLink connects to the system. The last ECU to be disconnected before the successful ServiceLink connection is the one causing the problem.

3. Check the suspected ECU.

3.1 Check the resistance and voltage at the ECU connectors. See **Testing the ECUs** in the DATALINK TESTING PROCEDURES section of this subject.

3.2 Temporarily replace the ECU with an ECU known to be good. If the ICU (or ServiceLink) now lists that ECU, install a new ECU.

4. Check the wires and connectors from the ICU at the connector for the suspected faulty ECU. See **Testing the J1587 Datalink**, **Testing the J1922 Datalink**, or **Testing the J1939 Datalink** in the DATALINK TESTING PROCEDURES section of this subject.

4.1 Check the power supply voltage.

4.2 Check the data signal voltage.

4.3 Check the continuity and resistance to ground. If the readings are outside the acceptable range and are found at several test points, suspect that the datalink has a fault.

5. Determine which branch includes the suspected faulty ECU. Find the connectors and junction blocks that are in series with the suspected faulty ECU.

6. Check the wiring between the branch connector and the ECU and the wiring from the ICU to the branch connector. See **Testing the J1587 Datalink**, **Testing the J1922 Datalink**, or **Testing the J1939 Datalink** in the DATALINK TESTING PROCEDURES section of this subject.

6.1 Check power supply voltage.

6.2 Check the data signal voltage.

6.3 Check the continuity and resistance to ground.

7. Check the ICU. See **Testing the ICU** in the DATALINK TESTING PROCEDURES section of this subject.

7.1 Check the voltages at the junction block to the ICU.

7.2 Replace the ICU with an ICU known to be good.

Datalink Testing Procedures

The following procedures give the test points and specifications for checking the various types of datalinks, connectors, ECUs and ICUs. Refer to the DATALINK TROUBLESHOOTING TABLES and the DATALINK TROUBLESHOOTING PROCEDURES, above, for information on when to test the particular parts of the datalink system.

Testing the ECUs

1. Make sure that the vehicle battery is charged and the fuses and circuit breakers are good before testing the ECUs.

2. The keyswitch must be in the OFF position. Disconnect the ECU datalink circuit at the connector closest to the ECU. Turn the keyswitch to the ON position and check the output voltage from the ECU at the connector. See **Table 1** for the ac-

ceptable results for J1587 and J1922 or see **Table 2** for testing the ECUs on a J1939 datalink.

3. Connect the ECU to the datalink connector when the keyswitch is in the OFF position. Turn the keyswitch to the ON position for this test. Touch the probes of the digital multimeter (on the DC voltmeter scale) to the metal terminals of the ECU connector as shown in **Table 1** to test the ECU. Use the AC scale for the voltage tests if your multimeter will not display the rapidly changing DC voltage using the DC scale. If the test results are not within the range shown, replace the ECU and test again.

Testing the J1587 Twisted-Pair Datalink

1. Make sure that all fuses and circuit breakers are in good condition.
2. Turn the keyswitch to the OFF position before disconnecting or connecting any part of the datalink system. Disconnect the J1587 connector for the datalink section you are testing.

IMPORTANT: Do NOT disconnect the datalink by disconnecting the engine, frontwall or chassis electrical connectors.

3. Turn the keyswitch to the OFF position. Test the continuity of a J1587 twisted-wire pair by touching the red (positive) probe of a digital multimeter (set to the ohmmeter mode) to the J1587+ terminal of the connector. Connect the black (negative) probe to the J1587– wire terminal. See **Table 3** for the results.

   Check the datalink isolation to the vehicle ground by holding one ohmmeter probe on the J1587– wire and the other probe to a good ground. Perform this test again with the ohmmeter leads reversed. **Table 3** shows the acceptable resistances for these tests.
4. Test the signal voltage on the J1587 twisted pair as shown in **Table 4**. The keyswitch must be in the ON position for the voltage tests. Use the AC scale for the voltage tests if your multimeter will not display the rapidly changing DC voltage using the DC scale.

ECU Voltage Tests for J1587 and J1922 Datalinks		
Meter (+) Probe	**Meter (–) Probe**	**Acceptable Meter Reading (VDC)**
ECU Datalink + Terminal	ECU Datalink – Terminal	1 to 4 VDC (1 to 3V on the AC Scale)
Battery Positive Post	ECU Datalink + Terminal	6 to 11 VDC *
Battery Positive Post	ECU Datalink – Terminal	9 to 13.5 VDC *

* If datalink wire connections are reversed, the results are reversed.

Table 1, ECU Voltage Tests for J1587 and J1922 Datalinks

J1939 ECU Voltage Tests		
Meter (+) Probe	**Meter (–) Probe**	**Acceptable Meter Reading (VDC)**
Diagnostics Pin C (J1939+)	Diagnostics Pin D (J1939–)	Varies from 1 to 5 VDC (0 to 4V on the AC Scale)
Diagnostics Pin C (J1939+)	Diagnostics Pin A	Varies from 0 to 7 VDC
Diagnostics Pin D (J1939–)	Diagnostics Pin A	Varies from –2.0 to 4.5 VDC

Table 2, J1939 ECU Voltage Tests

J1587 Datalink Resistance Tests		
Meter (+) Probe	**Meter (–) Probe**	**Acceptable Meter Reading (Ohms)**
J1587+	J1587–	8k to 18k Ohms

J1587 Datalink Resistance Tests		
Meter (+) Probe	**Meter (–) Probe**	**Acceptable Meter Reading (Ohms)**
J1587+	Vehicle Ground	More than 2k Ohms
J1587–	Vehicle Ground	More than 2k Ohms

Table 3, J1587 Datalink Resistance Tests

J1587 Datalink Voltage Tests		
Meter (+) Probe	**Meter (–) Probe**	**Acceptable Meter Reading (VDC)**
J1587+	J1587–	Varies from 1 to 4 VDC (1 to 3V on the AC Scale)
Battery Positive Post	J1587+	Varies from 6 to 11 VDC
Battery Positive Post	J1587–	Varies from 9 to 13.5 VDC

Table 4, J1587 Datalink Voltage Tests

NOTE: If any voltage reading is a steady 0 VDC or a steady 12 VDC, the ECU or datalink wiring has a fault.

Testing the J1922 Twisted-Pair Datalink

1. Make sure that all fuses and circuit breakers are in good condition before testing the J1922 datalink.

NOTE: A fault on the J1922 datalink should be reported on the vehicle's J1587 datalink by one or more of the ECUs. However, the report may not give a true indication of the actual fault.

2. Turn the keyswitch to the OFF position before disconnecting or connecting any part of the datalink system. Disconnect the J1922 connector for the datalink section you are testing.

IMPORTANT: Do NOT disconnect the datalink by disconnecting the engine, frontwall or chassis electrical connectors.

3. Turn the keyswitch to the OFF position. Test the continuity of a J1922 twisted-wire pair by touching the red (positive) probe of a digital multimeter (set to the ohmmeter mode) to the J1922+ wire. Connect the black (negative) probe to the J1922– wire. See **Table 5** for the results.

   Check the datalink isolation to the vehicle ground by holding one ohmmeter probe on the J1922– wire and the other probe to a good ground. Perform this test again with the ohmmeter leads reversed. **Table 5** shows the acceptable resistances for these tests.

4. Test the signal voltage on the J1922 twisted pair as shown in **Table 6**. The keyswitch must be in the ON position for the voltage tests. Use the AC scale for the voltage tests if your multimeter will not display the rapidly changing DC voltage using the DC scale.

J1922 Datalink Resistance Tests		
Meter (+) Probe	**Meter (–) Probe**	**Acceptable Meter Reading (Ohms)**
J1922+	J1922–	8k to 18k Ohms
J1922+	Vehicle Ground	More than 2k Ohms
J1922–	Vehicle Ground	More than 2k Ohms

Table 5, J1922 Datalink Resistance Tests

J1922 Datalink Voltage Tests		
Meter (+) Probe	**Meter (–) Probe**	**Acceptable Meter Reading (VDC)**
J1922+	J1922–	Varies from 1 to 4 VDC (1 to 3V on the AC Scale)
Battery Positive Post	J1922+	Varies from 6 to 11 VDC
Battery Positive Post	J1922–	Varies from 9 to 13.5 VDC

Table 6, J1922 Datalink Voltage Tests

NOTE: If any voltage reading is a steady 0 VDC or a steady 12 VDC, the ECU or datalink wiring has a fault.

Testing the J1939 Cable Datalink

1. Make sure that all fuses and circuit breakers are in good condition before testing the J1939 datalink.

NOTE: Most ECUs on the J1939 datalink will communicate on the J1587 datalink and can be diagnosed with the ICU or ServiceLink.

2. Turn the keyswitch to the OFF position before disconnecting or connecting any part of the datalink system. Disconnect the J1939 connector for the datalink section you are testing.

NOTE: Do NOT disconnect the datalink by disconnecting the engine, frontwall or chassis electrical connectors.

3. Turn the keyswitch to the OFF position. Test the resistance of the J1939 datalink backbone by touching the red (positive) probe of a digital multimeter (set to the ohmmeter mode) to Pin C of the diagnostics connector. Connect the black (negative) probe to Pin D. See **Table 7** for the results.
4. Turn the keyswitch to the OFF position. If the results of the J1939 backbone resistance tests were outside the acceptable range, disconnect the terminating resistors. Test the resistance of the terminating resistor by touching the probes of a digital multimeter (set to the ohmmeter mode) to the resistor leads. See **Table 8** for the results.
5. Test the signal voltage on the J1939 datalink as shown in **Table 9**. The keyswitch must be in the ON position for the voltage tests. Use the AC scale for the voltage tests if your multimeter will not display the rapidly changing DC voltage using the DC scale.

NOTE: If any voltage reading is a steady 0 VDC or a steady 12 VDC, the ECU or datalink wiring has a fault.

Testing the ICU

1. Make sure that all fuses and circuit breakers are in good condition before testing the ICU. The keyswitch must be in the OFF position before disconnecting any datalink connector.

J1939 Datalink Backbone Resistance Test		
Meter (+) Probe	**Meter (–) Probe**	**Acceptable Meter Reading (Ohms)**
Diagnostics Pin C	Diagnostics Pin D	55 to 65 Ohms

Table 7, J1939 Datalink Backbone Resistance Test

J1939 Terminating Resistors Test		
Meter (+) Probe	**Meter (–) Probe**	**Acceptable Meter Reading (Ohms)**
Resistor Lead	Resistor Lead	110 to 130 Ohms

Table 8, J1939 Terminating Resistors Test

2. Disconnect the two pink connectors (ICU2M, ICU2L, ICU3) at the ICU. ICU1 has two pink and two blue connectors.
3. Visually inspect the connectors for corrosion or other damage. Clean or replace the connectors if needed.
4. Turn the keyswitch to the ON position.
5. Check the power connections to the ICU connectors. Use a digital multimeter set on the high DC (20V) scale, and attach the probes as indicated in **Fig. 3** and **Fig. 4**. See **Table 10** for the acceptable readings.

NOTE: The datalink positive wire is connected to cavity B10 in the small pink connector. The datalink negative wire is connected to cavity B3 in the small pink connector.

6. Put the black (negative) probe of the digital multimeter (using the 20 VDC scale) in the cavity B4 and the red (positive) probe in cavity B11 of the datalink side of the small pink connector. See **Fig. 5**. The results of this datalink signal test must be as shown in **Table 10**.

J1939 Datalink Voltage Tests		
Meter (+) Probe	**Meter (–) Probe**	**Acceptable Meter Reading (VDC)**
Diagnostics Pin C (J1939+)	Diagnostics Pin D (J1939–)	Varies from 1 to 5 VDC (0 to 4V on the AC Scale)
Diagnostics Pin C (J1939+)	Diagnostics Pin A	Varies from 0 to 7 VDC
Diagnostics Pin D (J1939–)	Diagnostics Pin A	Varies from –2.0 to 4.5 VDC

Table 9, J1939 Datalink Voltage Tests

ICU Voltage Tests		
Meter (+) Probe	**Meter (–) Probe**	**Acceptable Meter Reading (VDC)**
ICU Datalink + Terminal (B11)	ICU Datalink – Terminal (B4)	–1.2 to +4.0 VDC (1 to 3V on the AC Scale)
ICU Datalink + Terminal (B11)	Vehicle Ground	2 to 5 VDC
ICU Datalink – Terminal (B4)	Vehicle Ground	0.0 to 3.0 VDC

Table 10, ICU Voltage Tests

Troubleshooting

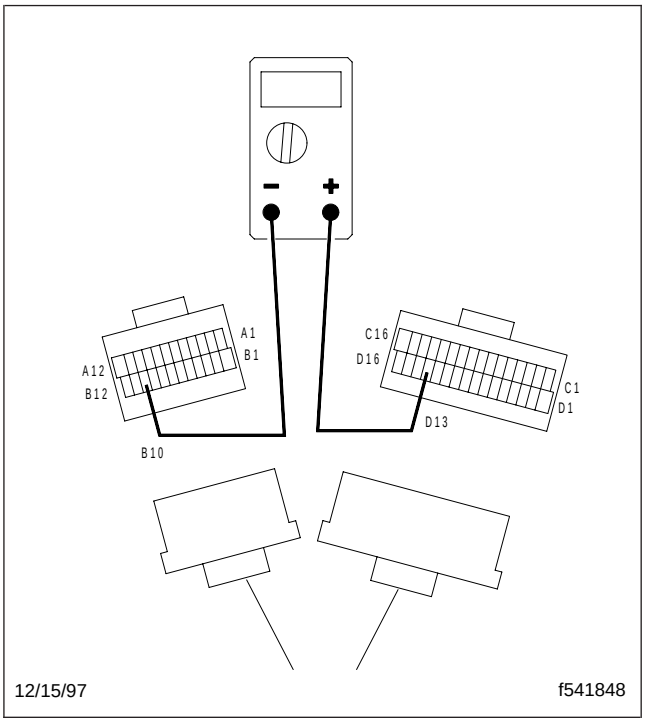


Fig. 3, ICU Power Connections, Positive Side

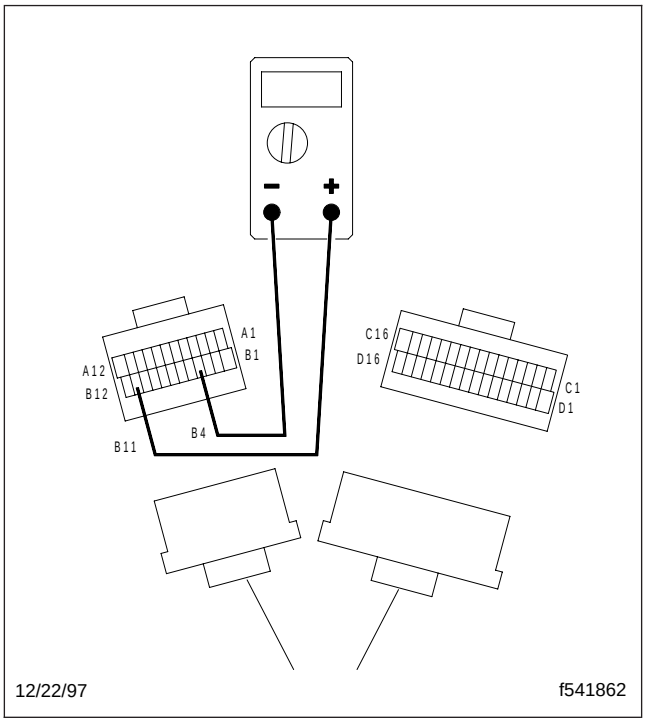


Fig. 5, Datalink Wire Test at the ICU

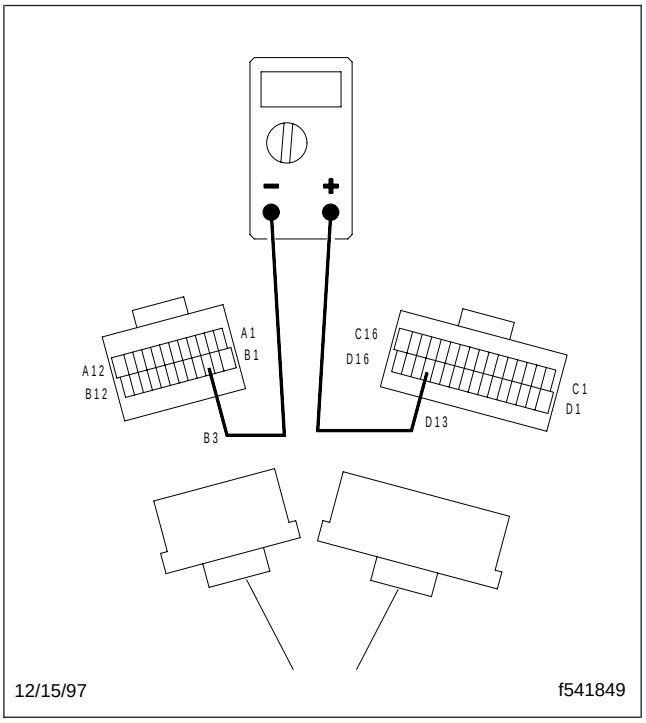


Fig. 4, ICU Power Connections, Negative Side

Datalink Wiring Diagrams

For vehicles built with the ICU1 through August 1996, see **Fig. 1**.

For vehicles built with the ICU1 from August 1996 to June 1997, see **Fig. 2**.

For vehicles built with the ICU1 from June 1997, see **Fig. 3**.

Vehicles with an ICU2M, ICU2L, or ICU3 use the layout shown in **Fig. 4**.

Figure 5 shows the communication relationships between the ECUs and other components on a vehicle with a J1939 datalink.

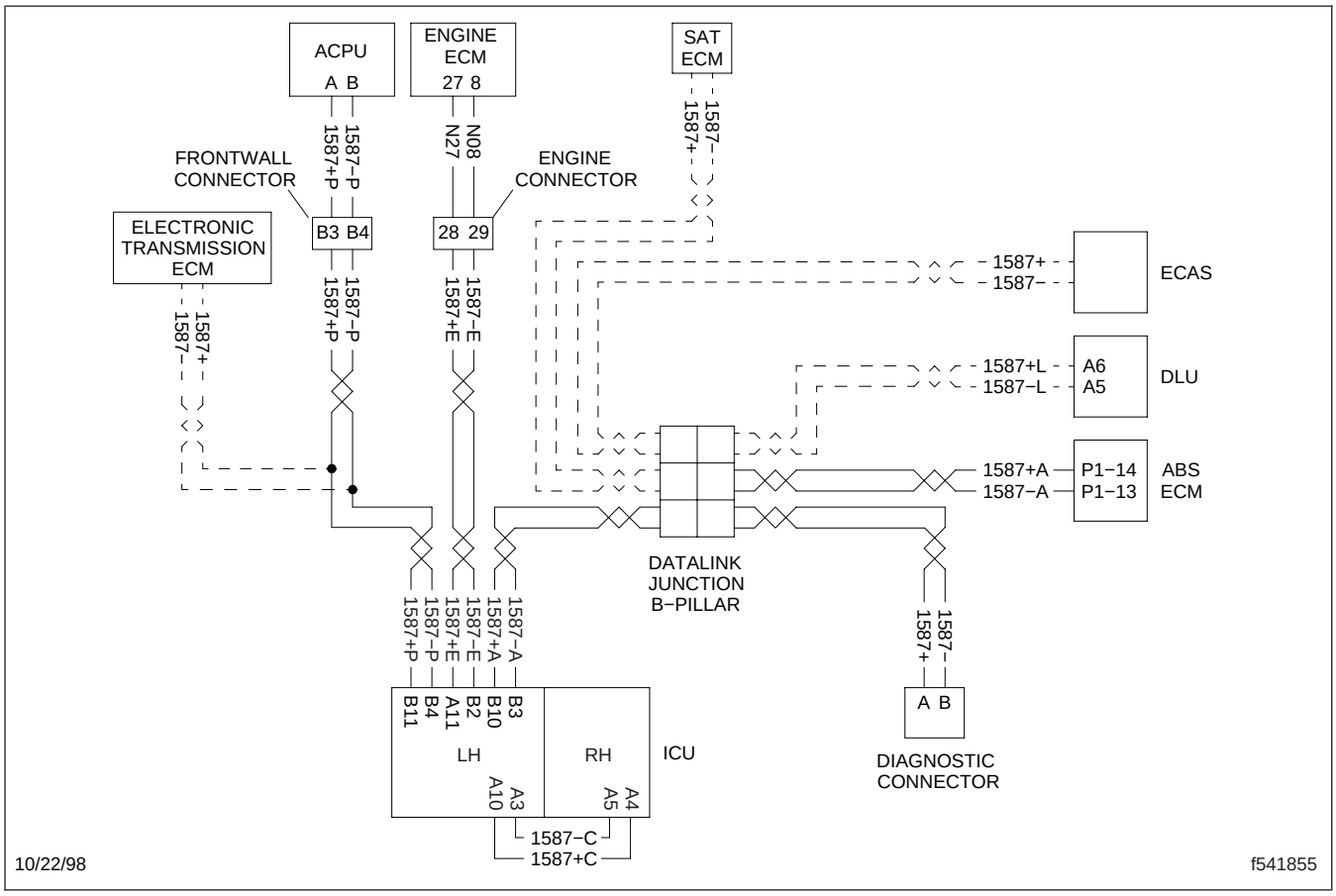


Fig. 1, J1587 Datalink Wiring-ICU1 (vehicles built through August 1996)

Specifications

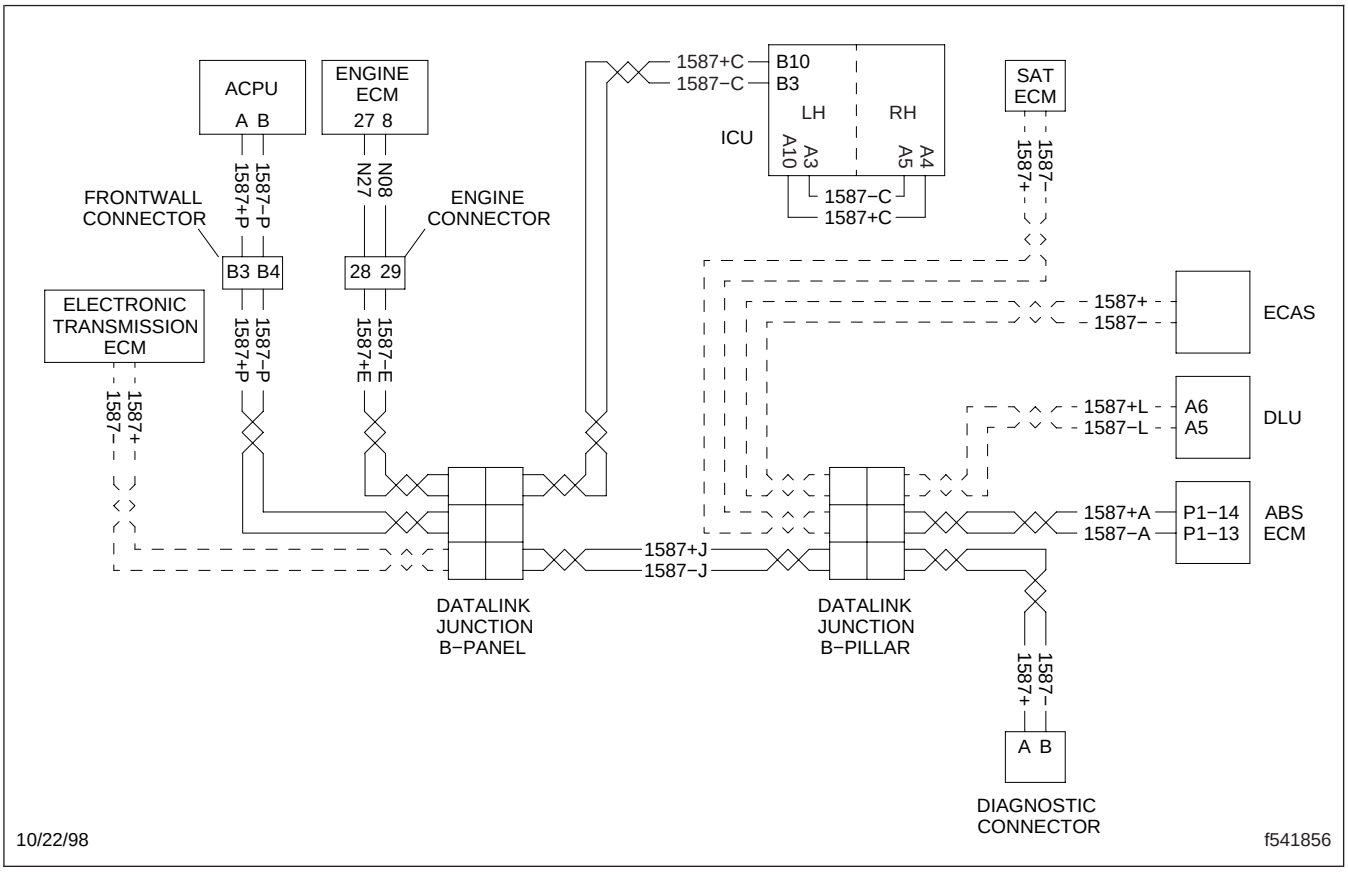


Fig. 2, J1587 Datalink Wiring-ICU1 (vehicles built from August 1996 through June 1997)

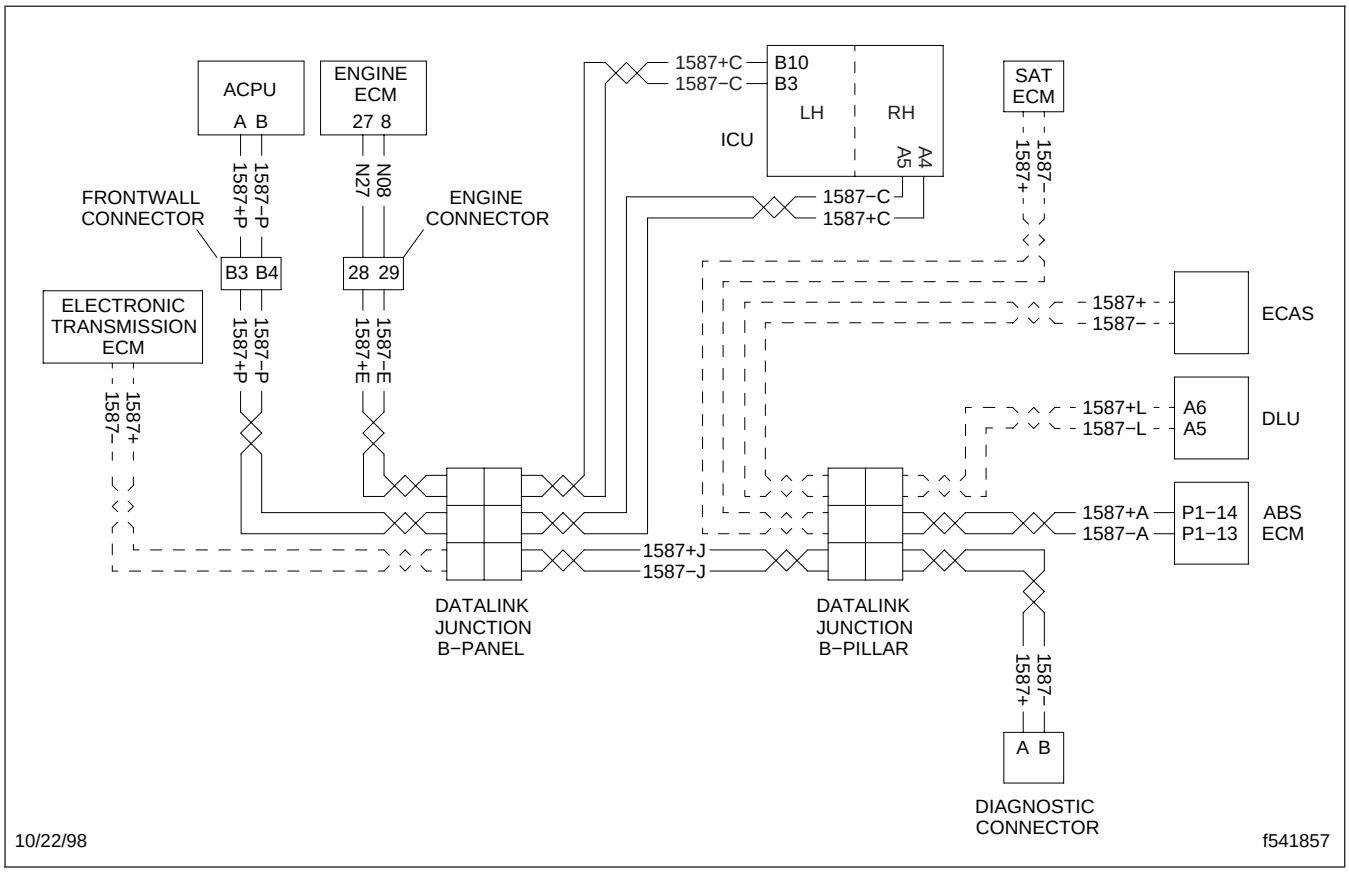


Fig. 3, J1587 Datalink Wiring-ICU1 (vehicles built from June 1997)

Specifications

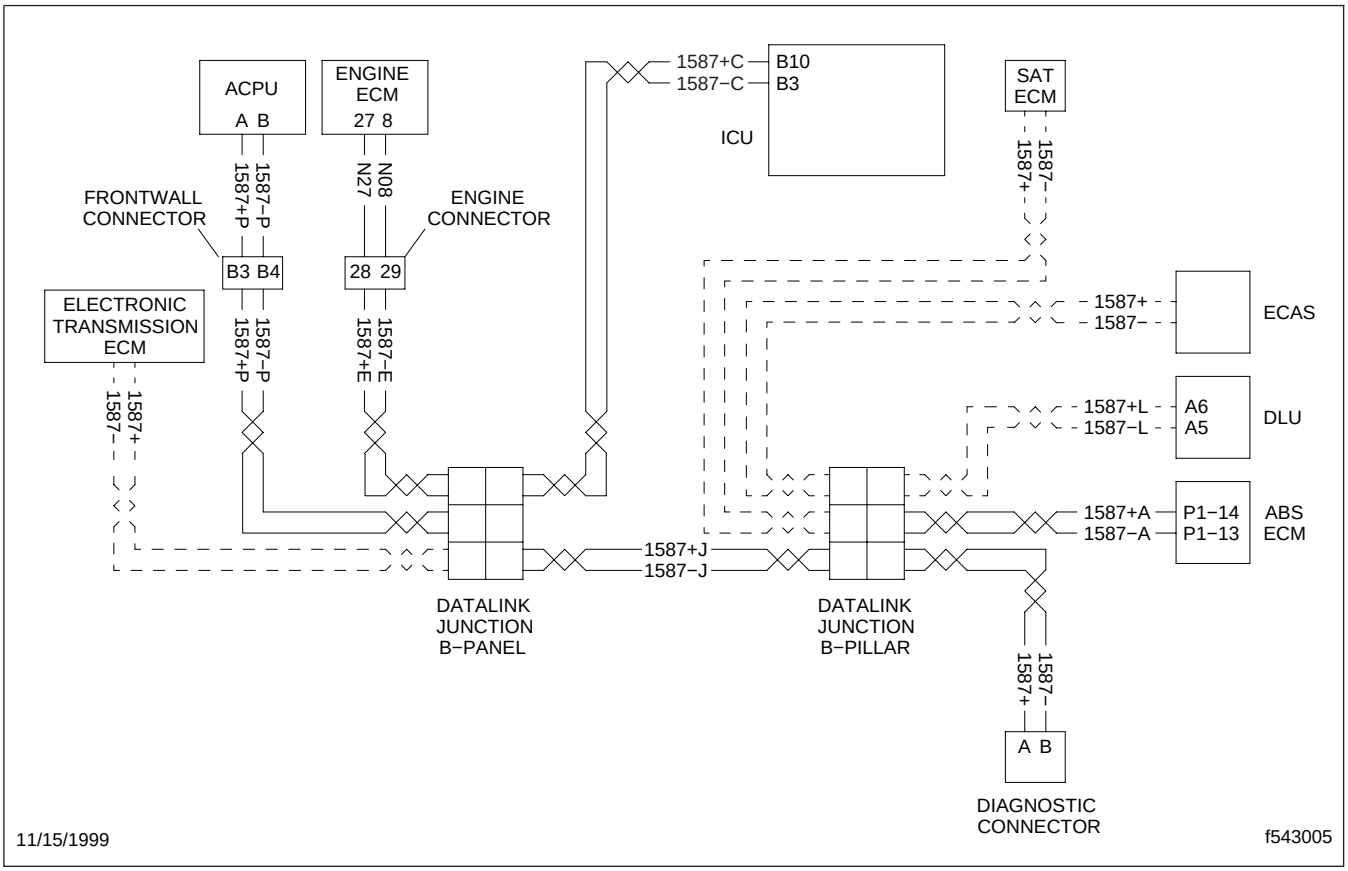
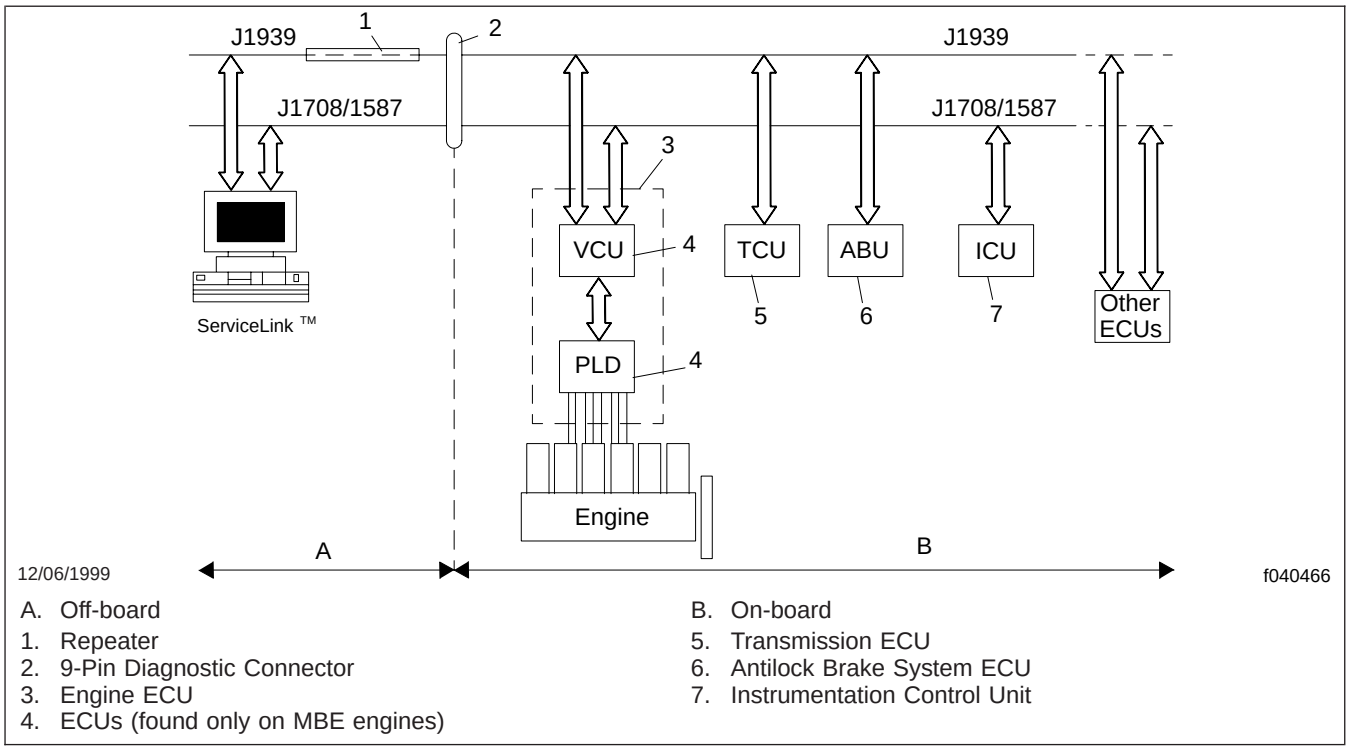


Fig. 4, J1587 Datalink Wiring-ICU2L, ICU2M, ICU3



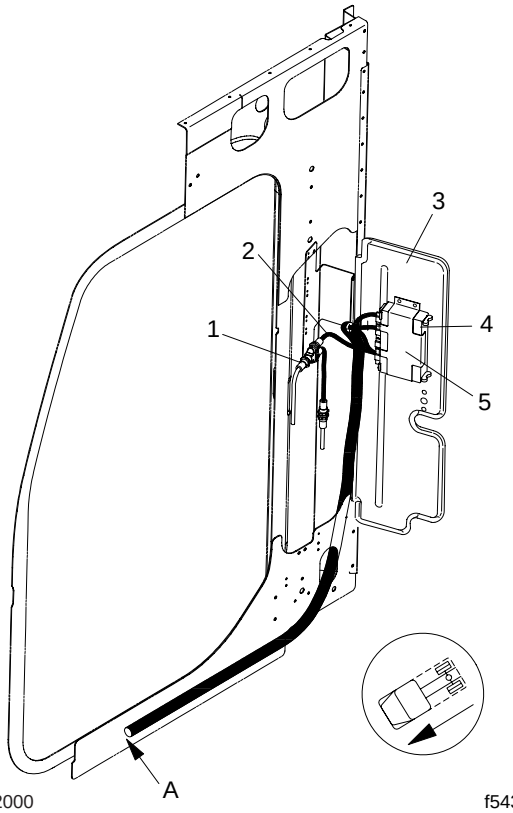
A. Off-board
1. Repeater
2. 9-Pin Diagnostic Connector
3. Engine ECU
4. ECUs (found only on MBE engines)

B. On-board
5. Transmission ECU
6. Antilock Brake System ECU
7. Instrumentation Control Unit

Fig. 5, J1939 Datalink Communication Relationships

Removal

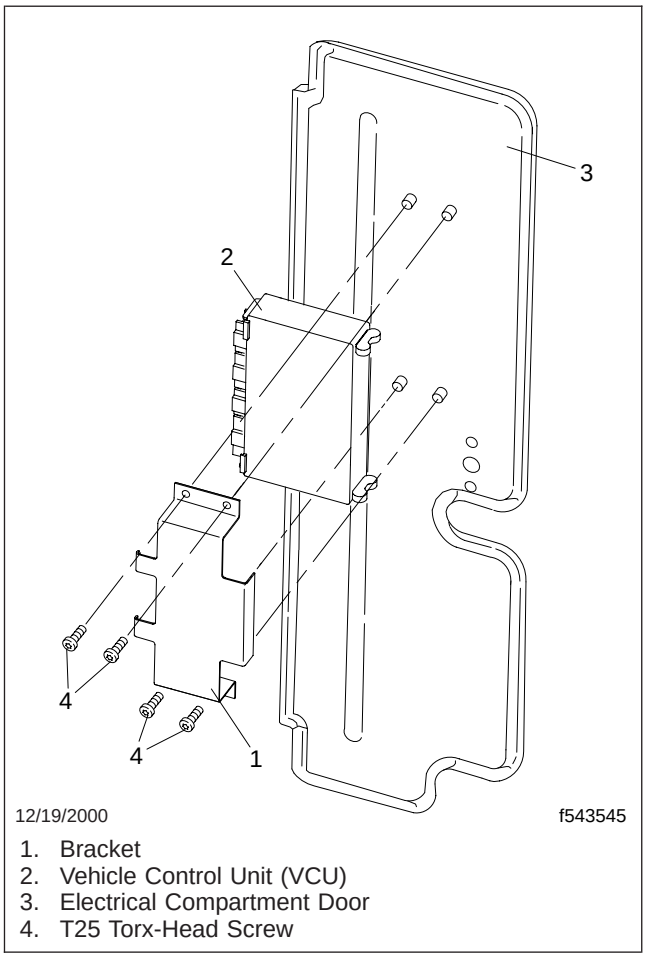
1. Open the electrical compartment door on the right-hand B-pillar, behind the seat. See **Fig. 1**.



A. To Dash Harness
1. J1939 Tee with Jumper
2. J1939 Diagnostic Harness
3. Electrical Compartment Door
4. Vehicle Control Unit (VCU)
5. Bracket

Fig. 1, VCU and J1939 Harness

2. Disconnect the three electrical connectors (violet, gray, and brown) by pressing the release at the bottom of each connector.
3. Using a T25 Torx®-head screwdriver, remove the four mounting screws attaching the bracket to the electrical compartment door. See **Fig. 2**.
4. Remove the bracket and the VCU from the vehicle.



1. Bracket
2. Vehicle Control Unit (VCU)
3. Electrical Compartment Door
4. T25 Torx-Head Screw

Fig. 2, VCU Removal and Installation

Installation

1. Place the VCU inside the bracket and position the holes in the bracket over the nutserts in the electrical compartment door, as removed.
2. Tighten the T25 Torx-head screws until firm in the nutserts.
3. Connect the violet, gray, and brown electrical connectors to the VCU, as removed.

IMPORTANT: The connectors cannot be installed on the wrong plug location on the VCU, because they each have different numbers of pins. Connector VC2 is not used at this time.

- Connector VC1 (brown) has 21 pins.

Vehicle Control Unit Removal and Installation

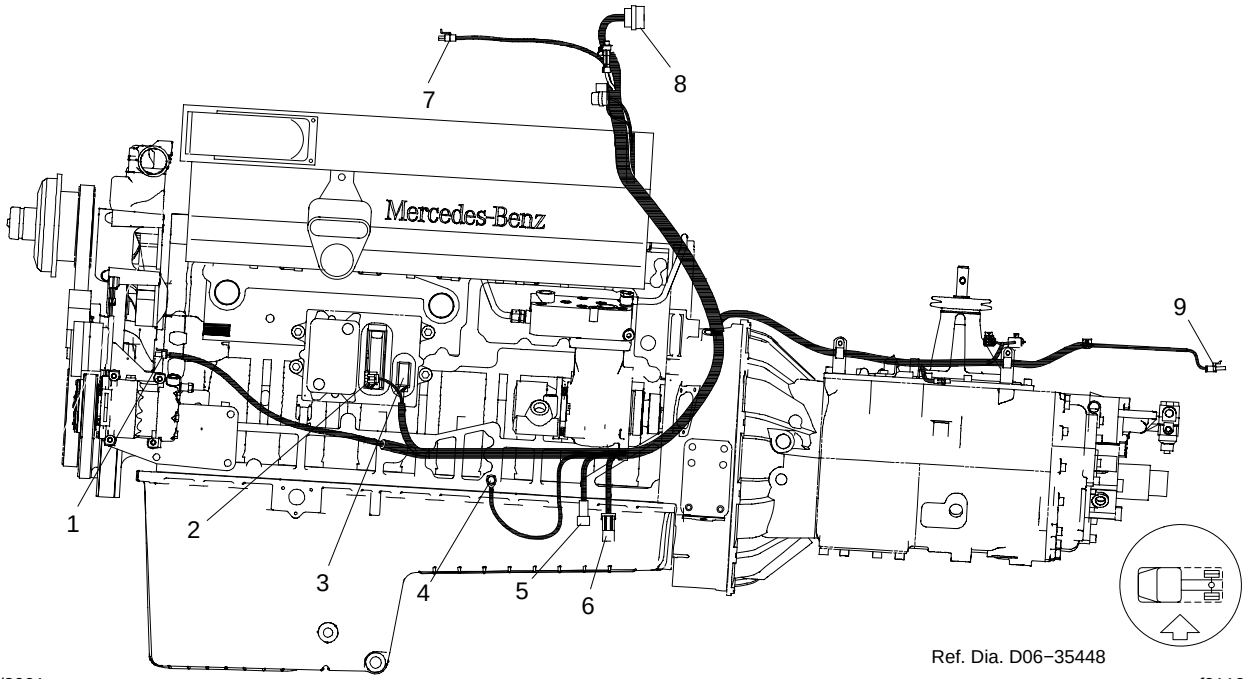
- Connector VC3 (gray) has 18 pins.
- Connector VC4 (violet) has 15 pins.

4. Close the electrical compartment door.

Harness Routing Diagrams

For a routing diagram showing the engine wiring harnesses, see **Fig. 1** for a view from the left-hand side, **Fig. 2** for a top view, and **Fig. 3** for a front view.

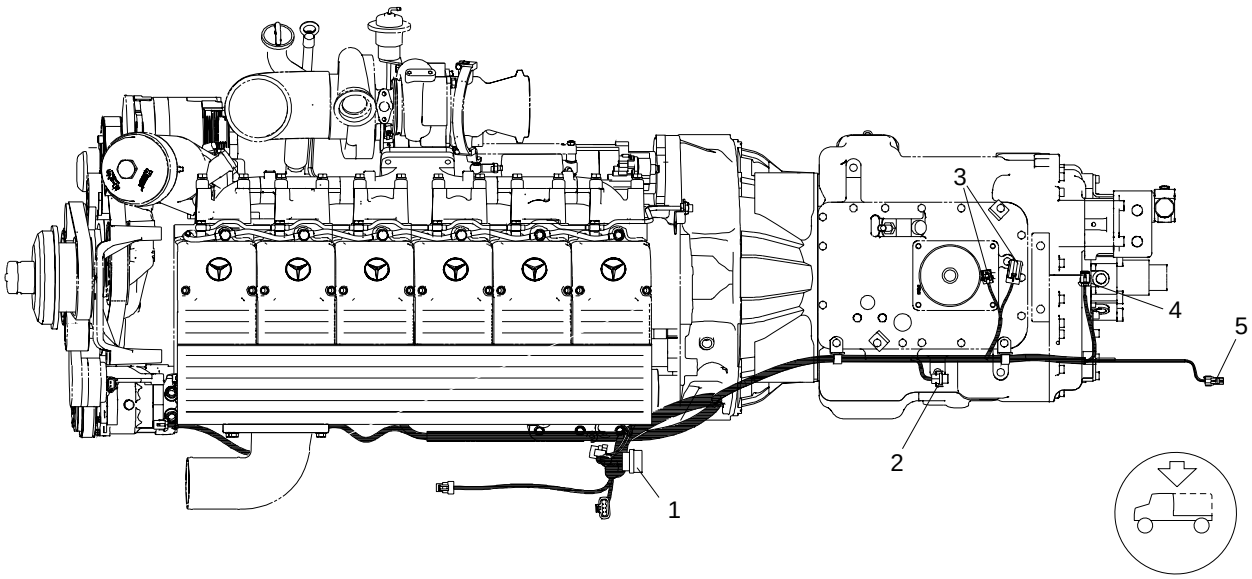
For a routing diagram showing the dash harness, see **Fig. 4**.



1. RefrigerantCompressor (2-pin plug)
2. 8-Pin Plug to Engine Electrical Connector
3. Vehicle Electrical Connector
4. Engine Block Ground
5. PLD 2-Pin Connector (circuit GNDE)
6. PLD 2-Pin Plug (circuit 439C)
7. Low Coolant Level Probe
8. To 31-Pin Frontwall Connector
9. Vehicle Speed Sensor

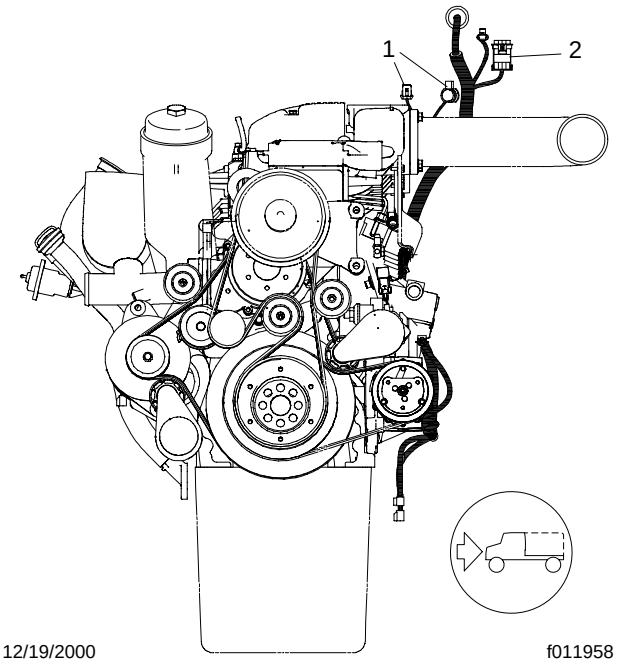
Fig. 1, MBE4000 Engine Routing Diagram (left-hand side view)

Harness Routing Diagrams



1. To 31-Pin Frontwall Connector
2. Transmission Temperature Sensor 2-Pin Plug (circuits 30, 30G)
3. Shift and Cruise (optional)
4. Back-Up Light Switch 2-Pin Plug (circuits 120, 120B)
5. Vehicle Speed Sensor 2-Pin Plug (circuits 439S+, 439S–)

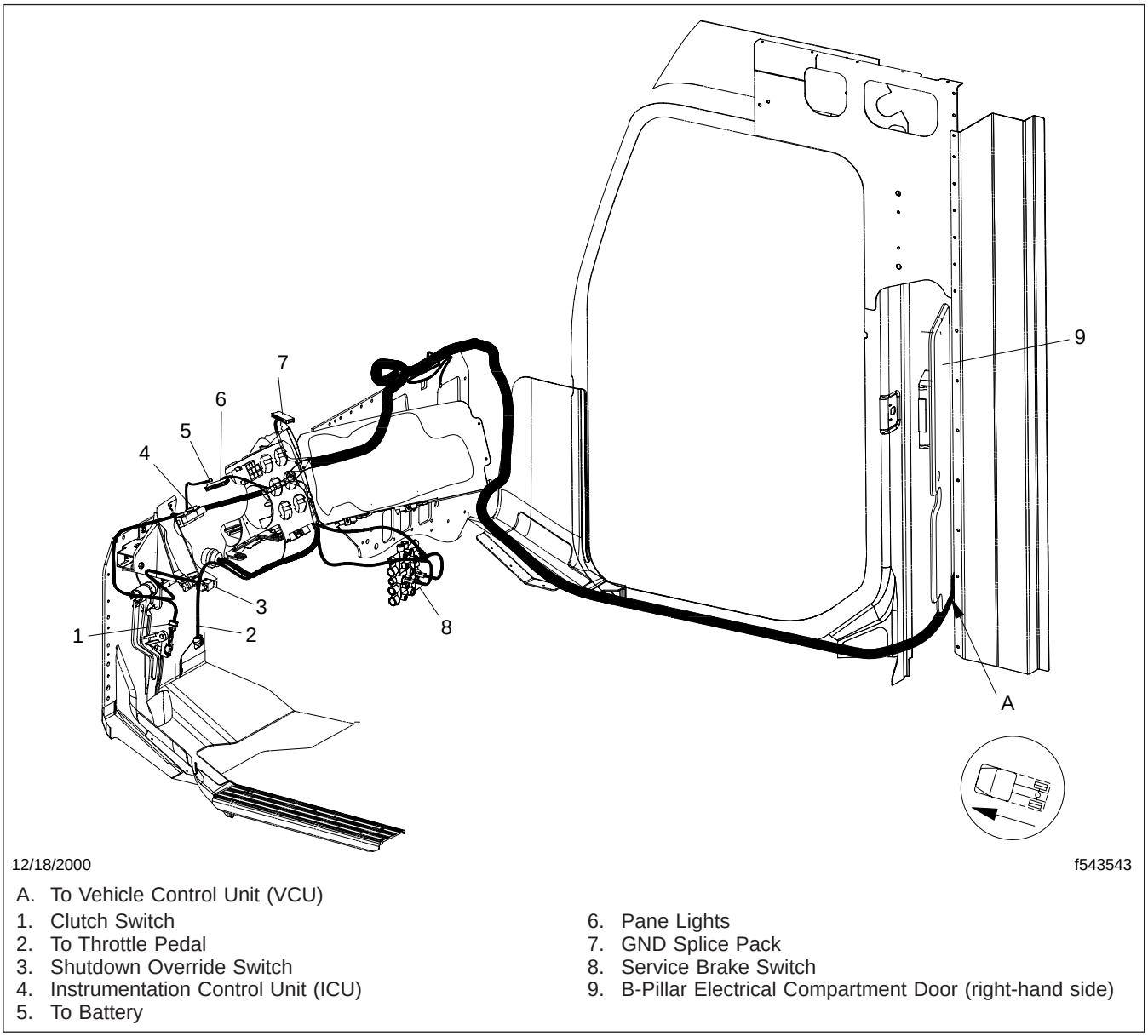
Fig. 2, MBE4000 Engine Routing Diagram (top view)



1. To Frontwall Harness
2. Flame Start/Air Intake Heater

Fig. 3, MBE4000 Engine Routing Diagram (front view)

Harness Routing Diagrams



A. To Vehicle Control Unit (VCU)
1. Clutch Switch
2. To Throttle Pedal
3. Shutdown Override Switch
4. Instrumentation Control Unit (ICU)
5. To Battery
6. Pane Lights
7. GND Splice Pack
8. Service Brake Switch
9. B-Pillar Electrical Compartment Door (right-hand side)

Fig. 4, MBE4000 Engine Dash Harness Routing Diagram

Schematics

For a schematic of the engine wiring between the PLD control unit and the 31-pin engine frontwall connector, see **Fig. 1** for vehicles without shift and cruise, **Fig. 2** for vehicles with Meritor shift and cruise, and **Fig. 3** for vehicles with Eaton shift and cruise.

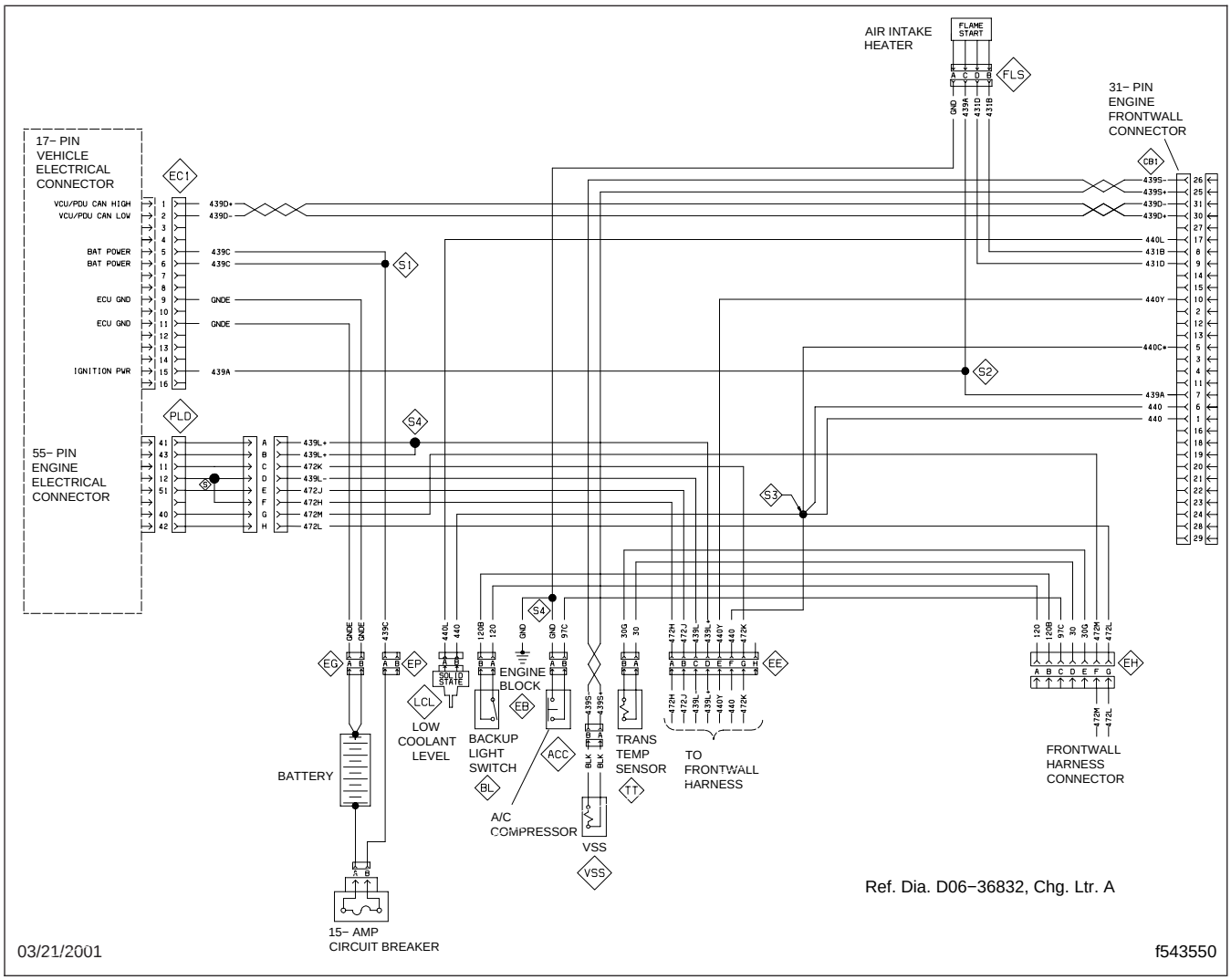


Fig. 1, MBE4000 Engine Wiring Schematic, Without Shift and Cruise

For a schematic of the cab wiring between the 31-pin engine frontwall connector and the vehicle control unit (VCU), and including the devices attached to the dash harness, see **Fig. 4**. For a detailed (partial) schematic showing the wiring to the cruise control switches (optional), panel lights, and instrumentation control unit (ICU), see **Fig. 5**. For a detailed (partial) schematic showing the wiring to the throttle, brake, fan, and shutdown override switches, see **Fig. 6**.

Wiring Schematics

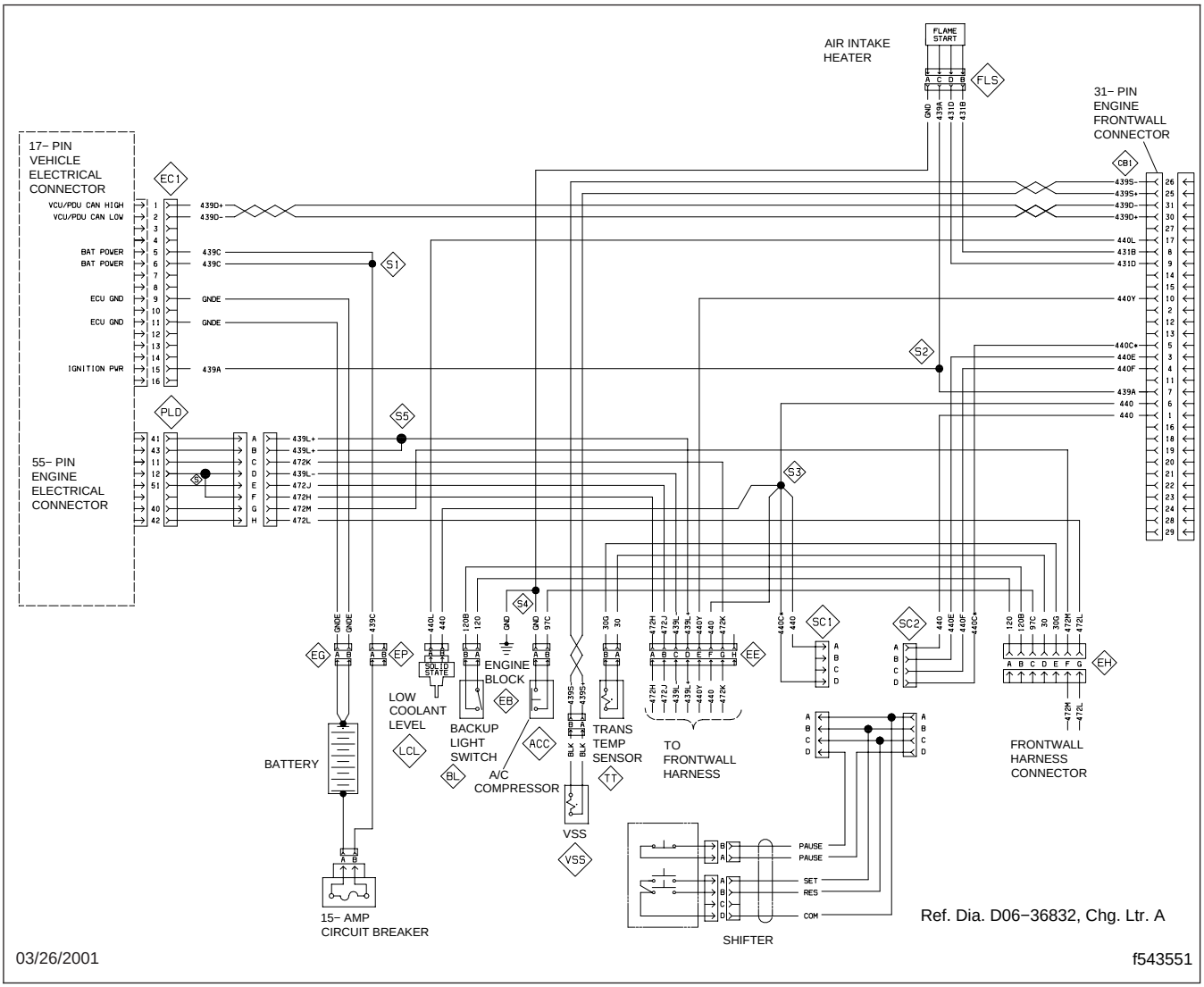


Fig. 2, MBE4000 Engine Wiring Schematic, With Shift and Cruise (Meritor)

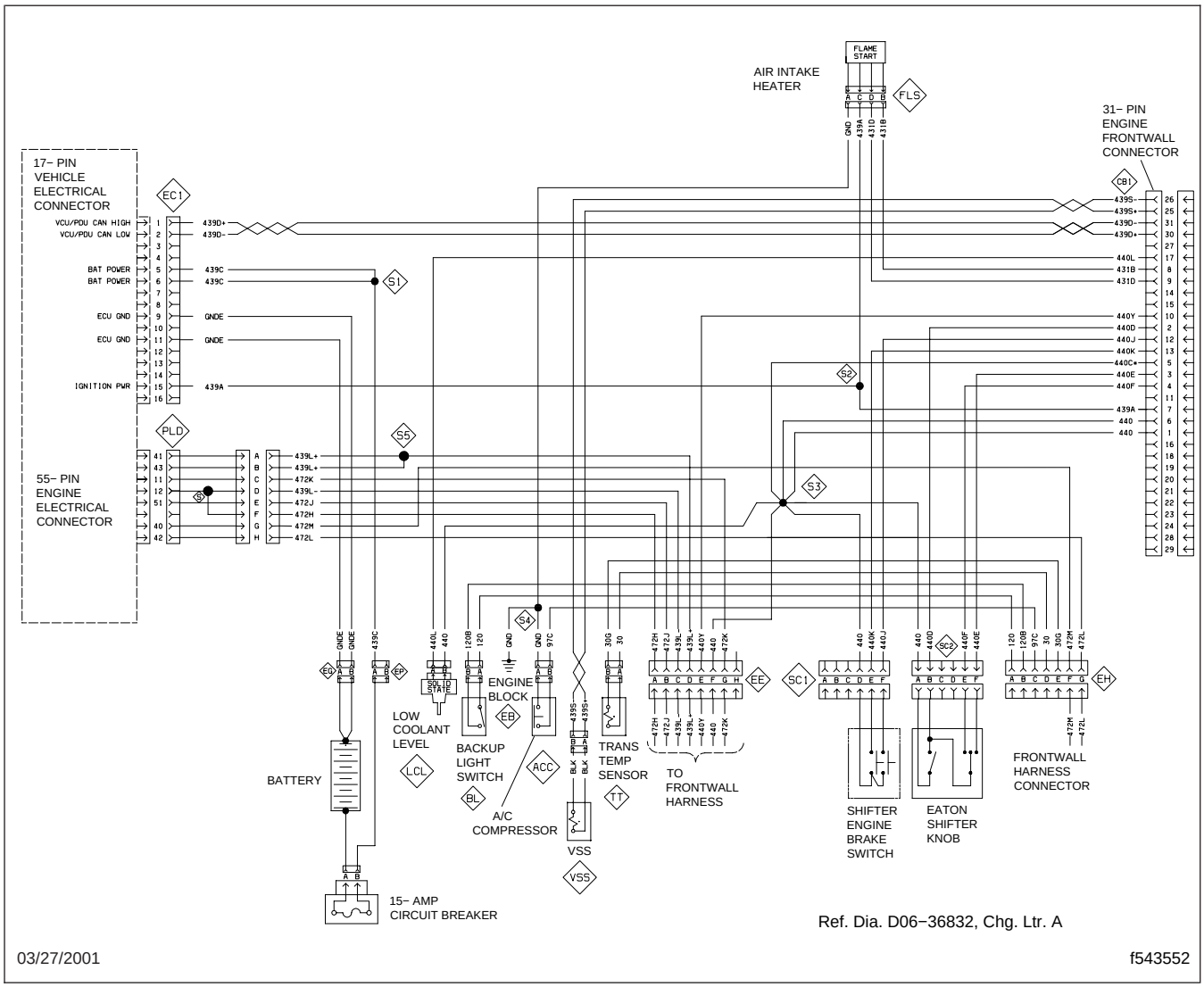


Fig. 3, MBE4000 Engine Wiring Schematic, With Shift and Cruise (Eaton)

Wiring Schematics

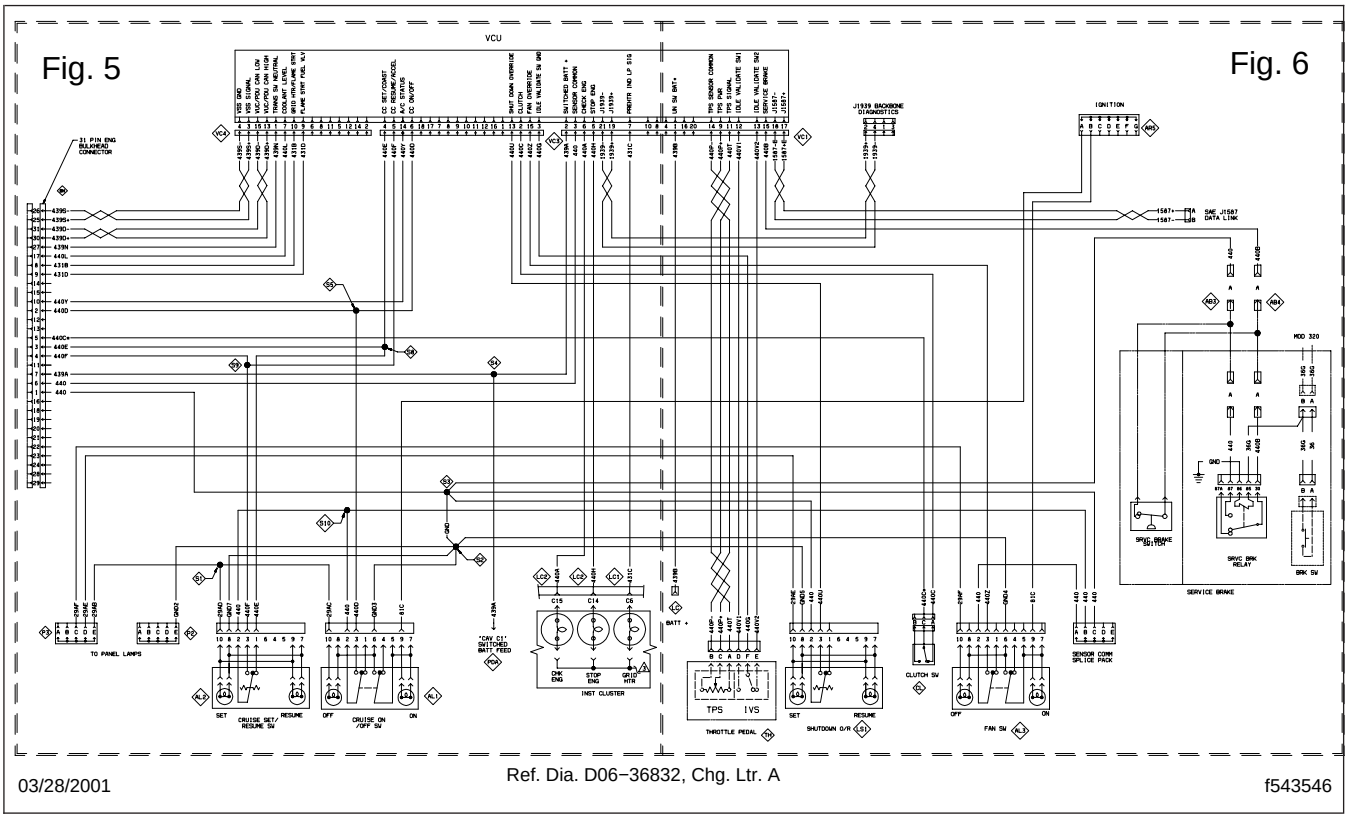


Fig. 4, MBE4000 Cab Wiring Schematic

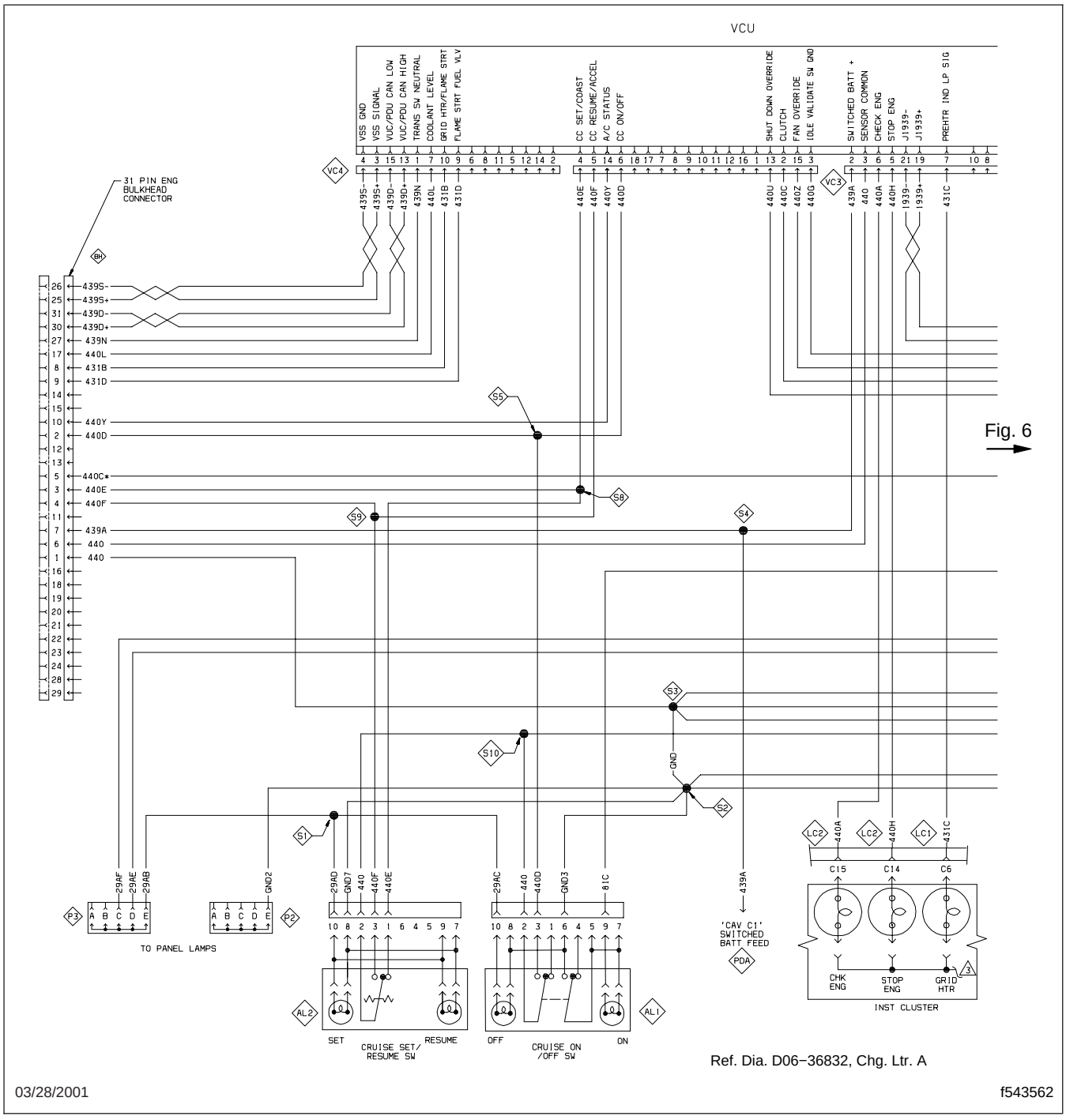


Fig. 5, MBE4000 Cab Wiring Schematic (detailed view)

Wiring Schematics

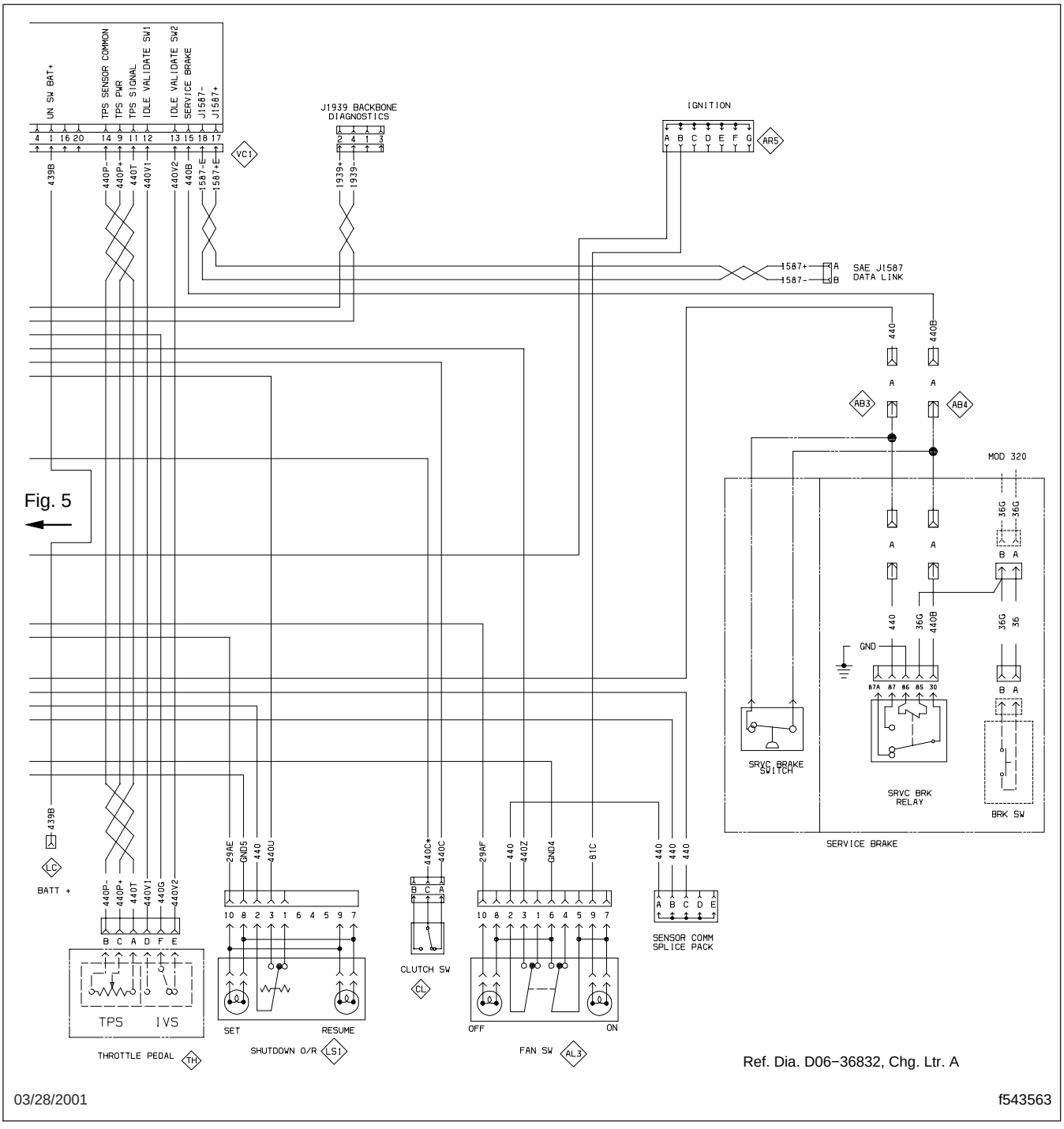


Fig. 6, MBE4000 Cab Wiring Schematic (detailed view)

Harness Wiring

For a drawing of the electronic engine harness for MBE4000 electronic engines, see **Fig. 1**.

For a drawing of the cab overlay harness for MBE4000 electronic engines, see **Fig. 2**.

For a drawing of the J1939 diagnostic harness for MBE4000 electronic engines, see **Fig. 3**.

Harness Wiring

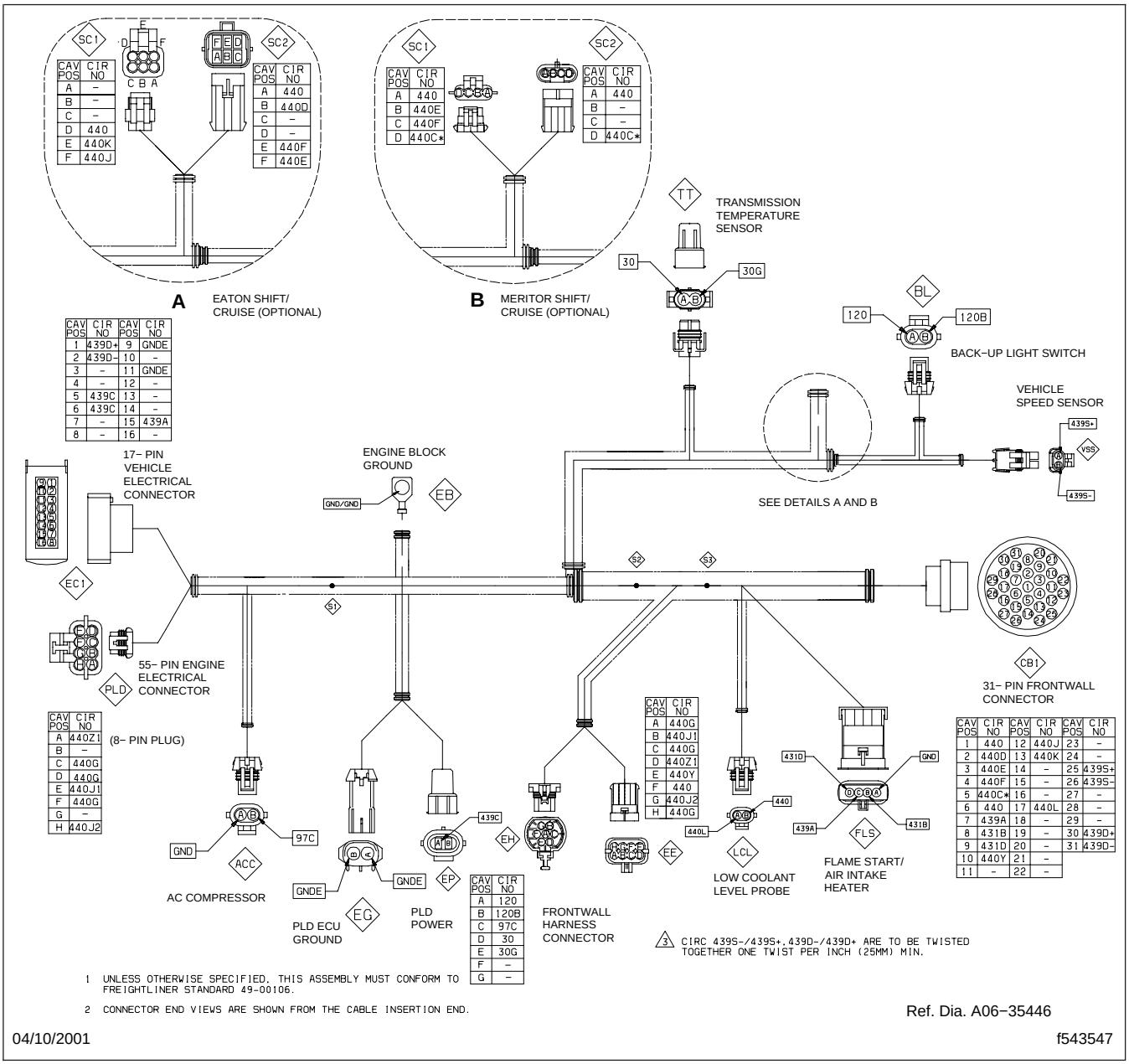
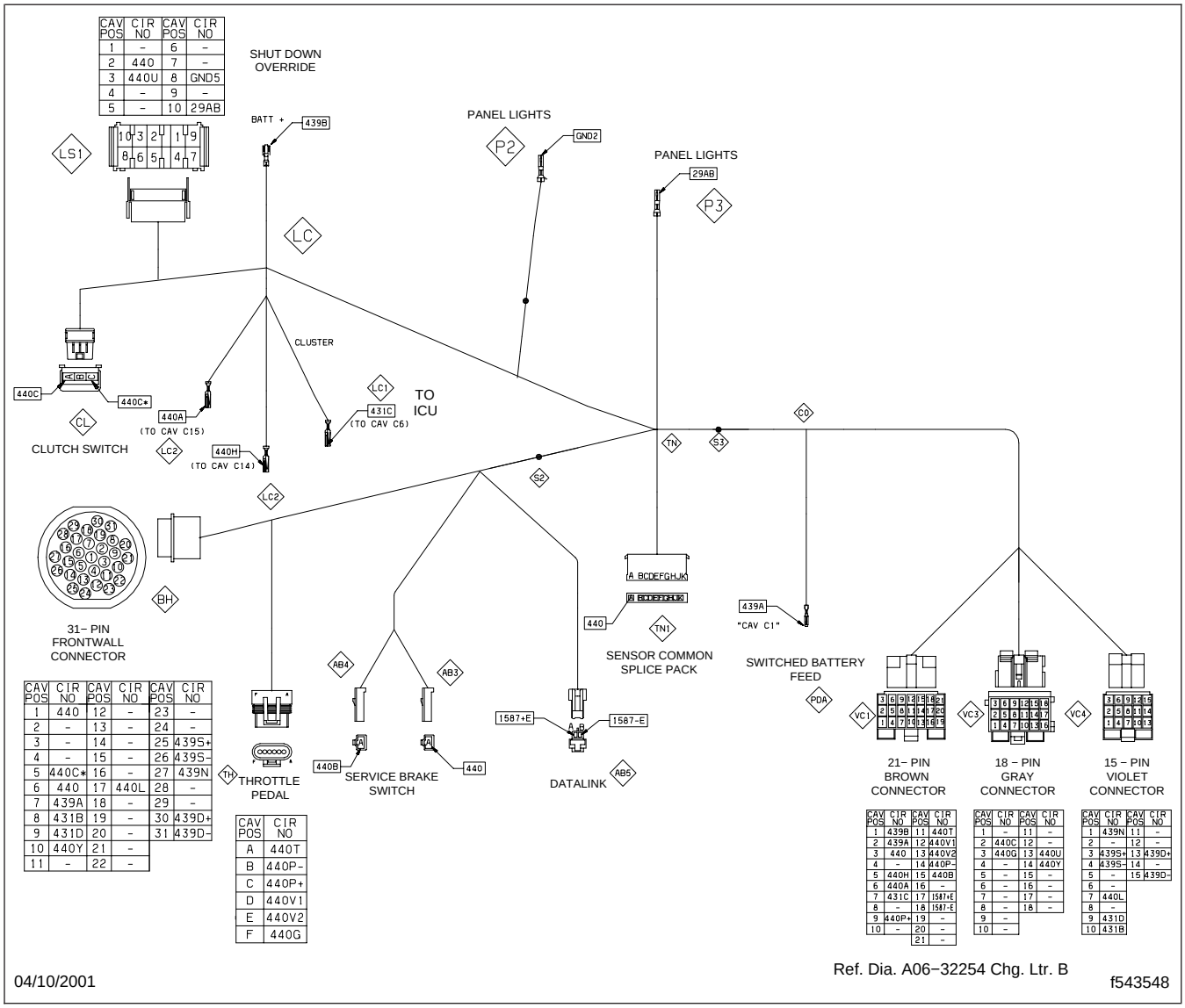


Fig. 1, MBE4000 Electronic Engine Harness



CAV POS	CIR NO	CAV POS	CIR NO
1	–	6	–
2	440	7	–
3	440U	8	GND5
4	–	9	–
5	–	10	29AB

CAV POS	CIR NO	CAV POS	CIR NO	CAV POS	CIR NO
1	440	12	–	23	–
2	–	13	–	24	–
3	–	14	–	25	439S+
4	–	15	–	26	439S-
5	440C*	16	–	27	439N
6	440	17	440L	28	–
7	439A	18	–	29	–
8	431B	19	–	30	439D+
9	431D	20	–	31	439D-
10	440Y	21	–		
11	–	22	–		

CAV POS	CIR NO
A	440T
B	440P-
C	440P+
D	440V1
E	440V2
F	440G

CAV POS	CIR NO	CAV POS	CIR NO
1	439B	11	440T
2	439A	12	440V1
3	440	13	440V2
4	–	14	440P-
5	440H	15	440B
6	440A	16	–
7	431C	17	1587+E
8	–	18	1587-E
9	440P+	19	–
10	–	20	–
		21	–

CAV POS	CIR NO	CAV POS	CIR NO
1	–	11	–
2	440C	12	–
3	440G	13	440U
4	–	14	440Y
5	–	15	–
6	–	16	–
7	–	17	–
8	–	18	–
9	–		
10	–		

CAV POS	CIR NO	CAV POS	CIR NO
1	439N	11	–
2	–	12	–
3	439S+	13	439D+
4	439S-	14	–
5	–	15	439D-
6	–		
7	440L		
8	–		
9	431D		
10	431B		

Fig. 2, MBE4000 Cab Harness Overlay

Harness Wiring

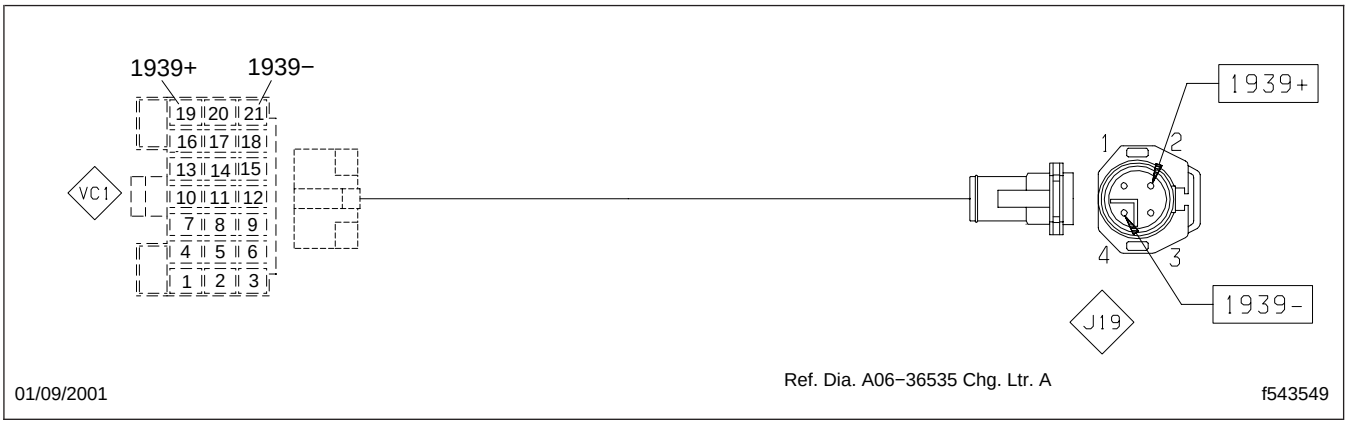


Fig. 3, MBE4000 Engine J1939 Diagnostic Harness

General Description

The Ametek instrumentation control unit model 4M (ICU4M) replaced the Pollak ICU2M in production in December 2004. See **Fig. 1**. The ICU4M is an individual-gauge cluster with an intelligent light bar (ILB) and a 10-key keypad on the auxiliary instrument panel. It is very similar to the ICU2M except for these differences:

- ICU4M gauges sweep 270 degrees and have pointers lit by an LED (light-emitting diode)
- Service intervals are programmable from the keypad
- A warning chime and alert message display warns the driver if the door is opened without first setting the parking brake
- If low oil pressure or high coolant temperature is detected, a red warning light at the bottom of the gauge illuminates, a warning buzzer sounds, and a flashing alert message appears on the display, along with a text message giving additional information.

The light bar is the heart of the ICU4M. It has three parts:

- a set of 24 warning and indicator lights
- a dash message center
- the printed circuit boards necessary to drive the other components

The message center display screen is a two-line by twenty-character liquid crystal display (LCD). See **Fig. 2**.

Gauges

There can be up to 14 removable gauges on the driver's instrument panel. The ICU4M can also drive gauges located on the auxiliary instrument panel. Gauges cannot be removed from the front of the panel.

The standard gauges are:

- speedometer
- engine coolant temperature
- engine oil pressure
- battery voltmeter
- fuel level

Other available gauges include:

- tachometer
- engine oil temperature
- transmission fluid temperature
- rear axle temperature; on vehicles with tandem or tridem axles, forward-rear, axle #3, and rearmost-rear
- ammeter
- system air pressure; primary, secondary, application, and suspension
- pyrometer
- turbo boost air pressure

Some gauges have a red warning light integrated into the gauge. These are listed below, with an indication of how the warning light is activated:

- engine coolant temperature—see **Table 1**

Maximum Coolant Temperature	
Engine Manufacturer	**°F (°C)**
Caterpillar	215 (101)
Cummins	220 (104)
Detroit Diesel	215 (101)
Mercedes-Benz	221 (105)

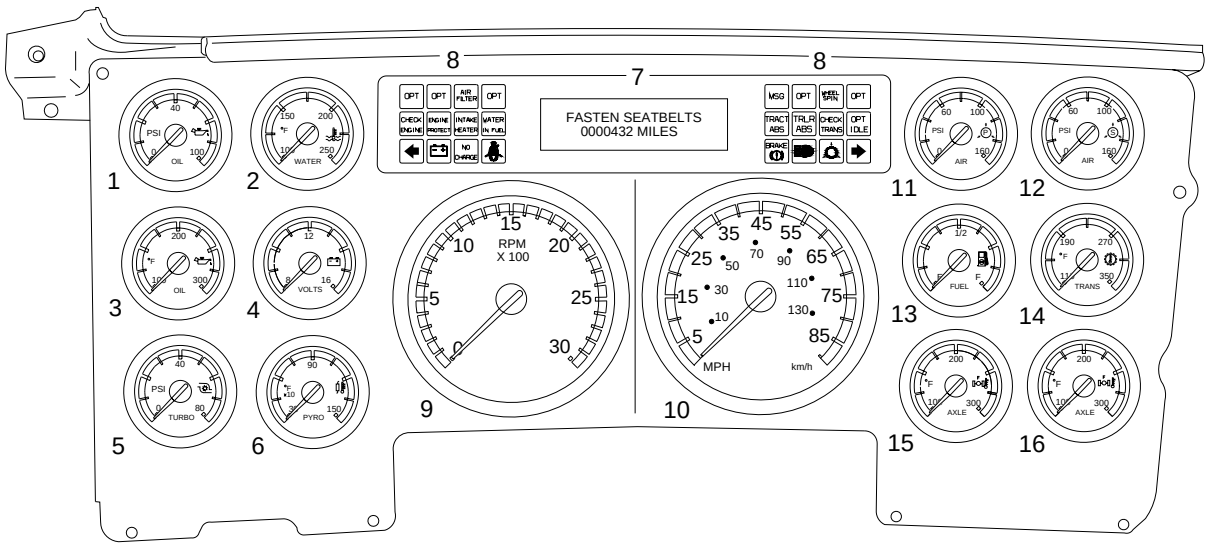
Table 1, Maximum Coolant Temperature

- engine oil pressure—5 to 9 psi (35 to 60 kPa) on most engines
- fuel level—less than 1/8 tank
- transmission temperature—356°F (180°C)

Warning and Shutdown Process

If the engine coolant temperature, the coolant level, or the engine oil pressure (on some engines, the engine oil temperature or the intake air temperature also) reach preset levels, the engine will begin a warning and shutdown process.

1. The red engine protection (ENGINE PROTECT) warning light comes on to indicate that the protection system available for the engine has been activated.
2. The engine ECU begins to reduce the maximum engine torque and speed.



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1. Engine Oil Pressure Gauge
2. Engine Coolant Temperature Gauge
3. Engine Oil Temperature Gauge
4. Voltmeter
5. Turbo Boost Air Pressure Gauge
6. Pyrometer
7. Dash Message Center (light bar faceplate)
8. Warning and Indicator Lights
9. Tachometer
10. Speedometer
11. Primary Air Pressure Gauge
12. Secondary Air Pressure Gauge
13. Fuel Level Gauge
14. Transmission Fluid Temperature Gauge
15. Tandem Rear Axle Temperature Gauge, Forward
16. Tandem Rear Axle Temperature Gauge, Rear

Fig. 1, ICU4M Gauge Layout (typical)

3. If the condition does not improve, the engine will shut down within 30 seconds.

The driver must safely bring the vehicle to a stop on the side of the road and shut down the engine as soon as the red light is seen. If the engine shuts down while the vehicle is in a hazardous location, the engine can be restarted after turning the key to the OFF position for a few seconds.

NOTE: Some engines can be programmed to derate rather than shut down.

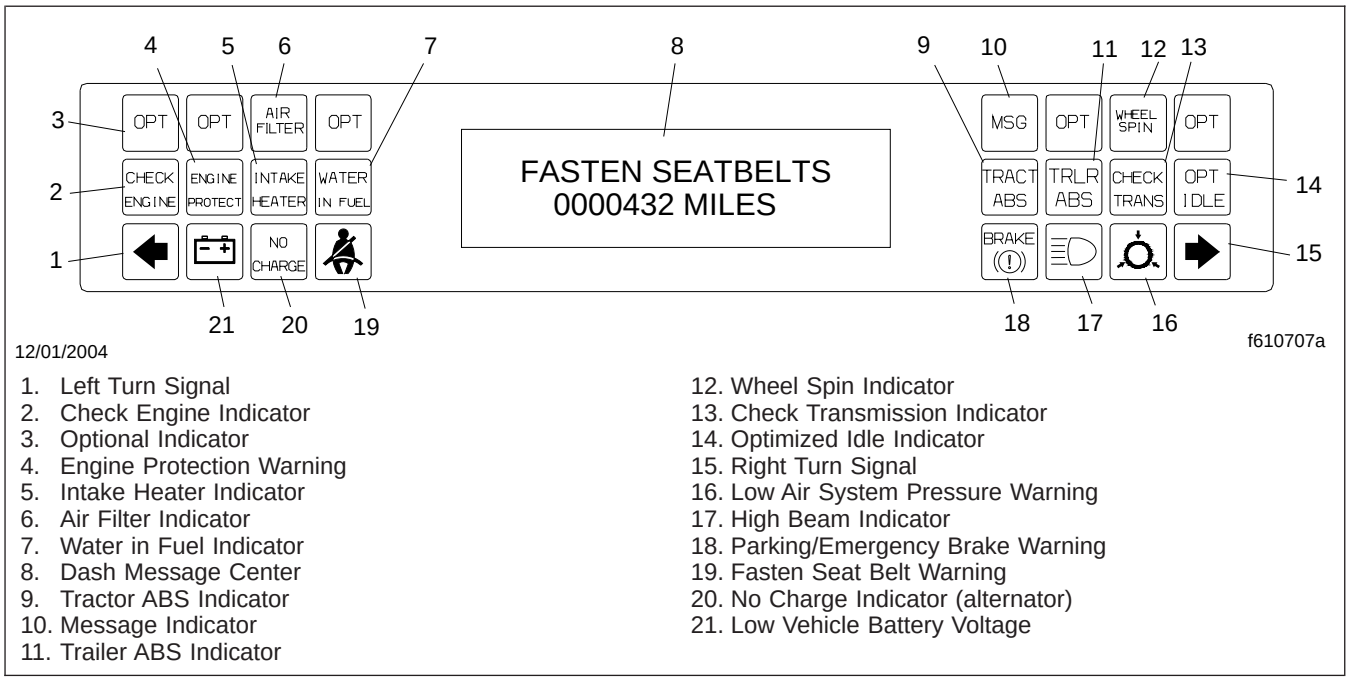
Warning and Indicator Lights

Up to 24 warning and indicator lights (telltales) can be installed in the ICU4M; the 16 positions in the bottom two rows are fixed, and the eight positions in the top row are optional. In addition, there may also be up to four gauges with a warning light integrated on the gauge.

In-Gauge Lights

Four gauges have a small warning or indicator light integrated into the gauge. The in-gauge light is located at the bottom of the gauge in the six-o'clock position.

- The red high coolant temperature warning (located on the engine coolant temperature gauge) and buzzer activate whenever the message center receives a high coolant fault message from the engine (MID 128, PID 110, and FMI 00). See **Table 1** for maximum coolant temperatures for each engine.
- The red low engine oil pressure warning (located on the engine oil pressure gauge) and buzzer activate whenever the message center receives a low oil pressure fault message from the engine (MID 128, PID 100, and FMI 01).



1. Left Turn Signal
2. Check Engine Indicator
3. Optional Indicator
4. Engine Protection Warning
5. Intake Heater Indicator
6. Air Filter Indicator
7. Water in Fuel Indicator
8. Dash Message Center
9. Tractor ABS Indicator
10. Message Indicator
11. Trailer ABS Indicator
12. Wheel Spin Indicator
13. Check Transmission Indicator
14. Optimized Idle Indicator
15. Right Turn Signal
16. Low Air System Pressure Warning
17. High Beam Indicator
18. Parking/Emergency Brake Warning
19. Fasten Seat Belt Warning
20. No Charge Indicator (alternator)
21. Low Vehicle Battery Voltage

Fig. 2, ICU4M Light-Bar Display (typical)

- The yellow high transmission temperature indicator (located on the optional transmission oil temperature gauge) activates when the transmission fluid temperature goes above 365°F (185°C). This light is directly controlled by the transmission via hard wire input to the message center.
- The yellow low fuel indicator (located on the fuel gauge) activates when the fuel tank is less than 1/8 full.

Standard Lights

The standard warning and indicator lights operate as follows:

- The green right-turn and left-turn signal indicators flash on and off whenever the outside turn signal lights are flashing.
- The blue high-beam indicator comes on when the headlights are on high beam.
- The yellow CHECK ENGINE indicator comes on when an engine fault is detected or recorded. The check engine light is controlled by the engine ECU. See the engine manufacturer's manuals for troubleshooting.
- The red low air pressure warning (pressure circle icon) and buzzer activate whenever air pressure in the primary or secondary air reservoir falls below 64 to 76 psi (440 to 525 kPa).
- The red parking/emergency brake (BRAKE! legend) warning light activates whenever the parking brake is set. A buzzer also activates when the vehicle is moving at least 2 mph (3 km/h) with the parking brake set.
- The red fasten seat belt warning (seat belt icon) illuminates for 15 seconds when the ignition key is turned to the ON position.
- The yellow INTAKE HEATER indicator illuminates to indicate that the intake air heater is active. This telltale is directly controlled by the engine via hard wire input to the message center.
- The yellow WATER IN FUEL indicator illuminates to indicate that the fuel could contain water. This telltale is directly controlled by the engine via hard wire input to the message center.
- The yellow tractor ABS (TRACT ABS) indicator illuminates when a problem with the ABS system is detected. This telltale is directly con-

trolled by the ABS via hard wire input to the message center.

- The yellow check transmission (CHECK TRANS) indicator illuminates when a problem with the electronic transmission is detected. This telltale is directly controlled by the transmission via hard wire input to the message center.
- Installed only on vehicles equipped with the Detroit Diesel optimized idle system, the yellow optimized idle (OPT IDLE) indicator illuminates when the vehicle is stopped, the parking brake is on, and optimized idle system is running. This telltale is directly controlled by the engine via hard wire input to the message center.
- The red low vehicle battery voltage warning (battery icon) illuminates when the battery voltage is 11.9 volts or less. This telltale is controlled by the message center by monitoring the voltage message from the engine.
- The yellow alternator NO CHARGE indicator illuminates to indicate an alternator charge output failure. This telltale is directly controlled by the alternator via hard wire input to the message center.

The yellow trailer ABS (TRLR ABS) indicator operates as follows when a compatible trailer is properly connected to a tractor before the engine is started (PLC trailers only):

- With the ignition key in the ON position, the trailer ABS telltale illuminates momentarily, then turns off.
- If the telltale comes on momentarily during vehicle operation, then shuts off, a fault was detected and corrected.
- If the telltale comes on and stays on during vehicle operation, there is a fault with the trailer ABS. Repair the trailer ABS system immediately to ensure full antilock braking capability.

The trailer ABS indicator will not illuminate unless a compatible trailer is connected to the tractor.

NOTE: When connected to a PLC-equipped trailer, this telltale is directly controlled by the **tractor** ABS ECU via hard wire input to the message center.

On non-PLC-equipped trailers, this telltale is directly controlled by the **trailer** ABS ECU via hard wire input to the message center.

Optional Lights

The eight warning and indicator light positions on the top row of the message center are optional. The positions are numbered from #1 to #8, with #1 on the far left and #8 on the far right. Available optional indicator lights include: low washer fluid, automatic transmission overheat warning, wheel spin warning, impaired air filter warning, ECAS (electronic suspension) transfer indicator, and ECAS failure warning.

Keypad

The ICU4M is controlled by a keypad located on the auxiliary dash panel. See **Fig. 3**. This keypad, which has 10 keys, can be used to do the following things:

- Call up information onto direct access screens while the vehicle is moving, using the dedicated keys (temp, fuel, trip, and leg).
- Move from screen to screen while the vehicle is stationary using the general keys (left, right, and down arrow keys).
- Program on-screen service intervals, screen brightness, language, units of measurement, and other display functions, using the set function of the set/reset key.
- Clear unused or obsolete data, reset fault code screens after the faults have been cleared, or reset the counters for trip or fuel information, using the reset function of the set/reset key.
- Record significant data using the event key (optional—if a data logging unit is installed).

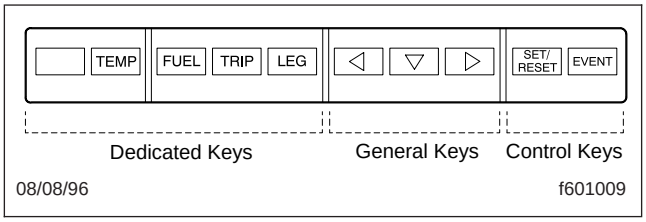


Fig. 3, 10-Key Keypad

NOTE: One key is blank and is not usable at this time.

See **Fig. 4** for information on how to use the set/reset key.

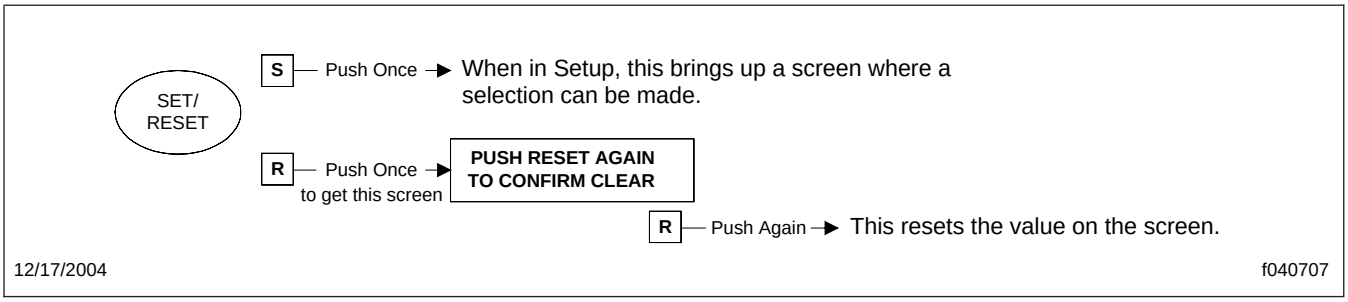


Fig. 4, Set/Reset Key Functions

Buzzer and Chime

The buzzer sounds for 3 seconds during the self-test at start-up, and when the following conditions exist:

- the engine oil pressure falls below the preset level of 5 to 9 psi (35 to 60 kPa) on most engines
- the coolant temperature rises above the preset level as given in **Table 1**
- the air pressure falls below the preset level of 64 to 76 psi (440 to 525 kPa)
- the parking brake is set and the vehicle is moving at a speed of at least 2 mph (3 km/h)

A friendly chime sounds when the parking brake is off and the door is open, or when the headlights are on and the door is open.

Principles of Operation

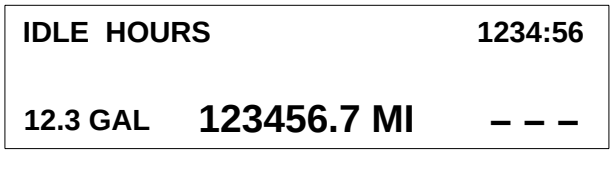
Ignition Sequence

When the ignition key is turned on, the ICU4M begins a self-test. During the first half of this process, the following events occur. Observing these events is a good way to make sure the ICU4M is functioning properly:

- all gauges controlled by the message center sweep to full scale and return
- all display segments of the message center turn on and then turn off
- the buzzer sounds for three seconds
- the battery voltage, low air pressure, and parking brake warning lights come on and then go off
- the fasten seat belt warning light illuminates for 15 seconds

In the second half of the self-test, the software revision level of the ICU4M displays on the message center, followed by the active faults, if any.

When the self-test is complete, the fasten seat belt screen displays if the engine is not running. If the engine is running, the idle hours screen displays. See **Fig. 5** for the idle hours screen (odometer display).



NOTE: On vehicles with automated manual transmission, the three digits on the lower right are reserved for current gear information.

Fig. 5, Idle Hours Screen

Alert Screens

Alert screens can display whenever a condition occurs that requires the driver's attention, whether the vehicle is in motion or parked. They warn, caution, or provide other messages, some critical to the operation of the vehicle.

On an alert screen, the top line contains a flashing message, such as "Warning" or "Alert." The lower line contains information about the content of the alert. See **Fig. 6**.

Some examples of alert messages:

- Park Brake On
- Park Brake Off

General Information

Fig. 6, Alert Message

- Low Oil Pressure
- High Coolant Temperature
- Low Voltage
- Turn Signal On
- No Datalink Activity

Automated Manual Transmissions

The ICU4M can display current gear information for vehicles with automated manual transmissions (AMT). The last three digits at the far right on the lower line are reserved for this information. On the diagrams for the stationary access screens, this is indicated by the legend "AMT."

If there is a need to shift, one digit displays an arrow, either up or down depending on the shift direction. The other two digits display the current gear.

On vehicles with conventional manual or automatic transmissions, these three digits do not display.

Stationary Access Screens

The stationary access screens provide a wealth of information. Using the general keys (arrow keys) to scroll up, down, and to the left or right, you control the following functions:

- trip information
- fuel information
- engine information
- diagnostic information including complete J1587 fault codes
- service information including mileage or time to next service
- setup information of various kinds
- vehicle information

With the parking brake released, only the odometer and alert screens can be displayed. Park the vehicle and set the parking brake to display additional screen functions.

Trip Information

Trip information allows you to view trip mileage and time, time spent idling, average miles per hour, and leg mileage and time. See **Fig. 7**.

Fuel Information

Fuel information allows you to view total fuel usage since the last reset, fuel mileage, and fuel consumed while idling or running the PTO. See **Fig. 8**.

Engine Information

Engine information allows you to view total engine mileage and hours, fuel consumption for the engine and PTO, and engine oil level (where installed). See **Fig. 9**.

NOTE: Engine oil level is an optional function available on vehicles with Mercedes-Benz engines.

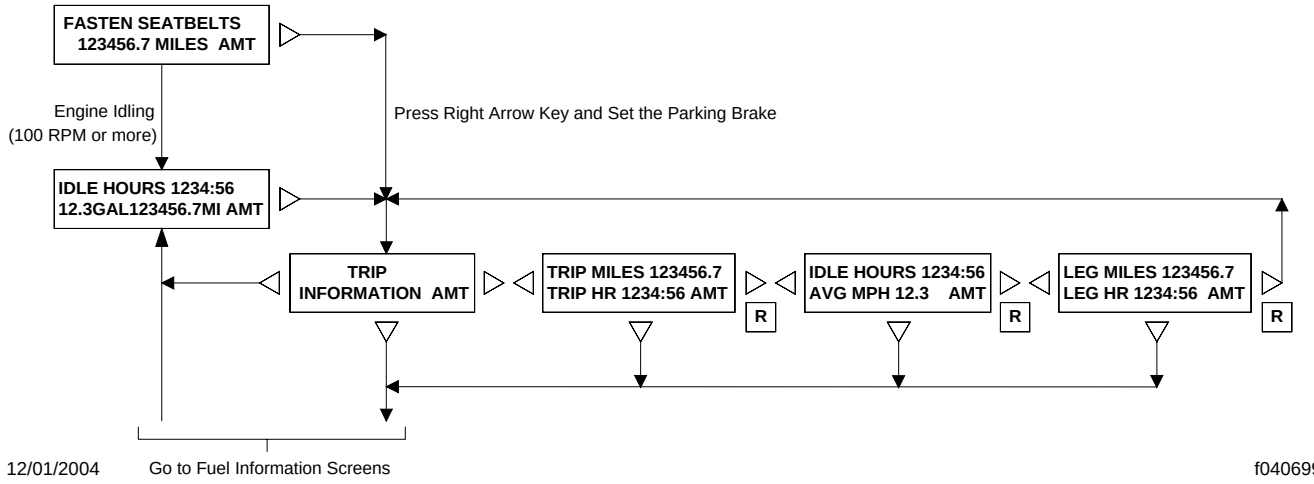
Diagnostic Information

Diagnostic information allows you to view any J1587 fault codes transmitted on the vehicle datalink. The complete fault code is displayed both as a text message and in numbers. Specific fault code information can be displayed only with the vehicle stopped and the parking brake set.

During vehicle start-up, with the parking brake set, the ICU4M displays active fault codes, if any, until the parking brake is released. With an active fault code on display, push the left arrow key to go to the active faults screen (gives the total number of active faults), and again to go to the diagnostic information screen. From here, any of the diagnostic information can be obtained, including information about any fault, active or historical.

NOTE: Historical faults are dash faults only.

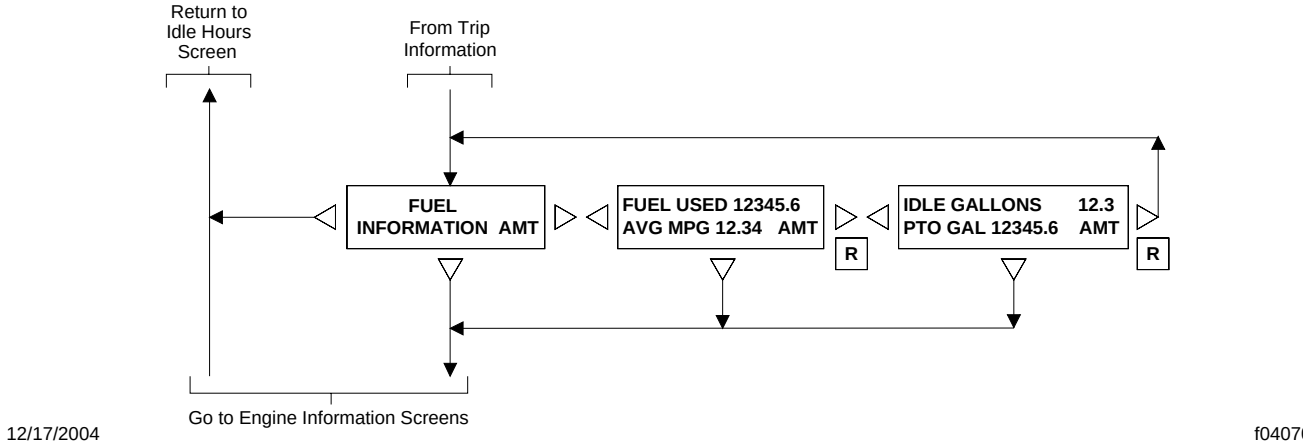
Diagnostic information can also be obtained at any time. From the odometer screen, press the right arrow key once and the down arrow key three times to display the diagnostic information screen. See **Fig. 10**.



AMT= Current gear information for automated manual transmissions.

NOTE: Metric unit screens are similar.

Fig. 7, Trip Information Screens



AMT= Current gear information for automated manual transmissions.

NOTE: Metric unit screens are similar.

Fig. 8, Fuel Information Screens

Active Faults

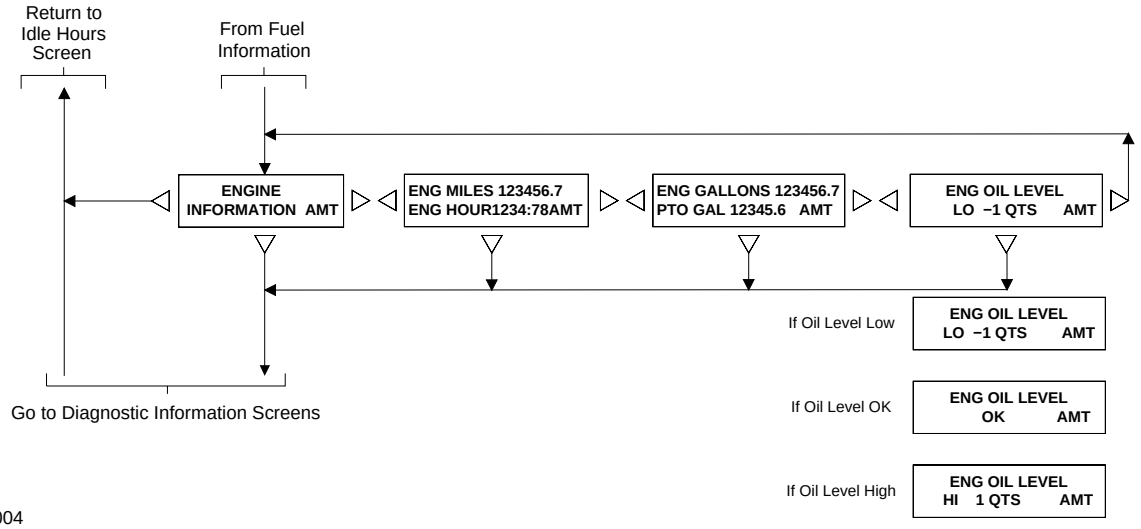
Active faults are communicated on the J1587 datalink. If active fault codes display during start-up or at any other time, make a note of the fault code and text message.

Historical Faults

Historical faults (dash faults only) are kept in the ICU4M's memory after the active fault has been cleared. The data are useful for situations where the same fault recurs over time, to indicate an underlying problem that may otherwise escape attention.

It is possible to clear historical fault data from the ICU4M's memory when the information is no longer

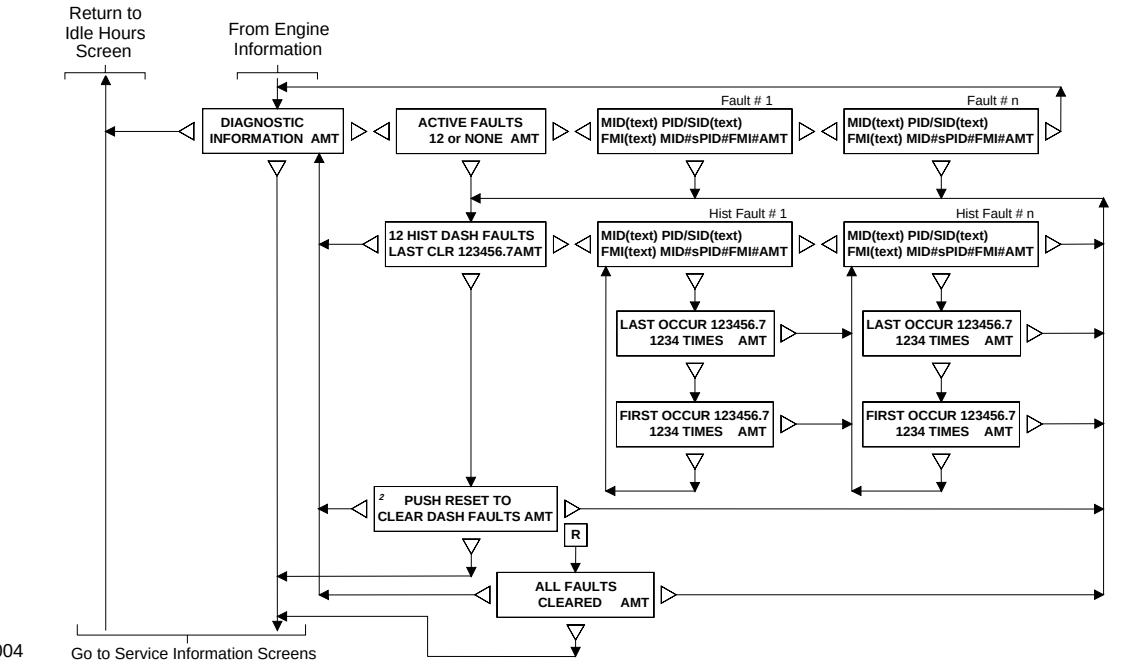
General Information



AMT= Current gear information for automated manual transmissions.

NOTE: Metric unit screens are similar.

Fig. 9, Engine Information Screens



AMT= Current gear information for automated manual transmissions.

NOTE: With less than 254 miles on the odometer, clearing historical faults also clears the memory of the electronic unit reporting the fault.

Fig. 10, Diagnostic Information Screens

needed. When there are less than 254 miles on the odometer, clearing historical faults also clears the memory of the electronic unit reporting the fault.

IMPORTANT: Do not reset historical faults unless you are sure that the data will not be needed in the future. It is not possible to clear individual historical faults: either all the data are cleared, or none.

To clear historical faults, press the set/reset key. When the message "all faults cleared" appears, all the historical fault data have been cleared. From this message, press the left arrow key to return to the diagnostic information screen, the right arrow key to return to the historical faults information screen, or the down arrow key to go on to service information.

Service Information

Service information allows you to view the next recurring service interval. Service intervals can be expressed in either miles or hours. See **Fig. 11**. They can also be inactivated, so they do not display at all. For programming service intervals, look under the heading "Setup Information."

NOTE: If the service information screen is not activated, the ICU4M will instead display the setup information screen, which can be used to activate service information.

If the vehicle has gone past the service interval, the "miles/hours remaining" screen is replaced by the "service was due" screen, followed by the number of miles/hours since the service fell due.

Setup Information

Setup information allows you to program various features of the ICU4M environment. These are the programmable features:

- service intervals
- target miles per gallon
- LCD lighting
- display brightness
- language
- units of measurement
- parameters

From the service information screen, press the down arrow key to display the setup information screen. See **Fig. 12**.

To set any feature, press the set/reset key when prompted. A decision screen appears, displaying the decision choices with the current selection flashing. To change the selection, move the left or right arrow key as many times as required until the desired selection is flashing. Then press the down arrow key to leave the decision screen and go to the next setup feature screen. See **Fig. 13**.

Service Interval Programming

For service intervals only, there is an extra programming step. From the service interval feature screen, press the set/reset key to display a decision screen for setting service interval units (the choices are miles, hours, or off).

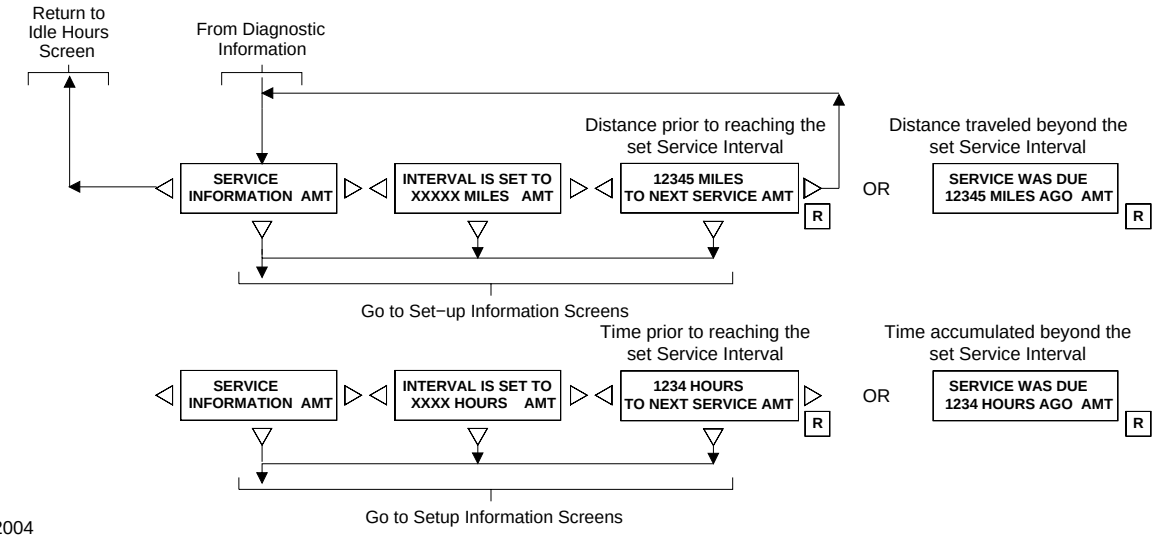
If you select miles or hours on this decision screen, press the down arrow key to go to a second decision screen. This decision screen allows you to select the length of the interval in the units you have chosen (either miles or hours). Once you have selected the interval length, press the down arrow key again to go to the next setup feature screen (target mpg).

If, on the other hand, you select "off" at the selection screen for service interval units (meaning you have turned off service interval information), you go directly to the next setup feature screen (target mpg).

Vehicle Information

Vehicle information allows you to view datalink activity in a dynamic graph format, datalink usage and error rate (datalink status), and ICU4M data, including ICU4M serial number and software revision level. See **Fig. 14**.

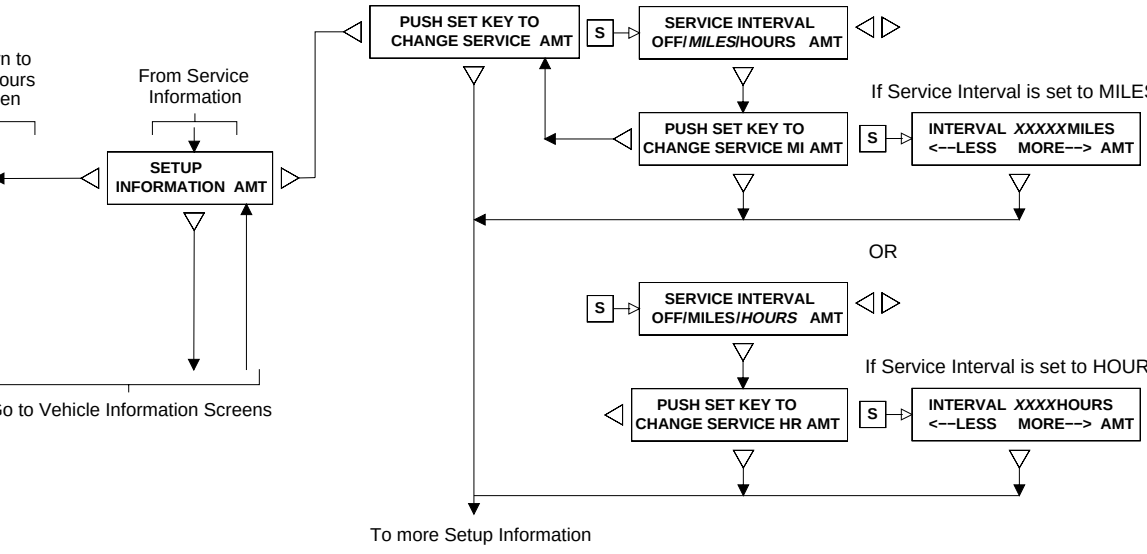
General Information



AMT= Current gear information for automated manual transmissions.

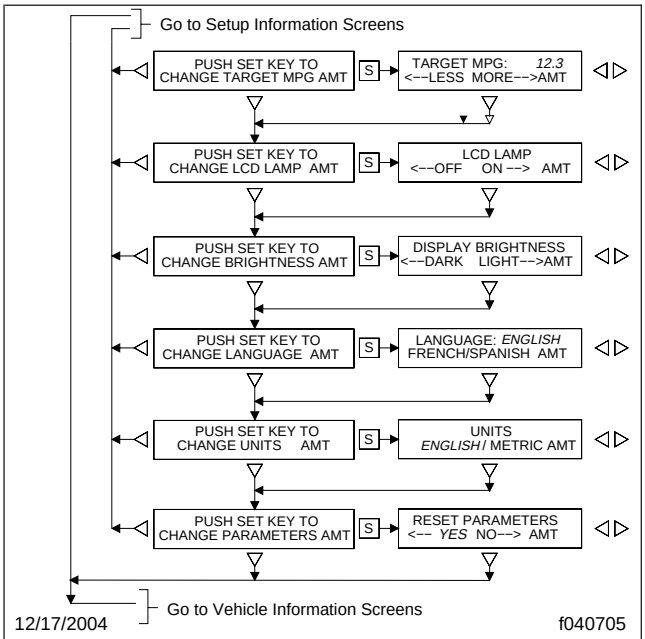
NOTE: Service information screens only appear if the service interval is set to MILES or HOURS in Setup Information. Metric unit screens are similar.

Fig. 11, Service Information Screens



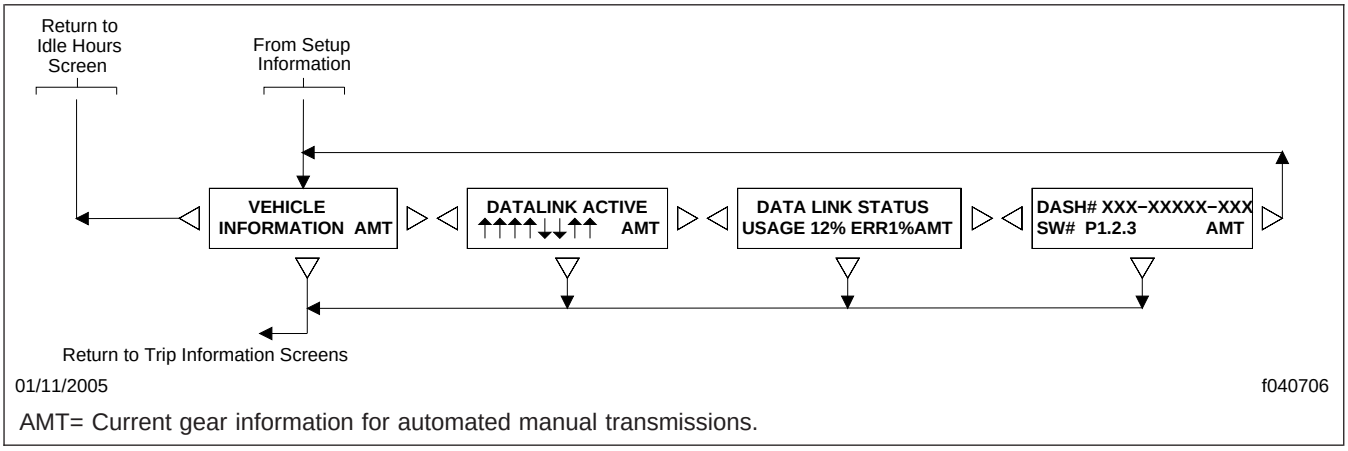
AMT= Current gear information for automated manual transmissions.
The current selection flashes. Press the left and/or right arrow key(s) to change the selection. To store the changes and exit the screen, press the down arrow key.

Fig. 12, Setup Information Screens (for service intervals)



The current selection flashes. Press the left and/or right arrow key(s) to change the selection. To store the changes and exit the screen, press the down arrow key.

Fig. 13, Other Setup Information



AMT= Current gear information for automated manual transmissions.

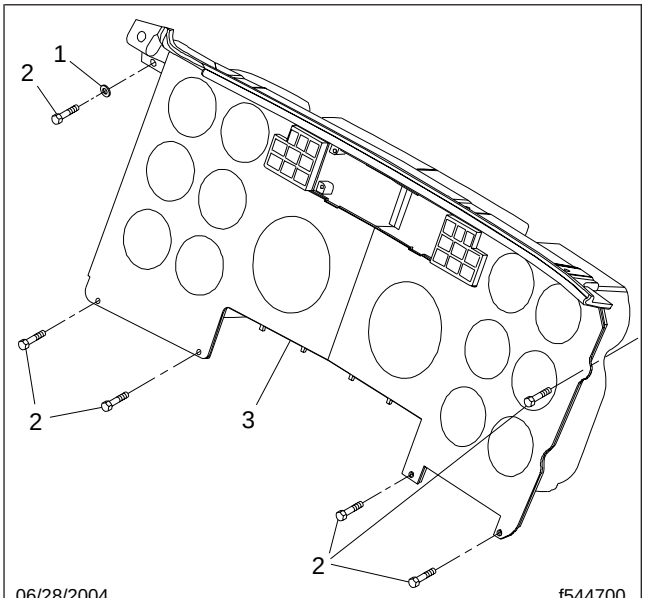
Fig. 14, Vehicle Information Screens

Replacement

To replace the individual components, see the subject listed below for procedures.

- Individual gauges, see **Subject 110**
- Light bar, see **Subject 120**
- Light bulbs or telltale lenses, see **Subject 130**

1. Remove the left-hand dash panels. Be sure the screws that attach the dash panel trimtop to the upper dash assembly have been removed. For instructions, see **Section 60.08, Subject 100**.
2. Remove the screw that attaches the dash panel trimtop to the lower dash panel. This screw is located on the far left of the trimtop.
3. Remove the fasteners that secure the ICU4M housing to the dash. Fasteners used on the ICU4M are 7/8" Torx pan-head dog-point screws. See **Fig. 1**.



1. #10 Stainless Steel Flatwasher, 1/2" OD
2. 7/8" Dog-Point Torx Screw
3. ICU4M Housing

Fig. 1, ICU4M Dash Panel Installation

CAUTION

Electronic components of the ICU are vulnerable to damage from static electricity. If available, wear a wrist grounding strap connected to a ground in the cab or workbench. If a grounding strap is not available, touch a grounded component immediately before doing any work which could bring a tool or body part in contact with ICU circuitry.

4. Disconnect the electrical harness connectors from the back of the light bar. These include the 32-pin light bar connector, the 24-pin light bar connector, and the two 6-pin gauge databus connectors. Also disconnect the 3-pin auxiliary input connector, if so equipped. See **Fig. 2**.

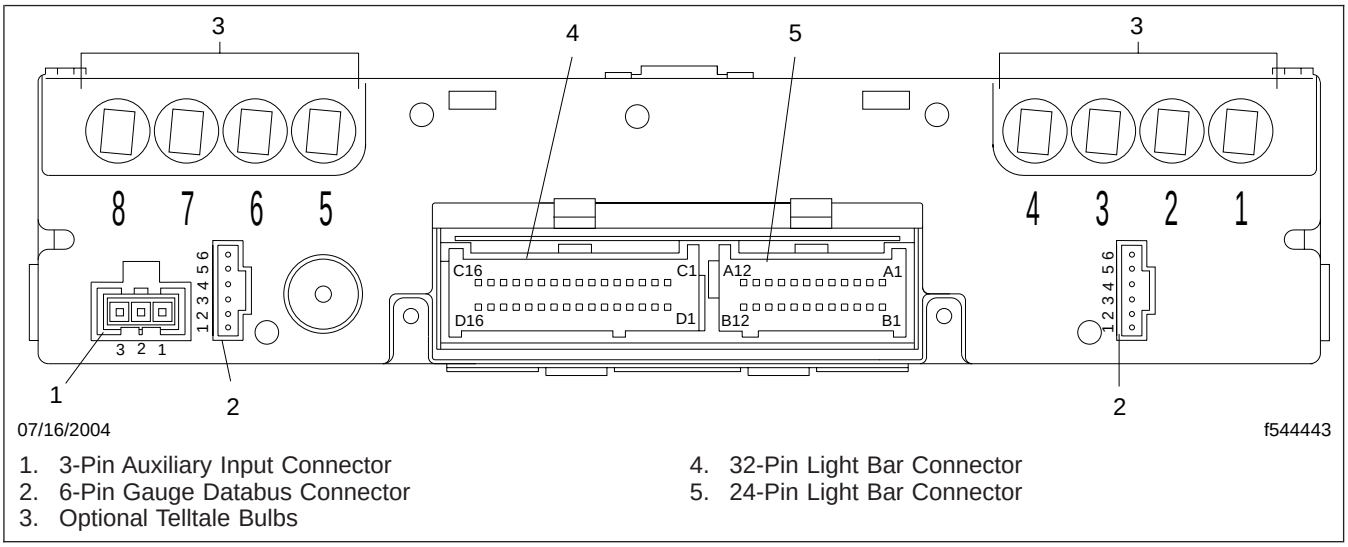
IMPORTANT: Bleed off all air before trying to remove the air hoses.

5. Using a paint pen, mark the air hoses for ease in installation. After bleeding all air from the system, disconnect all air gauge hoses.
6. Remove the light bar faceplate. Place a small flat blade under each end near the center and carefully pry it forward to release the locking tabs.
7. When all fasteners and connections between the ICU housing and the dash have been disconnected, remove the old ICU from the dash. See **Fig. 3**.
8. Remove the light bar from the back by removing its four Torx screws from the front of the ICU4M housing. The top two screws also secure the trimtop to the ICU4M housing.
9. Disconnect each gauge from the others by disconnecting the daisy chain harness connectors.

NOTE: Record the location of each gauge before removing it, if the same configuration is desired for reinstallation. Gauges must be installed in the appropriate size panel opening, and they must all be connected to each other in daisy-chain fashion in order to work, but a specific location for each gauge is not necessary.

10. Remove all gauges. See **Fig. 4**. For procedures, see **Subject 110**.
11. Remove the remaining screw that attaches the dash panel trimtop to the old ICU.

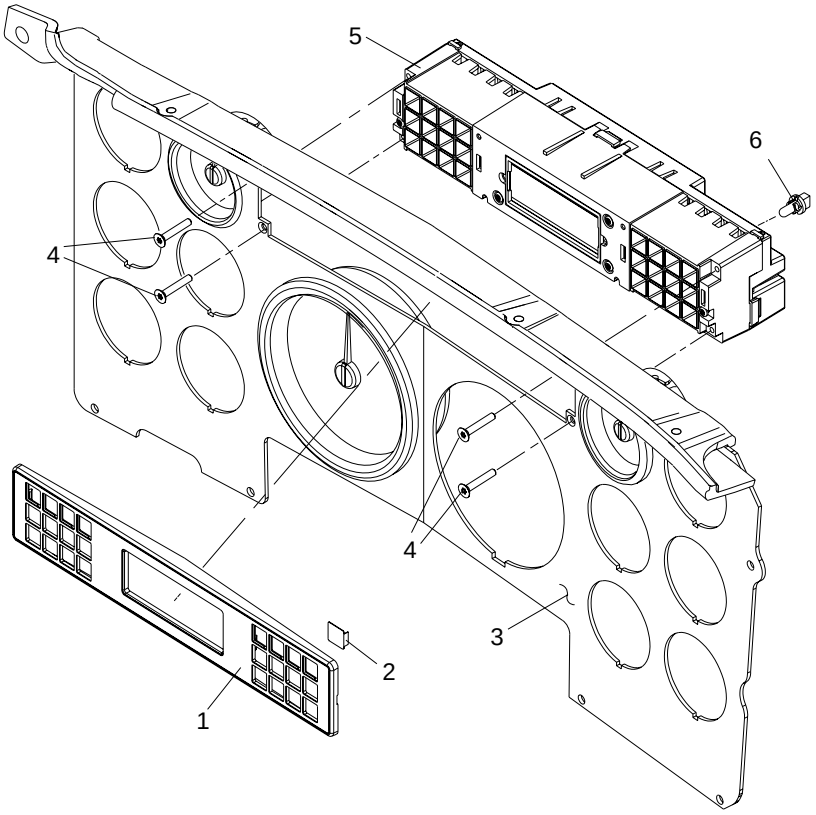
ICU4M Replacement



1. 3-Pin Auxiliary Input Connector
2. 6-Pin Gauge Databus Connector
3. Optional Telltale Bulbs
4. 32-Pin Light Bar Connector
5. 24-Pin Light Bar Connector

Fig. 2, Light Bar Connector Pin Locations (rear view)

12. Attach the dash panel trimtop to the replacement ICU4M housing.
13. Locate each replacement gauge in the correct gauge opening. See **Fig. 4**. For procedures, see **Subject 110**.
14. Install the light bar. Place it into the opening from the back and install its four Torx screws from the front of the ICU4M. The top two screws also secure the trimtop to the ICU4M housing. Hold the trimtop so its mounting tabs are flush with the ICU4M housing, then secure the light bar. See **Fig. 3**.
15. Install the light bar faceplate. Place it over the front of the light bar, then carefully press it on until its end tabs lock in place.
16. Connect each gauge to the others on each side of the ICU4M housing. Connect the harnesses in daisy-chain fashion.
    - 16.1 Start by connecting the inside harness of one of the two large gauges to the closest 6-pin connector on the light bar. Then connect the harness on the outside of the gauge to the nearest plug at the top of the column of small gauges next to it. Connect the other harness from the small gauge to the one below it. Continue working down, then across the bottom to the column of gauges next to it, then up the column. The final gauge in the chain will connect only to the gauge immediately below it.
    - 16.2 Connect the gauges on the other side of the ICU4M in similar fashion. Start with the other large gauge, connect it to the nearest 6-pin connector on the light bar, then connect the other harness from the large gauge to the small gauge nearest on the top inside column and work similarly down the inside column and up the outside column around so all gauges are connected in the chain.
17. Place the ICU4M close to its installed position and connect the air hoses to the air gauges as marked during removal.
18. Connect all remaining electrical harnesses to the back of the light bar. These include the 32-pin light bar harness connector, the 24-pin light bar harness connector, and the 3-pin auxiliary input harness connector, if so equipped. See **Fig. 2**.
19. Install the fasteners that secure the ICU4M housing to the dash. Fasteners used on the ICU4M are 7/8" Torx pan-head dog-point screws. See **Fig. 1**.
20. Install all remaining dash panels. Be sure to install the fasteners that attach the dash panel trimtop to the upper dash assembly and lower



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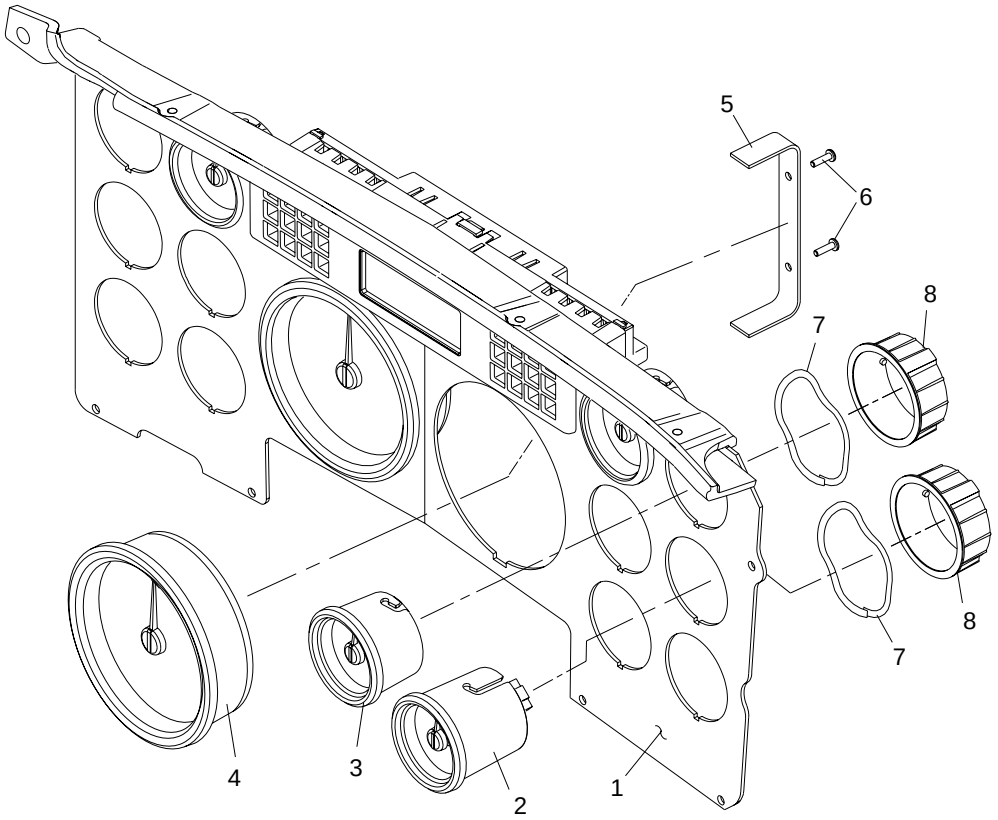
1. Light Bar Faceplate
2. Telltale Lens
3. ICU4M Housing
4. Light Bar Screws
5. Light Bar
6. Light Bulb

Fig. 3, Light Bar Replacement

dash panel. For instructions, see **Section 60.08, Subject 100**.

21. Turn on the ignition and test the operation of the ICU4M:
    - all gauges controlled by the ICU4M sweep to full scale and return
    - the buzzer sounds for 3 seconds
    - the fasten seat belt warning light illuminates for 15 seconds
    - the battery voltage, low air pressure, and parking brake warning lights illuminate, and then turn off.
22. Repair or replace any gauges that are not working properly.

ICU4M Replacement



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1. ICU4M Housing
2. Air Pressure Gauge
3. Small Gauge
4. Large Gauge (Speedometer or Tachometer)
5. Large Gauge Mounting Bracket
6. Large Gauge Mounting Screws
7. Wave Ring
8. Small Gauge Mounting Collar

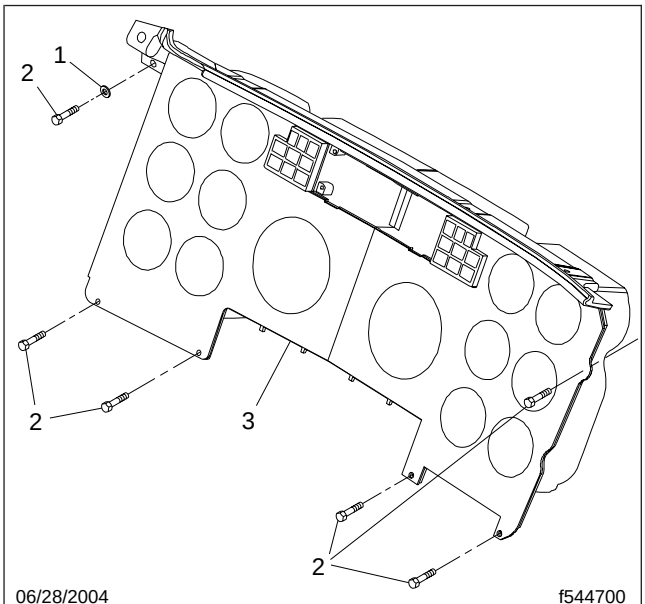
Fig. 4, ICU4M Gauge Installation

How to use these procedures:

1. Start with the instructions under the heading "Removing the Dash Panels."
2. Go to the instructions under the correct heading, as necessary to replace each type of gauge.
3. Finish with the instructions under the heading "Installing the Dash Panels." This will restore the ICU4M to service.

Removing the Dash Panels

1. Remove the left-hand dash panels. Be sure the screws that attach the dash panel trimtop to the upper dash assembly have been removed. For instructions, see **Section 60.08, Subject 100**.
2. Remove the screw that attaches the dash panel trimtop to the lower dash panel. This screw is located on the far left of the trimtop.
3. Remove the fasteners that secure the ICU4M housing to the dash. Fasteners used on the ICU4M are 7/8" Torx pan-head dog-point screws. See **Fig. 1**.



1. #10 Stainless Steel Flatwasher, 1/2" OD
2. 7/8" Dog-Point Torx Screw
3. ICU4M Housing

Fig. 1, ICU4M Dash Panel Installation

CAUTION

Electronic components of the ICU are vulnerable to damage from static electricity. If available, wear a wrist grounding strap connected to a ground in the cab or workbench. If a grounding strap is not available, touch a grounded component immediately before doing any work which could bring a tool or body part in contact with ICU circuitry.

4. Carefully pull the dash panel forward to gain access to the gauges from behind the panel.

Speedometer and Tachometer

1. Disconnect the electrical harness connectors from the back of the gauge.
2. Remove the two Torx screws that secure the mounting bracket and the gauge to the ICU4M housing. See **Fig. 2**.
3. Orient the replacement gauge and place it through the opening from the front. Then place the mounting bracket on the back of the gauge and install the two Torx screws.
4. Connect both wire harnesses to the back of the gauge.
5. See the instructions below under the heading "Installing the Dash Panels."

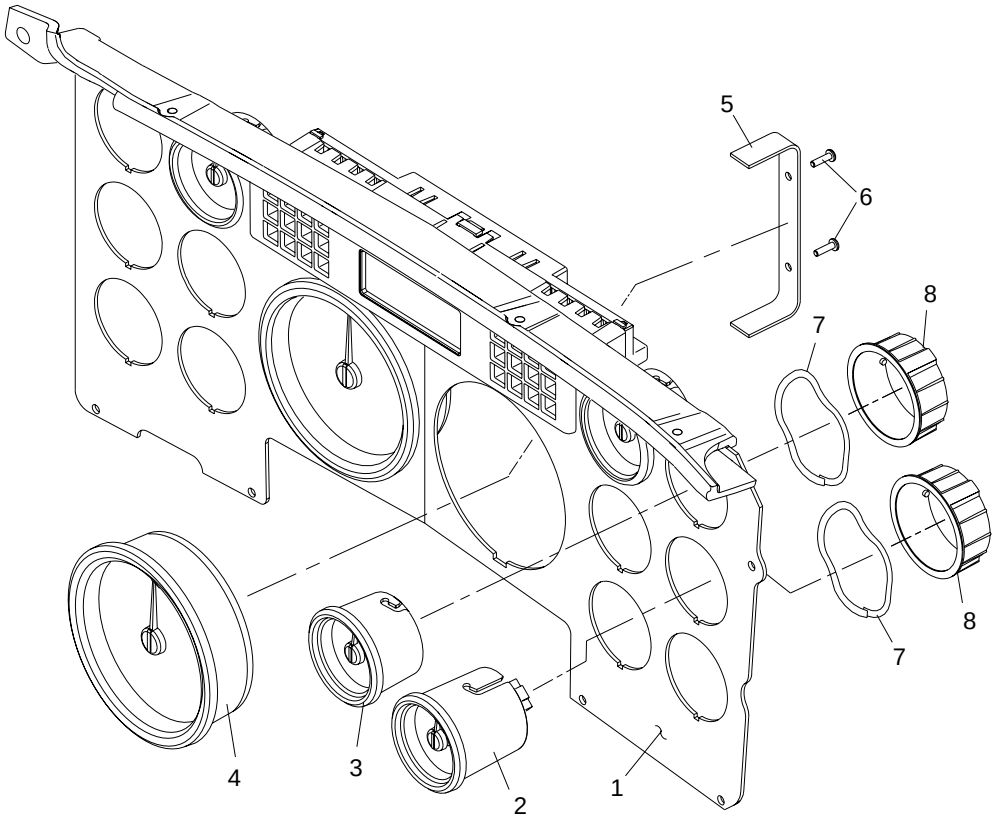
Air Pressure Gauges

IMPORTANT: Bleed off all air before trying to remove the air hoses.

1. Using a paint pen, mark the air hoses for ease in installation. After bleeding all air from the system, disconnect the air gauge hoses.
2. Unplug both wire harnesses from the back of the gauge.
3. Remove the ICU4M from the dash and place it on a bench with the gauge lens protected. See **Subject 100**.

NOTE: If multiple gauges are being replaced, note the location of each gauge before removal.

Gauge Replacement



05/24/2005 f610770

1. ICU4M Housing
2. Air Pressure Gauge
3. Small Gauge
4. Large Gauge (speedometer or tachometer)
5. Large Gauge Mounting Bracket
6. Large Gauge Mounting Screws
7. Wave Ring
8. Small Gauge Mounting Collar

Fig. 2, ICU4M Gauge Installation

4. Remove the old gauge from the ICU4M housing. See **Fig. 2**.
   - 4.1 Push in and give the gauge mounting collar (made of black plastic) a slight counterclockwise twist until the collar unlocks from the gauge.

   NOTE: The gauge collar may be difficult to remove, but it can be done without tools.

   - 4.2 Remove the collar and wave ring from the back of the ICU housing.
   - 4.3 Lift up the ICU housing and remove the gauge through the front of the ICU housing.
5. Install the new gauge in the ICU4M housing.
   - 5.1 Locate the replacement gauge in the correct gauge opening.
   - 5.2 Insert the tab on the gauge into the slot in the ICU4M housing until the gauge is flat against the front of the housing.
   - 5.3 Place the collar and wave ring on the back of the gauge. Push the gauge mounting collar against the wave ring and twist the collar clockwise until the collar locks in place.
6. Install the ICU4M in the dash. See **Subject 100**.
7. Connect both wire harnesses to the back of the gauge.
8. Connect the air gauge hoses.

9. See the instructions below under the heading "Installing the Dash Panels."

All Other Gauges

1. Unplug both wire harnesses from the back of the gauge.
2. Remove the ICU4M from the dash and place it on a bench with the gauge lens protected. See **Subject 100**.

NOTE: If multiple gauges are being replaced, note the location of each gauge before removal.

3. Remove the old gauge from the ICU4M housing. See **Fig. 2**.
   - 3.1 Push in and give the gauge mounting collar (made of black plastic) a slight counterclockwise twist until the collar unlocks from the gauge.

   NOTE: The gauge collar may be difficult to remove, but it can be done without tools.

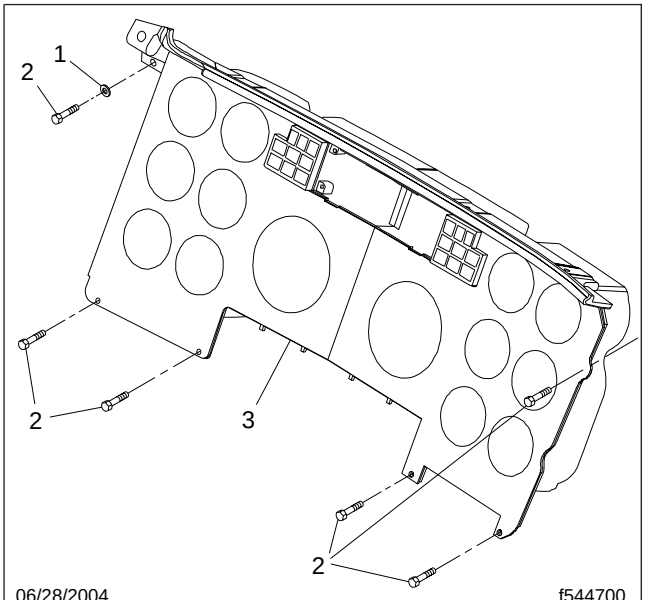
   - 3.2 Remove the collar and wave ring from the back of the ICU housing.
   - 3.3 Lift up the ICU housing and remove the gauge through the front of the ICU housing.
4. Install the new gauge in the ICU4M housing.
   - 4.1 Locate the replacement gauge in the correct gauge opening.
   - 4.2 Insert the tab on the gauge into the slot in the ICU4M housing until the gauge is flat against the front of the housing.
   - 4.3 Place the collar and wave ring on the back of the gauge. Push the gauge mounting collar against the wave ring and twist the collar clockwise until the collar locks in place.
5. Install the ICU4M in the dash. See **Subject 100**.
6. Connect both wire harnesses to the back of the gauge.
7. See the instructions below under the heading "Installing the Dash Panels."

Installing the Dash Panels

1. Install the fasteners that secure the ICU4M housing to the dash. Fasteners used on the ICU4M are 7/8" Torx pan-head dog-point screws. See **Fig. 1**.
2. Install all remaining dash panels. Be sure to install the fasteners that attach the dash panel trimtop to the upper dash assembly and lower dash panel. For instructions, see **Section 60.08, Subject 100**.
3. Turn on the ignition and test the operation of the ICU4M:
   - all gauges controlled by the ICU4M sweep to full scale and return
   - the buzzer sounds for 3 seconds
   - the fasten seat belt warning light illuminates for 15 seconds
   - the battery voltage, low air pressure, and parking brake warning lights illuminate, and then turn off.
4. Repair or replace any gauges that are not working properly.

Light Bar Replacement

1. Remove the left-hand dash panels. Be sure the screws that attach the dash panel trimtop to the upper dash assembly have been removed. For instructions, see **Section 60.08, Subject 100**.
2. Remove the screw that attaches the dash panel trimtop to the lower dash panel. This screw is located on the far left of the trimtop.
3. Remove the fasteners that secure the ICU4M housing to the dash. Fasteners used on the ICU4M are 7/8" Torx pan-head dog-point screws. See **Fig. 1**.



1. #10 Stainless Steel Flatwasher, 1/2" OD
2. 7/8" Dog-Point Torx Screw
3. ICU4M Housing

Fig. 1, ICU4M Dash Panel Installation

CAUTION

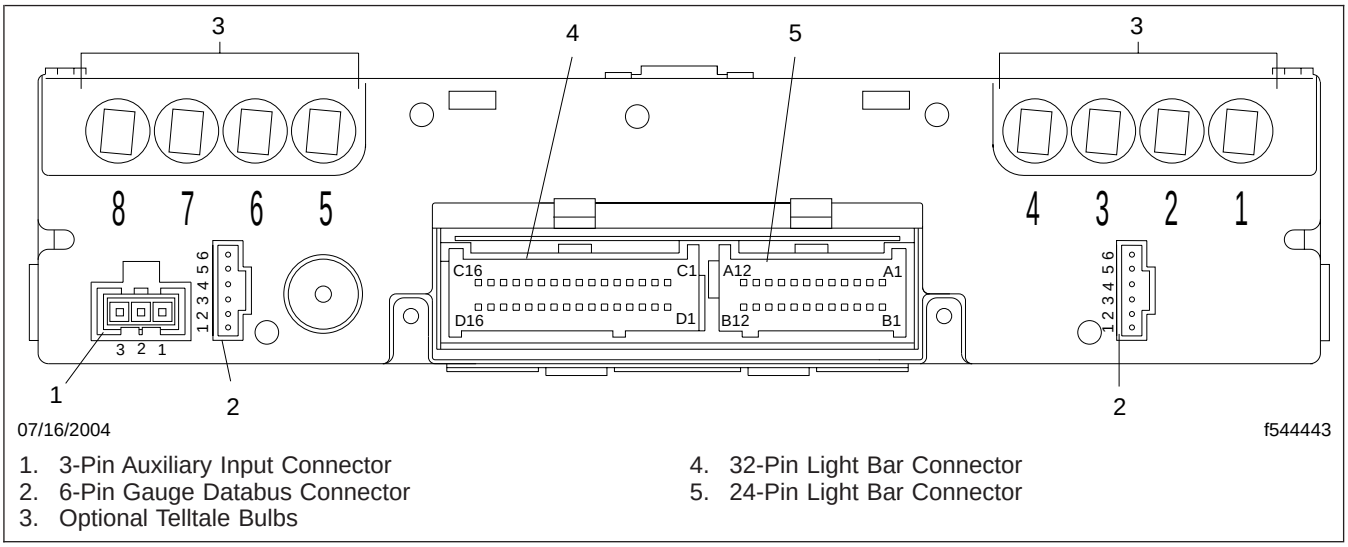
Electronic components of the ICU are vulnerable to damage from static electricity. If available, wear a wrist grounding strap connected to a ground in the cab or workbench. If a grounding strap is not available, touch a grounded component immediately before doing any work which could bring a tool or body part in contact with ICU circuitry.

4. Disconnect the electrical harness connectors from the back of the light bar. These include the 32-pin light bar connector, the 24-pin light bar connector, and the two 6-pin gauge databus connectors. Also disconnect the 3-pin auxiliary input connector, if so equipped. See **Fig. 2**.
5. Remove the light bar faceplate. Place a small flat blade under each end near the center and carefully pry it forward to release the locking tabs.
6. Remove the light bar from the back by removing its four Torx screws from the front of the ICU4M housing. The top two screws also secure the trimtop to the ICU4M housing. See **Fig. 3**.
7. Install the replacement light bar. See **Fig. 3**.
   - 7.1 From the back of the ICU4M housing, insert the light bar into the opening in the ICU4M housing.
   - 7.2 From the front, install four Torx screws, as removed.

   NOTE: The top two screws also secure the dash panel trimtop to the ICU4M housing.

   - 7.3 Hold the trimtop so its mounting tabs are flush to the ICU4M housing, then secure the light bar.
8. Install the light bar faceplate. Place it over the front of the light bar, then carefully press it on until its end tabs lock in place.
9. Connect the electrical harnesses to the back of the light bar; the 32-pin harness connector, the 24-pin harness connector, the two 6-pin databus harness connectors from the speedometer and tachometer, and the 3-pin auxiliary input harness connector, if so equipped. See **Fig. 2**.
10. Install the fasteners that secure the ICU4M housing to the dash. Fasteners used on the ICU4M are 7/8" Torx pan-head dog-point screws. See **Fig. 1**.
11. Install all remaining dash panels. Be sure to install the fasteners that attach the dash panel trimtop to the upper dash assembly and lower dash panel. For instructions, see **Section 60.08, Subject 100**.
12. Turn on the ignition and test the operation of the ICU4M:

Light Bar Replacement

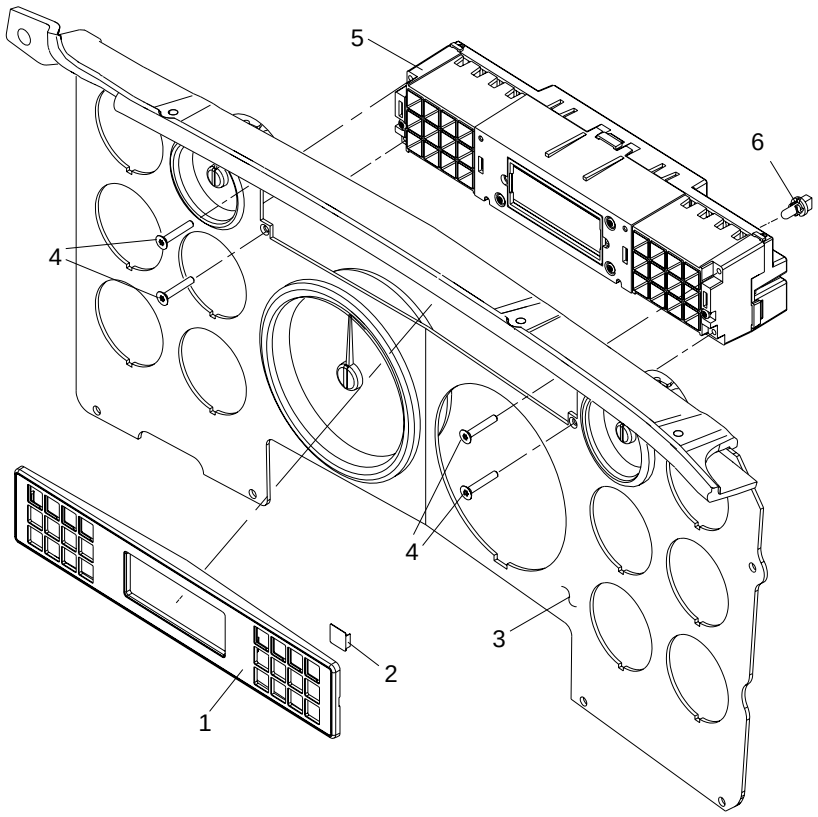


1. 3-Pin Auxiliary Input Connector
2. 6-Pin Gauge Databus Connector
3. Optional Telltale Bulbs
4. 32-Pin Light Bar Connector
5. 24-Pin Light Bar Connector

Fig. 2, Light Bar Connector Pin Locations (rear view)

- all gauges controlled by the ICU4M sweep to full scale and return
- the buzzer sounds for 3 seconds
- the fasten seat belt warning light illuminates for 15 seconds
- the battery voltage, low air pressure, and parking brake warning lights illuminate, and then turn off.

13. Repair or replace any gauges that are not working properly.



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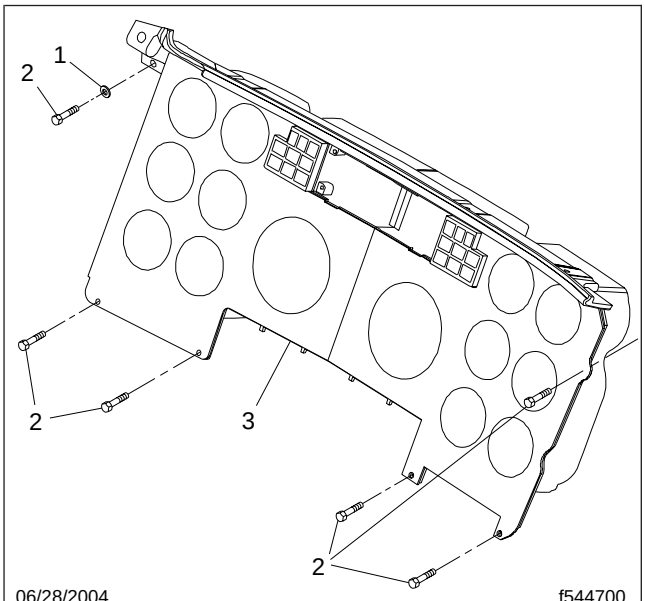
1. Light Bar Faceplate
2. Telltale Lens
3. ICU4M Housing
4. Light Bar Screws
5. Light Bar
6. Light Bulb

Fig. 3, ICU4M Light Bar Replacement

Light Bulb Replacement

NOTE: Only the top row of warning and indicator lights have replaceable bulbs. The replaceable bulbs are incandescent. All lights in this row are optional, so not all positions may be in use.

1. Remove the left-hand dash panels. Be sure the screws that attach the dash panel trimtop to the upper dash assembly have been removed. For instructions, see **Section 60.08, Subject 100**.
2. Remove the screw that attaches the dash panel trimtop to the lower dash panel. This screw is located on the far left of the trimtop.
3. Remove the fasteners that secure the ICU4M housing to the dash. Fasteners used on the ICU4M are 7/8" Torx pan-head dog-point screws. See **Fig. 1**.



1. #10 Stainless Steel Flatwasher, 1/2" OD
2. 7/8" Dog-Point Torx Screw
3. ICU4M Housing

Fig. 1, ICU4M Dash Panel Installation

CAUTION

Electronic components of the ICU are vulnerable to damage from static electricity. If available, wear a wrist grounding strap connected to a ground in the cab or workbench. If a grounding strap is not available, touch a grounded component immediately before doing any work which could bring a tool or body part in contact with ICU circuitry.

4. Carefully pull the dash panel forward to gain access to the light bar from behind the panel.
5. Twist the burned-out bulb about 1/8-turn counterclockwise and pull it out from the back of the light bar. See **Fig. 2**.
6. Insert a new bulb into the opening on the back of the light bar and twist it about 1/8-turn clockwise until it is securely in place.
7. Install the fasteners that secure the ICU4M housing to the dash. Fasteners used on the ICU4M are 7/8" Torx pan-head dog-point screws. See **Fig. 1**.
8. Install all remaining dash panels. Be sure to install the fasteners that attach the dash panel trimtop to the upper dash assembly and lower dash panel. For instructions, see **Section 60.08, Subject 100**.
9. Turn on the ignition and test the operation of the ICU4M:
   - all gauges controlled by the ICU4M sweep to full scale and return
   - the buzzer sounds for 3 seconds
   - the fasten seat belt warning light illuminates for 15 seconds
   - the battery voltage, low air pressure, and parking brake warning lights illuminate, and then turn off.
10. Repair or replace any gauges that are not working properly.

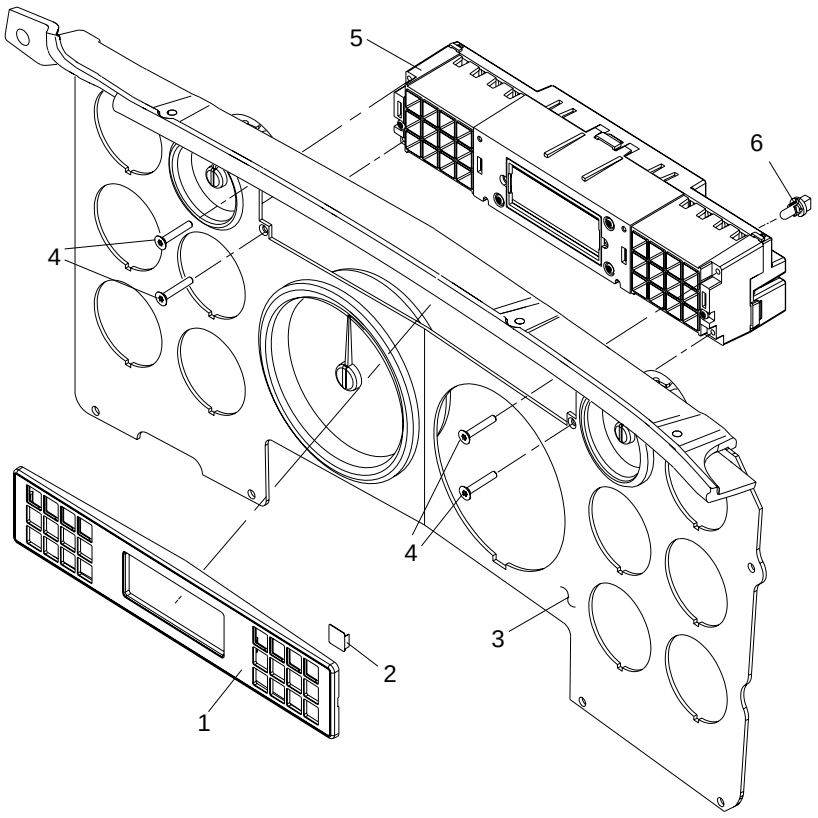
Telltale Lens Replacement

The term "telltale lens" refers to the small plastic inserts in the top row of the light bar with legends printed on them. These can be replaced.

CAUTION

Electronic components of the ICU are vulnerable to damage from static electricity. If available,

Light Bulb/Telltale Lens Replacement



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1. Light Bar Faceplate
2. Telltale Lens
3. ICU4M Housing
4. Light Bar Screws
5. Light Bar
6. Light Bulb

Fig. 2, ICU4M Light Bar

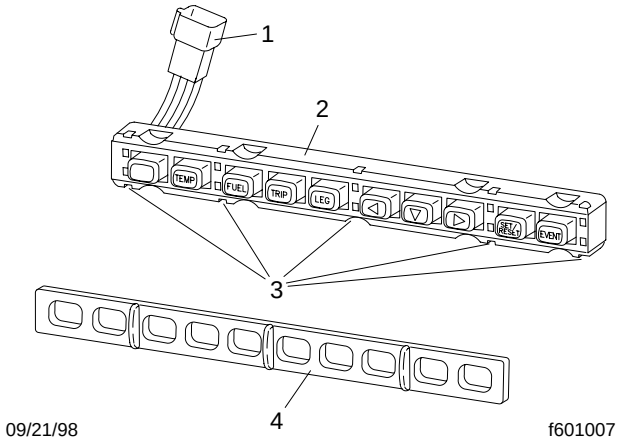
wear a wrist grounding strap connected to a ground in the cab or workbench. If a grounding strap is not available, touch a grounded component immediately before doing any work which could bring a tool or body part in contact with ICU circuitry.

1. Place a flat blade under each end of the light bar faceplate and carefully pry it off the light bar.
2. Using a pair of needlenose pliers or a similar tool, grab the exposed tab along the side of the telltale slot and carefully slide the telltale lens out from the slot.
3. Place the replacement telltale lens in its correct slot, as removed. Properly orient the telltale lens so the legend is readable from the front, then slide the telltale lens into its slot.

Turn on the ignition keyswitch. Check all bulbs and telltales for correct operation.

Replacement

1. Remove the auxiliary instrument panel. For instructions, see **Subject 100**.
2. Remove the keypad bezel. See **Fig. 1**.



1. Electrical Connector
2. Keypad Housing
3. Access Holes
4. Keypad Bezel

Fig. 1, Keypad Replacement

IMPORTANT: Proceed carefully with the keypad bezel removal. The locking tabs break easily when too much force is applied.

2.1 Beginning at one end, insert a small screwdriver into one of the access holes on the bottom edge of the keypad housing to release a tab.

2.2 Roll the bottom edge of the bezel outward and upward to disengage the locking tab. Insert a small screwdriver or blade under the bezel to prevent the bezel from snapping back into place.

2.3 Continue this process until all five locking tabs are released.

2.4 Carefully lift the edge of the keypad bezel over the keys to release the bezel from the keypad.

NOTE: It may be helpful to press each of the keys to help the bezel clear the tops of the keys.

3. Remove the keypad housing.

3.1 Pull the keypad housing away from the panel.

3.2 Unplug the electrical connector.

3.3 Remove the keypad housing from the vehicle.

4. Install the keypad housing.

4.1 Snap the electrical connector into the wiring harness.

4.2 Align the four tabs on the keypad housing with the four slots on the auxiliary instrument panel.

5. Install the keypad bezel.

5.1 Insert the five lower retainer hooks into the notches in the panel.

5.2 While holding the keypad housing from the back, roll the top edge of the bezel into the housing until the upper hooks snap into place and hold the housing against the panel.

6. Install the auxiliary instrument panel. For instructions, see **Subject 100**.
7. Turn on the ignition and check the new keypad for proper operation.

Contents

General Information
General Troubleshooting Procedures
Fault Code Troubleshooting
Gauge Troubleshooting
Warning Lamp Troubleshooting
Backlighting Troubleshooting
Keypad Troubleshooting
Gauge Control Strategy
Warning Lamp Control Strategy
Pin and Circuit Descriptions
Sensor Specifications

List of Figures

Figure 1 — Light Bar Control Unit Block Diagram
Figure 2 — Keypad
Figure 3 — Keypad Connector (viewed toward connector)
Figure 4 — Keypad Wiring Diagram
Figure 5 — Light Bar Connector Pin Locations (rear view)
Figure 6 — Transmission Oil Temperature Sensor (Hi-Stat) Resistance, Standard Gauge
Figure 7 —Transmission Oil Temperature Sensor (Hi-Stat) Resistance, Metric Gauge
Figure 8 — Axle Oil Temperature Sensor (Hi-Stat) Resistance, Standard Gauge
Figure 9 — Axle Oil Temperature Sensor (Hi-Stat) Resistance, Metric Gauge
Figure 10 — Pyrometer Sensor Temperature vs. Resistance (Hasaeus), Standard Gauge
Figure 11 — Pyrometer Sensor Temperature vs. Resistance (Hasaeus), Metric Gauge

List of Tables

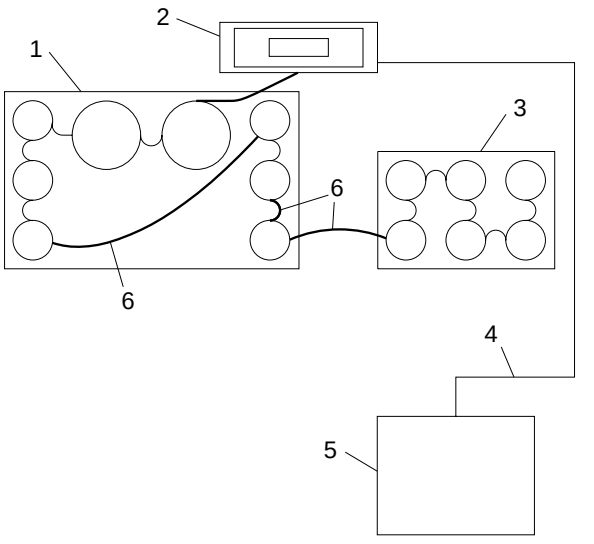
Table 1 — J1587 Fault Code Troubleshooting—ICU4M Specific Fault Codes
Table 2 — J1587 Fault Code Troubleshooting—Other Fault Codes That Are Only Displayed by the ICU4M, Not in Servicelink
Table 3 — Diagnosis for a Single Gauge Not Working
Table 4 — Diagnosis for Multiple Gauges Not Working (databus-driven gauges)
Table 5 — Diagnosis for Inaccurate Gauges
Table 6 — Air Pressure Gauge Diagnosis
Table 7 — Diagnosis for Warning Lamps in the Light Bar
Table 8 — Diagnosis for In-Gauge Warning Lamps
Table 9 — Backlighting Troubleshooting (gauges and light bar)
Table 10 — Keypad Diagnosis
Table 11 — Keypad Pigtail Connector Pin Descriptions
Table 12 — Standard and Optional Gauges Control Strategy (input types)
Table 13 — Light Bar Warning Lamp Control
Table 14 — Gauge Warning Lamp Control (warning lamps in gauge)
Table 15 — 24-Pin Light Bar Connector Pin Descriptions
Table 16 — 32-Pin Light Bar Connector Pin Descriptions
Table 17 — 6-Pin Gauge Databus Connector Pin Descriptions
Table 18 — 3-Pin Light Bar Auxiliary Input Connector Pin Descriptions
Table 19 — Fuel Level Sensor Resistance (Stewart-Warner)
Table 20 — Transmission Oil Temperature Sensor (Hi-Stat) Resistance, Standard Gauge
Table 21 — Transmission Oil Temperature Sensor (Hi-Stat) Resistance, Metric Gauge
Table 22 — Axle Oil Temperature Sensor (Hi-Stat) Resistance, Standard Gauge
Table 23 — Axle Oil Temperature Sensor (Hi-Stat) Resistance, Metric Gauge
Table 24 — Pyrometer Sensor Temperature vs. Resistance (Hasaeus), Standard Gauge

Table 25 — Pyrometer Sensor Temperature vs. Resistance (Hasaeus), Metric Gauge

General Information

The Ametek ICU4M replaced the Pollak ICU2M in production Century Class vehicles on December 20, 2004. The ICU4M is not used on Argosy vehicles.

The ICU4M contains up to 14 individual gauges, a light bar control unit, and a daisy-chain databus. See **Fig. 1**. The light bar is the brain of the system. It includes a message center with 2x20-character liquid crystal display (LCD) screen, and up to 24 warning and indicator lights.



1. A-Panel Gauges
2. Message Center
3. B-Panel Gauges
4. J1587 Databus
5. Engine
6. Cluster Databus (jumper wires or daisy chain)

Fig. 1, Light Bar Control Unit Block Diagram

The light bar controls all of the individual gauges. The light bar has two input types to drive the gauges: J1587 data from the engine ECM to control the databus driven gauges, and direct wired sensor input to control the other gauges. Each gauge has a unique address that the light bar communicates with.

The following gauges are driven by the J1587 databus inputs to the lightbar:

- speedometer
- tachometer
- oil pressure gauge
- coolant temperature gauge
- oil temperature gauge
- turbo boost pressure gauge
- voltmeter

The following gauges are driven by sensor inputs to the lightbar:

- fuel level gauge
- transmission temperature gauge
- forward tandem axle temperature gauge
- rear tandem axle temperature gauge
- pyrometer
- ammeter

The following air gauges are directly driven by air pressure; they are not controlled by the message center:

- primary air pressure gauge
- secondary air pressure gauge
- application air pressure gauge
- suspension air pressure gauge

General Troubleshooting Procedures

1. Check fault codes:

   Check for ICU fault codes (MID 140) and fault codes that are only displayed by the instrument cluster. Address these first. See *Fault Code Troubleshooting*, and **Table 1** and **Table 2** for MID 140 fault code definitions as well as roll call faults that are only displayed on the instrument cluster display and not in Servicelink. If this solves the problem, no further action is necessary. If the problem is still present, go to the next step.

2. For gauge problems do the following:

   2.1 For single gauge not working, see **Table 3** for diagnosis.

   2.2 For multiple gauges not working, see **Table 4** for diagnosis.

2.3 For gauges that are not accurate, see **Table 5** for diagnosis.

2.4 For air pressure gauge(s) not working, see **Table 6** for diagnosis.

3. For warning lamp problems, do the following:

3.1 For light bar warning lamp problems, see **Table 7** for diagnosis.

3.2 For in-gauge warning lamp problems, see **Table 8** for diagnosis.

4. For backlighting problems, see **Table 9** for diagnosis.

5. For keypad problems, see **Table 10** for diagnosis.

Fault Code Troubleshooting

The tables referenced under this heading provide provides fault codes that originate from the ICU4M message center (MID 140). Use **Table 1** to diagnose all MID 140 fault codes. Use **Table 2** to diagnose other J1587 fault codes only displayed by the ICU4M.

J1587 Fault Code Troubleshooting—ICU4M Specific Fault Codes				
MID	**PID/SID**	**FMI**	**Fault Code Description**	**Action**
140	p077	5	Forward rear axle temperature sensor—open	Check sensor and wiring for fault. Repair as necessary. For axle sensors, refer to **Fig. 8** and **Fig. 9**, and to **Table 22** and **Table 23** for sensor resistance values.
		6	Forward rear axle temperature sensor—shorted	
140	p078	5	Rear rear axle temperature sensor—open	
		6	Rear rear axle temperature sensor—shorted	
140	p096	5	Fuel level sensor—open	For fuel level sensors, refer to **Table 19** for resistance values.
		6	Fuel level sensor—shorted	
140	p168	1	Light bar voltage too low (less than 10.5 volts)	Check voltage supply to light bar. Repair as necessary.
140	p171	5	Ambient air temperature sensor—open	Check sensor and wiring for fault. Repair as necessary.
		6	Ambient air temperature sensor—shorted	
140	p173	5	Pyrometer sensor—open	Check sensor and wiring for fault. Repair as necessary. For pyrometer sensors, refer to **Fig. 10** and **Fig. 11**, and to **Table 24** and **Table 25** for resistance values.
		6	Pyrometer sensor—shorted	
140	p177	5	Transmission oil temperature sensor—open	For transmission oil temperature sensors, refer to **Fig. 6** and **Fig. 7**, and to **Table 20** and **Table 21** for resistance values.
		6	Transmission oil temperature sensor—shorted	
140	s240	12	Light bar program memory failure	Replace the light bar.
140	s254	12	Light bar controller failure	Replace the light bar.

Table 1, J1587 Fault Code Troubleshooting--ICU4M Specific Fault Codes

Troubleshooting

J1587 Fault Code Troubleshooting—Other Fault Codes That Are Only Displayed by the ICU4M, Not in Servicelink				
MID	**SID**	**FMI**	**Fault Code Description**	**Action**
128	254	7	Engine ECM not responding	Check J1587 databus, power, and ground connections to the electronic unit that is not responding. Repair as necessary. NOTE: Once the ICU4M cluster sees an ECU on the databus for the first time, it will “learn” it, and will expect to see that ECU on roll call for the remainder of its life, or until it is reset (see below.) If the ICU4M does not see an ECU it expects to see on roll call, it will display one of the faults listed in this table on the message center. IMPORTANT: If the cluster is used as a test cluster in another vehicle, it must be reset (see below) before placing it back into the original vehicle. If the other vehicle contains an ECU that the original truck does not, the cluster will learn this ECU and will expect to see it on the databus when the cluster is placed back in the original vehicle. This will cause one of these faults in this table to be active, unless the cluster is reset. TO RESET THE LEARNED ROLL CALL ECUs: Use the keypad to display the "Setup Information" screen. Press the right key then use the down arrow on the keypad to scroll to the "Push Set Key to Change Parameters" message. Press the set key on the keypad. A message will be displayed that says, "Reset Parameters YES NO". Press the left arrow key on the keypad to select YES. When selected, YES will be flashing. Press the down arrow key on the keypad to reset the parameters. In addition to resetting the ICU4M parameters, the display will also transition to the Vehicle Information screen. This will clear the instrument cluster’s previously learned ECUs for roll call. The cluster will now relearn what ECUs to expect on roll call.
130	254	7	Transmission ECU not responding	
136	254	7	ABS ECU not responding	
146	254	7	Front HVAC controller not responding	
150	254	7	Electronically Controlled Air Suspension (ECAS) not responding	
164	254	7	Bulkhead Module not responding*	
181	254	7	Qualcomm not responding	
190	254	7	Air Conditioning Protection Unit (ACPU) not responding*	
200	254	7	Rear HVAC controller not responding	
219	254	7	VORAD not responding	
223	254	7	Transmission shift unit not responding	
231	254	7	Cellular communications not responding	
232	254	7	SPACE and/or airbag system not responding	
236	254	7	Step Deployment Unit #1 not responding (Argosy only)*	
237	254	7	Step Deployment Unit #2 not responding (Argosy only)*	
249	254	7	Chassis Module not responding*	

* This component is not used on the Century Class, but may show up in a roll call. If so, perform the reset procedure.

Table 2, J1587 Fault Code Troubleshooting--Other Fault Codes That Are Only Displayed by the ICU4M, Not in Servicelink

Gauge Troubleshooting

The tables referenced under this heading detail specific troubleshooting procedures for gauge problems. For a single gauge that does not work, use **Table 3** for diagnosis. For multiple gauges not working, use **Table 4** for diagnosis. For inaccurate gauges, use **Table 5** for diagnosis. For air pressure gauge problems, use **Table 6**.

Diagnosis for a Single Gauge Not Working			
Test No.	**Test Description**	**Test Result**	**Action**
1	Does the gauge that is malfunctioning sweep when the ignition is turned on?	Yes	Go to test 4.
		No	Go to test 2.
2	Is the malfunctioning gauge the last one in the chain from the light bar? (This will be one of the gauges that only has one jumper wire connected to it.)	Yes	Go to test 3.
		No	Replace gauge.
3	Remove the jumper wire to this gauge and install a known good wire. Does the gauge now work?	Yes	Replace jumper wire.
		No	Replace gauge.
4	Is the malfunctioning gauge driven by direct sensor input to the light bar? See **Table 12** for gauge control strategy.	Yes	If the gauge is just inaccurate, the sensor may be defective. See **Table 5** for diagnosis. If the gauge is not working, check the sensor and sensor wiring to the light bar. See **Table 19** for fuel level sensor, **Table 20** for trans oil temp sensor (°F), **Table 21** for trans oil temp sensor (°C), **Table 22** for axle oil temp sensor (°F), **Table 23** for axle oil temp sensor (°C), **Table 24** for pyrometer sensor (°F), and **Table 25** for pyrometer sensor (°C) specifications. If no problem is found with the sensor or sensor wiring, the light bar may be defective.
		No	Go to test 5.
5	Connect Servicelink to vehicle and open the ICU4 Datalink Monitor template. Does the malfunctioning gauge work on the template?	Yes	Replace the light bar.
		No	Check sensor that drives gauge. It will usually be an input to the engine ECM. Repair as necessary.

Table 3, Diagnosis for a Single Gauge Not Working

Diagnosis for Multiple Gauges Not Working (databus-driven gauges)			
Test No.	**Test Description**	**Test Result**	**Action**
1	Do the gauges that are malfunctioning sweep when the ignition is turned on?	Yes	Go to Test 2.
		No	Go to Test 8.
2	Are all the gauges that are malfunctioning sensor driven by direct input to the light bar (gauges are not J1587 databus driven)? Refer to **Table 12** for gauge control strategy.	Yes	If the affected gauges are one or more of the following: transmission temp, ammeter, and axle temp #3, then check the common sensor ground that connects to pin C12 in the 32-pin connector. If OK, the light bar is probably faulty. If the gauges above are not affected, then the light bar is probably faulty. Repair as necessary.
		No	Go to Test 3.
3	Are all the malfunctioning gauges J1587 driven? Refer to **Table 12** for gauge control strategy.	Yes	Go to Test 4.
		No	Replace the light bar.

Troubleshooting

Diagnosis for Multiple Gauges Not Working (databus-driven gauges)			
Test No.	**Test Description**	**Test Result**	**Action**
4	Connect PC to vehicle and start Servicelink. Will Servicelink connect?	Yes	Go to Test 5.
		No	Assuming Servicelink and the vehicle adapter are working correctly, the most likely cause is something taking the entire J1587 databus down (short, etc.). Repair as necessary.
5	In Servicelink, does the ICU4 show up in the ECU list (MID 140)?	Yes	Go to Test 6.
		No	Check the J1587 databus to the ICU. If OK, the light bar is probably faulty. Repair as necessary.
6	In Servicelink, does the engine ECM show up in the ECU list (MID 128)?	Yes	Go to Test 7.
		No	Check the J1587 databus to the engine ECM. If OK, the engine ECM is probably faulty. Repair as necessary.
7	In Servicelink, open the ICU4 Datalink Monitor template. Do the affected gauges work on the template?	Yes	Replace the light bar.
		No	The engine ECM sensor wiring or the engine ECM itself is probably faulty. Repair as necessary.
8	Do any of the malfunctioning gauges sweep when the ignition is turned on?	Yes	Go to Test 9.
		No	Check power and ground to the light bar. If OK, the light bar is probably faulty. Repair as necessary.
9	Are all of the malfunctioning gauges in sequence with one another on the daisy chain?	Yes	Go to Test 10.
		No	Replace the light bar.
10	Locate the faulty gauge that is closest to the light bar in the daisy chain. Replace the jumper wire between this gauge and the next gauge closest to the light bar that works (or the light bar itself). Do the gauges now work?	Yes	Replace the jumper wire.
		No	Replace the light bar.

Table 4, Diagnosis for Multiple Gauges Not Working (databus-driven gauges)

Diagnosis for Inaccurate Gauges			
Test No.	**Test Description**	**Test Result**	**Action**
1	Is the gauge J1587 databus controlled? Refer to **Table 12** to determine gauge control strategy.	Yes	Go to Test 2.
		No	Go to Test 3.
2	Connect Servicelink to vehicle. Open the ICU4 Datalink Monitor template. Check if the template gauge reads the same as the cluster gauge. Does the template gauge read the same as the cluster gauge?	Yes	The gauge is OK. The sensor connected to the engine ECM may be faulty. Refer to engine manufacturer's literature for troubleshooting information.
		No	Try a known good gauge. If this does not correct the problem, replace the light bar.

Diagnosis for Inaccurate Gauges			
Test No.	**Test Description**	**Test Result**	**Action**
3	For sensor driven gauges, check if gauge sensor resistance matches the specified values. See **Table 19** for fuel level sensor, **Table 20** for trans oil temp sensor (°F), **Table 21** for trans oil temp sensor (°C), **Table 22** for axle oil temp sensor (°F), **Table 23** for axle oil temp sensor (°C), **Table 24** for pyrometer sensor (°F), and **Table 25** for pyrometer sensor (°C). NOTE: An accurate thermometer will have to be used to determine appropriate sensor values for temperature gauges. Does the sensor resistance match the published values?	Yes	Go to Test 4.
		No	Replace the sensor.
4	Repeat Test 3, except take the readings at the light bar connector (disconnect the connector). See **Fig. 5**, and **Table 15** for 24-pin connector, and **Table 16** for 32-pin connector. See **Table 19** for fuel level sensor, **Table 20** for trans oil temp sensor (°F), **Table 21** for trans oil temp sensor (°C), **Table 22** for axle oil temp sensor (°F), **Table 23** for axle oil temp sensor (°C), **Table 24** for pyrometer sensor (°F), and **Table 25** for pyrometer sensor (°C) values. Does the sensor resistance match the published values?	Yes	Try a known good gauge. If this does not correct the problem, replace the light bar.
		No	Repair sensor wiring as necessary.

Table 5, Diagnosis for Inaccurate Gauges

Air Pressure Gauge Diagnosis			
Test No.	**Test Description**	**Test Result**	**Action**
1	Which air pressure gauge is not functioning correctly?	Primary or secondary	Go to Test 2.
		Application	Go to Test 3.
		Suspension	Go to Test 4.
2	Drain the air tanks. Connect an accurate pressure gauge to the primary or secondary air tank (whichever one corresponds with the problem gauge). Start the engine and build air pressure until the compressor cuts out. Is the air pressure gauge in the cluster within 6 psi (41 kPa) of the test gauge?	Yes	No problem found.
		No	Check for kinked air lines to the gauge. If OK, replace the gauge.

Troubleshooting

Air Pressure Gauge Diagnosis			
Test No.	**Test Description**	**Test Result**	**Action**
3	Connect an accurate pressure gauge to a delivery port on the foot valve. Make a 90 psi (620 kPa) brake application while observing the application air pressure gauge in the cluster and the test gauge. Is the air pressure gauge in the cluster within 3 psi (21 kPa) of the test gauge?	Yes	No problem found.
		No	Check for kinked air lines to the gauge. If OK, replace the gauge.
4	Connect an accurate pressure gauge to the air suspension. Is the air pressure gauge in the cluster within 3 psi (21 kPa) of the test gauge?	Yes	No problem found.
		No	Check for kinked air lines to the gauge.. If OK, replace the gauge.

Table 6, Air Pressure Gauge Diagnosis

Warning Lamp Troubleshooting

Use the tables referenced under this heading to diagnose warning lamp problems. See **Table 7** to diagnose problems with warning lamps in the light bar and **Table 8** to diagnose problems with in-gauge warning lamps.

Diagnosis for Warning Lamps in the Light Bar			
Test No.	**Test Description**	**Test Result**	**Action**
1	What is the problem with the warning lamp?	Stays on	Go to Test 8.
		Does not turn on	Go to Test 2.
2	Is the warning lamp one of the following? • Park Brake/Brake Warning • Low Air Pressure • Low Battery Voltage • Fasten Seatbelt	Yes	Go to Test 3.
		No	Go to Test 4.
3	Does the warning lamp turn on when the ignition is turned on?	Yes	No problem found.
		No	Replace the light bar.
4	Is the warning lamp activated by a ground input or +12V input? See **Table 13**.	12V activated	Go to Test 5.
		Ground activated	Go to Test 6.

Diagnosis for Warning Lamps in the Light Bar			
Test No.	**Test Description**	**Test Result**	**Action**
5	Disconnect the light bar connector that contains the circuit for the warning lamp that is not working (see **Fig. 5**, and **Table 15** and **Table 16**). Turn the ignition on and activate the circuit that controls the warning lamp (for example, turn on the left turn signal for the left turn warning lamp). See **Fig. 5**, and **Table 15** and **Table 16**. Check for voltage at the light bar connector pin that corresponds to that warning lamp. What is the voltage? NOTE: For turn signal circuits, the voltage will alternate between 12V and 0V.	12V	Replace the light bar.
		0V	Check circuit that controls warning lamp and repair as necessary.
6	Is the warning lamp one of the optional warning lamps (top row of light bar)?	Yes	Check the bulb and replace if necessary. If the bulb is okay, go to Test 7.
		No	Go to Test 7.
7	Locate the light bar connector and circuit that controls the warning lamp (see **Fig. 5**, and **Table 15** and **Table 16**). Using a jumper to ground, backprobe the pin that corresponds to the problem warning lamp. Does the warning lamp turn on?	Yes	Problem is in the circuit that controls the warning lamp, repair as necessary.
		No	Replace the light bar.
8	Is the warning lamp that stays on the Low Air Pressure warning lamp?	Yes	Go to Test 11.
		No	Go to Test 9.
9	Is the problem with the Low Battery Voltage warning lamp?	Yes	Within Servicelink, open the ICU4 Datalink Monitor template and start the engine. Check the voltmeter voltage on the template. If the voltage is below 11.9V, check and repair the vehicle charging system or power and ground circuits to the engine ECM. If the voltage is above 11.9V, replace the light bar.
		No	Go to Test 10.
10	Is the problem with the Fasten Seatbelt warning lamp?	Yes	If the Fasten Seatbelt warning lamp does not turn off approximately 15 seconds after the ignition is turned ON, then replace the light bar.
		No	Go to Test 12.
11	Turn the ignition ON. Using a jumper to ground, backprobe pin A3 of the 24-pin light bar connector. Does the Low Air Pressure warning lamp turn off?	Yes	Either the air brake system pressure is too low or the problem is in the low air pressure warning circuit that controls the warning lamp. Repair as necessary.
		No	Replace the light bar.

Troubleshooting

Diagnosis for Warning Lamps in the Light Bar			
Test No.	**Test Description**	**Test Result**	**Action**
12	Is the warning lamp activated by a ground input or +12V input? See **Table 13**.	12V activated	Go to Test 13.
		Ground activated	Go to Test 14.
13	Disconnect the connector that contains the circuit for the warning lamp that stays on (see **Fig. 5**, and **Table 15** and **Table 16**). Turn the ignition ON. Check for voltage at the light bar connector pin that corresponds to the warning lamp. What is the voltage?	12V	The problem is not with the light bar. Check the system that controls the warning lamp for faults (the light may be on for a reason other than a faulty warning lamp circuit). Otherwise, check warning lamp circuit for short to power and repair as necessary.
		0V	Replace the light bar.
14	Disconnect the connector that contains the circuit for the warning lamp that stays on (see **Fig. 5**, and **Table 15** and **Table 16**). Turn the ignition ON. Check for voltage at the light bar connector pin that corresponds to the warning lamp by connecting the positive meter lead to battery (+) and the negative lead to the connector pin that corresponds to the warning lamp. What is the voltage?	12V	The problem is not with the light bar. Check the system that controls the warning lamp for faults (the light may be on for a reason other than a faulty warning lamp circuit). Otherwise, check warning lamp circuit for short to ground and repair as necessary.
		0V	Replace the light bar.

Table 7, Diagnosis for Warning Lamps in the Light Bar

Diagnosis for In-Gauge Warning Lamps			
Test No.	**Test Description**	**Test Result**	**Action**
1	Does the warning lamp illuminate during the ignition on gauge sweep?	Yes	Go to Test 2.
		No	Replace the gauge.
2	Is the problem with either one of the following gauge warning lamps? • Low Oil Pressure • High Coolant Temperature	Yes	Go to Test 3.
		No	Go to Test 5.

Diagnosis for In-Gauge Warning Lamps			
Test No.	**Test Description**	**Test Result**	**Action**
3	Is the problem that the warning lamp stays on?	Yes	Go to Test 4.
		No	The warning lamp is probably not illuminating because it is not receiving an active fault code from the engine ECM: • 128 p100 01 (oil pressure too low) • 128 p110 00 (coolant temp too high) If the appropriate code is active and the warning lamp does not work, then the light bar is probably faulty.
4	Check for either of the following engine fault codes: • 128 p100 01 (oil pressure too low) • 128 p110 00 (coolant temp too high) Are either of these faults active?	Yes	Check for a problem in the engine's lubrication or cooling system. Repair as necessary.
		No	Replace the light bar.
5	Is the problem with the High Transmission Temperature warning lamp?	Yes	Go to Test 6.
		No	Go to Test 9.
6	Is the problem that the warning lamp stays on?	Yes	Go to Test 8.
		No	Go to Test 7.
7	Using a jumper to ground, backprobe pin A4 of the 24-pin connector. Does the High Transmission Temperature warning lamp turn on?	Yes	The problem is in the circuit that controls the warning lamp. Repair as necessary.
		No	Replace the light bar.
8	Disconnect the 24-pin light bar connector. Turn the ignition ON. Check for voltage at the 24-pin light bar connector pin A4 by connecting the positive meter lead to battery (+) and the negative lead to pin A4.	12V	The problem is not with the light bar. Check the transmission for faults (the light may be on for a reason other than a faulty warning lamp circuit). Otherwise, check warning lamp circuit for short to ground and repair as necessary.
		0V	Replace the light bar.
9	Is the problem that the Low Fuel Level warning lamp stays on?	Yes	Go to Test 10.
		No	Go to Test 11.
10	Does the fuel gauge read below 1/8?	Yes	Normal condition; no further action is necessary.
		No	Replace the light bar.
11	Does the fuel gauge read below 1/8?	Yes	Replace the light bar.
		No	The warning lamp should not turn on until the fuel level is 1/8 or less for at least 60 seconds. No problem found.

Table 8, Diagnosis for In-Gauge Warning Lamps

Backlighting Troubleshooting

The backlighting signal to the light bar is a pulse-width-modulated (PWM) signal at approximately 320 Hz. See **Table 9** for diagnosis.

Backlighting Troubleshooting (gauges and light bar)			
Test No.	**Test Description**	**Test Result**	**Action**
1	Does any of the backlighting work (i.e., panel switches, etc.)?	Yes	Go to Test 2.
		No	Check the panel lamp dimmer switch, and panel lighting circuit. Repair as necessary.
2	Is all the cluster backlighting dead (light bar LCD and all gauges)?	Yes	Go to Test 3.
		No	Go to Test 5.
3	Disconnect the light bar 24-pin connector (see **Fig. 5**). Turn the headlamps ON, and the panel lamp dimmer switch to full bright. Measure the voltage at connector pin A1; it should be approximately +12V. What is the voltage?	12V	Go to Test 4.
		0V	Check backlighting circuit 29A for open between the instrument cluster and splice to other dash components. Repair as necessary.
4	Disconnect both the light bar 24-pin and 32-pin connectors (see **Fig. 5**). Turn the headlamps ON, and the panel lamp dimmer switch to full bright. Measure the voltage between pin A1 (24-pin connector) and pin D3 (32-pin connector). What is the voltage?	12V	Replace the light bar.
		0V	Check panel lamp ground circuit. Repair as necessary.
5	Is the light bar LCD backlighting the only thing with dead backlighting?	Yes	Replace the light bar.
		No	Go to Test 6.
6	Is only one gauge backlight dead?	Yes	Go to Test 7.
		No	Go to Test 8.
7	Is the gauge with dead backlighting the last gauge in the daisy chain (farthest from the light bar)?	Yes	Try a known good jumper wire to the gauge. If backlight now works on this gauge, this solved the problem. If the backlighting still does not work, replace the gauge.
		No	Replace the gauge.
8	Are all the gauges with dead backlighting in sequence with one another in the daisy-chain?	Yes	Try a known good jumper wire between the gauge with dead backlighting that is closest to the light bar and the next good gauge (one closer to light bar). If all backlighting now works, the jumper solved the problem. If not, replace all gauges with dead backlighting.
		No	Go to Test 9.

Backlighting Troubleshooting (gauges and light bar)			
Test No.	**Test Description**	**Test Result**	**Action**
9	Is one of the dead gauges the last gauge in the daisy-chain (farthest from the light bar)?	Yes	Try a known good jumper to the last gauge. If the last gauge now works, the jumper solved the problem to this gauge. Replace all other gauges with dead backlighting. If the jumper did not correct the backlighting to the last gauge in the daisy-chain, replace all gauges with dead backlighting.
		No	Replace all gauges with dead backlighting.

Table 9, Backlighting Troubleshooting (gauges and light bar)

Keypad Troubleshooting

Use **Table 10** to troubleshoot the keypad. Refer to **Fig. 2** for keypad layout, **Fig. 3** for keypad connector pin positions, and **Fig. 4** for keypad wiring diagram. See **Table 11** for keypad connector pin descriptions.

Keypad Diagnosis		
To test the keypad: Use a digital multimeter to measure resistance across each set of pins below, while pressing the appropriate keypad keys as noted in the table below. If any resistance measurement falls outside the acceptable resistance range, replace the keypad.		
Pins	Key to Press While Measuring Resistance	Acceptable Resistance Range
A and H	No keys pressed	361 to 369 Ohms
	DIAMOND* key	170 to 174 Ohms
	TEMP key	105 to 108 Ohms
B and H	No keys pressed	361 to 369 Ohms
	FUEL key	170 to 174 Ohms
	TRIP key	105 to 108 Ohms
C and H	No keys pressed	361 to 369 Ohms
	LEG key	170 to 174 Ohms
	LEFT ARROW key	105 to 108 Ohms
D and H	No keys pressed	361 to 369 Ohms
	DOWN ARROW key	170 to 174 Ohms
	RIGHT ARROW key	105 to 108 Ohms
E and H	No keys pressed	361 to 369 Ohms
	SET/RESET key	170 to 174 Ohms
	EVENT* key	105 to 108 Ohms

* These keys are not included on all keypads.

Table 10, Keypad Diagnosis

Troubleshooting

Keypad Pigtail Connector Pin Descriptions			
Pin	**Description**	**Pin**	**Description**
A	Diamond* and TEMP keys	E	SET/RESET and EVENT* keys
B	FUEL and TRIP keys	F	Backlight (+)
C	LEG and Left arrow keys	G	Backlight (-)
D	Down arrow and Right arrow keys	H	Keypad ground return

* These keys are not included on all keypads.

Table 11, Keypad Pigtail Connector Pin Descriptions

Gauge Control Strategy

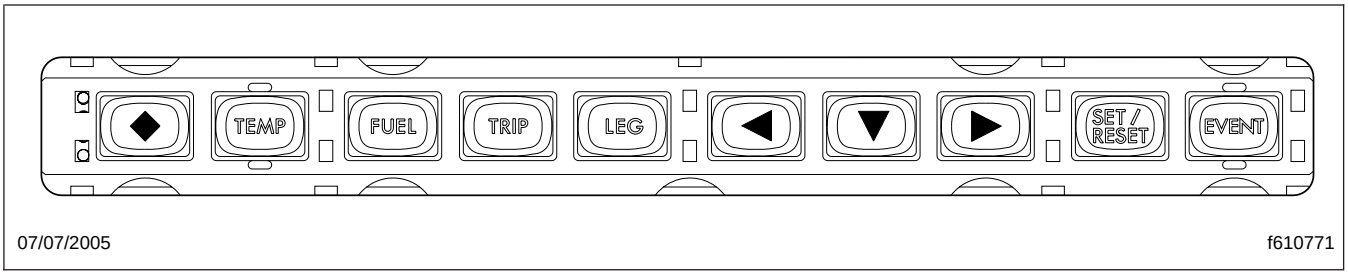


Fig. 2, Keypad

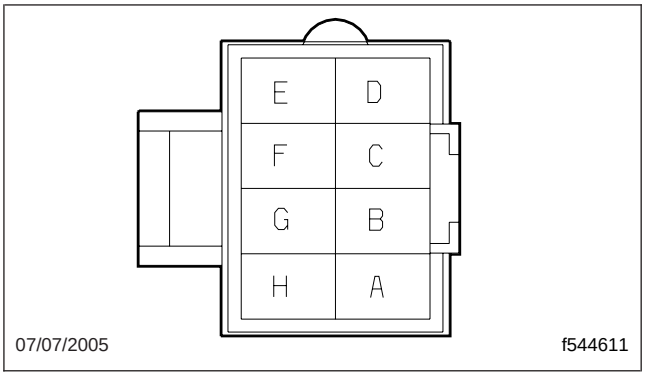


Fig. 3, Keypad Connector (viewed toward connector)

The information under this heading defines how each individual gauge, standard or optional, is controlled. Some gauges are J1587 databus driven, meaning the information is sent to the instrument cluster from the engine ECM. Other gauges are controlled by a sensor wired directly to the instrument cluster light bar. **Table 12** identifies each standard and optional gauge, and its method of control.

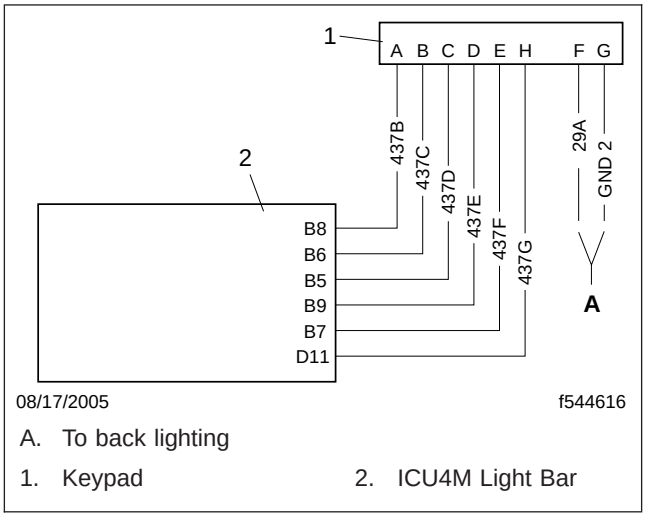


Fig. 4, Keypad Wiring Diagram

Standard and Optional Gauges Control Strategy—Input Types		
Gauge	**Input Type to Light Bar to Drive Gauge**	**Standard/ Optional**
Speedometer	J1587 databus—from engine (MID 128)	Standard
Engine Coolant Temperature	J1587 databus—from engine (MID 128)	Standard
Engine Oil Pressure	J1587 databus—from engine (MID 128)	Standard
Fuel Level	Sensor input	Standard
Tachometer	J1587 databus—from engine (MID 128)	Standard
Battery Voltage	J1587 databus—from engine (MID 128)	Standard
Transmission Oil Temperature	Sensor input	Optional
Primary Air System Pressure	NA—air line is connected directly to gauge	Standard
Secondary Air System Pressure	NA—air line is connected directly to gauge	Standard
Forward Rear Axle Temp	Sensor input	Optional
Rear Rear Axle Temp	Sensor input	Optional
Engine Oil Temperature	J1587 databus—from engine (MID 128)	Optional
Turbo Boost Pressure	J1587 databus—from engine (MID 128)	Optional
Pyrometer	Sensor input	Optional
Application Air Pressure	NA—air line is connected directly to gauge	Optional
Suspension Air Pressure	NA—air line is connected directly to gauge	Optional
Ammeter	Sensor input*	Optional

* Ammeters used are stand alone gauges that are not connected to the light bar.

Table 12, Standard and Optional Gauges Control Strategy--Input Types

Warning Lamp Control Strategy

The information under this heading defines how each individual warning lamp is controlled. Not all warning lamps are standard. Some in-gauge warning lamps are J1587 databus driven, meaning the information is sent to the instrument cluster from the engine ECM (see **Table 14**). The light bar warning lamps are controlled directly by a hardwire to the instrument cluster light bar (see **Table 13**). Other warning lamps are controlled by decisions made by the light bar (see **Table 13** and **Table 14**).

NOTE: In **Table 13**, the warning lamps that are indicated as having a bulb check after the ignition is turned on are controlled by the light bar. Other direct wired warning lamps may have a bulb check that is controlled by the device they are connected to (e.g. the engine ECM.) These externally controlled bulb checks are not indicated in **Table 13**.

Light Bar Warning Lamp Control						
Warning Lamp	**Legend**	**Bulb Check**	**Buzzer Operation**	**Power Source**	**Warning Lamp Operation/ Control**	**Control Pin**
Left Turn Signal		—	—	12V external	12V (activates)	C8

Troubleshooting

Light Bar Warning Lamp Control						
Warning Lamp	**Legend**	**Bulb Check**	**Buzzer Operation**	**Power Source**	**Warning Lamp Operation/ Control**	**Control Pin**
Right Turn Signal		—	—	12V external	12V (activates)	D8
Highbeam		—	—	12V external	12V (activates)	A12
Park Brake/ Brake System Warning		Yes	When vehicle is moving over 2 mph with brake set.	12V Ign (internal)	Ground (activates)	C5
Low Air Pressure		Yes	Coincides with operation of this warning lamp	12V Ign (internal)	Ground (deactivates)	A3
Low Battery Voltage		Yes	—	Internal	Controlled by light bar. If light bar receives battery voltage message from the engine less than 11.9V, the warning lamp will illuminate.	NA
Fasten Seat Belt		Yes	—	Internal	Controlled by light bar. On for approximately 15 sec after ignition is turned on.	NA
Check Engine		No*	—	12V Ign (internal)	Ground (activates)	C15
Engine Protection		No*	—	12V Ign (internal)	Ground (activates)	C16
Tractor ABS		No*	—	12V Ign (internal)	Ground (activates)	B11
Trailer ABS		No*	—	12V Ign (internal)	Ground (activates)	D12
Check Trans		No*	—	12V Ign (internal)	Ground (activates)	D10
Water in Fuel		No*	—	12V Ign (internal)	Ground (activates)	C10
Intake Heater		No*	—	12V Ign (internal)	Ground (activates)	A5
No Charge		No	—	12V Ign (internal)	Ground (activates)	A9
Optimized Idle		No	—	12V Ign (internal)	Ground (activates)	C1

Light Bar Warning Lamp Control						
Warning Lamp	**Legend**	**Bulb Check**	**Buzzer Operation**	**Power Source**	**Warning Lamp Operation/ Control**	**Control Pin**
Opt. #1 (Stop Engine)		No*	—	12V Ign (internal)	Ground (activates)	C14
Opt. #2	—	No	—	12V Batt (internal)	Ground (activates)	A6
Opt. #3	—	No	—	12V Ign (internal)	Ground (activates)	A7
Opt. #4	—	No	—	12V Ign (internal)	Ground (activates)	A8
Opt. #5	—	No	—	12V Ign (internal)	Ground (activates)	B1
Opt. #6	—	No	—	12V Ign (internal)	Ground (activates)	A2
Opt. #7	—	No	—	12V Ign (internal)	Ground (activates)	C11
Opt. #8	—	No	—	12V (external)	12V (activates)	D4

* Bulb check is not controlled by the lightbar. The controlling device (engine, ABS, transmission, etc.) may perform a bulb check.

Table 13, Light Bar Warning Lamp Control

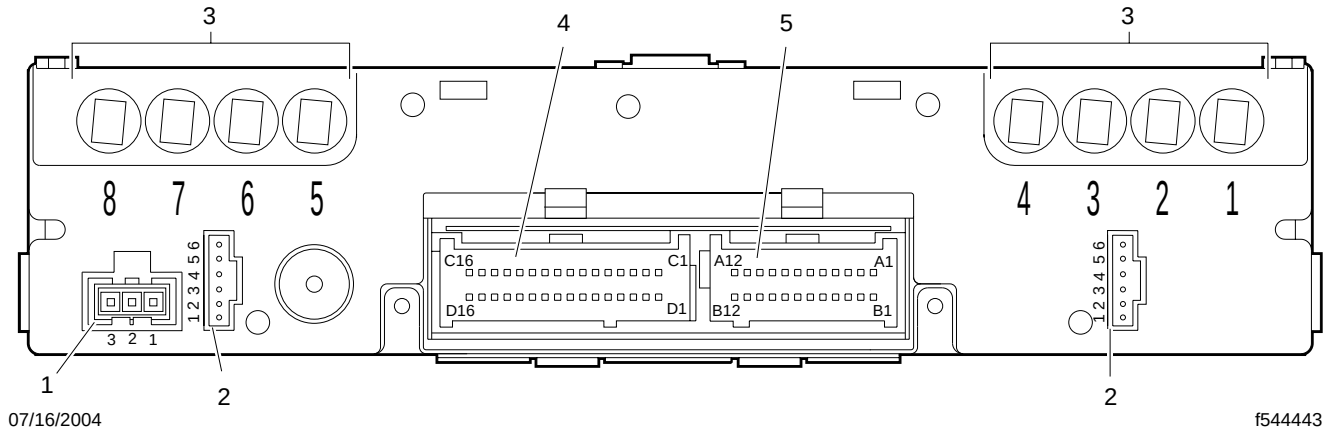
Gauge Warning Lamp Control (warning lamps in gauge)				
Gauge Warning Lamp	**Gauge**	**Bulb Check**	**Warning Lamp/Buzzer Operation**	**Warning Lamp/Buzzer Control**
Low Oil Pressure	Oil Pressure	Yes	Warning lamp and buzzer will remain on for a minimum of 30 seconds and will stay on as long as the fault remains active.	Light bar controls this gauge warning lamp when the engine sends low oil pressure fault MID 128, PID 100, FMI 01.
High Coolant Temperature	Engine Coolant Temperature	Yes	Warning lamp and buzzer will remain on for a minimum of 30 seconds and will stay on as long as the fault remains active.	Light bar controls this gauge warning lamp when the engine sends high coolant temperature fault MID 128, PID 110, FMI 00.
High Transmission Temperature	Transmission Temperature	Yes	On when input to light bar is grounded.	Ground activated from hard wire input to light bar pin A4.
Low Fuel Level	Fuel Level	Yes	The light bar turns this warning lamp on if the fuel level is less than 1/8 of a tank for at least 60 seconds.	Light bar compares fuel level sensor input to programmed resistance values to determine when to illuminate this warning lamp.

Table 14, Gauge Warning Lamp Control (warning lamps in gauge)

Pin and Circuit Descriptions

See **Fig. 5** for a rear view of the light bar, showing connector pin locations. See **Table 15** for 24-pin light-bar connector pin descriptions, **Table 16** for 32-pin light-bar connector pin descriptions, **Table 17** for 6-pin gauge databus connector pin descriptions, and **Table 18** for 3-pin auxiliary input connector pin descriptions.

Troubleshooting



1. 3-Pin Auxiliary Input Connector
2. 6-Pin Gauge Databus Connector
3. Optional Telltale Bulbs
4. 32-Pin Light Bar Connector
5. 24-Pin Light Bar Connector

Fig. 5, Light Bar Connector Pin Locations (rear view)

24-Pin Light-Bar Connector Pin Descriptions			
Pin	**Description**	**Pin**	**Description**
A1	(+) Panel Backlight Power (Pulse Width Modulated)	B1	Optional Indicator #5—Ground Activated
A2	Optional Warning Lamp #6—Ground Activated	B2	(+) Rear rear Axle Temp Sensor
A3	Low Air Pressure Warning Lamp—Ground Activated	B3	J1587 Databus (–)
A4	High Trans Temp Warning Lamp—Ground Activated	B4	(–) Rear rear Axle Temp Sensor
A5	Intake Heater Warning Lamp—Ground Activated	B5	Keypad
A6	Optional Warning Lamp #2—Ground Activated	B6	Keypad
A7	Optional Warning Lamp #3—Ground Activated	B7	Keypad
A8	Optional Warning Lamp #4—Ground Activated	B8	Keypad
A9	No Charge Warning Lamp—Ground Activated	B9	Keypad
A10	(+) Forward rear Axle Temp Sensor	B10	J1587 Databus (+)
A11	(–) Forward rear Axle Temp Sensor	B11	Tractor ABS Warning Lamp
A12	High Beam Warning Lamp—12V Activated	B12	Optional Buzzer Input—Ground Activated

Table 15, 24-Pin Light-Bar Connector Pin Descriptions

32-Pin Light-Bar Connector Pin Descriptions			
Pin	**Description**	**Pin**	**Description**
C1	Optimized Idle Warning Lamp	D1	(+) Fuel Level Sensor
C2	Optional Low Current Output (gnd)—Starter Lockout Relay	D2	(–) Fuel Level Sensor
C3	Optional Low Current Output (gnd)—Key Illumination	D3	(–) Panel Backlight Ground

32-Pin Light-Bar Connector Pin Descriptions			
Pin	**Description**	**Pin**	**Description**
C4	Optional 12V Input (Door Open)*	D4	Optional Warning Lamp #8—12V Activated
C5	Park Brake Warning Lamp—Ground Activated	D5	Reserved
C6	(+) Pyrometer	D6	(–) Pyrometer
C7	Reserved	D7	Reserved
C8	Left Turn Warning Lamp—12V Activated	D8	Right Turn Warning Lamp
C9	Reserved	D9	Reserved
C10	Water In Fuel Warning Lamp	D10	Check Trans Warning Lamp—Ground Activated
C11	Optional Warning Lamp #7—Ground Activated	D11	Keypad Ground
C12	(–) Sensor Common (trans temp, ammeter, axle #3 temp, ammeter)	D12	Trailer ABS Warning Lamp
C13	(+) Transmission Oil Temperature	D13	Ground
C14	Optional Warning Lamp #1—Ground Activated	D14	(+) Battery Power
C15	Check Engine Warning Lamp—Ground Activated	D15	(+) Ignition Power
C16	Engine Protection Warning Lamp—Ground Activated	D16	Headlight Power Input 12v (used to control LCD brightness)

* Pin C4 (door open input) is used for the Door Open/Park Brake Not Set chime. If the park brake is off, and the door is open, then the light bar will sound a chime.

Table 16, 32-Pin Light-Bar Connector Pin Descriptions

6-Pin Gauge Databus Connector Pin Descriptions		
Pin	**Description**	**Jumper Wire Color**
1	(+) Gauge Power	Blue
2	(–) Gauge Ground	Green
3	Gauge Databus (+)	Black
4	Gauge Databus (–)	Violet
5	Gauge Backlighting (–)	Red
6	Gauge Backlighting (+)	Yellow

Table 17, 6-Pin Gauge Databus Connector Pin Descriptions

3-Pin Light-Bar Auxiliary Input Connector Pin Descriptions	
Pin	**Description**
1	Reserved
2	(+) Third Drive Axle Temperature Input
3	Reserved

Table 18, 3-Pin Light-Bar Auxiliary Input Connector Pin Descriptions

Sensor Specifications

See **Table 19** for Stewart-Warner fuel level sensor resistance values.

Fuel Level Sensor Resistance (Stewart-Warner)		
Gauge Reading	**Sensor Resistance (Ohms)**	
	Acceptable Range	**Nominal Value**
Empty Stop	244.0 to 249.0	246.5
Empty	232.0 to 239.2	235.6
1/8	190.8 to 196.9	193.8
1/4	149.6 to 154.5	152.1
3/8	126.1 to 129.0	127.5
1/2	102.5 to 103.5	103.0
5/8	84.4 to 85.7	85.0
3/4	66.2 to 67.8	67.0
7/8	47.8 to 49.2	48.5
Full	29.4 to 30.6	30.0

Table 19, Fuel Level Sensor Resistance (Stewart-Warner)

Troubleshooting

NOTE: If the fuel level sensor is below the minimum resistance (short to ground) or above the maximum (open), the fuel gauge will read empty. Shorting the fuel sensor wires will not test the gauge circuit.

See **Table 20** for Transmission Oil Temperature Sensor (Hi-Stat) Resistance, Standard Gauge (°F), and **Fig. 6** for a graph of the same information.

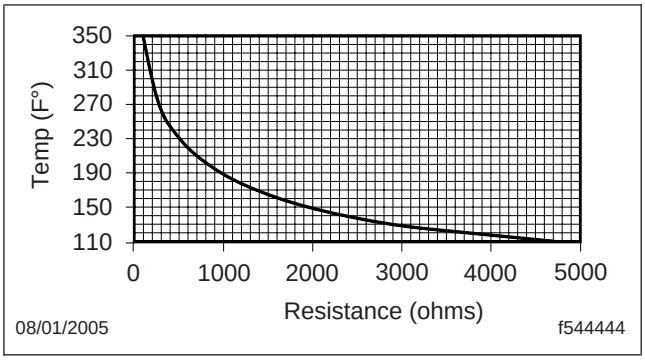


Fig. 6, Transmission Oil Temperature Sensor (Hi-Stat) Resistance, Standard Gauge

See **Table 21** for Transmission Oil Temperature Sensor (Hi-Stat) Resistance, Metric Gauge (°C), and **Fig. 7** for a graph of the same information.

See **Table 22** for Axle Oil Temperature Sensor (Hi-Stat) Resistance, Standard Gauge (°F), and **Fig. 8** for a graph of the same information.

Transmission Oil Temperature Sensor (Hi-Stat) Resistance, Standard Gauge (°F)	
Gauge Temperature (°F)	**Sensor Resistance (Ohms)**
110	4752
150	2079
190	991
230	510
270	285
310	167
350	102

Table 20, Transmission Oil Temperature Sensor (Hi-Stat) Resistance, Standard Gauge

Transmission Oil Temperature Sensor (Hi-Stat) Resistance, Metric Gauge (°C)	
Gauge Temperature (°C)	**Sensor Resistance (Ohms)**
60	2490
80	1255
100	680
120	390
140	234
160	145
180	95

Table 21, Transmission Oil Temperature Sensor (Hi-Stat) Resistance, Metric Gauge

Axle Oil Temperature Sensor (Hi-Stat) Resistance, Standard Gauge (°F)	
Gauge Temperature (°F)	**Sensor Resistance (Ohms)**
100	5933
125	3419
150	2079
175	1283
200	837
225	557
250	380
275	267
300	190

Table 22, Axle Oil Temperature Sensor (Hi-Stat) Resistance, Standard Gauge

See **Table 23** for Axle Oil Temperature Sensor (Hi-Stat) Resistance, Metric Gauge (°C), and **Fig. 9** for a graph of the same information.

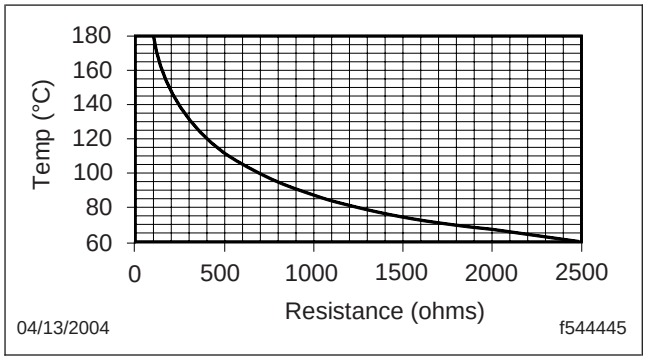


Fig. 7, Transmission Oil Temperature Sensor (Hi-Stat) Resistance, Metric Gauge

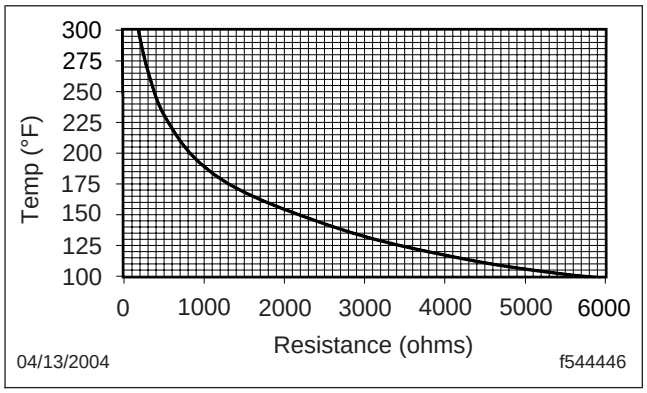


Fig. 8, Axle Oil Temperature Sensor (Hi-Stat) Resistance, Standard Gauge

See **Table 24** for Pyrometer Sensor Temperature (°F) vs. Resistance (Hasaeus), and **Fig. 10** for a graph of the same information.

Axle Oil Temperature Sensor (Hi-Stat) Resistance, Metric Gauge (°C)	
Gauge Temperature (°C)	**Sensor Resistance (Ohms)**
30	8060
45	4465
60	2490
75	1503
90	915
105	595
120	390
135	267
150	185

Table 23, Axle Oil Temperature Sensor (Hi-Stat) Resistance, Metric Gauge

Pyrometer Sensor Temperature (°F) vs. Resistance (Hasaeus)	
Temperature (°F)	**Resistance (Ohms)**
32	201
75	219
100	229
200	271
212	276
300	312
450	372
600	430
750	487
900	542
1050	596
1200	648
1350	698
1500	747

Table 24, Pyrometer Sensor Temperature vs. Resistance, Standard Gauge

See **Table 25** for Pyrometer Sensor Temperature (°C) vs. Resistance (Hasaeus), and **Fig. 11** for a graph of the same information.

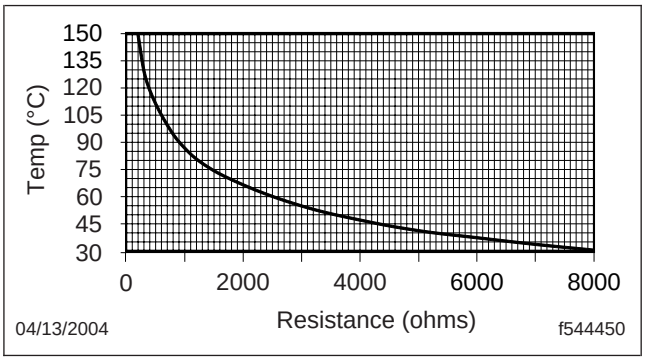


Fig. 9, Axle Oil Temperature Sensor (Hi-Stat) Resistance, Metric Gauge

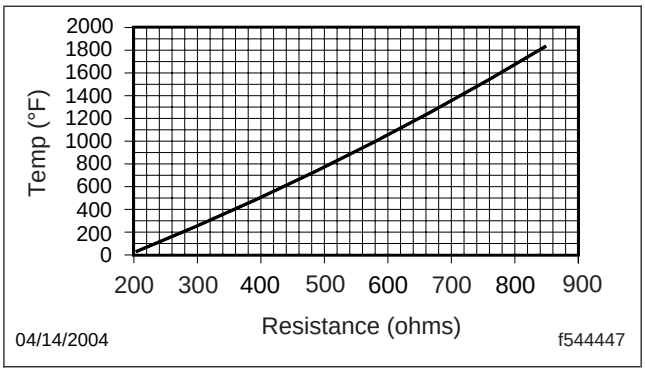


Fig. 10, Pyrometer Sensor Temperature vs. Resistance (Hasaeus), Standard Gauge

Pyrometer Sensor Temperature (°C) vs. Resistance (Hasaeus)	
Temperature (°C)	**Resistance (Ohms)**
0	201
50	239
100	276
200	349
300	420
400	488
500	554
600	618
700	679
800	738

Table 25, Pyrometer Sensor Temperature vs. Resistance, Metric Gauge

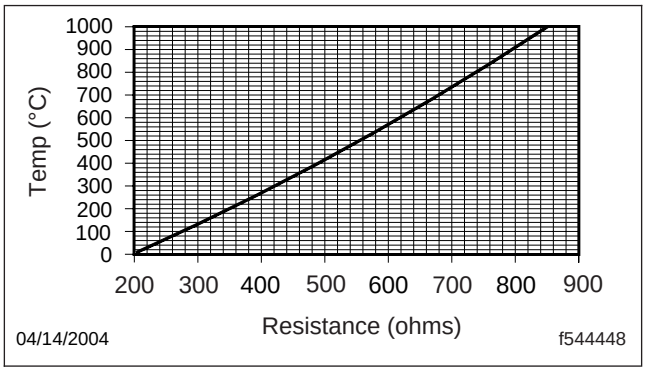
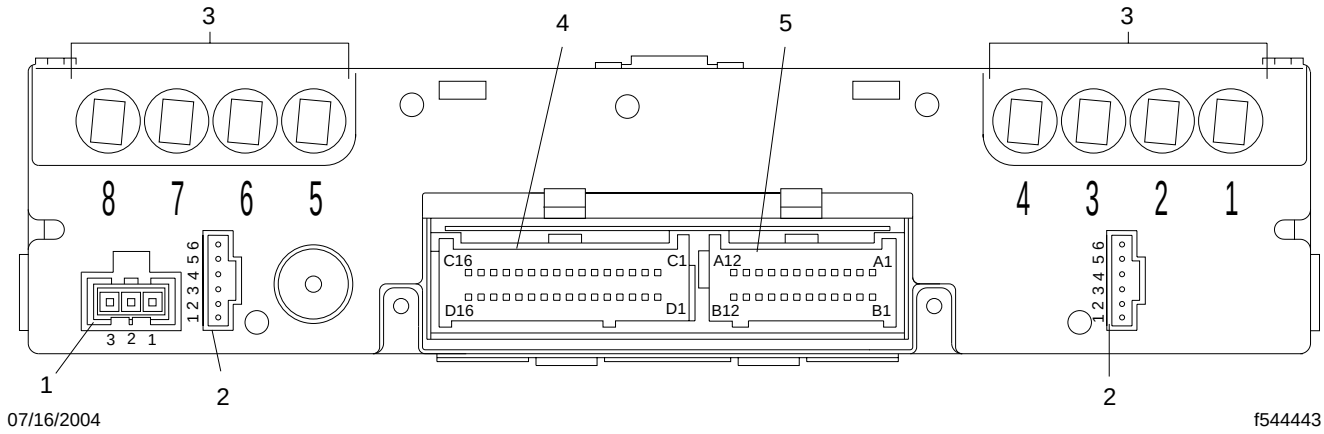


Fig. 11, Pyrometer Sensor Temperature vs. Resistance (Hasaeus), Metric Gauge

Pin and Circuit Descriptions

See **Fig. 1** for a rear view of the light bar, showing connector pin locations. See **Table 1** for 24-pin light-bar connector pin descriptions, **Table 2** for 32-pin light-bar connector pin descriptions, **Table 3** for 6-pin gauge databus connector pin descriptions, and **Table 4** for 3-pin auxiliary input connector pin descriptions.



1. 3-Pin Auxiliary Input Connector
2. 6-Pin Gauge Databus Connector
3. Optional Telltale Bulbs
4. 32-Pin Light-Bar Connector
5. 24-Pin Light-Bar Connector

Fig. 1, Light Bar Rear View with Connector Pin Locations

24-Pin Light-Bar Connector Pin Descriptions			
Pin	**Description**	**Pin**	**Description**
A1	(+) Panel Backlight Power (Pulse Width Modulated)	B1	Optional Indicator #5—Ground Activated
A2	Optional Warning Lamp #6—Ground Activated	B2	(+) Rear rear Axle Temp Sensor
A3	Low Air Pressure Warning Lamp—Ground Activated	B3	J1587 Databus (–)
A4	High Trans Temp Warning Lamp—Ground Activated	B4	(–) Rear rear Axle Temp Sensor
A5	Intake Heater Warning Lamp—Ground Activated	B5	Keypad
A6	Optional Warning Lamp #2—Ground Activated	B6	Keypad
A7	Optional Warning Lamp #3—Ground Activated	B7	Keypad
A8	Optional Warning Lamp #4—Ground Activated	B8	Keypad
A9	No Charge Warning Lamp—Ground Activated	B9	Keypad
A10	(+) Forward rear Axle Temp Sensor	B10	J1587 Databus (+)
A11	(–) Forward rear Axle Temp Sensor	B11	Tractor ABS Warning Lamp
A12	High Beam Warning Lamp—12V Activated	B12	Optional Buzzer Input—Ground Activated

Table 1, 24-Pin Light-Bar Connector Pin Descriptions

Specifications

32-Pin Light-Bar Connector Pin Descriptions			
Pin	**Description**	**Pin**	**Description**
C1	Optimized Idle Warning Lamp	D1	(+) Fuel Level Sensor
C2	Optional Low Current Output (gnd)—Starter Lockout Relay	D2	(–) Fuel Level Sensor
C3	Optional Low Current Output (gnd)—Key Illumination	D3	(–) Panel Backlight Ground
C4	Optional 12V Input (Door Open)*	D4	Optional Warning Lamp #8—12V Activated
C5	Park Brake Warning Lamp—Ground Activated	D5	Reserved
C6	(+) Pyrometer	D6	(–) Pyrometer
C7	Reserved	D7	Reserved
C8	Left Turn Warning Lamp—12V Activated	D8	Right Turn Warning Lamp
C9	Reserved	D9	Reserved
C10	Water In Fuel Warning Lamp	D10	Check Trans Warning Lamp—Ground Activated
C11	Optional Warning Lamp #7—Ground Activated	D11	Keypad Ground
C12	(–) Sensor Common (trans temp, ammeter, axle #3 temp, ammeter)	D12	Trailer ABS Warning Lamp
C13	(+) Transmission Oil Temperature	D13	Ground
C14	Optional Warning Lamp #1—Ground Activated	D14	(+) Battery Power
C15	Check Engine Warning Lamp—Ground Activated	D15	(+) Ignition Power
C16	Engine Protection Warning Lamp—Ground Activated	D16	Headlight Power Input 12v (used to control LCD brightness)

* Pin C4 (door open input) is used for the Door Open/Park Brake Not Set chime. If the park brake is off, and the door is open, then the light bar will sound a chime.

Table 2, 32-Pin Light-Bar Connector Pin Descriptions

6-Pin Gauge Databus Connector Pin Descriptions		
Pin	**Description**	**Jumper Wire Color**
1	(+) Gauge Power	Blue
2	(–) Gauge Ground	Green
3	Gauge Databus (+)	Black
4	Gauge Databus (–)	Violet
5	Gauge Backlighting (–)	Red
6	Gauge Backlighting (+)	Yellow

Table 3, 6-Pin Gauge Databus Connector Pin Descriptions

3-Pin Light-Bar Auxiliary Input Connector Pin Descriptions	
Pin	**Description**
1	Reserved
2	(+) Third Drive Axle Temperature Input
3	Reserved

Table 4, 3-Pin Light-Bar Auxiliary Input Connector Pin Descriptions

Sensor Specifications

See **Table 5** for Stewart-Warner fuel level sensor resistance values.

NOTE: If the fuel level sensor is below the minimum resistance (short to ground) or above the maximum (open), the fuel gauge will read

empty. Shorting the fuel sensor wires will not test the gauge circuit.

Fuel Level Sensor Resistance (Stewart-Warner)		
Gauge Reading	Sensor Resistance (Ohms)	
	Acceptable Range	Nominal Value
Empty Stop	244.0 to 249.0	246.5
Empty	232.0 to 239.2	235.6
1/8	190.8 to 196.9	193.8
1/4	149.6 to 154.5	152.1
3/8	126.1 to 129.0	127.5
1/2	102.5 to 103.5	103.0
5/8	84.4 to 85.7	85.0
3/4	66.2 to 67.8	67.0
7/8	47.8 to 49.2	48.5
Full	29.4 to 30.6	30.0

Table 5, Fuel Level Sensor Resistance (Stewart-Warner)

See **Table 6** for Transmission Oil Temperature Sensor (Hi-Stat) Resistance, Standard Gauge (°F), and **Fig. 2** for a graph of the same information.

Transmission Oil Temperature Sensor (Hi-Stat) Resistance, Standard Gauge (°F)	
Gauge Temperature (°F)	Sensor Resistance (Ohms)
110	4752
150	2079
190	991
230	510
270	285
310	167
350	102

Table 6, Transmission Oil Temperature Sensor (Hi-Stat) Resistance, Standard Gauge

See **Table 7** for Transmission Oil Temperature Sensor (Hi-Stat) Resistance, Metric Gauge (°C), and **Fig. 3** for a graph of the same information.

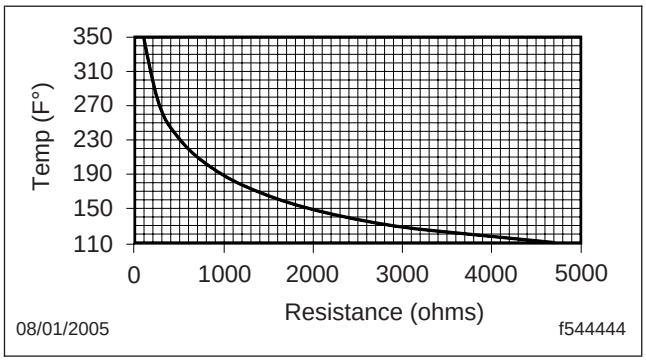


Fig. 2, Transmission Oil Temperature Sensor (Hi-Stat) Resistance, Standard Gauge

Transmission Oil Temperature Sensor (Hi-Stat) Resistance, Metric Gauge (°C)	
Gauge Temperature (°C)	Sensor Resistance (Ohms)
60	2490
80	1255
100	680
120	390
140	234
160	145
180	95

Table 7, Transmission Oil Temperature Sensor (Hi-Stat) Resistance, Metric Gauge

See **Table 8** for Axle Oil Temperature Sensor (Hi-Stat) Resistance, Standard Gauge (°F), and **Fig. 4** for a graph of the same information.

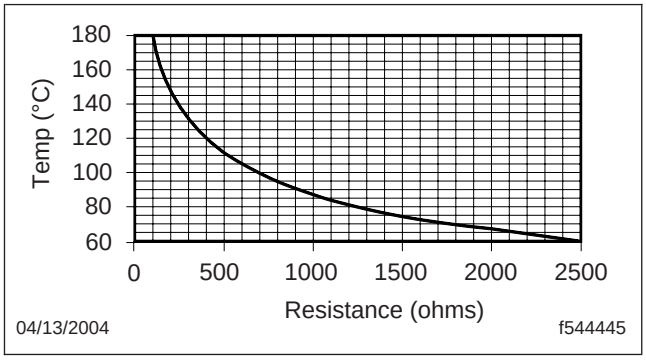


Fig. 3, Transmission Oil Temperature Sensor (Hi-Stat) Resistance, Metric Gauge

Specifications

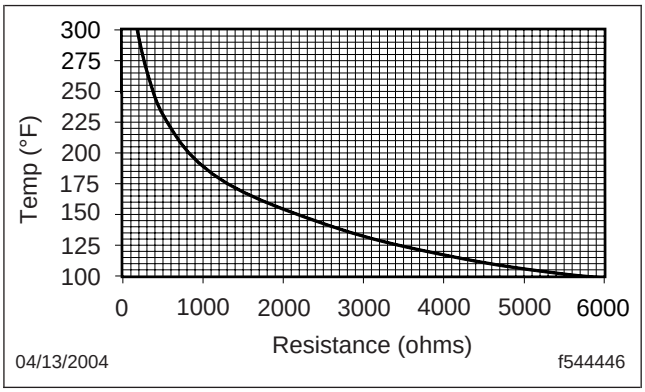


Fig. 4, Axle Oil Temperature Sensor (Hi-Stat) Resistance, Standard Gauge

Axle Oil Temperature Sensor (Hi-Stat) Resistance, Standard Gauge (°F)	
Gauge Temperature (°F)	**Sensor Resistance (Ohms)**
100	5933
125	3419
150	2079
175	1283
200	837
225	557
250	380
275	267
300	190

Table 8, Axle Oil Temperature Sensor (Hi-Stat) Resistance, Standard Gauge

See **Table 9** for Axle Oil Temperature Sensor (Hi-Stat) Resistance, Metric Gauge (°C), and **Fig. 5** for a graph of the same information.

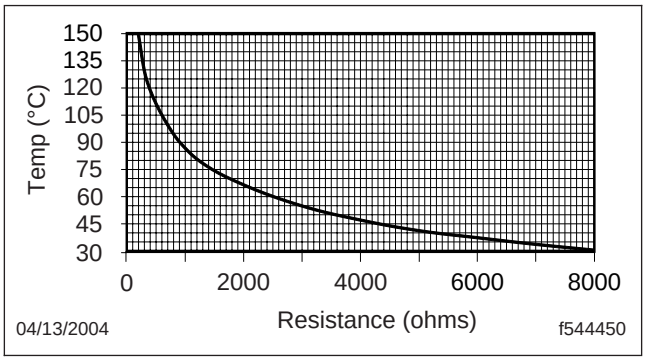


Fig. 5, Axle Oil Temperature Sensor (Hi-Stat) Resistance, Metric Gauge

Axle Oil Temperature Sensor (Hi-Stat) Resistance, Metric Gauge (°C)	
Gauge Temperature (°C)	**Sensor Resistance (Ohms)**
30	8060
45	4465
60	2490
75	1503
90	915
105	595
120	390
135	267
150	185

Table 9, Axle Oil Temperature Sensor (Hi-Stat) Resistance, Metric Gauge

See **Table 10** for Pyrometer Sensor Temperature (°F) vs. Resistance (Hasaeus), and **Fig. 6** for a graph of the same information.

See **Table 11** for Pyrometer Sensor Temperature (°C) vs. Resistance (Hasaeus), and **Fig. 7** for a graph of the same information.

Pyrometer Sensor Temperature (°F) vs. Resistance (Hasaeus)	
Temperature (°F)	**Resistance (Ohms)**
32	201
75	219
100	229
200	271

Pyrometer Sensor Temperature (°F) vs. Resistance (Hasaeus)	
Temperature (°F)	**Resistance (Ohms)**
212	276
300	312
450	372
600	430
750	487
900	542
1050	596
1200	648
1350	698
1500	747

Table 10, Pyrometer Sensor Temperature vs. Resistance, Standard Gauge

Pyrometer Sensor Temperature (°C) vs. Resistance (Hasaeus)	
Temperature (°C)	**Resistance (Ohms)**
0	201
50	239
100	276
200	349
300	420
400	488
500	554
600	618
700	679
800	738

Table 11, Pyrometer Sensor Temperature vs. Resistance, Metric Gauge

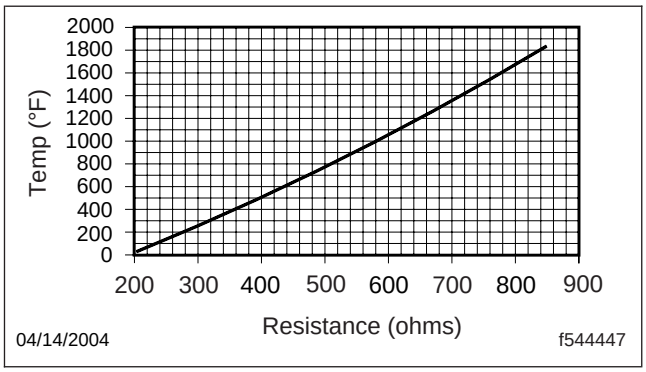


Fig. 6, Pyrometer Sensor Temperature vs. Resistance (Hasaeus), Standard Gauge

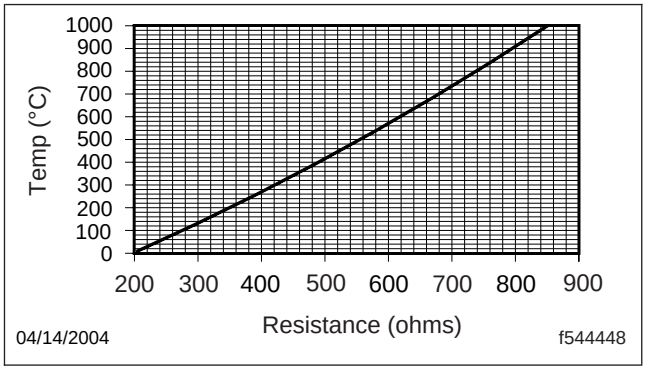
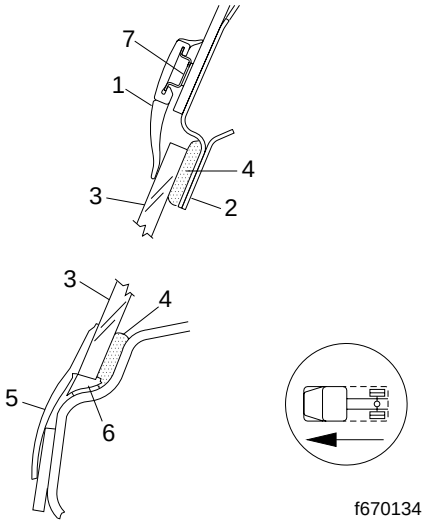


Fig. 7, Pyrometer Sensor Temperature vs. Resistance (Hasaeus), Metric Gauge

General Information

The windshield is either a one-piece or a two-piece installation. The windshield glass is held in place on the windshield mask by a bead of urethane adhesive/sealant. Rubber molding strips are installed at the top and bottom edges of the glass. Two-piece windshields have an additional molding strip on the center post, between the right and left glass panes.

The windshield is installed in a manner similar to automobile windshields, in that the urethane sealant holds the windshield in place and seals out moisture; see **Fig. 1**. The molding strips are installed mainly for appearance.



NOTE: Installation with top molding retainer strip is shown.

1. Top Molding Strip
2. Windshield Mask
3. Windshield Glass
4. Urethane Adhesive/Sealant
5. Bottom Molding Strip
6. Positioning Block
7. Retainer Strip

Fig. 1, Windshield Installation, Cross-Sectional View

See **Specifications 400** for special tools and materials needed to replace a windshield.

One-Piece Windshield Replacement, Century Class Conventional and Coronado

Replacement

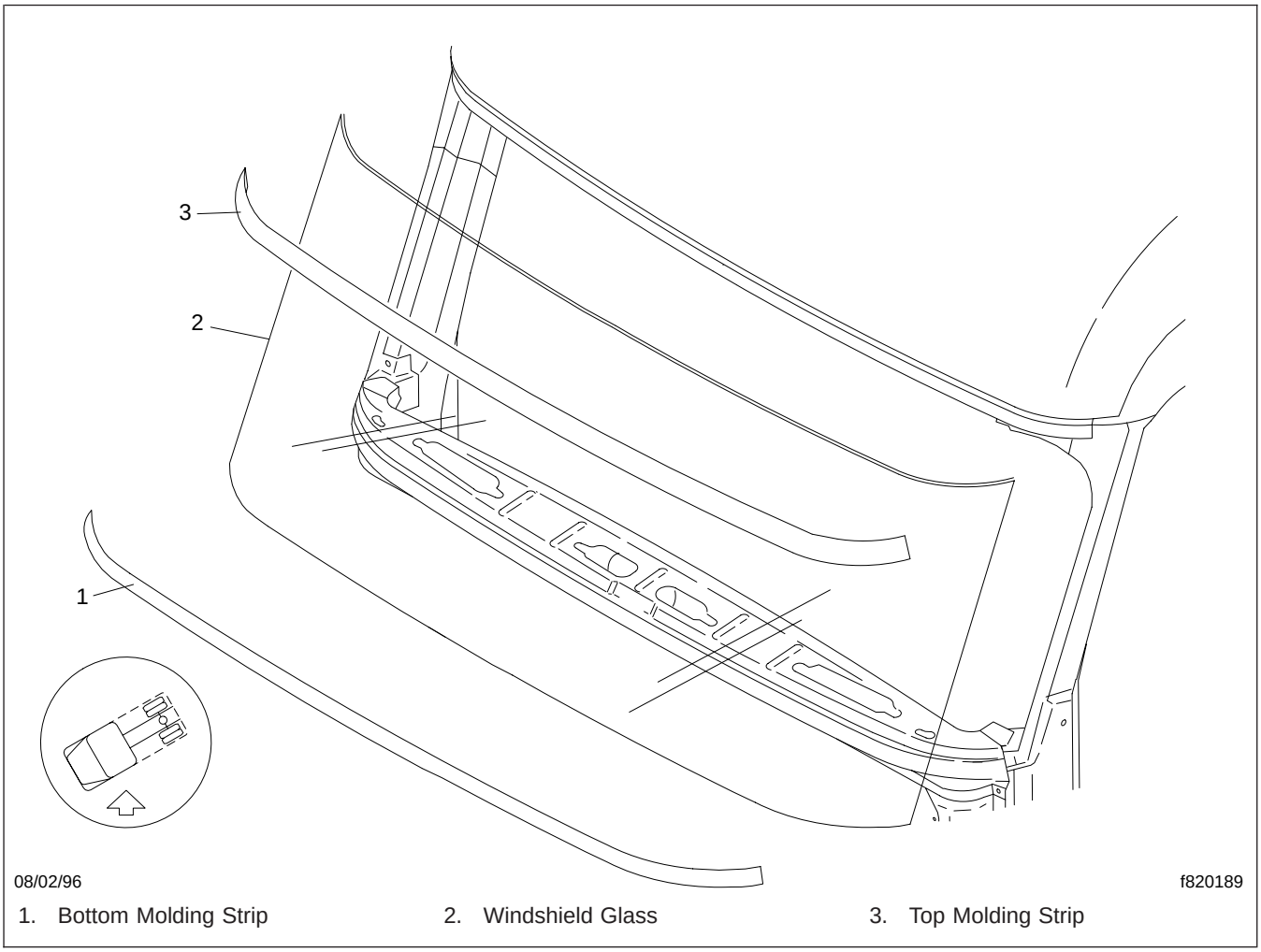
See **Fig. 1** for a one-piece windshield installation.

If the windshield is cracked, carefully inspect the glass, urethane sealant, and the windshield mask to determine the cause. Correct the problem before installing a new windshield. If the underlying cause for the crack is not corrected, the replacement windshield may crack when exposed to high winds, pressure, temperature extremes, or vehicle motion.

NOTE: At least two people are needed to replace a windshield.

1. Apply the parking brakes and chock the tires.
2. Open the hood.
3. Remove the windshield wiper arms; see **Group 82**.
4. Protect the paint finish and instrument panel by taping paper around the windshield opening.
5. Remove the lower capscrew from the exterior A-pillar panel; see **Fig. 2**.
6. If the vehicle is a Coronado, remove the two fasteners that attach the middle span of the panel to the A-pillar.

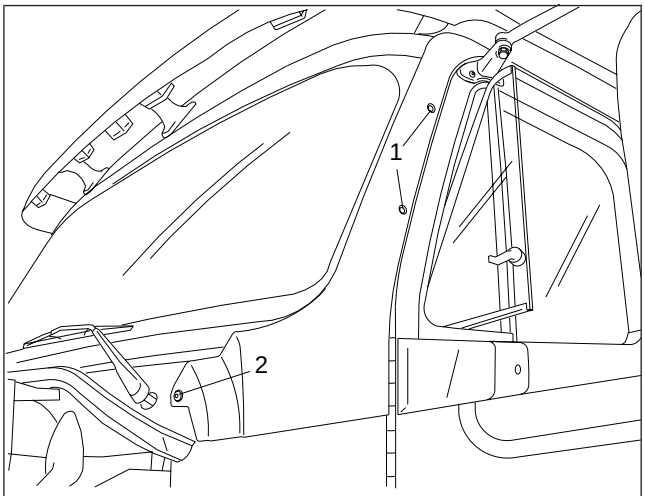
   If the vehicle is a Century Class Conventional, the exterior panel mounting is concealed under



1. Bottom Molding Strip
2. Windshield Glass
3. Top Molding Strip

Fig. 1, One-Piece Windshield Installation

One-Piece Windshield Replacement, Century Class Conventional and Coronado



1. Middle A-Pillar Fasteners (Coronado only)
2. Lower A-Pillar Fastener

Fig. 2, A-Pillar Exterior Panel Fasteners

the A-pillar interior trim. Remove the mounting nuts, as follows.

6.1 Remove the grab handle from the right-hand A-pillar.

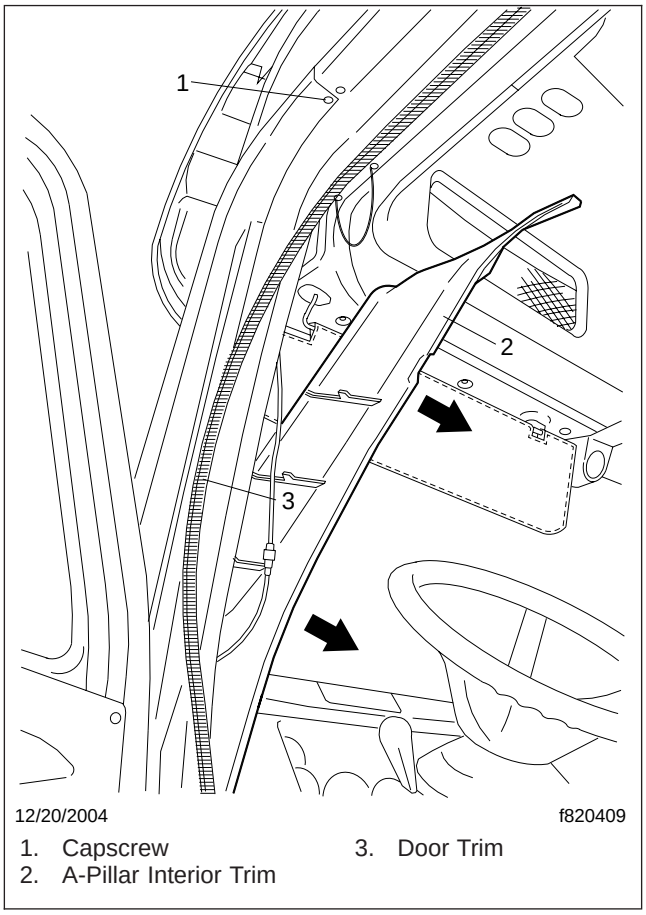
6.2 On both sides of the vehicle, loosen the door trim, then remove the A-pillar interior trim; see **Fig. 3**.

6.3 If the vehicle is equipped with an Eaton® VORAD® collision warning system, disconnect the sensor located on the inside of the right-hand A-pillar.

6.4 Through the access holes on each A-pillar, remove the three nuts that attach the exterior panel to the A-pillar; see **Fig. 4**.

7. Remove the capscrew that attaches the exterior A-pillar panel to the top of the door frame; see **Fig. 3**. Remove the panel.
8. Remove the Torx® screw and bushing at each end of the top molding strip; see **Fig. 5**.
9. Slide the top molding strip off the retainer strip.

NOTE: Vehicles built before July 21, 2000 are not equipped with a retainer strip; remove the top molding strip by pulling it loose from the gap between the windshield glass and the windshield mask.



1. Capscrew
2. A-Pillar Interior Trim
3. Door Trim

Fig. 3, Removing A-Pillar Interior Trim

10. Remove the bottom molding strip.
11. Using a pneumatic cutting tool (**Fig. 6**), a piano wire (**Fig. 7**), or a pull knife (**Fig. 8**), cut through the urethane sealant all around the edges of the windshield glass.

NOTE: To order a BTB pneumatic cutting tool, see **Specifications 400**.

⚠ WARNING

Wear protective gloves and safety glasses when replacing windshield glass. Gloves will protect your hands from sharp edges, and allow a better grip. Failure to wear gloves and safety glasses when handling glass could result in injury to hands or eyes.

12. Carefully remove the damaged windshield glass.

One-Piece Windshield Replacement, Century Class Conventional and Coronado

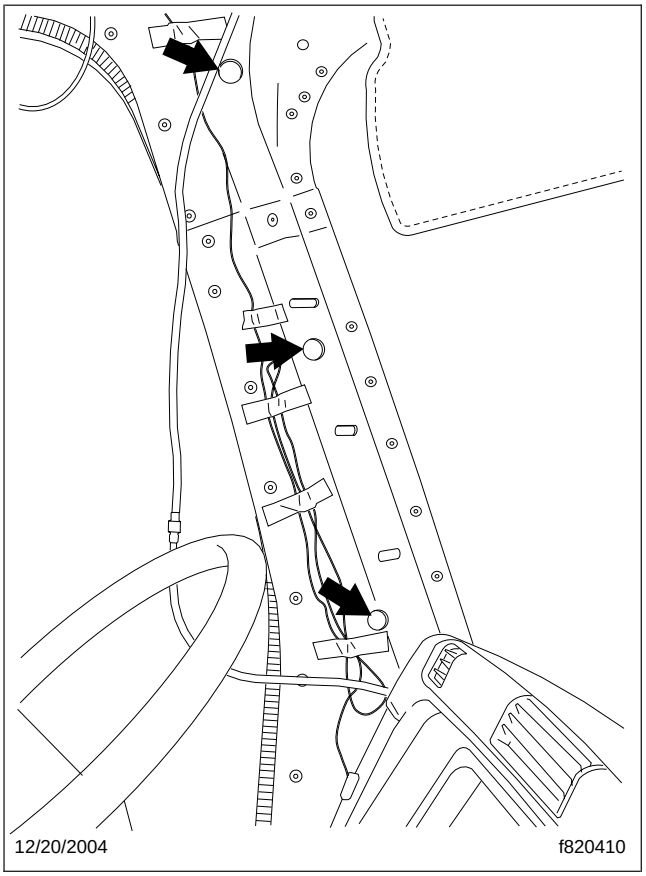


Fig. 4, A-Pillar Fastener Access Holes

13. Remove the four rubber positioning blocks from the lower windshield mask; see **Fig. 9**. Discard them.
14. Using a BTB pneumatic cutting tool or a sharp knife, trim down the old urethane sealant to a thickness of about 1/8 inch (3 mm).
15. Brush the remaining adhesive and debris from the windshield-seating cavity.
16. Check the windshield mask. Apply Betaprime® U-413 Body Primer to any bare metal.
17. Install eight spacer buttons on the windshield mask; see **Fig. 9**.
18. Install four new rubber positioning blocks in the cavity; see **Fig. 9**.
19. Prepare the new windshield glass, as follows.

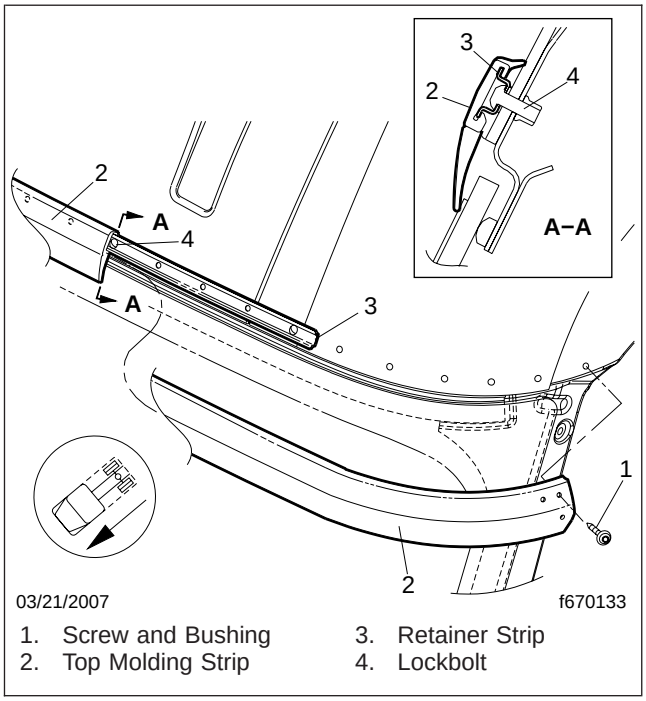


Fig. 5, Top Molding Strip Installation

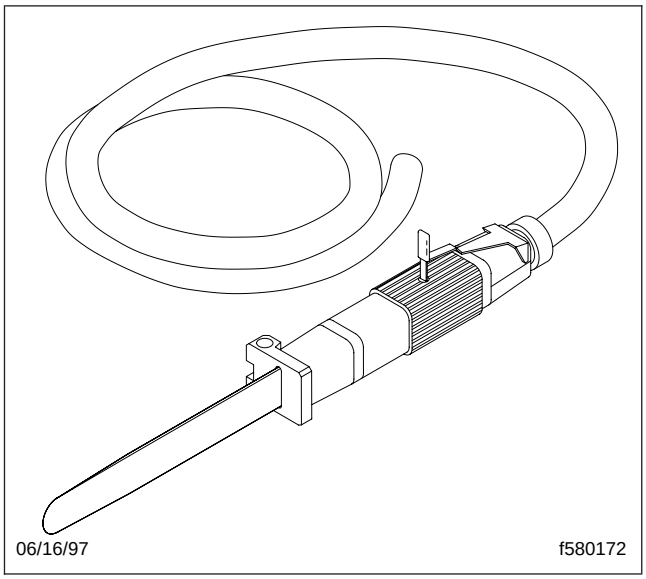
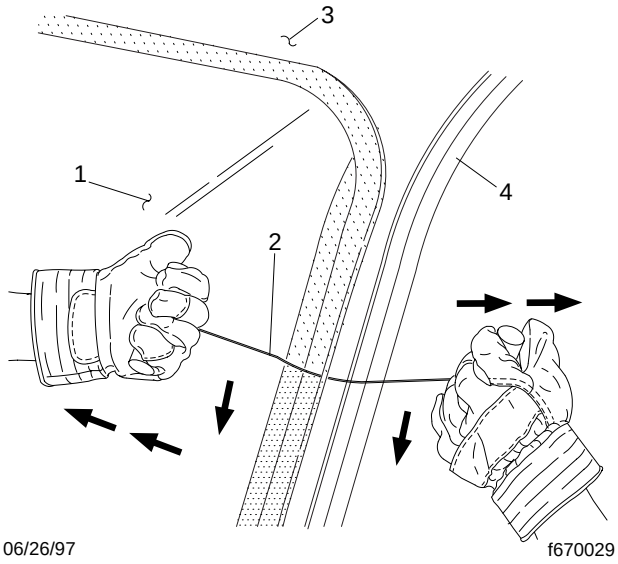


Fig. 6, BTB Pneumatic Cutting Tool

19.1 Put the new windshield glass on a suitable stand or fixture, with the inside surface of the glass facing up.

One-Piece Windshield Replacement, Century Class Conventional and Coronado



1. Windshield Glass
2. Piano Wire
3. Roof
4. Door Frame

Fig. 7, Windshield Glass Removal with Piano Wire

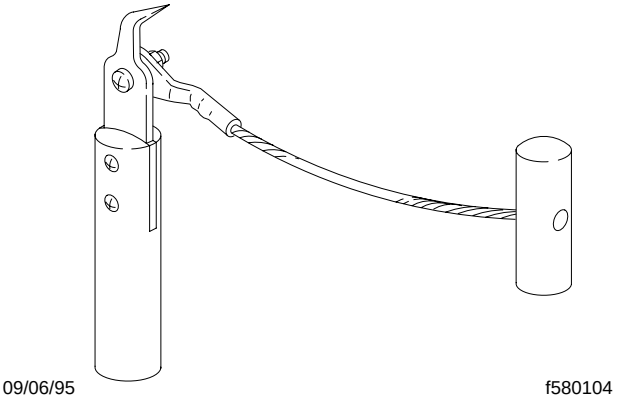
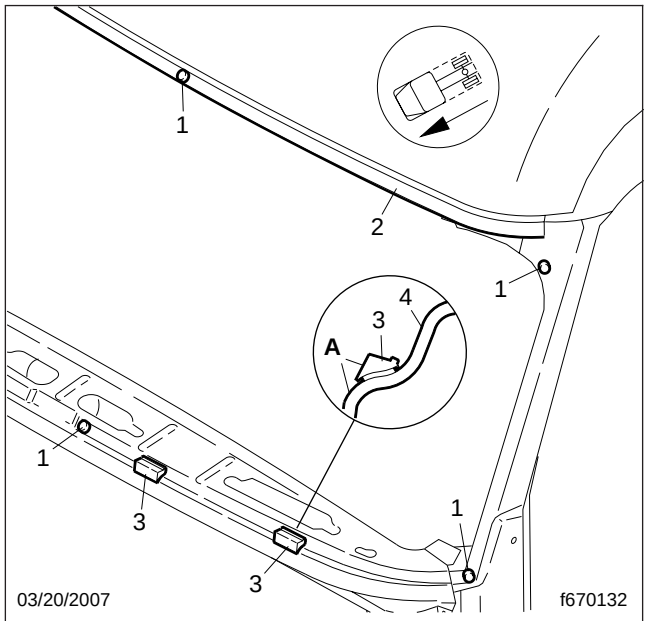


Fig. 8, Typical Pull Knife

19.2 Clean the edges of the glass with a 50/50 mixture of isopropyl alcohol and water.

19.3 Apply Betaprime U-401 Glass Prep all the way around the edge of the glass to a width of about 1-1/2 inches (40 mm).

19.4 Wait five seconds, then wipe off the glass prep, using a clean, lint-free cloth.



A. These two surfaces are to be flush.

1. Spacer Button
2. Windshield Mask (upper)
3. Positioning Block
4. Windshield Mask (lower)

Fig. 9, Cab Area for Windshield Installation

20. Apply Betaprime U-402 Glass Primer all the way around the edge of the glass to a width of about 1 inch (25 mm). *Do not get any of the primer on the black dot pattern of the glass.* Apply one streak-free coat.

21. Using the manufacturer's directions, load the Betagun® III electric caulking gun with Betaseal® U-216 two-part urethane adhesive/sealant. Extrude a bead about 10 inches (250 mm) long into a waste can. This will ensure complete mixing, and removal of any air pockets.

    Apply a uniform and continuous bead all the way around the edges of the windshield mask on the cab. The bead should be a minimum of 3/8 inch (10 mm) thick.

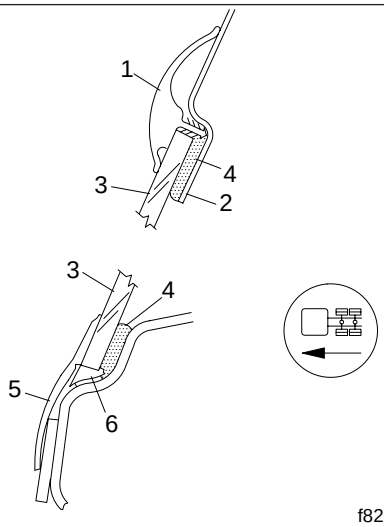
    Keep the spiked edge of the applicator tip against the edge of the mask, and overlap the bead slightly.

IMPORTANT: Do not apply the urethane adhesive/sealant to the windshield glass. Aligning a windshield with adhesive on the glass is very difficult to do without getting the adhesive/

One-Piece Windshield Replacement, Century Class Conventional and Coronado

sealant on the painted cab surface outside the windshield mask.

22. Attach a suction device to the outside of the windshield. Lift and install the windshield. Make sure the glass is centered on the windshield mask, and that the bottom edge of the glass seats onto the positioning blocks correctly; see **Fig. 10** or **Fig. 11**.

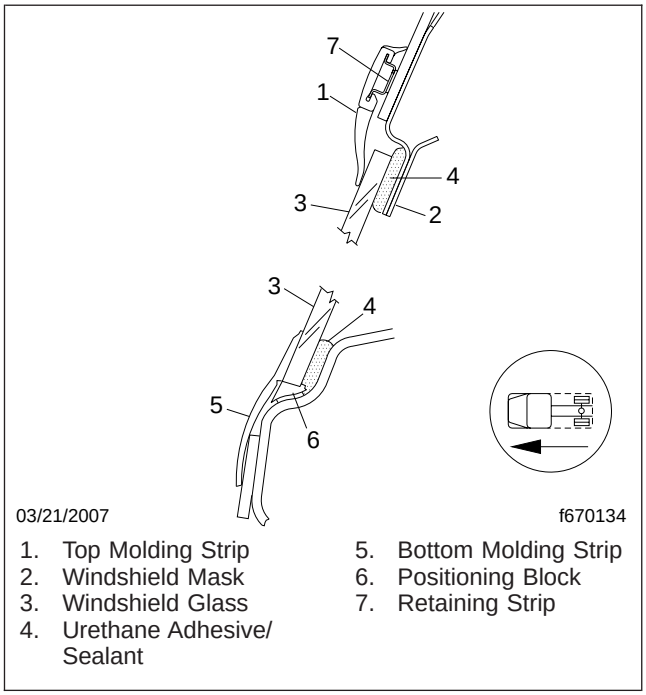


1. Top Molding Strip
2. Windshield Mask
3. Windshield Glass
4. Urethane Sealant
5. Bottom Molding Strip
6. Positioning Block

Fig. 10, Cross-Section View (vehicles built before July 21, 2000)

23. Gently press down on the glass all the way around the bead line to firmly seat the windshield.
24. With a spatula or a paddle, smooth the adhesive flat along the edge of the windshield.
25. Apply Betaprime U-401 Glass Prep along the bottom outside edge of the windshield glass, then install the bottom rubber molding strip, using Betaseal U-418 primerless auto glass urethane adhesive. Do not use a silicone hot glue.
26. Slide the top molding strip onto the retainer strip, if so equipped. Fasten each end of the strip to the A-pillar with a Torx screw and bushing; see **Fig. 5**.

NOTE: Vehicles built before July 21, 2000 are not equipped with a retainer strip; apply Betaprime U-401 Glass Prep to the top outside edge of the glass, then attach the molding strip using Betaseal U-418 primerless auto glass urethane adhesive.



1. Top Molding Strip
2. Windshield Mask
3. Windshield Glass
4. Urethane Adhesive/ Sealant
5. Bottom Molding Strip
6. Positioning Block
7. Retaining Strip

Fig. 11, Cross-Section View (vehicles built from July 21, 2000)

27. Attach each A-pillar exterior panel to the top of the door frame with a capscrew; see **Fig. 3**.
28. If the vehicle is a Coronado, install the two fasteners that attach the middle span of the panel to the A-pillar; see **Fig. 2**.

    If the vehicle is a Century Class Conventional, install the A-pillar exterior panel mounting nuts and interior trim, as follows.

    28.1 Through the access holes on each A-pillar, install the three nuts that attach the exterior panel to the A-pillar; see **Fig. 4**.

    28.2 If the vehicle is equipped with an Eaton® VORAD® collision warning system, connect the sensor located on the inside of the right-hand A-pillar.

    28.3 On both sides of the vehicle, install the A-pillar interior trim, then secure the door trim; see **Fig. 3**.

One-Piece Windshield Replacement, Century Class Conventional and Coronado

28.4 Attach the grab handle to the right-hand A-pillar.

29. Secure the lower end of the A-pillar exterior panel with a capscrew; see **Fig. 2**.
30. Install the wiper arms; see **Group 82**.
31. Clean both sides of the new windshield glass.
32. Remove the protective coverings from the dash.
33. Close the hood.
34. Remove the chocks.
35. Let the urethane sealant cure for 30 minutes before driving the vehicle.

Two-Piece Windshield Replacement, Century Class Conventional and Coronado

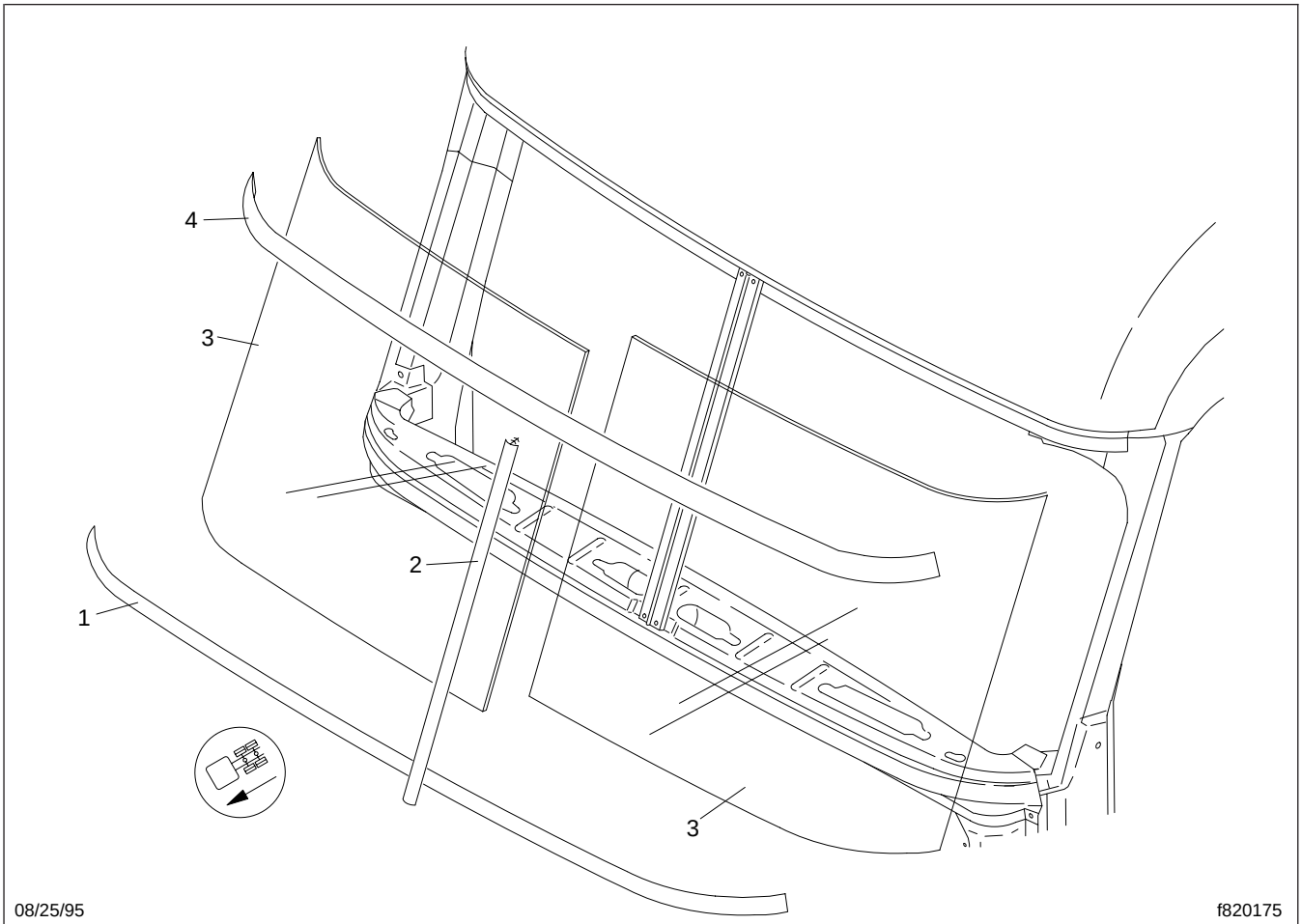
Replacement

See **Fig. 1** for a two-piece windshield installation.

If the windshield is cracked, carefully inspect the glass, urethane sealant, and the windshield mask to determine the cause. Correct the problem before installing a new windshield. If the underlying cause for the crack is not corrected, the replacement windshield may crack when exposed to high winds, pressure, temperature extremes, or vehicle motion.

NOTE: At least two people are needed to replace a windshield.

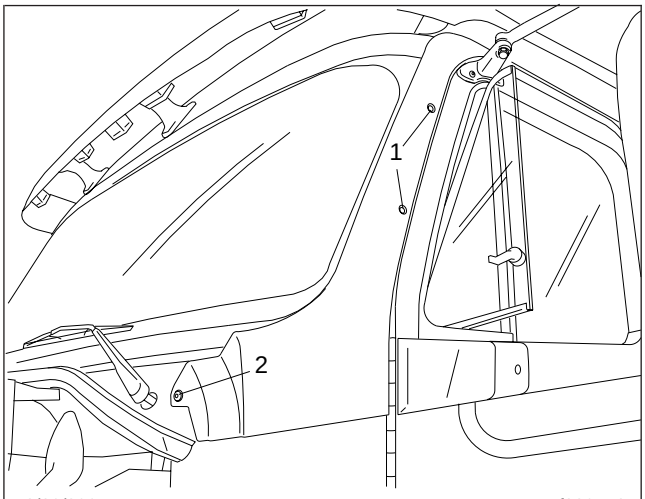
1. Apply the parking brakes and chock the tires.
2. Open the hood.
3. Remove the windshield wiper arm(s); see **Group 82**.
4. Remove the exterior sun visor.
5. Protect the paint finish and instrument panel by taping paper around the windshield opening.
6. Remove the lower capscrew from the exterior A-pillar panel; see **Fig. 2**.



1. Bottom Molding Strip
2. Center Molding Strip
3. Windshield Glass
4. Top Molding Strip

Fig. 1, Two-Piece Windshield Installation

Two-Piece Windshield Replacement, Century Class Conventional and Coronado



1. Middle A-Pillar Fasteners (Coronado only)
2. Lower A-Pillar Fastener

Fig. 2, A-Pillar Exterior Panel Fasteners

7. If the vehicle is a Coronado, remove the two fasteners that attach the middle span of the panel to the A-pillar.

   If the vehicle is a Century Class Conventional, the exterior panel mounting is concealed under the A-pillar interior trim. Remove the mounting nuts, as follows.

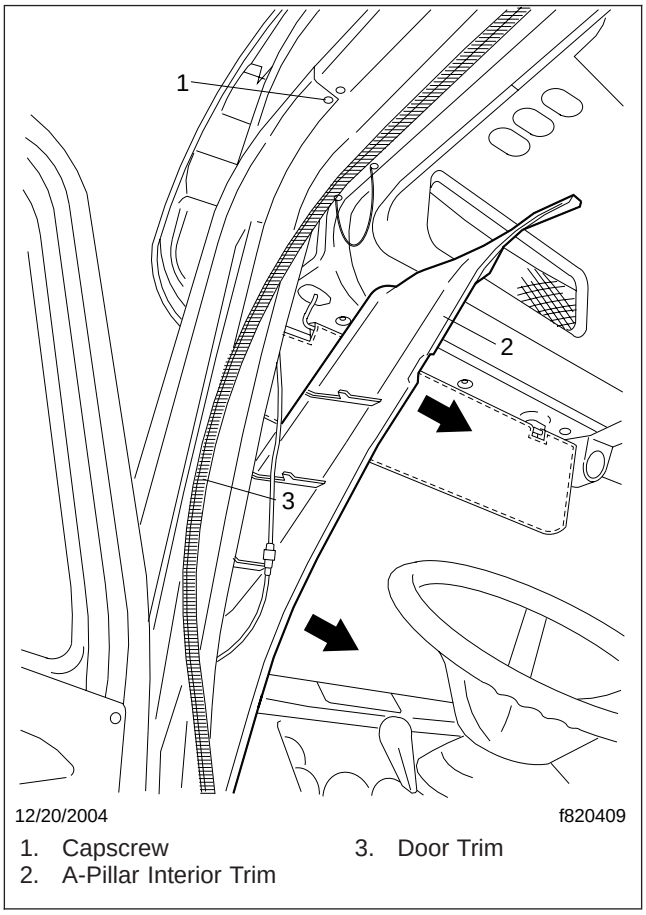
   7.1 If applicable, remove the grab handle from the right-hand A-pillar.

   7.2 Loosen the door trim, then remove the A-pillar interior trim; see **Fig. 3**.

   7.3 If applicable, disconnect the sensor for the Eaton® VORAD® collision warning system, located on the inside of the right-hand A-pillar.

   7.4 Through the access holes on the A-pillar, remove the three nuts that attach the exterior panel to the A-pillar; see **Fig. 4**.

8. Remove the capscrew that attaches the exterior A-pillar panel to the top of the door frame; see **Fig. 3**. Remove the panel.
9. Remove the center molding strip from the windshield center post; see **Fig. 1**.
10. Remove the Torx® screw and bushing at each end of the top molding strip; see **Fig. 5**.



1. Capscrew
2. A-Pillar Interior Trim
3. Door Trim

Fig. 3, Removing A-Pillar Interior Trim

11. Slide the top molding strip off the retainer strip.

NOTE: Vehicles built before July 21, 2000 are not equipped with a retainer strip; remove the top molding strip by pulling it loose from the gap between the windshield glass and the windshield mask.

12. Remove the bottom molding strip.
13. Using a pneumatic cutting tool (**Fig. 6**), a piano wire (**Fig. 7**), or a pull knife (**Fig. 8**), cut through the urethane sealant all around the edges of the windshield glass.

NOTE: To order a BTB pneumatic cutting tool, see **Specifications 400**.

Two-Piece Windshield Replacement, Century Class Conventional and Coronado

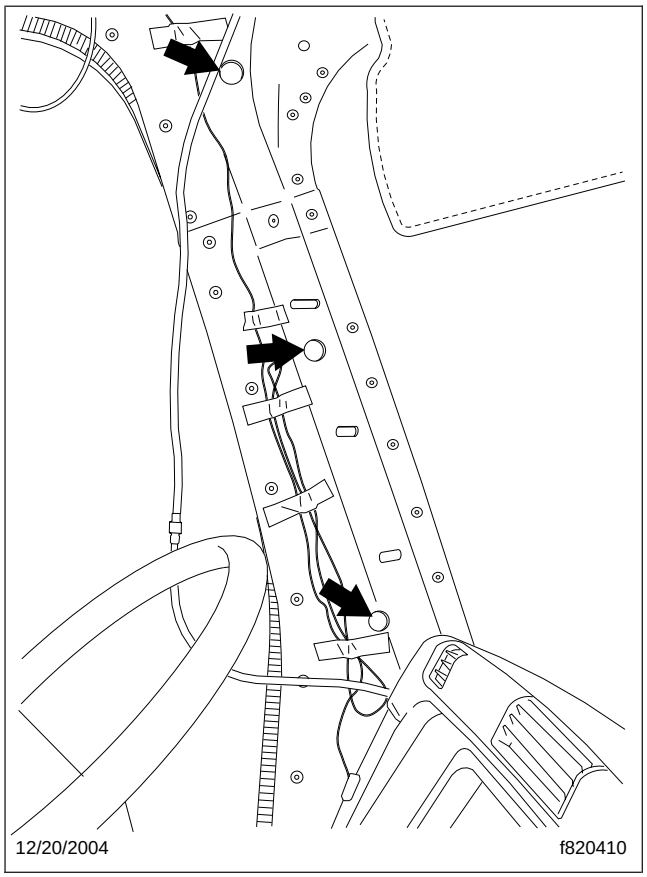


Fig. 4, A-Pillar Fastener Access Holes

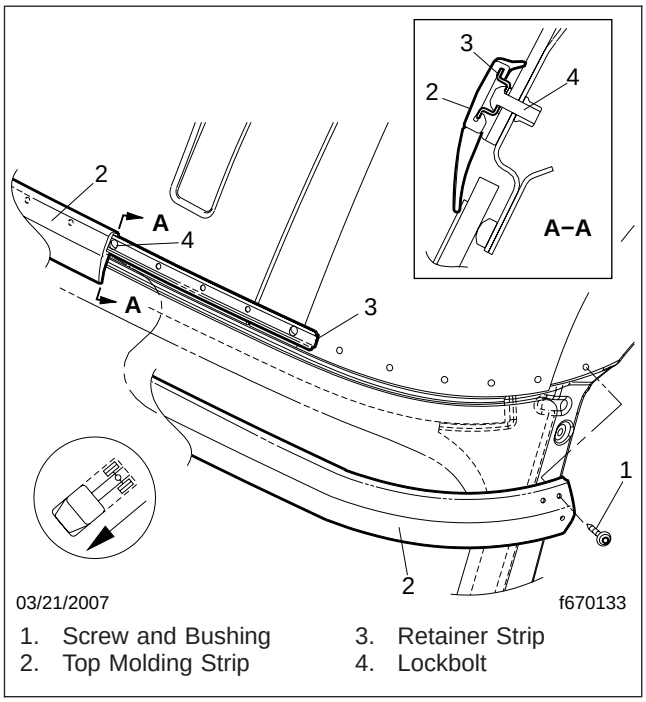


Fig. 5, Top Molding Strip Installation

WARNING

Wear protective gloves and safety glasses when replacing windshield glass. Gloves will protect your hands from sharp edges, and allow a better grip. Failure to wear gloves and safety glasses when handling glass could result in injury to hands or eyes.

14. Carefully remove the damaged windshield glass.
15. Remove the rubber positioning blocks from the lower windshield mask; see **Fig. 9**. Discard them.
16. Using a BTB pneumatic cutting tool or a sharp knife, trim down the old urethane sealant to a thickness of about 1/8 inch (3 mm).
17. Check the windshield mask. Apply Betaprime® U-413 Body Primer to any bare metal.
18. Install a spacer button in each corner of the windshield mask; see **Fig. 9**.

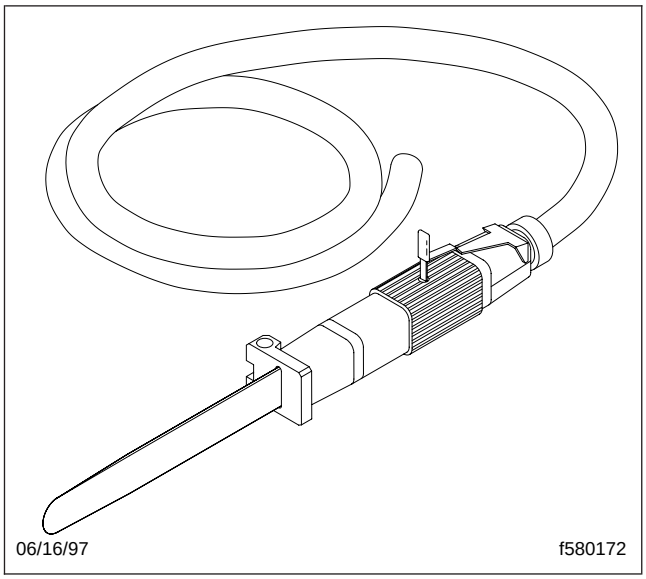
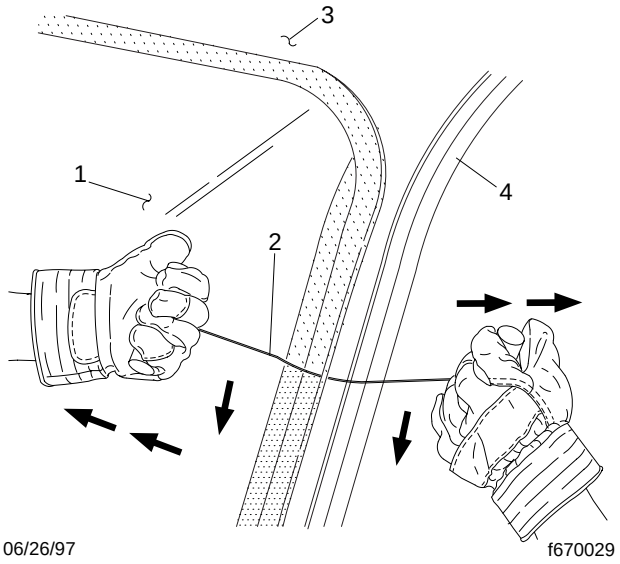


Fig. 6, BTB Pneumatic Cutting Tool

19. Install new positioning blocks at the bottom of the windshield mask. Make sure the front edge of each block is flush with the front edge of the windshield mask; see **Fig. 9**.

Two-Piece Windshield Replacement, Century Class Conventional and Coronado



1. Windshield Glass
2. Piano Wire
3. Door Frame
4. Roof

Fig. 7, Windshield Glass Removal with Piano Wire

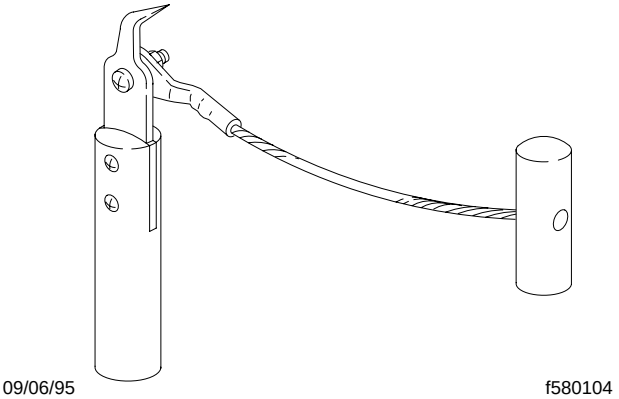
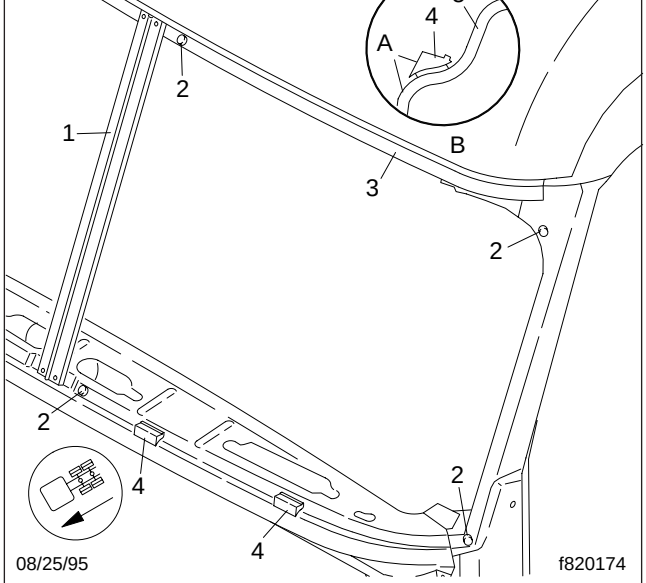


Fig. 8, Typical Pull Knife

20. Prepare the new windshield glass, as follows.

    20.1 Put the new windshield glass on a suitable stand or fixture, with the inside surface of the glass facing up.

    20.2 Clean the edges of the glass with a 50/50 mixture of isopropyl alcohol and water.



A. These two surfaces are to be flush.
B. Cross-Section View

1. Center Post
2. Spacer Button
3. Windshield Mask (upper)
4. Positioning Block
5. Windshield Mask (lower)

Fig. 9, Cab Area for Windshield Installation

    20.3 Apply Betaprime U-401 Glass Prep all the way around the edge of the glass to a width of about 1-1/2 inches (40 mm).

    20.4 Wait five seconds, then wipe off the glass prep, using a clean, lint-free cloth.

    20.5 Apply Betaprime U-402 Glass Primer all the way around the edge of the glass to a width of about 1 inch. *Do not get any of the primer on the black dot pattern of the glass.* Apply one streak-free coat.

21. Using the manufacturer's directions, load the Betagun® III electric caulking gun with Betaseal® U-216 two-part urethane adhesive/sealant. Extrude a bead about 10 inches (250 mm) long into a waste can. This will ensure complete mixing, and removal of any air pockets.

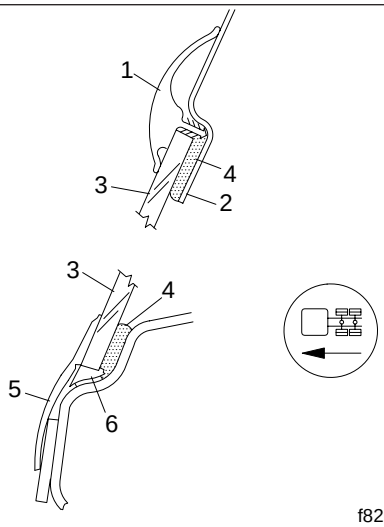
    Apply a uniform and continuous bead all the way around the edges of the windshield mask on the cab. The bead should be a minimum of 3/8 inch (10 mm) thick.

Two-Piece Windshield Replacement, Century Class Conventional and Coronado

Keep the spiked edge of the applicator tip against the edge of the mask, and overlap the bead slightly.

IMPORTANT: Do not apply the urethane adhesive/sealant to the windshield glass. Aligning a windshield with adhesive on the glass is very difficult to do without getting the adhesive/sealant on the painted cab surface outside the windshield mask.

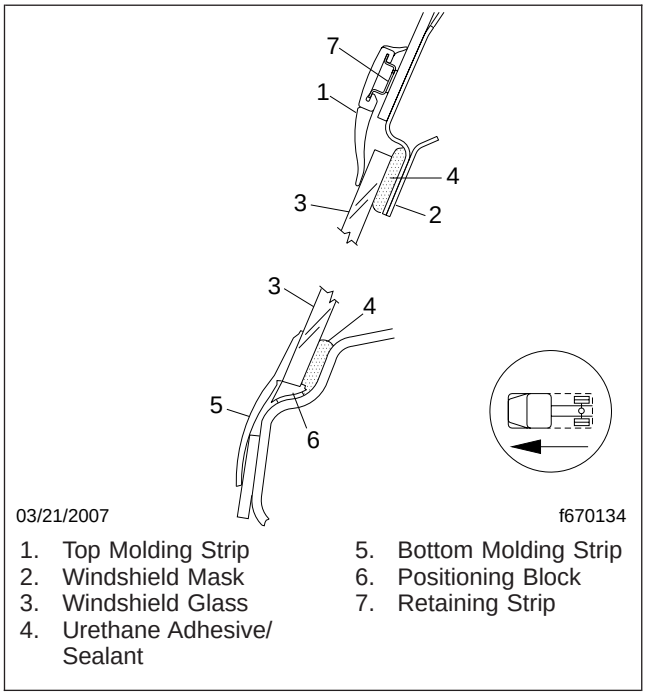
22. Using suction cups, carefully install the new windshield onto the windshield mask. Make sure the alignment marks on the glass are lined up with the center of the bolts holding the rain tray in place, and that the bottom edge of the windshield seats onto the positioning blocks correctly; see **Fig. 10** or **Fig. 11**.



1. Top Molding Strip
2. Windshield Mask
3. Windshield Glass
4. Urethane Sealant
5. Bottom Molding Strip
6. Positioning Block

Fig. 10, Cross-Section View (vehicles built before July 21, 2000)

23. Gently press down on the glass all the way around the bead line to firmly seat the windshield.
24. With a spatula or a paddle, smooth the adhesive flat along the edge of the windshield.
25. Install the center molding strip into the windshield center post, using Betaseal U-418 primerless auto glass urethane adhesive. Do not use a silicone hot glue.



1. Top Molding Strip
2. Windshield Mask
3. Windshield Glass
4. Urethane Adhesive/ Sealant
5. Bottom Molding Strip
6. Positioning Block
7. Retaining Strip

Fig. 11, Cross-Section View (vehicles built from July 21, 2000)

26. Apply Betaprime U-401 Glass Prep along the bottom outside edge of the windshield glass, then install the bottom rubber molding strip, using Betaseal U-418 primerless auto glass urethane adhesive.
27. Slide the top molding strip onto the retainer strip, if so equipped. Fasten each end of the strip to the A-pillar with a Torx screw and bushing; see **Fig. 5**.

NOTE: Vehicles built before July 21, 2000 are not equipped with a retainer strip; apply Betaprime U-401 Glass Prep to the top outside edge of the glass, then attach the molding strip using Betaseal U-418 primerless auto glass urethane adhesive.

28. Attach the A-pillar exterior panel to the top of the door frame with a capscrew; see **Fig. 3**.
29. If the vehicle is a Coronado, install the two fasteners that attach the middle span of the panel to the A-pillar; see **Fig. 2**.

Two-Piece Windshield Replacement, Century Class Conventional and Coronado

If the vehicle is a Century Class Conventional, install the A-pillar exterior panel mounting nuts and interior trim, as follows.

29.1 Through the access holes on the A-pillar, install the three nuts that attach the exterior panel to the A-pillar; see **Fig. 4**.

29.2 If applicable, connect the sensor for the Eaton® VORAD® collision warning system, located on the inside of the right-hand A-pillar.

29.3 Install the A-pillar interior trim, then secure the door trim; see **Fig. 3**.

29.4 If applicable, attach the grab handle to the right-hand A-pillar.

30. Secure the lower end of the A-pillar exterior panel with a capscrew; see **Fig. 2**.
31. Install the wiper arm(s); see **Group 82**.
32. Clean both sides of the new windshield glass.
33. Remove the protective coverings from the dash.
34. Install the exterior sun visor.
35. Close the hood.
36. Remove the chocks.
37. Let the urethane sealant cure for 30 minutes before driving the vehicle.

One-Piece Windshield Replacement, Argosy COE

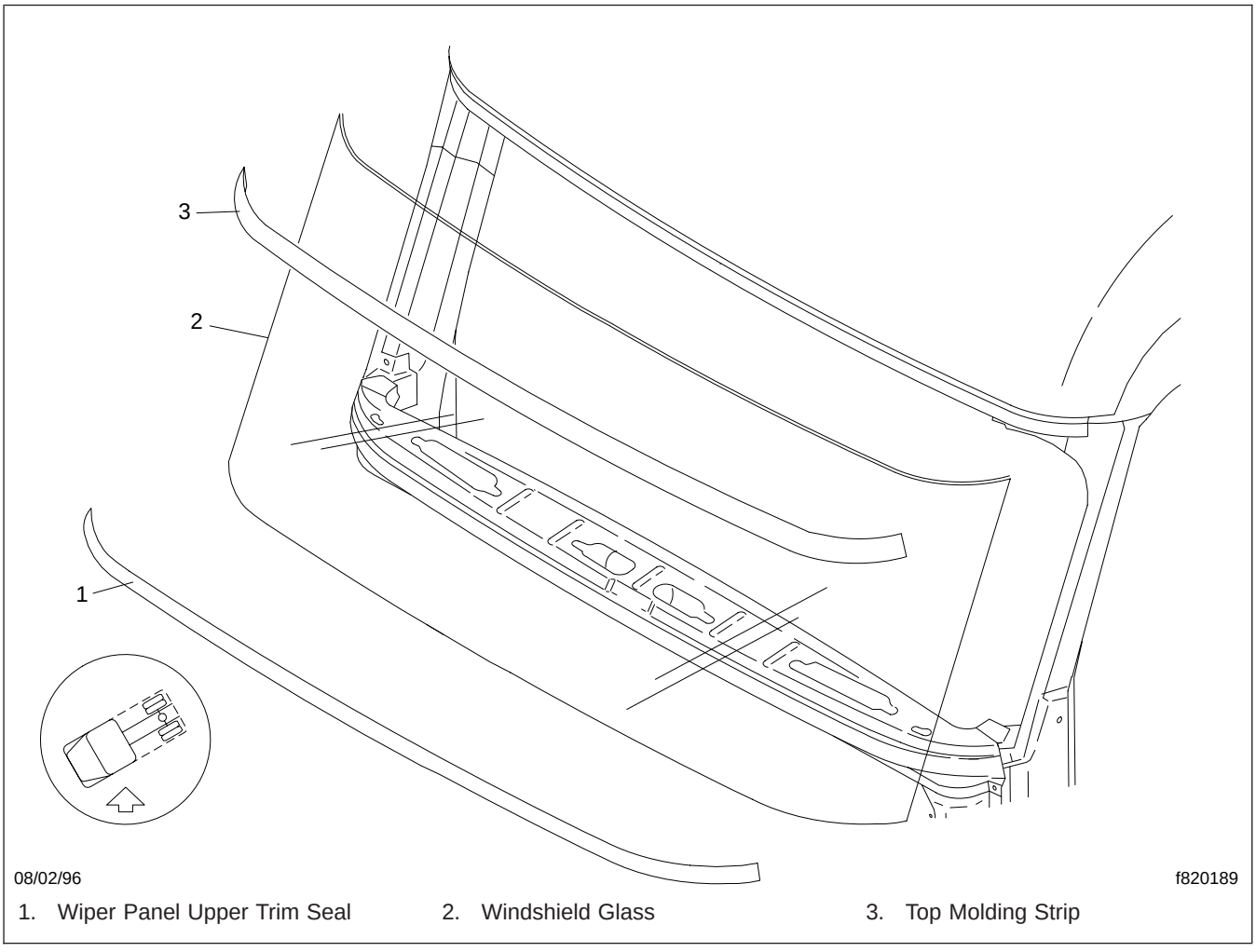
Replacement

See **Fig. 1** for a one-piece windshield installation.

If the windshield is cracked, carefully inspect the glass, urethane sealant, and the windshield mask to determine the cause. Correct the problem before installing a new windshield. If the underlying cause for the crack is not corrected, the replacement windshield may crack when exposed to high winds, pressure, temperature extremes, or vehicle motion.

NOTE: At least two people are needed to replace a windshield.

1. Apply the parking brakes and chock the tires.
2. Remove the windshield wiper arms; see **Group 82**.
3. Disconnect the windshield wiper fluid hoses.
4. Protect the paint finish and instrument panel by taping paper around the windshield opening.
5. Remove the lower capscrew from the exterior A-pillar panel.
6. The exterior panel mounting is concealed under the A-pillar interior trim. Remove the mounting nuts, as follows.
   - 6.1 Remove the grab handle from the right-hand A-pillar.

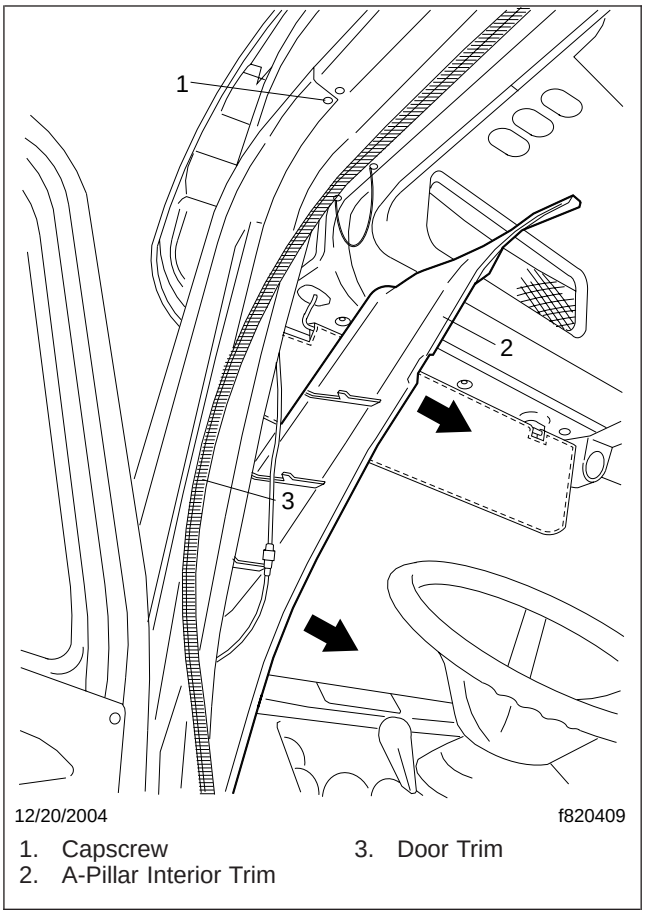


1. Wiper Panel Upper Trim Seal
2. Windshield Glass
3. Top Molding Strip

Fig. 1, One-Piece Windshield Installation

One-Piece Windshield Replacement, Argosy COE

6.2 On both sides of the vehicle, loosen the door trim, then remove the A-pillar interior trim; see **Fig. 2**.



1. Capscrew
2. A-Pillar Interior Trim
3. Door Trim

Fig. 2, Removing A-Pillar Interior Trim

6.3 If the vehicle is equipped with an Eaton® VORAD® collision warning system, disconnect the sensor located on the inside of the right-hand A-pillar.

6.4 Through the access holes on each A-pillar, remove the three nuts that attach the exterior panel to the A-pillar; see **Fig. 3**.

7. Remove the capscrew that attaches the exterior A-pillar panel to the top of the door frame; see **Fig. 2**. Remove the panel.
8. Remove the Torx® screw and bushing at each end of the top molding strip; see **Fig. 4**.
9. Slide the top molding strip off the retainer strip.

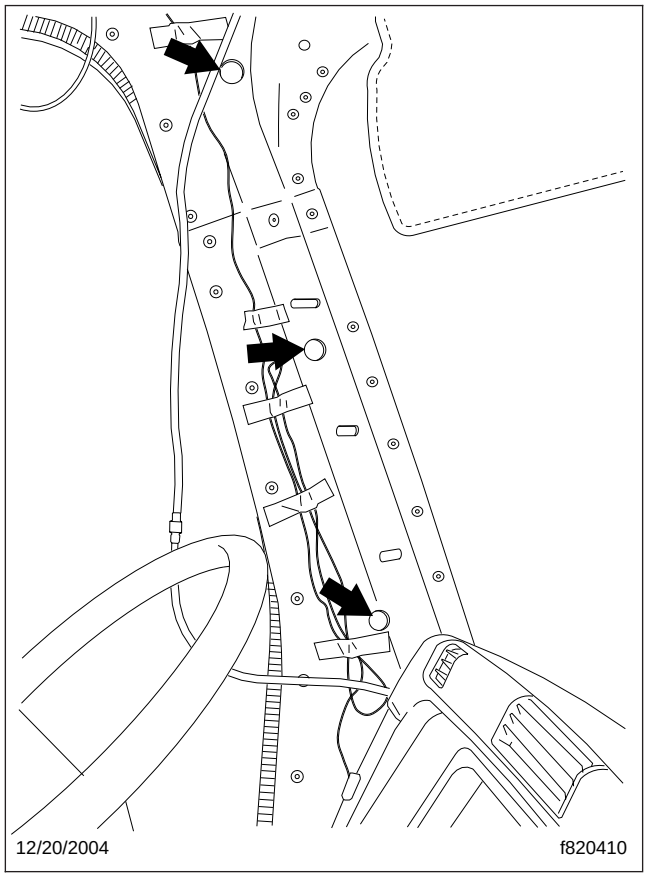


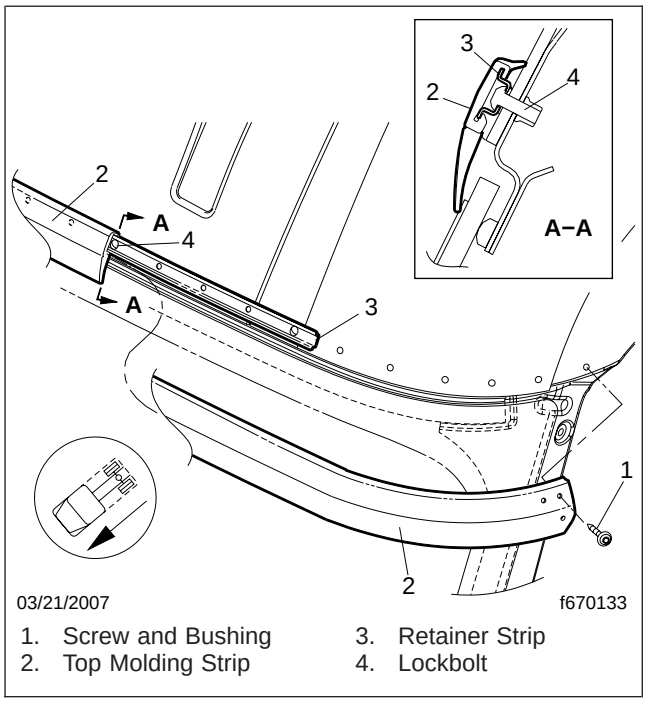
Fig. 3, A-Pillar Fastener Access Holes

NOTE: Vehicles built before July 21, 2000 are not equipped with a retainer strip; remove the top molding strip by pulling it loose from the gap between the windshield glass and the windshield mask.

10. Remove the wiper panel upper trim seal.
11. Remove the exterior sunvisor.
12. Using a pneumatic cutting tool (**Fig. 5**), a piano wire (**Fig. 6**), or a pull knife (**Fig. 7**), cut through the urethane sealant all around the edges of the windshield glass.

NOTE: To order a BTB pneumatic cutting tool, see **Specifications 400**.

13. Remove the four rubber positioning blocks from the lower windshield mask; see **Fig. 8**. Discard them.



1. Screw and Bushing
2. Top Molding Strip
3. Retainer Strip
4. Lockbolt

Fig. 4, Top Molding Strip Installation

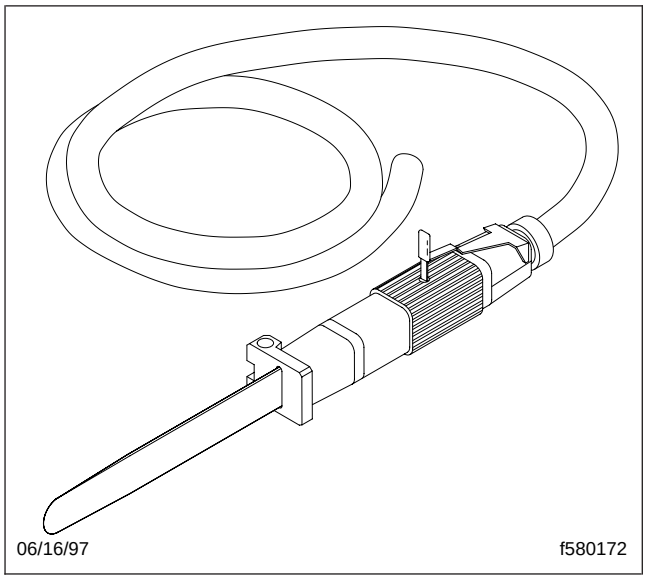
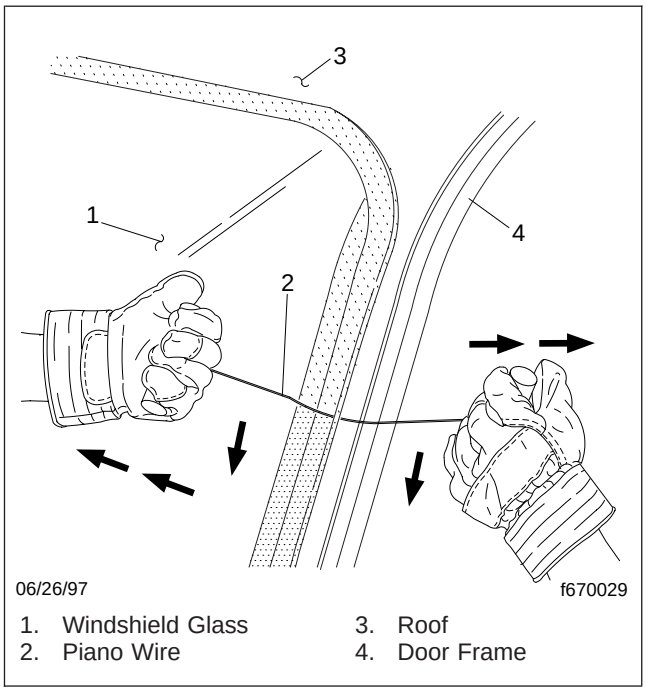


Fig. 5, BTB Pneumatic Cutting Tool



1. Windshield Glass
2. Piano Wire
3. Roof
4. Door Frame

Fig. 6, Windshield Glass Removal with Piano Wire

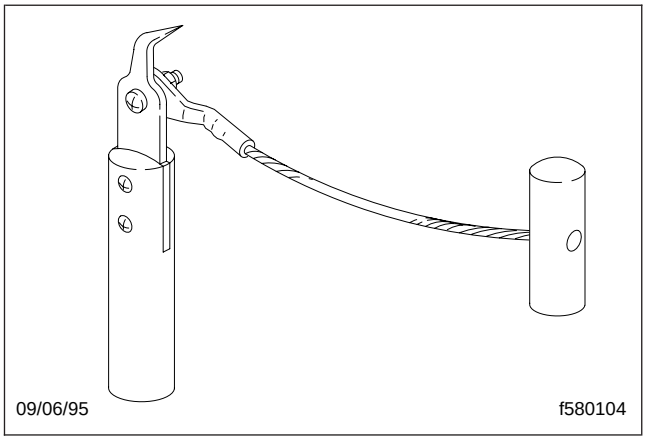


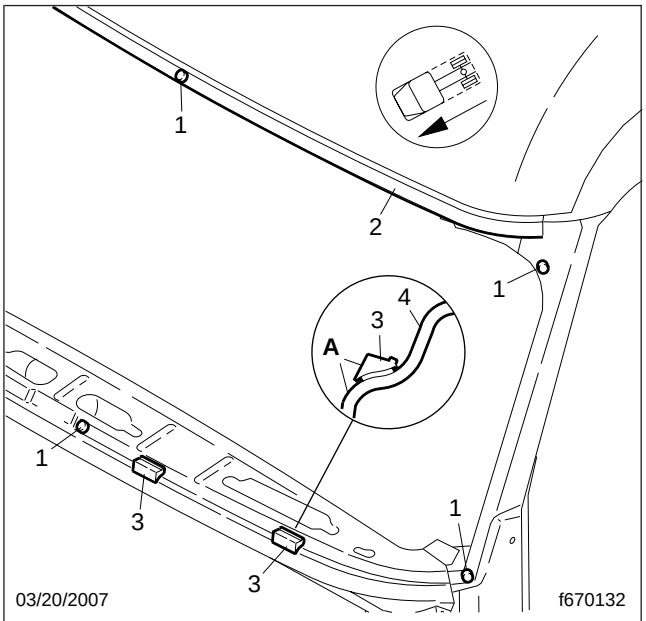
Fig. 7, Typical Pull Knife

⚠ WARNING

Wear protective gloves and safety glasses when replacing windshield glass. Gloves will protect your hands from sharp edges, and allow a better grip. Failure to wear gloves and safety glasses when handling glass could result in injury to hands or eyes.

14. Carefully remove the damaged windshield glass.

One-Piece Windshield Replacement, Argosy COE



A. These two surfaces are to be flush.

1. Spacer Button
2. Windshield Mask (upper)
3. Positioning Block
4. Windshield Mask (lower)

Fig. 8, Cab Area for Windshield Installation

15. Using a BTB pneumatic cutting tool or a sharp knife, trim down the old urethane sealant to a thickness of about 1/8 inch (3 mm).
16. Brush the remaining adhesive and debris from the windshield-seating cavity.
17. Check the windshield mask. Apply Betaprime® U-413 Body Primer to any bare metal.
18. Install eight spacer buttons on the windshield mask; see **Fig. 8**.
19. Install four new rubber positioning blocks in the cavity; see **Fig. 8**.
20. Prepare the new windshield glass, as follows.
    - 20.1 Put the new windshield glass on a suitable stand or fixture, with the inside surface of the glass facing up.
    - 20.2 Clean the edges of the glass with a 50/50 mixture of isopropyl alcohol and water.
    - 20.3 Apply Betaprime U-401 Glass Prep all the way around the edge of the glass to a width of about 1-1/2 inches (40 mm).
    - 20.4 Wait five seconds, then wipe off the glass prep, using a clean, lint-free cloth.
    - 20.5 Apply Betaprime U-402 Glass Primer all the way around the edge of the glass to a width of about 1 inch (25 mm). *Do not get any of the primer on the black dot pattern of the glass.* Apply one streak-free coat.
21. Using the manufacturer's directions, load the Betagun® III electric caulking gun with Betaseal® U-216 two-part urethane adhesive/sealant. Extrude a bead about 10 inches (250 mm) long into a waste can. This will ensure complete mixing, and removal of any air pockets.

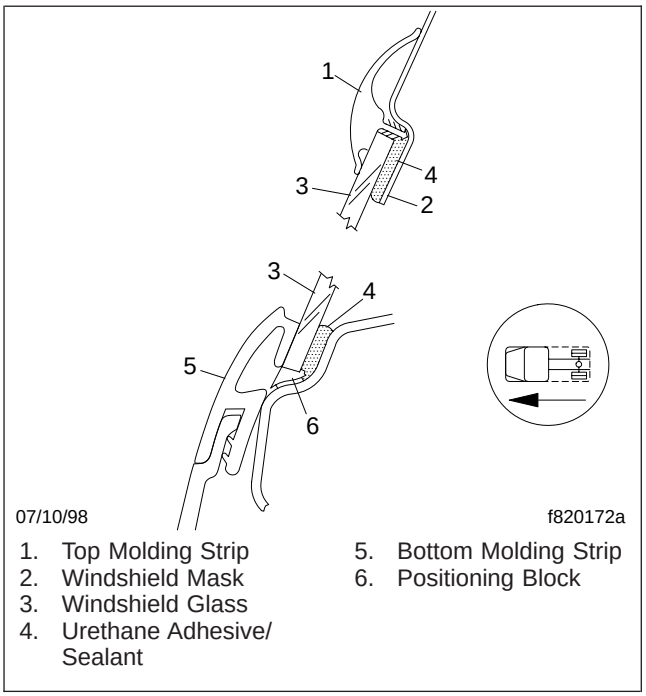
    Apply a uniform and continuous bead all the way around the edges of the windshield mask on the cab. The bead should be a minimum of 3/8 inch (10 mm) thick.

    Keep the spiked edge of the applicator tip against the edge of the mask, and overlap the bead slightly.

IMPORTANT: Do not apply the urethane adhesive/sealant to the windshield glass. Aligning a windshield with adhesive on the glass is very difficult to do without getting the adhesive/sealant on the painted cab surface outside the windshield mask.

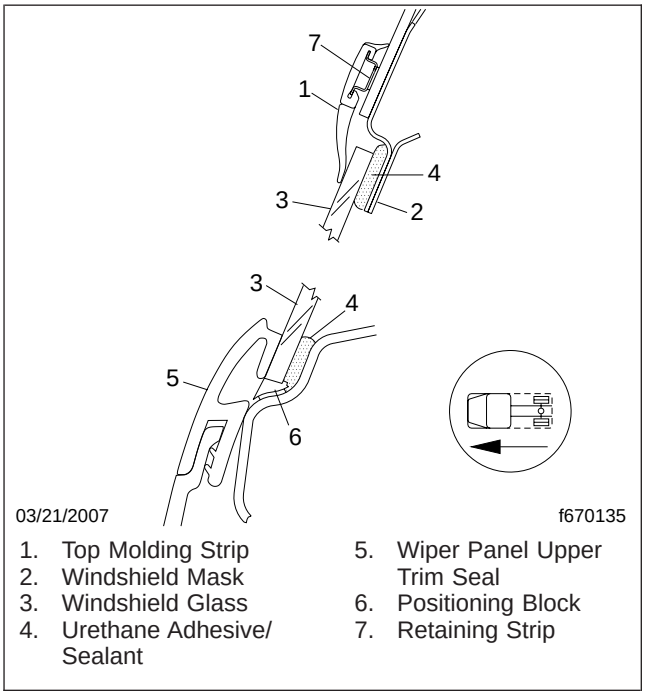
22. Attach a suction device to the outside of the windshield. Lift and install the windshield. Make sure the glass is centered on the windshield mask, and that the bottom edge of the glass seats onto the positioning blocks correctly; see **Fig. 9** or **Fig. 10**.
23. Gently press down on the glass all the way around the bead line to firmly seat the windshield.
24. With a spatula or a paddle, smooth the adhesive flat along the edge of the windshield.
25. Apply Betaprime U-401 Glass Prep along the bottom outside edge of the windshield glass, then install the wiper panel upper trim seal, using Betaseal U-418 primerless auto glass urethane adhesive. Do not use a silicone hot glue.
26. Slide the top molding strip onto the retainer strip, if so equipped. Fasten each end of the strip to the A-pillar with a Torx screw and bushing; see **Fig. 4**.

One-Piece Windshield Replacement, Argosy COE



1. Top Molding Strip
2. Windshield Mask
3. Windshield Glass
4. Urethane Adhesive/ Sealant
5. Bottom Molding Strip
6. Positioning Block

Fig. 9, Cross-Section View (vehicles built before July 21, 2000)



1. Top Molding Strip
2. Windshield Mask
3. Windshield Glass
4. Urethane Adhesive/ Sealant
5. Wiper Panel Upper Trim Seal
6. Positioning Block
7. Retaining Strip

Fig. 10, Cross-Section View (vehicles built from July 21, 2000)

NOTE: Vehicles built before July 21, 2000 are not equipped with a retainer strip; apply Betaprime U-401 Glass Prep to the top outside edge of the glass, then attach the molding strip using Betaseal U-418 primerless auto glass urethane adhesive.

27. Attach each A-pillar exterior panel to the top of the door frame with a capscrew; see **Fig. 2**.
28. Install the A-pillar exterior panel mounting nuts and interior trim, as follows.
    - 28.1 Through the access holes on each A-pillar, install the three nuts that attach the exterior panel to the A-pillar; see **Fig. 3**.
    - 28.2 If the vehicle is equipped with an Eaton® VORAD® collision warning system, connect the sensor located on the inside of the right-hand A-pillar.
    - 28.3 On both sides of the vehicle, install the A-pillar interior trim, then secure the door trim; see **Fig. 2**.
    - 28.4 Attach the grab handle to the right-hand A-pillar.
29. Secure the lower end of the A-pillar exterior panel with a capscrew.
30. Connect the windshield wiper fluid hoses.
31. Install the wiper arms; see **Group 82**.
32. Clean both sides of the new windshield glass.
33. Remove the protective coverings from the dash.
34. Install the exterior sunvisor.
35. Remove the chocks.
36. Let the urethane sealant cure for 30 minutes before driving the vehicle.

Two-Piece Windshield Replacement, Argosy COE

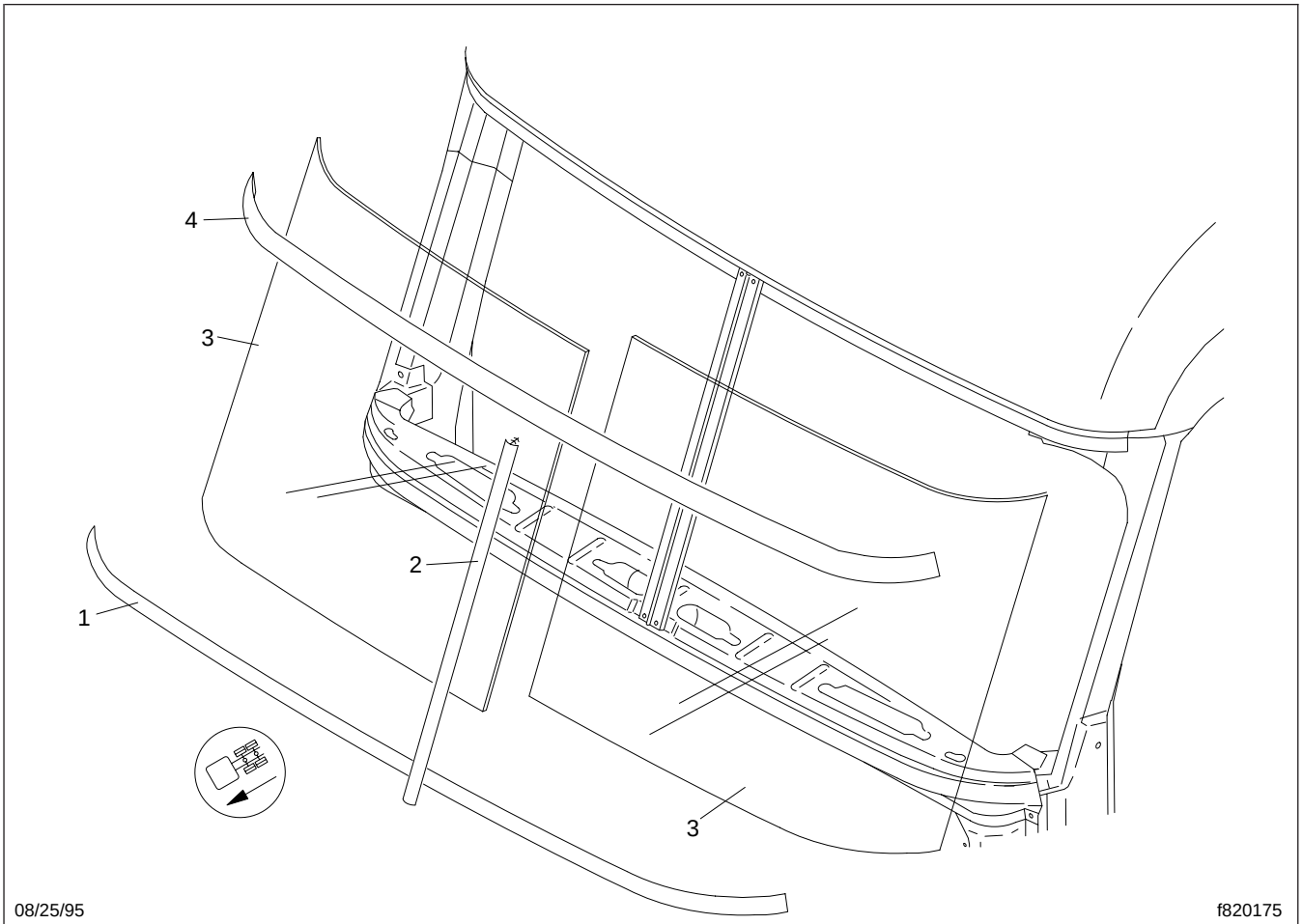
Replacement

See **Fig. 1** for a two-piece windshield installation.

If the windshield is cracked, carefully inspect the glass, urethane sealant, and the windshield mask to determine the cause. Correct the problem before installing a new windshield. If the underlying cause for the crack is not corrected, the replacement windshield may crack when exposed to high winds, pressure, temperature extremes, or vehicle motion.

NOTE: At least two people are needed to replace a windshield.

1. Apply the parking brakes and chock the tires.
2. Remove the windshield wiper arms; see **Group 82**.
3. Protect the paint finish and instrument panel by taping paper around the windshield opening.
4. Remove the capscrew that attaches the lower end of the exterior A-pillar panel to the wiper panel.
5. The exterior panel mounting is concealed under the A-pillar interior trim. Remove the mounting nuts, as follows.



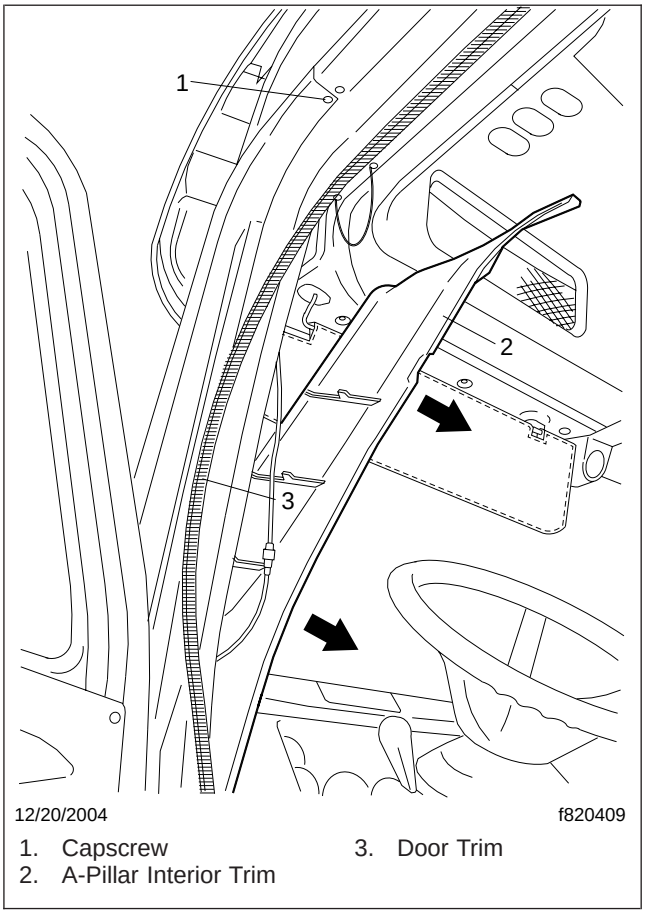
1. Wiper Panel Upper Trim Seal
2. Center Molding Strip
3. Windshield Glass
4. Top Molding Strip

Fig. 1, Two-Piece Windshield Installation

Two-Piece Windshield Replacement, Argosy COE

5.1 If applicable, remove the grab handle from the right-hand A-pillar.

5.2 Loosen the door trim, then remove the A-pillar interior trim; see **Fig. 2**.



1. Capscrew
2. A-Pillar Interior Trim
3. Door Trim

Fig. 2, Removing A-Pillar Interior Trim

5.3 If applicable, disconnect the sensor for the Eaton® VORAD® collision warning system, located on the inside of the right-hand A-pillar.

5.4 Through the access holes on the A-pillar, remove the three nuts that attach the exterior panel to the A-pillar; see **Fig. 3**.

6. Remove the capscrew that attaches the exterior A-pillar panel to the top of the door frame; see **Fig. 2**. Remove the panel.
7. Remove the center molding strip from the windshield center post; see **Fig. 1**.

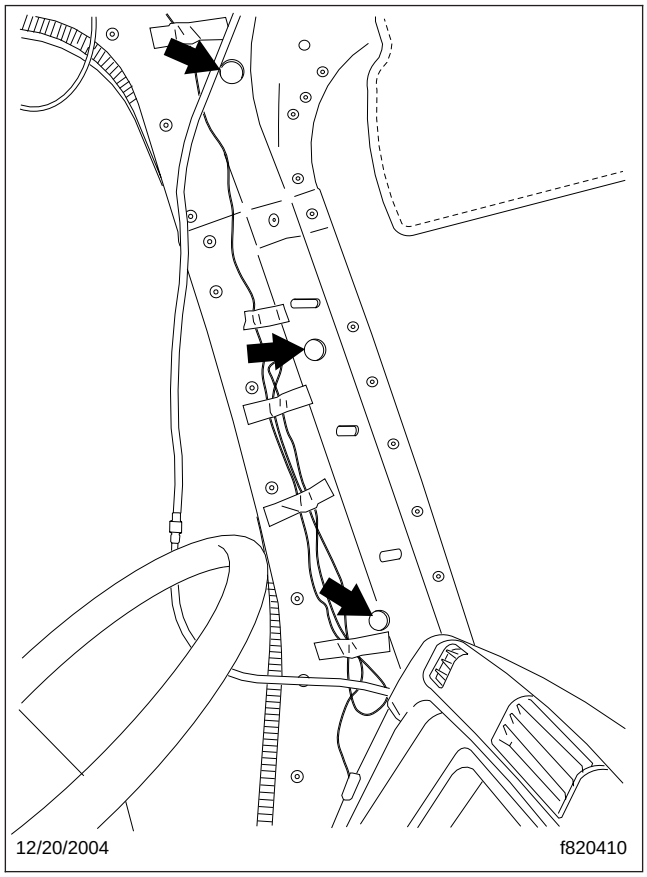


Fig. 3, A-Pillar Fastener Access Holes

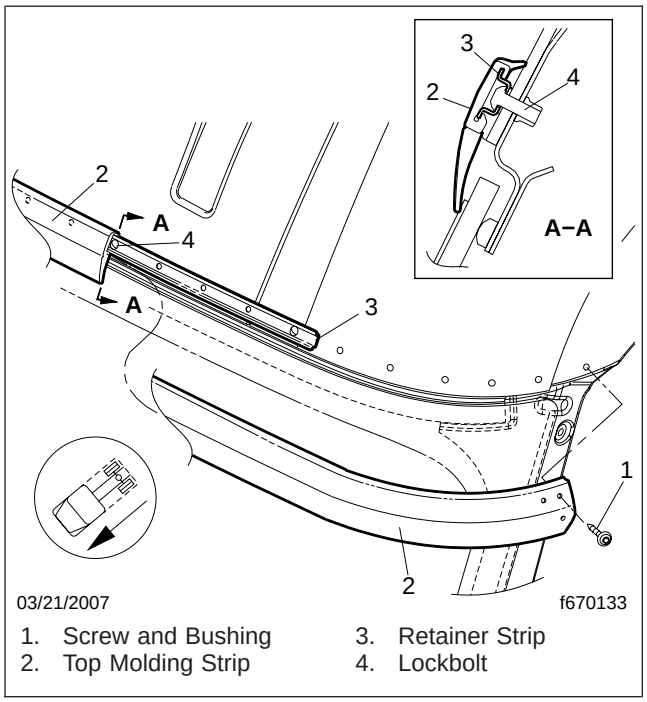
8. Remove the Torx® screw and bushing at each end of the top molding strip; see **Fig. 4**.
9. Slide the top molding strip off the retainer strip.

NOTE: Vehicles built before July 21, 2000 are not equipped with a retainer strip; remove the top molding strip by pulling it loose from the gap between the windshield glass and the windshield mask.

10. Remove the wiper panel upper trim seal.
11. Remove the exterior sunvisor.
12. Using a pneumatic cutting tool (**Fig. 5**), a piano wire (**Fig. 6**), or a pull knife (**Fig. 7**), cut through the urethane sealant all around the edges of the windshield glass.

NOTE: To order a BTB pneumatic cutting tool, see **Specifications 400**.

Two-Piece Windshield Replacement, Argosy COE



1. Screw and Bushing
2. Top Molding Strip
3. Retainer Strip
4. Lockbolt

Fig. 4, Top Molding Strip Installation

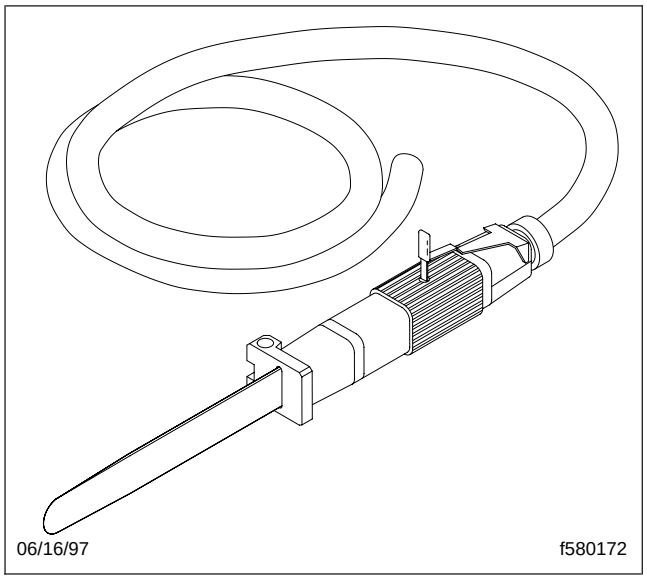
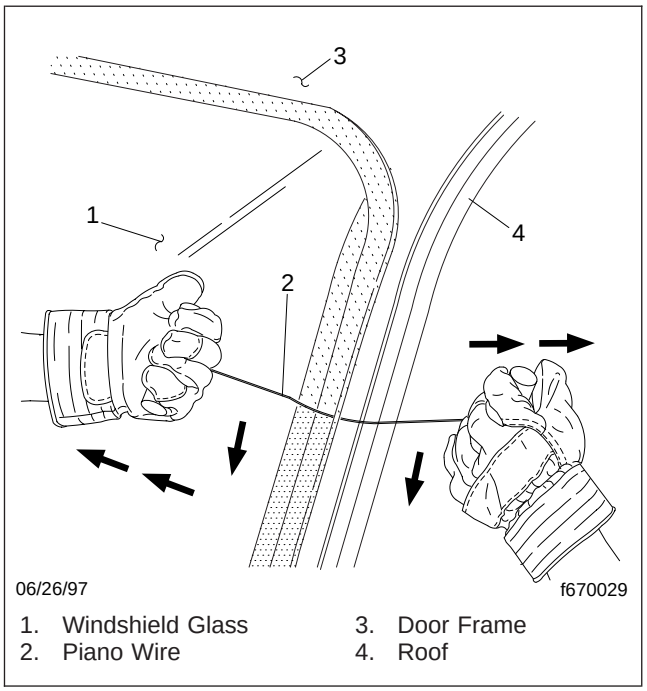


Fig. 5, BTB Pneumatic Cutting Tool



1. Windshield Glass
2. Piano Wire
3. Door Frame
4. Roof

Fig. 6, Windshield Glass Removal with Piano Wire

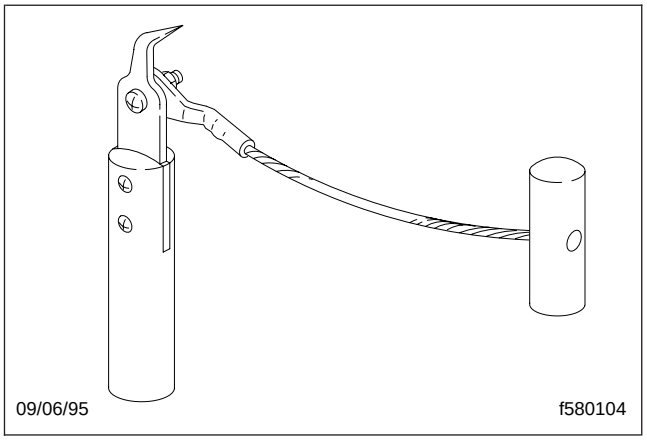


Fig. 7, Typical Pull Knife

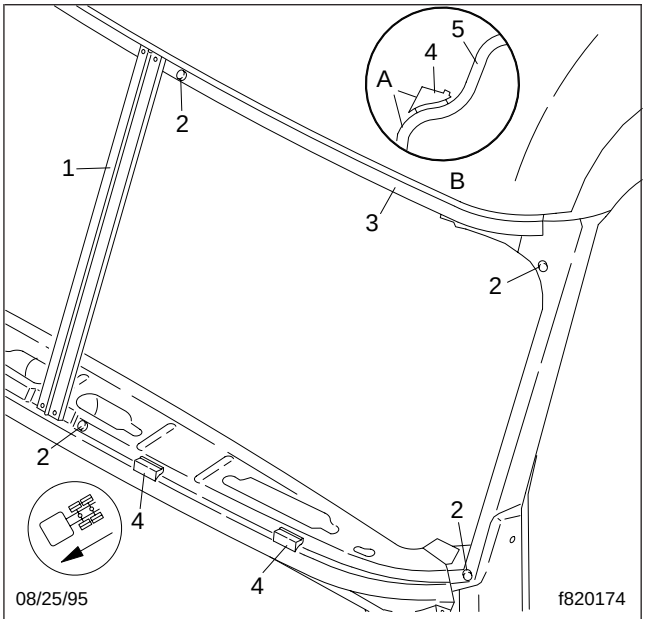
⚠ WARNING

Wear protective gloves and safety glasses when replacing windshield glass. Gloves will protect your hands from sharp edges, and allow a better grip. Failure to wear gloves and safety glasses when handling glass could result in injury to hands or eyes.

13. Carefully remove the damaged windshield glass.

Two-Piece Windshield Replacement, Argosy COE

14. Remove the rubber positioning blocks from the lower windshield mask; see **Fig. 8**. Discard them.



A. These two surfaces should be flush.
B. Cross-Section View

1. Center Post
2. Spacer Button
3. Windshield Mask (upper)
4. Positioning Block
5. Windshield Mask (lower)

Fig. 8, Cab Area for Windshield Installation

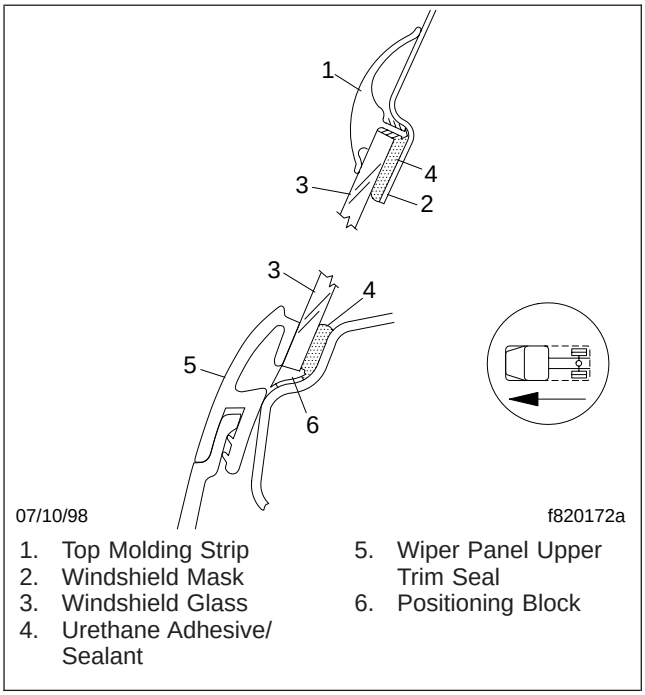
15. Using a BTB pneumatic cutting tool or a sharp knife, trim down the old urethane sealant to a thickness of about 1/8 inch (3 mm).
16. Brush the remaining adhesive and debris from the windshield-seating cavity.
17. Check the windshield mask. Apply Betaprime® U-413 Body Primer to any bare metal.
18. Install a spacer button in each corner of the windshield mask; see **Fig. 8**.
19. Install new positioning blocks at the bottom of the windshield mask. Make sure the front edge of each block is flush with the front edge of the windshield mask; see **Fig. 8**.
20. Prepare the new windshield glass, as follows.
    - 20.1 Put the new windshield glass on a suitable stand or fixture, with the inside surface of the glass facing up.
    - 20.2 Clean the edges of the glass with a 50/50 mixture of isopropyl alcohol and water.
    - 20.3 Apply Betaprime U-401 Glass Prep all the way around the edge of the glass to a width of about 1-1/2 inches (40 mm).
    - 20.4 Wait five seconds, then wipe off the glass prep, using a clean, lint-free cloth.
    - 20.5 Apply Betaprime U-402 Glass Primer all the way around the edge of the glass to a width of about 1 inch. *Do not get any of the primer on the black dot pattern of the glass.* Apply one streak-free coat.
21. Using the manufacturer's directions, load the Betagun® III electric caulking gun with Betaseal® U-216 two-part urethane adhesive/sealant. Extrude a bead about 10 inches (250 mm) long into a waste can. This will ensure complete mixing, and removal of any air pockets.

    Apply a uniform and continuous bead all the way around the edges of the windshield mask on the cab. The bead should be a minimum of 3/8 inch (10 mm) thick.

    Keep the spiked edge of the applicator tip against the edge of the mask, and overlap the bead slightly.

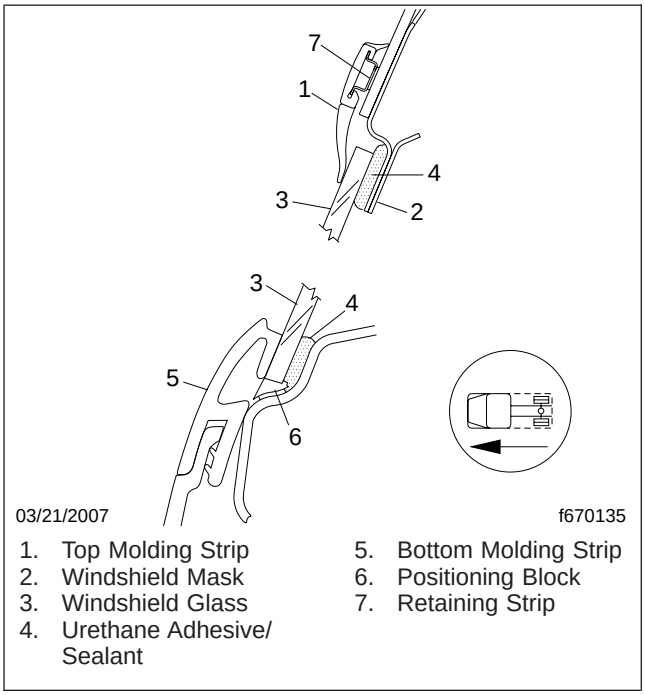
IMPORTANT: Do not apply the urethane adhesive/sealant to the windshield glass. Aligning a windshield with adhesive on the glass is very difficult to do without getting the adhesive/sealant on the painted cab surface outside the windshield mask.

22. Attach a suction device to the outside of the windshield. Lift and install the windshield. Make sure the glass is centered on the windshield mask, and that the bottom edge of the glass seats onto the positioning blocks correctly; see **Fig. 9** or **Fig. 10**.
23. Gently press down on the glass all the way around the bead line to firmly seat the windshield.
24. With a spatula or a paddle, smooth the adhesive flat along the edge of the windshield.
25. Install the center molding strip into the windshield center post.
26. Apply Betaprime U-401 Glass Prep along the bottom outside edge of the windshield glass,



1. Top Molding Strip
2. Windshield Mask
3. Windshield Glass
4. Urethane Adhesive/ Sealant
5. Wiper Panel Upper Trim Seal
6. Positioning Block

Fig. 9, Cross-Section View (vehicles built before July 21, 2000)



1. Top Molding Strip
2. Windshield Mask
3. Windshield Glass
4. Urethane Adhesive/ Sealant
5. Bottom Molding Strip
6. Positioning Block
7. Retaining Strip

Fig. 10, Cross-Section View (vehicles built from July 21, 2000)

then install the wiper panel upper trim seal, using Betaseal U-418 primerless auto glass urethane adhesive. Do not use a silicone hot glue.

27. Slide the top molding strip onto the retainer strip, if so equipped. Fasten each end of the strip to the A-pillar with a Torx screw and bushing; see **Fig. 4**.

NOTE: Vehicles built before July 21, 2000 are not equipped with a retainer strip; apply Betaprime U-401 Glass Prep to the top outside edge of the glass, then attach the molding strip using Betaseal U-418 primerless auto glass urethane adhesive.

28. Attach the A-pillar exterior panel to the top of the door frame with a capscrew; see **Fig. 2**.
29. Install the A-pillar exterior panel mounting nuts and interior trim, as follows.
    - 29.1 Through the access holes on the A-pillar, install the three nuts that attach the exterior panel to the A-pillar; see **Fig. 3**.
    - 29.2 If applicable, connect the sensor for the Eaton® VORAD® collision warning system, located on the inside of the right-hand A-pillar.
    - 29.3 If applicable, install the A-pillar interior trim, then secure the door trim; see **Fig. 2**.
    - 29.4 Attach the grab handle to the right-hand A-pillar.
30. Secure the lower end of the A-pillar exterior panel with a capscrew to the wiper panel.
31. Install the wiper arms; see **Group 82**.
32. Clean both sides of the new windshield glass.
33. Remove the protective coverings from the dash.
34. Install the exterior sunvisor.
35. Remove the chocks.
36. Let the urethane sealant cure for 30 minutes before driving the vehicle.

See **Table 1** for the materials and tools needed for windshield installation. The items in **Table 1** are available from your local Dow/Essex dealer.

Materials and Tools Needed for Windshield Installation	
Material or Tool	**Part Number**
Betaprime® Glass Prep	U-401
Betaprime Glass Primer	U-402
Betaprime Body Primer	U-413
Betaseal® Two-Part Adhesive	U-216
Betaseal Primerless Auto Glass Adhesive	U-418
Betagun® III Electric Caulking Gun	Betagun III

Table 1, Materials and Tools Needed for Windshield Installation

See **Fig. 1** and **Fig. 2** for the special tools needed for windshield removal.

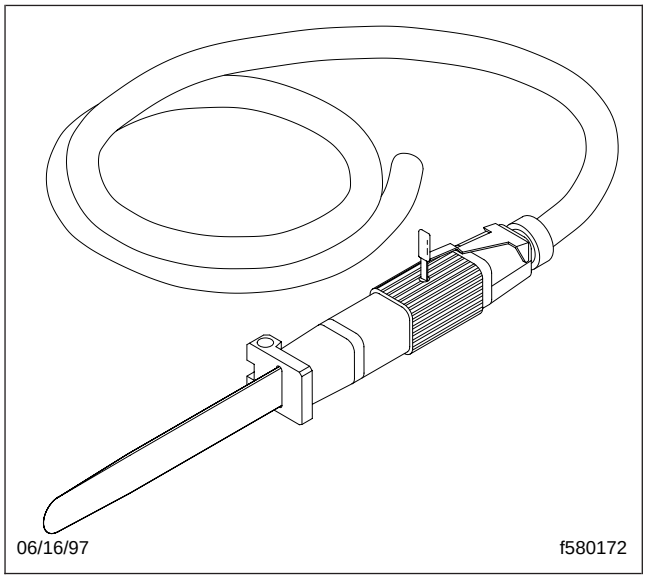


Fig. 1, BTB Pneumatic Cutting Tool

To obtain the BTB pneumatic cutting tool (J–43029) contact:

SPX Kent-Moore
28635 Mound Road
Warren, Michigan 48092-3499
1-800-328-6657

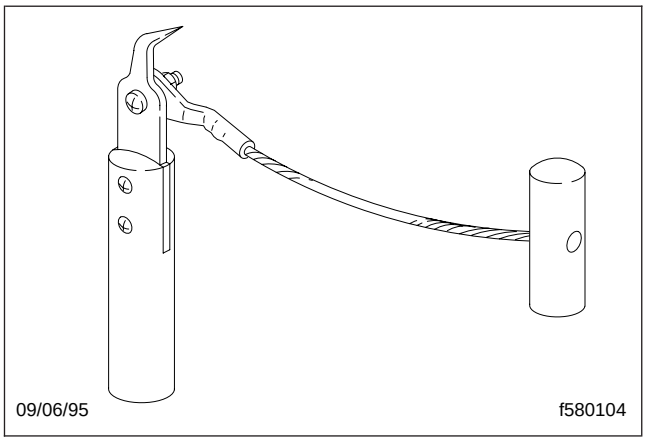


Fig. 2, Typical Pull Knife

General Information

Cab air-suspension systems consist of two air springs, a height-control valve, a lateral control rod or sway bar, two shock absorbers, and a vertical linkage; see **Fig. 1**, **Fig. 2**, and **Fig. 3**.

The cab rear air-suspension system absorbs road shocks better than a solid-mount system, and thus provides a smoother ride for cab occupants and cab-mounted equipment.

Air Springs

The top of the air spring is mounted to a bracket on the cab underbody, and the bottom is mounted to a bracket on the frame rail crossmember. On Argosy COEs, the air springs are connected to the sway bar assembly and the hydraulic cab latches. Together with the height-control valve, the air springs compensate for changes in cab load by maintaining the correct cab height at the rear of the cab.

Height-Control Valve

NOTE: If a leak occurs in the cab air-suspension system, a pressure protection valve (located at the secondary air tank, which supplies the air to the height-control valve) will maintain a minimum pressure of about 65 psi (450 kPa) in the vehicle secondary air system.

All of the air in the cab air-suspension system is admitted through or exhausted from the height-control valve. It mounts on the control rod bracket, which is attached to the frame rail. The height-control valve has a horizontal control lever, the outboard end of which is connected to a vertical linkage. The upper end of the vertical linkage is attached to the cab underbody.

When the load on the cab increases, the dimension between the cab and the crossmember decreases, causing the vertical linkage to push downward on the end of the horizontal control lever. This turns the height-control valve shaft, which activates the height-control valve. Air flows through the valve and into the air springs until the pressure in the springs raises the cab to the correct height. At this height, the control lever and the control shaft are returned to their neutral positions, closing the intake air supply.

When the load on the cab decreases, the rear of the cab rises, causing the vertical linkage to pull up on the end of the horizontal control lever. Turning the height-control valve shaft in this direction activates an exhaust port in the valve. This allows air pressure in the air springs to decrease until the cab is lowered to the correct height. Again, the control lever and control shaft are returned to their neutral positions, and air flow is stopped.

When the vehicle is in motion, small and abrupt movements of the cab will occur, resulting in small or abrupt movements of the control lever. These movements of the control lever do not activate the height-control valve to correct the cab ride height.

Changes in load that occur when occupants or heavy items are added to or removed from the cab will activate the height-control valve to correct the cab ride height. Also, when the vehicle is moving forward at high speed or in a high headwind, a major change in load occurs from the downforce applied to an optional air shield or air fairing. When these changes in load occur, the cab air-suspension system will correct the cab ride height at the rear of the cab.

Lateral Control Rod

On the Century Class Conventional, the lateral control rod limits the side-to-side motion of the rear of the cab. The inboard end of the control rod is mounted on the crossmember bracket that the height-control valve is mounted to, and the outboard end is attached to a bracket on the cab underbody.

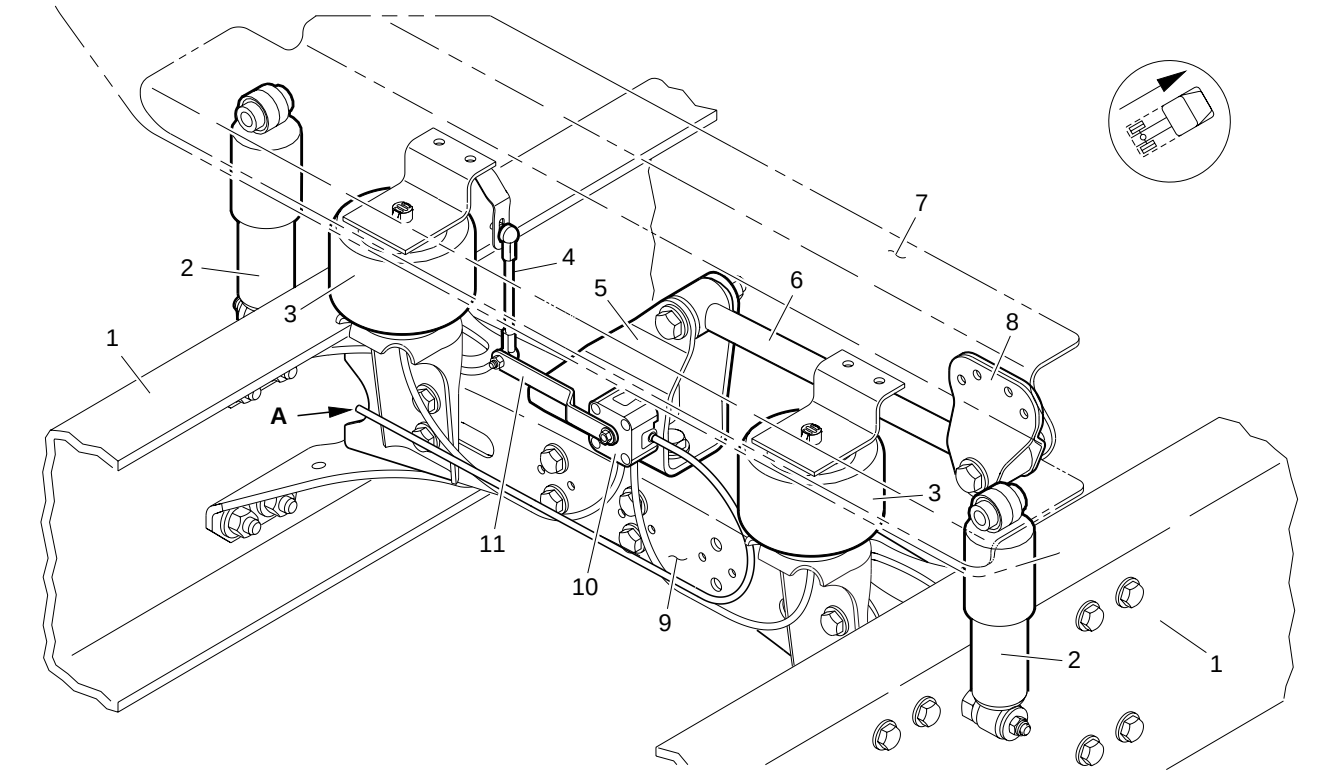
Sway Bar

On the Argosy COE, a sway bar extends between the two air spring assemblies, and is supported on the overslung crossmember. The sway bar limits cab roll and the side-to-side movement of the cab.

Shock Absorbers

The shock absorbers control the air spring and cab suspension movement, and dampen oscillation in the cab suspension system.

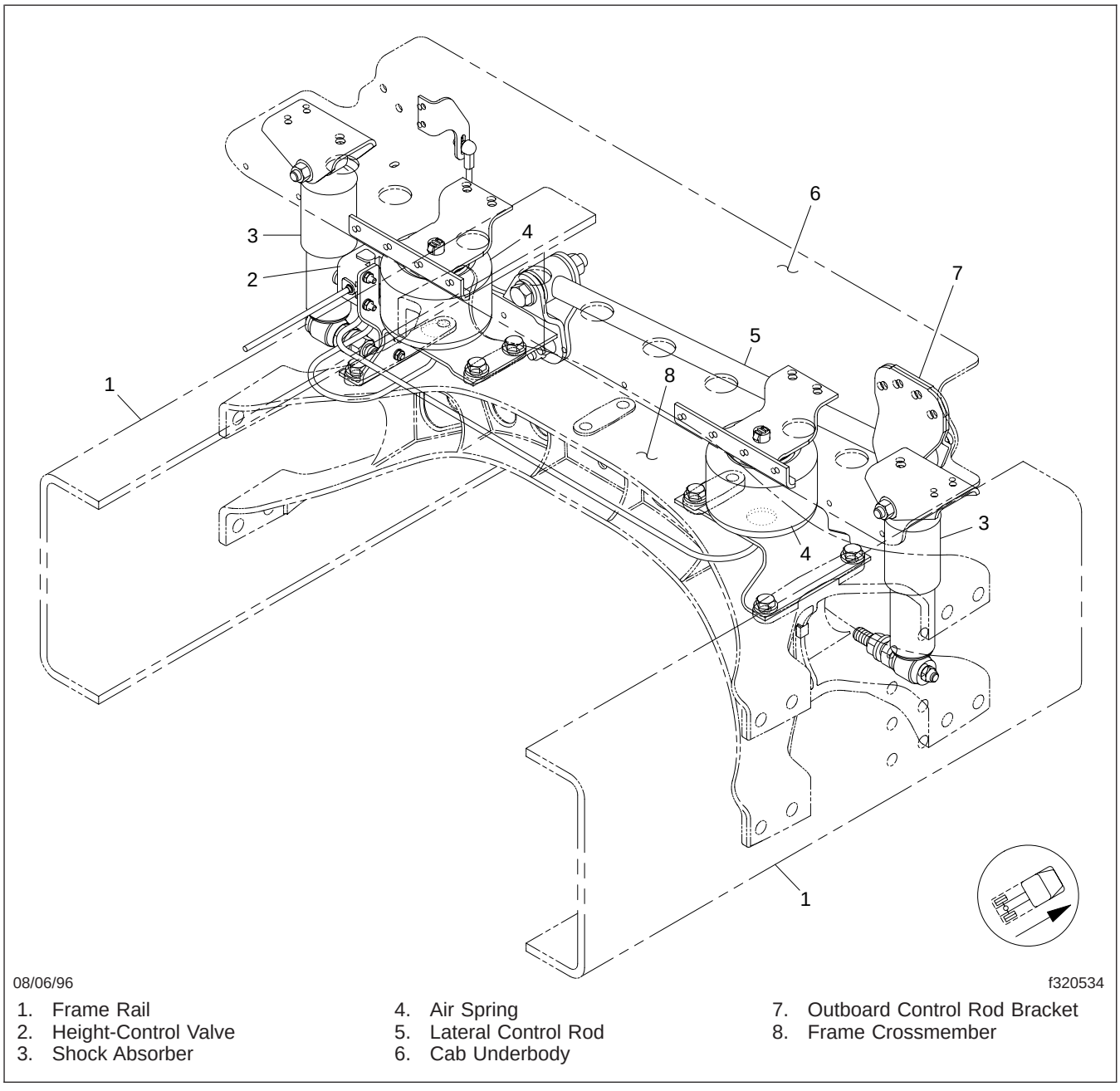
General Information



A. From secondary air tank

1. Frame Rail
2. Shock Absorber
3. Air Spring
4. Vertical Linkage Rod
5. Mounting Bracket
6. Lateral Control Rod
7. Cab Underbody
8. Outboard Control Rod Bracket
9. Frame Crossmember
10. Height-Control Valve
11. Horizontal Control Lever

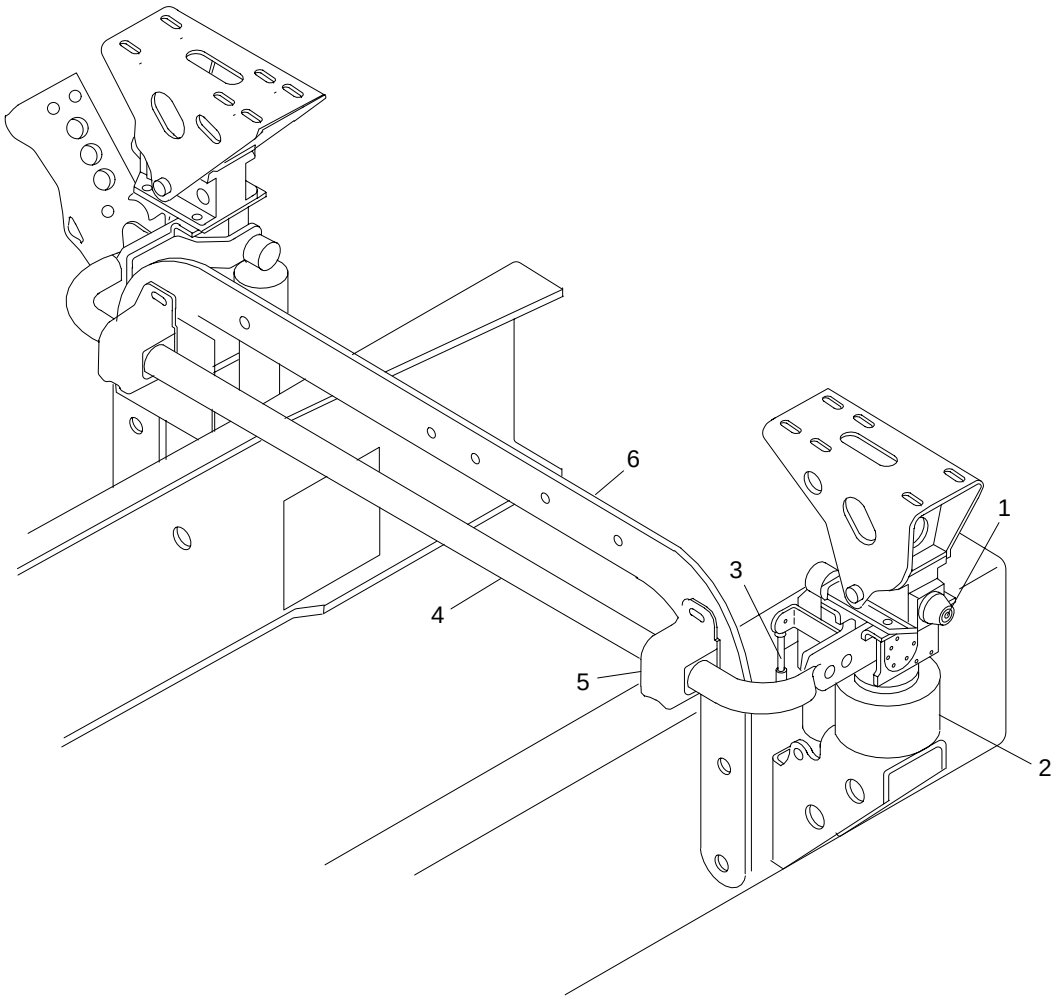
Fig. 1, Cab Rear Air-Suspension Installation, Century Class Conventional SleeperCab



1. Frame Rail
2. Height-Control Valve
3. Shock Absorber
4. Air Spring
5. Lateral Control Rod
6. Cab Underbody
7. Outboard Control Rod Bracket
8. Frame Crossmember

Fig. 2, Cab Rear Air-Suspension Installation, Century Class Conventional Day Cab

General Information



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1. Indicator Pin
2. Air Spring
3. Vertical Linkage
4. Sway Bar
5. Sway Bar Support Bracket
6. Overslung Crossmember

Fig. 3, Cab Rear Air Suspension Assembly, Argosy COE

If it is necessary to remove a Barksdale height-control valve from a mounting bracket, note the following.

CAUTION

When removing or loosening a Barksdale height-control valve from a mounting bracket, always hold the valve-side mounting studs in place with an Allen wrench while loosening or tightening the nuts that attach the valve to the bracket. Because the mounting studs are threaded into the valve body, loosening the nuts without holding the studs can tighten the studs, which can crush the valve body and damage the valve. Conversely, tightening the nuts without holding the studs can back the studs out, causing a separation of the two halves of the valve body, and possibly a leak.

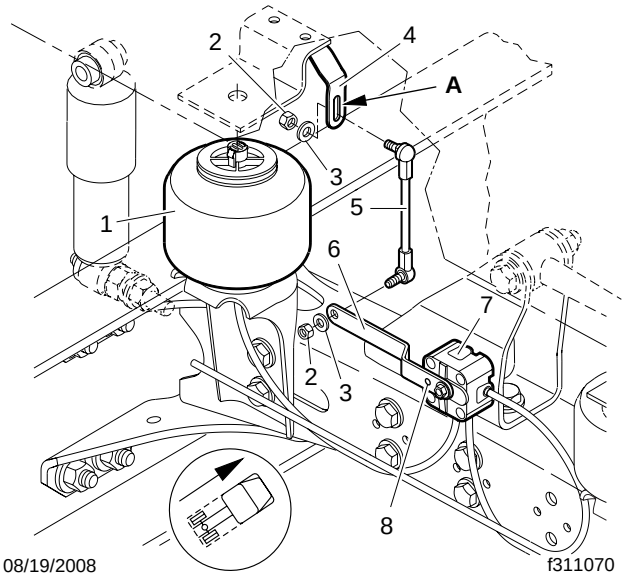
Height Adjustment

Century Class Conventional

1. Park the vehicle on a level surface, apply the parking brakes, and chock the tires.
2. Run the engine to build vehicle air pressure to at least 100 psi (690 kPa). Turn off the engine and wait 5 to 10 minutes for the system to equalize.
3. Disconnect the vertical linkage from the slotted hole in the bracket under the cab deck; see **Fig. 1**.

NOTE: On a day cab air suspension, the height-control valve is mounted outboard of the left-side air spring; see **Fig. 2**.

4. Raise the control lever on the height-control valve to exhaust the air from the air springs.
5. Lower the control lever on the height-control valve to fill the air springs. Raise the cab until the distance from the rear cab underbody flange to the lower shock absorber bolt is 9-1/16 to 9-7/16 inches (231 to 240 mm); see **Fig. 3** and **Fig. 4**.
6. Lock the height-control valve in the neutral position by inserting a 5/32-inch (4-mm) pin or drill bit in the neutral-position hole in the height-control valve and the horizontal control lever.
7. With the height-control valve locked in the neutral position, connect the vertical linkage to the bracket under the cab deck. The vertically slotted hole in the bracket allows for the height adjustment. Tighten the nut 96 lbf·in (1080 N·cm).
8. Remove the pin or drill bit previously inserted in the height-control valve.
9. Check the cab height again. The distance from the rear cab underbody flange to the lower shock absorber bolt should be 9-1/16 to 9-7/16 inches (231 to 240 mm). If the height is not correct, repeat the entire procedure.



A. Slotted hole allows for height adjustment.

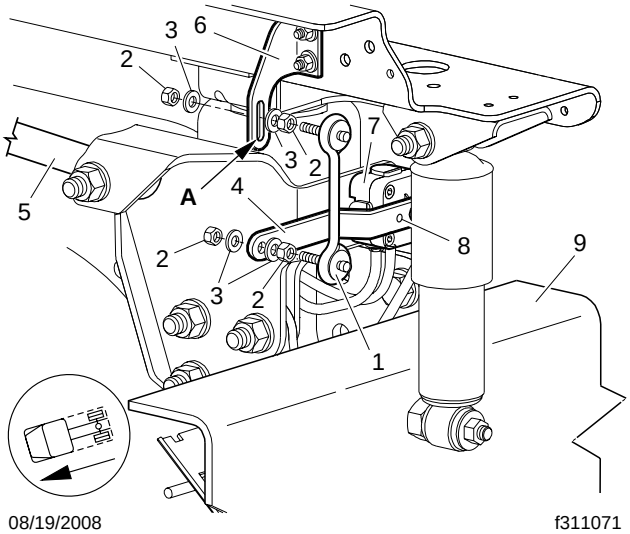
1. Air Spring
2. 1/4–20 Locknut
3. Washer
4. Vertical Linkage Bracket
5. Vertical Linkage
6. Horizontal Control Lever
7. Height-Control Valve
8. Hole for Installing Locking Pin

Fig. 1, Vertical Linkage Installation, SleeperCab

Argosy COE

1. Park the vehicle on a level surface, apply the parking brakes, and chock the tires.
2. Run the engine to build vehicle air pressure to at least 100 psi (690 kPa). Turn off the engine and wait 5 to 10 minutes for the system to equalize.

Cab Height Adjustment

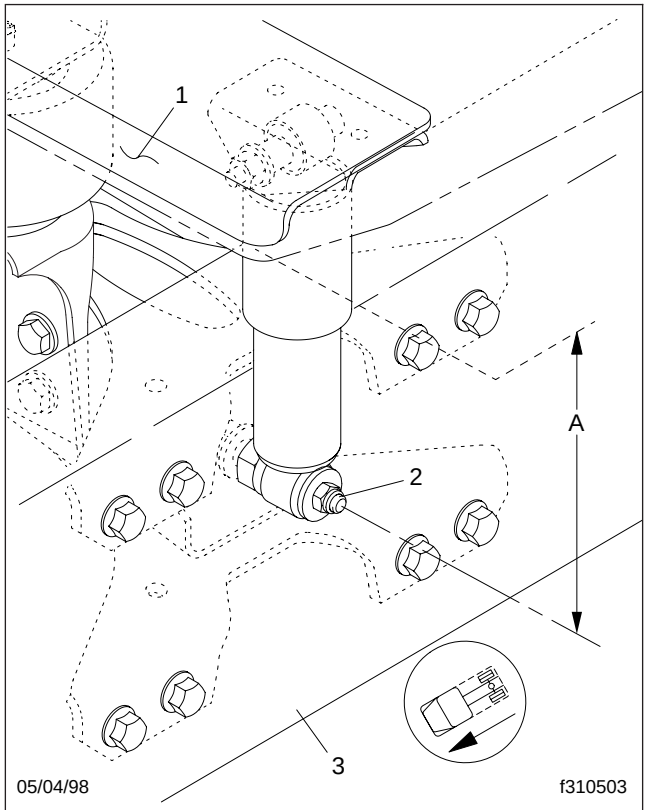


A. Slotted hole allows for height adjustment.

1. Vertical Linkage
2. Locknut
3. Washer
4. Horizontal Control Lever
5. Lateral Control Rod
6. Vertical Linkage Bracket
7. Height-Control Valve
8. Hole for Installing Locking Pin
9. Frame Rail

Fig. 2, Vertical Linkage Installation, Day Cab

3. Disconnect the vertical linkage by removing the linkage from the slotted hole in the bracket between the air spring and the sway bar; see **Fig. 5**.
4. Raise the horizontal control lever on the height-control valve to exhaust the air from the air springs.
5. Lower the horizontal control lever on the height-control valve to fill the air springs. Raise the cab until the distance between the upper and lower air spring mounting points is 4-1/8 ±1/16 inches (104 ±2 mm).
6. Lock the height-control valve in the neutral position by inserting a 5/32-inch (4-mm) pin or drill bit in the neutral-position hole in the height-control valve and the horizontal control lever.
7. Connect the vertical linkage. Tighten the nut 96 lbf·in (1080 N·cm).



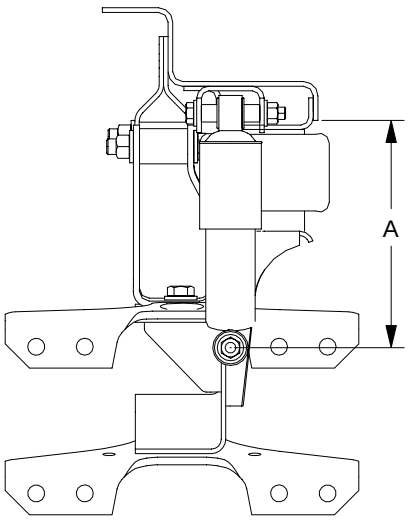
A. 9-1/16 to 9-7/16 inches (231 to 240 mm)

1. Rear Cab Underbody Flange
2. Lower Shock Absorber Bolt
3. Frame Rail

Fig. 3, Cab Height Measurement

8. Remove the pin or drill bit previously inserted in the height-control valve.
9. Check the cab height again. The distance from the rear cab underbody flange to the lower shock absorber bolt should be 4-1/8 inches (104 mm). If the height is not correct, repeat the entire procedure.

Cab Height Adjustment



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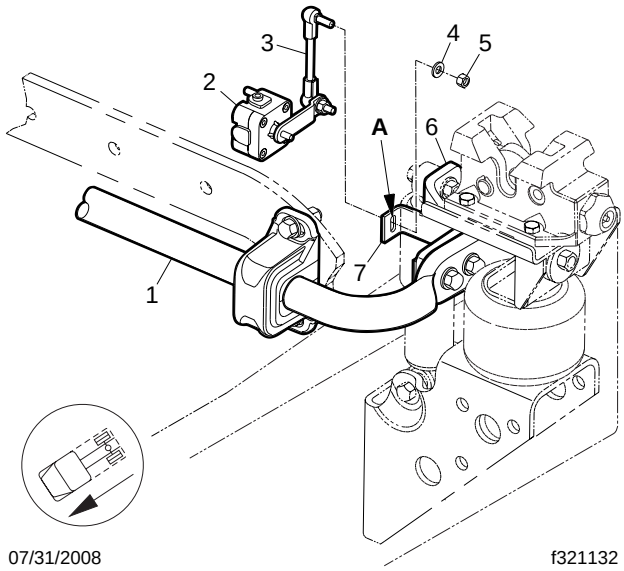
A. 9-1/16 to 9-7/16 inches (231 to 240 mm)

Fig. 4, Cab Height Measurement (side view)



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A. Slotted hole allows for height adjustment.

1. Sway Bar
2. Height-Control Valve
3. Vertical Linkage
4. Washer
5. Nut
6. Shock Absorber Upper Bracket
7. Vertical Linkage Upper Bracket

Fig. 5, Vertical Linkage Installation, Argosy COE

Height-Control Valve Checking

It is normal to hear air leaking from the height-control valve for as much as five minutes after getting out of the vehicle. This air leakage is just the height-control valve exhausting air from the cab suspension air springs to reach the neutral position.

Height-control valves used on the Century Class are Barksdale valves. Two methods are available to check the operation of Barksdale height-control valves. A leak in the valve may be discovered without using a test kit, but a test kit is necessary to determine if the valve has an unacceptable rate of leakage.

Some Barksdale height-control valves have been returned for warranty because the four bolts in the valve housing were overtightened, often, enough to crack the valve housing. These bolts should not be loose, and should not normally require tightening, as there are no serviceable parts in the valve.

IMPORTANT: To prevent voiding the warranty on Barksdale height-control valves, note the following:

- Do not overtighten the bolts in the Barksdale height-control valve housing if you detect leaks in the housing. The bolts should not be loose, and should not require tightening. Only if necessary, tighten the valve housing bolts 45 lbf·in (500 N·cm). Any damage to the valve housing will void the warranty.
- Do not attempt to disassemble the Barksdale valve body or the control lever. There are no serviceable parts in the valve, and any disassembly will void the warranty.

⚠ CAUTION

When removing or loosening a Barksdale height-control valve from a mounting bracket, always hold the valve-side mounting studs in place with an Allen wrench while loosening or tightening the nuts that attach the valve to the bracket. Because the mounting studs are threaded into the valve body, loosening the nuts without holding the studs can tighten the studs, which can crush the valve body and damage the valve. Conversely, tightening the nuts without holding the studs can back the studs out, causing a separation of the two halves of the valve body, and possibly a leak.

Checking the Height-Control Valve Without Using a Test Kit

⚠ WARNING

Keep your hands and all objects away from the area under and around the cab when removing the pressure from the air system. Parts will move as the air is released and can cause personal injury or damage to any objects that are between the moving parts.

1. With the vehicle parked on a level surface, run the engine to build vehicle air pressure to at least 100 psi (690 kPa), then shut off the engine, apply the parking brakes, and chock the tires.
2. Wait 5 to 10 minutes for the air suspension system to equalize.

NOTE: Normal operation of the height-control valve requires a maximum of 10 minutes to settle. Any air leakage during this time is considered normal, and does not indicate a defective valve. This air leakage is the height-control valve exhausting air due to a decreased load on the cab suspension.

3. Disconnect the vertical linkage from the horizontal control lever.
4. Pull the control lever up about 45 degrees for 6 to 8 seconds. If air passes through the valve, that section of the valve is okay.
5. Return the control lever to the neutral position.
6. Push the control lever down about 45 degrees for 6 to 8 seconds. If the air spring inflates, that section of the valve is okay.
7. Return the control lever to the neutral position. If the air stops again in the neutral position, the valve is working correctly.
8. If the valve works as stated in all of the above steps, no further checking is needed. Connect the vertical linkage to the control lever, then tighten the linkage nut. If needed, adjust the cab ride height; see **Subject 100**.

NOTE: If the valve leaks, go to "Checking the Height-Control Valve Using a Test Kit." Barks-

Height-Control Valve Checking

dale valves have an acceptable leakage rate of 3 cubic inches (50 cc) per minute. You can determine if a leak is acceptable only by using the Barksdale test kit.

Checking the Height-Control Valve Using a Test Kit

IMPORTANT: The procedure described below is for use on Barksdale height-control valves only.

NOTE: The Barksdale field test kit is designed to be used with the height-control valve installed on the vehicle. Refer to **Specifications 400** for information on ordering the Barksdale height-control valve test kit KD2264.

1. If not already done, park the vehicle on a level surface, apply the parking brakes, and chock the tires.
2. Run the engine to build vehicle air pressure to at least 100 psi (690 kPa).
3. Shut off the engine and wait 5 to 10 minutes for the air suspension system to equalize.

NOTE: Normal operation of the height-control valve requires a maximum of 10 minutes to settle. Any air leakage during this time is considered normal, and does not indicate a defective valve.

4. Check the rubber exhaust flapper at the back of the valve housing for leaks. Use a soapy solution.
5. Disconnect the vertical linkage from the control lever.
6. Rotate and hold the control lever up at about 45 degrees to exhaust air from the air springs.
7. Disconnect the air lines from the air spring ports on the height-control valve. Leave the elbow fittings (if equipped) in place. Install a Parker plug into each air spring port (or elbow fitting); see **Fig. 1**.
8. If a flapper is present on the exhaust port of the height-control valve, remove it using needlenose pliers.
9. Clean the surface around the exhaust port, then install the test fitting into the exhaust port. The centering pin on the fitting must align with the slot on the exhaust port. Rotate the test fitting 45 degrees clockwise to lock it in place; see **Fig. 1**.
10. Connect one end of the air hose from the kit to the test connector on the exhaust port, and the other end to the test gauge.
11. Check the height-control valve in the fill mode, as follows.

    11.1 Rotate the valve control lever down 45 degrees from the horizontal to the fill position.

    11.2 Press the reset button on the test gauge.

    11.3 Observe the test gauge for 30 seconds. Refer to **Fig. 2** for the maximum allowable exhaust pressure change versus inlet pressure.

    The valve is not working correctly if the gauge pressure reading exceeds the maximum allowable within 30 seconds.

    If the gauge reads less than the maximum allowable pressure change in 30 seconds, the valve is okay.

NOTE: The test gauge will register the exhausting air. *This does not indicate a defective valve.*

12. Check the height-control valve in the exhaust mode, as follows.

    12.1 Rotate the valve control lever up 45 degrees from the horizontal to the exhaust position.

    12.2 Press the reset button on the test gauge.

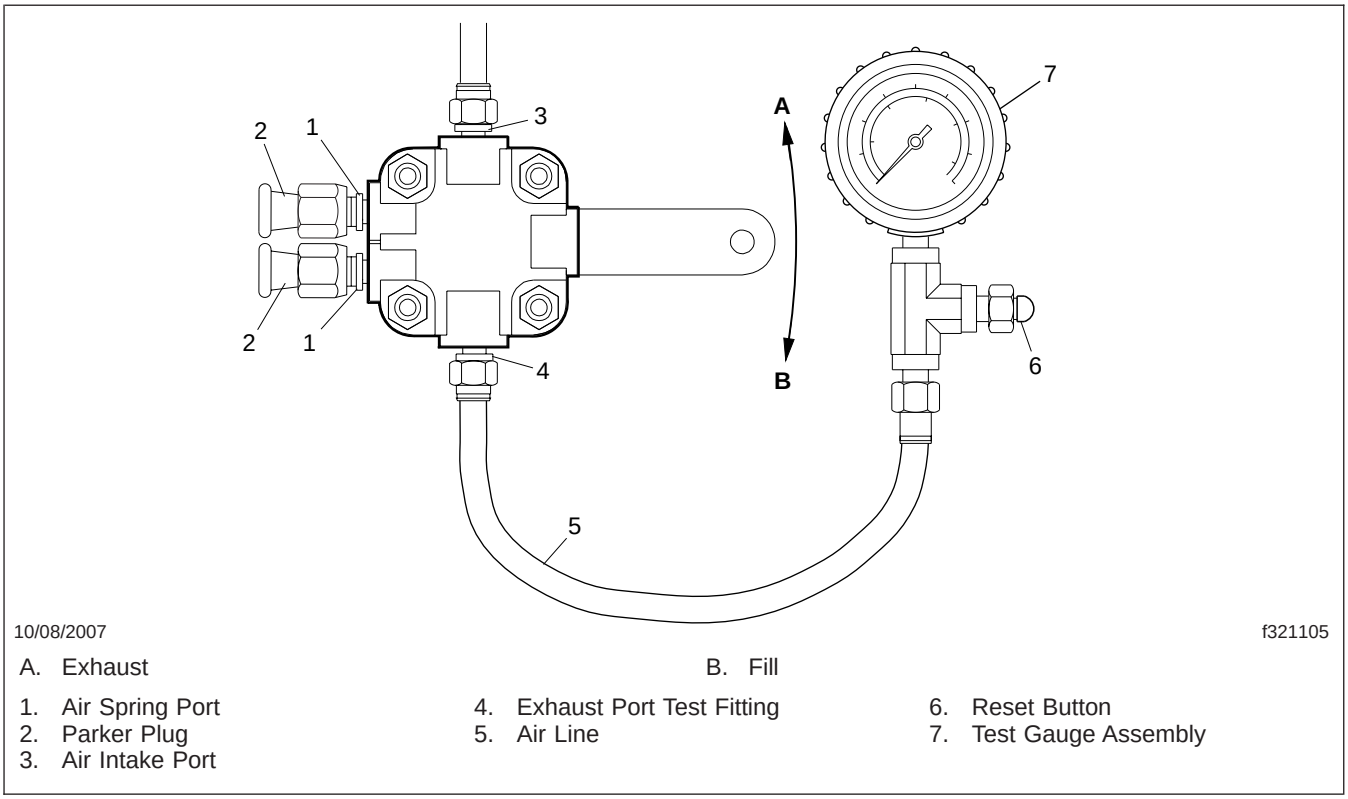
    12.3 Observe the test gauge for 30 seconds. Refer to **Fig. 2** for the maximum allowable exhaust pressure change versus inlet pressure.

    The valve is not working correctly if the gauge pressure reading exceeds the maximum allowable within 30 seconds.

    If the gauge reads less than the maximum allowable pressure change in 30 seconds, the valve is okay.

NOTE: The test gauge will register the exhausting air. *This does not indicate a defective valve.*

13. Disconnect the test gauge and connector from the valve exhaust port.



A. Exhaust
B. Fill

1. Air Spring Port
2. Parker Plug
3. Air Intake Port
4. Exhaust Port Test Fitting
5. Air Line
6. Reset Button
7. Test Gauge Assembly

Fig. 1, Test Connections

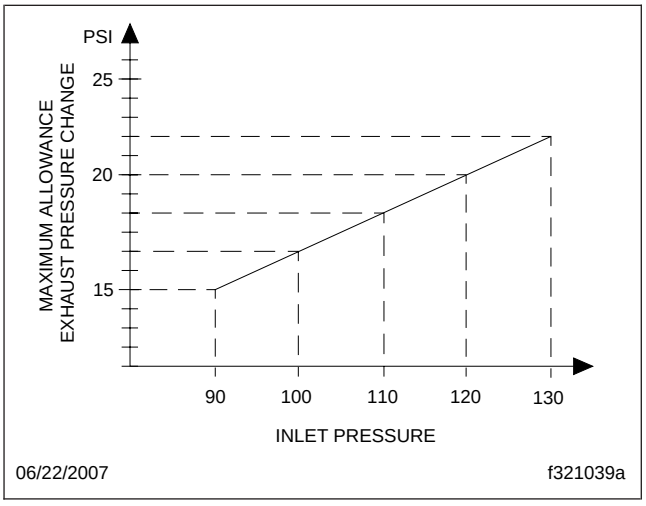


Fig. 2, Inlet Pressure vs. Exhaust Pressure Change in 30 Seconds

14. If the height-control valve is defective, replace it; see **Subject 120**.
15. Install the flapper on the exhaust port by pressing it into place.
16. Remove the two Parker plugs from the air spring ports, and connect the air lines to the air spring ports (or elbow fittings). Connect the vertical linkage to the height-control valve control lever. The ride height will automatically return to the correct position.

Replacement

IMPORTANT: Before replacing the height-control valve, perform the steps in **Subject 110** to see if the valve is actually damaged or just out of adjustment.

1. With the vehicle parked on a level surface, apply the parking brakes and chock the tires.

⚠ WARNING

Do not disconnect any air lines in the cab suspension system without first blocking or tilting the cab. If the cab isn't securely blocked or tilted, disconnecting an air line could cause the cab to fall abruptly, possibly resulting in serious injury.

2. On the Century Class Conventional, block the cab at normal ride height by placing a wooden block between the cab underbody and the top of the frame crossmember.

   On the Argosy COE, tilt the cab; see **Section 60.15, Subject 060**.

3. Drain all air from the air tanks.

⚠ WARNING

Air lines under pressure can whip dangerously if disconnected under pressure. Drain all air from the air tanks before disconnecting air lines. Disconnecting pressurized air lines can cause personal injury and/or property damage.

4. Disconnect the height-control valve vertical linkage from the control lever; see **Fig. 1** or **Fig. 2**. Push the lever down, and hold it there until all air is exhausted from the air springs.
5. Mark the air lines to the height-control valve for later reference, then disconnect them.

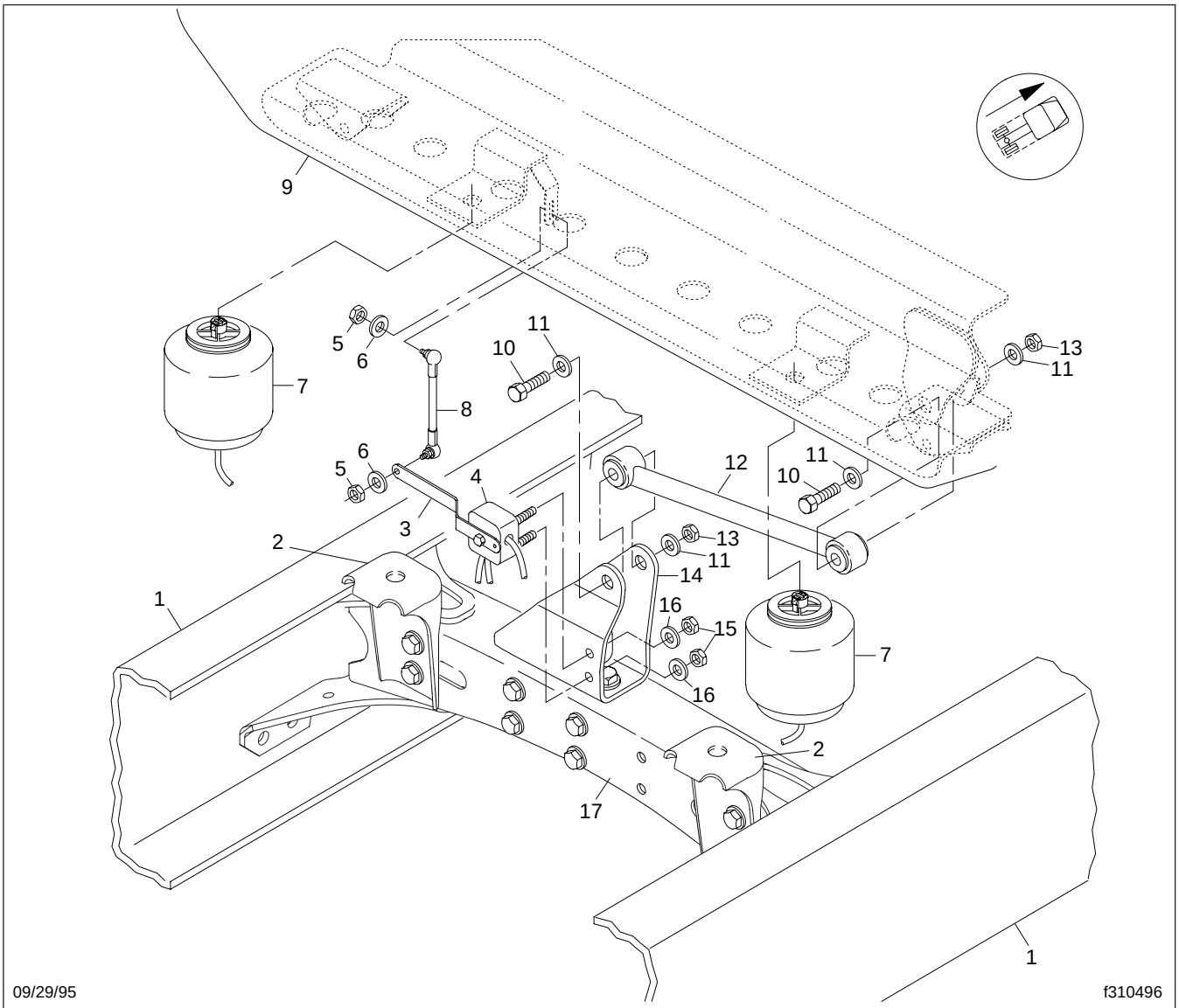
⚠ CAUTION

When removing or loosening a Barksdale height-control valve from a mounting bracket, always hold the valve-side mounting studs in place with an Allen wrench while loosening or tightening the nuts that attach the valve to the bracket. Because the mounting studs are threaded into the valve body, loosening the nuts without holding the studs can tighten the studs, which can crush the valve body and damage the valve. Conversely, tightening the nuts without holding the studs can back the studs out, causing a separation of the two halves of the valve body, and possibly a leak.

6. While holding the height-control valve mounting studs in place with an Allen wrench, remove the nuts and washers that attach the valve to the mounting bracket. Remove the height-control valve.
7. Position the new height-control valve on the height-control bracket. While holding the height-control valve mounting studs in place with an Allen wrench, install the nuts and washers, and tighten the nuts 95 lbf·in (1100 N·cm). Do not overtighten.
8. Connect the air lines to the height-control valve. Install the air lines into the fittings until they seat completely. Tug on the lines to make sure they are completely seated.
9. Connect the vertical linkage to the horizontal control lever.
10. Close the drain cocks on all air reservoirs. Run the engine to build vehicle air pressure to at least 100 psi (690 kPa).
11. Check all air lines and connections for leaks; eliminate all leaks.
12. Check the operation of the new height-control valve; see **Subject 110**.
13. Adjust the height-control valve, if needed; see **Subject 100**.
14. On the Century Class Conventional, remove the cab supports.

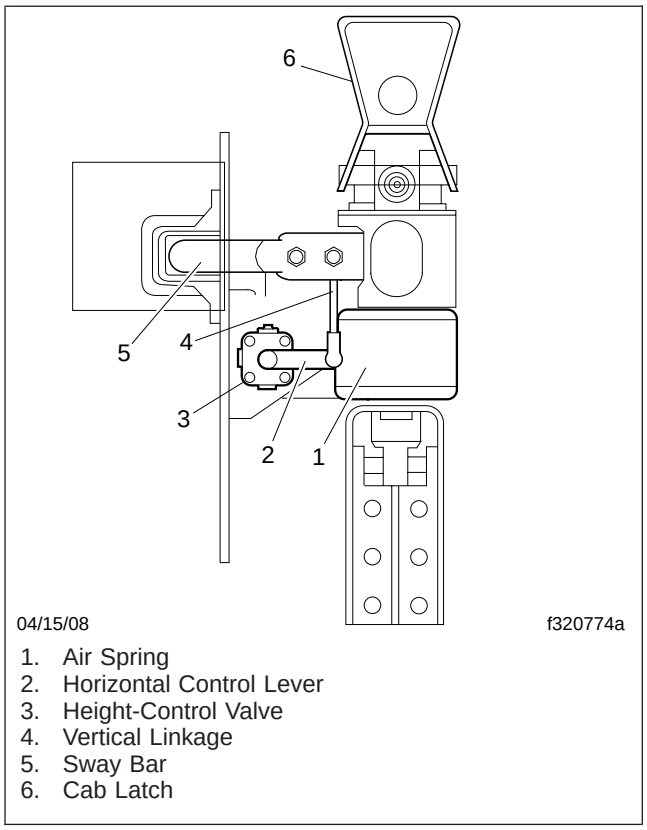
    On the Argosy COE, return the cab to the operating position; see **Section 60.15, Subject 060**.

Height-Control Valve Replacement



1. Frame Rail
2. Air Spring Mounting Bracket
3. Horizontal Control Lever
4. Height-Control Valve
5. 1/4–20 Hexnut
6. Flatwasher
7. Air Spring
8. Vertical Linkage
9. Rear of Cab
10. 5/8–11 Hexbolt
11. Flatwasher
12. Lateral Control Rod
13. 5/8–11 Hexnut
14. Mounting Bracket
15. 1/4–20 Hexnut
16. Flatwasher
17. Crossmember

Fig. 1, Cab Rear Air-Suspension Installation, SleeperCab



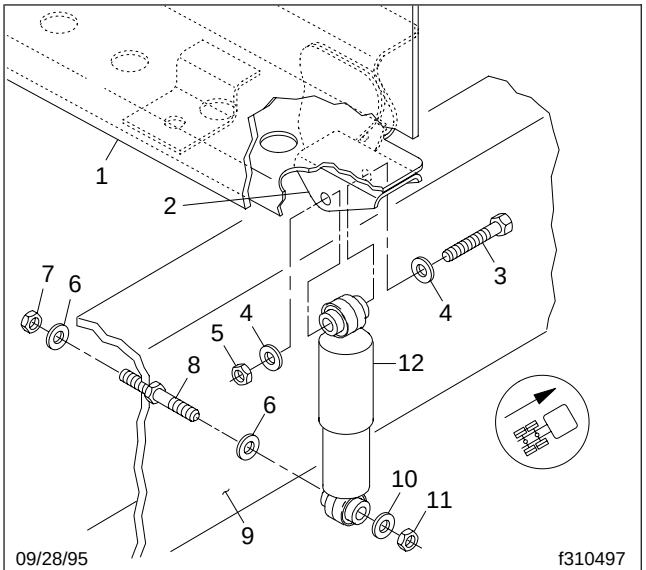
1. Air Spring
2. Horizontal Control Lever
3. Height-Control Valve
4. Vertical Linkage
5. Sway Bar
6. Cab Latch

Fig. 2, Height-Control Valve And Linkage, Argosy COE

Replacement

1. With the vehicle parked on a level surface, apply the parking brakes and chock the tires.
2. On the Century Class Conventional, place blocks between the frame and the bottom of the cab, or use jack stands to keep the cab in position when the shock is removed.

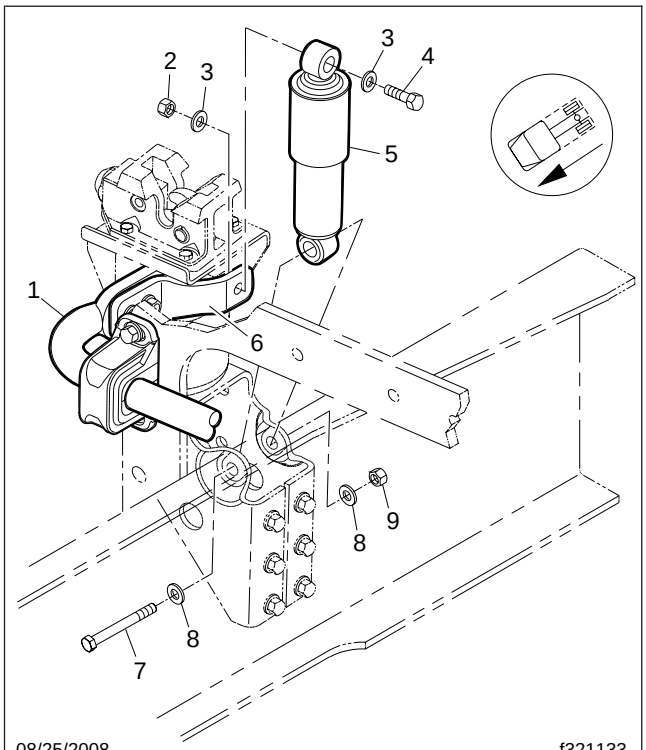
   On the Argosy COE, tilt the cab; see **Section 60.15, Subject 060**.
3. Remove the 7/16–20 hexnut and washer from the lower mounting stud; see **Fig. 1** or **Fig. 2**.



1. Rear of Cab
2. Shock Absorber Upper Mounting Bracket
3. 1/2–13 Hexbolt
4. Flatwasher
5. 1/2–13 Hexnut
6. 5/8" Flatwasher
7. 5/8–11 Hexnut
8. Shock Absorber Lower Mounting Stud
9. Frame Rail
10. 7/16" Washer
11. 7/16–20 Hexnut
12. Shock Absorber

Fig. 1, Shock Absorber Installation, Century Class Conventional

4. Remove the upper hexbolt, hexnut, and washers that attach the shock absorber to the shock absorber upper mounting bracket. On conventionals, the upper mounting bracket is attached to the cab underbody, on the Argosy COE, to the air spring upper support bracket. Remove the shock absorber.



1. Sway Bar
2. 1/2–13 Hexnut
3. Flatwasher
4. 1/2–13 Hexbolt
5. Shock Absorber
6. Shock Absorber Upper Mounting Bracket
7. 7/16–20 Hexbolt
8. 7/16" Washer
9. 7/16–20 Hexnut

Fig. 2, Shock Absorber Installation, Argosy COE

5. Install the new shock absorber on the mounting stud on the frame rail, using the hexnut and washers. Do not tighten the hexnut yet.
6. Position the upper end of the shock absorber in the upper bracket, and install the hexbolt, washers, and hexnut. On the Century Class Conventional, the hexbolt head should be facing toward the front of the vehicle, on the Argosy COE, to inboard.

Shock Absorber Replacement

7. Tighten the upper hexnut 45 lbf·ft (61 N·m). Tighten the lower hexnut 22 to 32 lbf·ft (30 to 44 N·m).
8. On the Century Class Conventional, remove the cab supports.

   On the Argosy COE, return the cab to the operating position; see **Section 60.15, Subject 060**.

Replacement

1. With the vehicle parked on a level surface, apply the parking brakes and chock the tires.

⚠ WARNING

Do not disconnect any air lines in the cab suspension system without first blocking or tilting the cab. If the cab isn't securely blocked or tilted, disconnecting an air line could cause the cab to fall abruptly, possibly resulting in serious injury.

2. On the Century Class Conventional, jack up the cab, and block it at about 1 inch (25 mm) higher than its normal ride height. Block the cab between the frame rail crossmember and the cab underbody.

   On the Argosy COE, tilt the cab; see **Section 60.15, Subject 060**.

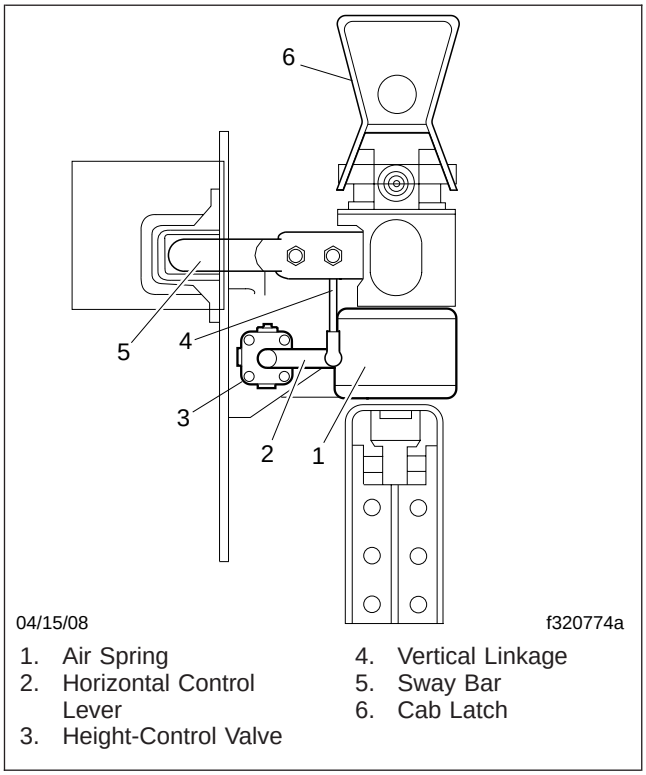
3. Drain all air from the air tanks.

⚠ WARNING

Air lines under pressure can whip dangerously if disconnected under pressure. Drain all air from the air tanks before disconnecting air lines. Disconnecting pressurized air lines can cause personal injury and/or property damage.

4. Remove the nut and washer that attach the vertical linkage to the horizontal control lever. Disconnect the vertical linkage from the control lever; see **Fig. 1** or **Fig. 2**.
5. Disconnect the supply air line from the bottom of the air spring to be replaced. Push in the brass ring at the connection, then pull the air line straight out. Cover the open end of the air line to prevent dirt or other foreign material from entering.
6. Using a screwdriver, depress the tangs at the top of the air spring, then pop it out of the upper bracket. Repeat the procedure for the bottom of the air spring, then remove the air spring.
7. Install the new air spring by snapping it in to the top bracket first, then the bottom bracket.
8. Remove the cover from the air line, then connect it by pushing it into the fitting on the bottom of the air spring. Push the air line all the way in. If it is not pushed all the way in, the connection will leak air. Tug on the air line to seat it completely.
9. Connect the vertical linkage to the horizontal control lever.
10. Start the engine, and run it until air pressure builds to at least 100 psi (690 kPa). Check for air leaks at the air springs and at the height-control valve. Tighten the fittings or replace the parts, as needed.
11. On the Century Class Conventional, jack up the cab, and remove the block.

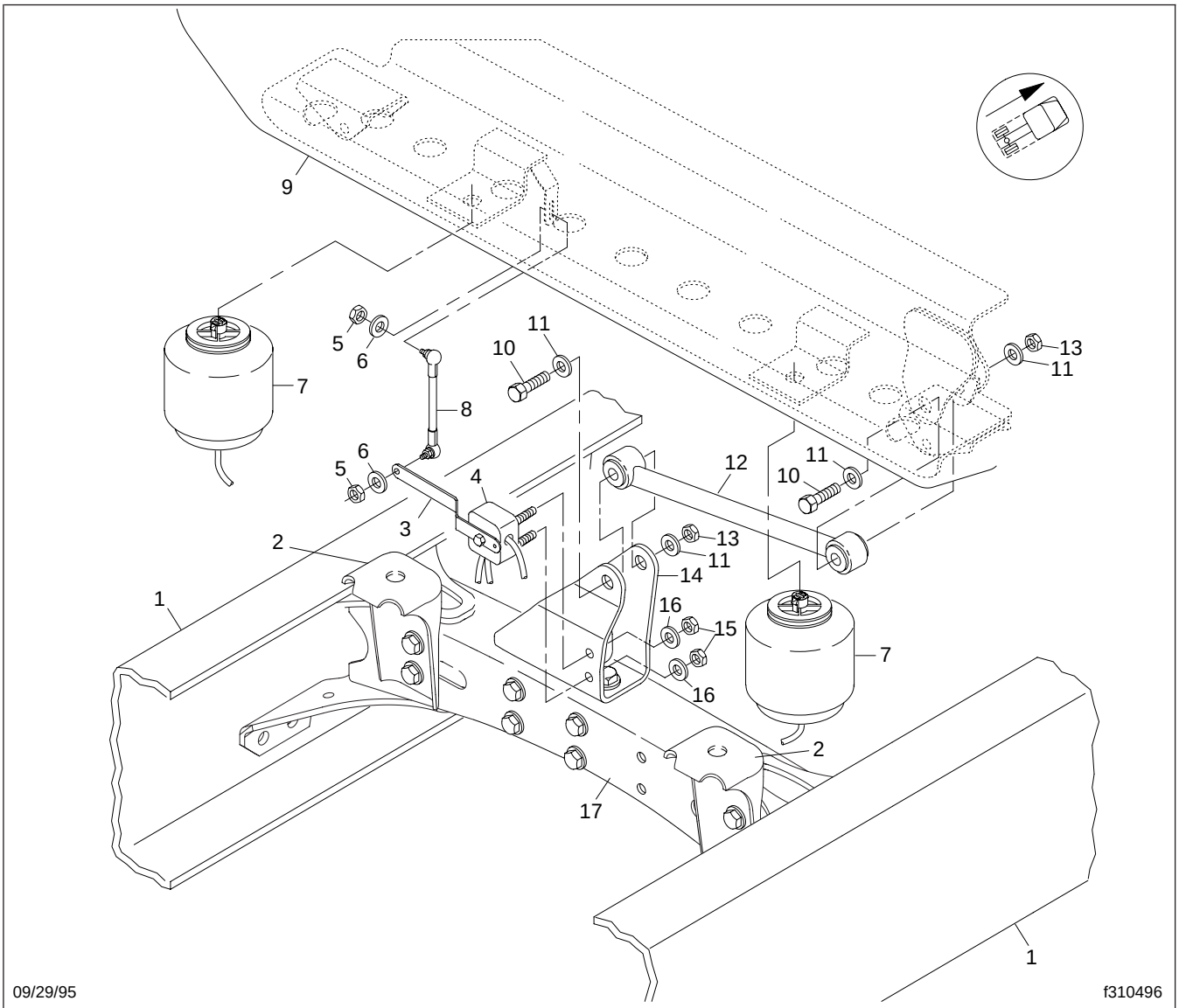
    On the Argosy COE, return the cab to the operating position; see **Section 60.15, Subject 060**.



1. Air Spring
2. Horizontal Control Lever
3. Height-Control Valve
4. Vertical Linkage
5. Sway Bar
6. Cab Latch

Fig. 1, Height-Control Valve And Linkage, Argosy COE

Air Spring Replacement



1. Frame Rail
2. Air Spring Mounting Bracket
3. Horizontal Control Lever
4. Height-Control Valve
5. 1/4–20 Hexnut
6. Flatwasher
7. Air Spring
8. Vertical Linkage
9. Rear of Cab
10. 5/8–11 Hexbolt
11. Flatwasher
12. Control Rod
13. 5/8–11 Hexnut
14. Mounting Bracket
15. 1/4–20 Hexnut
16. Flatwasher
17. Crossmember

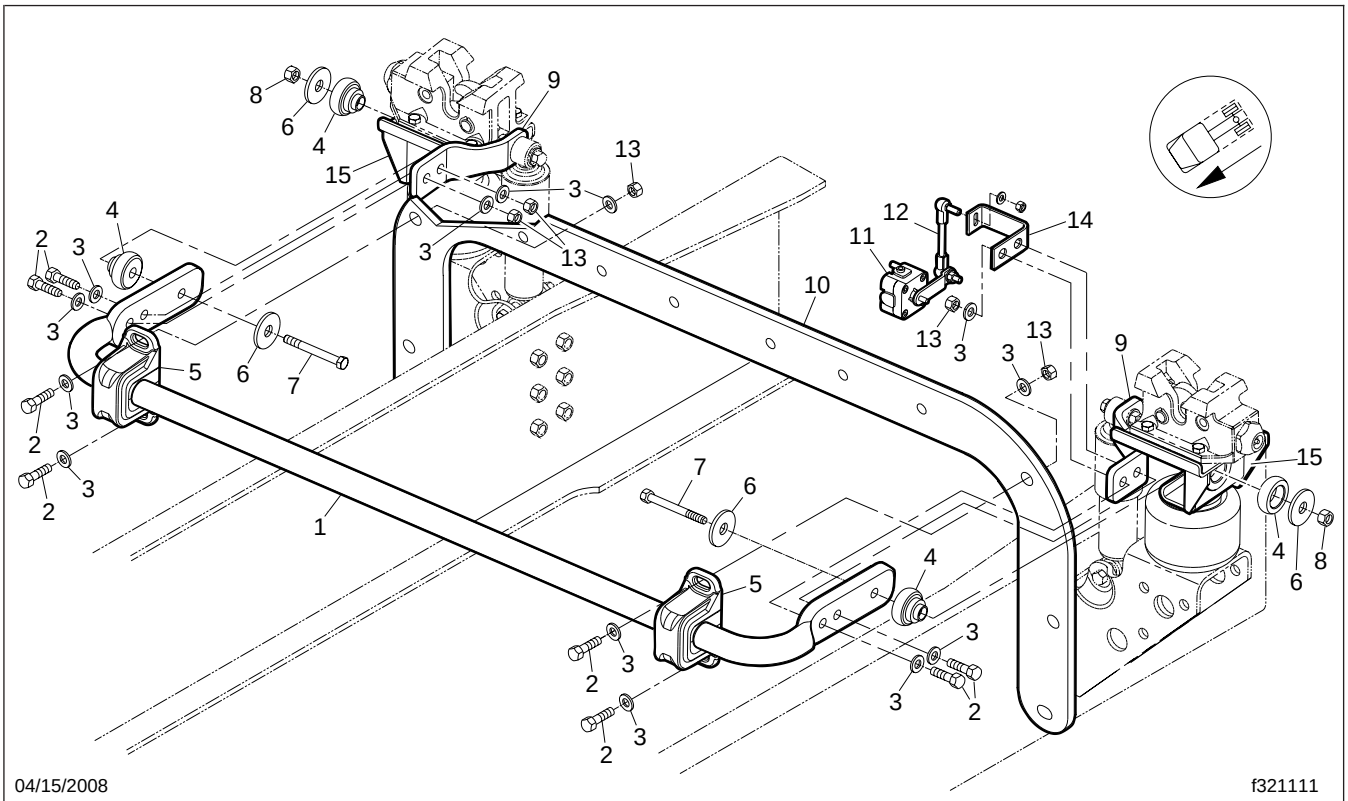
Fig. 2, Cab Rear Air-Suspension Installation, Century Class Conventional (SleeperCab shown)

Sway Bar Replacement, Argosy COE

Replacement

1. With the vehicle parked on a level surface, apply the parking brakes and chock the tires.
2. Drain all air from the air tanks.
3. Tilt the cab; see **Section 60.15, Subject 060**.
4. On both sides of the vehicle, remove the bolt, washer, and nut that attaches the sway bar and the sway bar isolator to the air spring upper support bracket; see **Fig. 1**.
5. On both sides of the vehicle, remove the two bolts, nuts, and washers that attach the sway bar to the shock absorber upper mounting bracket. On the right-hand side of the vehicle, the two bolts also secure the vertical linkage upper bracket to the shock absorber upper mounting bracket. Leave the bracket attached to the vertical linkage.
6. Remove the two bolts and nuts that attach each sway bar support bracket to the overslung crossmember.
7. Pull the sway bar away from the vehicle.
8. Position a new sway bar on the vehicle.
9. Install the two bolts that secure each sway bar support bracket to the overslung crossmember. Tighten the bolts 77 lbf·ft (104 N·m).
10. On both sides of the vehicle, install the bolt, nut, and washer that secures the sway bar and the sway bar isolator to the air spring upper support bracket. Tighten the bolt 77 lbf·ft (104 N·m).
11. On both sides of the vehicle, attach the sway bar to the shock absorber upper mounting bracket, using the two bolts, nuts, and washers. On the right-hand side of the vehicle, also install the vertical linkage upper bracket. Tighten the bolts 77 lbf·ft (104 N·m).
12. Return the cab to the operating position; see **Section 60.15, Subject 060**.

Sway Bar Replacement, Argosy COE



1. Sway Bar
2. Hexbolt
3. Washer
4. Sway Bar Isolator
5. Sway Bar Support Bracket
6. Flatwasher
7. Hexbolt
8. Hexnut
9. Shock Absorber Upper Mounting Bracket
10. Overslung Crossmember
11. Height-Control Valve
12. Vertical Linkage
13. Hexnut
14. Vertical Linkage Upper Bracket
15. Air Spring Upper Support Bracket

Fig. 1, Cab Suspension Sway Bar Installation

Troubleshooting Tables

Problem—Both Air Springs Are Flat

Problem—Both Air Springs Are Flat	
Possible Cause	**Remedy**
Low air pressure in the secondary air system.	Check the air pressure gauge on the instrument panel. If secondary air pressure is low, run the engine until at least 70 psi (482 kPa) is indicated.
Air is leaking from the cab air-suspension system.	Check for leakage from fittings, air lines, air springs, and the height-control valve. Tighten loose fittings to stop leakage; replace worn or damaged parts.
The height-control valve is out of adjustment.	Adjust the height-control valve; see **Subject 100**.
The height-control valve is inoperative.	If upward movement of the lever on a properly adjusted valve fails to inflate the air springs, replace the height-control valve; see **Subject 120**.
The height-control valve linkage is damaged.	Check for damage to the height-control valve linkage and the lever. Repair or replace damaged linkage parts.

Problem—Air Springs Deflate Rapidly When the Engine Is Not Running

Problem—Air Springs Deflate Rapidly When the Engine Is Not Running	
Possible Cause	**Remedy**
Air is leaking from the cab air-suspension system.	Check for leakage from fittings, air lines, air springs, and the height-control valve. Tighten loose fittings to stop leakage; replace worn or damaged parts.

Problem—Rear of Cab Rides Too High or Too Low

Problem—Rear of Cab Rides Too High or Too Low	
Possible Cause	**Remedy**
The height-control valve is out of adjustment.	Adjust the height-control valve; see **Subject 100**.

Problem—Collapsed Air Spring

Problem—Collapsed Air Spring	
Possible Cause	**Remedy**
An air spring is punctured.	Locate leaks by listening for escaping air, or by applying a soap and water solution to the air spring and watching for bubbles. Repair punctures and cuts that are less than 1/8 inch (3 mm). Replace the air spring if damage is greater. Check the area around the damaged air spring for contact with other components. Correct the problem areas as needed.
The air spring is continually or repeatedly over-extended.	Check the suspension height. Make sure the correct height is maintained. Adjust if needed; see **Subject 100** for the correct height and adjustment procedures. Check for a broken shock absorber or shock bracket; replace if broken.

Checking the Cab Height-Control System for Air Leaks

IMPORTANT: To prevent voiding the warranty on Barksdale height-control valves, note the following:

- Do not overtighten the bolts in the Barksdale height-control valve housing if you detect leaks in the housing. The bolts should not be loose, and should not require tightening. Only if necessary, tighten the valve housing bolts 45 lbf·in (500 N·cm). Any damage to the valve housing will void the warranty.
- Do not attempt to disassemble the Barksdale valve body or the control lever. There are no serviceable parts in the valve, and any disassembly will void the warranty.

⚠ CAUTION

When removing or loosening a Barksdale height-control valve from a mounting bracket, always hold the valve-side mounting studs in place with an Allen wrench while loosening or tightening the nuts that attach the valve to the bracket. Because the mounting studs are threaded into the valve body, loosening the nuts without holding the studs can tighten the studs, which can crush the valve body and damage the valve. Conversely, tightening the nuts without holding the studs can back the studs out, causing a separation of the two halves of the valve body, and possibly a leak.

1. Park the vehicle on a level surface, apply the parking brakes, and chock the tires.
2. Run the engine to build vehicle air pressure to at least 100 psi (690 kPa). Turn off the engine and wait 5 to 10 minutes for the system to equalize.

   NOTE: Normal operation of the height-control valve requires a maximum of 10 minutes to settle. Any air leakage during this time is considered normal and does not indicate a damaged valve.
3. Apply a soap-and-water solution to the outside of the air fittings on the height-control valve and on the suspension air springs. Look for bubbles indicating an air leak.
4. If bubbles are seen, check that the air tubing is installed correctly into the fitting.

   If no bubbles are seen, check the height-control valve for air leaks; see **Subject 110**.

Diagnostics and Testing

Air Spring

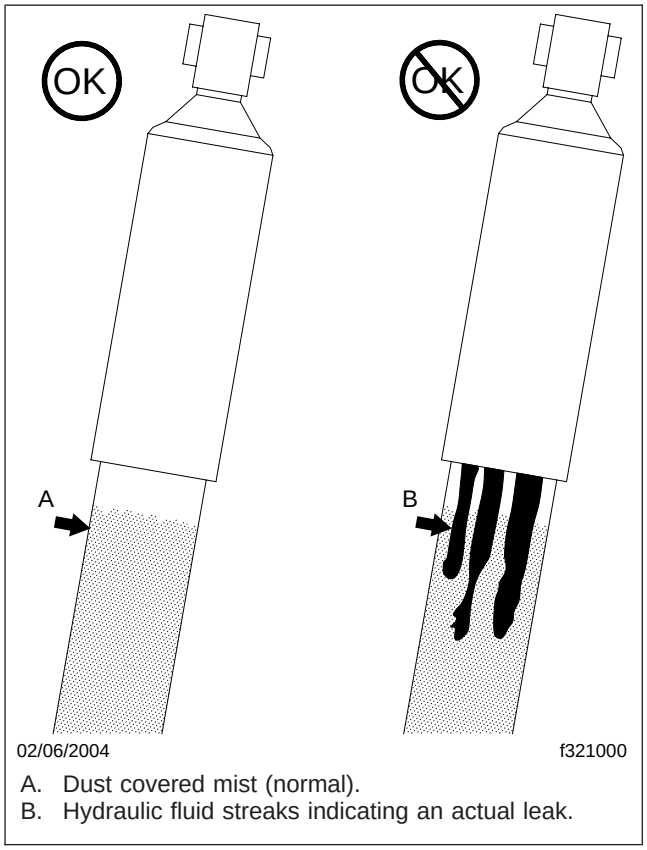
Inspect the exterior surfaces of the air spring, looking for wear. With the air spring fully inflated, check to see if there is sufficient clearance around the air spring to prevent lines or objects from rubbing against the air spring. Air tubing or cab components that rub against the air spring will cause damage to the air spring. If the air spring is not capable of lifting the cab to its proper ride height, check to see if the shock absorber is damaged. A binding shock absorber will limit the air spring's ability to extend. To clean the air spring, use soap and water.

NOTE: Do not use organic solvents, abrasives, or pressurized steam cleaners to clean the air spring.

Shock Absorber

Inspect the shock body for damage such as bends or dents in the piston. Bends or dents in the shock body will negatively affect the operation of the shock. Inspect the shock body for signs of leaking fluid. Normal operation of the shock will result in some misting of the hydraulic fluid onto the exterior shock body. Large streams of fluid indicate a leak and the shock should be replaced; see **Fig. 1**. To test the operation of a shock absorber, hold the shock in an upright position and cycle the piston at least five times by pushing the piston up and down. The piston should move evenly throughout each section of the cycle. If the shock does not move evenly when pushed down or pulled up, the shock should be replaced. Noises such as squeaks, which may be intermittent, may be caused by the valves used to regulate the internal hydraulic fluid. This problem is not repairable and the shock will need to be replaced. Noises from the shock, such as knocking or rattling, may be due to movement between the bushings and mounting brackets. Inspect the bushings or mounting brackets for wear. Repair worn components as necessary. Check the torque of the shock absorber mounting nuts and tighten if necessary.

NOTE: The shock absorber bushings do not require any type of lubrication. Do not attempt to stop bushing noise by lubricating them; grease and mineral-oil-base lubricants will deteriorate the bushing rubber.



A. Dust covered mist (normal).
B. Hydraulic fluid streaks indicating an actual leak.

Fig. 1, Differences Between Misting and Leaking

Torque Specifications

Unless listed in **Table 1**, tighten all fasteners using the torque specifications found in **Section 00.05**.

IMPORTANT: To prevent voiding the warranty on Barksdale height-control valves, note the following:

- Do not overtighten the bolts in the Barksdale height-control valve housing. The bolts should not be loose, and should not require tightening. Only if necessary, tighten the valve housing bolts 45 lbf·in (500 N·cm). Any damage to the valve housing will void the warranty.
- Do not attempt to disassemble the Barksdale valve body or the control lever. There are no serviceable parts in the valve, and any disassembly will void the warranty.

⚠ CAUTION

When removing or loosening a Barksdale height-control valve from a mounting bracket, always hold the valve-side mounting studs in place with an Allen wrench while loosening or tightening the nuts that attach the valve to the bracket. Because the mounting studs are threaded into the valve body, loosening the nuts without holding the studs can tighten the studs, which can crush the valve body and damage the valve. Conversely, tightening the nuts without holding the studs can back the studs out, causing a separation of the two halves of the valve body, and possibly a leak.

Plumbing Diagram

For the cab air suspension plumbing diagram, see **Fig. 1**.

Special Tools

Use the kit shown in **Fig. 2** to test a Barksdale height-control valve. Test kit BKS KD2264 is available via the Direct Ship program in paragon.

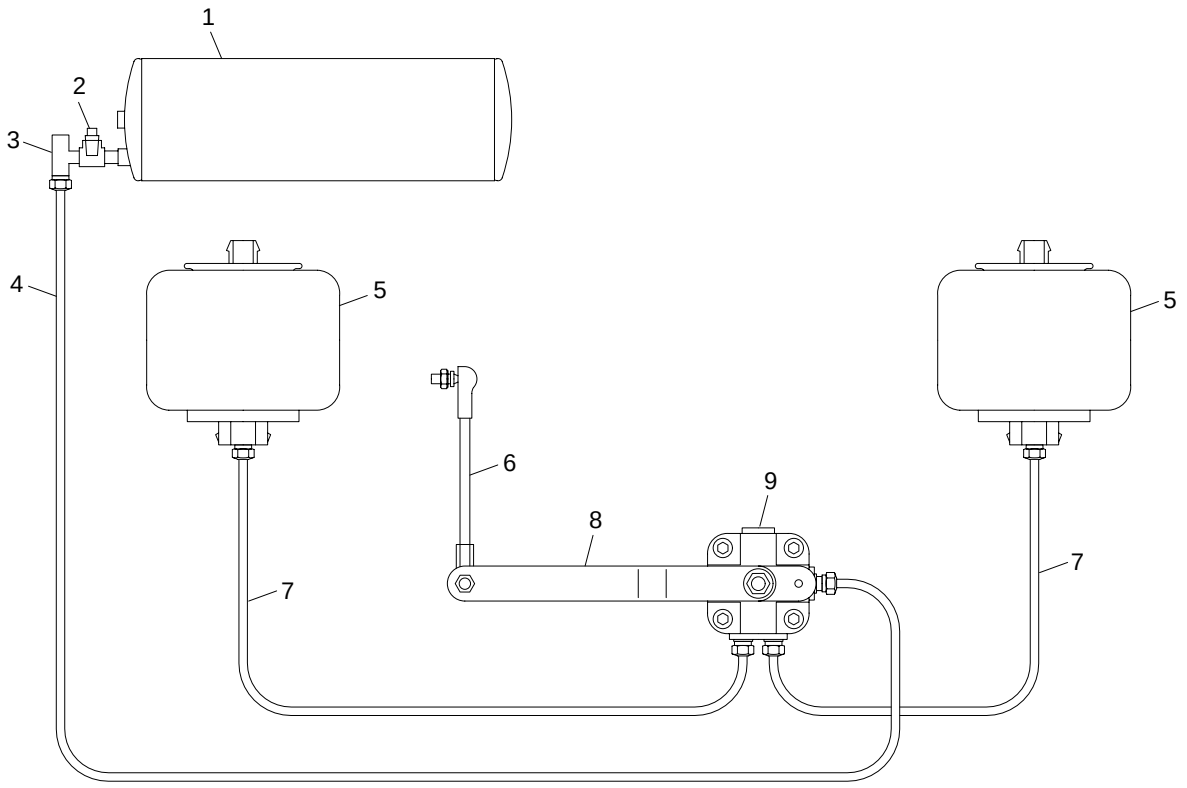
Torque Values			
Description	Size	Torque*	
		lbf·ft (N·m)	lbf·in (N·cm)
Height-Control Valve Housing Bolts†	1/4–20	—	45 (500)
Height-Control Valve Mounting Locknuts†	1/4–20	—	95 (1100)
Lower Shock Absorber Hexnuts	7/16–20	22–32 (30–44)	—
Upper Shock Absorber Hexnuts	1/2–13	45 (61)	—
Lateral Control Rod Fasteners	1/2–13	45 (61)	—
Control Rod Bracket Fasteners	5/8–11	150 (203)	—
Lower Air-Spring Bracket Fasteners	1/2–13	75 (102)	—
Sway Bar Support Fasteners	1/2–20	77 (104)	—

* Grade 8 bolts with phosphate- and oil-coated threads, and cadmium-plated, wax-coated Grade C hexnuts; both used with hardened washers.

† See the cautionary statements below.

Table 1, Torque Values

Specifications



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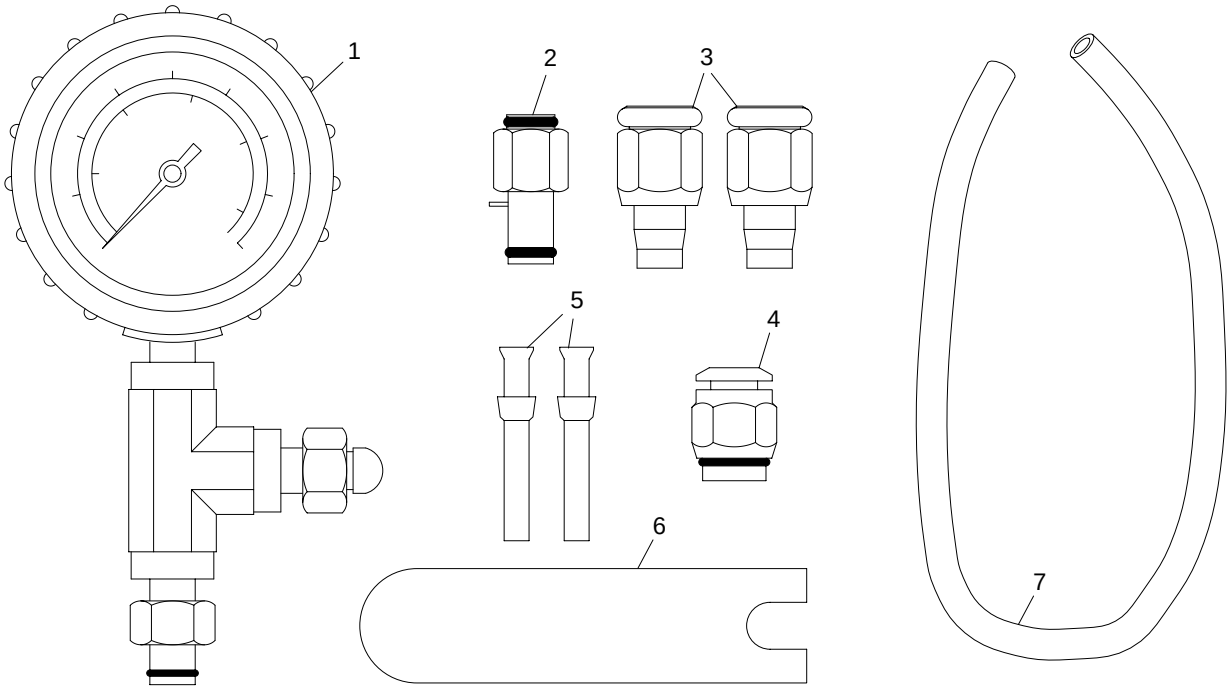
1. Secondary Air Tank
2. Pressure Protection Valve
3. Tee
4. Air Supply Line (nylon tubing)
5. Air Spring
6. Vertical Linkage
7. Air Spring Supply Line (nylon tubing)
8. Horizontal Control Lever
9. Height-Control Valve

Fig. 1, Plumbing Diagram, Century Class Conventional

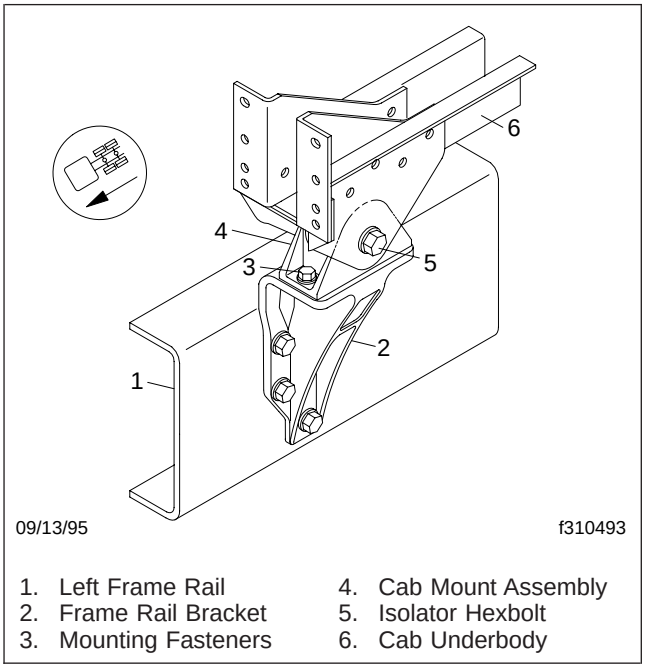


1. Test Gauge Assembly with Reset Button
2. Exhaust Port Test Connector for Cab Suspension Valve
3. Parker Plugs
4. Exhaust Port Test Connector for Chassis Suspension Valve
5. Test Plugs for Cab Suspension Valve
6. Special Tool for Disconnecting Air Line
7. Air Line

Fig. 2, Barksdale Height-Control Valve Test Kit KD2264

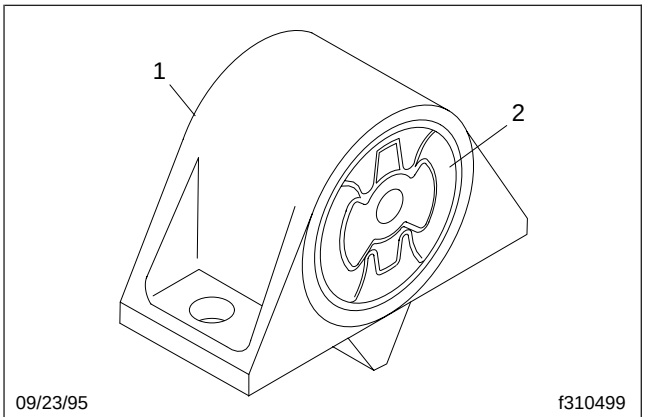
The forward part of the cab is attached to the frame rails by means of two cab mount assemblies. **See Fig. 1.** Each forward cab mount assembly consists of a hard rubber islolator surrounded by a steel bracket. **See Fig. 2.** The assembly is attached to a frame rail bracket and the cab underbody.

Cab mounts are replaceable only as complete units. **See Fig. 2.**



1. Left Frame Rail
2. Frame Rail Bracket
3. Mounting Fasteners
4. Cab Mount Assembly
5. Isolator Hexbolt
6. Cab Underbody

Fig. 1, Left Forward Cab Mount Installation



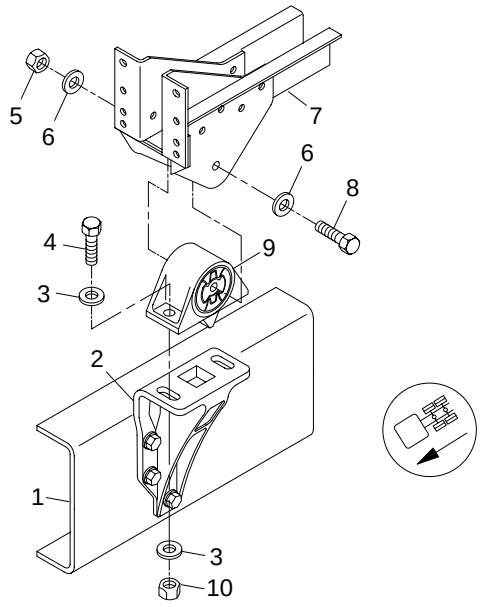
1. Cab-Mount Bracket
2. Isolator

Fig. 2, Forward Cab Mount Assembly

Forward Cab Mount Replacement

Replacement

1. Park the vehicle, apply the parking brakes, then chock the tires.
2. Jack up the front of the cab to take the weight off of the forward cab mount. Support the cab with jackstands.
3. Remove the 1/2–13 fasteners holding the cab mount assembly to the frame rail brackets. **See Fig. 1.**



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1. Frame Rail
2. Frame Rail Bracket
3. Flatwasher
4. 1/2–13 Hexbolt
5. 5/8–11 Hexnut
6. Flatwasher
7. Cab Framework
8. 5/8–11 Isolator Hexbolt
9. Cab Mount Assembly
10. 1/2–13 Hexnut

Fig. 1, Forward Cab Mount Fasteners

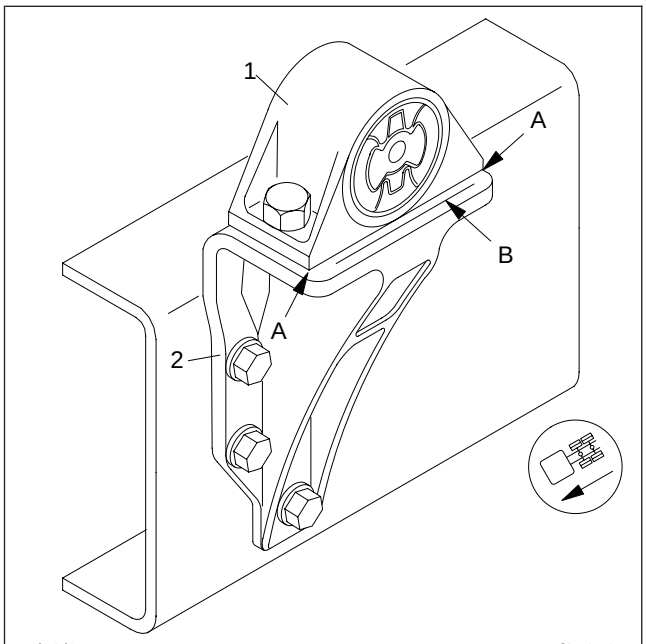
4. Remove the 5/8–11 fasteners that hold the cab mount assembly to the cab underbody bracket.
5. If needed, raise the cab so the tab on the bottom of the cab mount assembly clears the hole on the frame rail bracket; then remove the cab mount assembly.
6. Install a new cab mount assembly.

6.1 Put the cab mount assembly between the ears of the cab underbody bracket; then install the 5/8–11 isolator hexbolt, washers and nut. Make sure the bolt head is facing outboard.

6.2 Hand tighten the nut

6.3 Carefully lower the cab, making sure the tab at the bottom of the cab mount assembly lines up with the square hole in the frame rail bracket.

Make sure the outboard edge of the cab mount assembly is parallel with the grooves machined into the top surface of the frame rail mounting bracket. **See Fig. 2.** Also make sure that the same number of grooves is showing on both sides of the vehicle.



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A. The edge of the cab mount assembly is to be parallel to the grooves on the bracket.
B. The same number of grooves is to be showing on both sides of the vehicle.
1. Cab Mount Assembly
2. Frame Rail Bracket

Fig. 2, Forward Cab Mount Installation

6.4 Install the 1/2–13 hexbolts, washers and nuts through the cab mount assembly and

Forward Cab Mount Replacement

the frame rail bracket, with the bolt heads facing up. Tighten the nuts 68 lbf·ft (92 N·m).

6.5 Tighten the nut on the isolator hexbolt 136 lbf·ft (184 N·m).

7. Remove the chocks from the tires.

Forward Cab Mount Replacement, Argosy COE

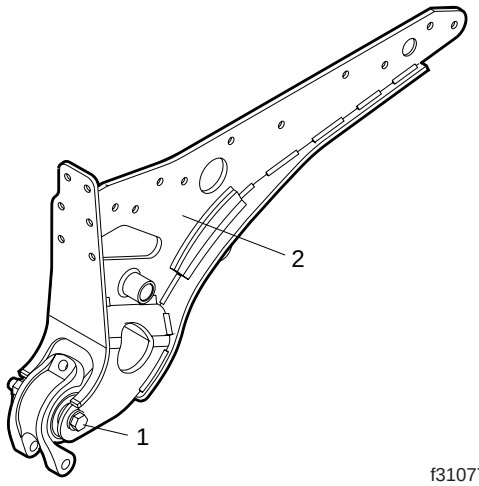
Replacement

1. With the vehicle parked, apply the parking brakes and chock the tires.

⚠ CAUTION

Stand away from the front-wall access panel when opening it. The access panel can open quickly and could hit a person, possibly resulting in personal injury.

2. Raise the front-wall access panel.
3. Remove the lower grille panel, as follows.
   - 3.1 Remove the four Allen-head screws that secure the grille panel support brackets to the front-wall crossmember.
   - 3.2 Lift the grille panel up and away from the vehicle.
4. Remove the headlight fascia, as follows.
   - 4.1 Disconnect the electrical connections to the headlights and parking lights.
   - 4.2 Remove the five fasteners that secure the headlight fascia to the cab, and remove the fascia.
5. Disconnect the tilt cylinder, as follows.
   - 5.1 Remove the cotter pin and washers. Have an assistant adjust the cab height until the clevis pin loosens.
   - 5.2 Remove the cylinder clevis pin.
   - 5.3 Disconnect the tilt cylinder.
6. Using a hydraulic jack, raise the cab and support it with jack stands.
7. Remove the cab mount hinge bolt; see **Fig. 1**.
8. On the left side of the vehicle, remove the clamps that secure the heater hoses to the front wall. Move the hoses aside.
9. On the right side of the vehicle, disconnect the clutch linkage; see **Section 25.03**.
10. Remove the six bolts that secure the cab mount bracket to the front wall.
11. Under the cab, remove the ten bolts that secure the cab mount bracket to the cab underbody.



1. Cab Mount Hinge Bolt
2. Cab Mount Bracket

Fig. 1, Forward Cab Mount Assembly

NOTE: For easier access to the cab mount on the left side of the vehicle, remove the engine oil and ATF/fill dipsticks.

12. On the left side of the vehicle, remove the brackets that secure the A/C lines to the cab underbody. Move the A/C lines aside.

NOTE: Using a hoist, or other suitable lifting device, adjust the cab height as necessary for clearance when removing the cab mount.

13. Remove the cab mount bracket.
14. Position a new cab mount on the cab underbody, and tighten the ten bolts finger-tight.
15. Place the brackets around the A/C lines, and tighten them securely.
16. If removed, install the engine oil and ATF/fill dipsticks.
17. Install the six bolts that secure the cab mount bracket to the front wall. Tighten the bolts 40 lbf·ft (54 N·m).
18. Tighten the ten bolts on the cab underbody 40 lbf·ft (54 N·m).
19. On the right side of the vehicle, connect the clutch linkage; see **Section 25.03**.

Forward Cab Mount Replacement, Argosy COE

20. On the left side of the vehicle, install the clamps that secure the heater hoses to the front wall. Tighten the clamps securely.
21. Support the cab with a hydraulic jack, and remove the jack stands. Lower the cab onto the vehicle chassis.
22. Install the cab mount hinge bolt; see **Fig. 1**. Tighten the bolt 130±10 lbf·ft (176±14 N·m).
23. Position the tilt cylinder on the cab underbody. Install the clevis pin, the washers, and the cotter pin.
24. Position the lower grille panel on the vehicle. Tighten the four support bolts 95 lbf·ft (129 N·m).
25. Install the headlight fascia, as follows.
    - 25.1 Attach the headlight fascia to the cab with the five fasteners.
    - 25.2 Connect the electrical connections to the headlights and parking lights.
26. Lower the front wall access panel.
27. Remove the chocks.

Forward Cab Isolator Replacement, Argosy COE

Replacement

1. Apply the parking brakes and chock the tires.

CAUTION

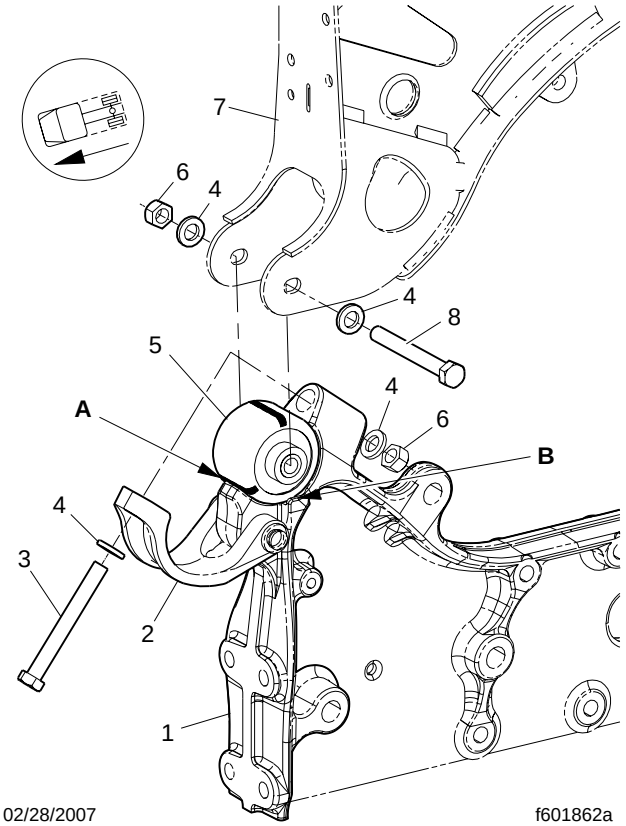
Stand away from the front-wall access panel when opening it. The access panel can open quickly and could hit a person, possibly resulting in personal injury.

2. Raise the front-wall access panel.
3. Remove the lower grille panel, as follows.
   - 3.1 Remove the four Allen-head screws that secure the grille panel support brackets to the front-wall crossmember.
   - 3.2 Lift the grille panel up and away from the vehicle.
4. Remove the headlight fascia, as follows.
   - 4.1 Disconnect the electrical connections to the headlights and parking lights.
   - 4.2 Remove the five fasteners that secure the headlight fascia to the cab, and remove the fascia.
5. Disconnect the tilt cylinder, as follows.
   - 5.1 Remove the cotter pin and washers. Have an assistant adjust the cab height until the clevis pin loosens.
   - 5.2 Remove the cylinder clevis pin.
   - 5.3 Disconnect the tilt cylinder.
6. Remove the isolator cap bolt, washers, and hexnut from the left-hand forward frame; see **Fig. 1**. Rotate the isolator cap downward to expose the isolator.

WARNING

When using a hydraulic jack to raise the cab, ensure that the jack is stabilized and that the cab remains in the intended position. An improperly raised cab can fall, possibly resulting in serious injury and property damage.

7. Using a hydraulic jack, raise the cab just enough to take the weight off the isolator.



A. Align the center of the wide stripe on the isolator with the forward edge of the casting.
B. The isolator must seat between the locator nubs on the casting.

1. Forward Frame
2. Isolator Cap
3. Isolator Cap Bolt
4. Washer
5. Isolator
6. Hexnut
7. Cab Mount Bracket
8. Cab Mount Hinge Bolt

Fig. 1, Cab Tilt Pivot Assembly (left-hand shown)

8. Remove the cab mount hinge bolt, washers, and hexnut. If necessary, raise or lower the cab slightly in order to remove the bolt.
9. Remove the isolator.
10. Repeat the above steps to remove the isolator cap bolt, cab mount hinge bolt, and isolator from the right-hand forward frame.
11. Carefully position a new isolator on the left-hand forward frame. Align the center of the wide stripe on the isolator with the forward edge of the for-

Forward Cab Isolator Replacement, Argosy COE

ward frame casting. Make sure the isolator is seated between the locator nubs on the casting; see **Fig. 1**.

NOTE: The elasticity of the isolator is direction-dependent to provide vertical flexibility and lateral stability. During installation, the isolator must be correctly aligned in the forward frame to function properly.

12. Insert the cab mount hinge bolt through a washer, the cab mount bracket, and the isolator. Install the second washer and hexnut on the bolt. Tighten the hexnut 130 lbf·ft (176 N·m).
13. Rotate the isolator cap up to enclose the isolator.
14. Install the isolator cap bolt, two washers, and the hexnut. Tighten the hexnut 90±10 lbf·ft (122±14 N·m).
15. Repeat the previous steps to install the isolator, cab mount hinge bolt, and isolator cap bolt on the right-hand forward frame.
16. Position the tilt cylinder on the cab underbody. Install the clevis pin, the washers, and the cotter pin.
17. Lower the cab and remove the hydraulic jack.
18. Install the headlight fascia, as follows.
    - 18.1 Attach the headlight fascia to the cab with the five fasteners.
    - 18.2 Connect the electrical connections to the headlights and parking lights.
19. Position the lower grille panel on the vehicle. Tighten the four support bolts 95 lbf·ft (129 N·m).
20. Lower and secure the cab front-wall access panel.
21. Remove the chocks.

Specifications

See **Table 1** for torque specifications.

Torque Specifications		
Description	**lbf·ft**	**N·m**
Century Class Conventional and Coronado		
Cab Mount Isolator-to-Chassis Bracket Nut, 1/2–13	68	92
Cab Mount Isolator Hexnut, 5/8–11	136	184
Argosy COE		
Cab Mount Bracket Bolts	40	54
Cab Mount Hinge Hexnut	130±10	176±14
Isolator Cap Hexnut	90±10	122±14

Table 1, Torque Specifications

Lower Bunk Structure Removal and Installation

Removal

1. Park the vehicle on a level surface. Shut down the engine. Set the parking brake and chock the front and rear tires.
2. Disconnect the batteries.

⚠ WARNING

Support the bunk assembly before removing the gas springs. If not supported, the bunk could fall on you, which could result in personal injury.

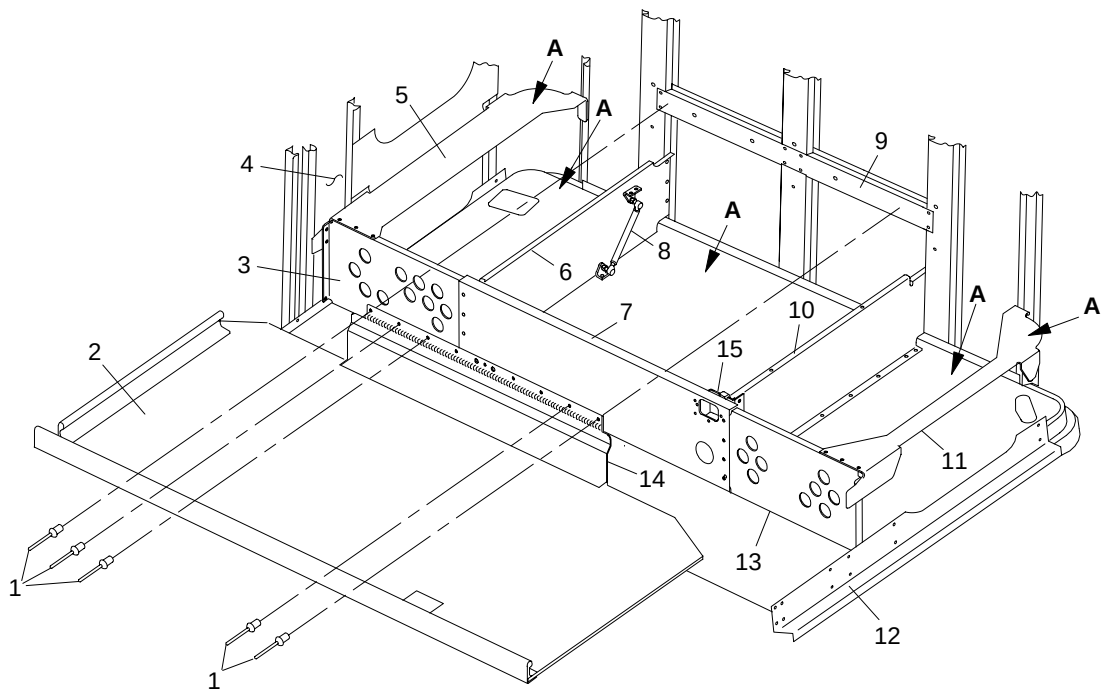
3. Remove the bunk. See **Fig. 1.**

3.1 Remove the mattress pad; then raise the bunk.

3.2 Disconnect the wiring from the lights on the bottom surface of the bunk.

3.3 Support the bunk to keep it from falling; then disconnect the two gas springs from the bunk and the bunk side partitions. Disconnect them by first pulling out the end cap, then removing the gas spring from the ball stud. See **Fig. 2.**

3.4 Lower the bunk; then remove the bunk hinge assembly from the sleeper back wall. See **Fig. 1.**



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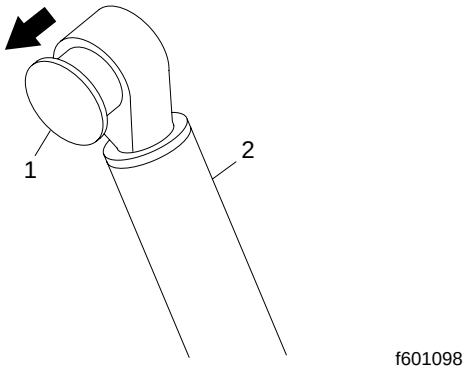
NOTE: Not all parts are shown.

A. Remove upholstery from here.

1. Blind Rivets
2. Bunk Assembly
3. Right Front Bunk Partition
4. Sleeper Right Side Wall
5. Right Bunk Support Angle
6. Right-Hand Side Bunk Partition
7. Front Center Bunk Partition
8. Right Gas Spring
9. Sleeper Back Wall
10. Left-Hand Side Bunk Partition
11. Left Bunk Support Angle
12. Sleeper Deck
13. Left Front Bunk Partition
14. Bunk Hinge Assembly
15. Bunk Latch Mounting Bracket

Fig. 1, Bunk Structure

Lower Bunk Structure Removal and Installation



1. End Cap (shown pulled out)
2. Gas Spring

Fig. 2, Disconnecting the Gas Spring

3.5 Remove the bunk assembly from the vehicle.

4. Remove the upholstery, floor mats, and carpeting from inside the bunk partition area and the tops of the bunk partitions and supports.

NOTE: Some vehicles have a slot built into the under bunk structure. This area may be used for a cooler. See **Fig. 3.**

5. Disconnect the wiring from the auxiliary HVAC; then move the wiring harness up forward by the "B" pillar, and out of the way.
6. Disconnect, then remove the auxiliary HVAC ducting.
7. Remove the bunk support angles and partitions. See **Fig. 1.**

7.1 Remove the fasteners holding the bunk latch mounting bracket in place; then remove it.

7.2 Remove the fasteners holding the support angles in place; then remove them.

7.3 Remove the fasteners holding the front center bunk partition in place; then remove it.

7.4 Remove the fasteners holding the right and left front bunk partitions in place; then remove them.

7.5 Remove the fasteners holding the right-hand and left-hand side bunk partitions in place; then remove them.

Installation

1. Using 1/4-inch Magnabulb fasteners, install the bunk partitions and support angles. See **Fig. 1.**

1.1 Install the front center bunk partition to the sleeper deck.

1.2 Install the right and left front bunk partitions to the sleeper deck; then the center front bunk partition and the side partitions.

1.3 Install the side support angles to the Z-strips on the back wall, the side walls, and the tops of the right and left front bunk partitions.

1.4 Install the left-hand and right-hand side bunk partitions to the sleeper deck, the back wall, and the front partitions.

1.5 Install the bunk latch mounting bracket to the center bunk partition and to the left-hand side bunk partition.

2. Install the HVAC ducting.
3. Route the wiring harness along the sleeper back wall, and inside the bunk partitions; then connect the wiring to the auxiliary HVAC unit.
4. Install the floor mats and carpeting inside the bunk partition.
5. Install the HVAC ducting.
6. Install the bunk.

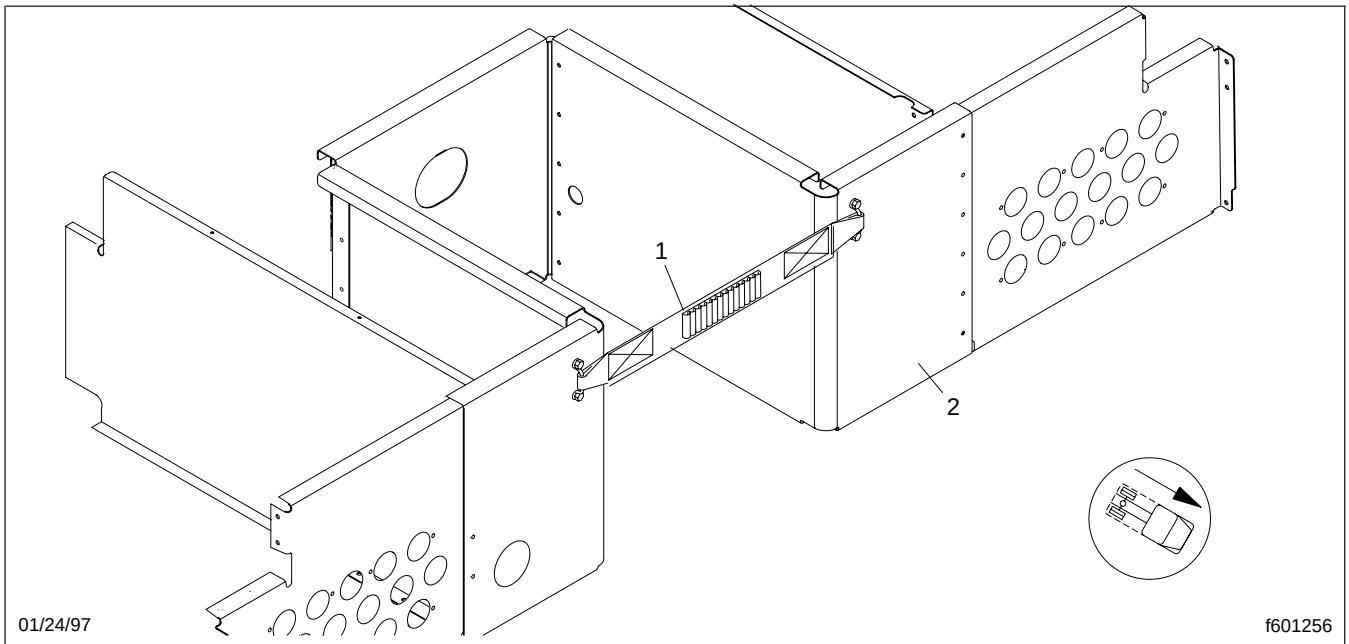
6.1 If not already done, install the hinge assembly to the rear edge of the bunk.

6.2 Using 1/4-inch Magnabulb fasteners, install the bunk and hinge assembly to the back wall of the sleeper.

6.3 Install the gas springs to the bunk and bunk side partitions.

6.4 Connect the wiring to the lights on the bottom surface of the bunk.

7. Close the bunk, then install the mattress pad.
8. Remove the chocks from the tires.



1. Strap
2. Bunk Partition

Fig. 3, Under Bunk Slot

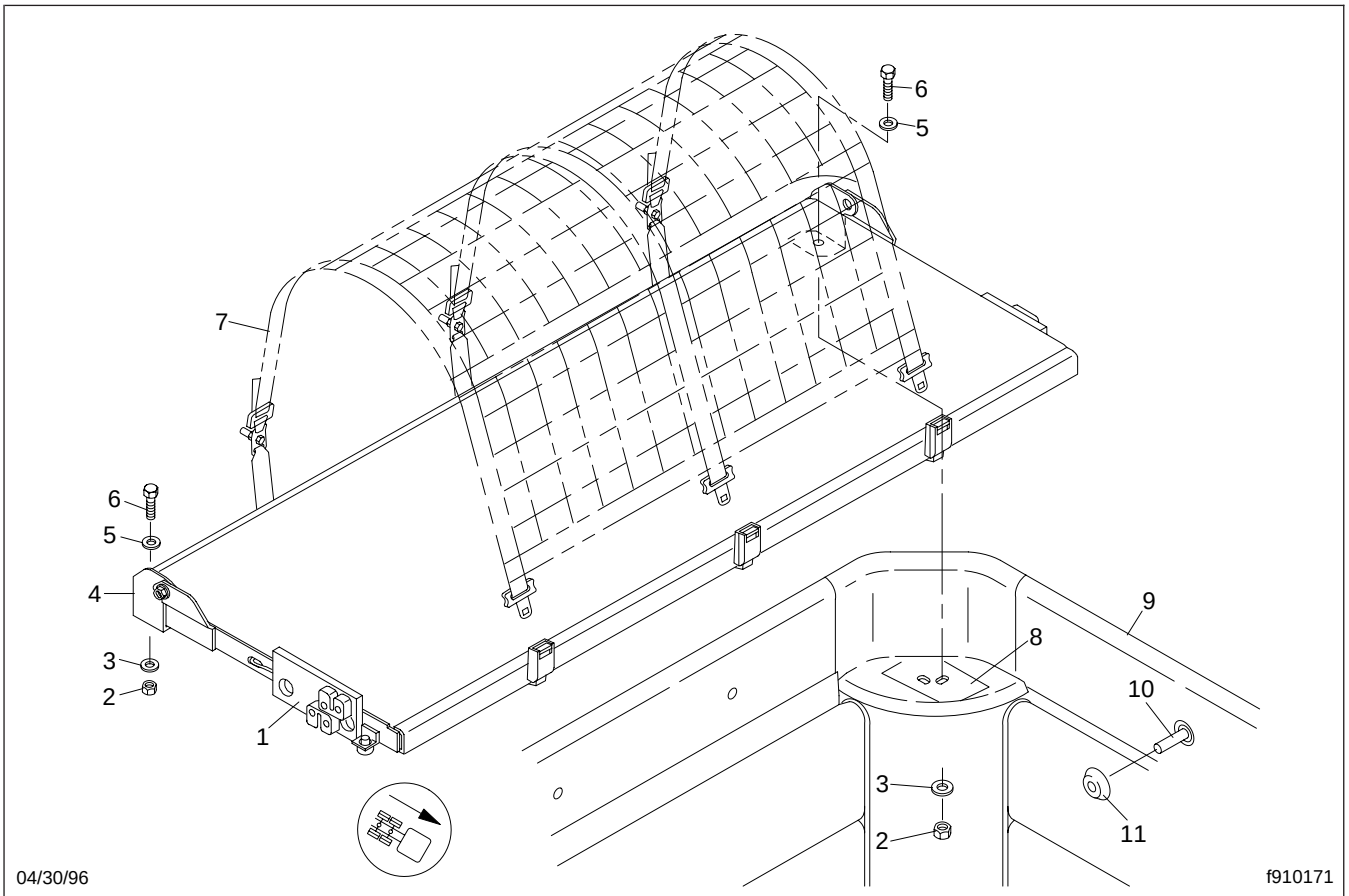
Dymetrol Upper Bunk Removal and Installation

Removal

1. Park the vehicle and apply the parking brake.
2. Chock the tires.
3. Remove the bunk. See **Fig. 1.**

WARNING

WARNING: Support the bunk assembly before removing the mounting bolts. If not supported, the bunk could fall on you, which could result in



1. Latch Mounting Bracket
2. Nut
3. Washer
4. Bunk Assembly
5. Washer
6. Bolt
7. Bunk Restraint
8. Bunk Mount
9. Cab Sidewall
10. Striker Pin
11. Trim Washer

Fig. 1, Upper Bunk Structure

3.1 Raise the bunk and make sure it is securely latched .

3.2 Remove the two bunk mounting bracket covers.

personal injury.

3.3 Support the bunk assembly, then remove the nut, bolt, and washers from each of the two bunk mounts.

Dymetrol Upper Bunk Removal and Installation

3.4 With the aid of a helper, remove the bunk assembly from the vehicle.

Installation

1. Install the bunk. See **Fig. 1.**

   1.1 With the aid of a helper, set the bunk in its raised position onto the mounts. Support the bunk securely.

⚠ WARNING

WARNING: Support the bunk assembly while installing the mounting bolts. If not supported, the bunk could fall on you, which could result in personal injury.

   1.2 Carefully lower the bunk and secure the latches to the striker pins.

   1.3 On each side, install the mounting bolt and washers and tighten the nut.

   1.4 Place the two mounting bracket covers in position over the bunk mounting brackets.

   1.5 Secure each cover with two Christmas-tree fasteners.

2. Remove the chocks from the tires.

General Information

Although the raised roof cap exterior panels and the interior panels are made of different materials, they are closely related in manufacture and repair procedures.

Exterior Panel Manufacture

Raised roof cap panels are made of glass fiber reinforced plastic (FRP) materials. FRP panels are manufactured using both male and female molds. The steel molds are maintained at temperatures ranging between 120° and 150°F (49° and 66°C).

Initially, the mold halves are coated with a release agent to permit part removal after the resin hardens. Next, the glass reinforcing fabric is attached to the female mold half. Now the resin is catalyzed and poured into the female mold half. The mold halves are then nested together, but with a gap between them in order to produce the specified thickness in the finished panel.

The resin is allowed to harden in the mold. After the resin hardens, the mold is separated and the part removed. This process produces parts with uniform wall thickness and smooth inner and outer walls.

Roof Cap Construction

The roof cap is assembled in the following manner:

1. After the parts are molded, any holes or cutouts that were not molded are added.
2. All parts are cleaned and then sanded.
3. A two-part urethane adhesive is applied to the mating surfaces.
4. The exterior cap panels are assembled in a fixture. The fixture includes heated clamping blocks that clamp the outer panels at the bond lines to speed the cure process.
5. The outer panel assembly is inverted in another fixture. The front interior panels and the rear interior panels have urethane adhesive applied to their bonding surfaces and are then bonded to the exterior cap subassembly.
6. Finally, the rear interior panel subassemblies are bonded to the exterior cap, completing the roof cap assembly. After assembly, the interior panels provide structural reinforcement to the exterior cap panels.

If it is damaged, the cap can be repaired by following the procedures specified in **Subject 100**. If the cap is so badly damaged that the major subassemblies described above need to be replaced, remove the entire roof cap and replace it with a service cap available through the Daimler Trucks North America Parts Distribution Centers.

Interior Panel Manufacture

The interior panels are made of RIM polyurethane. Because it is a different material than fiberglass, the repair and replacement of the RIM components varies from the repair of the exterior panels of the raised roof components.

The RIM components are manufactured using a closed-mold process, in which a male and a female mold are brought together to form a part.

The mold, or cavity, is textured, which gives the part its final surface texture. Just prior to closing the mold, the mold is painted with the final surface finish.

A mixture of two liquid compounds is then injected into the closed molds. This, coupled with the mold temperature, initiates a chemical reaction that will eventually yield the finished part after the liquid mixture is allowed to harden in the mold.

The mold is separated, and the part is removed. This process produces parts with uniform wall thickness and surfaces of any given texture and color.

If damaged, the cabinets can be repaired by following the procedures specified in **Subject 110**.

Repair Safety Precautions

Before performing any roof cap repairs, read the following precautions. Observe any additional precautions given by the manufacturers of the repair materials used.

1. All of the raw materials used in repairing roof cap panels are harmful to the eyes and could cause blindness. Wear goggles or other protective eye shields to reduce the chances of splash contacting your eyes.
2. Wear protective gloves, as some people may have skin sensitivity to repair adhesives. Also, don't allow the adhesives to contact your skin; the adhesives can be a skin irritant.

IMPORTANT: In case the adhesives contact your skin, wash with soap and water. If the hardener or resin should contact your eyes, rinse with plenty of water (15 minutes), and call a doctor.

3. When working with roof cap materials, wear disposable or old clothing, since the repair adhesives may damage the cloth. Wash the clothing before wearing it again.
4. Most of the liquids involved in panel repair and cleanup (especially when using acetone as a solvent) are flammable; some are also toxic. Don't perform repairs in areas where exposed (or stored) flammable liquids may contact an open flame or any burning material, such as a cigarette. Don't perform repairs in areas that are not well ventilated.

⚠ WARNING

WARNING: Ensure that roof cap panel repairs are done in a safe workshop area with adequate ventilation. Failure to do so could result in severe personal injury due to explosion of flammable liquids or breathing of toxic fumes.

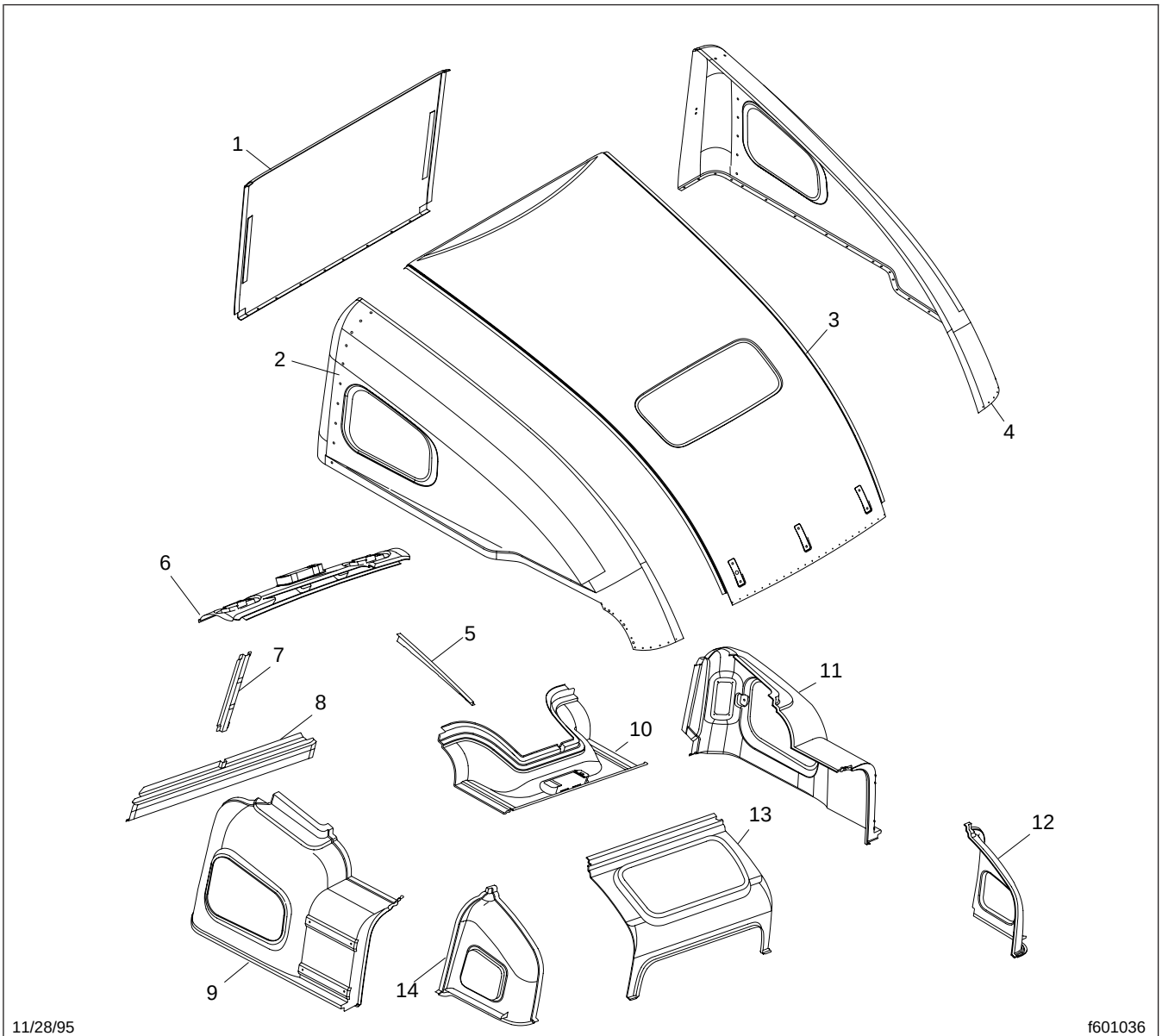
5. Do not use electric tools when the fumes of flammable solvents are present. The heat or sparks generated by the tools could create a fire hazard.
6. When grinding or sanding roof cap panels, wear goggles or other protective eye shields, and also an air-purifying respirator, either a throwaway type or one with a replaceable particulate filter(s). Don't breathe grinding dust or particles, otherwise irritation may occur. Also, during grinding and sanding operations, wear a disposable (paper) shop coat to keep dust and fibers off your clothing.
7. Because fiberglass dust can shorten the life of electrical units, air-powered tools are preferred (for frequent use).

Surface Damage Repair — Exterior and Interior Panels

Surface damage refers to scratches, chips, or nicks on the exterior roof cap panels or roof cap panels. See **Fig. 1**. To repair surface damage, do the following steps:

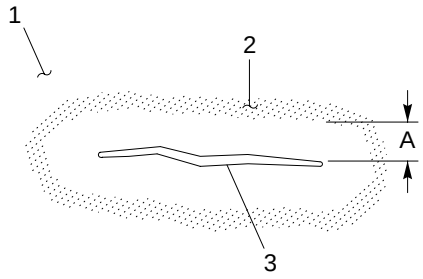
1. Locate the damaged area. If there are cracks, see if they go all the way through the panel. If they do, refer to "Structural Damage Repair" for instructions.
2. Clean the area with xylene or an equivalent grease- and wax-removing solvent. Inspect the area closely.
3. Using 220-grit or finer sandpaper, remove all of the paint around the damaged area to a distance of about 1-1/2 inches (4 cm). See **Fig. 2**.
4. Using an air nozzle, blow off all dust.
5. Wipe filler (Ashland Pliogrip 7775L) over the non-coated area and spread a thin layer using a squeegee applicator. Cover the entire damaged area, overlapping onto the painted surface. Leave a crowned excess of filler, slightly higher than the painted surface.
6. After the filler dries (about 50 minutes), sand it with a hand-held disc pad. Use 320-grit or finer sandpaper. Feather the edges of the fill so there are no visible sharp edges.
7. Clean the area with compressed air. Mask the area, then spot prime and paint it. Use Sherwin Williams BB–11 black conductive primer. See **Group 98** for spot-painting instructions.

Raised Roof Cap Repairs



1. Center Rear Skin
2. Right-Hand Side Skin
3. Center Front Skin
4. Left-Hand Side Skin
5. Upper Roof Trim Reinforcement
6. Upper Rear Panel
7. Center Rear Vertical Reinforcement
8. Lower Rear Reinforcement, Horizontal Center Rear Halo Support
9. Right-Hand Window Surround Panel
10. Upper Panel Assembly
11. Left-Hand Window Surround Panel
12. Front Overhead Assembly, Left-Hand Side
13. Front Storage Panel Halo
14. Front Overhead Assembly, Right-Hand Side

Fig. 1, Roof Cap Assembly Components (SleeperCab shown)



A. Remove paint and primer 1-1/2 inches (4 cm) around the damaged area. Use 220-grit or finer sandpaper.

1. Paint
2. Primer
3. Scratch

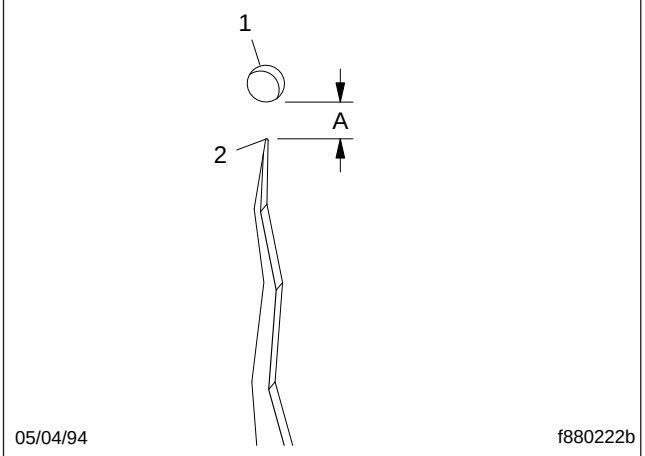
Fig. 2, Damaged Area With Paint Removed

Structural Damage Repair

CRACK OR SMALL HOLE REPAIR

A crack (fracture) or small hole through the laminate requires repair with a fiberglass reinforced patch. This repair is valid for panels 1 through 4, **Fig. 1**.

1. Examine the damage to the roof cap assembly. Apply hand pressure all around the damaged area to check for any concealed damage.
2. If upholstery and/or thermal insulating material is present in the damaged area, remove the material to provide an adequate working area.
3. Clean the area with xylene, acetone, or an equivalent grease- and wax-removing solvent. Inspect the area closely. All dirt, water, grease, and oils must be removed.
4. If repairing a crack, use a 1/8-inch diameter bit to drill a hole completely through the uncracked laminate 1/8 inch (3 mm) from each end of the crack, to prevent the crack from lengthening. See **Fig. 3**
5. On the inner surface of the panel, use a router bit (on a grinder or a drill) to grind away a shallow recess one-quarter the depth of the roof panel and 1/2 inch (13 mm) outward from all sides of the damage. Taper the outside edge of the ground area. See **Fig. 4**.

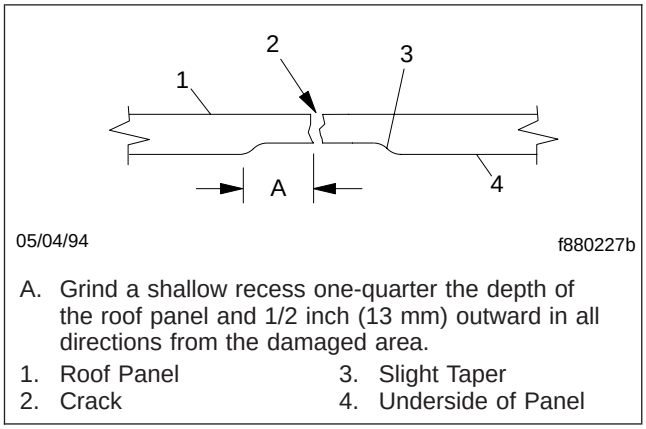


A. Drill a 1/8-inch hole, 1/8 inch (3 mm) away from the end of a crack.

1. 1/8-Inch Hole
2. End of Crack

Fig. 3, Crack Prevention

If repairing a crack, grind outward to the drilled hole at the end of the crack, but not beyond. See **Fig. 5**, Ref. A.



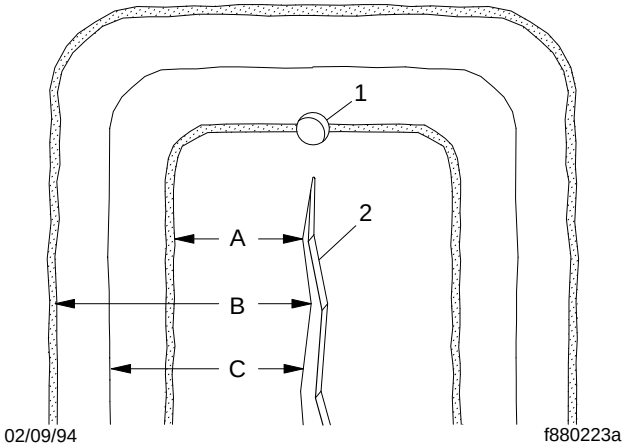
A. Grind a shallow recess one-quarter the depth of the roof panel and 1/2 inch (13 mm) outward in all directions from the damaged area.

1. Roof Panel
2. Crack
3. Slight Taper
4. Underside of Panel

Fig. 4, Recessed Area (cross-sectional view)

6. Use 80- to 220-grit sandpaper to scuff an area at least 1 inch (25 mm) away from the fracture on all sides. Be sure to scuff thoroughly, since this will give the patch a surface to which it can stick. See **Fig. 5**, Ref. B.
7. Blow the dust away with compressed air and wipe the area with a clean cloth.

Raised Roof Cap Repairs



A. Use a router to grind away a shallow recess one-quarter the depth of the roof panel and 1/2 inch (13 mm) outward from the damage. If repairing a crack, don't grind past the hole drilled at the end of the crack.
B. Use 80- to 220-grit sandpaper to scuff the area one inch (25 mm) around the damage.
C. Cut the fiberglass cloth to fully cover the damage, and overlay about 3/4 inch (19 mm).
1. Hole
2. Crack

Fig. 5, Preparing the Damaged Area on the Inner Side of the Roof Panel

8. If necessary, align the panel sections on both sides of the crack, using weights or clamps to re-establish the original panel profile.
9. With a razor-blade knife, cut a section of woven fiberglass cloth to fully cover the crack and to overlay about 3/4 inch (19 mm). See **Fig. 5**, Ref. C.
10. To bond the fiberglass cloth to the damaged panel, use Ashland Pliogrip® 7775 urethane adhesive.

    When using Ashland Pliogrip 7775: Dispense the required adhesive from the cartridge in a continuous bead of uniform size and a uniform green color. Discard the initial few inches of discolored bead.
11. Use a plastic or metal device to spread a thin layer of the bonding agent over the scuffed area.
12. Lay the cut section of fiberglass cloth on the repair area, centered over the damage. Using a fiberglass roller, press the cloth down firmly into the layer of bonding agent to completely soak the glass fibers.
13. Apply another layer of bonding agent over the glass cloth. Spread the agent evenly using the fiberglass roller.
14. After two to five minutes, the bonding agent will start to jell. It may take more time when cool, less when warm.

IMPORTANT: To avoid pre-jelling or skin-over, mate the FRP parts to be bonded within five minutes after extruding and applying the bonding agent.

NOTE: To get a smoother surface, press a piece of masking tape, wider than the repair, directly over the wet bonding agent and smooth it before it hardens. The tape can be removed after 15 minutes when the agent has set.

15. The patch should be hard enough in 50 minutes to allow sanding to a smooth flat surface if required.
16. Repair the damage on the outside surface of the panel and paint the surface on both sides, using the instructions in "Surface Damage Repair."

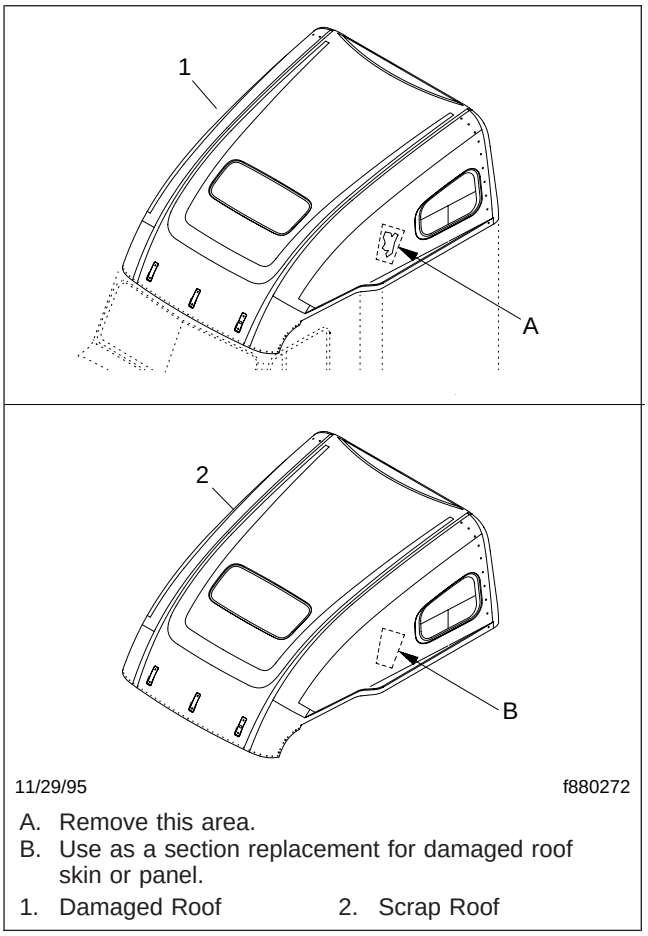
PUNCTURE AND LARGE FRACTURE REPAIR (SECTION REPLACEMENT)

On very large damaged areas (for example, structural damage on the roof cap covering an area of a square foot or more) it may be easier to do a section replacement rather than make a patch. Panels and roof reinforcements may be used in section replacements. Also, another damaged roof with the needed section intact may be available as scrap.

IMPORTANT: Do not use interior panel sections as replacement for damaged outer skin panels. The interior panels have no reinforcement, and cannot be sanded and refinished.

1. Push in on the area immediately surrounding and underneath the damaged area to determine the extent of the damage.
2. If upholstery and/or thermal insulating material is present in the damaged area, remove the material to provide an adequate working area.

3. Clean the area with xylene, acetone, or an equivalent grease- and wax-removing solvent. Inspect the area closely. All dirt, water, grease, and oils must be removed.
4. Using a saber saw, cut out a large, straight-sided panel containing the damaged area. See the example in **Fig. 6**, Ref. A. If the damage extends to a joint where the part is bonded to another, first separate the bonded portion of the damaged section with a heat gun and putty knife before cutting.



A. Remove this area.
B. Use as a section replacement for damaged roof skin or panel.
1. Damaged Roof
2. Scrap Roof

Fig. 6, Section Replacement of a Damaged Fiberglass Roof

WARNING

WARNING: Wear goggles and an air purifying respirator when grinding, cutting, or sanding during all fiberglass repairs. The ground dust and particles could cause temporary or permanent damage to your eyes and, if inhaled, could cause throat or lung irritation.

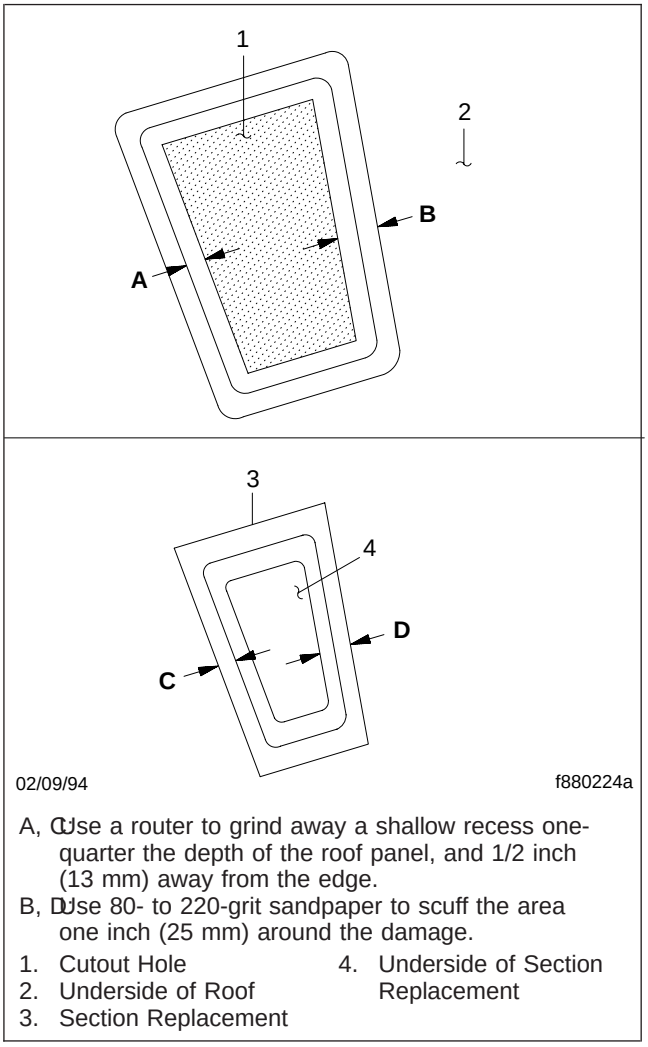
CAUTION

CAUTION: Do not use a heat gun on the interior panels. The interior roof cap panels are made with a urethane based material that has the same melting properties as the urethane adhesive used to manufacture the cap. Heat will destroy the interior panel before the glue debonds.

5. From the scrap roof panel or new part, cut a section replacement panel from the same area, only slightly larger than the original cutout. See the example in **Fig. 6**, Ref. B. Then, trim the section replacement to fit both the size and contour of the original cutout.
6. After the trimming is completed, sand the edges to allow a 1/16- to 1/8-inch (about 2- to 3-mm) gap around the cutout.
7. On the inner side of the panel, use a router bit (on a grinder or drill) to grind away a shallow recess one-quarter the depth of the roof panel, 1/2 inch (13 mm) outward from all sides of the cutout area. See **Fig. 7**, Ref. A. Also, grind 1/2 inch (13 mm) inward from all sides of the section replacement. See **Fig. 7**, Ref. C. Slightly taper the outside edge of the ground area on the roof panel and the inside edge of the ground area on the section replacement. See **Fig. 8**.
8. Use 80- to 220-grit sandpaper to scuff an area at least 1 inch (25 mm) out from all sides of the cutout area. See **Fig. 7**, Ref. B.

   Also, scuff at least 1 inch (25 mm) in from all sides of the section replacement. See **Fig. 7**, Ref. D. Be sure to scuff thoroughly, since this will give the section replacement a surface to which it can stick. Be sure to completely sand off any undercoating sprayed on these areas.
9. On the outer sides of both the cutout and the section replacement, bevel the edges about 45 degrees. See **Fig. 9**.
10. Gently feather the outer painted surfaces back about 1/2 inch (13 mm) beyond the edges of the repair areas (on both the cutout and the section replacement), using 220-grit or finer sandpaper.

Raised Roof Cap Repairs



A, C. Use a router to grind away a shallow recess one-quarter the depth of the roof panel, and 1/2 inch (13 mm) away from the edge.
B, D. Use 80- to 220-grit sandpaper to scuff the area one inch (25 mm) around the damage.

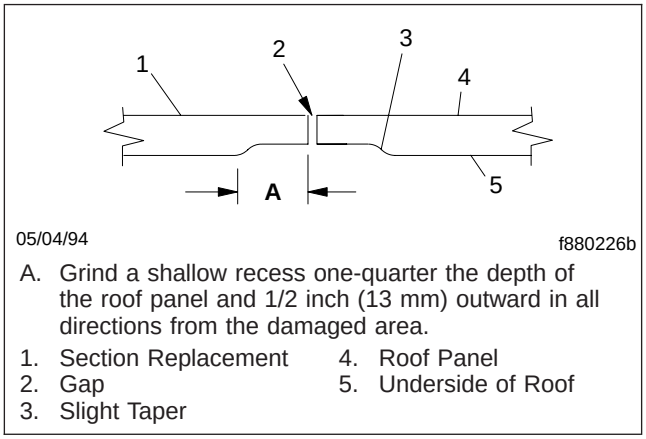
1. Cutout Hole
2. Underside of Roof
3. Section Replacement
4. Underside of Section Replacement

Fig. 7, Preparing the Section Replacement and Roof Panel Cutout on the Unexposed Side

11. Blow the dust away with compressed air and wipe the area with a clean cloth.

12. If the section replacement is close enough to an edge, use clamps to temporarily secure it during the repair. If the replacement is too far from an edge to use clamps, use bond strips as shown in **Fig. 10**.

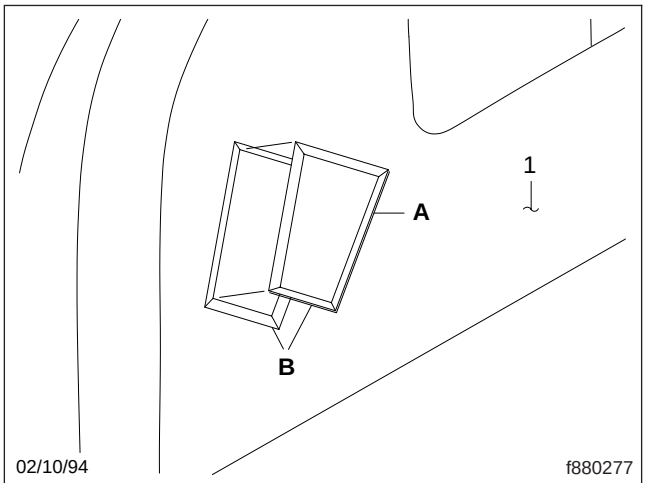
    12.1 Cut some scrap FRP into strips. Make enough strips to hold the section replacement in position, about one every six inches (15 cm). If the surface of the replacement panel is contoured or curved,



A. Grind a shallow recess one-quarter the depth of the roof panel and 1/2 inch (13 mm) outward in all directions from the damaged area.

1. Section Replacement
2. Gap
3. Slight Taper
4. Roof Panel
5. Underside of Roof

Fig. 8, Cutout Area (cross-sectional view)



A. Insert section replacement.
B. Bevel outer surface edges on all sides.

1. Exposed Side of Roof

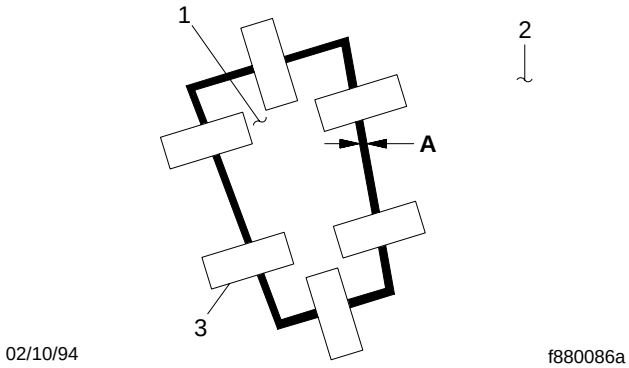
Fig. 9, Areas to be Beveled

use many small bond strips. Larger strips could deform the curves.

12.2 On the inner side of the repair, use 80- to 220-grit sandpaper to scuff sand the areas on the roof and section replacement panels where you plan to bond the strips.

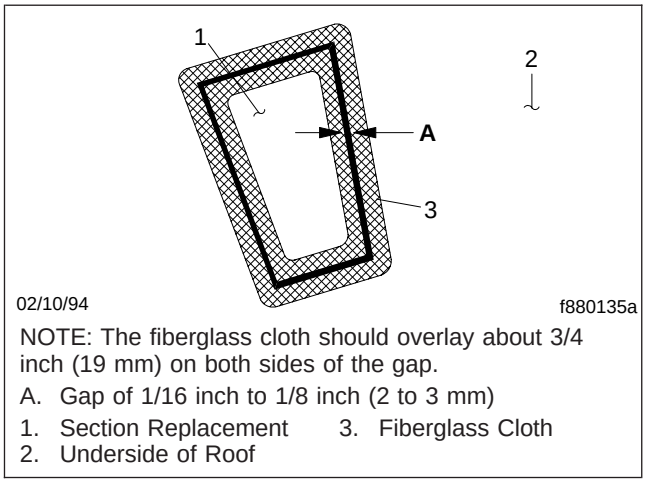
12.3 If a joint between parts was separated for the repair, rebond the joint. Refer to "Roof Cap Assembly Rebonding" for instructions.

12.4 Holding the section replacement in position, bond the strips to both roof and replacement panels in the area already



A. Gap of 1/16 inch to 1/8 inch (2 to 3 mm)
1. Section Replacement
2. Underside of Roof
3. Bond Strip

Fig. 10, Securing the Section Replacement to the Roof Panel Using Bond Strips



NOTE: The fiberglass cloth should overlay about 3/4 inch (19 mm) on both sides of the gap.

A. Gap of 1/16 inch to 1/8 inch (2 to 3 mm)
1. Section Replacement
2. Underside of Roof
3. Fiberglass Cloth

Fig. 11, Fiberglass Cloth Overlay

scuffed. Use Ashland Pliogrip 7773 to bond the strips.

12.5 The Pliogrip 7773 adhesive will set in 10 minutes, and will be sandable in 30 minutes. Cure times may be shortened by using a heat gun. Do not expose the adhesive to temperatures in excess of 180°F (82°C).

12.6 After the bonding agent has hardened, use 80- to 220-grit sandpaper to scuff the bond strips.

12.7 Blow the dust away with compressed air and wipe the area with a clean cloth.

13. With a razor-blade knife, cut sections of woven fiberglass cloth to fully cover the gap between the cutout and the section replacement, all the way around the damaged area. The cloth should overlay about 3/4 inch (19 mm) on both sides of the gap. See **Fig. 11**.

14. To bond the fiberglass cloth to the damaged panel, use Ashland Pliogrip 7775L urethane adhesive.

    When using Ashland Pliogrip 7775L: Dispense the required adhesive from the cartridge in a continuous bead of uniform size and a uniform green color. Discard the initial few inches of discolored bead.

15. Use a plastic or metal device to spread a thin layer of the bonding agent over the scuffed area.

16. Lay the cut sections of fiberglass cloth on the repair area, centered over the damage. Using a fiberglass roller, press the cloth down firmly into the layer of bonding agent to completely soak the glass fibers.

17. Apply another layer of bonding agent over the glass cloth. Spread the agent evenly using the fiberglass roller.

18. After two to five minutes, the bonding agent will start to jell. It may take more time when cool, less when warm.

IMPORTANT: To avoid pre-jelling or skin-over, mate the FRP parts to be bonded within five minutes after extruding and applying the bonding agent.

NOTE: To get a smoother surface, press a piece of masking tape, wider than the repair, directly over the wet bonding agent and smooth it before it hardens. The tape can be removed after fifteen minutes when the bonding agent has set.

19. Repair the damage on both inner and outer surfaces of the roof, and paint the surface on both sides, using the instructions in "Surface Damage Repair." Surfaces on the inside of the roof cap that will be covered with insulation and upholstery panels do not require paint.

Raised Roof Cap Repairs

ROOF CAP ASSEMBLY REBONDING

1. If rebonding a joint that has separated, or if replacing a damaged part, completely separate each part. The outer FRP panels are separated using a heat gun and putty knife. Remove as much of the old adhesive as possible. The heat gun will soften the adhesive and allow it to be peeled off the FRP roof cap subassemblies. The inner RIM panels must be separated mechanically. Work folded medium-grit sandpaper or a section of a steel hacksaw blade between the two surfaces to remove the old adhesive.
2. Scuff the surfaces of the outer FRP panels with with 80- to 220-grit sandpaper. Do not sand or scratch the interior RIM panels.
3. Clean the surfaces to be bonded with Ashland 6036 primer or methylene chloride. Inspect the area closely to be sure all of the old adhesive, dirt, water, grease, and oils are removed.
4. If replacing a large part, such as an outer panel, align the part on the roof cap assembly and clamp it in place. Drill holes through the bonding surfaces and install clamping bolts in the holes. Use two washers, one on each side of the joint. See **Fig. 12**. There should be enough clamping bolts to hold the panel in place and keep the bonding surfaces together, or at least one bolt every 12 to 18 inches (30 to 45 cm). Remove the part for application of bonding agent. If RIM panels will be drilled, use a fluted or a parabolic drill bit. Do not use standard 180-degree ground drill bits.
5. Use the Pliogrip urethane cartridge materials 7773 or 7779 or equivalents to bond panels together.

   When using Ashland Pliogrip 7773 or 7779: Dispense the required adhesive from the cartridge in a continuous bead of uniform size and a uniform green color. Discard the initial few inches of discolored bead.
6. Within four minutes after applying the bead, align the part on the roof assembly and clamp it firmly in place. If it is a large part, install the clamping bolts. Tighten the clamps or clamping bolts just enough to ensure that a uniform amount of pressure is applied along the seam. Ideally, the bonding agent should be compressed to form a bond line one inch (25 mm) wide and 0.030 inch (0.76 mm) thick. This thickness can be ensured by sprinkling 0.030 inch glass beads into the bonding agent before mating the parts.

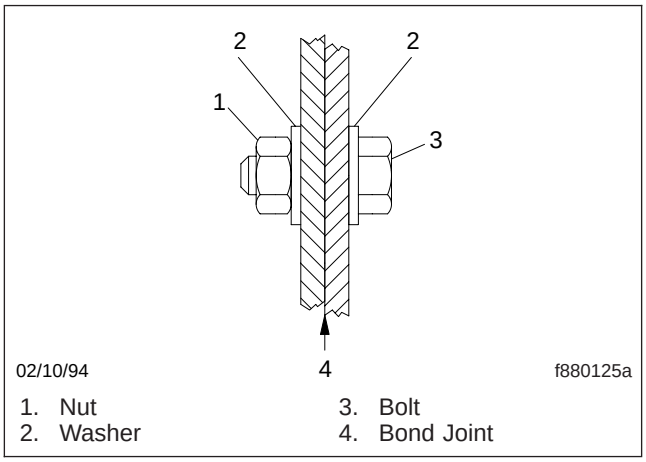


Fig. 12, Clamping Bolt at Bond Joint

7. Before it cures, within seven to 10 minutes, remove any excess bonding agent that squeezes out the edges of the bond.
8. If a heat gun is used, remove the clamps when the bonded FRP parts are cool to the touch; in about one hour. If no heat is applied, leave the bonded parts clamped together for twenty-four hours.

NOTE: Do not use a heat gun in excess of 180°F (82°C) when working with Ashland Pliogrip adhesive.

9. If holes were drilled for clamping bolts, repair them using the instructions under "Crack or Small Hole Repair."
10. If necessary, prime and paint the repair area using the instructions under "Surface Damage Repair."

Repair Safety Precautions

Before performing any polyurethane repairs, read the following precautions. Observe any additional precautions given by the manufacturers of the repair materials used.

1. All of the raw materials used in repairing polyurethane are harmful to the eyes and could cause blindness. Wear goggles or other protective eye shields to reduce the chances of splash contacting your eyes.
2. Wear protective gloves, as some people may have skin sensitivity to resin, epoxy, or other repair material. Also, don't allow the hardener to contact your skin; the hardener can be a skin irritant.

IMPORTANT: In case the hardener or resin contacts your skin, wash with soap and water. If the hardener or resin should contact your eyes, rinse with plenty of water for 15 minutes, and call a doctor.

3. When working with these materials, wear old clothing, since the resin may damage the cloth. Wash the clothing before wearing it again.
4. Most of the liquids involved in repair and cleanup (especially when using acetone as a solvent) are flammable; some are also toxic. Don't perform repairs in areas where exposed (or stored) flammable liquids may contact an open flame or any burning material, such as a cigarette. Don't perform repairs in areas that are not well ventilated.

⚠ WARNING

WARNING: Ensure that polyurethane repairs are done in a safe workshop area with adequate ventilation. Failure to do so could result in severe personal injury due to explosion of flammable liquids or breathing of toxic fumes.

5. Do not use electric tools when the fumes of flammable solvents are present. The heat or sparks generated by the tools could create a fire hazard.
6. When grinding or sanding polyurethane surfaces, wear goggles or other protective eye shields, and also an air-purifying respirator, either a throwaway type or one with a replaceable particulate filter(s). Don't breathe grinding dust or particles, otherwise irritation may occur. Also, during grinding and sanding operations, wear a disposable (paper) shop coat to keep dust and fiber slivers off your clothing.
7. Because dust can shorten the life of electrical units, air-powered tools are preferred (for frequent use).
8. Unless repairs are done on a regular (daily) basis, don't save leftover liquids. If liquids must be saved, store them in cool, dark areas, away from direct sunlight.

Surface Damage Repair

Surface damage refers to scratches, chips, or nicks in the outer surface of the interior panels. To repair surface damage, do the following steps:

1. Locate the damaged area. If there are cracks, see if they go all the way through the component. If they do, refer to "Structural Damage Repair" for instructions.
2. Clean the area with xylene or an equivalent grease- and wax-removing solvent. Inspect the area closely.
3. Depending on the depth and extent of the damage, simply retouching the affected areas with paint may be sufficient. If the damage is significant, follow the next steps.
4. Using an air nozzle, blow off all dust.
5. Wipe filler (Akemi AP–3030) over the non-coated area and spread a thin layer using a squeegee applicator. Cover the entire damaged area, overlapping onto the painted surface. Leave a crowned excess of filler, slightly higher than the painted surface.
6. After the filler dries (about five minutes), sand it with a hand-held disc pad. Use 320-grit or finer sandpaper. Feather the edges of the fill so there are no visible sharp edges.
7. Clean the area with compressed air. Mask the area, then spot prime and paint it. Use Sherwin Williams BB–11 black conductive primer. See **Group 98** for spot-painting instructions.

Interior Panel Repairs

Structural Damage Repair

The interior panels are bonded together with a structural bonding agent.

If there is damage at any joint between two parts, the damage is not repairable. For example, if the panel is damaged so badly that the roof panel is also damaged, replace the panel.

If a joint between two parts has separated and there is no damage at the joint area, the parts can be rebonded. Or, if a part is damaged and its adjoining parts are not damaged, the damaged part can be separated from the roof and new or used parts can be bonded in place. A section of a part can be replaced as long as the section does not include a joint between two parts. Panels are available as replacement parts or for use in section replacements.

CAUTION

CAUTION: As noted above, the panels serve as structural reinforcement for the outer panels. Removing the larger interior panels may cause the outer panels to deform, making reassembly impossible.

If the damage is such that the parts cannot be replaced, or a section replacement cannot be done, replace the entire roof cap assembly.

For damage in the form of a small crack or hole, refer to "Crack or Small Hole Repair."

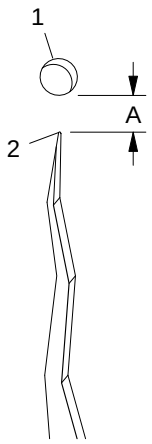
For larger damaged areas, see **Subject 100**.

For replacing or rebonding parts, see **Subject 100**.

CRACK OR SMALL HOLE REPAIR

A crack (fracture) or small hole through the polyurethane may require repair with a fiberglass reinforced patch, depending on the size and the extent of the fracture.

1. Examine the damage to the assembly. Apply hand pressure all around the damaged area to check for any concealed damage.
2. If upholstery and/or thermal insulating material is present in the damaged area, remove the material to provide an adequate working area.
3. Clean the area with xylene, acetone, or an equivalent grease- and wax-removing solvent. Inspect the area closely. All dirt, water, grease, and oils must be removed.
4. If repairing a crack, use a 1/8-inch diameter bit to drill a hole completely through the uncracked polyurethane 1/8 inch (3 mm) from each end of the crack, to prevent the crack from lengthening. See **Fig. 1**.



A. Drill a 1/8-inch hole, 1/8 inch (3 mm) away from the end of a crack.
1. 1/8-Inch Hole
2. End of Crack

Fig. 1, Drilling for Repair

5. On the outer surface (at the surface between the interior panels and the exterior panel skins), use 80- to 220-grit sandpaper to scuff an area at least 1 to 2 inches (25 to 51 mm) surrounding the damaged area. This will give the patch a surface to stick to.
6. Blow the dust away with compressed air and wipe the area with a clean cloth.
7. If necessary, align the panel sections on both sides of the crack, using weights or clamps to re-establish the original panel profile.
8. With a razor-blade knife, cut a section of woven fiberglass cloth to fully cover the crack and to overlay about 3/4 inch (19 mm).
9. To bond the fiberglass cloth to the damaged panel, choose one of the following bonding agents:

- Magnolia Magnabond 58 epoxy resin
- Ashland Pliogrip® 7773 polyurethane adhesive

IMPORTANT: Do not mix epoxy and polyurethane.

When using Magnolia Magnabond 58: Measuring the volumes with a spoon, and using a wooden stir stick, mix equal parts of Magnolia Magnabond 58 A and B epoxy resins on a clean sheet of glass, metal, or a section of scrap laminate. Mix for fifteen seconds to ensure a good blend.

IMPORTANT: With Magnolia Magnabond 58, it is critical to measure the A:B ratio accurately. Also, make sure the two components are adequately mixed.

When using Ashland Pliogrip 7773: Dispense the required adhesive from the cartridge in a continuous bead of uniform size and a uniform green color. Discard the initial few inches of discolored bead.

10. Use a plastic or metal device to spread a thin layer of the bonding agent over the scuffed area.
11. Lay the cut section of fiberglass cloth on the repair area, centered over the damage. Using a fiberglass roller, press the cloth down firmly into the layer of bonding agent to completely soak the glass fibers.
12. Apply another layer of bonding agent over the glass cloth. Spread the agent evenly using the fiberglass roller.
13. After two to five minutes, the bonding agent will start to jell. It may take more time when cool, less when warm.

IMPORTANT: To avoid pre-jelling or skin-over, mate the parts to be bonded within one to four minutes after extruding and applying the bonding agent.

NOTE: To get a smoother surface, press a piece of masking tape, wider than the repair, directly over the wet bonding agent and smooth it before it hardens. The tape can be removed after fifteen minutes when the agent has set.

14. The patch should be hard enough in fifteen minutes to allow sanding to a smooth flat surface if required.
15. Repair the damage on the outside surface of the panel and paint the surface on both sides, using the instructions in "Surface Damage Repair."

Skylight Window Glass Replacement

Replacement

⚠ WARNING

WARNING: When handling glass, wear protective gloves to protect your hands from sharp edges and to allow a better grip. Not wearing protective gloves when handling glass could result in personal injury.

1. Park the vehicle on a flat surface. Shut down the engine, set the parking brake, and chock the tires.
2. Inside the cab, attach a suction device onto the skylight window glass surface. See **Fig. 1**. See **Fig. 2** for the tools needed to perform this procedure.

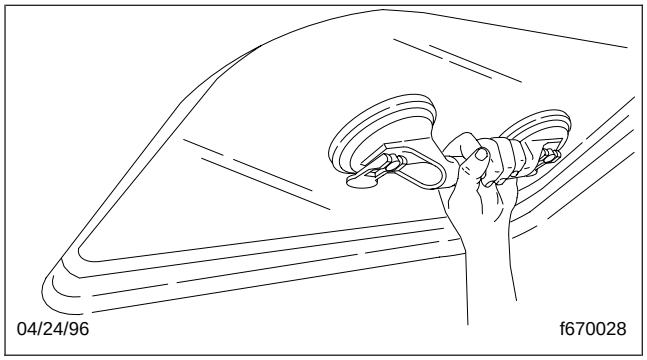
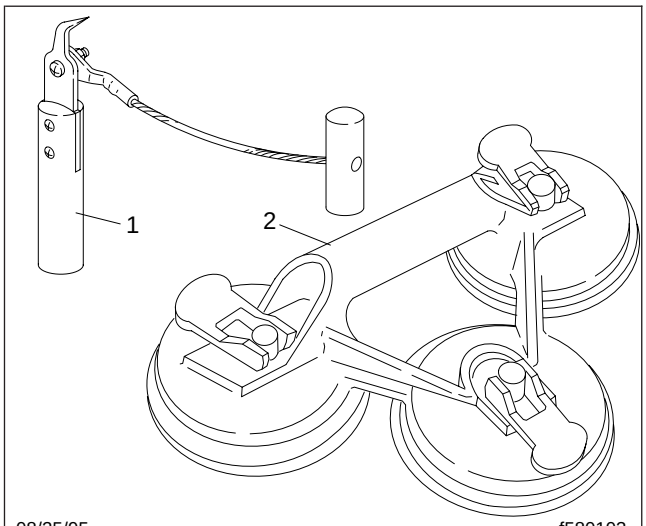


Fig. 1, Attaching the Suction Device to Skylight Window Glass

3. With a pull-knife and a utility knife, cut through the adhesive attaching the glass and seal to the roof.
4. Apply a slight upward pressure to the glass.

NOTE: When removing the glass be sure to note the location of the manufacturer's ID on the lower left corner of the inside surface of the glass. The new glass must be replaced in the same position.

5. From inside the cab, remove the glass from the opening.
6. Check for rough spots on the roof cap panel perimeter, and sand and prime, as necessary. Apply urethane primer to the opening.
7. Prepare the new skylight glass.



1. Pull Knife
2. Suction Device

Fig. 2, Typical Windshield Tools

⚠ CAUTION

CAUTION: When handling the replacement skylight window glass, be careful not to nick or splinter the edges of the glass. Chipped edges could cause cracking later on.

7.1 Put the new glass on a suitable stand or fixture, with the inside surface of the glass facing up.

7.2 Clean the edges of the glass with a mixture of 50/50 isopropyl alcohol and water.

7.3 Apply Betaseal® U–401 Glass Prep all the way around the edge of the glass to a width of about 1-1/2 inches (40 mm).

7.4 Wait five seconds, then wipe off the glass prep, using a clean, lint-free cloth.

8. With a Betagun, first discard the first 6 to 8 inches (15 to 20 cm) of the adhesive before applying any to the glass, then apply a continuous bead of adhesive approximately 1/2 inch (13 mm) high around the inside sealing surface of the glass (not on the rubber seal).
9. Check the location of the manufacturer's ID on the glass.
10. Return the assembly to the cab.

Skylight Window Glass Replacement

11. Attach the suction device to the glass.
12. Position the glass from the inside of the vehicle above the window opening.
13. Lower the glass into place on the opening. Pull the glass into position by gripping the suction device.
14. Remove the suction device, and clean the glass and the area surrounding the skylight window.

Cab Removal and Installation

When removing the cab, make sure you have equipment that is suitable for lifting the entire weight of the cab. For the front wall disconnections, work first on one side of the vehicle, then the other.

Removal

1. Park the vehicle, set the parking brakes, then chock the tires
2. Support the rear of the cab with blocks.
3. Disconnect the batteries at the negative terminal.
4. Drain the air system tanks.
5. Tilt the hood, and support it on a padded table or bench.
6. If so equipped, remove the roof fairing and side extenders.
7. Remove the chassis side fairings. See the applicable section in **Group 31** for instructions.
8. Drain the radiator.

NOTE: The following steps are done on the left side of the vehicle.

9. Remove the windshield washer reservoir.
10. Disconnect the left-side radiator strut from the front wall.
11. Mark the upper end of the steering column connection, then disconnect it from the lower end of the steering column.
12. Disconnect the lower steering column from the steering gear and the upper steering column. See the applicable section in **Group 46** for instructions.
13. Mark, then disconnect all the electrical wiring from the left side of the front wall.
14. Disconnect the clutch linkage. See the applicable section in **Group 25** for instructions.
15. Mark, then disconnect all the air lines at their quick-disconnects.
16. Mark, then disconnect all the lines from the air/oil junction block.
17. Remove the left-side mudflap and bracket assembly.
18. Find the ground wire coming from under the cab, below the forward cab-mount bracket. Disconnect it from the frame rail.
19. If so equipped, disconnect the engine block heater wiring from the chassis.
20. Remove fasteners holding the forward cab-mount assemblies to the frame rail mounting brackets.
21. Disconnect the air line from the air horn, which is mounted underneath the cab deck, below the driver's seat.
22. If so equipped, disconnect the front-axle ABS harness from the underside of the cab deck, in back of the driver's seat area.
23. Go to the right side of the front wall.
24. Disconnect the right radiator strut from the front wall.
25. Remove the air cleaner and the heat shield below it.
26. Mark, then disconnect all the electrical wiring from the right side of the front wall.
27. Evacuate the air conditioning system. See the applicable section in **Group 83** for instructions.
28. Mark, then disconnect the lines from the HVAC receiver/drier. Cover the lines to keep out contaminants.
29. Mark, then disconnect the cab heater supply and return hoses.
30. Disconnect the auxiliary (sleeper) heater hose from the large supply hose coming from the radiator.
31. Put a container under the engine, then disconnect the auxiliary heater supply hose from the engine block.
32. Disconnect the lines from the HVAC expansion valve on the right side of the front wall.
33. Remove the right-side mud flap and bracket assembly
34. Remove the transmission shift lever.
    - 34.1 From inside the cab, remove the metal bezel from the cab deck, then slide the rubber boot up the shift lever
    - 34.2 If so equipped, disconnect the splitter airline and the cruise control wiring.

Cab Removal and Installation

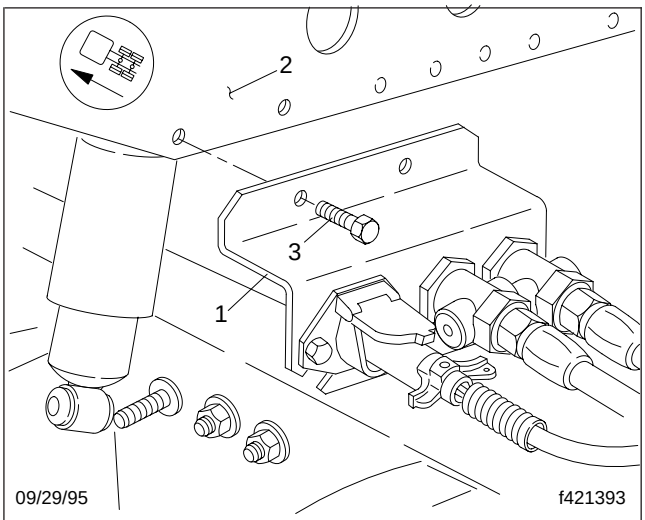
34.3 Using a 5/32-inch allen wrench, and a 1/2-inch crescent wrench, disconnect the shift lever from the shift tower.

35. Remove the fasteners holding the right-side forward cab-mount bracket to the frame rail mounting bracket.

36. At the back of the cab, disconnect the cab rear air suspension. See the applicable section in this group for instructions.

37. Remove the mufflers and heat shields. See the applicable section in **Group 47** for instructions.

38. Remove the bracket for the trailer air connections from the back wall of the cab. **See Fig. 1.**



1. Bracket
2. Back Wall of Cab
3. Hexbolt (2 qty.)

Fig. 1, Trailer Air-Connection Bracket

⚠ WARNING

Before lifting the cab from the chassis, make sure the cab is correctly balanced, that it is supported in at least four places, and that the hoist is strong enough to support the cab. Failure to do so could result in the cab falling, which could cause serious personal injury and damage to the cab.

39. Using a suitable hoist, and attaching straps at four points on the cab (two forward, and two rear), lift the cab off the chassis.

⚠ CAUTION

CAUTION: Do not try to lift the cab by the door frames unless you install a special door lifting insert into each door frame. The door frames are not strong enough to support the full weight of the cab, and damage to the cab could result if it is lifted without the use of lifting inserts. Using the inserts also ensures that the cab will be correctly balanced in the lifting straps.

39.1 Open the doors; then install a lifting insert into each door frame, and clamp it in place, using padded clamps. **See Fig. 2.**

Right and left lifting door insert assemblies are available through Daimler Trucks North America Parts Distribution Centers. The part numbers are A22-45473-000 (left-side), and A22-45473-001 (right-side).

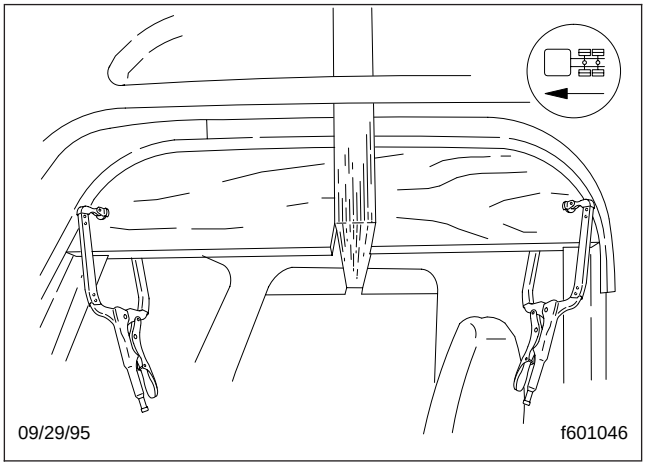


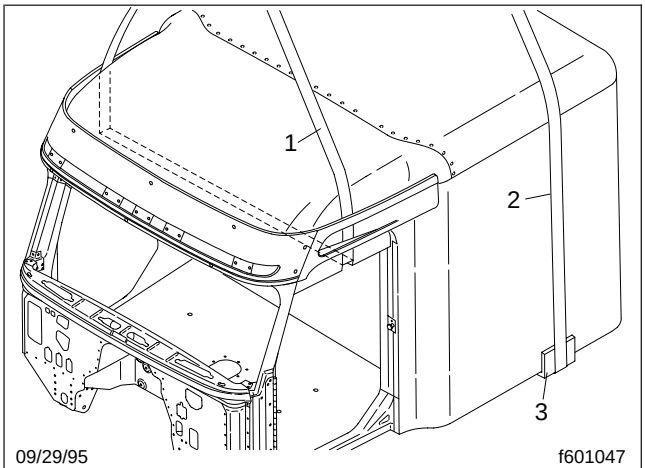
Fig. 2, Door Lifting Insert Installed and Lifting Strap in Place

39.2 Attach the forward lifting strap. Make sure it fits into the groove of each lifting insert.

39.3 Attach lifting straps to the rear of the right and left side walls, using suitable padded clamps. **See Fig. 3.**

39.4 Lift the cab slightly to make sure it is balanced, and that nothing is holding it to the chassis. If needed, lower the cab and adjust the placement of the rear straps.

39.5 Lift the cab clear of the chassis.



1. Forward Lifting Strap
2. Rear Lifting Strap
3. Padded Clamp

Fig. 3, Lifting the Cab

Installation

1. Lower the cab onto the chassis. Make sure the forward cab mounts line up with the frame rail mounting brackets, both fore and aft, and side to side.
2. Attach the forward cab mounts to the frame rail mounting brackets. See the applicable section in this group for instructions.
3. Connect the rear cab air suspension. See the applicable section in this group for instructions.
4. Install the bracket for the trailer air connections to the left side of the cab back wall.
5. Install the mufflers and heat shields. See the applicable section in **Group 47** for instructions.
6. From inside the cab, connect the transmission shift lever to the shift tower. Install the rubber boot to the cab deck.
7. On the right side of the front wall, connect the lines to the HVAC expansion valve.
8. Connect the lines to the HVAC receiver-drier.
9. Connect the auxiliary (sleeper) heater supply hose to the engine block.
10. Connect the other auxiliary heater hose to the large supply hose coming from the radiator.
11. Connect the cab heater hoses as previously marked.
12. As previously marked, connect all the wiring on the right side of the front wall.
13. Install the air cleaner and the heat shield.
14. Attach the right radiator strut to the front wall.
15. On the left side of the vehicle, connect the front-axle ABS wiring harness to the underside of the cab deck, at the rear of the driver's seat.
16. Connect the air line to the air horn.
17. If so equipped, connect the engine block heater wiring.
18. Connect the ground wire coming from under the cab deck.
19. As previously marked, connect the lines to the air/oil junction block.
20. As previously marked, connect all the air lines.
21. As previously marked, connect all the electrical wiring on the left side of the front wall.
22. Connect the clutch linkage. See the applicable section in **Group 25** for instructions.
23. Connect the lower steering column to the steering gear and the upper steering column. Make sure you use a new pinch bolt at the steering gear connection. See the applicable section in **Group 46** for instructions.
24. Attach the right radiator strut to the front wall.
25. Install the windshield washer reservoir.
26. Install the right- and left-side mudflaps and brackets to the chassis.
27. If so equipped, install the chassis side fairings. See the applicable section in **Group 31** for instructions.
28. If so equipped, install the roof fairing and side extenders.
29. Fill the radiator with coolant.
30. Connect the batteries.
31. Charge the HVAC system. See the applicable section in **Group 83** for instructions.
32. Start the engine and check all the coolant and heater hoses for leaks. Check all the electrical systems and gauges.

Cab Removal and Installation

33. Build the air pressure to 110 psi.
34. Adjust the cab height. For instructions, see the section on cab air suspension in this group.
35. Close the hood.
36. Remove the chocks from the tires.

Cab Removal and Installation, Argosy COE

Removal

1. With the vehicle parked on a level surface, apply the parking brakes and chock the tires.
2. Tilt the cab slightly, until the cab latches are disengaged; see **Section 60.15, Subject 060**. Place blocks on the cab latches, then lower the cab.
3. Drain the air system.
4. Evacuate the refrigerant; see **Section 83.02, Subject 250**.
5. Drain the radiator; see **Section 20.01, Subject 100**.
6. Remove the cab access stairs; see **Section 60.20, Subject 100**.

⚠ CAUTION

Stand away from the front-wall access panel when opening it. The access panel can open quickly and could hit a person, possibly resulting in personal injury.

7. Raise the front-wall access panel.
8. Remove the lower grille panel, as follows; see **Fig. 1**.
   - 8.1 Remove the four Allen screws that secure the grille panel support brackets to the front-wall crossmember.
   - 8.2 Lift the grille panel up and away from the vehicle.
9. Tilt the cab; see **Section 60.15, Subject 060**.
10. Disconnect the batteries.
11. Disconnect the shift cables, as follows.
    - 11.1 Remove the shift tower boot.
    - 11.2 Remove the four bolts that secure the shift assembly to the cab inner wall; see **Fig. 2**. Pull the assembly, including the shift lever, away from the cab inner wall.
    - 11.3 Remove the clamps that secure the shift cables to the cab inner wall.
    - 11.4 Remove the shift lever electrical line from the shift chassis.
    - 11.5 Pull the shift assembly away from the vehicle.
12. On the right side of the cab underbody, mark and disconnect the electrical harness. This includes the solenoid wire, the actuator wires, and the ABS wires; see **Fig. 3**.
13. Working on the left side of the cab underbody, disconnect the following components:
    - 13.1 Disconnect and cover the A/C lines.
    - 13.2 Mark and disconnect the ACPU wires.
    - 13.3 Place a container under the engine to catch any remaining fluid, then disconnect the heater lines.
14. Remove tie straps as needed from the cab front wall.
15. Mark and disconnect the air brake lines.
16. Disconnect the cab ground, located on the cab inner wall above the headlights, on the right side of the vehicle.

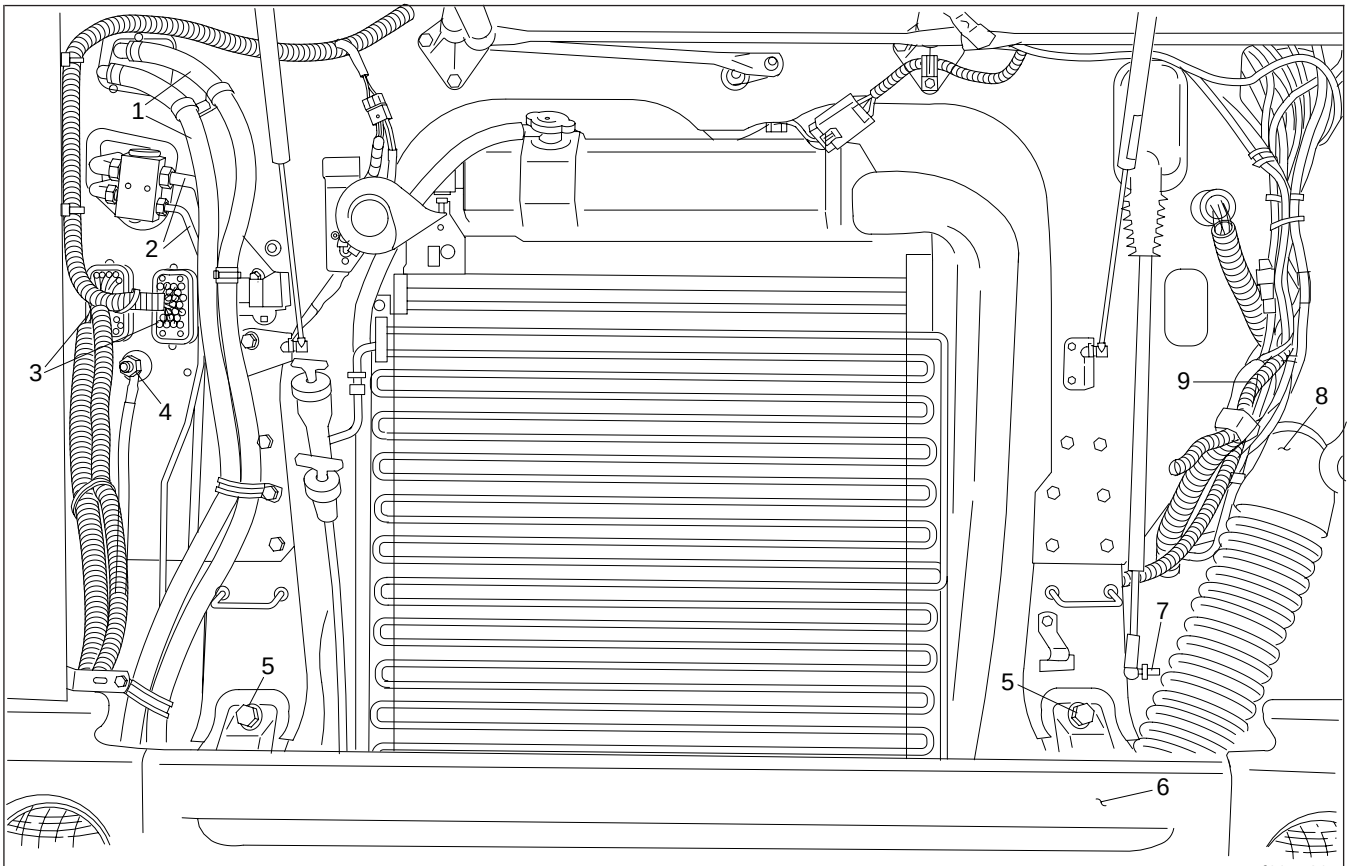
NOTE: For easier access to the cab ground, remove the cowl side panel; see **Section 60.16, Subject 100**.

17. Disconnect the air junction block.
18. Remove the two harness plugs from the left side of the front wall.
19. Disconnect the lower clutch linkage; see **Section 25.03, Subject 120**.
20. Disconnect the steering driveline, as follows.
    - 20.1 Loosen the clamp that secures the boot over the driveline linkage, and pull the boot down.
    - 20.2 Remove the pinch bolt that secures the steering driveline linkage to the steering column; see **Fig. 4**.

NOTE: Before disconnecting the heater lines, have a pan ready to catch any remaining coolant.

21. Remove all tie straps from the auxiliary heater lines, then disconnect the lines. Plug the lines and cap the fittings.
22. Remove the positive cab stud on the left side of the front wall.

Cab Removal and Installation, Argosy COE



1. Auxiliary Heater Lines
2. A/C Lines
3. Cab Harness Plugs
4. Positive Cab Stud
5. Cab Pivot Bushing Swingout Bolt
6. Lower Grille Panel
7. Lower Clutch Linkage
8. Steering Column (covered)
9. Air Brake Lines

Fig. 1, Cab Front Wall

23. Disconnect the tilt cylinders, located on the left and right side of the cab underbody, as follows.
    - 23.1 Remove the cotter pins and washers. Have an assistant adjust the cab height until the clevis pin loosens.
    - 23.2 Remove the cylinder clevis pins.
    - 23.3 Disconnect the two tilt cylinders.
24. Support the cab with a hoist or other suitable lifting device; see **Fig. 5**.
25. Disconnect the cab mounts. This includes the hinge bolt and the bushing swingout bracket bolt; see **Fig. 6**.

⚠ DANGER

Before lifting the cab from the chassis, make sure the cab is correctly balanced, that it is supported in at least four places, and that the hoist is strong enough to support the cab. Failure to do so could result in the cab falling, which could cause serious personal injury and damage to the cab.

26. Using a suitable hoist, and attaching straps at four points on the cab (two forward, and two rear), lift the cab off the chassis, as follows.

Cab Removal and Installation, Argosy COE

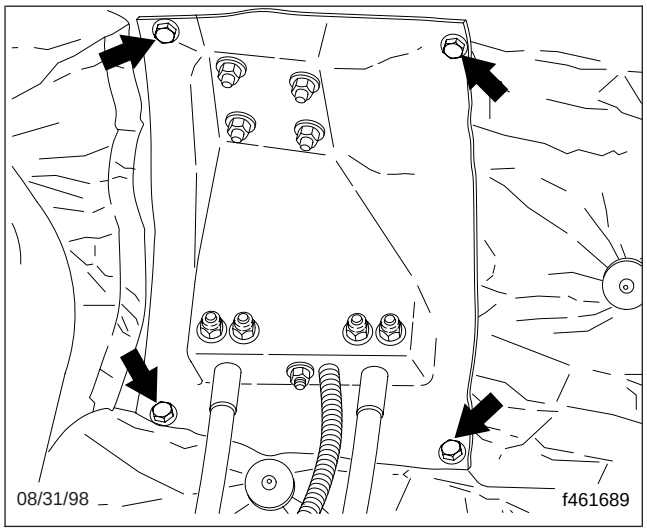


Fig. 2, Shift Panel Support Bolts

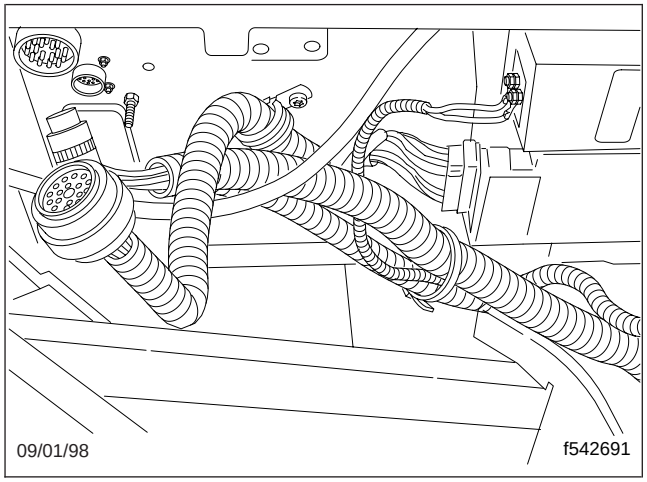


Fig. 3, Cab Electrical Harness

⚠ CAUTION

Do not try to lift the cab by the door frames unless you install a special door lifting insert in to each door frame. The door frames are not strong enough to support the full weight of the cab, and damage to the cab could result if it is lifted without the use of lifting inserts. Using the inserts also ensures that the cab will be correctly balanced in the lifting straps.

26.1 Open the doors; then install a lifting insert into each door frame, and, using padded clamps, clamp it in place; see **Fig. 7**.

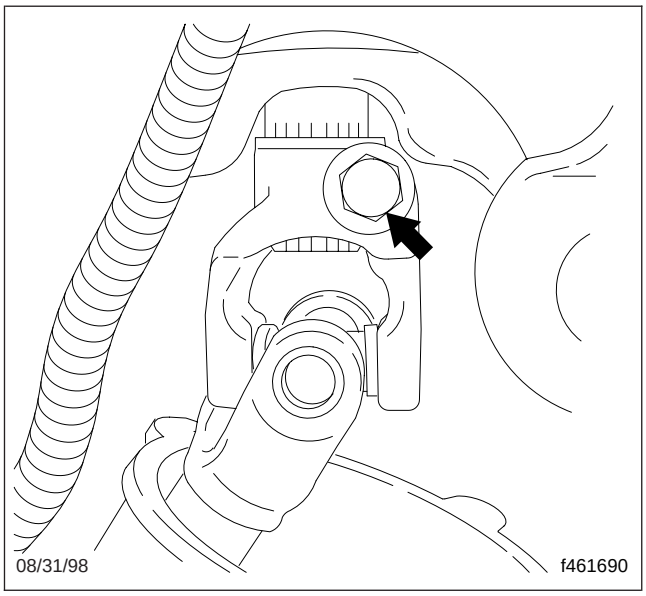


Fig. 4, Steering Linkage Pinch Bolt

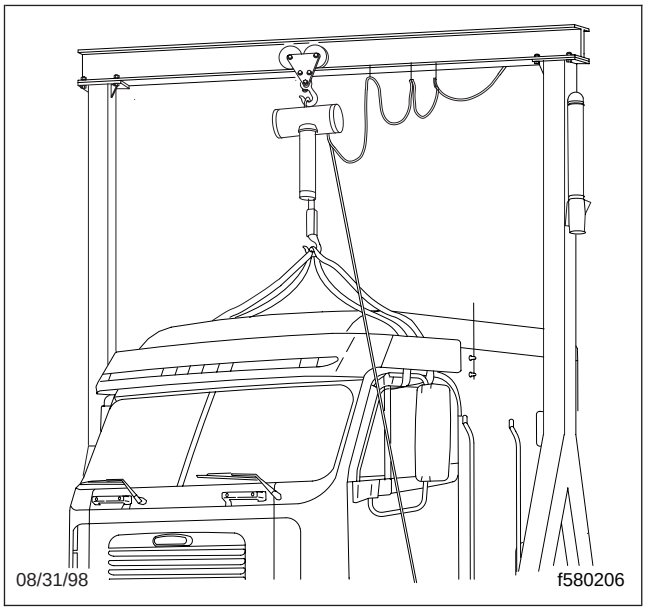
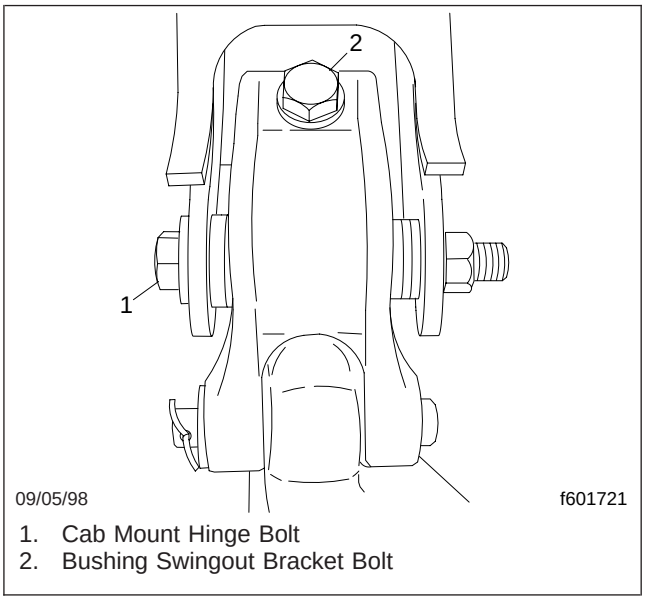


Fig. 5, Cab Lifting Device

26.2 Attach the forward lifting strap. Make sure it fits into the groove of each lifting insert.

26.3 Using suitable padded clamps, attach lifting straps to the rear of the right and left side walls.

Cab Removal and Installation, Argosy COE



1. Cab Mount Hinge Bolt
2. Bushing Swingout Bracket Bolt

Fig. 6, Forward Cab Mount Assembly

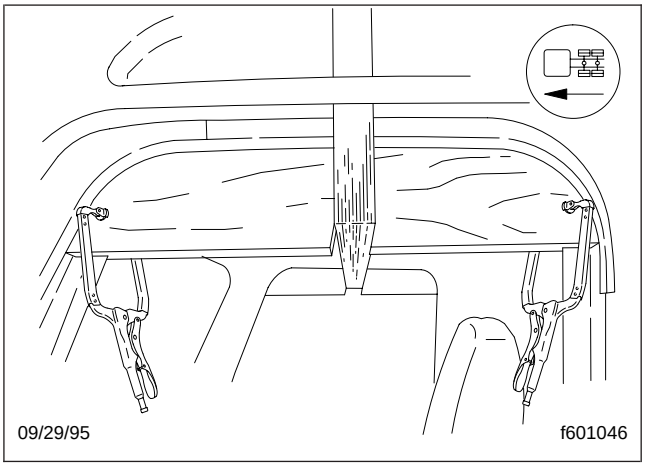


Fig. 7, Door Lifting Insert Installed and Lifting Device Strap in Place

26.4 Lift the cab slightly to make sure it is balanced, and that nothing is holding it to the chassis. If needed, lower the cab and adjust the placement of the rear straps.

26.5 Lift the cab clear of the chassis.

Installation

1. Lower the cab onto the chassis. Make sure the forward cab mounts line up with the frame rail mounting brackets.
2. Install the left and right cab mount hinge bolts. Tighten the bolts 95 lbf·ft (129 N·m).
3. Remove the lifting straps.
4. Install the left and right bushing swingout bracket bolts. Tighten the bolts 95 lbf·ft (129 N·m).
5. Position the tilt cylinders on the left and right side of the cab underbody. Install the clevis pins and the washers, and install new cotter pins.
6. Connect the positive cab stud on the front wall, and tighten the screw securely.
7. Connect the engine harness plugs on the front wall, and tighten the capscrews securely.
8. Connect the auxiliary heater lines.
9. Connect the steering driveline, as follows.

   9.1 Have an assistant adjust the steering wheel until the driveline is properly aligned.

   9.2 Using a new bolt, connect the steering column to the driveline, and tighten the bolt 70 lbf·ft (95 N·m).

   9.3 Pull the boot over the driveline, and tighten the clamp.

10. Connect the lower clutch linkage; see **Section 25.03, Subject 120**. Tighten the bolt 28 lbf·ft (38 N·m).
11. Connect the air junction block.
12. Connect the cab ground to the cab inner wall above the headlights, on the right side of the vehicle. Tighten the bolt securely.
13. Connect the air brake lines.
14. If removed, install the cowl side panel; see **Section 60.16, Subject 100**.
15. Tilt the cab; see **Section 60.15, Subject 060**.
16. On the left side of the cab underbody, connect the A/C lines, the ACPU wires, and the heater lines.

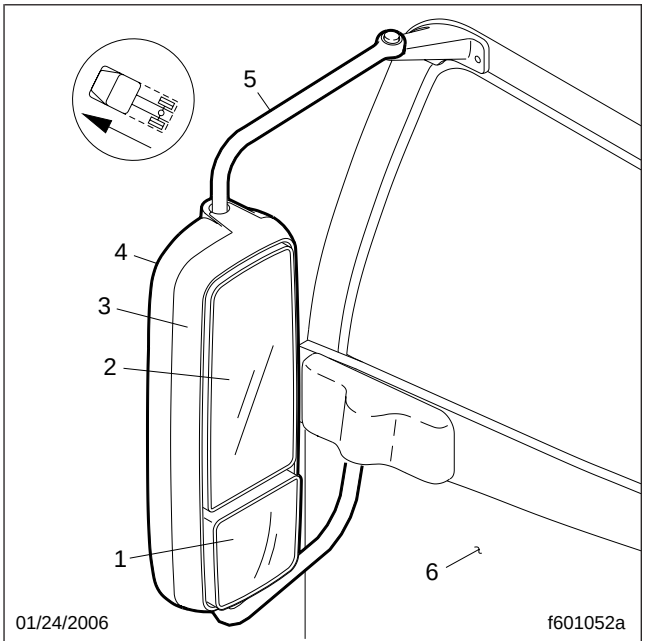
17. On the right side of the cab underbody, connect the solenoid wire, the actuator wires, and the ABS wires.
18. Connect the shift cables, as follows.
    - 18.1 Clamp the shift cables to the cab inner wall.
    - 18.2 Connect the electrical line to the shift chassis.
    - 18.3 Position the shift lever in the vehicle.
    - 18.4 Insert the four bolts that secure the shift panel to the cab inner wall. Tighten the bolts 22 lbf·ft (30 N·m).
19. Return the cab to the operating position; see **Section 60.15**.
20. Install the shift tower boot.
21. Position the lower grille panel on the front-wall crossmember. Insert the four support bolts, and tighten 95 lbf·ft (129 N·m).
22. Install the cab access stairs; see **Section 60.20, Subject 100**.
23. Fill the radiator with coolant; see **Section 20.01, Subject 100**.
24. Connect the batteries.
25. Charge the A/C system; see **Section 83.02, Subject 250**.
26. Start the engine and check all the coolant and heater hoses for leaks. Check all the electrical systems and gauges.
27. Close the front-wall access panel.
28. Remove the chocks.

General Information

The Lang-Mekra and Truck-Lite mirrors are electrically heated, remote-controlled mirrors. The mirror unit consists of an upper rectangular main (flat) mirror, and a lower square (convex) mirror. The mirror is mounted in a housing, and the entire mirror head assembly is mounted to the door by a fold-away tubular support loop. See **Fig. 1** and **Fig. 2**.

The main mirror can be actuated remotely, or moved manually in case of an electrical problem. The convex mirror is not remotely actuated, but can be adjusted manually. An indicator light on the dash alerts the driver that the heating element in the mirror is on.

Dual electric motors (one for vertical movement, and one for horizontal movement) are mounted inside the mirror housing, and are equipped with a clutch to prevent damage in case of binding. All the wiring is hidden within the support loop and the mirror housing.

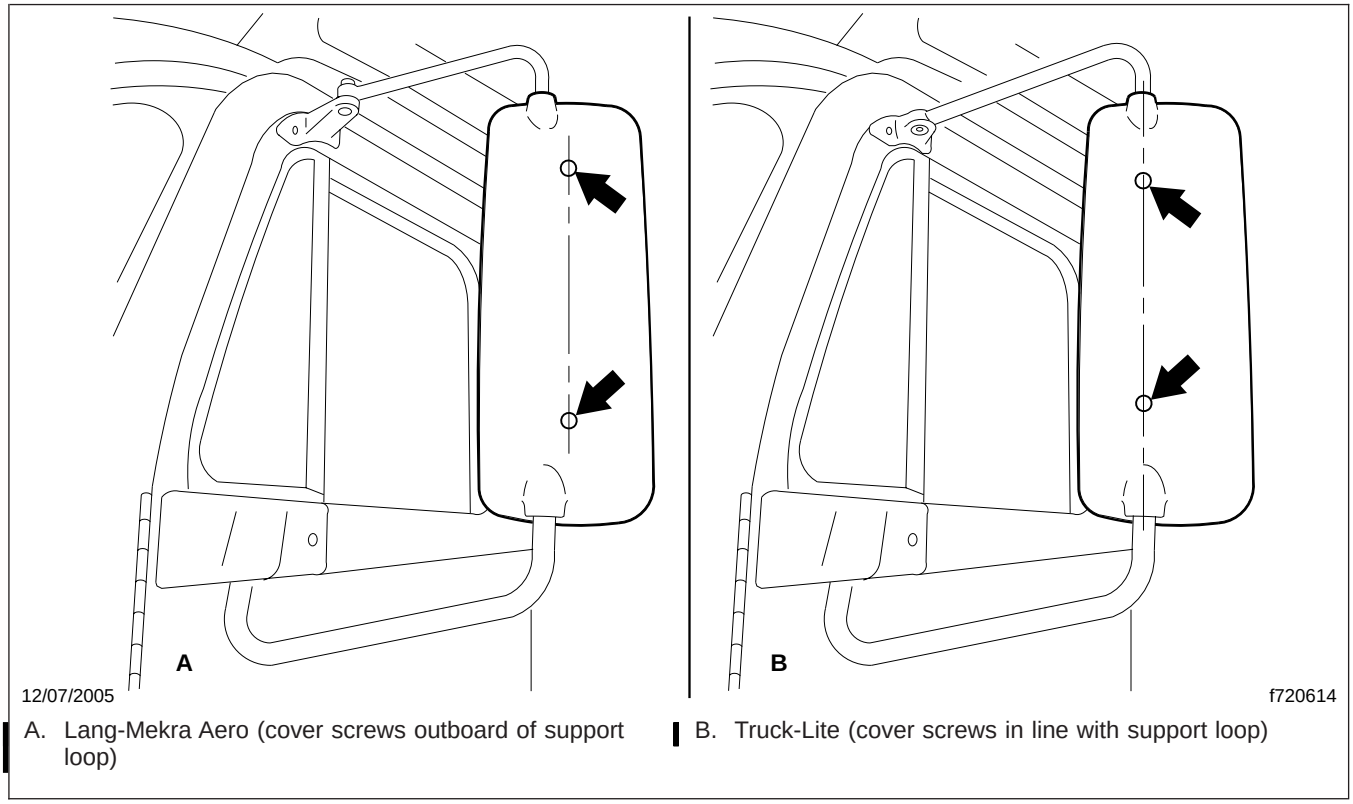


1. Square, Convex Mirror
2. Rectangular, Flat Main Mirror
3. Housing
4. Back Cover
5. Fold-Away Support Loop
6. Door (left side)

Fig. 1, Mirror Assembly (Lang-Mekra Aero Shown)

The mirror can be identified as a Lang-Mekra Aero or a Truck-Lite by the placement of the two screws that attach the back cover to the mirror housing assembly. On the Truck-Lite mirror they are in line with the support loop, while on the Lang-Mekra they are offset, outboard from the support loop. See **Fig. 2**. There are also differences in the upper mounting bracket and pivot joint.

General Information



A. Lang-Mekra Aero (cover screws outboard of support loop)

B. Truck-Lite (cover screws in line with support loop)

Fig. 2, Mirror Identification

Mirror Assembly Removal and Installation

This procedure applies to the following mirrors:

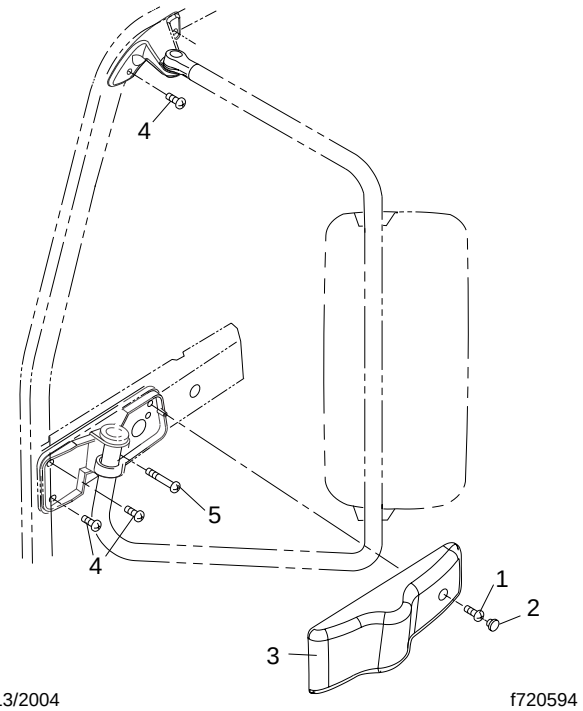
- Lang-Mekra Aero
- Truck-Lite

The procedure is the same for both mirrors.

NOTE: Many parts of the mirror can be serviced without removing the entire mirror assembly from the vehicle. If the entire mirror assembly need not be replaced, see the appropriate procedure for the component to be serviced.

Removal

1. Park the vehicle on a level surface, apply the parking brake, shut down the engine, and chock the front and rear tires.
2. Remove the lower mirror-bracket cover. See **Fig. 1**.



1. Bracket Cover Mounting Screw
2. Screw Cover Cap
3. Lower Bracket Cover
4. Bracket Screws
5. Hexbolt

Fig. 1, Mirror Assembly Mounting

   2.1 Remove the screw cover cap from the lower mirror-bracket cover.

   2.2 Remove the screw that attaches the cover to the mirror bracket.

   2.3 Remove the cover by pulling the rear of the cover away from the bracket while sliding the front of the cover towards the front of the vehicle.
3. Disconnect the cables at the lower bracket.
4. Remove the three screws that attach the lower bracket to the door.
5. While supporting the mirror, remove the two screws that attach the upper bracket to the door. Remove the mirror assembly from the door.

Installation

1. Position the mirror assembly on the door.
2. Attach the upper bracket to the door with the two screws. Torque the screws 11 lbf·ft (15 N·m).
3. Attach the lower bracket to the door with the three screws. Torque the screws 11 lbf·ft (15 N·m).
4. Connect the cables at the lower bracket.
5. Install the lower mirror-bracket cover.

   5.1 Slide the front of the cover onto the lower bracket and push the rear of the cover onto the bracket.

   5.2 Install the screw that attaches the cover to the bracket.

   5.3 Install the screw cover cap.
6. Remove the chocks from the tires.

Mirror Support Loop Folding Repair

This procedure applies to the following mirrors:

- Lang-Mekra Aero
- Truck-Lite

The procedure is the same for both mirrors.

Folding Repair

Mirrors are designed to fold away if they contact an immovable object. In some cases, however, the mirror support loop may pivot too easily.

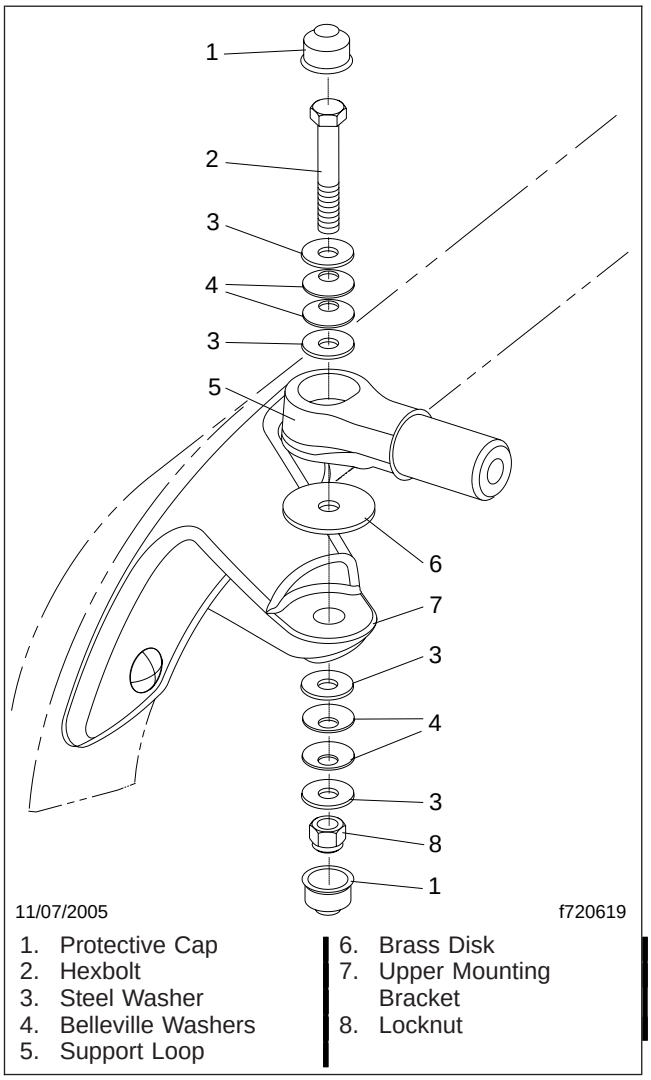
During manufacture, the upper pivot-point fasteners are torqued 31 to 35 lbf·ft (42 to 48 N·m).

If a mirror support loop moves due to high wind loads or slamming the door, retorque the upper pivot-point fasteners after removing the two protective caps from the hexbolt and locknut. See **Fig. 1**. Check the fastener torque to confirm that it is 31 to 35 lbf·ft (42 to 48 N·m).

If the torque is correct and the support loop continues to move too easily, disassemble the pivots, remove any grease, replace the hexbolt with a 3/8–24 x 2 bolt, and then assemble the pivots.

An upper pivot-point fastener kit is available for Lang-Mekra mirrors. See **Subject 210** for instructions on replacing the upper pivot-point fasteners.

NOTE: The upper pivot-point fastener kit is not serviceable on Truck-Lite mirrors.



1. Protective Cap
2. Hexbolt
3. Steel Washer
4. Belleville Washers
5. Support Loop
6. Brass Disk
7. Upper Mounting Bracket
8. Locknut

Fig. 1, Upper Pivot-Point Fasteners (Lang-Mekra)

Mirror Back Cover Removal and Installation

This procedure applies to the following mirrors:

- Lang-Mekra Aero
- Truck-Lite

The procedure is slightly different for each mirror.

Lang-Mekra Aero

Removal

1. Park the vehicle on a level surface, apply the parking brake, shut down the engine, and chock the front and rear tires.
2. Remove the CB antenna from the mirror head, using a wrench to keep the antenna base from loosening.
3. Remove the two screw covers on the back of the mirror.
4. Remove the two screws that attach the back cover to the mirror head.
5. Pull the bottom of the cover away from the mirror head, and carefully lift the cover up over the antenna base.

Installation

1. Position the top of the cover over the antenna base, and push the bottom of the cover into place against the mirror head.
2. Install the two screws that attach the cover to the mirror head. Torque the screws 36 lbf·in (400 N·cm).
3. Install the two screw covers.
4. Install the CB antenna on the mirror head assembly. Tighten the antenna hexnut 85 lbf·in (960 N·cm).
5. Remove the chocks from the tires.

Truck-Lite

Removal

1. Park the vehicle on a level surface, apply the parking brake, shut down the engine, and chock the front and rear tires.
2. Remove the CB antenna from the mirror head, using a wrench to keep the antenna base from loosening.
3. Remove the two screw covers on the back of the mirror.
4. Remove the two screws that attach the back cover to the mirror housing.
5. Pull the bottom of the cover away from the mirror housing, and carefully lift the cover up over the antenna base.

Installation

1. Position the top of the cover over the antenna base, and push the bottom of the cover into place against the mirror head.

IMPORTANT: Ensure that the mirror back cover is properly seated in the mirror housing. The gap around the edge should be uniform, and the tabs at the top and bottom should seat securely in their respective grooves.

2. Install the two screws that attach the cover to the mirror housing. Torque the screws 31 lbf·in (340 N·cm).
3. Install the two screw covers.
4. Install the CB antenna on the mirror head assembly. Tighten the antenna hexnut 85 lbf·in (960 N·cm).
5. Remove the chocks from the tires.

Mirror Head Assembly Removal and Installation

This procedure applies to the following mirrors:

- Lang-Mekra Aero
- Truck-Lite

The Lang-Mekra Aero is attached to the support loop with four clamps, while the Truck-Lite is attached to the support loop with the actuator and pivot assembly screws, requiring the removal of the mirror plate.

Lang-Mekra Aero

Removal

1. Park the vehicle on a level surface, apply the parking brake, shut down the engine, and chock the front and rear tires.
2. Remove the CB antenna from the mirror head, using a wrench to keep the antenna base from loosening.
3. Remove the mirror back cover.
   - 3.1 Remove the two screw cover caps on the back of the mirror.
   - 3.2 Remove the two screws that attach the back cover to the mirror housing.
   - 3.3 Pull the bottom of the cover away from the mirror housing, and carefully lift the cover up over the antenna base.
4. Disconnect the CB and control cables from the mirror head. See **Fig. 1**.
5. While holding the mirror head, remove the screws on the four mounting clamps. Remove the mirror head from the support loop.

Installation

1. Position the mirror head assembly on the support loop.
2. Attach the mirror head assembly to the support loop by placing the four mounting clamps over the support loop and attaching them to the mirror head using the screws.
3. Adjust the angle of the mirror head on the support loop as needed. The angle of the mirror glass to the window glass should be 55 degrees on the driver's side, and 45 degrees on the passenger's side. Tighten the screws 53 lbf·in (600 N·cm).

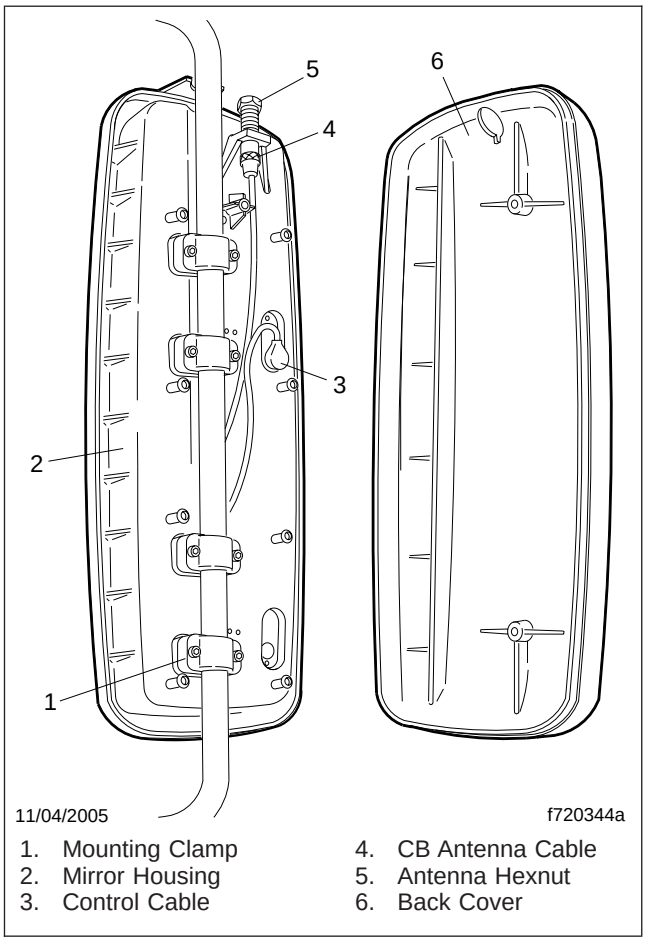


Fig. 1, Mirror Head Installation, Lang-Mekra Aero

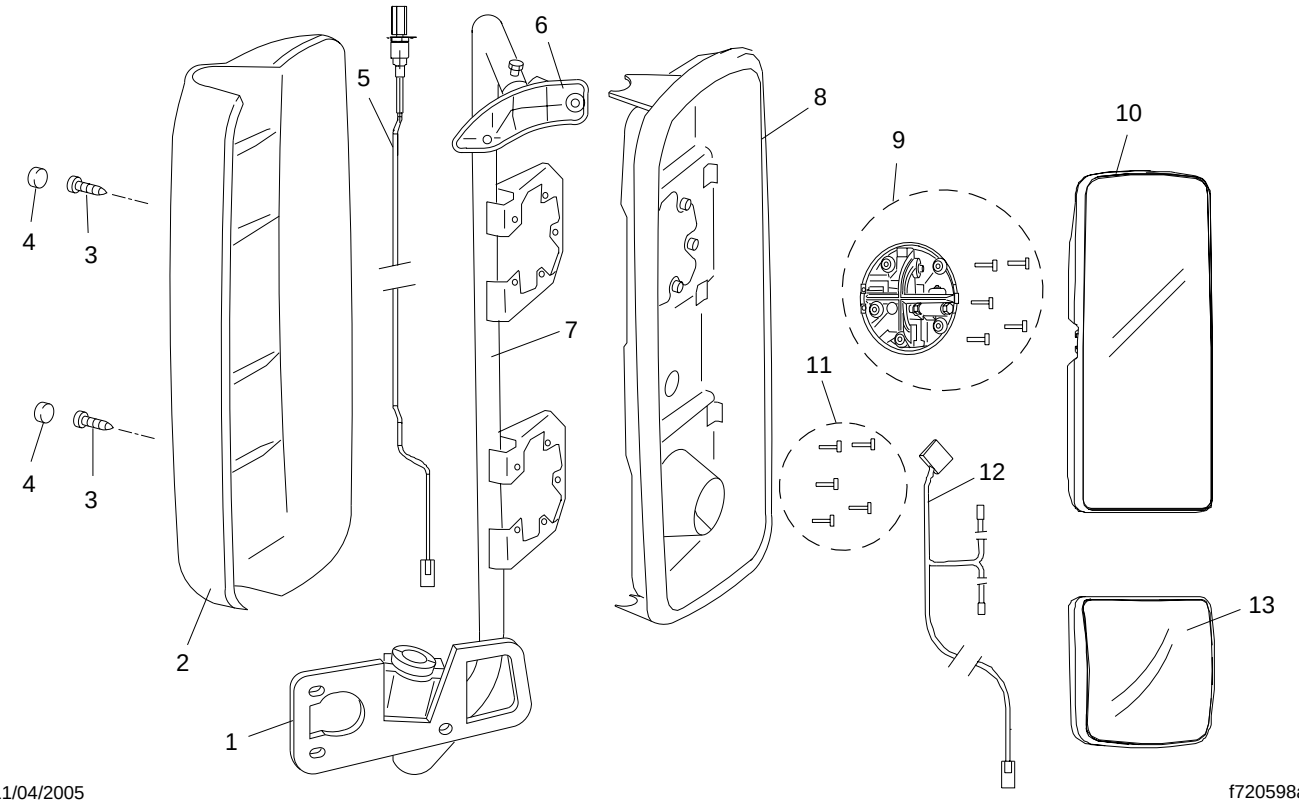
4. Attach the CB cable and the control cable to the mirror head.
5. Install the mirror back cover.
   - 5.1 Position the top of the cover over the antenna base, and push the bottom of the cover into place against the mirror housing.
   - 5.2 Install the two screws that attach the cover to the mirror housing. Torque the screws 36 lbf·in (400 N·cm).
   - 5.3 Install the two screw cover caps.
6. Install the CB antenna on the mirror head assembly. Tighten the antenna hexnut 85 lbf·in (960 N·cm).
7. Remove the chocks from the tires.

Mirror Head Assembly Removal and Installation

Truck-Lite

Removal

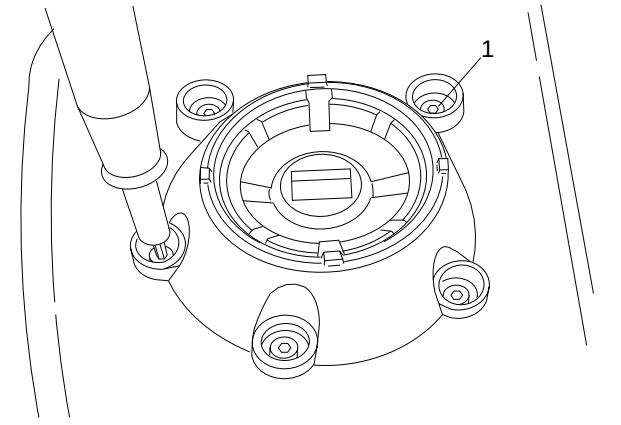
1. Park the vehicle on a level surface, apply the parking brake, shut down the engine, and chock the front and rear tires.
2. Remove the CB antenna from the mirror head, using a wrench to keep the antenna base from loosening.
3. Remove the mirror back cover. See **Fig. 2**.
   - 3.1 Remove the two screw covers on the back of the mirror.
   - 3.2 Remove the two screws that attach the back cover to the mirror head.
   - 3.3 Pull the bottom of the cover away from the mirror head, and carefully lift the cover up over the antenna base.
4. Remove the main mirror plate. See **Subject 150** for instructions.
5. Remove the convex mirror plate. See **Subject 160** for instructions.
6. Remove the actuator assembly. See **Subject 170** for instructions.



1. Lower Mounting Bracket
2. Back Cover
3. Screw
4. Screw Cover Cap
5. CB Coax Assembly
6. Upper Mounting Bracket
7. Support Loop
8. Mirror Housing
9. Actuator Assembly
10. Flat Mirror
11. Pivot Assembly Screws
12. Heater Wiring Harness
13. Convex Mirror

Fig. 2, Truck-Lite Mirror Assembly

7. Remove the five screws that attach the convex glass pivot assembly to the support loop. See **Fig. 3**. Remove the mirror head from the support loop.



1. Pivot Assembly Mounting Screw

Fig. 3, Convex Glass Pivot Assembly

Installation

1. Position the mirror head on the support loop.
2. Attach the convex glass pivot assembly to the support loop with the five screws.
3. Install the actuator assembly. See **Subject 170** for instructions.
4. Install the convex mirror plate. See **Subject 160** for instructions.
5. Install the main mirror plate. See **Subject 150** for instructions.
6. Install the mirror back cover.
   - 6.1 Position the top of the cover over the antenna base, and push the bottom of the cover into place against the mirror head.

   IMPORTANT: Ensure that the mirror back cover is properly seated in the mirror housing. The gap around the edge should be uniform, and the tabs at the top and bottom should seat securely in their respective grooves.

   - 6.2 Install the two screws that attach the cover to the mirror head. Torque the screws 31 lbf·in (340 N·cm).
   - 6.3 Install the two screw covers.
7. Install the CB antenna on the mirror head assembly. Tighten the antenna hexnut 85 lbf·in (960 N·cm).
8. Remove the chocks from the tires.

Support Loop Replacement

This procedure applies to the following mirrors:

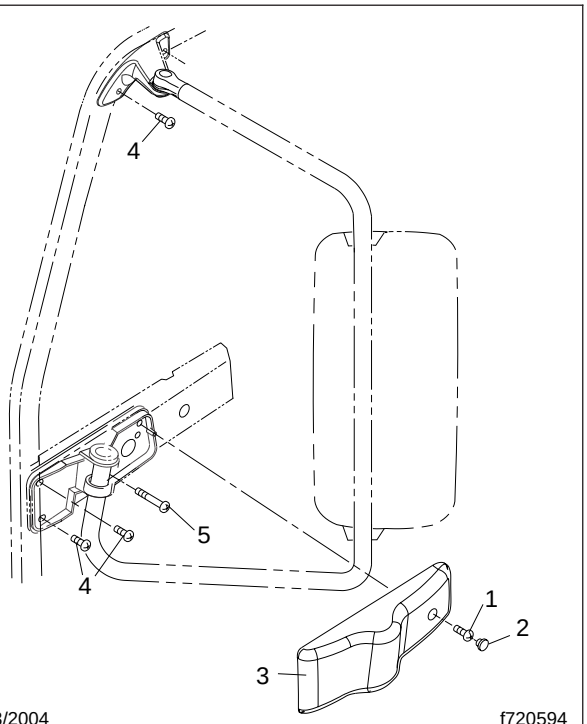
- Lang-Mekra Aero
- Truck-Lite

The Lang-Mekra Aero and Truck-Lite support loops are slightly different, but the replacement procedure is similar, with the exception of the removal and installation of the mirror head.

Replacement

NOTE: The lower bracket and the wiring harness are not serviceable. If there is a problem with either one, replace the whole support loop assembly.

1. Park the vehicle on a level surface, apply the parking brake, shut down the engine, and chock the front and rear tires.
2. Remove the lower mirror-bracket cover. See **Fig. 1**.
   - 2.1 Remove the screw cover cap from the lower mirror-bracket cover.
   - 2.2 Remove the screw that attaches the cover to the mirror bracket.
   - 2.3 Remove the cover by pulling the rear of the cover away from the bracket while sliding the front of the cover towards the front of the vehicle.
3. Remove the mirror head assembly from the support loop. The procedure is different for each mirror. See **Subject 130** for applicable instructions.
4. Disconnect the cables at the lower bracket.
5. Remove the three screws that attach the lower bracket to the door.
6. While supporting the support loop, remove the two screws that attach the upper bracket to the door. Remove the support loop from the door.
7. Position the new support loop on the door.
8. Attach the upper bracket to the door using the two screws. Torque the screws 11 lbf·ft (15 N·m).
9. Attach the lower bracket to the door using the three screws. Torque the screws 11 lbf·ft (15 N·m).
10. Connect the cables at the lower bracket.



1. Bracket Cover Mounting Screw
2. Screw Cover Cap
3. Lower Bracket Cover
4. Bracket Screws
5. Hexbolt

Fig. 1, Mirror Assembly Mounting

11. Install the mirror head on the support loop. The procedure is different for each mirror. See **Subject 130** for applicable instructions.
12. Install the lower mirror-bracket cover.
    - 12.1 Slide the front of the cover onto the lower bracket and push the rear of the cover onto the bracket.
    - 12.2 Install the screw that attaches the cover to the bracket.
    - 12.3 Install the screw cover cap.
13. Remove the chocks from the tires.

Main Mirror Plate Removal and Installation

This procedure applies to the following mirrors:

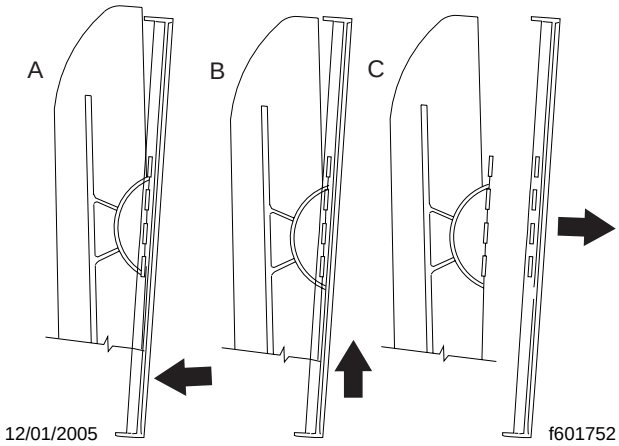
- Lang-Mekra Aero
- Truck-Lite

The procedure is different for each mirror.

Lang-Mekra Aero

Removal

1. Park the vehicle on a level surface, apply the parking brake, shut down the engine, and chock the front and rear tires.
2. Move the mirror plate in at the bottom, either manually or by remote actuation. See **Fig. 1**.



A. Actuate the mirror down.
B. Slide the mirror plate up.
C. Pull the mirror plate out.

Fig. 1, Mirror Plate Removal

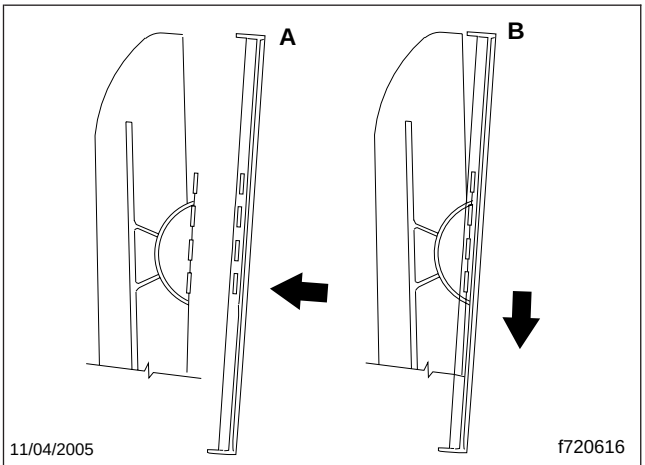
3. Slide the mirror plate up.
4. When the mirror plate is disengaged, carefully lift it to expose the heater wires.

IMPORTANT: Do not pull or cut the wires when disconnecting them. Disconnect the wires by pulling on the wire terminal covers only. Connect the wires by pushing on the wire terminal covers only.

5. Disconnect the heater wires by pulling on the wire terminal covers.
6. Remove the mirror plate.

Installation

1. Attach the wire terminals to the back of the mirror plate.
2. Position the mirror plate against the structure plate, using care not to pinch the heater wires between the socket plate and the mirror plate.
3. Slide the mirror plate down to engage the locking tabs. See **Fig. 2**.



A. Position the mirror plate against the structure plate.
B. Slide the mirror plate down.

Fig. 2, Mirror Plate Installation

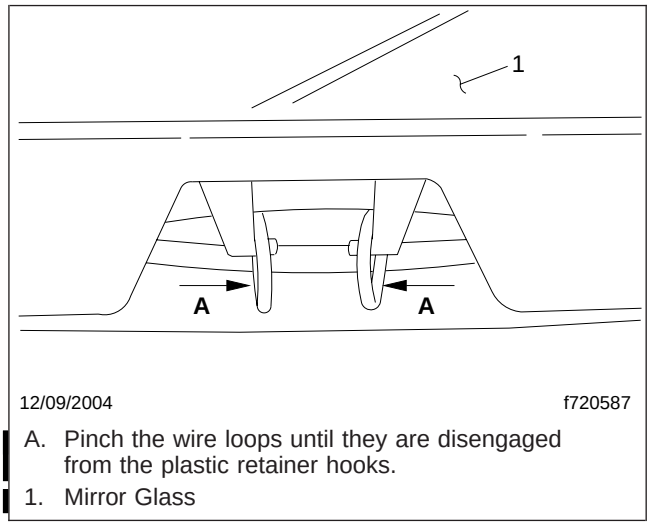
4. Pull on the mirror to ensure that the plate is properly locked.
5. Remove the chocks from the tires.

Truck-Lite

Removal

1. Park the vehicle on a level surface, apply the parking brake, shut down the engine, and chock the front and rear tires.
2. Manually adjust the mirror plate to the fully outboard position to allow access to the plastic retainer hooks.
3. Using your fingers or a pair of needlenose pliers, unlatch the wire loops from the plastic retainer hooks by squeezing the ends of the two loops together. See **Fig. 3**.

Main Mirror Plate Removal and Installation



A. Pinch the wire loops until they are disengaged from the plastic retainer hooks.
1. Mirror Glass

Fig. 3, Mirror Plate Brackets

NOTE: It is only necessary to disengage the wire loops on one side of the mirror.

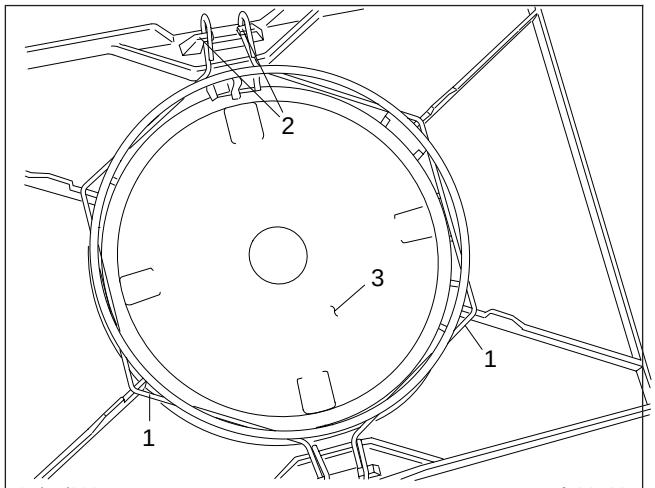
4. When disengaged, carefully lift the mirror plate from the actuator to expose the heater wires.
5. Slide the mirror plate connector off the mirror housing support tab, and disconnect it from the mirror wiring harness.
6. Remove the mirror plate from the mirror assembly.

Installation

1. Install the wire loops on the back of the mirror plate. Engage the ends of the wire loops on the plastic retainer hooks. See **Fig. 4**.
2. Connect the mirror plate connector to the mirror wiring harness, and slide the connector onto the mirror housing support tab.

NOTE: Keep the wires free of the socket plate. Do not pinch the wires between the socket plate and the mirror plate.

3. Position the mirror plate over the actuator and press it securely in place.
4. Actuate the glass in all directions, and gently pull on the outer edges to ensure proper assembly.
5. Remove the chocks from the tires.



1. Wire Loops
2. Plastic Hooks
3. Actuator

Fig. 4, Wire Loop Installation

Convex Mirror Plate Removal and Installation

This procedure applies to the following mirrors:

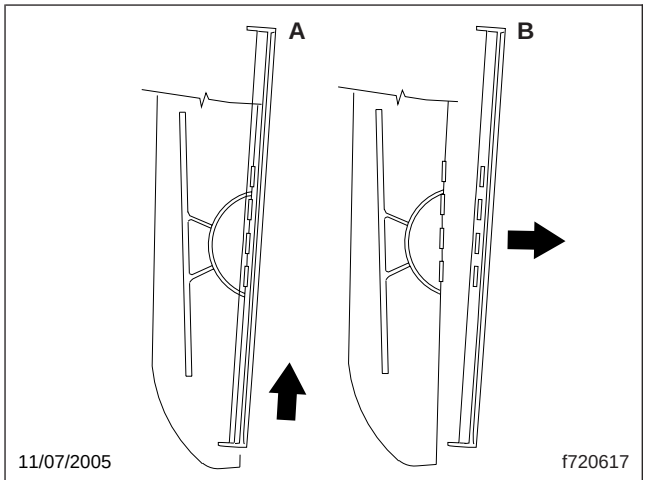
- Lang-Mekra Aero
- Truck-Lite

The procedure is different for each mirror. In order to remove the convex mirror plate on the Lang-Mekra Aero mirror, it is necessary to remove the main mirror plate first. On the Truck-Lite mirror, it is necessary to remove the back cover first.

Lang-Mekra Aero

Removal

1. Park the vehicle on a level surface, apply the parking brake, shut down the engine, and chock the front and rear tires.
2. Remove the main mirror plate. See **Subject 150** for instructions.
3. Slide the convex mirror plate up. See **Fig. 1**.



A. Slide the mirror plate up.
C. Pull the mirror plate out.

Fig. 1, Mirror Plate Removal

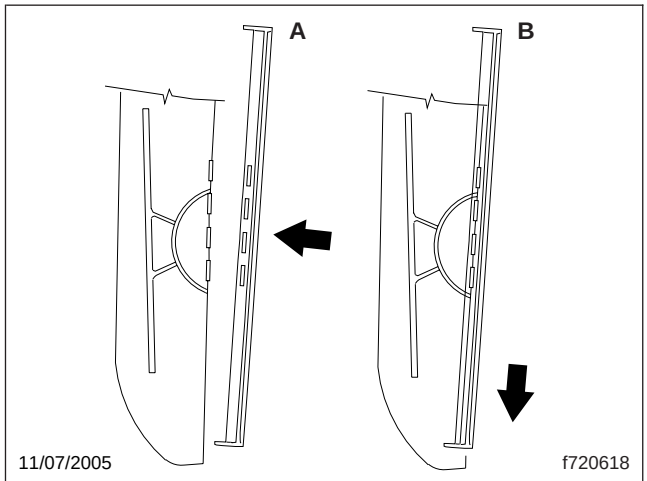
4. When the mirror plate is disengaged, carefully pull it out to expose the heater wires.

IMPORTANT: Do not pull or cut the wires when disconnecting them. Disconnect the wires by pulling on the wire terminal covers only. Connect the wires by pushing on the wire terminal covers only.

5. Disconnect the heater wires by pulling on the wire terminal covers.
6. Remove the mirror plate.

Installation

1. Attach the wire terminals to the back of the convex mirror plate.
2. Position the convex mirror plate against the structure plate, using care not to pinch the heater wires between the socket plate and the mirror plate.
3. Slide the convex mirror plate down to engage the locking tabs. See **Fig. 2**.



A. Position the mirror plate against the structure plate.
B. Slide the mirror plate down.

Fig. 2, Mirror Plate Installation

4. Pull on the mirror to ensure that the plate is properly locked.
5. Install the main mirror plate. See **Subject 150** for instructions.
6. Remove the chocks from the tires.

Truck-Lite

Removal

1. Park the vehicle on a level surface, apply the parking brake, shut down the engine, and chock the front and rear tires.

Convex Mirror Plate Removal and Installation

2. Remove the mirror back cover.
   - 2.1 Remove the two screw covers on the back of the mirror.
   - 2.2 Remove the two screws that attach the back cover to the mirror head.
   - 2.3 Pull the bottom of the cover away from the mirror head, and carefully lift the cover up over the antenna base.
3. Using a pair of needlenose pliers, pull and twist the white tab on the back of the convex mirror plate one quarter turn to align with the slot. See **Fig. 3**.

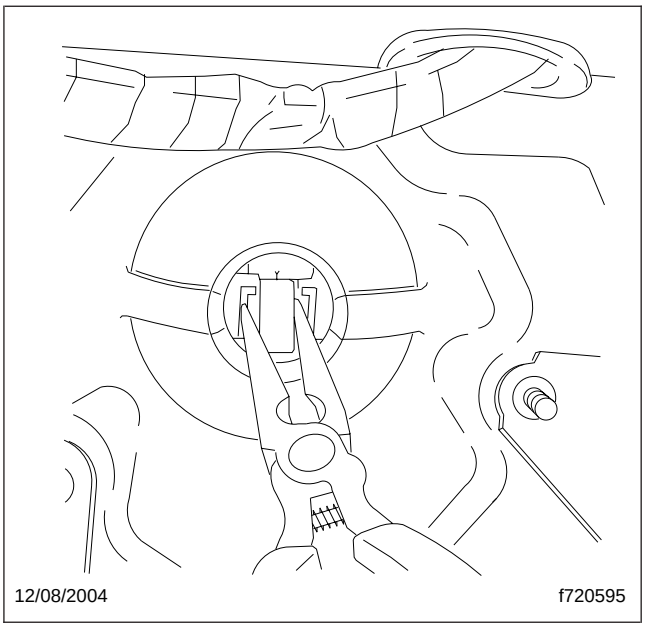


Fig. 3, Turning the White Tab to Align with the Slot

4. Disconnect the electrical connector from the mirror heater.
5. Remove the convex mirror plate from the mirror housing.

Installation

1. Connect the electrical connector to the mirror heater.
2. Position the convex mirror plate in the mirror housing. Twist the white tab on the back of the convex mirror one quarter turn until it locks.
3. Install the mirror back cover.
   - 3.1 Position the top of the cover over the antenna base, and push the bottom of the cover into place against the mirror head.

   IMPORTANT: Ensure that the mirror back cover is properly seated in the mirror housing. The gap around the edge should be uniform, and the tabs at the top and bottom should seat securely in their respective grooves.
   - 3.2 Install the two screws that attach the cover to the mirror housing. Torque the screws 31 lbf·in (340 N·cm).
   - 3.3 Install the two screw covers.
4. Remove the chocks from the tires.

Mirror Actuator Replacement

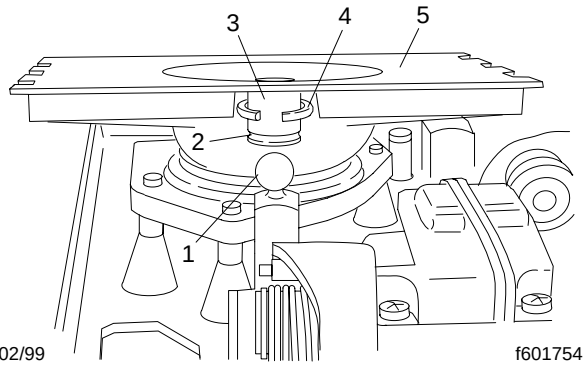
This procedure applies to the following mirrors:

- Lang-Mekra Aero
- Truck-Lite

The procedure is different for each mirror.

Lang-Mekra Aero

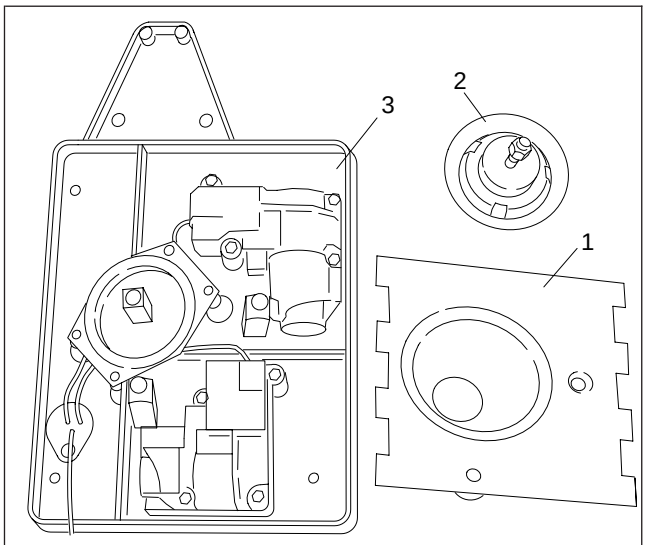
1. Park the vehicle on a level surface, apply the parking brake, shut down the engine, and chock the front and rear tires.
2. Disconnect the batteries.
3. Remove the main mirror plate. See **Subject 150** for instructions.
4. Disassemble the two ball-and-socket joints. See **Fig. 1**.
   - 4.1 On one of the split socket tubes, slide the split ring out of the retaining groove and away from the motor.
   - 4.2 Firmly press down on the opposite side of the socket plate to detach the ball-and-socket joint.
   - 4.3 Repeat the disassembly steps for the other ball-and-socket joint.



1. Ball
2. Retaining Groove
3. Split Socket Tube
4. Split Ring
5. Socket Plate

Fig. 1, Ball-and-Socket Joint

5. Remove the socket plate by removing the center pivot screw. See **Fig. 2**. Note the order of the center pivot components.



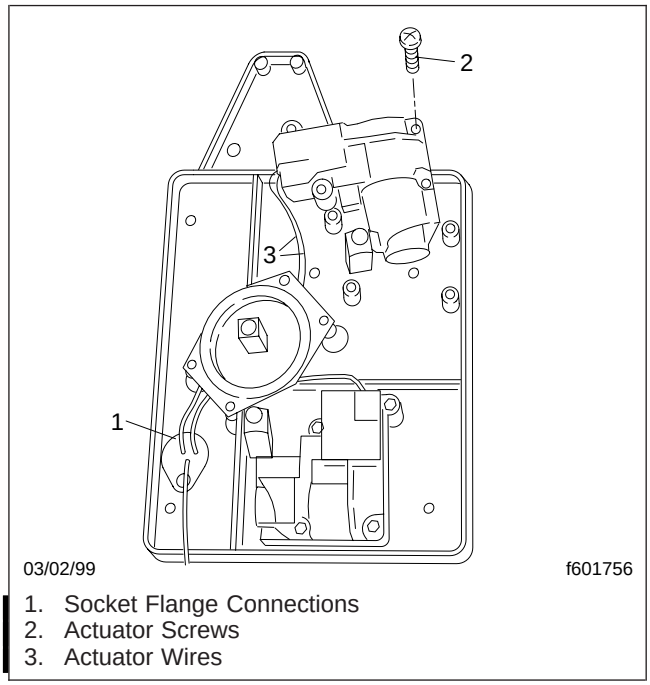
1. Socket Plate
2. Center Pivot Assembly
3. Structure Plate

Fig. 2, Socket Plate Assembly

IMPORTANT: Use care not to damage the socket flange connections when cutting the actuator wires.

6. Cut the two wires (Ref. 3 in **Fig. 3**) to the actuator, leaving at least 2-1/2 inches (60 mm) of wire for the socket.
7. Remove the four screws that attach the actuator to the structure plate. Remove the actuator. See **Fig. 3**.
8. Place the new actuator in position and attach it to the structure plate using the four screws. See **Fig. 3**. Tighten the screws 13 lbf·in (150 N·cm).
9. Connect the wires from the new actuator to the wires leading from the socket. Use butt splice connectors, or solder and shrink wrap.
10. Place the socket plate in position. Install the center pivot components and screw, in reverse order of removal. Tighten the screw 44 lbf·in (500 N·cm).
11. Assemble the two ball-and-socket joints. See **Fig. 1**.

Mirror Actuator Replacement



1. Socket Flange Connections
2. Actuator Screws
3. Actuator Wires

Fig. 3, Actuator Wiring Harness

11.1 Push the split ring up one of the split socket tubes, away from the motor assembly.

11.2 Actuate the motor towards the split socket tube.

11.3 Align the motor arm into the split socket tube.

11.4 Push firmly on the socket plate to snap the ball into the split socket tube.

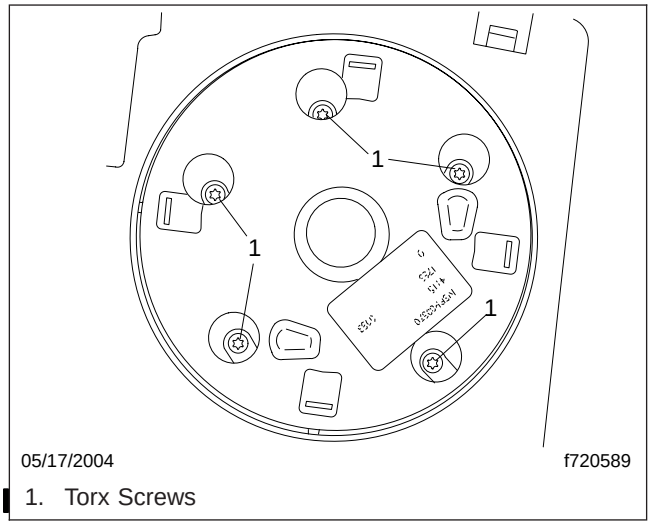
11.5 Slide the split ring into the retaining groove on the split socket tube.

11.6 Repeat the assembly steps for the other ball-and-socket joint.

12. Install the main mirror plate. See **Subject 150** for instructions.
13. Connect the batteries.
14. Remove the chocks from the tires.

Truck-Lite

1. Park the vehicle on a level surface, apply the parking brake, shut down the engine, and chock the front and rear tires.
2. Disconnect the batteries.
3. Remove the main mirror plate. See **Subject 150** for instructions.
4. Remove the five Torx® screws that attach the actuator to the mirror housing. See **Fig. 4**.



1. Torx Screws

Fig. 4, Actuator Retaining Screws

5. Lift the actuator out of the mirror housing and disconnect the electrical wires. See **Fig. 5**.

NOTE: The electrical connections are labeled A and B to prevent incorrect installation.

6. Connect the electrical wires to the new actuator. See **Fig. 5**
7. Position the actuator in the mirror housing and install the five Torx screws. Tighten the screws 35 to 40 lbf·in (400 to 460 N·cm).
8. Install the main mirror plate. See **Subject 150** for instructions.
9. Connect the batteries.
10. Remove the chocks from the tires.

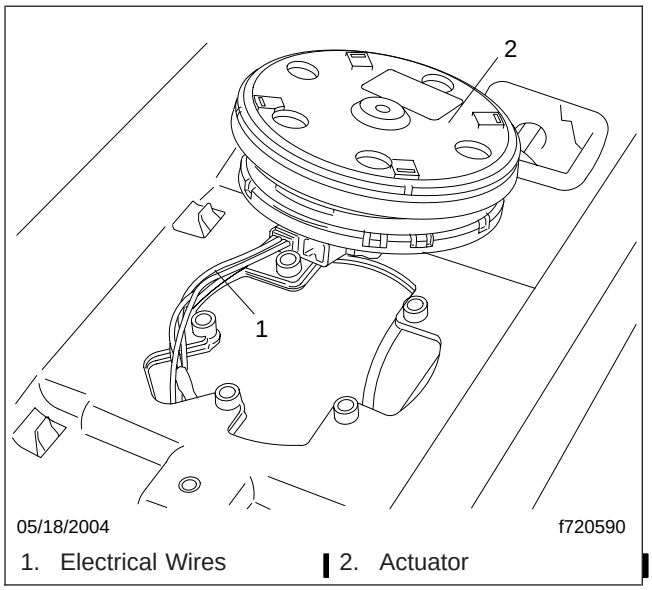


Fig. 5, Actuator Electrical Wires

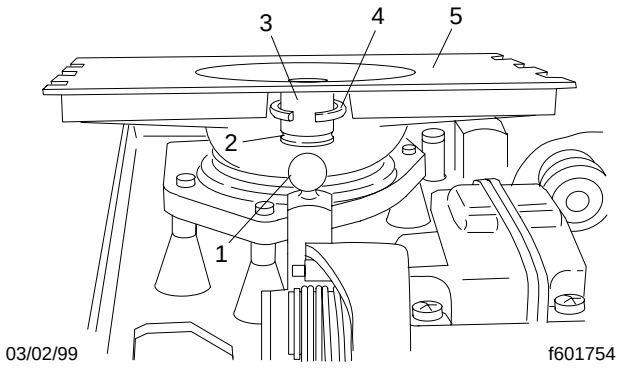
Ball-and-Socket Joint

This procedure applies to the following mirror only:

- Lang-Mekra Aero

Disassembly

1. Park the vehicle on a level surface, apply the parking brake, shut down the engine, and chock the front and rear tires.
2. Disconnect the batteries.
3. Remove the main mirror plate. See **Subject 150** for instructions.
4. Slide the split ring out of the retaining groove and away from the motor. See **Fig. 1**.



1. Ball
2. Retaining Groove
3. Split Socket Tube
4. Split Ring
5. Socket Plate

Fig. 1, Ball-and-Socket Joint

5. Firmly press down on the opposite side of the socket plate to disengage the ball-and-socket joint.

Assembly

1. Push the split ring up the split socket tube, away from the motor assembly. See **Fig. 1**.
2. Actuate the motor towards the split socket tube.
3. Align the motor arm into the split socket tube.
4. Push firmly on the socket plate to snap the ball into the split socket tube.
5. Slide the split ring into the retaining groove on the split socket tube.
6. Install the main mirror plate. See **Subject 150** for instructions.
7. Connect the batteries.
8. Remove the chocks from the tires.

Structure Plate Assembly Replacement

This procedure applies to the following mirror only:

- Lang-Mekra Aero

Replacement

1. Park the vehicle on a level surface, apply the parking brake, shut down the engine, and chock the front and rear tires.
2. Remove the mirror head assembly from the support loop. See **Subject 130** for instructions.
3. Remove the applicable mirror plate from the mirror housing. See **Subject 150** for instructions.
4. If replacing the main mirror structure plate assembly, remove the CB antenna mount from the structure plate.
5. Disconnect the electrical wiring from the structure plate.
6. Remove the screws that attach the structure plate to the mirror housing. See **Fig. 1**.

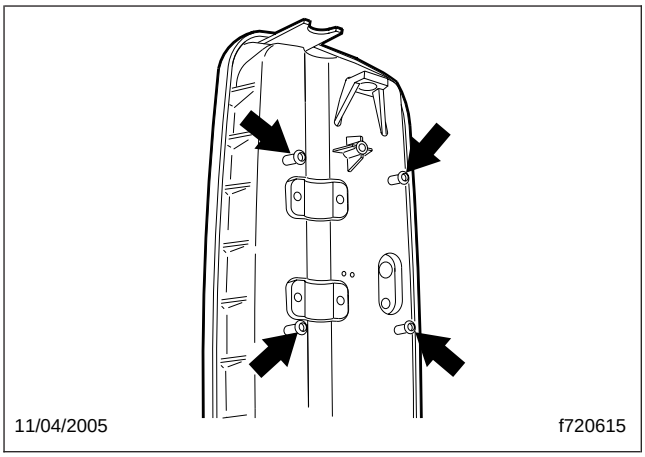
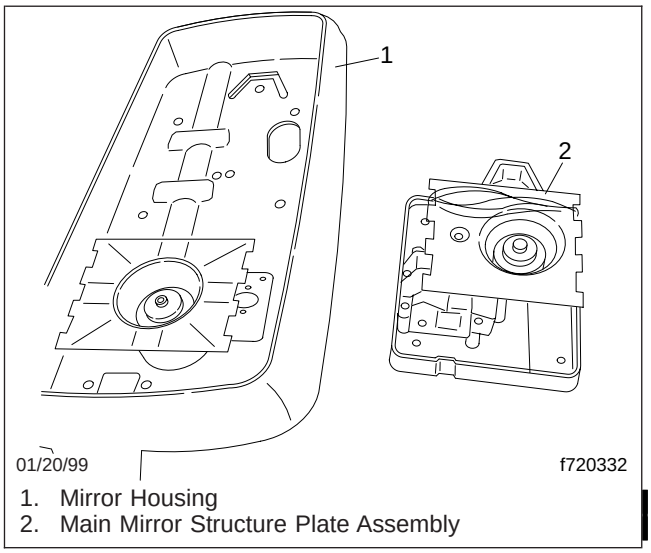


Fig. 1, Main Mirror Structure Plate Screws

7. Remove the structure plate from the mirror housing. See **Fig. 2**.
8. Position the new structure plate in the mirror housing.
9. Install the screws that attach the structure plate to the mirror housing. See **Fig. 1**.
10. Connect the electrical wiring to the structure plate.



1. Mirror Housing
2. Main Mirror Structure Plate Assembly

Fig. 2, Mirror Housing with Main Mirror Structure Plate Removed

11. Install the CB antenna mount on the main mirror structure plate, if applicable.
12. Install the mirror plate in the mirror housing. See **Subject 150** for instructions.
13. Attach the mirror head to the support loop. See **Subject 130** for instructions.
14. Remove the chocks from the tires.

Mirror Housing Replacement

This procedure applies to the following mirrors:

- Lang-Mekra Aero
- Truck-Lite

The procedure is different for each mirror.

Lang-Mekra Aero

1. Park the vehicle on a level surface, apply the parking brake, shut down the engine, and chock the front and rear tires.
2. Remove the mirror head assembly from the support loop. See **Subject 130** for instructions.
3. Remove the main mirror plate from the mirror housing. See **Subject 150** for instructions.
4. Remove the convex mirror plate from the mirror housing. See **Subject 160** for instructions.
5. Remove the CB antenna mount from the main mirror structure plate.
6. Disconnect the electrical connections from the main and convex mirror structure plates.
7. Remove the screws that attach the main mirror structure plate to the mirror housing. See **Fig. 1**. Remove the main mirror structure plate from the mirror housing.

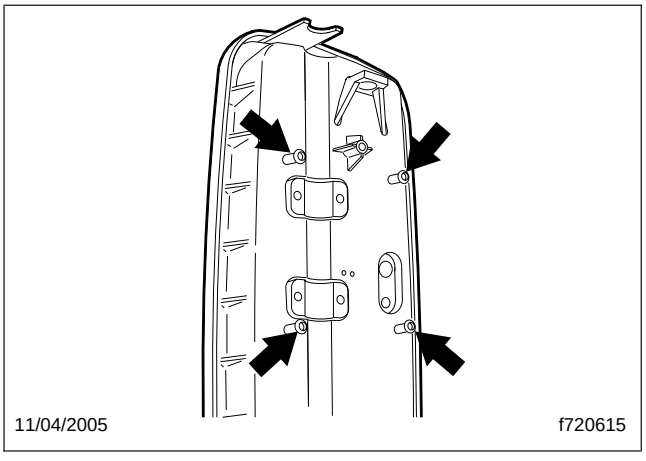


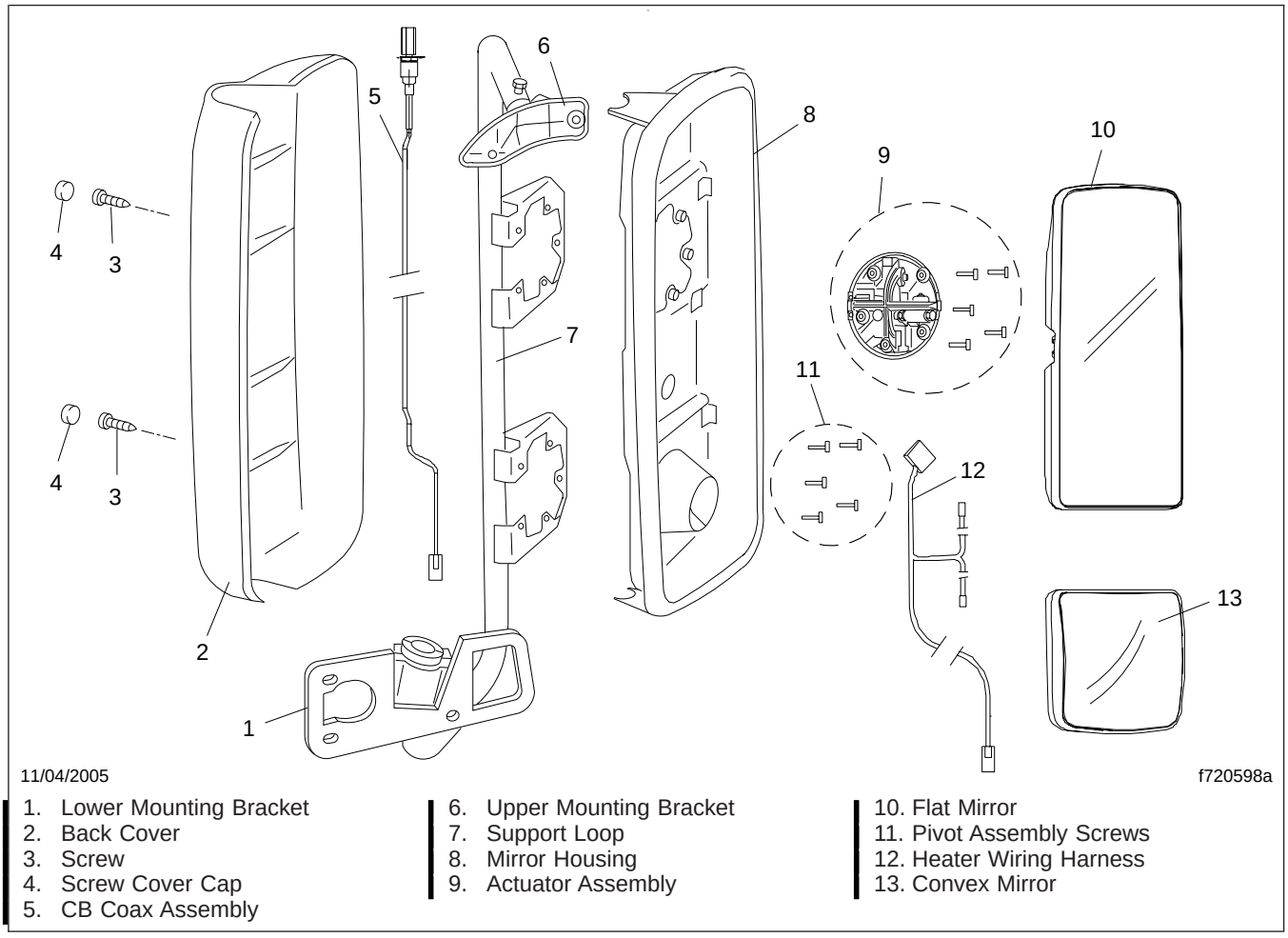
Fig. 1, Main Mirror Structure Plate Screws

8. Remove the screws that attach the convex mirror structure plate to the mirror housing. Remove the convex mirror structure plate from the mirror housing.
9. Position the convex mirror structure plate in the new mirror housing.
10. Install the screws that attach the convex mirror structure plate to the mirror housing.
11. Position the main mirror structure plate in the new mirror housing.
12. Install the screws that attach the main mirror structure plate to the mirror housing. See **Fig. 1**.
13. Connect the electrical connections to both structure plates.
14. Install the CB antenna mount on the main mirror structure plate.
15. Install the convex mirror plate in the mirror housing. See **Subject 160** for instructions.
16. Install the main mirror plate in the mirror housing. See **Subject 150** for instructions.
17. Attach the mirror head to the support loop. See **Subject 130** for instructions.
18. Remove the chocks from the tires.

Truck-Lite

1. Park the vehicle on a level surface, apply the parking brake, shut down the engine, and chock the front and rear tires.
2. Remove the CB antenna from the mirror head, using a wrench to keep the antenna base from loosening.
3. Remove the mirror back cover. See **Fig. 2**.
   - 3.1 Remove the two screw covers on the back of the mirror.
   - 3.2 Remove the two screws that attach the back cover to the mirror head.
   - 3.3 Pull the bottom of the cover away from the mirror head, and carefully lift the cover up over the antenna base.
4. Remove the main mirror plate from the mirror housing. See **Subject 150** for instructions.
5. Remove the convex mirror plate from the mirror housing. See **Subject 160** for instructions.
6. Remove the actuator assembly from the mirror head. See **Subject 170** for instructions.

Mirror Housing Replacement



1. Lower Mounting Bracket
2. Back Cover
3. Screw
4. Screw Cover Cap
5. CB Coax Assembly
6. Upper Mounting Bracket
7. Support Loop
8. Mirror Housing
9. Actuator Assembly
10. Flat Mirror
11. Pivot Assembly Screws
12. Heater Wiring Harness
13. Convex Mirror

Fig. 2, Truck-Lite Mirror Assembly

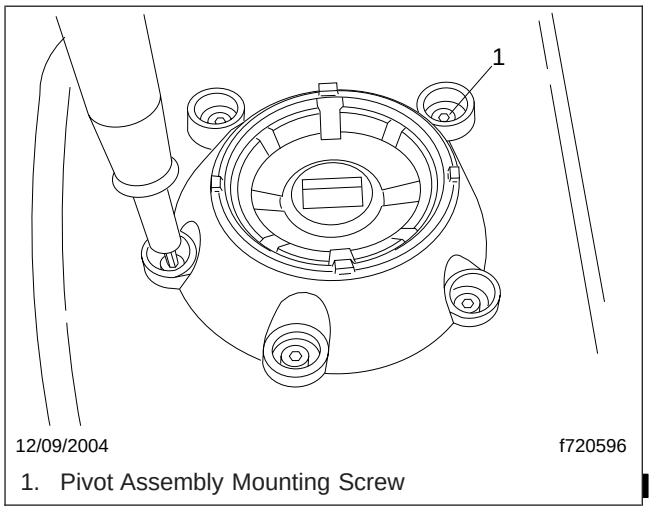
7. Remove the five screws that attach the convex glass pivot assembly to the support loop. See **Fig. 3**. Remove the mirror housing from the support loop.
8. Position the new mirror housing on the support loop.
9. Attach the convex glass pivot assembly to the support loop with the five screws. See **Fig. 3**.
10. Install the actuator assembly. See **Subject 170** for instructions.
11. Install the convex mirror plate. See **Subject 160** for instructions.
12. Install the main mirror plate. See **Subject 150** for instructions.
13. Install the mirror back cover.

    13.1 Position the top of the cover over the antenna base, and push the bottom of the cover into place against the mirror head.

    IMPORTANT: Ensure that the mirror back cover is properly seated in the mirror housing. The gap around the edge should be uniform, and the tabs at the top and bottom should seat securely in their respective grooves.

    13.2 Install the two screws that attach the cover to the mirror head. Torque the screws 31 lbf·ft (340 N·m).

    13.3 Install the two screw covers.



1. Pivot Assembly Mounting Screw

Fig. 3, Convex Glass Pivot Assembly

14. Install the CB antenna on the mirror head assembly. Tighten the antenna hexnut 85 lbf·in (960 N·cm).
15. Remove the chocks from the tires.

Upper Pivot-Point Fastener Kit Replacement

This procedure applies to the following mirror only:

- Lang-Mekra Aero

NOTE: The upper pivot-point fastener kit is not serviceable on Truck-Lite mirrors.

Replacement

CAUTION

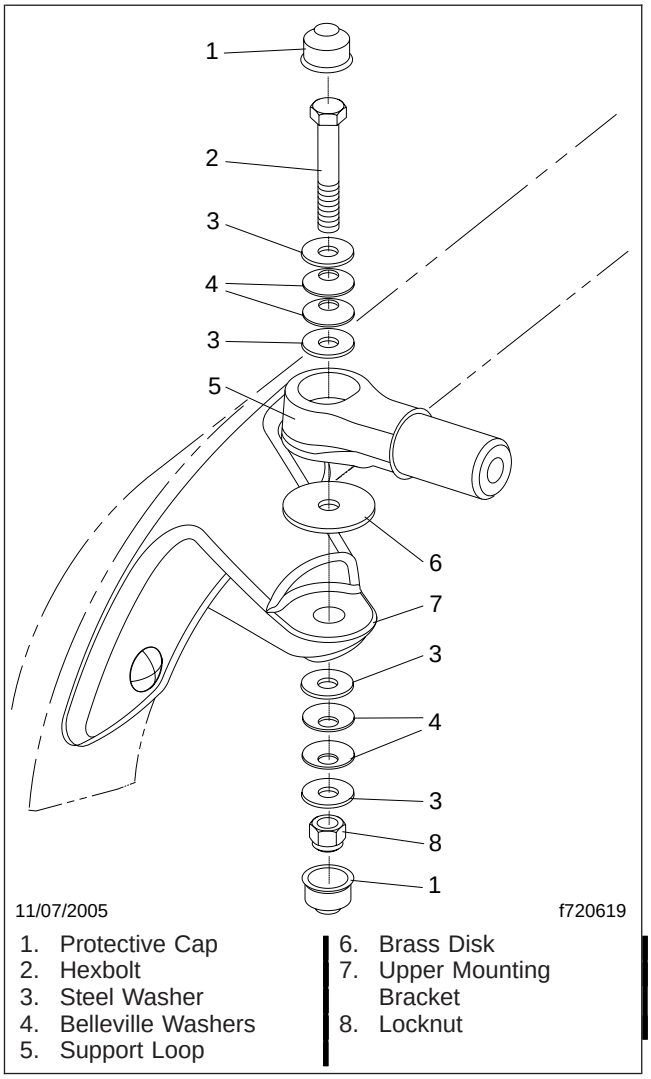
If any fasteners in the kit are over-torqued, the entire fastener kit must be replaced.

1. Remove the two protective fastener caps from the nut and bolt. See **Fig. 1**.
2. Remove the nut and bolt from the upper mounting bracket. If reinstalling the fasteners, note the order of the washers.
3. Lightly grease both sides of the brass disk.

CAUTION

When assembling the fastener kit, make sure that all components are installed in the correct order, and that the Belleville washers are oriented with the concave sides facing the upper mounting bracket and support loop. Incorrect installation may damage the fastener kit and cause the support loop pivot to bind or move too easily.

4. Place the brass disk between the upper mounting bracket and the upper arm of the support loop. See **Fig. 1**.
5. Insert the bolt through, in this order, a steel washer, two Belleville washers with concave sides towards the end of the bolt, and a permaglide steel washer with the lubricated side towards the end of the bolt.
6. Insert the assembled bolt and washers through the support loop, the brass disk, and the upper mounting bracket.
7. Install, in this order, a permaglide washer with the lubricated side towards the upper support bracket, two Belleville washers with the concave sides towards the upper support bracket, and a steel washer on the bolt.
8. Install the locknut on the bolt. Torque the nut 31 to 35 lbf·ft (42 to 48 N·m).



1. Protective Cap
2. Hexbolt
3. Steel Washer
4. Belleville Washers
5. Support Loop
6. Brass Disk
7. Upper Mounting Bracket
8. Locknut

Fig. 1, Fastener Kit Installation

9. Install the two protective caps on the nut and bolt.

Troubleshooting Tables

Problem—Mirror Support Loop Does Not Fold Back

Problem—Mirror Support Loop Does Not Fold Back	
Possible Cause	**Remedy**
An incorrect adjustment of the upper mirror-pivot bolt.	Adjust the upper mirror-pivot bolt. See **Subject 110** for instructions.

Problem—Mirror Support Loop Folds Back Too Easily or Vibrates

Problem—Mirror Support Loop Folds Back Too Easily or Vibrates	
Possible Cause	**Remedy**
The upper mirror-pivot bolt is loose.	Adjust the upper mirror-pivot bolt. See **Subject 110** for instructions.
The upper mirror-pivot bolt has been over-torqued (Lang-Mekra Aero).	Replace the upper mirror-pivot bolt, bushing, and hexnut. See **Subject 210** for instructions.
The attachments to the door are loose.	Secure the brackets to the door. See **Subject 100** for instructions.

Problem—Remote-Controlled Mirror Will Not Adjust

Problem—Remote-Controlled Mirror Will Not Adjust	
Possible Cause	**Remedy**
Loose or damaged cables.	Connect any loose cables. Check all cables for damage and replace as needed.
Detached ball and socket joint (Lang-Mekra Aero).	Push the split ring up the split socket tube, away from the actuator. Direct the actuator towards the split socket tube, then align the actuator arm into the tube. Push firmly on the socket plate to snap the ball into the split socket tube. Slide the split ring back into the retaining groove. See **Subject 180** for instructions.
Broken rivet or socket at ball and socket joint (Lang-Mekra Aero).	Replace the socket plate. See **Subject 180** for instructions.
Broken actuator arm (Lang-Mekra Aero).	Replace the failed actuator. See **Subject 170** for instructions.
Faulty control cable (Lang-Mekra Aero).	Replace the control cable. See **Subject 130** for instructions.
Failed actuator.	Replace the failed actuator. See **Subject 170** for instructions.
No continuity from socket flange (Lang-Mekra Aero).	Replace the structure plate assembly, including the actuators. See **Subject 190** for instructions.

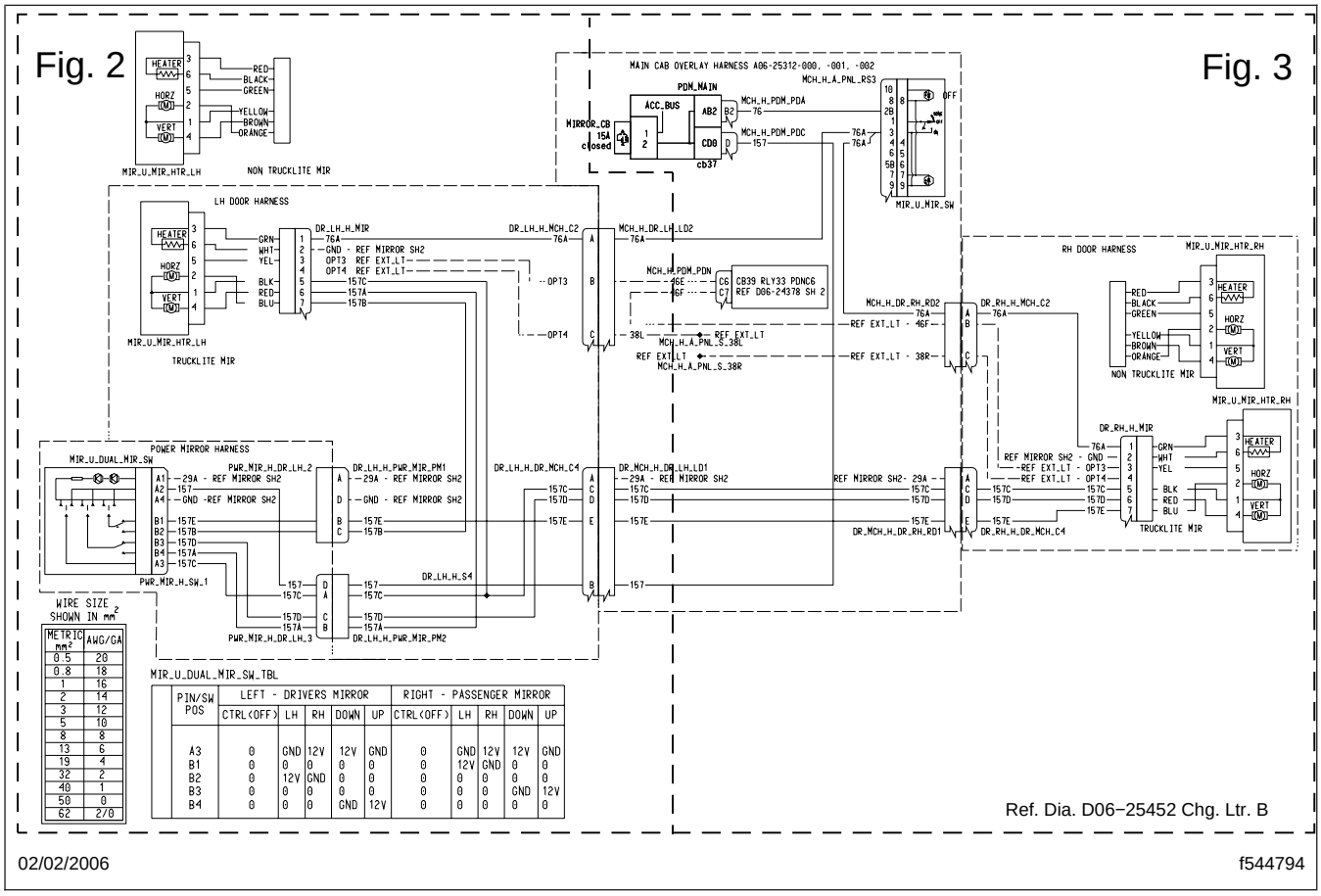
Problem—Mirror Plate Will Not Heat

Problem—Mirror Plate Will Not Heat	
Possible Cause	**Remedy**
Loose or damaged cables.	Connect any loose cables. Check all cables for damage and replace as needed.
Detached heater wires.	Attach the heater wires. See **Subject 150** (main mirror), or **Subject 160** (convex mirror) for instructions.

Troubleshooting

Problem—Mirror Plate Will Not Heat	
Possible Cause	**Remedy**
Loose or damaged heater spades.	Replace the mirror plate assembly. See **Subject 150** (main mirror), or **Subject 160** (convex mirror) for instructions.
Faulty control cable.	Replace the control cable. See **Subject 130** for instructions.
Faulty glass plate assembly.	Replace the mirror plate assembly. See **Subject 150** (main mirror), or **Subject 160** (convex mirror) for instructions.
No continuity from socket flange (Lang-Mekra Aero).	Replace the structure plate assembly. See **Subject 190** for instructions.

See **Fig. 1**, **Fig. 2**, and **Fig. 3** for the wiring diagram for a motorized and/or heated mirror.



PIN/SW POS	LEFT - DRIVERS MIRROR					RIGHT - PASSENGER MIRROR				
	CTRL(OFF)	LH	RH	DOWN	UP	CTRL(OFF)	LH	RH	DOWN	UP
A3	0	GND	12V	12V	GND	0	GND	12V	12V	GND
B1	0	0	0	0	0	0	12V	GND	0	0
B2	0	12V	GND	0	0	0	0	0	0	0
B3	0	0	0	0	0	0	0	0	GND	12V
B4	0	0	0	GND	12V	0	0	0	0	0

METRIC mm²	AWG/GA
0.5	20
0.8	18
1	16
2	14
3	12
5	10
8	8
13	6
19	4
32	2
40	1
50	0
62	2/0

Fig. 1, Mirror Wiring Diagram

Specifications

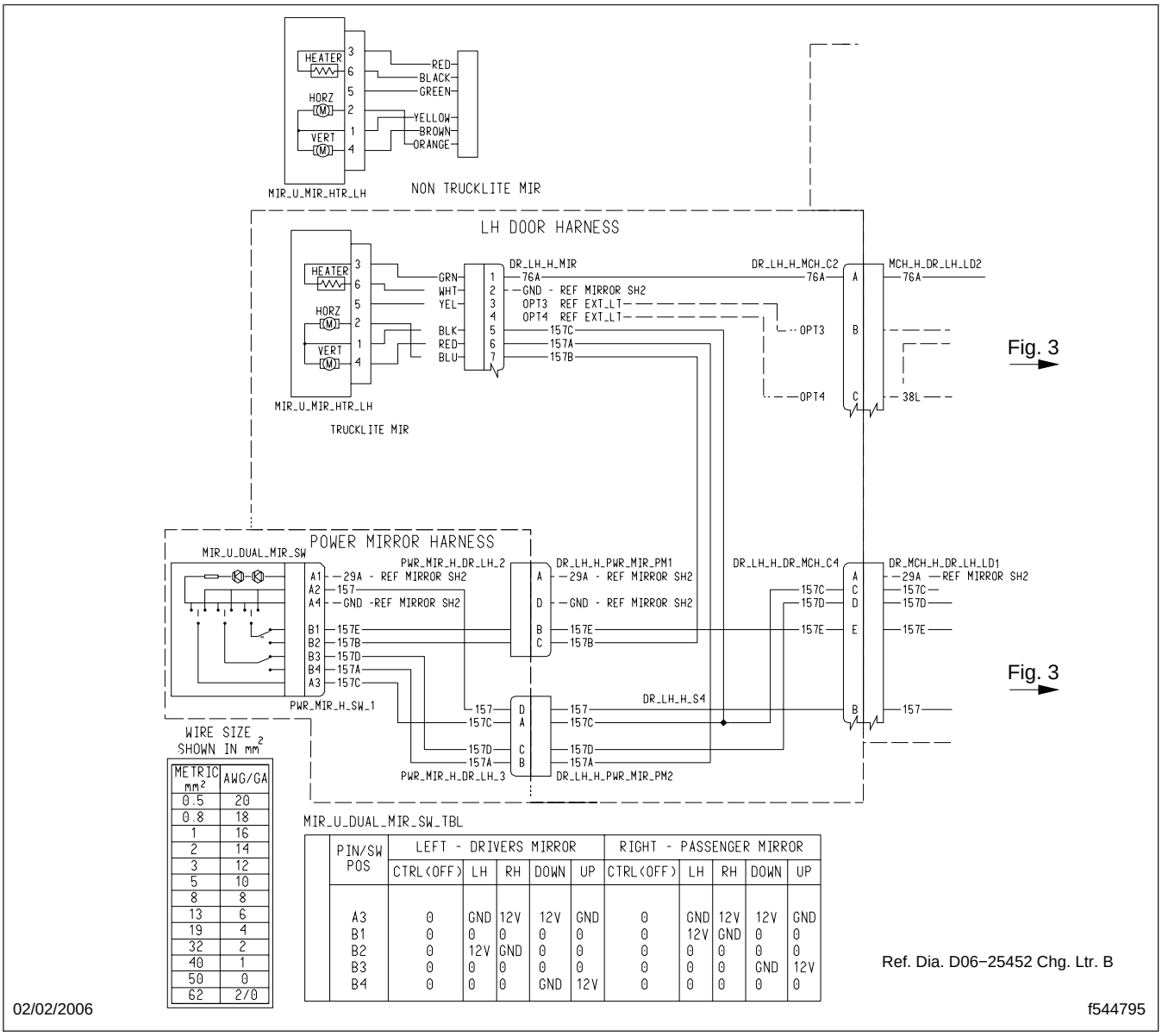


Fig. 2, Mirror Wiring Diagram (detailed view)

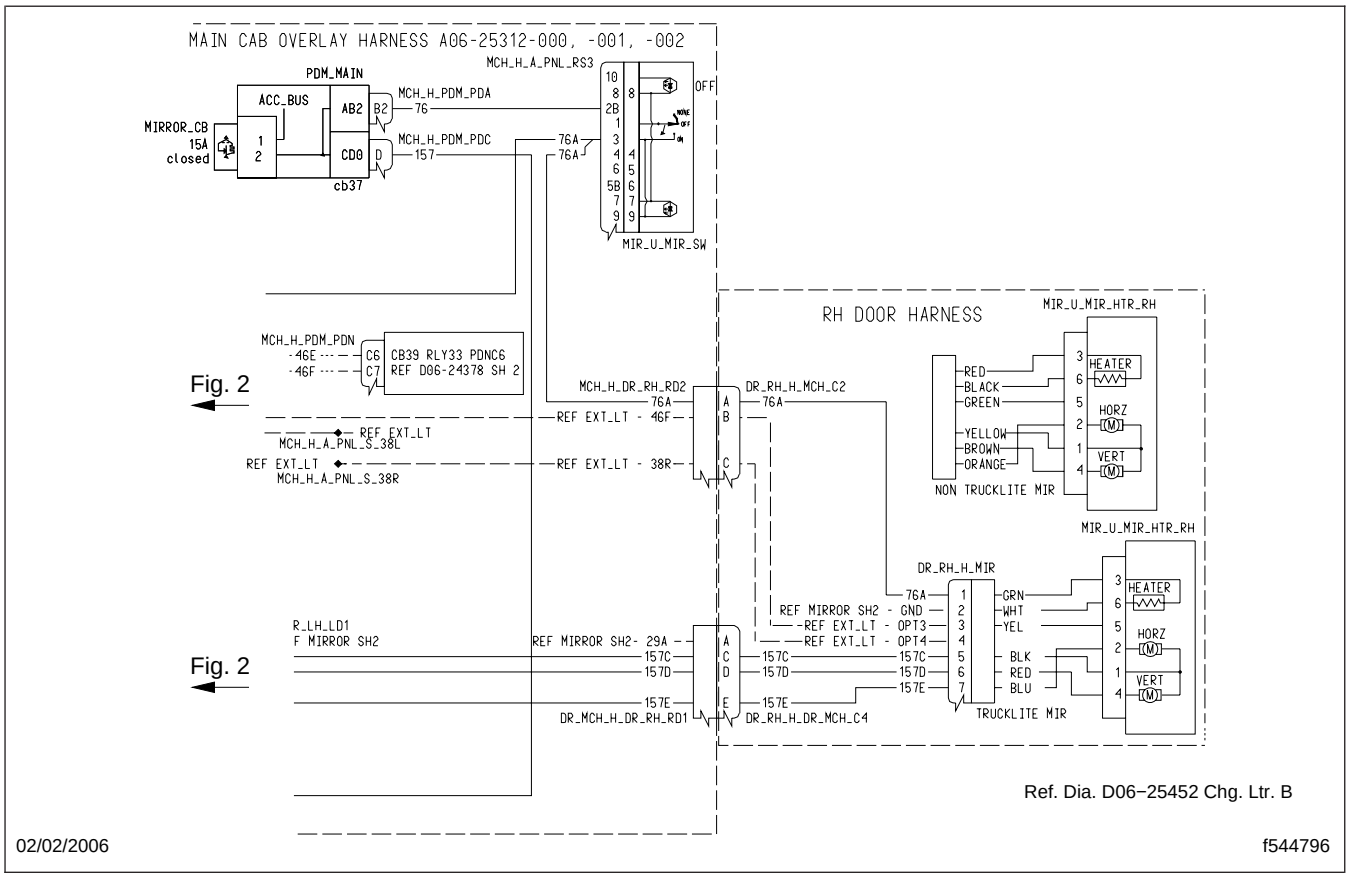


Fig. 3, Mirror Wiring Diagram (detailed view)

General Information

The aluminum cab is a semi-monocoque design, which means that the outer skin panels are load-bearing as is the internal framework. This type of construction requires less framework than standard cab construction, and results in a very strong, yet lightweight cab. See **Fig. 1**.

There are three basic cab configurations: non-sleeper cab, mid-roof SleeperCab®, and raised-roof SleeperCab. Non-sleeper cabs are 48-inch lengths. The mid-roof SleeperCabs are 48-inch, 58-inch, or 70-inch lengths. Raised-roof SleeperCabs are 58-inch or 70-inch lengths.

The major cab parts are the front-wall assembly, right and left door-frame assemblies, right and left side-wall assemblies, back-wall assembly, front and rear roof cap assemblies (for mid-roof SleeperCabs), and the cab deck assembly. See **Fig. 2**. Non-sleeper cabs have one roof-cap assembly. Raised-roof SleeperCabs have one SMC fiberglass roof assembly.

The side-wall skins are bonded to the frame instead of riveted. The roof cap assemblies are attached to the cab side walls and the back wall by means of a coach joint. The coach joint is held together with 5/16–18 Torx®-head screws. Foam sealant tape is installed between the roof caps and the side walls and back wall.

The cab deck consists of a framework of longitudinal sills and transverse crossmembers, with forward and rear deck plates fastened to them. Non-SleeperCabs have one deck plate.

The cab front-wall assembly is a complete unit attached to the front of the door frame assemblies. It can be replaced as an entire unit, or in parts.

The cab parts are held together with a variety of fasteners. See **Subject 100** for more information on cab fasteners.

When any repairs are done to the cab, it is necessary to check the frame rails for correct alignment and squaring. Then the cab must be leveled and squared. If the cab is repaired without straightening the frame rails, undue stress could be put on the cab, which could weaken it. Also, it may be impossible to square up the cab.

General Information

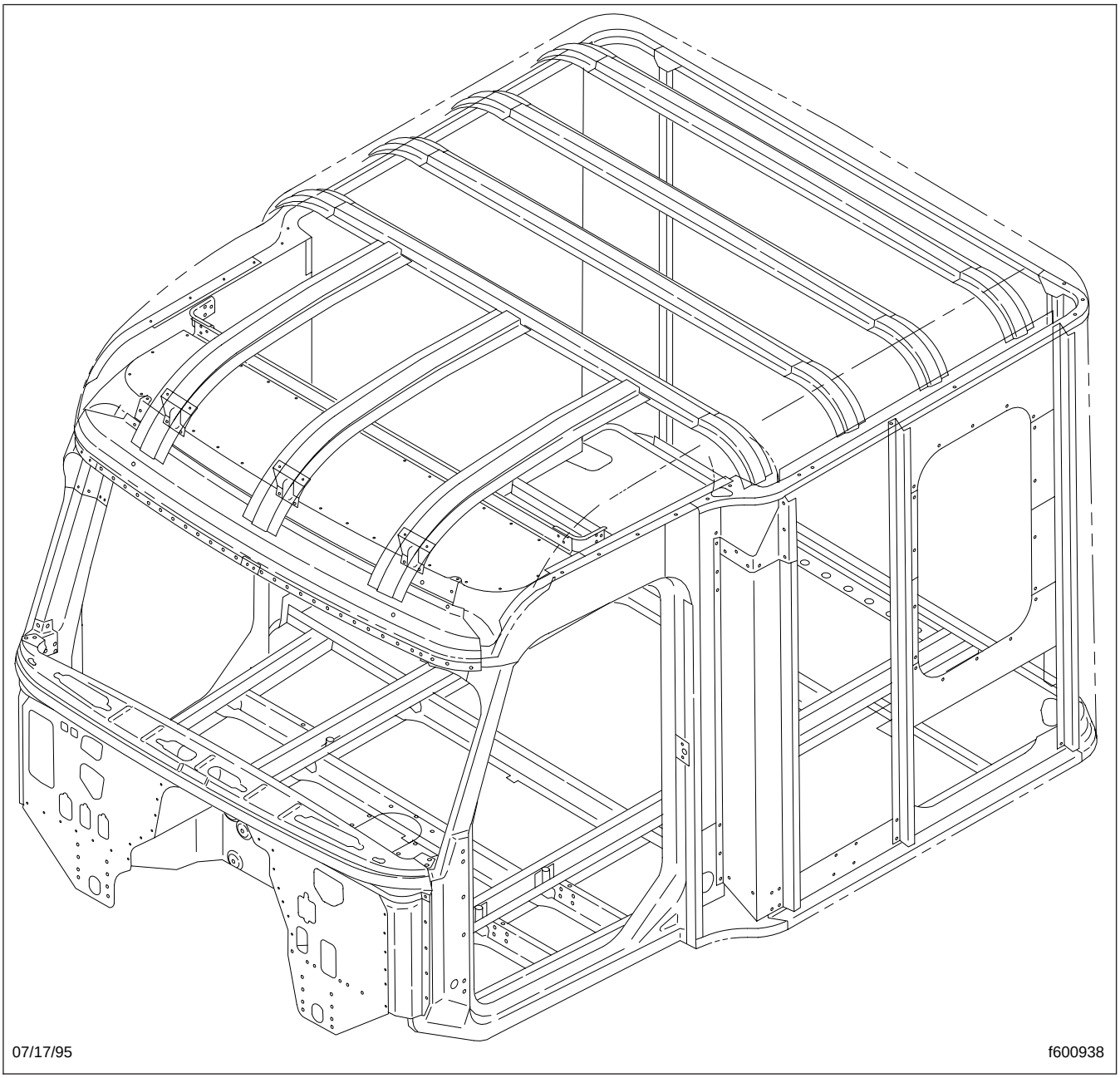
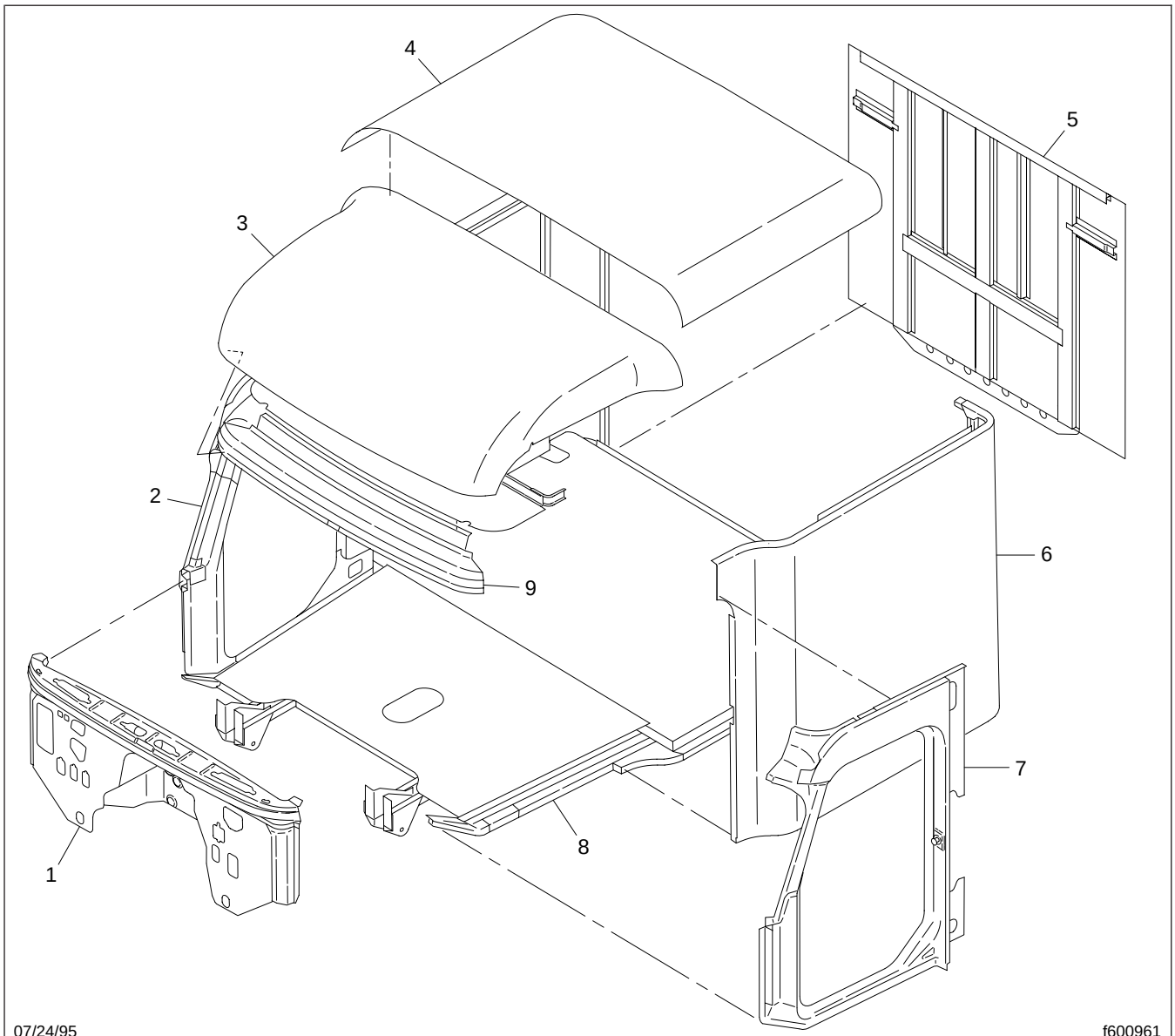


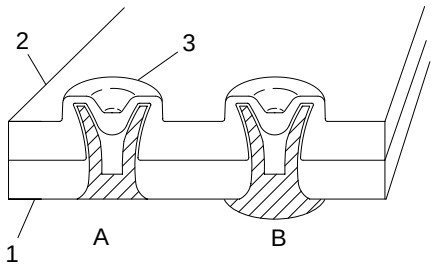
Fig. 1, Cab Structure (48-inch SleeperCab® shown)



1. Front-wall Assembly
2. Right Door Frame Assembly
3. Front Roof-Cap Assembly
4. Rear Roof-Cap Assembly
5. Back-Wall Assembly
6. Left Side-Wall Assembly
7. Left Door Frame Assembly
8. Cab Deck Assembly
9. Windshield Header Assembly

Fig. 2, Major Cab Parts, Typical 48-Inch SleeperCab

Different types of fasteners are used to hold the cab together. In addition to Huck® bolts and blind rivets, steel Henrob® rivets are used extensively. These differ from other fasteners, in that they are installed without drilling holes in the material. Specialized equipment punches them directly through the metal, then extrudes a bulb on the opposite metal surface. No bucking bar is used. Henrob rivets have hollow shanks, and either brazier or countersunk heads. **See Fig. 1.** They are replaced with either Huck fasteners, aluminum bucked rivets, or blind rivets, such as Magnabulb® or Monobolt® fasteners.



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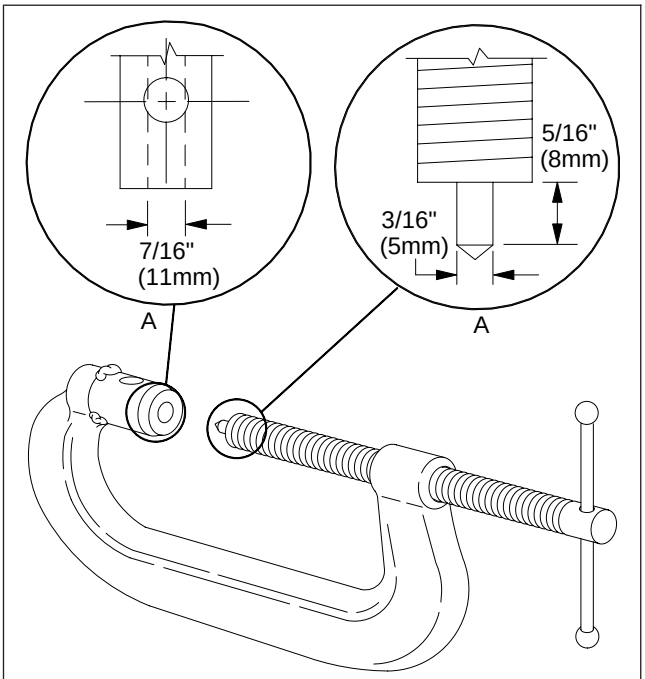
A. Countersunk Head
B. Brazier Head
1. Outer Skin
2. Inner Skin
3. Extruded Bulb

Fig. 1, Henrob Rivet Types

Remove Huck fasteners by chiseling off the collars. Remove a blind rivets by either grinding off the head, then punching out the center, or by drilling out the center, and then removing the fastener.

Remove Henrob rivets by drilling them out or pushing them out. To drill them out, use a 3/16-inch cobalt drill on low speed. When you have drilled completely through the material, remove the rivet head using a cold chisel or a punch. To push out Henrob rivets, a special tool can be made from a C-clamp. **See Fig. 2.** Grind down the extruded bulb on the back surface of the metal until it is flush. Put the special C-clamp, with the cylinder end over the head of the rivet, then line up the peg on the other end of the C-clamp with the depresssion of the shank. Tighten the C-clamp until the Henrob rivet is pushed out the front surface, and into the C-clamp cylinder.



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A. Top View

Fig. 2, C-Clamp Specially Adapted for Removing Henrob Rivets

Leveling and Squaring the Cab

IMPORTANT: Before any repairs can be made to a damaged cab, the vehicle frame rails must be level and squared. If this is not done, the cab sections will not fit together correctly. Level the frame rails using jackstands. For instructions on squaring the frame rails, see the applicable section in **Group 31**.

There are several methods for correctly squaring the cab. This subject will cover only one technique, using a specially made squaring tool. The tool can be used for measuring squareness, and can be lengthened or shortened to bring the cab parts into correct alignment. The measurements given in this procedure are also applicable for any other method of cab squaring. All measurements are to be taken from inside the cab, and with all the interior contents, and the roof cap(s) and doors removed.

1. With the cab empty, and using a 4- to 5-foot (122 to 152 cm) long straight-edge of suitable material, make sure the cab deck is level.

    1.1 Place the straight-edge cross-wise on the cab deck at the front of the cab, then the middle, then at the rear. At each place, check that the deck plates are parallel and flush with the straight-edge.

    1.2 Place the straight-edge lengthwise on the cab deck on the right side, the middle, then the left side. At each place, check that the deck plates are parallel and flush with the straight-edge.

    1.3 If the cab deck surface is not flush and parallel with the straight-edge everywhere, level the deck, using jackstands or a suitable fixture.

NOTE: The following procedure for squaring the cab involves using a special squaring tool that can be fabricated from suitable metal stock. See **Specifications, 400** for the configuration and measurements of this tool.

2. Measure the cab for squareness, starting at the front, and moving to the rear. **See Fig. 1.** Each measurement is diagonal, and taken from both the left and right sides of the cab, in an "X" configuration. For example, if you measure from the top right side to the bottom left side of the cab, you then need to take the identical measurement from the top left side to the bottom right side of the cab.

    Install a door plug into each door frame before beginning the squaring procedure. See **Specifications, 400** for measurements and materials needed to construct the door plugs.

    2.1 Find the outboard, forward clinch-nut hole on the left-side cab deck (Ref. 6). Remove the fastener (if present) from the hole. (The clinch nut itself is underneath the cab deck). Install the lower end of the squaring tool into the hole, using a 5/16–18 hexbolt or screw. Then, on the right side-wall top flange, find the second fastener hole from the front (Ref. 1). Install the top end of the squaring tool into the hole, using a 5/16–18 hexbolt or screw and hexnut. Use the turnbuckle on the tool to lengthen or shorten the tool as needed. Measure the distance between the two holes (Ref. A). It should be 97-5/16 inches (2488 mm). If it is not, shorten or lengthen the squaring tool as needed, to push or pull the side walls into alignment.

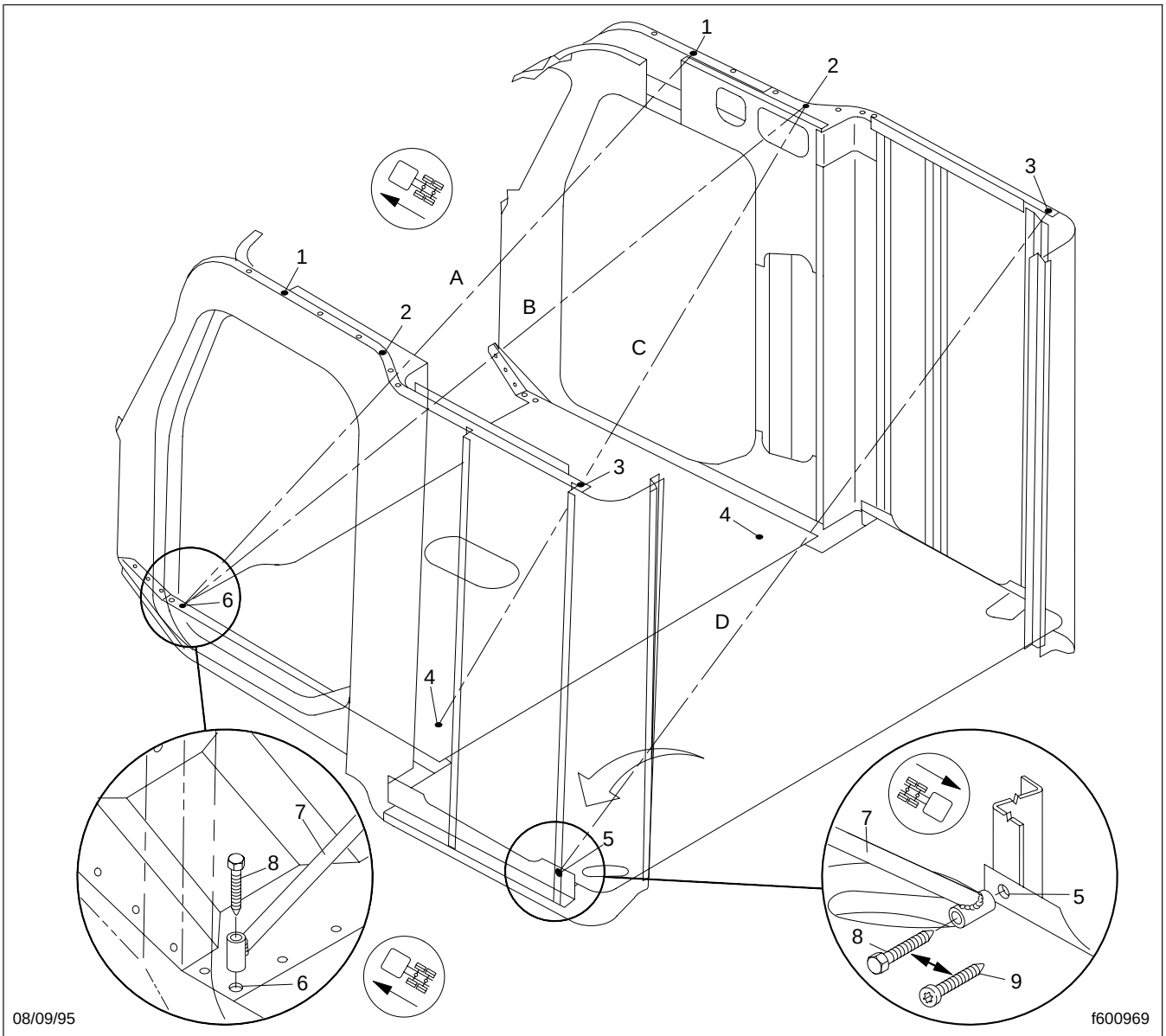
    Repeat the procedure on the other side of the cab, measuring from the right-side cab deck to the left-side top of the side wall.

    2.2 On the right side-wall top flange, find the first fastener hole (Ref. 2) at the start of the sleeper transition bracket. For a non-SleeperCab, find the last hole in the side wall top flange before the corner radius. Install the top end of the squaring tool into the hole, using a 5/16–18 hexbolt or screw and hexnut. Install the other end of the squaring tool into the outboard, most forward clinch nut hole on the right side of the cab deck (Ref. 6). Measure the distance between the two holes (Ref. B). It should be 104-7/16 inches (2653 mm). If it is not, lengthen or shorten the squaring tool as needed.

    Repeat the procedure on the other side of the cab, measuring from the right-side cab deck to the left-side top of the side wall.

    2.3 Find the same fastener hole (Ref. 2) in the side-wall top flange that was used in the previous substep, and install the top end

Leveling and Squaring the Cab



A. 97-5/16 inches (2488 mm)
B. 104-7/16 inches (2653 mm)
C. 94-5/16 inches (2396 mm)
D. 108-3/16 inches (2748 mm)

1. Outboard, Most Forward Clinch-Nut Hole
2. First Fastener Hole at the Beginning of the Sleeper Transition Bracket
3. Rearmost Fastener Hole in Side-Wall Top Flange
4. Outboard Seat Belt Anchor Hole
5. Bottom Clinch-Nut Hole on Rearmost Z-Strip
6. Outboard Forward Clinch-Nut Hole
7. Squaring Tool
8. 5/16–18 Hexbolt
9. 5/16–18 Torx-Head Screw

Fig. 1, Squaring Measurements and Location Holes, Front and Back Walls Not Shown

of the squaring tool into it. Install the other end of the squaring tool into the threaded hole on the cab deck that is used to anchor the right outboard seat belt (Ref. 4).

Measure the distance between the two holes (Ref. C). It should be 94-5/16 inches (2396 mm). If it's not, lengthen or shorten the tool as needed.

Repeat the procedure on the other side of the cab, measuring from the right-side cab deck to the left-side top of the side wall.

For a non-SleeperCab®), the procedure is complete. If the cab is a SleeperCab, go to the next substep.

2.4 For a SleeperCab, find the bottom clinch nut hole on the last Z-strip before the corner of the right side wall (Ref.5). Install the bottom end of the squaring tool, using a 5/16–18 hexbolt or screw. Then find the rearmost fastener hole on the left side-wall top flange (Ref. 3). Install the top end of the special squaring tool, using a 5/16–18 hexbolt or screw, and hexnut to hold the tool in the upper hole. Measure the distance between the two holes (Ref. D). It should be 108-3/16 inches (2748 mm). Lengthen or shorten the squaring tool as needed.

Repeat the procedure on the other side of the cab, measuring from the bottom of the left side wall to the top of the right side wall.

Sidewall Assembly Replacement

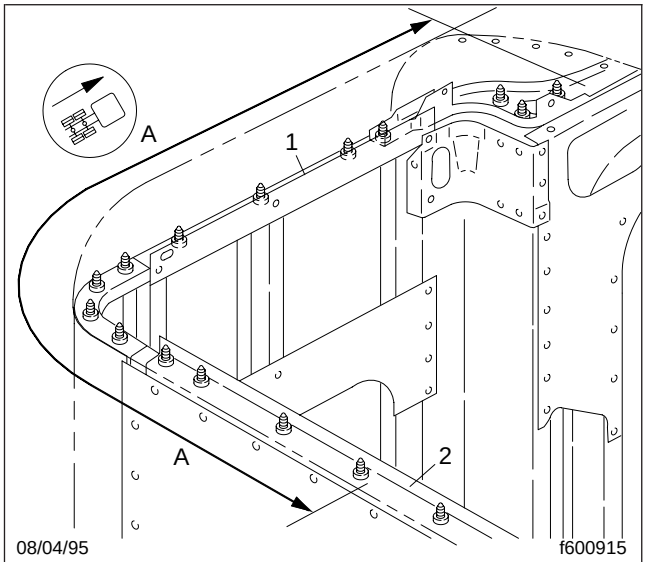
Removal

CAUTION

Check the vehicle chassis for correct alignment before making repairs to the cab. Failure to repair and align the chassis before repairing the cab could prevent you from correctly squaring the cab, and cause undue stress on the cab structure.

IMPORTANT: Prior to any work being performed on the sidewall assembly, the vehicle must be prepared. See the applicable groups and sections in this manual for instructions.

1. Park the vehicle on a level surface. Shut down the engine. Set the parking brake and chock the front and rear tires.
2. Level the chassis, using jack stands.
3. Remove the seats, the bunk(s), the upholstery panels, the cabinets, the floor mats, and the carpeting from the cab interior. If so equipped, remove the auxiliary HVAC unit.
4. Move the wiring harness and all wiring located in or near the sidewall assembly out of the way.
5. Remove the door from the affected side of the vehicle. See **Group 72** for instructions.
6. Cover the remaining interior components of the cab to protect them during the replacement work.
7. Install a door plug in the open door frame. See **Specifications, 400** for the measurements and materials needed to construct door plugs.
8. Remove the brackets attaching the sun visor to the side of the cab above the door frame.
9. Remove the eight Torx®-head screws that attach the side extender and extender brackets to the rear wall assembly. Remove the side extender.
10. From inside the cab, remove the Torx-head screws holding the roof cap assembly to the upper edge of the damaged sidewall. Remove the screws from along the sidewall, around the rear wall, and as far forward on the opposite sidewall as the door frame. See **Fig. 1**.
11. Raise and block up the rear roof cap enough to allow removal of the monobolts at the top of the roof transition bracket.
12. Remove the fasteners attaching the upper B-pillar to the upper B-pillar reinforcement assembly.
13. Remove the fasteners that attach the upper and lower assembly to the sidewall. See **Fig. 2**. There is no need to remove the fasteners that attach the door plates to the door frame assembly.

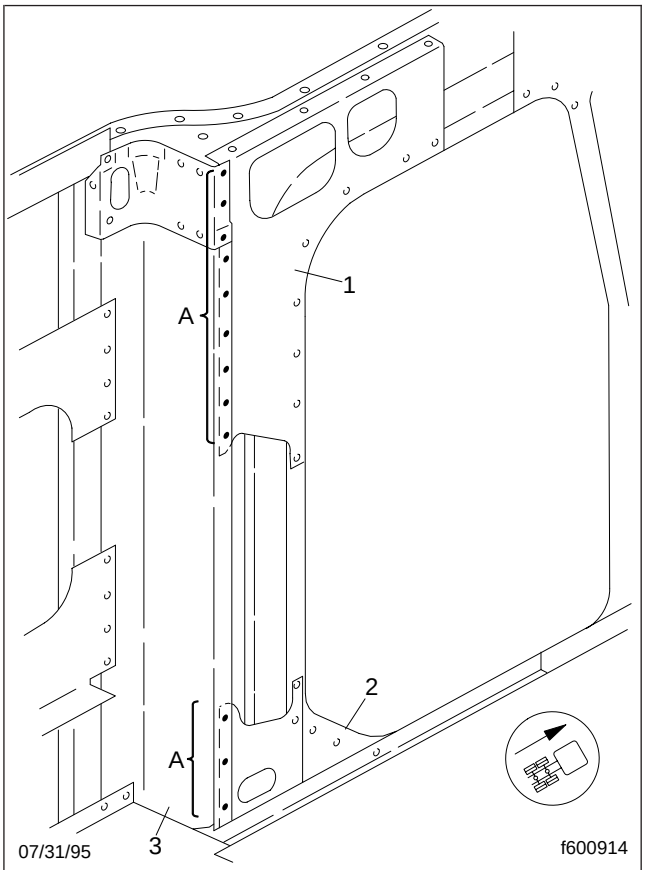


A. Remove all of these Torx-head screws.
1. Sidewall Assembly 2. Rear Wall Assembly

Fig. 1, Rear Roof Cap Fasteners, SleeperCab

14. Remove the three monobolts that attach the roof transition bracket to the sidewall. See **Fig. 3**.
15. Remove the fasteners that attach the sidewall transition bracket to the door frame. See **Fig. 3**.
16. Remove the Torx-head screws that attach the lower ends of the Z-strips to the cab deck sill. Make sure to also remove those screws that are underneath the cab deck. See **Fig. 4**.
17. From outside the cab, remove the monobolts that attach the drip rail to the door frame.
18. Remove the nine Henrob rivets and three monobolts that attach the forward edge of the sidewall skin to the door frame. See **Fig. 5**.

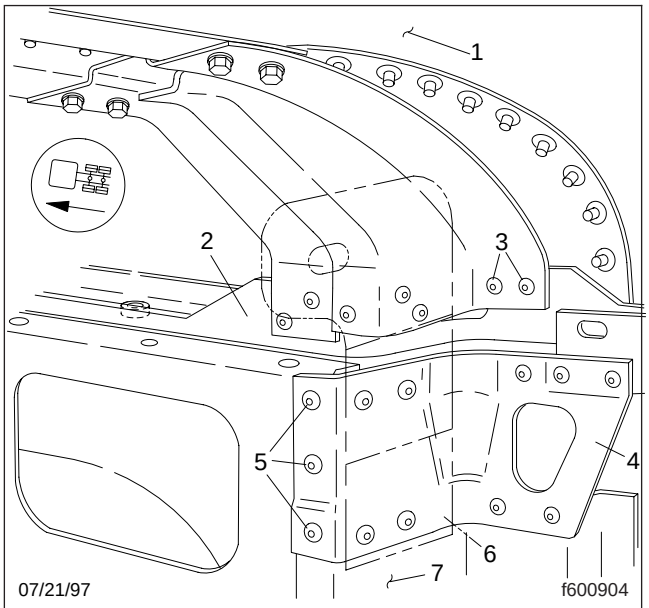
Sidewall Assembly Replacement



A. Remove these fasteners.
1. Upper B-pillar Reinforcement Assembly
2. Lower B-pillar Reinforcement Assembly
3. B-pillar

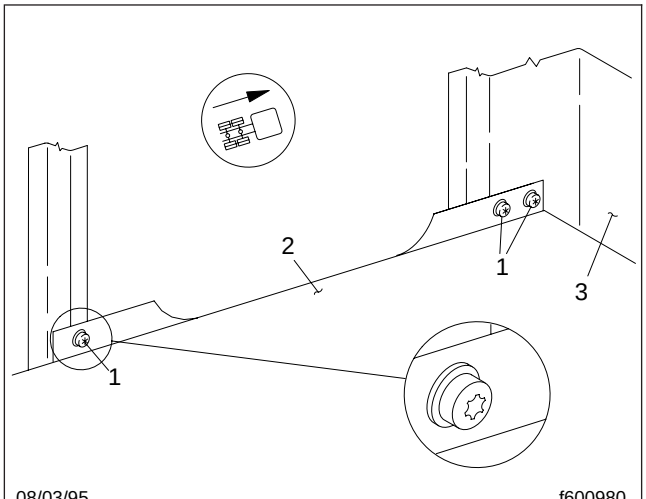
Fig. 2, Left Side, Inside View

19. Remove the Henrob rivets that attach the lower edge of the sidewall skin to the bottom of the deck sill. See **Fig. 6**.
20. Remove the fasteners that join the rear edge of the sidewall skin to the rear wall. See **Fig. 6**. Carefully pry up the skin to loosen the adhesive-tape bond.
21. Remove the two outer fasteners that attach the top side extender bracket to the rear wall.
22. Check to be sure that all wiring is routed or taped out of the way.
23. Support the sidewall assembly.



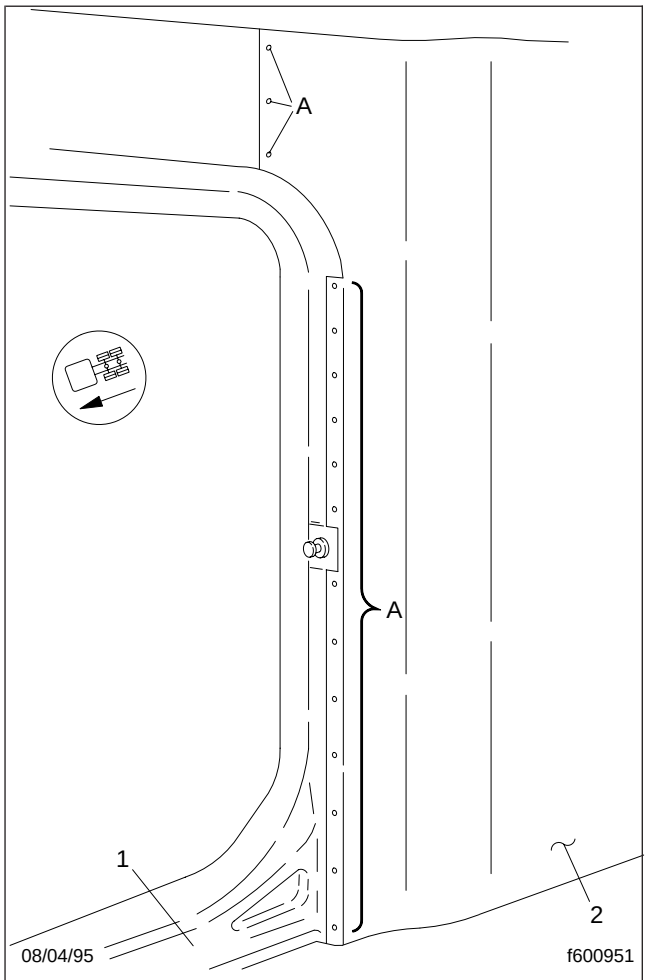
1. Roof Cap
2. Sidewall Transition Reinforcement
3. Roof Transition Mounting Bracket Fasteners
4. Upper B-pillar
5. Sidewall Transition Mounting Bracket Monobolts
6. Upper B-pillar Reinforcement (mid-roof only)
7. Sidewall (interior wall)

Fig. 3, Transition Brackets, Right Side



1. Torx-head Screws
2. Cab Deck Sill
3. Sidewall Transition Area

Fig. 4, Left Side, Interior View



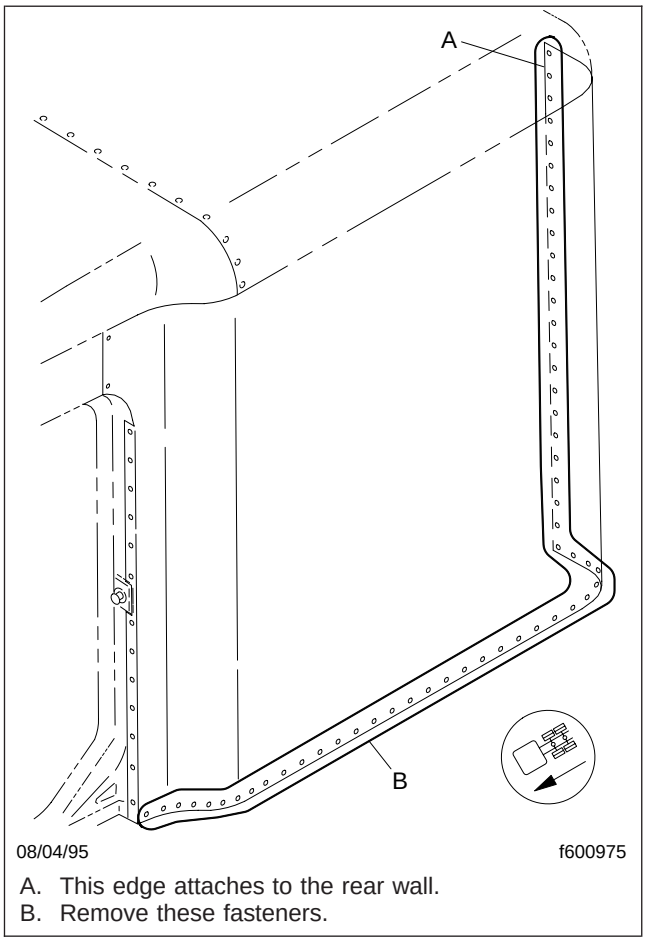
A. Remove these fasteners (lower three are monobolts).
1. Left Door-Frame Assembly
2. Left Sidewall Assembly

Fig. 5, Sidewall-to-Door Frame Henrob Rivets

CAUTION

Do not overheat the sidewall skin. Aluminum will melt or change shape under extreme heat, and overheating can damage the side skin.

24. Using a suitable heat source, such as a heat gun or a propane torch, and working on the cab exterior, heat the forward edge of the sidewall skin at the door frame to release the glue bond. The glue bond will soften at about 275°F (135°C). Pry up the edge to prevent the glue from rebonding.



A. This edge attaches to the rear wall.
B. Remove these fasteners.

Fig. 6, Sidewall Fasteners to the Cab Deck and Rear Wall

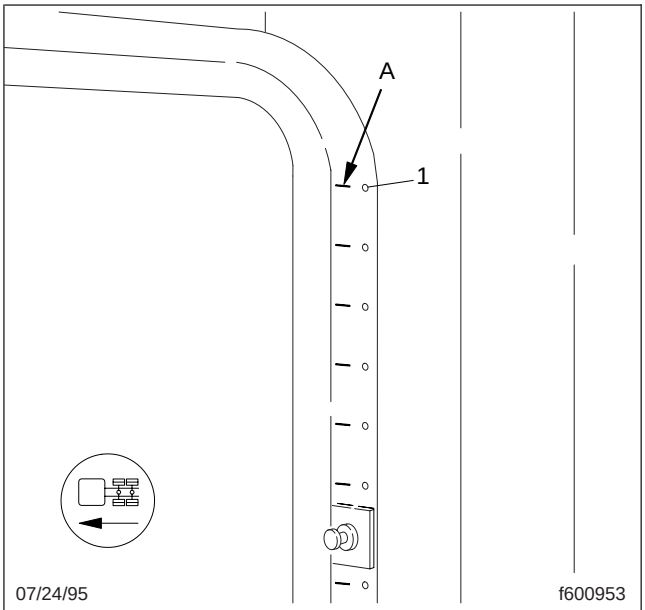
25. Remove the sidewall assembly from the cab.

Installation

1. With the door plug in place, make sure the cab is square and level. See **Subject 110** for instructions.
2. Using a putty knife, then fine sandpaper or a grinding disk, remove any adhesive residue from the surface of the door frame. Sand down to bare metal.
3. Clean the surface of the metal with a cloth.
4. Clean the exposed, bottom edge of the roof cap assembly.

Sidewall Assembly Replacement

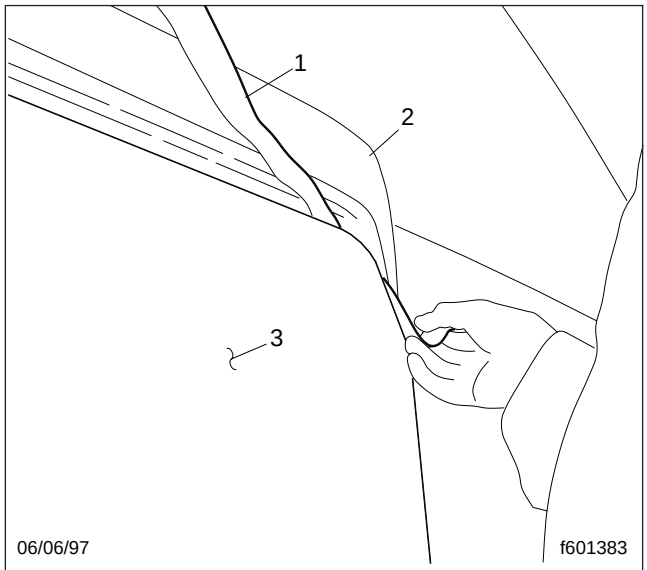
5. On the inboard edge of the rear door frame, mark the location of the existing holes that were used to attach the forward edge of the sidewall skin to the door frame. Make sure the marks are far enough inboard so they won't be covered up by the forward edge of the new sidewall skin. See **Fig. 7**.



A. Put marks here.
1. Existing B-Pillar Hole

Fig. 7, Marking the Existing Holes in the B-Pillar

6. Install new foam seal tape along the rear edge of the sidewall skin (where it joins the edge of the rear wall skin).
7. Apply foam seal tape along the entire upper edge of the sidewall assembly, where it will be attached to the roof cap assembly. See **Fig. 8**.
8. Using a knife, remove the portions of foam seal tape from the areas of the upper edge of the sidewall assembly where the Torx-head screws will be installed.
9. Clean with Scotchbrite® the forward edge of the new sideskin that joins the door frame.
10. Position the new sidewall assembly in place, making sure the holes in the bottom of the Z-strips line up with those in the deck sill, and the holes at the top hem line up with those in the clinch nuts in the roof cap hem. Also, make sure the forward edge of the sidewall skin is flush against the door frame.



1. Foam Seal Tape
2. Roof Cap
3. Sidewall Skin

Fig. 8, Applying Foam Seal Tape

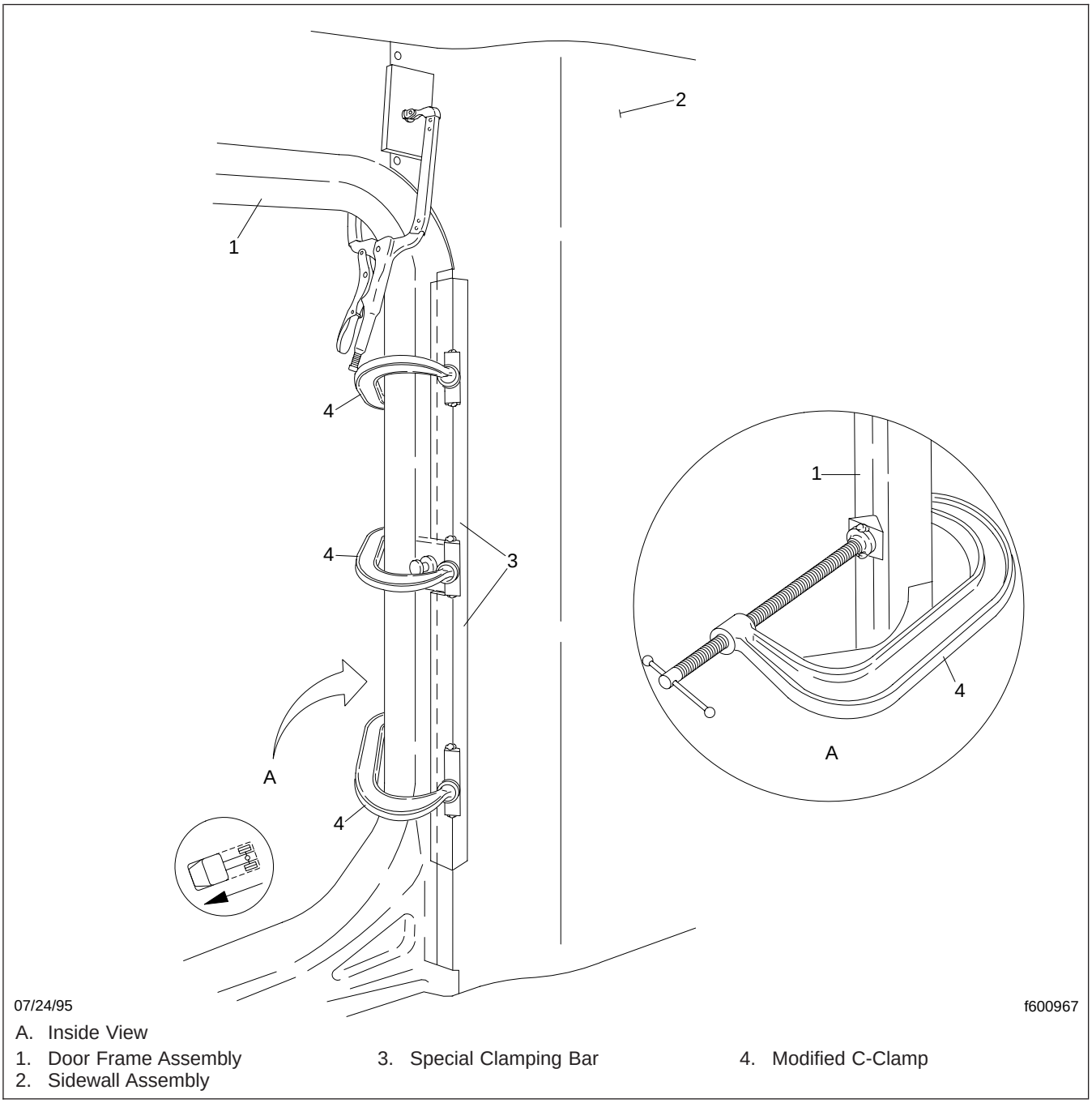
11. Attach enough fasteners to keep the sidewall assembly in position during the installation procedure.
12. Apply a 1/8 inch (3 mm) bead of Magnolia 112–448 A & B two-part adhesive to the surface of the door frame between the frame surface and the sidewall skin. Apply the adhesive from the top of the door to the bottom. Follow the manufacturer's directions and safety information when using the adhesive.
13. Make sure the sidewall assembly is in position, then clamp the forward edge of the sidewall skin to the door frame, using the special clamping bar and modified C-clamps. See **Fig. 9**.
14. Allow the adhesive to cure for at least 40 minutes. Complete curing takes 24 hours. Remove any excess adhesive that is squeezed out.
15. Using 5/16–18 Torx-head screws, attach the front edge of the sidewall assembly to the forward edge of the roof cap. Don't tighten the screws all the way.

16. Attach the upper B-pillar bracket to the upper B-pillar reinforcement assembly.
17. Attach the sidewall transition bracket to the door frame.
18. Attach the sidewall to the upper B-pillar and lower B-pillar reinforcement assembly.
19. Using the marks on the door frame as a guide for locating existing holes, use a #11 drill bit and drill 12 new holes through the new sidewall skin and the door frame.
20. Using a 5/16-inch counterbore, countersink from the top the nine holes and install countersunk bucked rivets that have a 5/16-inch head and a 3/16-inch shank into these nine holes. Then, install 3/16-inch monobolts in the bottom three holes.
21. Drill out along the bottom edge of the sidewall assembly the holes for fastening the sidewall skin to the cab deck. From underneath the cab, use the existing holes as a guide for drilling through the sidewall skin.
22. Remove the burrs from the drilled holes in the exterior sidewall skin.

IMPORTANT: Perform the next steps in the procedure as listed so that the sidewall skin is fastened forward-to-aft. This allows the metal to more or less remain tight against the cab structure from the door frame to where the skin joins to the rear wall. Otherwise, gaps may appear between the fasteners.

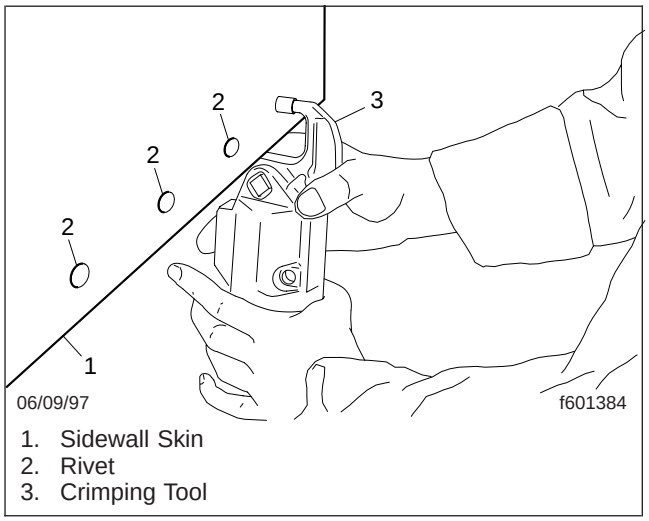
23. Using an air-powered crimping tool (see **Fig. 10**) or a buck-riveter, install 3/16 inch aluminum brazier-head bucked rivets along the bottom edge of the sidewall assembly.
24. Install the remaining 5/16–18 Torx-head screws in the upper sidewall and rear roof cap. Tighten 15 lbf·ft (20 N·m). See **Fig. 11**.
25. Using 3/16-inch aluminum brazier-head Huck® bolts (p/n lockbolt, 23–12209–000; collar, 23–11037–603), and adding a special patch of sealant on the underside of each bolt head, attach the sidewall skin to the rear wall skin. Install the bolts with the heads outside. Be sure the side extender tapping plate, if the vehicle is so equipped, is installed with this row of fasteners.
26. Install the side extender brackets and side extender.
27. Install the drip rail. Then, install the sun visor and its rear mounting bracket.
28. Prime and paint the new sidewall assembly.
29. Remove the protective coverings from the interior of the cab.
30. Remove the door plug and install the door. See **Group 72** for instructions.
31. Route the wiring harness as needed. If so equipped, install the auxiliary HVAC unit. Install the seats, the bunk(s), the upholstery panels, the cabinets, the floor mats, and the carpeting in the cab. See the applicable groups and sections for instructions.
32. Remove the jack stands from the chassis.
33. Remove the chocks from the tires.

Sidewall Assembly Replacement



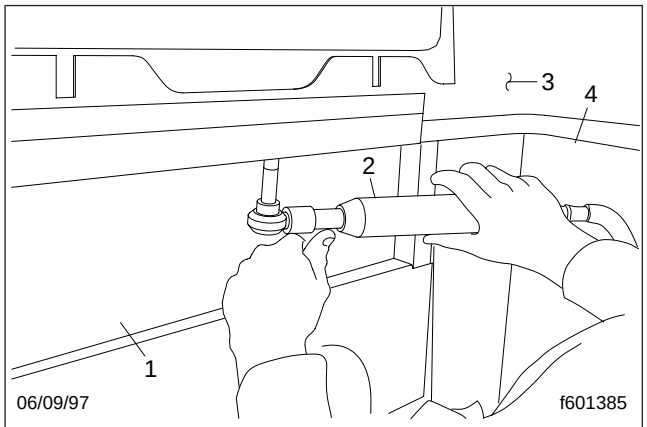
A. Inside View
1. Door Frame Assembly
2. Sidewall Assembly
3. Special Clamping Bar
4. Modified C-Clamp

Fig. 9, Special Clamp for Door Frame



1. Sidewall Skin
2. Rivet
3. Crimping Tool

Fig. 10, Installing Rivets Along the Bottom Edge (with a crimping tool)

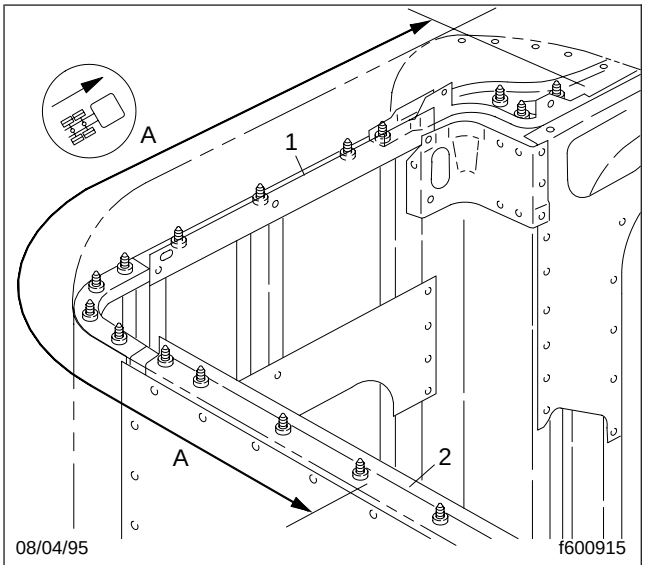


1. Sidewall Skin
2. Air-Powered Rachet
3. Roof Cap
4. Rear Wall

Fig. 11, Install the Roof Cap Screws

Removal

1. Park the vehicle, apply the parking brakes, then chock the tires.
2. If not already done, remove the seats, the bunk(s), the upholstery panels, the cabinets, the floor mats, and the carpeting from the cab. Put the electrical harness to one side. See the applicable sections is this group for instructions.
3. From inside the cab, remove the Torx®-head screws holding the roof cap assembly to the upper edge of the back wall and the left and right side walls. See **Fig. 1.**
4. Remove the fasteners that attach the back-wall hat sections to the cab deck. See **Fig. 2.**



A. Remove these Torx-head screws.
1. Side-Wall Assembly
2. Back-Wall Assembly

Fig. 1, Rear Roof Cap Fasteners

5. Remove the fasteners that hold the bottom of the back wall to the deck sill.
   - 5.1 Remove the two rows of fasteners that attach the reinforcement plate and the bottom of the back wall to the deck sill and the cab suspension mounting bracket. See **Fig. 3.**
   - 5.2 Remove the fasteners that attach the outboard edges of the back-wall bottom to the deck sill and the rear outboard edge of the side wall skin.
   - 5.3 Pry up the skin to loosen the sealant tape adhesive bond.
6. Support the back-wall assembly.
7. Lift up the rear roof cap assembly, and support it.
8. Using a putty knife, remove the foam sealant tape between the underside of the roof cap assembly and the chair section at the top of the back wall.
9. On each outboard side, pull the upper part of the back wall out of the corner bracket. See **Fig. 4.** (These are slip-joints.)
10. Remove the back-wall assembly from the cab.

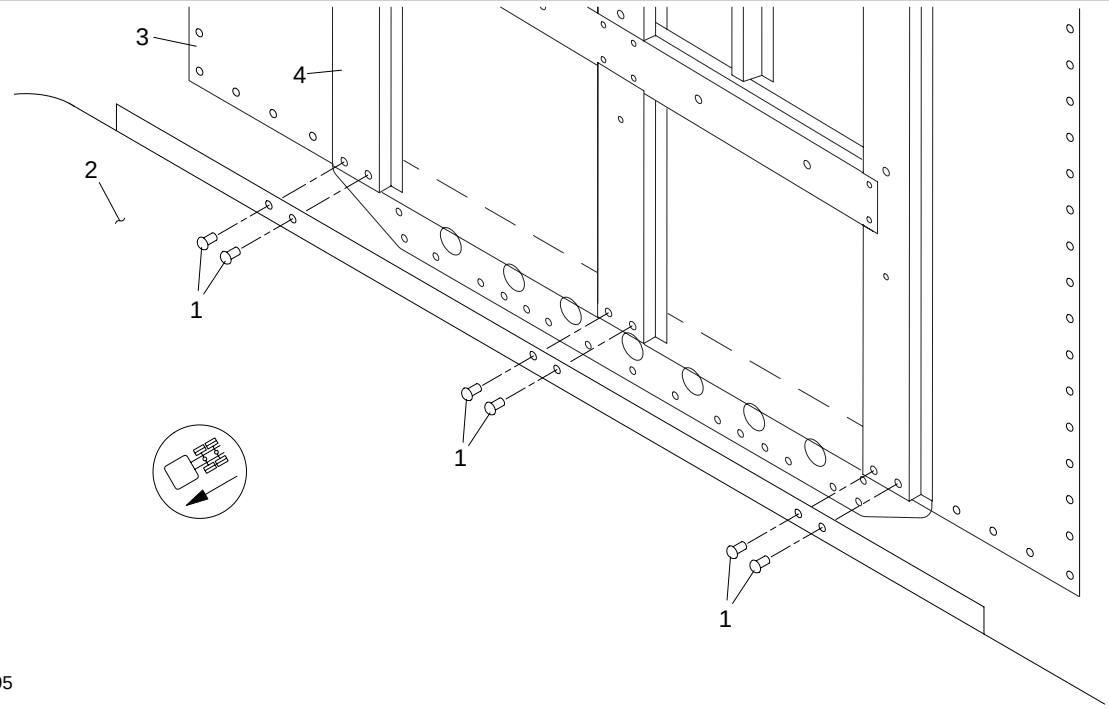
Installation

CAUTION

CAUTION: Check the vehicle chassis for correct alignment before making repairs to the cab. Failure to repair and align the chassis before repairing the cab could prevent you from correctly squaring the cab, and cause undue stress on the cab structure.

1. Level the chassis, using jackstands.
2. Remove any traces of adhesive or foam sealant tape from the bottom surfaces of the rear roof cap assembly and the side wall Z-strips.
3. Make sure the cab is square and level. See **Subject 110** for instructions.
4. Install new foam sealant tape on the bottom surface of the rear roof cap hem and the outer surface of the rearmost side wall Z-strips.
5. Place the new back-wall assembly against the rear of the cab with the upper part tilted in under the roof cap hem..
6. On each side, put the upper framework into the corner bracket slip joint.
7. Line up the back-wall assembly, top and bottom, and left and right.
8. Clamp the back-wall assembly in place.
9. From inside the cab, and using a #11 drill bit, backdrill through the existing holes in the rearmost side-wall Z-strip, side-wall skin, and the

Back-Wall Assembly Removal and Installation

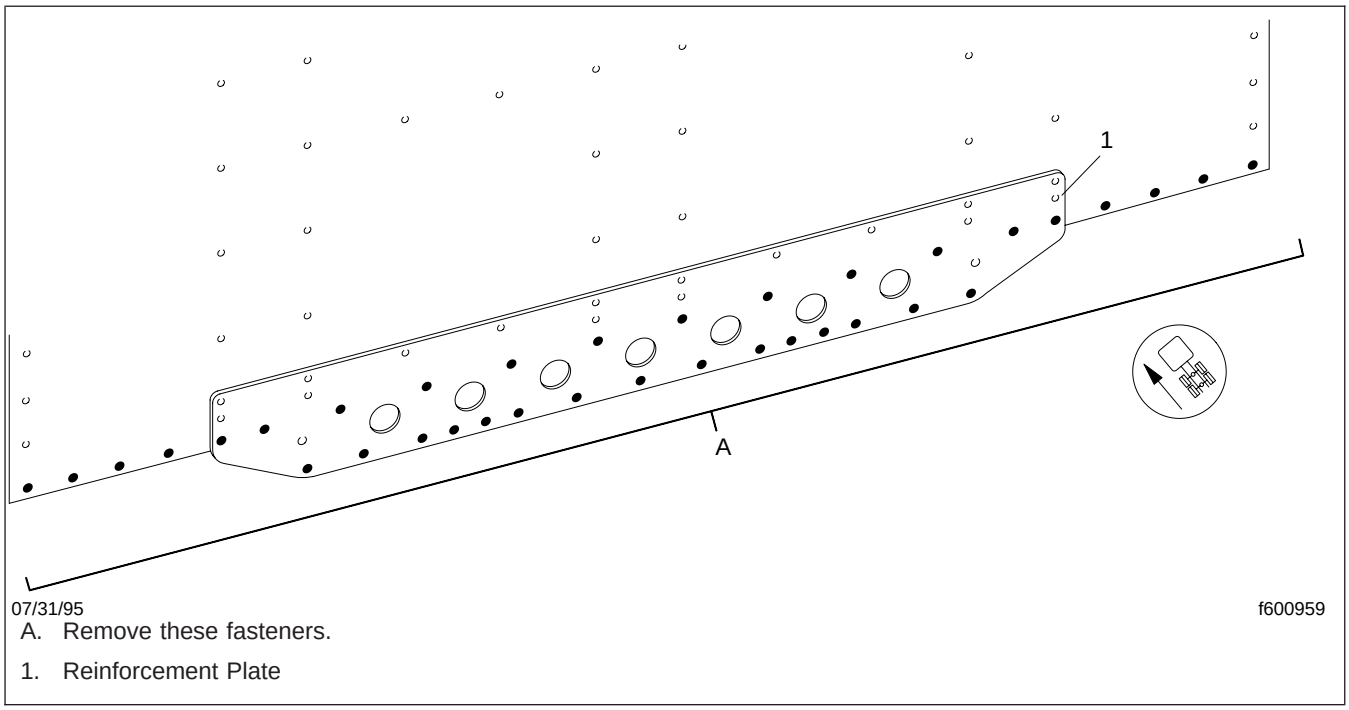


1. Torx-Head Screws
2. Cab Deck Assembly
3. Back-Wall Assembly
4. Hat Section

Fig. 2, Inside Back-Wall-to Cab Deck Fasteners

new back-wall skin. Do this on both sides of the back wall.

10. Install the special 3/16-inch diameter aluminum Huckbolts (with the sealant patch on the underside of the heads) through the side wall Z-strips, the side wall skin, and the new back-wall skin. Install the Huckbolts with the heads on the outside of the cab.
11. Install 3/16-inch diameter aluminum bucked rivets with countersunk heads along the outer edges of the bottom of the back wall and the deck sill.
12. Attach the back-wall reinforcement plate to the deck sill and the cab suspension mounting bracket, using #13 Magnabulb® rivets.
13. Install Monobolt® rivets in the upper corners of the back wall.
14. Prime and paint the new back-wall assembly.
15. Install the cab upholstery panels, bunk(s), cabinets, carpeting, floor mats, and seats. For instructions, refer to the applicable sections in this group of the service manual.
16. Remove the jackstands from the chassis
17. Remove the chocks from the tires.

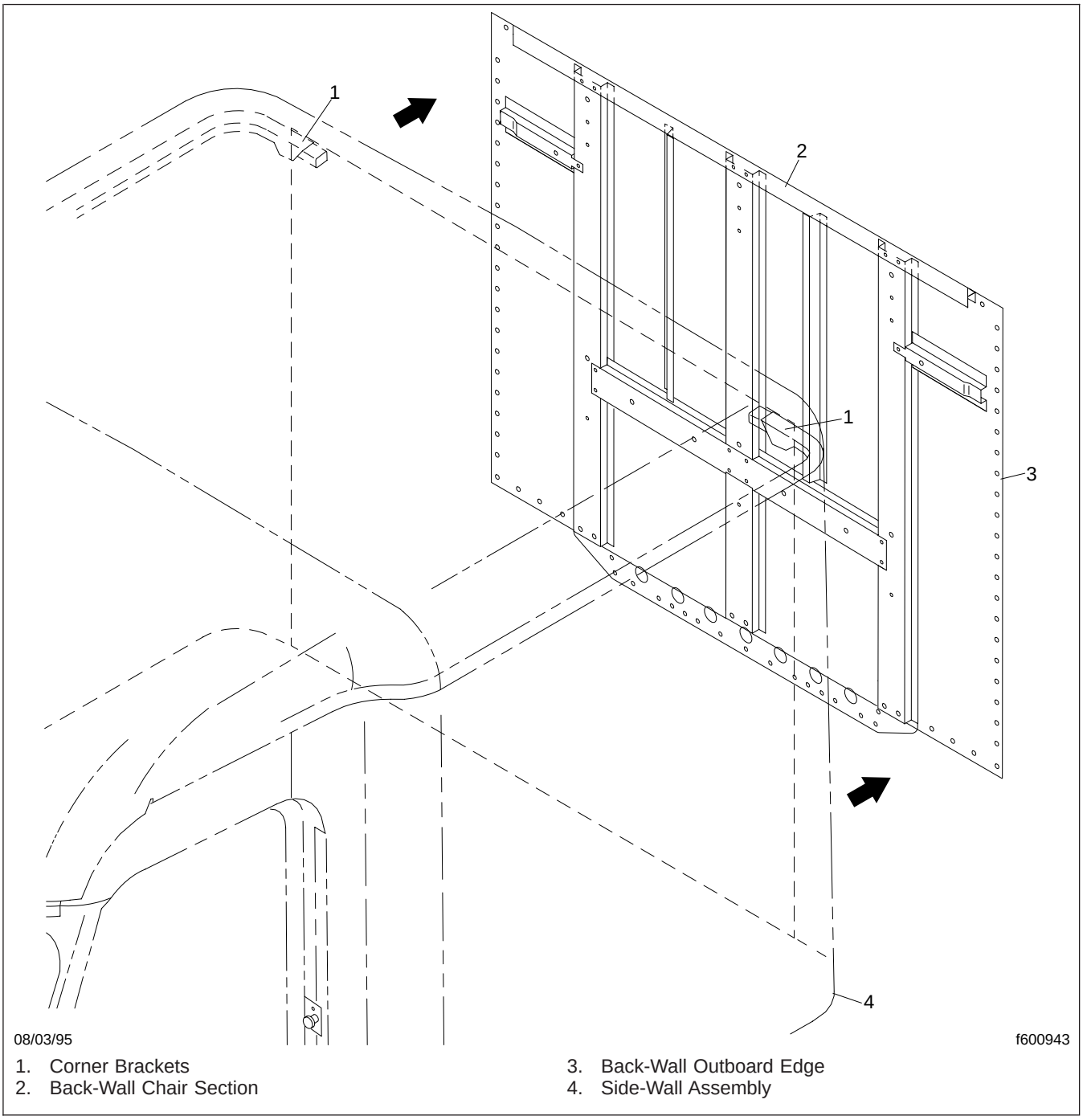


A. Remove these fasteners.

1. Reinforcement Plate

Fig. 3, Outside Back-Wall Fasteners

Back-Wall Assembly Removal and Installation



1. Corner Brackets
2. Back-Wall Chair Section
3. Back-Wall Outboard Edge
4. Side-Wall Assembly

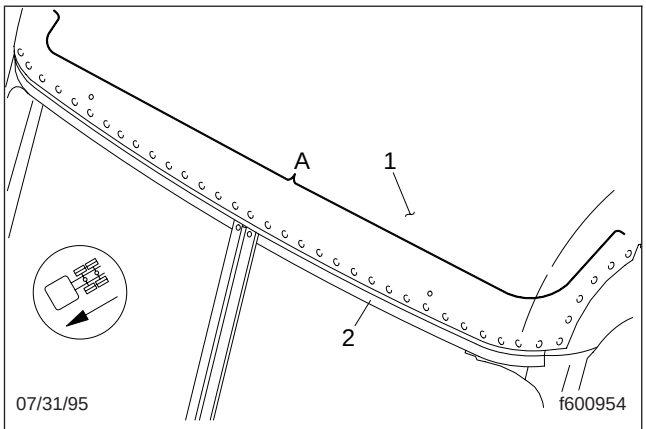
Fig. 4, Back Wall Assembly Removed from the Cab Deck and Side Walls

Front Roof-Cap Assembly Removal and Installation

Removal

NOTE: Use both this subject and **Subject 150** to replace the roof cap on a non-SleeperCab®.

1. Park the vehicle on a level surface. Apply the parking brakes; then chock the tires.
2. Remove the exterior sun visor and its mounting brackets from the front of the roof cap and the top of the door frame.
   - 2.1 Mark, then disconnect the wiring from the marker lights.
   - 2.2 Remove the fasteners that attach the sun visor brackets to the roof cap; then remove the exterior sunvisor and its mounting brackets.
   - 2.3 If the exterior sun visor is undamaged, set it aside.
3. If not already done, remove the seats, the upholstery panels, cabinets, carpeting, the floor mats, and the wiring harness from the cab. See the applicable sections is this group for instructions.
4. From inside the cab, grind down the extruded bulb on the back side of each Henrob rivet holding the windshield header to the front edge of the roof cap.
5. From outside the cab, and using a 7/32-inch cobalt drill on low speed, drill out and remove the Henrob rivets that attach the front edge of the roof cap to the windshield header. See **Fig. 1.** See **Subject 100** for information on removing Henrob rivets
6. Remove the fasteners from the front corners of the roof cap.
7. Remove the Huckbolts® that attach the front and rear roof caps to the curtain bow roof support. See **Fig. 2.**
8. From inside the cab, loosen the Torx®-head screws that hold the front roof cap assembly to the top of the door frames.
9. Remove the Magnabulb® rivets that attach the three forward brackets on the longitudinal roof bows to the edge of the front storage console. See **Fig. 3.**
10. Pry up the front roof cap assembly; then remove it from the cab.



A. Remove these fasteners.
1. Front Roof-Cap Assembly
2. Windshield Header

Fig. 1, Front Roof Cap Assembly Fasteners

11. If the front storage console is damaged, remove it. See **Fig. 4.**
    - 11.1 Remove the bolts from the L-brackets that attach the sides of the front storage console to the door frames.
    - 11.2 Remove the fasteners that attach the forward edge of the front storage console to the windshield header.
    - 11.3 Remove the front storage console.
12. If the windshield header is damaged, remove it. See **Subject 170** for instructions.

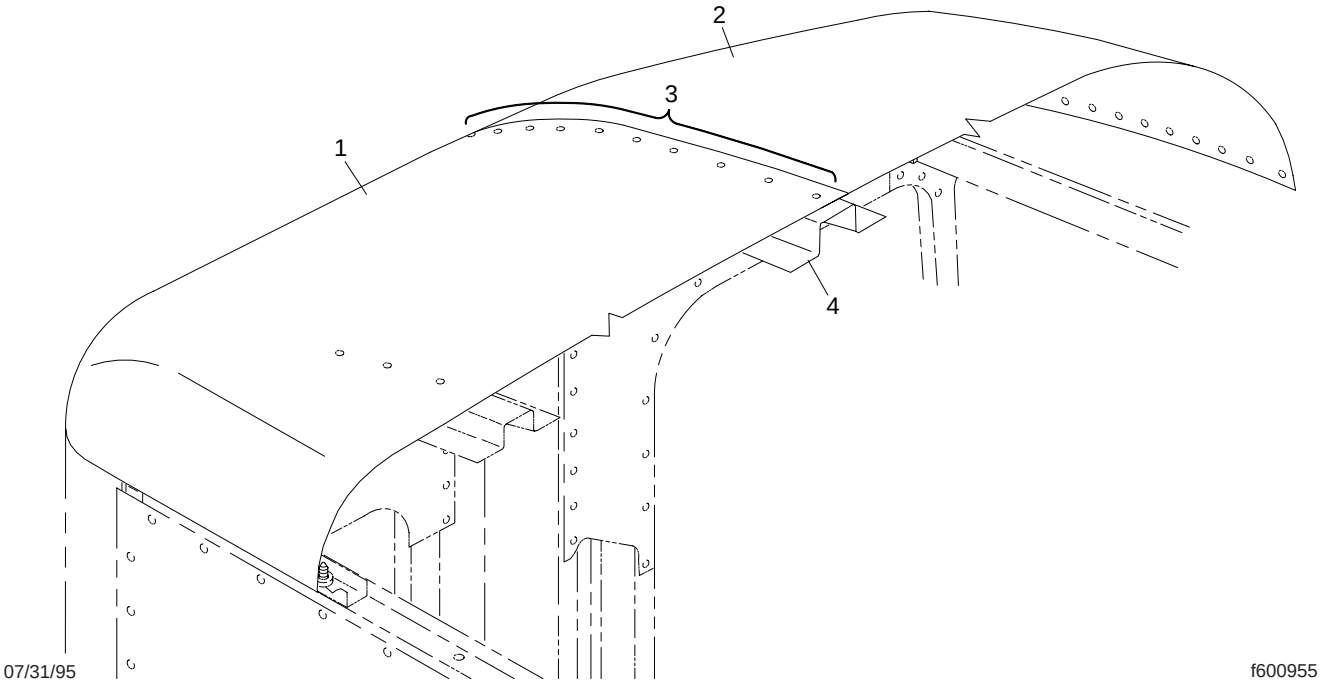
Installation

CAUTION

CAUTION: Check the vehicle chassis for correct alignment before making repairs to the cab. Failure to repair and align the chassis before repairing the cab could prevent you from correctly squaring the cab, and cause undue stress on the cab structure.

1. Level the chassis, using jackstands.
2. Make sure the cab is level and square. See **Subject 110** for instructions.
3. If the front storage console is being replaced, install a new one. See **Fig. 4.**

Front Roof-Cap Assembly Removal and Installation



1. Rear Roof Cap
2. Front Roof Cap
3. Huckbolts
4. Curtain Bow Roof Support

Fig. 2, Rear View, 48-Inch SleeperCab

3.1 Install the fasteners that attach the front storage console to the windshield header.

3.2 Attach the existing L-brackets to the new front storage console.

3.3 Attach the L-brackets to the door frames. Tighten the Torx-head screws 15 lbf·ft (20 N·m).

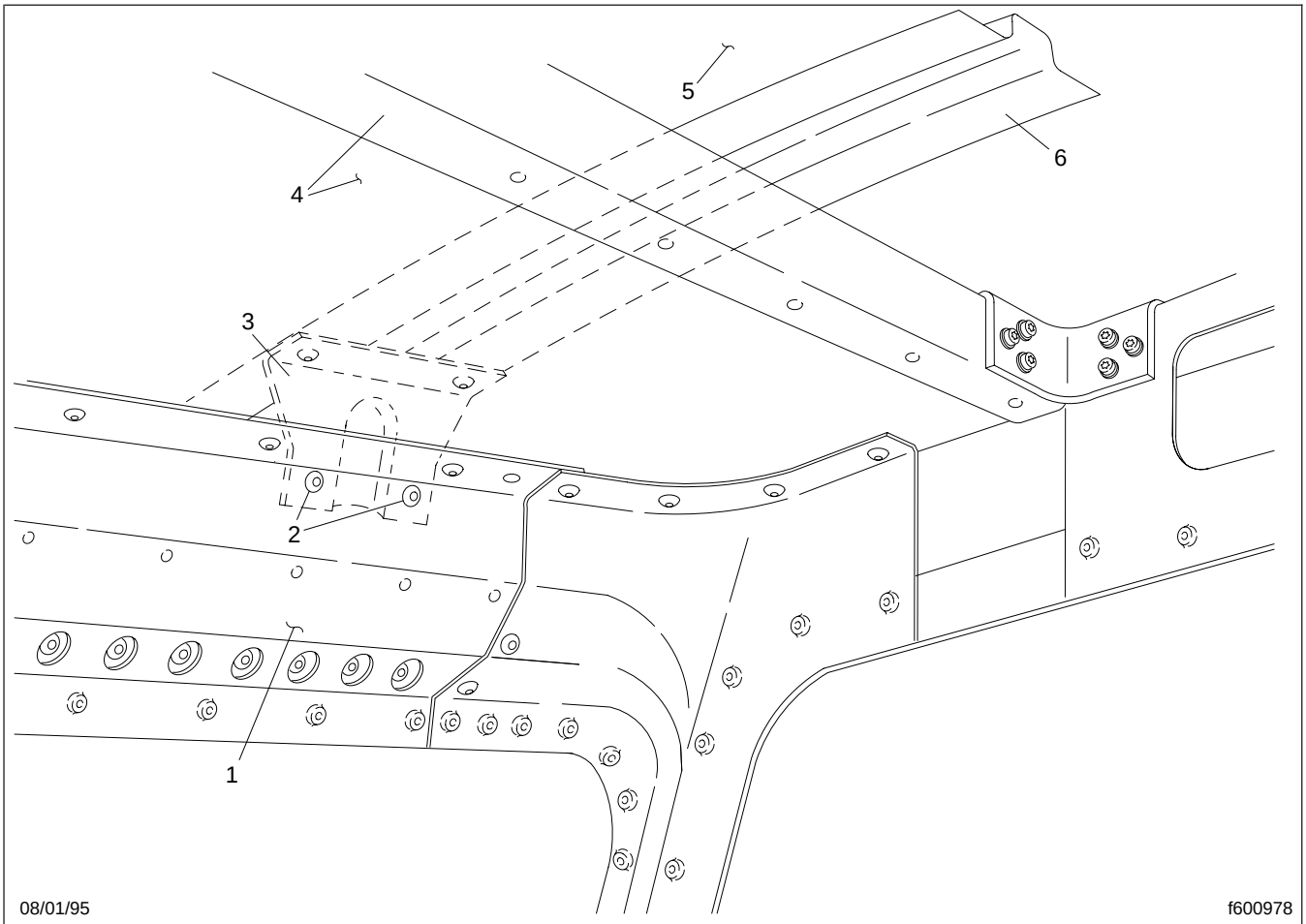
4. Clean the top surface of the door frames. Make sure all traces of foam tape and adhesive are removed.
5. Apply new foam sealant tape to the top of the door frames.
6. Apply Uniseal® 116.15 sealant along the top edge of the windshield header, where the edge of the roof cap was.
7. Put the new forward roof cap assembly in place, making sure it is centered and fits flush against the windshield header. Clamp it in place.
8. Attach the forward edge of the roof cap to the windshield header, using 3/16-inch countersunk aluminum Huck bolts or countersunk bucked rivets.

   8.1 Using the existing holes in the windshield header, backdrill through the roof-cap skin.

   8.2 Counterbore the holes, using a 5/16-inch counterbore.

   8.3 Install 3/16-inch aluminum bucked rivets with countersunk heads, or countersunk aluminum Huck fasteners. Install the fasteners in an alternating sequence. See **Fig. 5.**
9. Line up the sides of the roof cap with the door frame
10. Make sure the holes in the roof-cap align with those of the clinch nuts in the door frames and forward part of the side walls.
11. Install the Torx-head screws. Tighten them 15 lbf·ft (20 N·m.)

Front Roof-Cap Assembly Removal and Installation

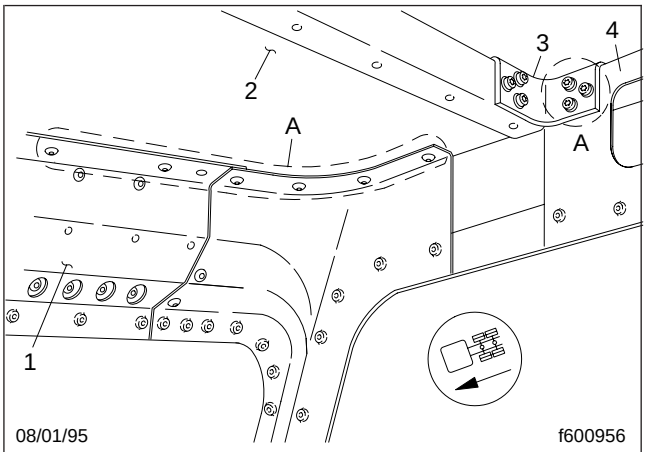


1. Windshield Header
2. Magnabulb Rivets
3. Forward Bracket (3 qty.)
4. Front Storage Console
5. Front Roof Cap
6. Longitudinal Roof Bow (3 qty.)

Fig. 3, Right Side, Interior View

12. Using 3/16-inch diameter Monobolts® rivets, attach the three forward roof-bow brackets to the windshield header.
13. Using 3/16-diameter special seal Huck bolts, attach the front roof-cap skin to the rear roof-cap skin and the curtain bow roof support.
    - 13.1 Clamp the front roof-cap skin in place, underneath the rear roof-cap skin.
    - 13.2 Using a #11 drill bit, and the existing holes in the rear roof-cap skin, drill through the new front roof-cap skin.
    - 13.3 Install 3/16-inch diameter Huck bolts, with the heads facing out.
14. Prime and paint the new roof cap assembly .
15. Install the cab upholstery panels, cabinets, seats, floor mats, carpeting, and the wiring harness. See the applicable groups and sections in this manual for instructions.
16. Remove the jackstands from the chassis.
17. Remove the chocks from the tires.

Front Roof-Cap Assembly Removal and Installation



A. Remove these fasteners.

1. Windshield Header
2. Front Storage Console
3. L-Bracket
4. Door Frame

Fig. 4, Front Console Fasteners

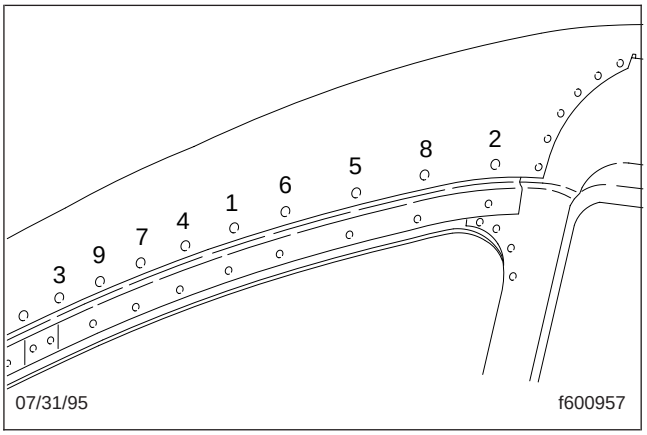


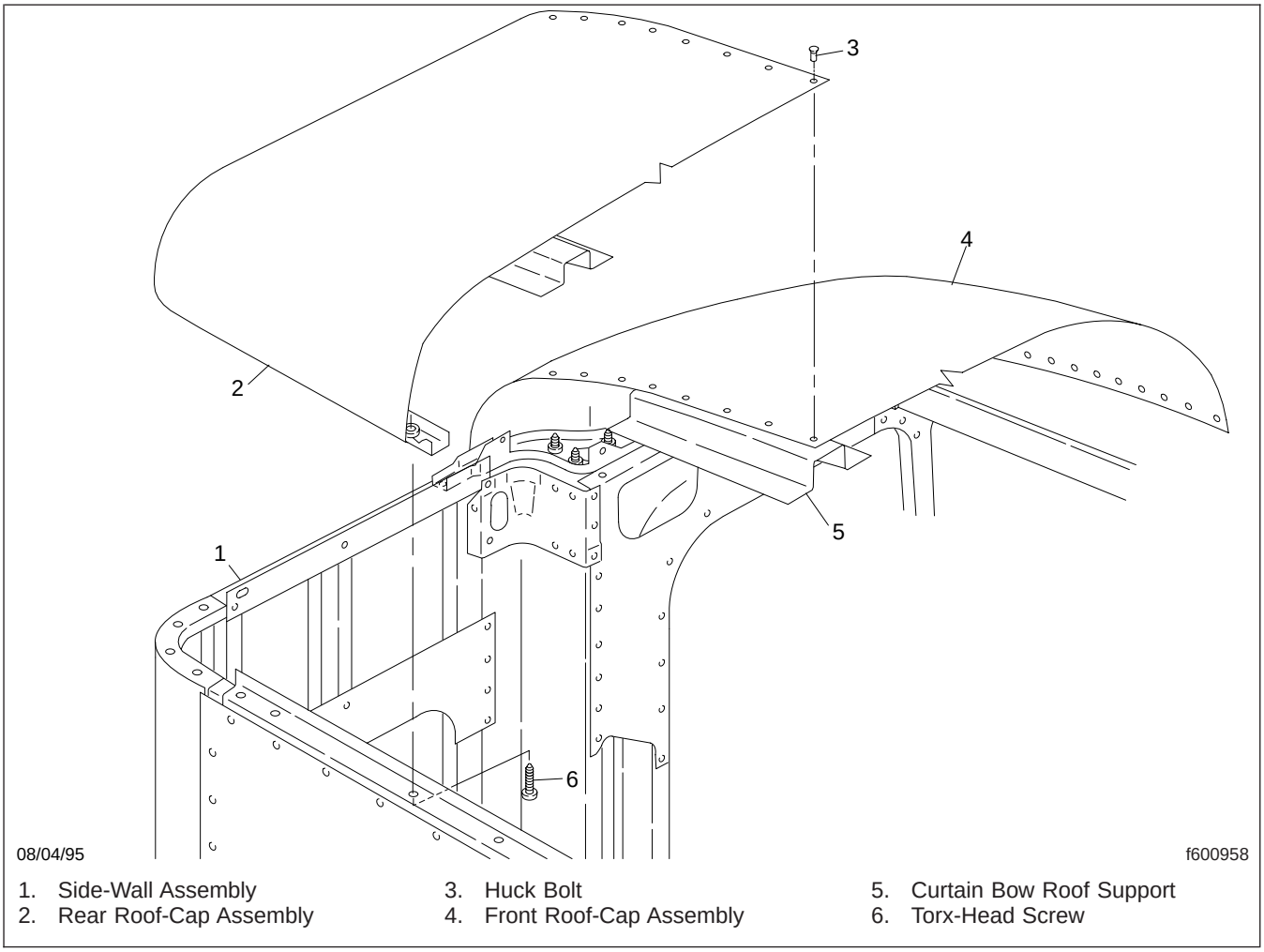
Fig. 5, Installation Sequence for Front Roof Cap Fasteners (left side)

Rear Roof-Cap Assembly Removal and Installation

Removal

NOTE: Use both this subject and **Subject 140** to replace the roof cap on a non-SleeperCab®.

1. Park the vehicle on a level surface. Apply the parking brakes; then chock the tires.
2. If not already done, remove the seats, the bunk(s), all the upholstery panels, the floor mats, the carpeting, and the wiring harness from the cab. See the applicable groups and sections in this manual for instructions.
3. Remove the 5/16–18 Torx®-head screws that attach the roof cap assembly to the back wall and the side walls. See **Fig. 1.**
4. For a SleeperCab, remove the Huck® bolts that attach the forward edge of the rear roof cap to the curtain bow roof support and the front roof cap assembly.
5. Pry up the roof cap section from the back wall and the side walls to release the foam sealant tape.
6. Remove the rear roof cap assembly.



1. Side-Wall Assembly
2. Rear Roof-Cap Assembly
3. Huck Bolt
4. Front Roof-Cap Assembly
5. Curtain Bow Roof Support
6. Torx-Head Screw

Fig. 1, 48-Inch SleeperCab Shown

Rear Roof-Cap Assembly Removal and Installation

Installation

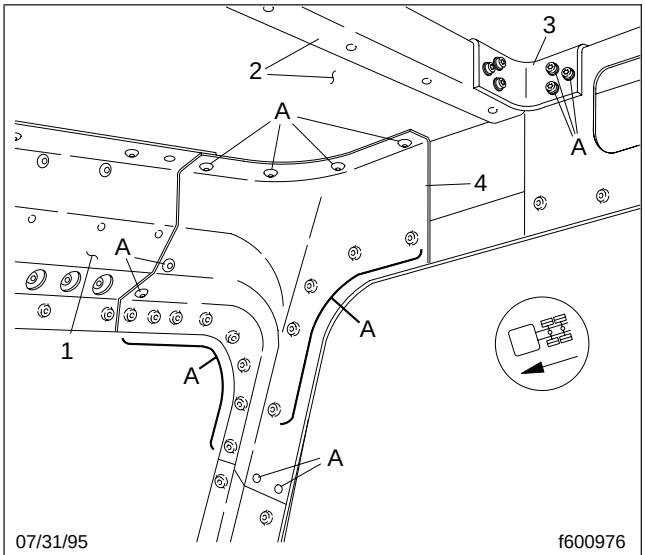
CAUTION

CAUTION: Check the vehicle chassis for correct alignment before making repairs to the cab. Failure to repair and align the chassis before repairing the cab could prevent you from correctly squaring the cab, and cause undue stress on the cab structure.

1. Level the chassis, using jackstands.
2. Make sure the cab is level and square. See **Subject 110** for instructions.
3. Clean the top edge of the side walls and the back wall. Remove all adhesive and foam sealant tape.
4. Install new foam sealant tape all the way around the top of the side walls.
5. Put the new rear roof cap assembly in place, making sure the holes in the hem line up with those in the clinch nuts in the back wall and side walls.
6. Install the 5/16–18 Torx-head screws holding the roof cap assembly to the side walls and back wall.
   - 6.1 Install the two front screws on both sides loosely.
   - 6.2 Push the edges of the roof cap in or out to line up the holes in the roof cap and the side walls; then install the screws, working your way back toward the back wall.
   - 6.3 Install the screws that attach the roof-cap assembly to the back wall.
   - 6.4 Tighten all the Torx-head screws 15 lbf·ft (20 N·m).
7. Using 3/16-diameter special seal Huck bolts, attach the front roof-cap skin to the rear roof-cap skin and the curtain bow roof support.
   - 7.1 Clamp the front roof-cap skin in place, underneath the rear roof-cap skin.
   - 7.2 Using a #11 drill bit, and the existing holes in the rear roof-cap skin, drill through the new front roof-cap skin.
   - 7.3 Install 3/16-inch diameter Huckbolts, with the heads facing out.
8. Prime and paint the new back wall.
9. Install the seats, upholstery panels, bunk(s), cabinets, floor mats, and carpeting. See the applicable groups and sections in this manual for instructions.
10. Remove the jackstands from the chassis.
11. Remove the chocks from the tires.

Door-Frame Assembly Removal and Installation

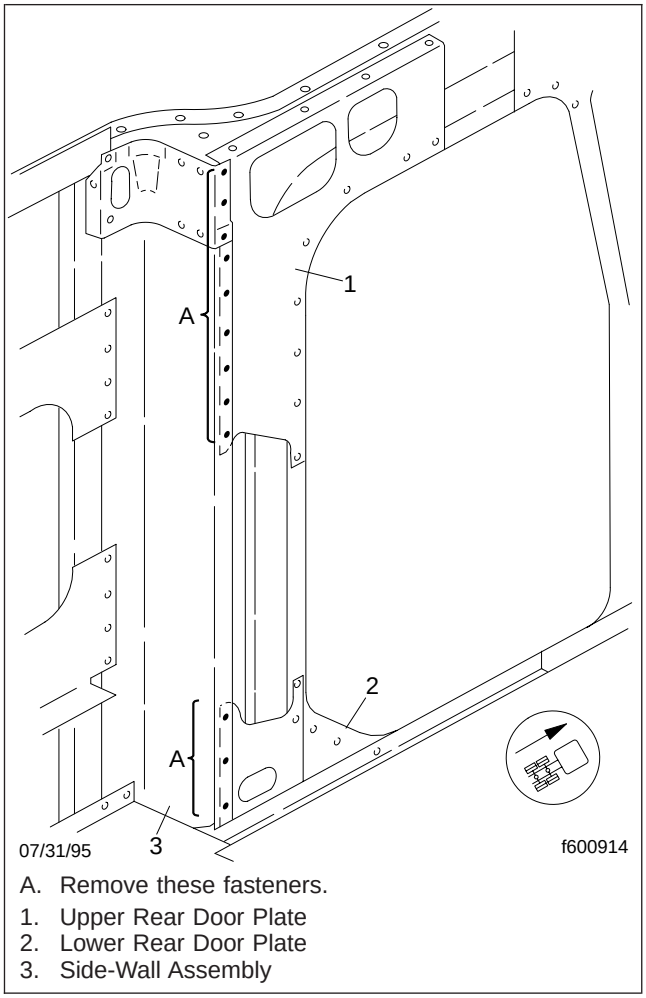
1. Park the vehicle on a level surface. Apply the parking brakes; then chock the tires.
2. If not already done, remove the seats, the side upholstery panels, the dash panels, cabinets, carpeting, and the floor mats from the cab. See the applicable sections in this group for instructions.
3. Remove the door. See the applicable section in **Group 72** for instructions.
4. If not already done, remove the windshield. See the windshield section in this group for instructions.
5. From inside the cab, remove the fasteners holding the door header plate to the door frame and the windshield header; then remove the door header. See **Fig. 1**.



A. Remove these fasteners.
1. Windshield Header
2. Front Storage Console
3. L-Bracket
4. Door Header

Fig. 1, Right Side, Inside View

6. Remove the bolts that attach the front console L-bracket to the top of the door-frame assembly. See **Fig. 1**.
7. Remove the fasteners that hold the upper and lower rear door plates to the side-wall assembly. See **Fig. 2**.

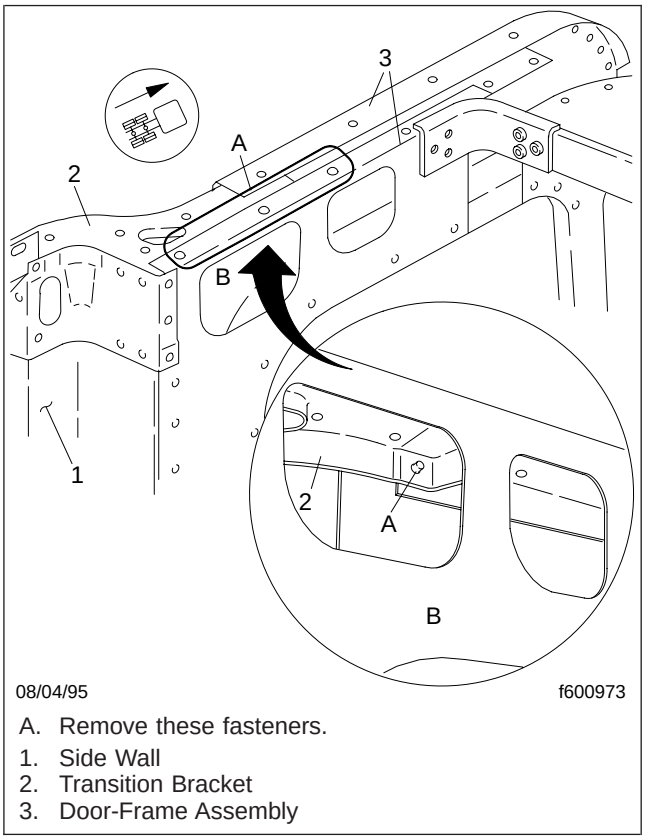


A. Remove these fasteners.
1. Upper Rear Door Plate
2. Lower Rear Door Plate
3. Side-Wall Assembly

Fig. 2, Door Plate Fasteners, Inside View

8. Remove the fasteners that hold the transition bracket to the door frame. See **Fig. 3**.
9. From outside the cab, remove the two rows of Henrob® rivets that hold the bottom of the door frame to the cab deck. See **Fig. 4**. See **Subject 100** for information on removing Henrob rivets.
10. Remove the fasteners that attach the front corner of the roof-cap skin and the windshield header to the top of the door frame assembly. See **Fig. 5**.

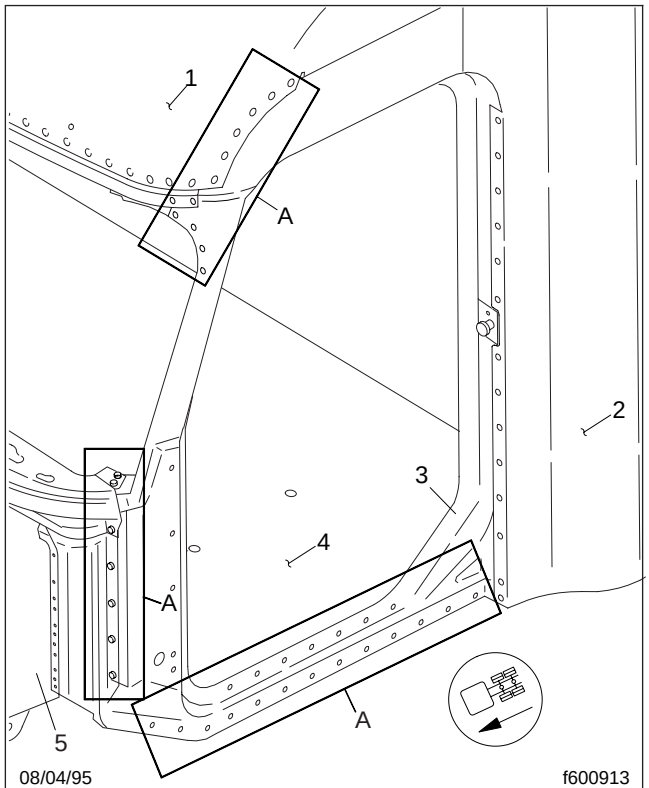
Door-Frame Assembly Removal and Installation



A. Remove these fasteners.
1. Side Wall
2. Transition Bracket
3. Door-Frame Assembly

Fig. 3, Transition Bracket Fasteners

11. Remove the bolts that hold the front of the door frame assembly to the front wall assembly. See **Fig. 3**.
12. Remove the Henrob rivets that attach the side-wall skin to the door frame. See **Fig. 6**.
13. Using a suitable heat source, such as a heat gun or a propane torch, heat the forward edge of the side-wall skin to release the glue bond at the door frame. The glue bond will soften at about 275°F (135°C). Pry up the edge to prevent the glue from rebonding.
14. Pull the rear end of the door frame out of the slip joint at the sidewall.
15. Remove the door frame from the vehicle.



A. Remove these fasteners.
1. Front Roof-Cap Assembly
2. Side-Wall Assembly
3. Door-Frame Assembly
4. Cab Deck
5. Front-Wall Assembly

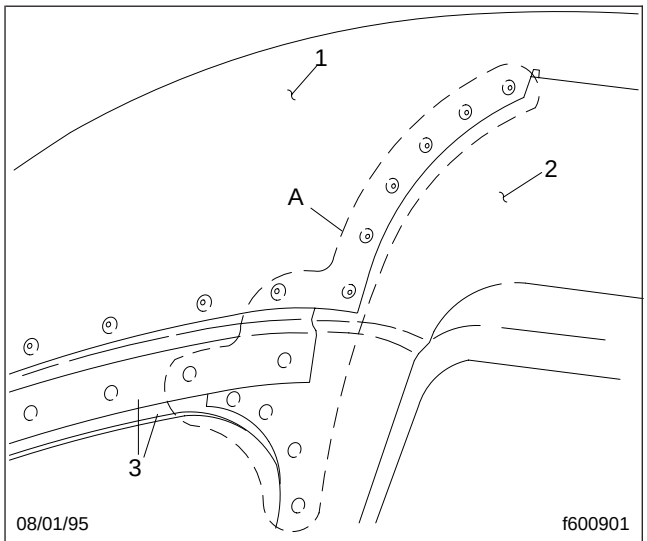
Fig. 4, Door Frame Fasteners

Installation

CAUTION

Check the vehicle chassis for correct alignment before making repairs to the cab. Failure to repair and align the chassis before repairing the cab could prevent you from correctly squaring the cab, and cause undue stress on the cab structure.

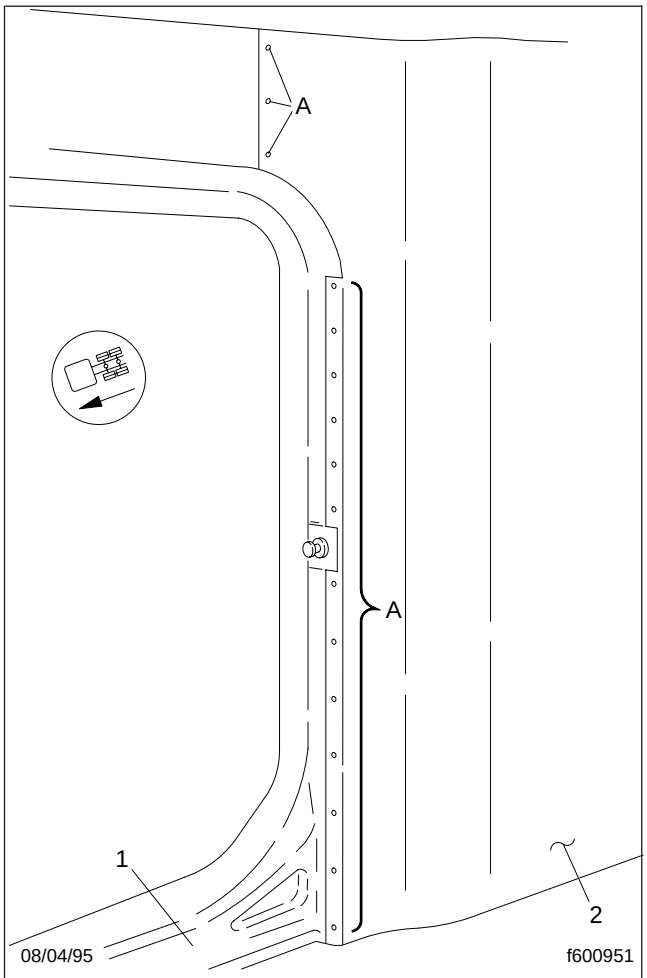
1. Level the chassis, using jack stands.
2. Make sure the cab is level and square. See **Subject 110** for instructions.



A. Remove these fasteners.
1. Roof Cap Assembly
2. Door Frame Assembly
3. Windshield Header Assembly

Fig. 5, Fasteners Attaching Door Frame to Windshield Header and Roof Cap

3. Put the new door frame in place up against the front wall, with the top of the door frame inside of the windshield header.
4. Attach the new door frame assembly to the front wall, using the Torx-head bolts previously removed.
5. From inside the cab, attach the front console L-brackets to the door frame assembly, using the previously removed Torx-head bolts.
6. Attach the upper plate of the door frame to the side wall.
7. Attach the lower plate of the door frame to the lower part of the side wall.
8. Install the transition bracket into the upper part of the door frame.
9. Clamp the bottom of the door frame to the cab deck sill.
10. Using the existing holes in the cab sill, backdrill into the new door frame with a #11 drill bit. On the outside of the door frame, counterbore the holes with a 5/16-inch counterbore.

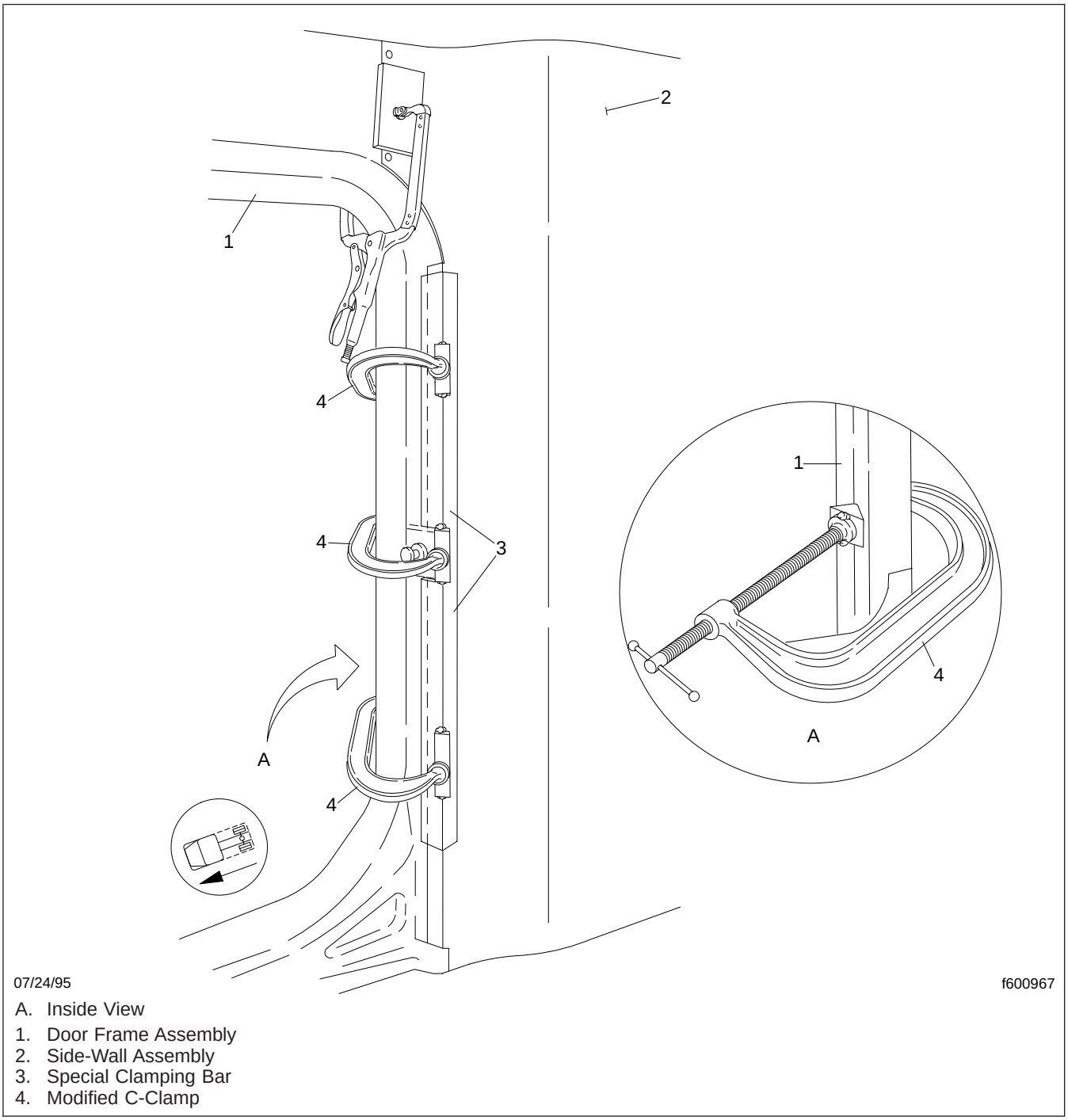


A. Remove these fasteners.
1. Left Door-Frame Assembly
2. Left Side-Wall Assembly

Fig. 6, Side-Wall to Door Frame Henrob® Rivets

11. Install 3/16-inch-diameter countersunk-head aluminum Huck bolts in the bottom row of holes.
12. Install 3/16-inch-diameter aluminum bucked rivets in the top row of holes.
13. Using a caulking gun, apply a 1/8-inch (3-mm) bead of Magnolia MPI 6155 A & B two-part adhesive to the surface of the door frame. Follow the manufacturer's directions and safety information when using the adhesive.
14. Clamp the forward edge of the side-wall skin to the door frame, using the special clamping bar and modified C-clamps. See **Fig. 7**.

Door-Frame Assembly Removal and Installation



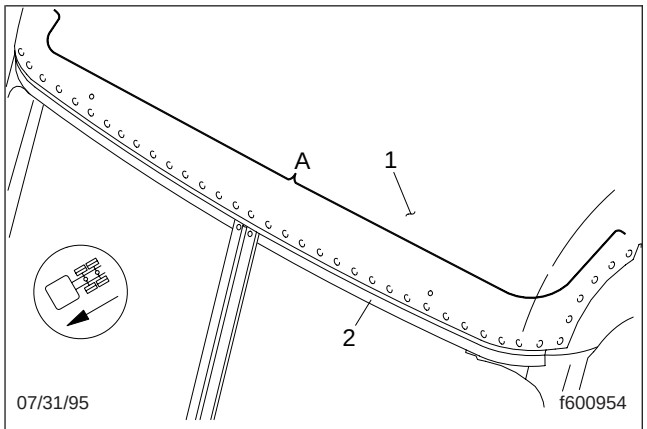
A. Inside View
1. Door Frame Assembly
2. Side-Wall Assembly
3. Special Clamping Bar
4. Modified C-Clamp

Fig. 7, Special Clamp for Door Frame

15. Remove any excess adhesive that is squeezed out. Let the adhesive cure for at least 40 minutes. Complete curing takes 24 hours.
16. Using a #11 drill bit, and the existing holes in the side-wall skin, drill holes through the new door frame.
17. Using a 5/16-inch counterbore, countersink each hole, then install countersunk aluminum bucked rivets that have a 5/16-inch head and a 3/16-inch shank. See **Specifications, 400** for the correct fastener part number.
18. Prime and paint the new door assembly.
19. Install the windshield. See the windshield section in this group for instructions.
20. Install the side upholstery panels, cabinets, dash panels, seats, floor mats, and carpeting. See the applicable groups and sections in this manual for instructions.
21. Remove the jack stands from the chassis.
22. Remove the chocks from the tires.

Removal

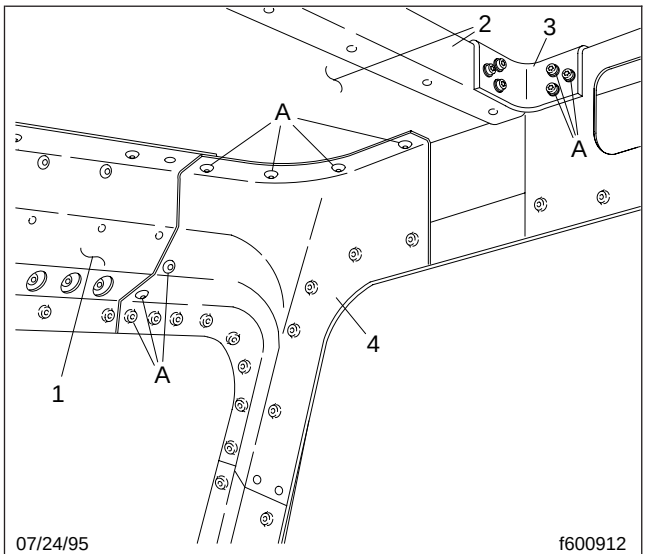
1. Park the vehicle on a level surface. Apply the parking brakes; then chock the tires.
2. If not already done, remove all the windshield glass. See the windshield section for instructions.
3. If not already done, remove the seats, the bunk(s), the upholstery panels, the dash panels, the floor mats, the carpeting, and the doors from the cab. See the applicable groups and sections is this manual for instructions.
4. If the front roof cap assembly is damaged, remove it. **See Subject 140** for instructions.
5. If the front roof cap assembly is not being removed, remove the Henrob® rivets that attach it to the windshield header assembly. **See Fig. 1.** See **Subject 100** for information on removal of Henrob rivets.



A. Remove these fasteners.
1. Front Roof Cap
2. Windshield Header

Fig. 1, Fasteners Holding Roof Cap to Windshield Header

6. From inside the cab, remove the fasteners that attach the right and left door headers to the windshield header. **See Fig. 2.**
7. Remove the bolts that hold the front storage console L-brackets to the door frame assemblies. **See Fig. 2.**
8. Remove the Magnabulb® rivets that hold the three roof-bow brackets to the windshield header. **See Fig. 3.**



A. Remove these fasteners.
1. Windshield Header
2. Front Storage Console
3. L-Bracket
4. Door Header

Fig. 2, Passenger-Side, Interior View

9. Remove the windshield center post, if present. **See Fig. 4.**
10. Remove the windshield header assembly and the front storage console assembly from the cab.
11. Remove the front storage console from the windshield header. Save it if it is undamaged.

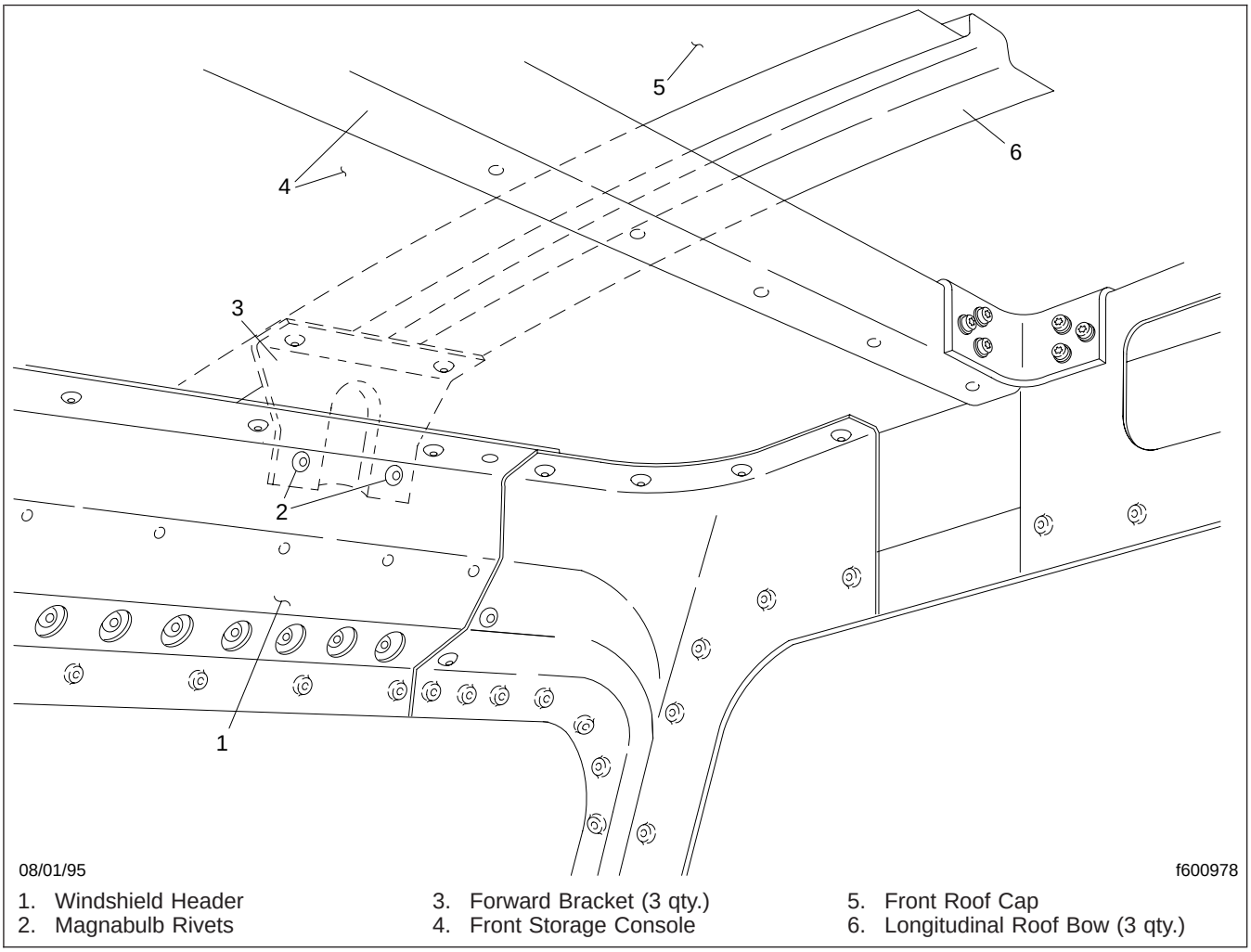
Installation

CAUTION

CAUTION: Check the vehicle chassis for correct alignment before making repairs to the cab. Failure to repair and align the chassis before repairing the cab could prevent you from correctly squaring the cab, and cause undue stress on the cab structure.

1. Level the chassis, using jackstands.
2. Make sure the cab is level and square. **See Subject 110** for instructions.
3. Attach the front storage console assembly to the new windshield header. Use 3/16-inch diameter

Windshield Header Removal and Installation

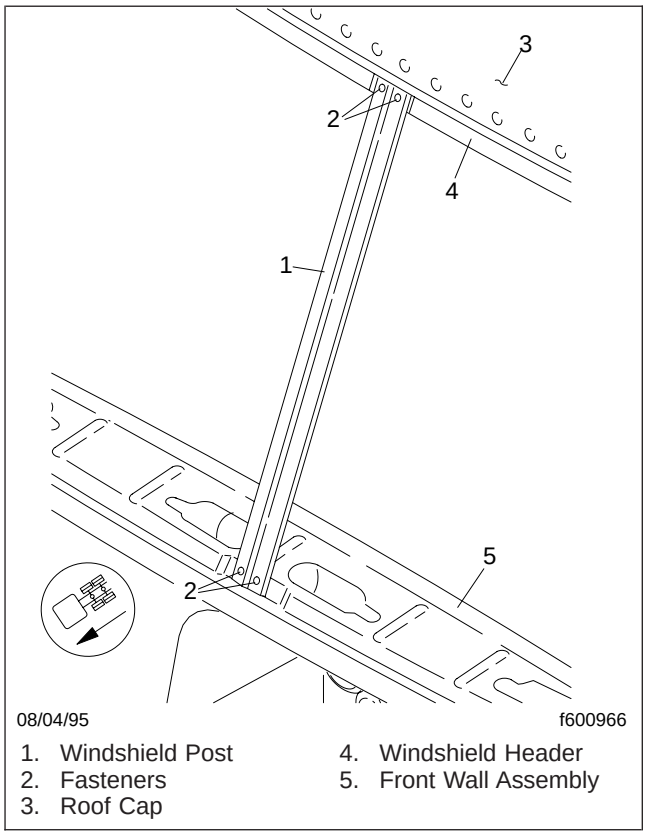


1. Windshield Header
2. Magnabulb Rivets
3. Forward Bracket (3 qty.)
4. Front Storage Console
5. Front Roof Cap
6. Longitudinal Roof Bow (3 qty.)

Fig. 3, Right Side, Interior View

Monobolt® blind rivets. If holes are not present, drill them, using a #11 drill bit. Install the Monobolts with the heads on the bottom surface of the windshield header.

4. Put the windshield header and the front storage console assembly in place.
5. Attach the windshield header to the door headers.
   - 5.1 Using 3/16-inch diameter aluminum rivets with countersunk heads, attach each corner of the windshield header to the top of each door header.
   - 5.2 Install 3/16-inch Monobolt rivets in the remaining existing door header holes
6. From outside the cab, install the roof cap onto the windshield header.
   - 6.1 Put the roof cap in place over the new windshield header
   - 6.2 Using the existing holes in the roof cap, drill through the new windshield header.
   - 6.3 Counterbore the holes, using a 5/16-inch counterbore.
   - 6.4 Install 3/16-inch flush-head countersunk aluminum bucked rivets or countersunk



1. Windshield Post
2. Fasteners
3. Roof Cap
4. Windshield Header
5. Front Wall Assembly

Fig. 4, Windshield Post Fasteners

aluminum Huck bolts. Install them in an alternate sequence. **See Fig. 5.**

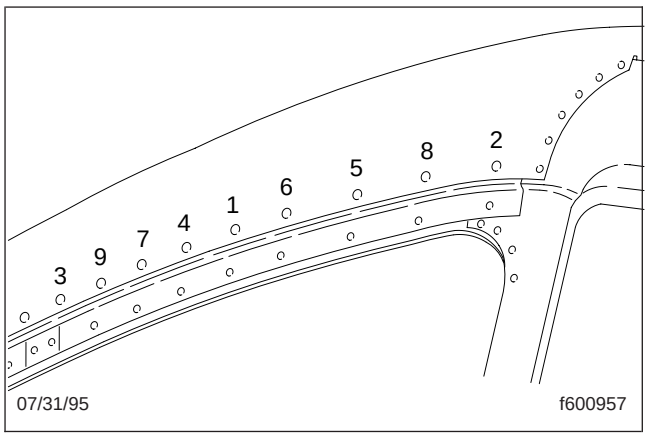


Fig. 5, Installation Sequence for Roof Cap Rivets

7. If equipped with a two-piece windshield, install the windshield post, using two #15 Magnabulb rivets at the top and bottom of the windshield post. **See Fig. 4.**
8. Prime and paint the new windshield header.
9. Install the windshield glass. See the windshield section for instructions.
10. Install the dash panels, upholstery panels, bunk(s), cabinets, seats, floor mats, and carpeting. See the applicable groups and sections in this manual for instructions
11. Remove the jackstands from the chassis.
12. Remove the chocks from the tires.

Removal

IMPORTANT: Depending on the amount and severity of damage, you may need to remove the cab from the chassis to correctly repair the cab deck.

1. Park the vehicle on a level surface. Apply the parking brakes; then chock the tires.
2. If not already done, remove the seats, the bunk(s), the upholstery panels, dash panels, cabinets, the floor mats, and the carpeting from the cab. See the applicable groups and sections is this manual for instructions.
3. Remove the doors. See **Group 72** for instructions.
4. If necessary, remove the cab from the chassis. See the applicable section in this group for instructions.
5. Remove all the fasteners that attach the deck plate to the framework. **See Fig. 1.** Remove only the deck plate needed.
6. Remove the damaged section of framework.
   - 6.1 Remove the necessary cab structures to expose the damaged area. For example, if you need to replace an outboard longitudinal sill, you will need to remove the sidewall assembly. See the applicable subject in this section for instructions.
   - 6.2 Remove the Huck® fasteners and brackets needed.

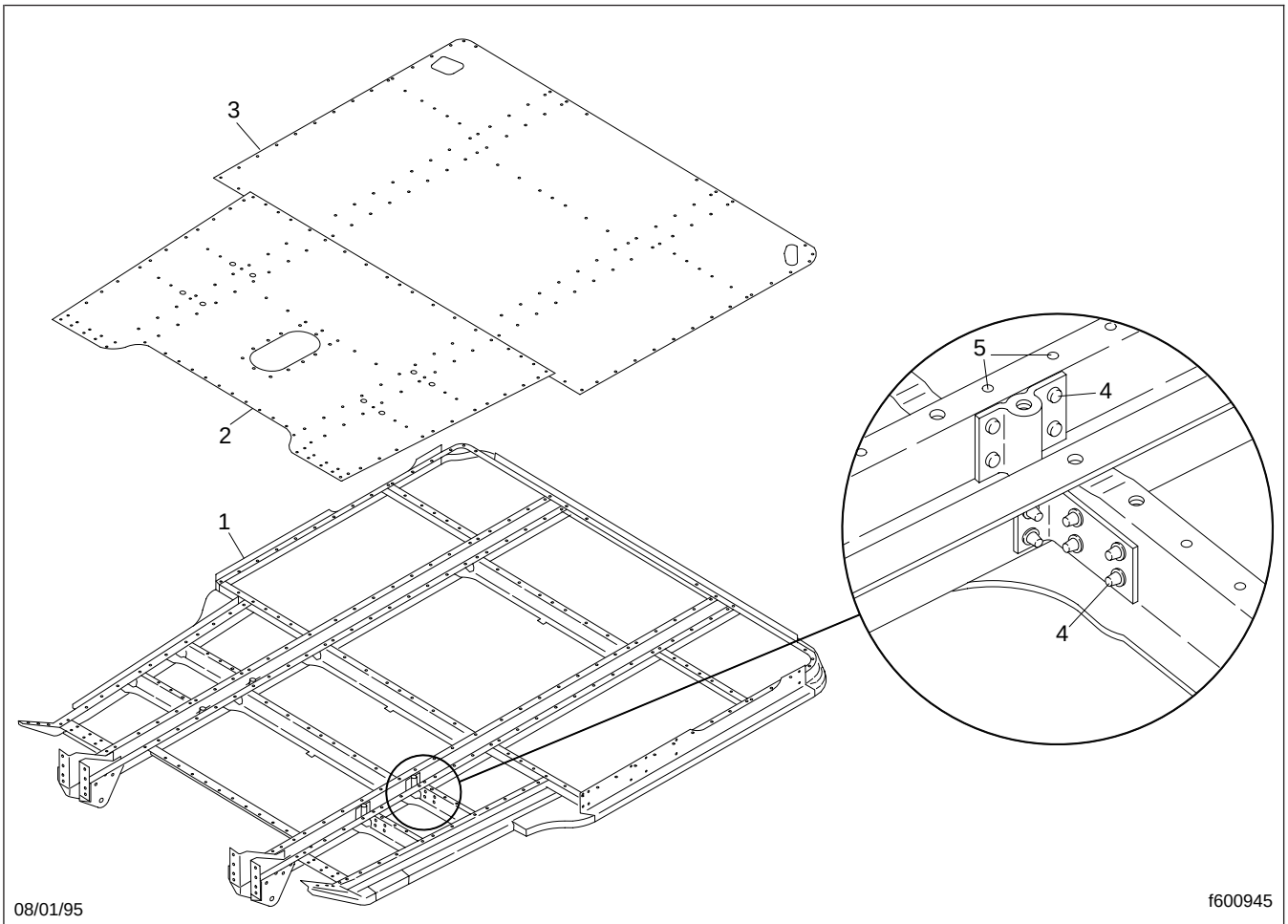
Installation

⚠ CAUTION

CAUTION: Check the vehicle chassis for correct alignment before making repairs to the cab. Failure to repair and align the chassis before repairing the cab could prevent you from correctly squaring the cab, and cause undue stress on the cab structure.

1. Level the chassis, using jackstands.
2. Install the new replacement part, using Huck bolts. Make sure that the fasteners match those that were removed, especially on the top surface of the frameworks. These must be flush, so that you can install the deck plate.
3. Install the deck plate, using the same kind of fasteners that were removed.
4. Make sure the cab deck is level and square. See **Subject 110** for instructions.
5. Install any cab structures that were removed, then make sure the cab is square. See **Subject 110** for instructions.
6. If the cab was removed from the chassis, install it on the chassis. See the applicable section in this group for instructions.
7. Install the bunk(s), cabinets, seats, dash panels, upholstery panels, floor mats, and carpeting. See the applicable groups and sections in this manual for instructions.
8. Install the cab doors. See **Group 72** for instructions.
9. Remove the jackstands from the chassis.
10. Remove the chocks from the tires.

Cab Deck Repair



1. Cab Deck Framework
2. Forward Deck Plate
3. Rear Deck Plate
4. Huck Bolt
5. Countersunk (flush) Fasteners

Fig. 1, Cab Deck Parts

Cab Water-Leak Detection

Use the following procedure to locate areas where water may intrude into the cab.

1. Park the vehicle, apply the parking brakes, and chock the front and rear tires.
2. Prepare a wash solution of at least one-quarter cup of soap to one gallon of water in a spray bottle.
3. Place tape over the cab exhausters.
4. Close all doors, windows, and vents.
5. With the HVAC system in "Fresh Air" mode, turn the fan blower motor on high.

NOTE: Perform the leak detection test with the HVAC system in the "Fresh Air" mode only. Do not set the system in the "Recirculation" mode.

6. Spray the cab, and sleeper if so equipped, with the wash solution, and look for bubbles. See **Fig. 1**. Inspect all applicable areas listed below:
    - windshield center post
    - windshield perimeter (especially the lower outboard corners)
    - upper windshield molding retainer strip
    - visor brackets (outboard more likely than center)
    - air horns and marker lights
    - roof deflector mounts (if so equipped)
    - coach joint
    - cab roof seams (especially raised-roof cap fore-aft seams)
    - sleeper roof seams (if present)
    - sleeper roof side windows (if present)
    - skylight window
7. Mark areas of suspected leaks.

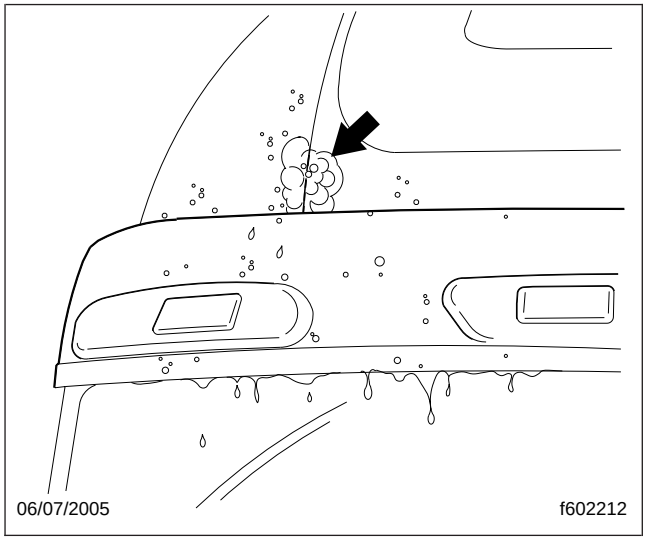


Fig. 1, Cab Water-Leak Detection with Wash Solution

NOTE: This method of leak detection may also identify areas that will not leak water, even though those areas produce bubbles. Bubbles around door seals, baggage doors, and along the vehicle side walls will likely not cause water intrusion issues.

If small bubbles are found in an area that is not suspected to leak, a repair may not be necessary.

8. Rinse the wash solution off the vehicle with water.
9. Turn off the fan blower motor.
10. Remove the tape from the cab exhausters.
11. Remove the chocks from the tires.

Cab Water-Leak Repair

If a leak is found, the repair method will depend on the area and type of leak. It may be necessary to remove some components, though most leaks should be repairable by sealing the area of the leak with silicone sealant.

Leaks in the Windshield or Skylight Sealant

Repair leaks in the windshield or skylight sealant using the approved method and adhesive. Refer to **Section 60.00** for instructions on windshield repair.

Leaks Caused by Structural Damage to a Roof Cap

Repair leaks caused by structural damage to a roof cap by using the procedures outlined in the appli-

Cab Water-Leak Detection and Repair

cable sections in this manual. Use the repair method appropriate to the material used in the roof cap construction.

To repair small leaks, clean with shop air and a clean rag, then seal with a silicone sealant.

Leaks in the Coach Joint Area

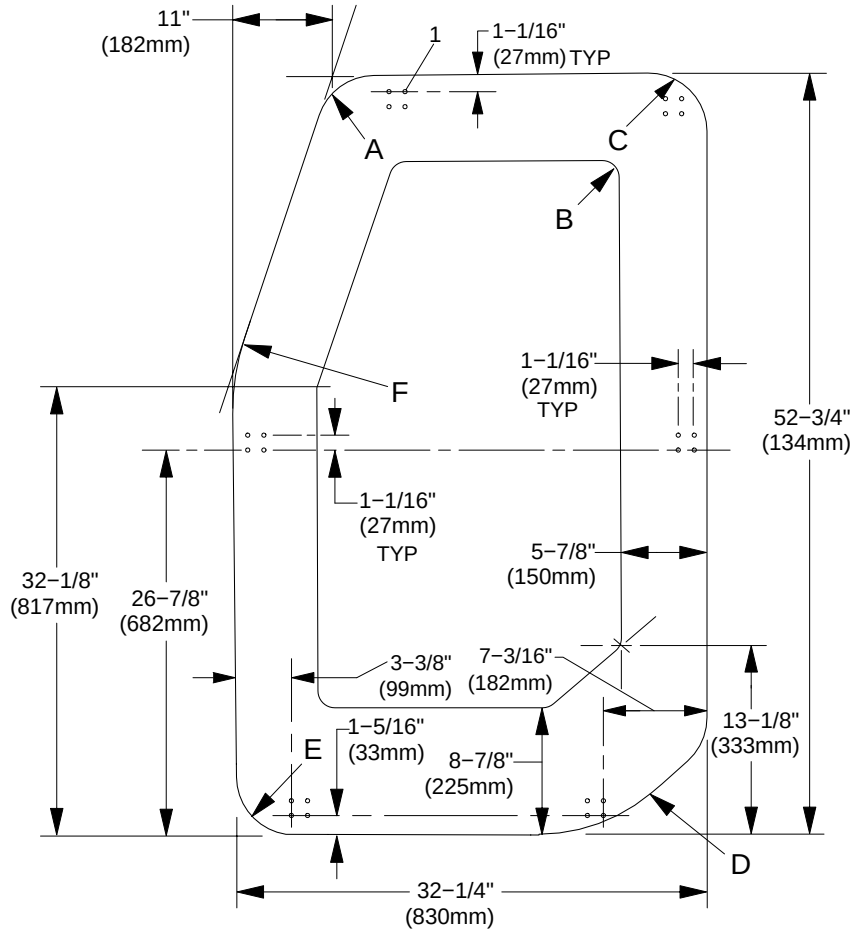
Repair leaks in the coach joint area without removing the roof cap, if possible. Seal the leak with silicone or a similar sealant.

See **Fig. 1** and **Fig. 2** for information and measurements to fabricate door plug assemblies.

See **Fig. 3** for information and measurements to fabricate the cab squaring tool.

See **Fig. 4** for information and measurements to fabricate door frame clamps.

See **Fig. 5** for information to modify C-clamps for use with door frame clamps.



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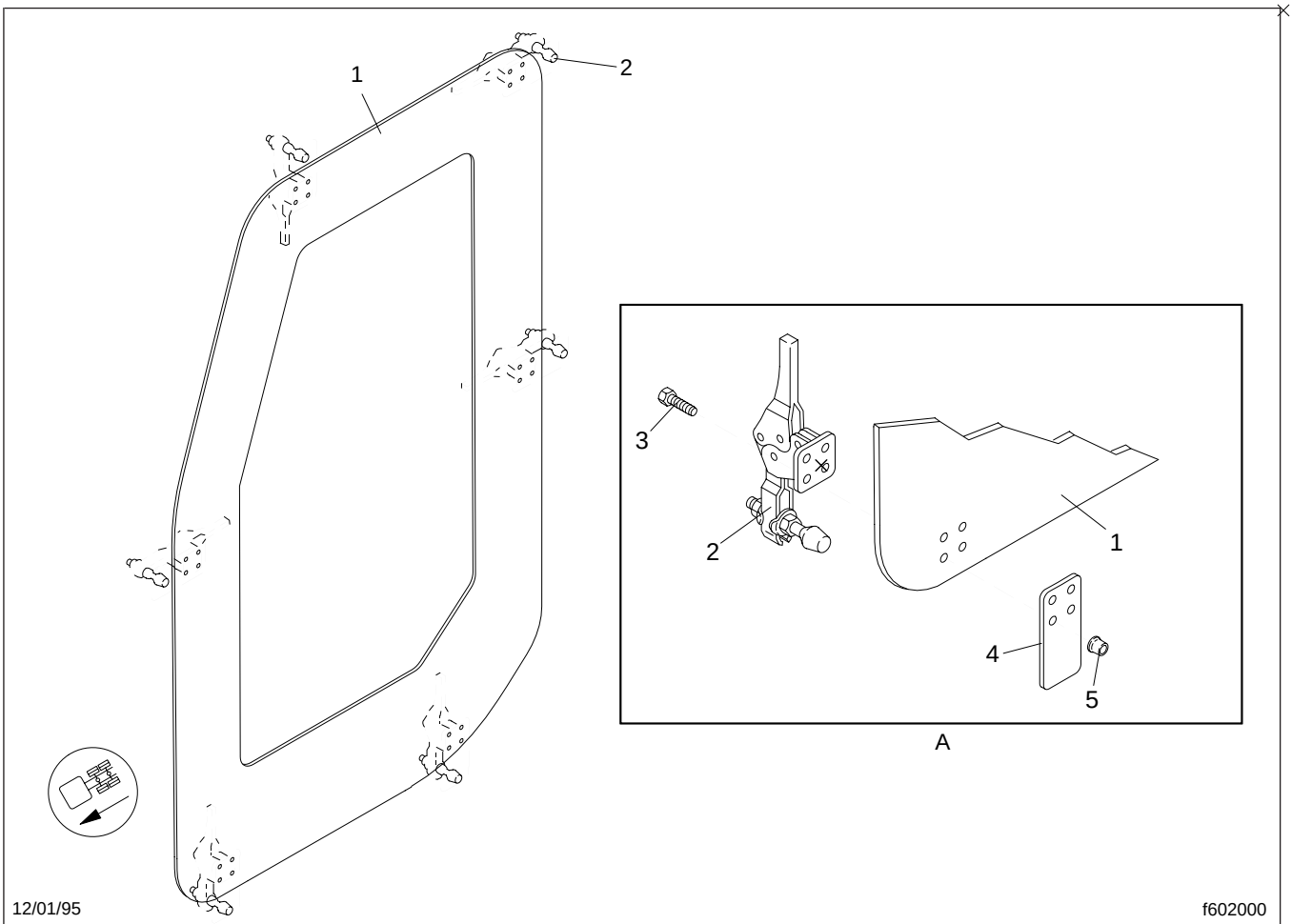
NOTE: Door plug material is to be 1/4-inch thick aluminum plate.

A. 4-inch (102 mm) Radius
B. 1-inch (25 mm) Radius
C. 4-inch (102 mm) Radius
D. 12-inch (305 mm) Rdius
E. 4-inch (102 mm) Radius
F. 20-inch (508 mm) Radius
1. 1/4-Inch Diameter Hole

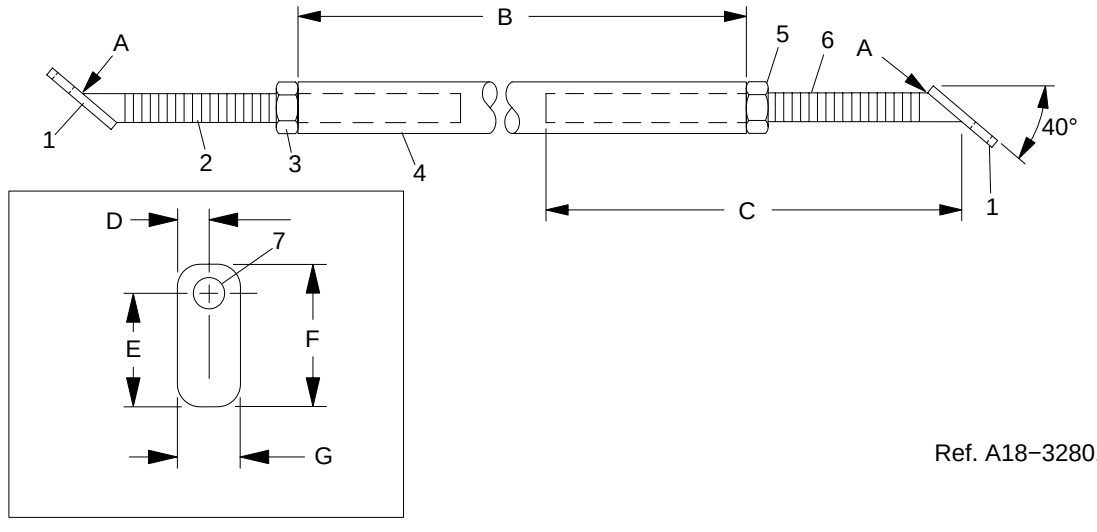
Fig. 1, Door Plug Specifications for Left Side of Vehicle

Specifications



A. Detail of Clamp Installation
1. Door Plug, 1/8-inch Thick Aluminum Plate
2. Special Clamp
3. 1/4-inch Huck® Bolt (4 qty.)
4. 1/8-Inch Thick Aluminum Plate, 1-3/4" (44 mm) x 3-7/8" (99 mm)
5. Huck Collar (4 qty.)

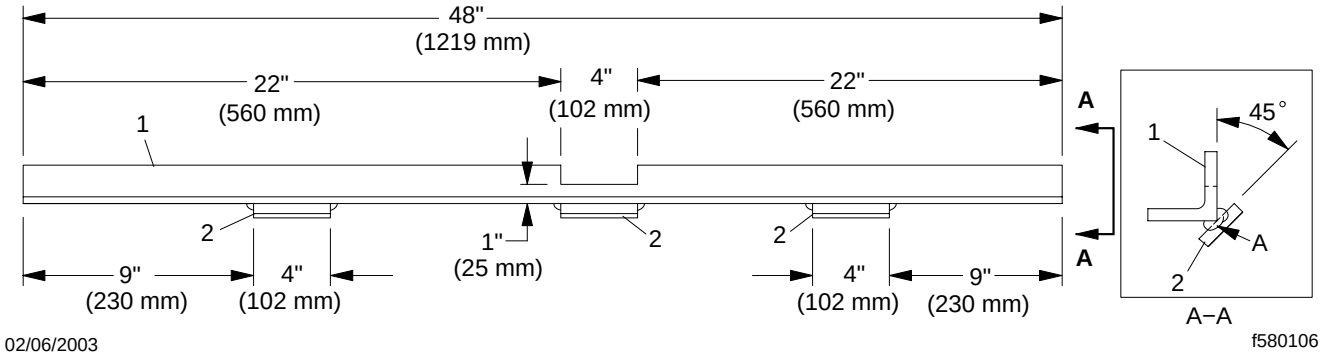
Fig. 2, Door Plug Clamp Installation



A. Instruction: Fillet weld all the way around.
B. Measurement: 74-7/16 inches (1890 mm) [2] and 64-7/16 inches (1638 mm) [2]
C. Measurement: 20-1/16 inches (510 mm)
D. Measurement: 5/16 inches (8 mm)
E. Measurement: 1-1/8 inches (30 mm)
F. Measurement: 1-1/2 inches (38 mm)
G. Measurement: 5/8 inches (16 mm)
H. Plate Dimensions

1. 1/4-inch Thick Steel Plate
2. Threaded Rod, 1/2–13, Left-Hand Thread
3. Hexnut, 1/2–13, Left-Hand Thread (welded to pipe)
4. Steel Pipe, 1/2-Inch Diameter
5. Hexnut, 1/2–13, Right-Hand Thread (welded to pipe)
6. Threaded Rod, 1/2–13, Right-Hand Thread
7. Hole, 5/16" Diameter

Fig. 3, Cab Squaring Tool

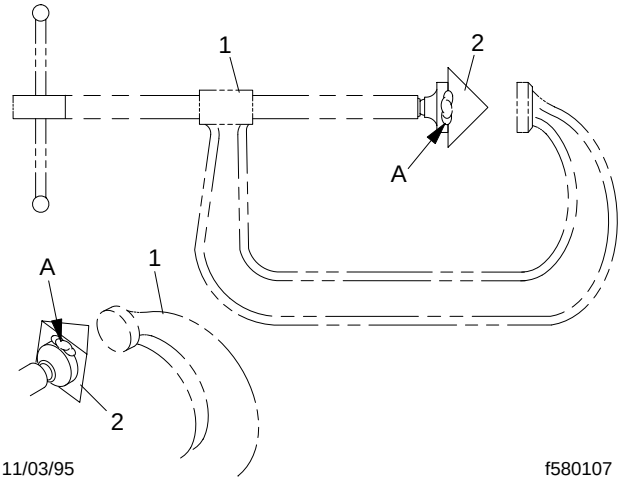


A. Fillet weld here.

1. 2" x 2" x 1/4" Aluminum Angle
2. Aluminum Plate, 1/4-Inch Thick, 4" x 1" (100 mm x 25 mm)

Fig. 4, Special Clamp for Door Frame, Left Side Shown

Specifications



A. Fillet weld here.
1. C-Clamp
2. Steel Wedge, 90-Degree Angle

Fig. 5, Modified C-Clamp for Use With Door Frame Clamp

Dash Panels Removal and Installation

Removal

NOTE: When the dash is completely assembled (see **Fig. 1**), all dash fasteners are hidden from view.

Removing the right-hand dash panels allows access to the following components: blower motor, resistor module, thermostat, heater core, evaporator core, and power distribution module.

Removing the left-hand dash panels allows access to the following components: the instrumentation control unit and auxiliary instrument panel.

Removing the upper dash assembly allows access to the following components: the face and defrost ducts, cab wiring, and the rear of the instrument panel.

Removing the lower dash panels allows access to the following components: the steering column cover, the keyswitch housing, waste bin slides, and the driver's console support.

Right-Hand Dash Panels

⚠ CAUTION

If the right-hand upper dash cover is difficult to remove, pry gently with a small screwdriver against the edge of the cover, using the slots provided. Be careful to protect the underlying dash panel and not damage its finish.

1. Remove the right-hand upper dash cover by pulling gently aftward on the corners to disengage the four speed clips. This will expose the two screws that attach the top of the HVAC cover to the HVAC unit. See **Fig. 2**.

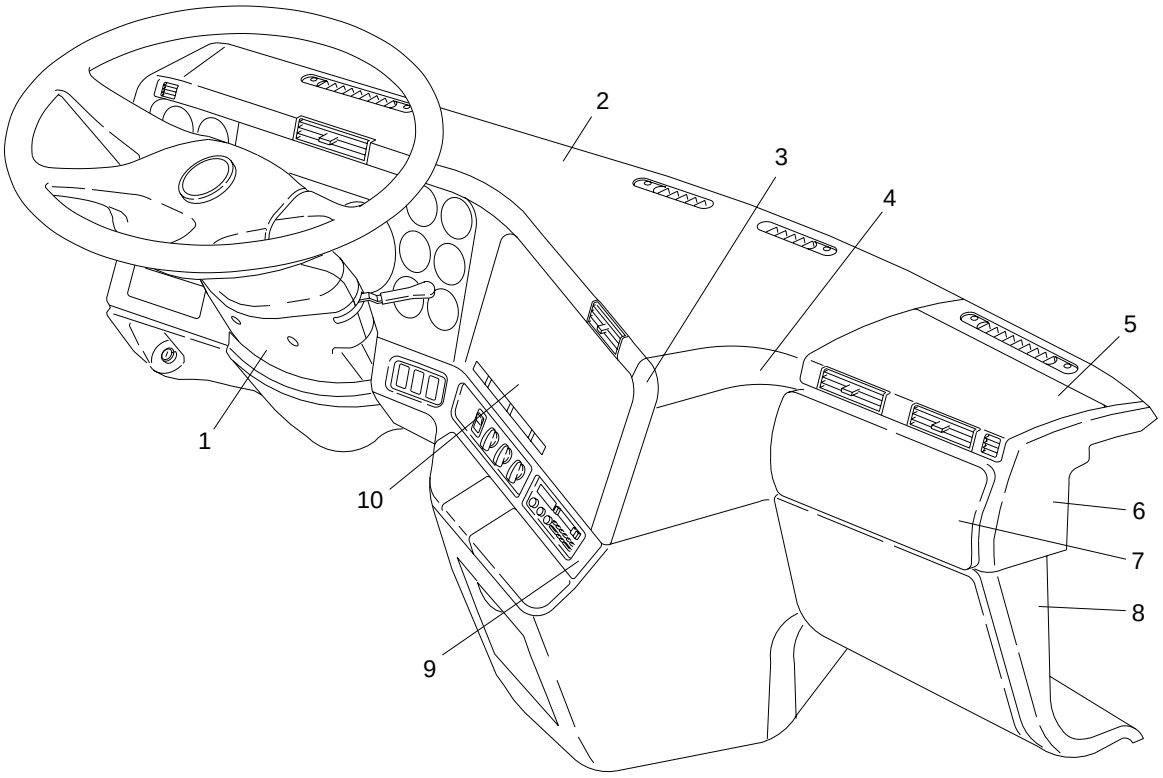
NOTE: All screws used in the dash installation, unless otherwise called out, are T25 Torx® dog-point screws. See **Fig. 3**.

2. Remove the HVAC cover and footwell light (see **Fig. 4**).
   - 2.1 Remove the two screws at the top of the HVAC cover.
   - 2.2 Remove the two screws at the bottom of the HVAC cover. Remove the HVAC cover from the dash.
   - 2.3 Disconnect the electrical connector on the footwell light.
   - 2.4 If needed, pry out the footwell light lens and replace the bulb.
3. Remove the electrical cover from the dash by pushing the push-button release that attaches the electrical cover to the upper dash assembly.
4. Remove the waste bin.
   - 4.1 Slide the waste bin out as far as it will go.
   - 4.2 Reach inside the waste bin and push the release tab.
   - 4.3 Remove the waste bin from the dash assembly.
5. Remove the cup holder by pulling up on the cup holder to unseat the two speed clips.
6. Remove the ashtray assembly.
   - 6.1 Open the ashtray.
   - 6.2 Press on the metal tab and pull the ashtray out.
   - 6.3 Remove the two 1-inch (25-mm) Torx screws that hold the ashtray housing to the left-hand console cover.
   - 6.4 Remove the ashtray housing.
7. Remove the right-hand console cover.
   - 7.1 Remove the two screws that attach the cover to the lower left-hand console cover.
   - 7.2 Remove the screw that attaches the cover to the lower left-hand console cover.
   - 7.3 Remove the screw at the back of the cover in the passenger footwell.
   - 7.4 Remove the screw that attaches the cover to the HVAC unit.
   - 7.5 Pull the bottom of the cover out to clear the tabs at the top of the lower right-hand console cover from the upper dash assembly.
   - 7.6 Remove the console cover.

Left-Hand Dash Panels

1. Remove the left-hand dash trim panels. See **Fig. 5**.

Dash Panels Removal and Installation



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1. Steering Column Cover
2. Upper Dash Assembly (left-hand panel)
3. Right-Hand Dash Trimcap
4. Upper Dash Assembly (center panel)
5. Electrical Cover
6. Upper Dash Assembly (right-hand panel)
7. Right-Hand Upper Dash Cover
8. HVAC Cover
9. HVAC/Radio Trimplate
10. Auxiliary Instrument Panel

Fig. 1, Fully Installed Dash Panel

NOTE: Removing the left-hand dash trim allows access to the left-hand and right-hand accessory switch panels.

1.1 Rotate the driver's cupholder up and out of the way to expose two T25 dog-point screws that attach the HVAC/radio trimplate to the upper dash panel. Remove these screws.

1.2 Remove the four speed clips that attach the HVAC/radio trimplate to the upper dash panel. Remove the HVAC/radio trimplate from the dash.

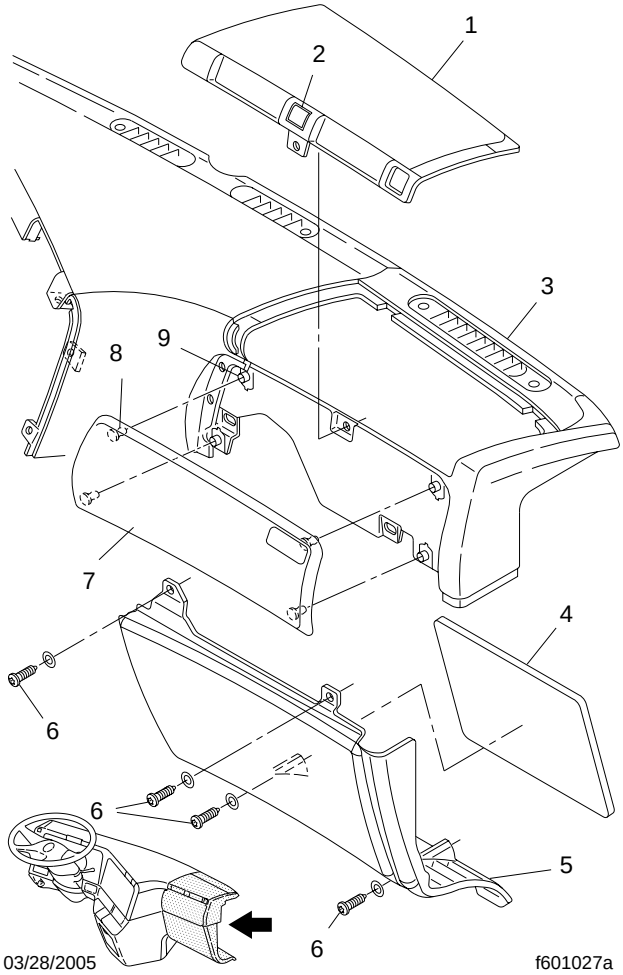
1.3 Remove the two speed clips that attach the keyswitch trimplate to the keyswitch housing. Remove the keyswitch trimplate from the dash.

1.4 Remove the screw and the speed clip that attaches the right-hand dash trimcap to the upper dash panel. Remove the right-hand dash trimcap from the dash.

2. Remove the instrument panel trim. See **Fig. 6**.

NOTE: Removing the instrument panel trim allows access to the instrumentation control unit and auxiliary instrument panels.

2.1 Remove the screw that attaches the left-hand dash endcap to the keyswitch housing. Remove the speed clip that attaches the left-hand dash endcap to the dash



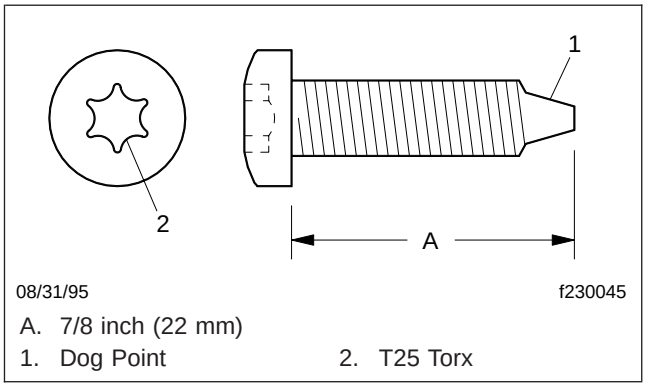
1. Electrical Cover
2. Push Button
3. Upper Dash Assembly
4. Cover Seal
5. HVAC Cover
6. Dog-Point Screws and Washers
7. Right-Hand Upper Dash Cover
8. Speed Clip
9. Speed Nut

Fig. 2, Right-Hand Dash Panels

panel trimtop. Remove the left-hand dash endcap from the dash.

2.2 Remove the dash message center bezel.

2.3 Remove the two screws that attach the dash panel trimtop to the upper dash assembly. Leave the dash panel trimtop attached to the instrumentation control unit (ICU).



A. 7/8 inch (22 mm)
1. Dog Point
2. T25 Torx

Fig. 3, Dog-Point Screw

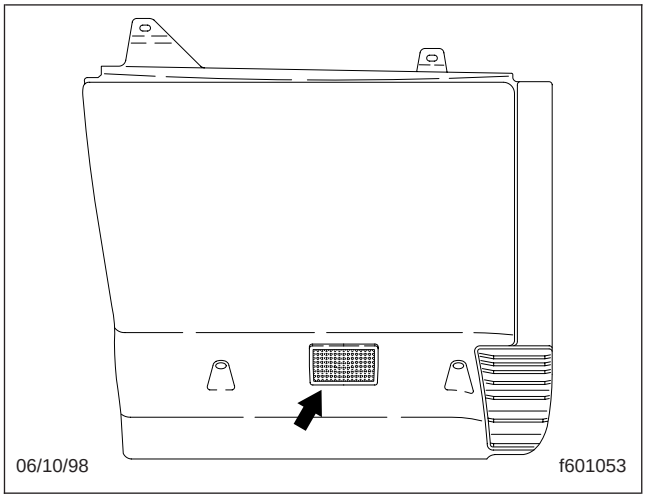


Fig. 4, Footwell Light

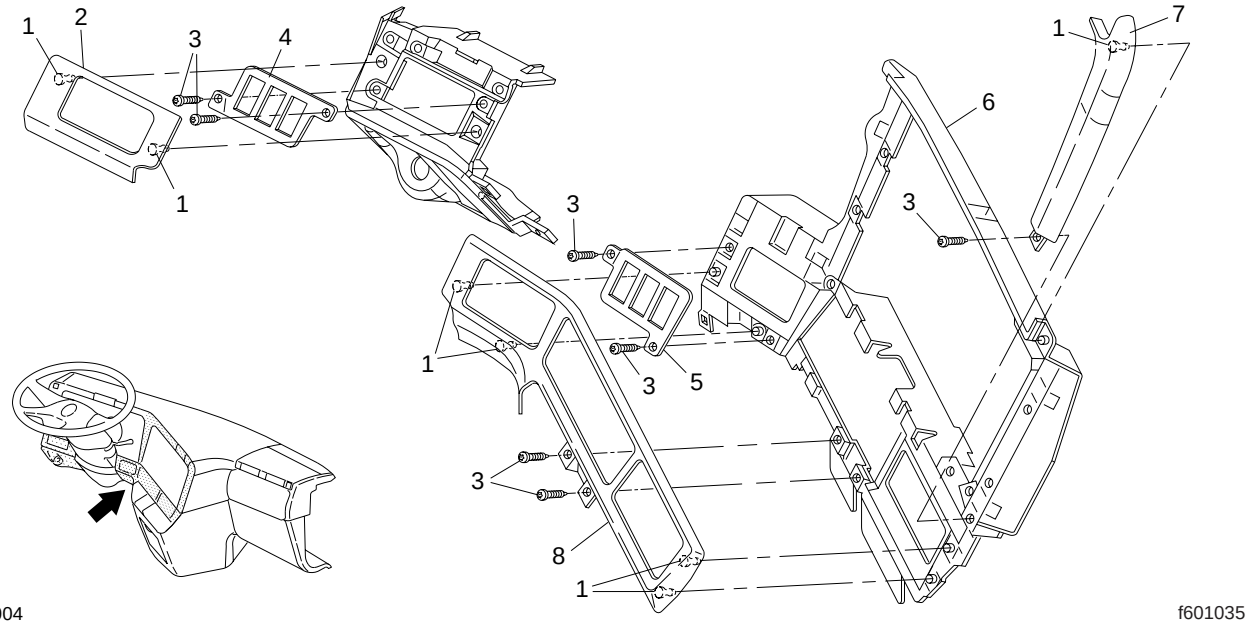
2.4 If necessary to gain access, remove the steering column cover (clamshell cover).

2.5 Work the bottom part of the instrument panel center trim out of the slot in the upper dash panel. Pull down on the center trim piece to free it from the mating surface on the upper dash assembly. Remove the center trim from the dash.

Upper Dash Assembly

1. Remove the electrical cover and right-hand upper dash cover using the instructions in "Right-Hand Dash Panels."
2. Remove the keyswitch trimplate and left-hand dash endcap, using the instructions in "Left-Hand Dash Panels."

Dash Panels Removal and Installation



1. Speed Clip
2. Keyswitch Trimplate
3. T25 Dog-Point Screw
4. Left-Hand Accessory Switch Panel
5. Right-Hand Accessory Switch Panel
6. Upper Dash Panel
7. Right-Hand Dash Trimcap
8. HVAC/Radio Trimplate

Fig. 5, Left-Hand Dash Trim Panels

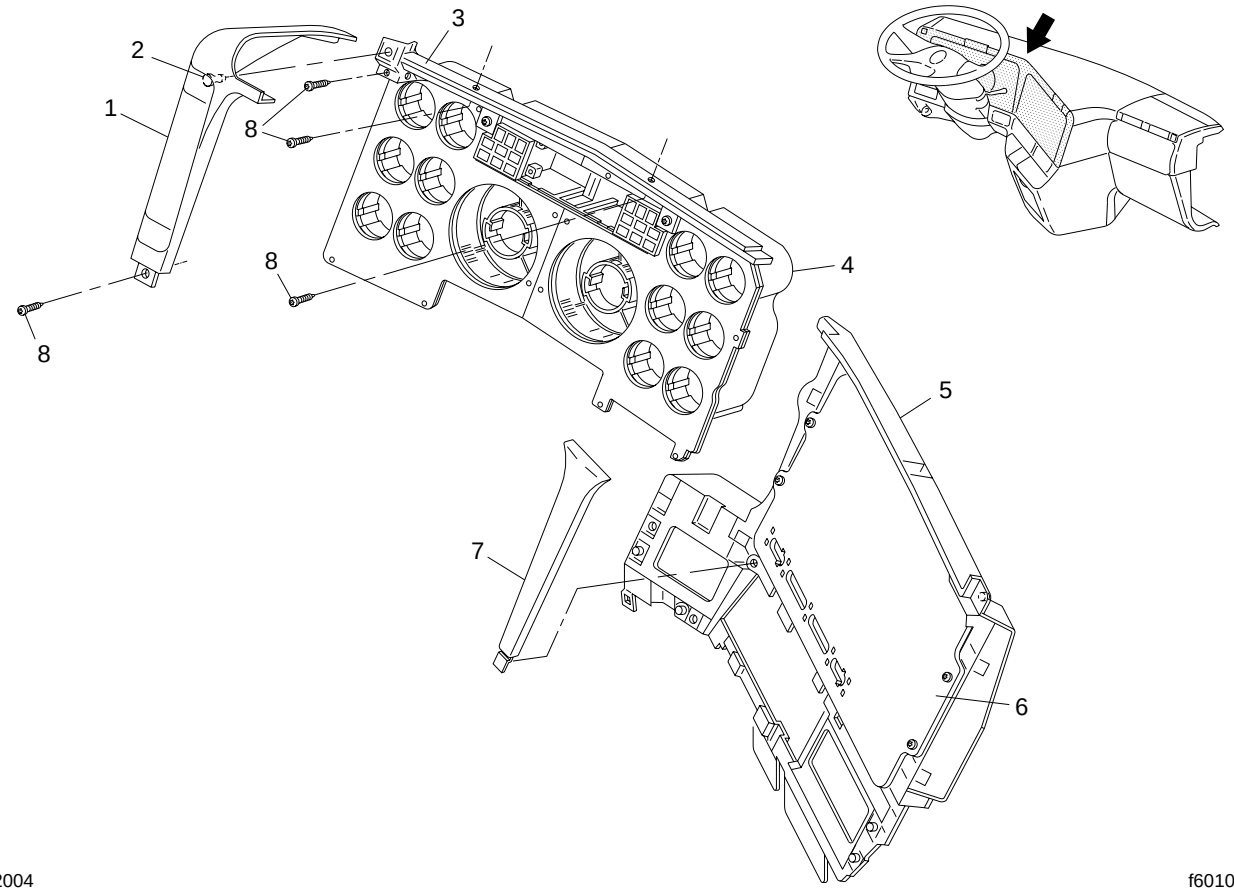
3. Remove the upper dash assembly. See **Fig. 7**.
   - 3.1 Remove the three 1-1/4 inch (3 cm) screws that attach the upper dash panel to the inserts along the underside of the upper dash assembly (left-hand panel).
   - 3.2 Remove the three 1-1/4 inch (3 cm) screws that attach the upper dash assembly to the dash panel trim top.
   - 3.3 Remove the plug in the lower right-hand console cover.
   - 3.4 Remove the screw that attaches the dash brace to the upper dash assembly (center panel).
   - 3.5 Remove the two screws that attach the upper dash assembly (right-hand panel) to the HVAC unit.
   - 3.6 Remove the six screws located in the recessed areas around the louvers along the edge of the windshield.
   - 3.7 Remove the two screws that attach the upper dash assembly to the upper dash panel.
   - 3.8 Remove the upper dash assembly from the vehicle.

Lower Dash Panels

1. Remove the driver's knee bolster. See **Fig. 8**.

   NOTE: Removing the driver's knee bolster allows access to the steering column cover (clamshell cover).
   - 1.1 Remove the two speed clips that attach the lower part of the bolster to the keyswitch housing and the steering column bracket.
   - 1.2 Unhook the knee bolster from the slots in the keyswitch housing and upper dash panel.
   - 1.3 Remove the driver's knee bolster from the dash.

Dash Panels Removal and Installation

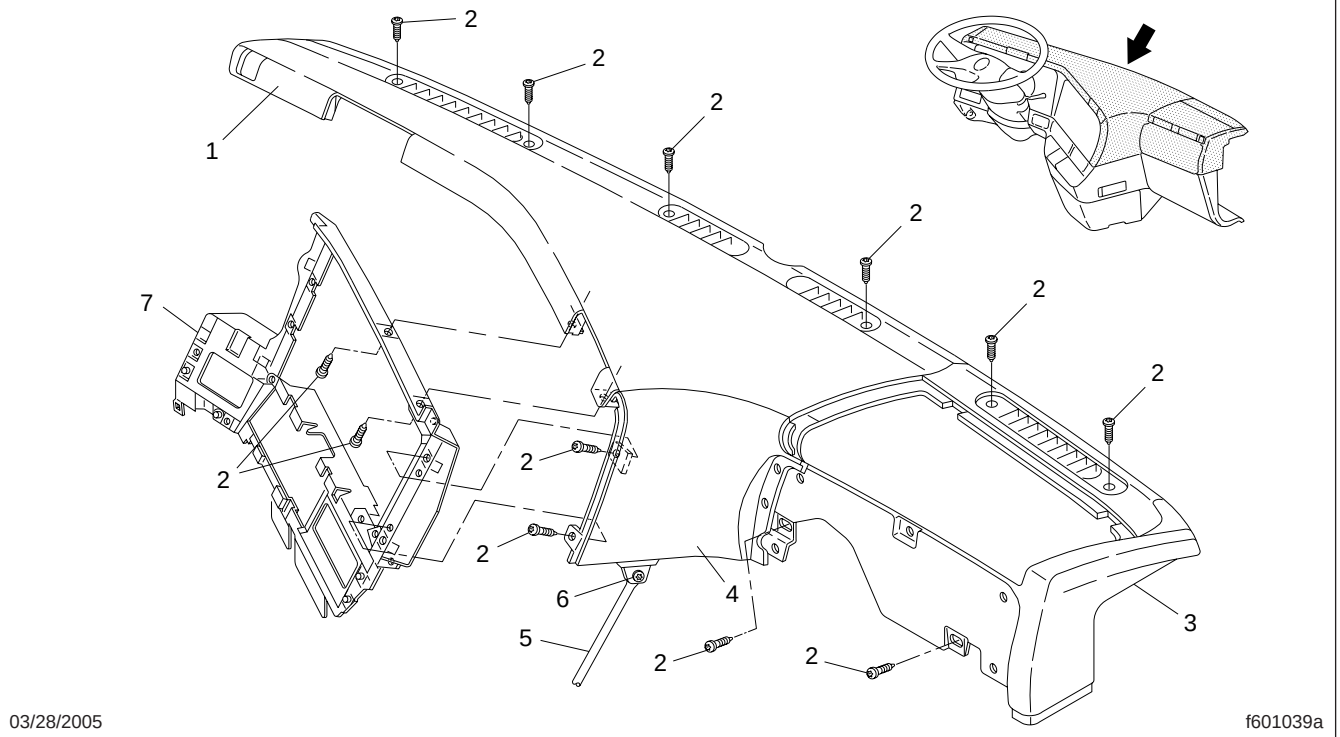


1. Left-Hand Dash Endcap
2. Speed Clip
3. Dash Panel Trimtop
4. Instrumentation Control Unit Housing
5. Upper Dash Panel
6. Auxiliary Instrument Panel
7. Instrument Panel Center Trim
8. T25 Dog-Point Screw

Fig. 6, Instrument Panel Trim

2. Remove the cup holder by pulling up on the cup holder to unseat the two speed clips.
3. Remove the HVAC/radio trimplate.
   - 3.1 Remove the two screws and washers that attach the trimplate to the upper dash panel.
   - 3.2 Pull up on the trimplate to disengage the four speed clips.
4. Remove the ashtray assembly.
   - 4.1 Open the ashtray.
   - 4.2 Press on the metal tab.
   - 4.3 Pull the ashtray out.
   - 4.4 Remove the two 1-inch (25-mm) Torx screws that hold the ashtray housing to the left-hand console cover.
   - 4.5 Pull the housing out.
5. Remove the waste bin.
   - 5.1 Slide the waste bin out as far as it will go.
   - 5.2 Reach in the waste bin and push up on the tab at the top of the waste bin compartment.
   - 5.3 Remove the waste bin.

Dash Panels Removal and Installation



1. Upper Dash Assembly (left-hand panel)
2. T25 Dog-Point Screw
3. Upper Dash Assembly (right-hand panel)
4. Upper Dash Assembly (center panel)
5. Dash Brace
6. Dash Brace Screw
7. Upper Dash Panel

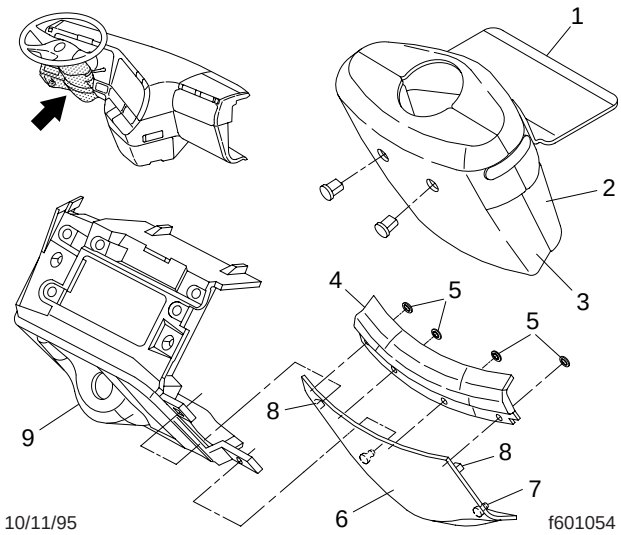
Fig. 7, Upper Dash Assembly

6. Remove the left-hand console cover.
   - 6.1 Remove the screw located behind the cover along the driver-side footwell edge.
   - 6.2 Remove the screw and washer that attaches the cover to the steering column bracket.
   - 6.3 Remove the three screws that attach the cover to the upper dash panel.
   - 6.4 Remove the two screws that hold the cover to the lower right-hand console cover located through the ashtray and waste bin openings.
   - 6.5 Remove the two 1-1/4 inch (30 mm) Torx screws that hold the cover to the engine tunnel cover.
   - 6.6 Pull the cover out and reach behind to disconnect the cigarette lighter connector.
   - 6.7 Remove the cover.

Installation

Lower Dash Panels

1. Install the left-hand console cover.
   - 1.1 Connect the cigarette lighter connector to the cigarette lighter housing.
   - 1.2 Install the two Torx screws that hold the cover to the engine tunnel cover.
   - 1.3 Install the two screws that hold the left-hand console cover to the lower right-hand console cover located through the ashtray and waste bin opening.



1. Steering Column Upper Cover Seal
2. Upper Steering Column Cover
3. Lower Steering Column Cover
4. Steering Column Lower Cover Seal
5. Push-On Retainer
6. Driver's Knee Bolster
7. Speed Clip
8. Hook
9. Keyswitch Housing

Fig. 8, Driver's Knee Bolster

1.4 Remove the three screws that attach the cover to the upper dash panel.

1.5 Install the screw and washer that attaches the cover to the steering column bracket.

1.6 Install the screw located behind the cover along the driver side foot-well edge.

2. Install the ashtray assembly.

2.1 Install the ashtray housing into the left-hand console cover.

2.2 Install the two Torx screws that hold the housing to the left-hand console cover.

2.3 Slide the ashtray in the ashtray housing and close the ashtray.

3. Slide the waste bin into the left-hand console cover.

4. Install the HVAC/radio trim plate.

4.1 Position the speed clips over the holes in the upper dash panel.

4.2 Install the two screws and washers that attach the trimplate to the upper dash panel.

5. Align the speed clips on the cup holder with the holes in the left-hand console cover and push the cupholder down into position.

6. Install the driver's knee bolster. See **Fig. 8**.

6.1 Install the hooks on the top of the driver's knee bolster into the slots in the keyswitch housing and the upper dash panel.

6.2 Install the speed clips that attach the knee bolster to the keyswitch housing and the steering column bracket.

6.3 Press firmly against all four corners of the knee bolster to be sure all hooks and clips are firmly seated.

Upper Dash Assembly

1. Install the upper dash assembly. See **Fig. 7**.

1.1 Fit the dash assembly into place along the edge of the windshield and over the top of the instrument panels.

1.2 Install the six T25 dog-point screws in the recessed areas around the louvers along the edge of the windshield.

1.3 Install the two screws that attach the upper dash assembly to the upper dash panel.

1.4 Install the screw that attaches the dash brace to the upper dash assembly (center panel).

1.5 Install the plug in the lower right-hand console cover.

1.6 Install the three screws that attach the upper dash panel to the underside of the upper dash assembly.

1.7 Install the three screws that attach the upper dash panel to the dash panel trim top.

1.8 Install the two screws that attach the upper dash assembly (right-hand panel) to the HVAC unit.

2. Install the electrical cover and right-hand upper dash cover using the instructions in "Right-Hand Dash Panels."

Dash Panels Removal and Installation

3. Install the keyswitch trimplate and left-hand dash endcap, using the instructions in "Left-Hand Dash Panels."

Left-Hand Dash Panels

1. Install the instrument panel trim. See **Fig. 6**.
   - 1.1 Insert the top edge of the instrument panel trim into its mating surface on the upper dash assembly. Insert the bottom edge of the instrument panel center trim down into the slot in the upper dash panel until it snaps into place.
   - 1.2 If removed, install the steering column cover (clamshell cover).
   - 1.3 Install the two screws that attach the dash panel trimtop to the upper dash assembly (left-hand panel).
   - 1.4 Snap the dash message center bezel into place.
   - 1.5 Install the speed clip that attaches the left-hand dash endcap to the dash panel upper trimtop. Install the screw that attaches the left-hand dash endcap to the keyswitch housing.
2. Install the left-hand dash trim panels. See **Fig. 3**.
   - 2.1 Install the screw and the speed clip that attaches the right-hand dash trimcap to the upper dash panel.
   - 2.2 Install the two speed clips that attach the keyswitch trimplate to the keyswitch housing. If needed, replace the left-hand accessory/switch panel.
   - 2.3 Install the four speed clips and two screws that attach the HVAC/radio trimplate to the upper dash panel.
   - 2.4 Rotate the driver's cupholder down and into place, covering the screws on the HVAC/radio trimplate.

Right-Hand Dash Panels

1. Install the right-hand console cover.
   - 1.1 Slide the tabs at the top of the cover into the slots in the upper dash panel assembly.
   - 1.2 Install the screw that attaches the cover to the HVAC unit.
   - 1.3 Install the screw at the back of the cover in the passenger footwell area.
   - 1.4 Install the screw that attaches the cover to the left-hand console cover located in the cup holder area.
   - 1.5 Install the two screws that attach the cover to the left-hand console cover located through the ashtray and waste bin openings.
2. Install the HVAC cover (see **Fig. 2**) and footwell light.
   - 2.1 Connect the electrical connector on the footwell light.
   - 2.2 Place the HVAC cover into position over the upper dash assembly and install the two screws into the holes at the top of the HVAC cover.
   - 2.3 Install the two screws at the bottom of the HVAC cover.
3. Install the electrical cover on the dash.
4. Attach the four speed clips on the right-hand upper dash cover to the HVAC cover. See **Fig. 2**.
5. Align the speed clips on the cup holder with the holes in the left-hand console cover and push the cup holder into position.
6. Slide the waste bin into the left-hand console cover.
7. Install the ashtray assembly.
   - 7.1 Place the ashtray housing into the left-hand console cover.
   - 7.2 Install the two Torx screws that attach the ashtray housing to the left-hand console cover.
   - 7.3 Slide the ashtray into the ashtray housing and close the ashtray.

Dash Panels Removal and Installation, Argosy COE

Removal

IMPORTANT: Many of the dash components are accessible only after the removal of other dash components. The following service procedures start on the right side of the dash and generally move left toward the operator's side of the vehicle.

NOTE: When the dash is completely assembled (see **Fig. 1**), all dash fasteners are hidden from view.

Removing the right-hand dash panels allows access to the following components: blower motor, resistor module, thermostat, heater core, evaporator core, and power distribution module.

Removing the left-hand dash panels allows access to the following components: the instrumentation control unit and the auxiliary instrument panel.

Removing the upper dash assembly allows access to the following components: the face and defrost ducts, cab wiring, and the rear of the instrument panel.

Removing the lower dash panels allows access to the following components: the steering column cover and the keyswitch housing.

RIGHT-HAND UPPER DASH PANELS

⚠ CAUTION

If the right-hand upper dash cover is difficult to remove, pry gently with a small screwdriver against the edge of the cover, using the slots provided. Be careful to protect the underlying dash panel and not damage its finish.

1. Remove the upper dash electrical access panel by pushing the button in the middle of the panel fore edge.
2. Remove the righthand upper dash cover by pulling gently aftward on the corners to disengage the four speed clips and expose the two screws attaching the top of the HVAC cover to the HVAC unit. See **Fig. 2**.

IMPORTANT: All screws used in the dash installation, unless otherwise called out, are T25 Torx-head dog-point screws. See **Fig. 3**.

3. Remove the HVAC cover and footwell light (see **Fig. 4**).
   - 3.1 Remove the two screws at the top of the HVAC cover.
   - 3.2 Remove the two screws at the bottom of the HVAC cover. Remove the HVAC cover from the dash.
   - 3.3 Disconnect the electrical connector on the footwell light.
   - 3.4 If needed, pry out the footwell light lens and replace the bulb.

LOWER DASH CONSOLE

1. Remove the HVAC/radio assembly trimplate and the transmission boot. See **Fig. 1**.
2. Remove the knee bolster. See **Fig. 5**.

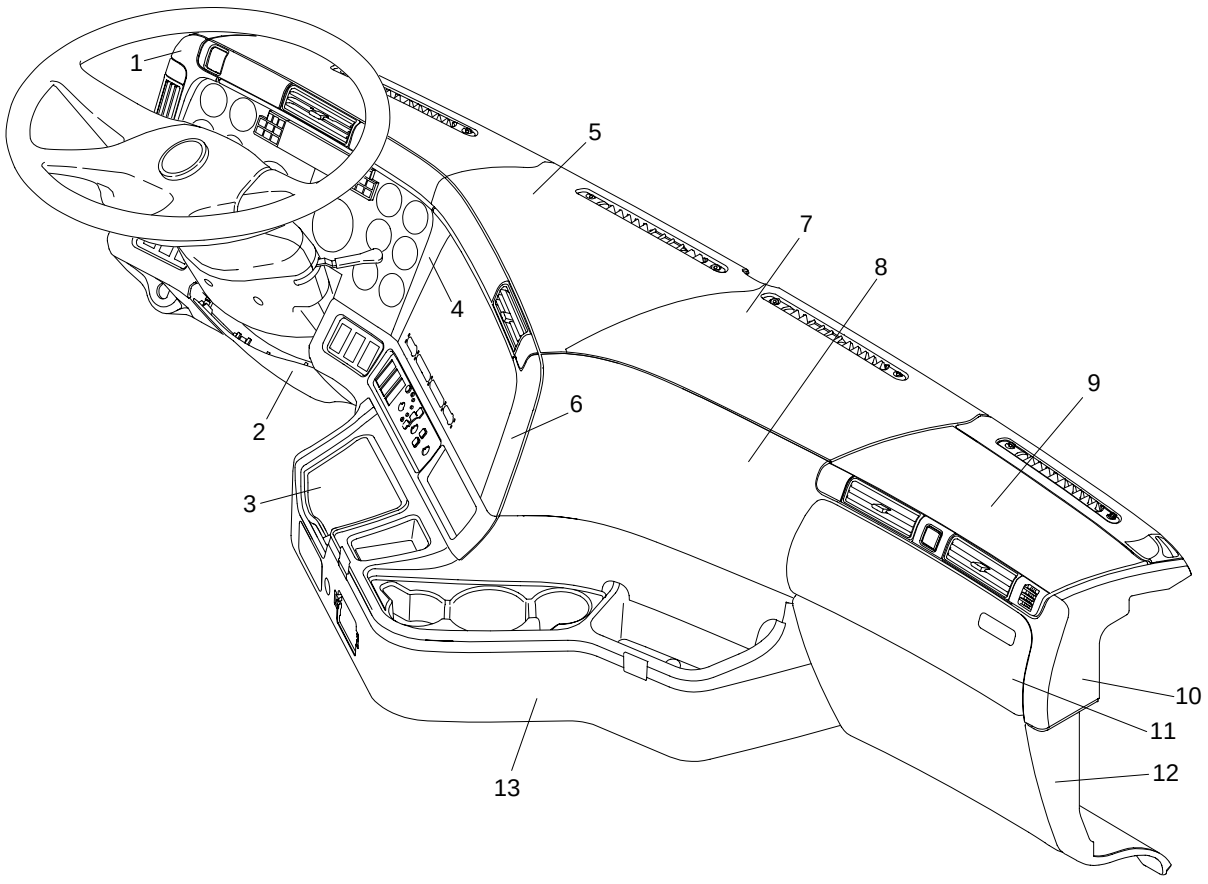
   NOTE: Removing the driver's knee bolster allows access to the steering column cover (clamshell cover).
   - 2.1 Remove the two speed clips attaching the lower part of the bolster to the keyswitch housing and the steering column bracket.
   - 2.2 Unhook the knee bolster from the slots in the keyswitch housing and upper dash panel.
   - 2.3 Remove the driver's knee bolster from the dash.
3. Remove the lower dash console by removing the eight fasteners holding it in place.
4. Pull the console from under the dash.

LEFT-HAND DASH PANELS

1. Remove the left-hand dash trim panels. See **Fig. 6**.

   NOTE: Removing the left-hand dash trim allows access to the left-hand and right-hand accessory switch panels.
   - 1.1 Remove the four speed clips attaching the HVAC/radio trimplate to the upper dash panel. Remove the HVAC/radio trimplate from the dash.
   - 1.2 Remove the two speed clips attaching the keyswitch trimplate to the keyswitch hous-

Dash Panels Removal and Installation, Argosy COE



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1. Dash End Cap
2. Steering Column Cover
3. Transmission Boot Opening
4. Instrument Panel Center Trim
5. Upper Dash Assembly (left-hand panel)
6. Right-Hand Dash Trimcap
7. Upper Dash Assembly (right-hand panel)
8. Upper Dash Assembly (center panel)
9. Upper Dash Electrical Access Panel
10. Dash Assembly, RH
11. Dash Cover
12. HVAC Cover
13. Lower Dash Console

Fig. 1, Fully-Installed Dash Panel, Argosy COE

ing. Remove the keyswitch trimplate from the dash.

1.3 Remove the screw and the speed clip attaching the right-hand dash trimcap to the upper dash panel. Remove the right-hand dash trimcap from the dash.

1.4 Remove the keyswitch trim plate.

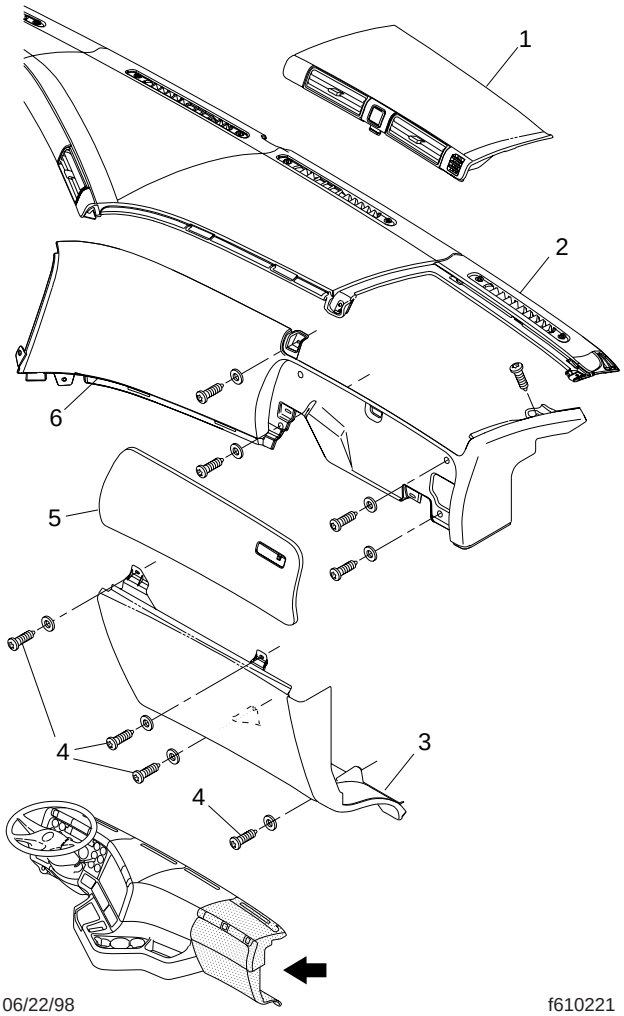
1.5 Remove the dash end caps.

2. Remove the instrument panel trim. See **Fig. 7**.

NOTE: Removing the instrument panel trim allows access to the instrumentation control unit and auxiliary instrument panels.

2.1 Remove the screw attaching the left-hand dash endcap to the keyswitch housing. Remove the speed clip attaching the left-hand dash endcap to the dash panel trim-

Dash Panels Removal and Installation, Argosy COE



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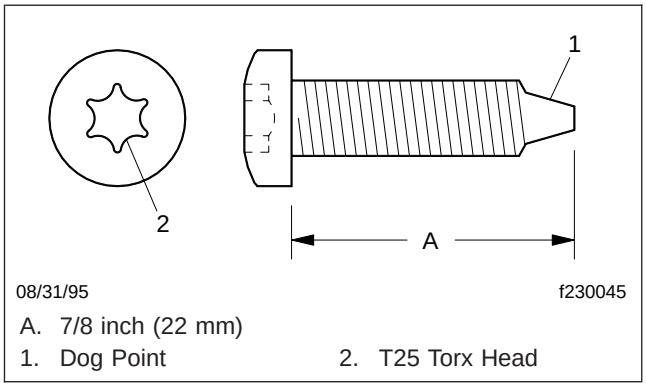
1. Electrical Cover
2. Upper Dash Assembly
3. HVAC Cover
4. T25 Dog-Point Screw
5. Dash Cover
6. Upper Dash Assembly (center panel)

Fig. 2, Right-Hand Dash Panels, Argosy COE

top. Remove the left-hand dash endcap from the dash.

2.2 Remove the dash message center bezel.

2.3 Remove the two screws attaching the dash panel trimtop to the upper dash assembly. Leave the dash panel trimtop attached to the instrumentation control unit (ICU).



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A. 7/8 inch (22 mm)
1. Dog Point
2. T25 Torx Head

Fig. 3, Dog-Point Screw

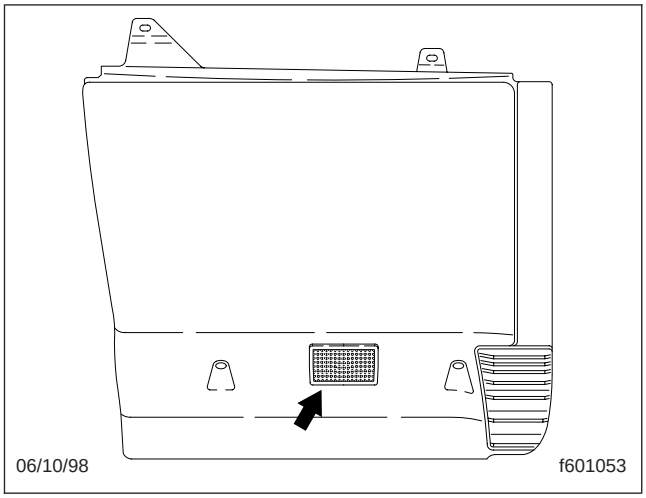

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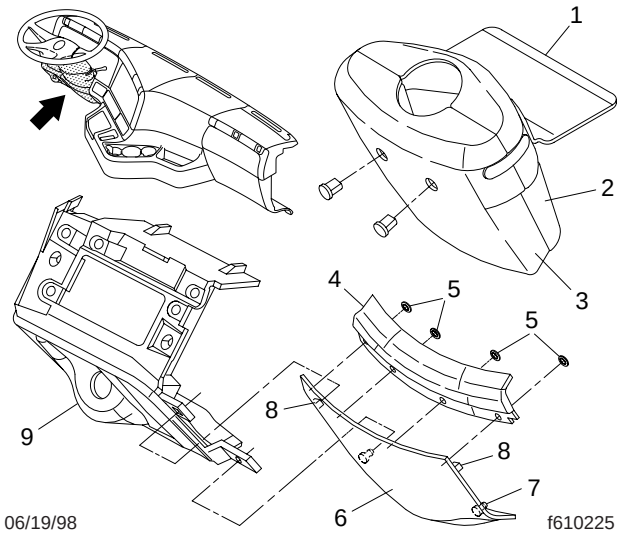
Fig. 4, Footwell Light

2.4 If necessary to gain access, remove the steering column cover (clamshell cover). For more information, refer to **Section 46.06**.

2.5 Work the bottom part of the instrument panel center trim out of the slot in the upper dash panel. Pull down on the center trim piece to free it from the mating surface on the upper dash assembly. Remove the center trim from the dash.

NOTE: Removing this trim piece allows removal of the ICU and the auxiliary instrument panel. For instructions, refer to **Section 54.03**.

Dash Panels Removal and Installation, Argosy COE



1. Steering Column Upper Cover Seal
2. Upper Steering Column Cover
3. Lower Steering Column Cover
4. Steering Column Lower Cover Seal
5. Push-On Retainer
6. Driver's Knee Bolster
7. Speed Clip
8. Hook
9. Keyswitch Housing

Fig. 5, Driver's Knee Bolster

UPPER DASH COMPONENTS

1. Remove the right-hand dash panels, using the instructions above.
2. Remove the keyswitch trimplate and left-hand dash endcap, using the instructions in "Left-Hand Dash Panels."
3. Remove the two screws attaching the dash panel trimtop to the upper dash assembly.
4. Remove the upper dash assembly. See **Fig. 8**.
   - 4.1 Remove the two screws attaching the upper dash panel to the inserts along the underside of the upper dash assembly (left-hand panel).
   - 4.2 Remove the two screws attaching the upper dash assembly (center panel) to the upper dash panel.
   - 4.3 Remove the screw attaching the dash brace to the upper dash assembly (center panel).
   - 4.4 Remove the two screws attaching the upper dash assembly (right-hand panel) to the HVAC unit.
   - 4.5 Remove the six screws located in the recessed areas around the louvers along the edge of the windshield.
   - 4.6 Remove the upper dash components from the vehicle.

Installation

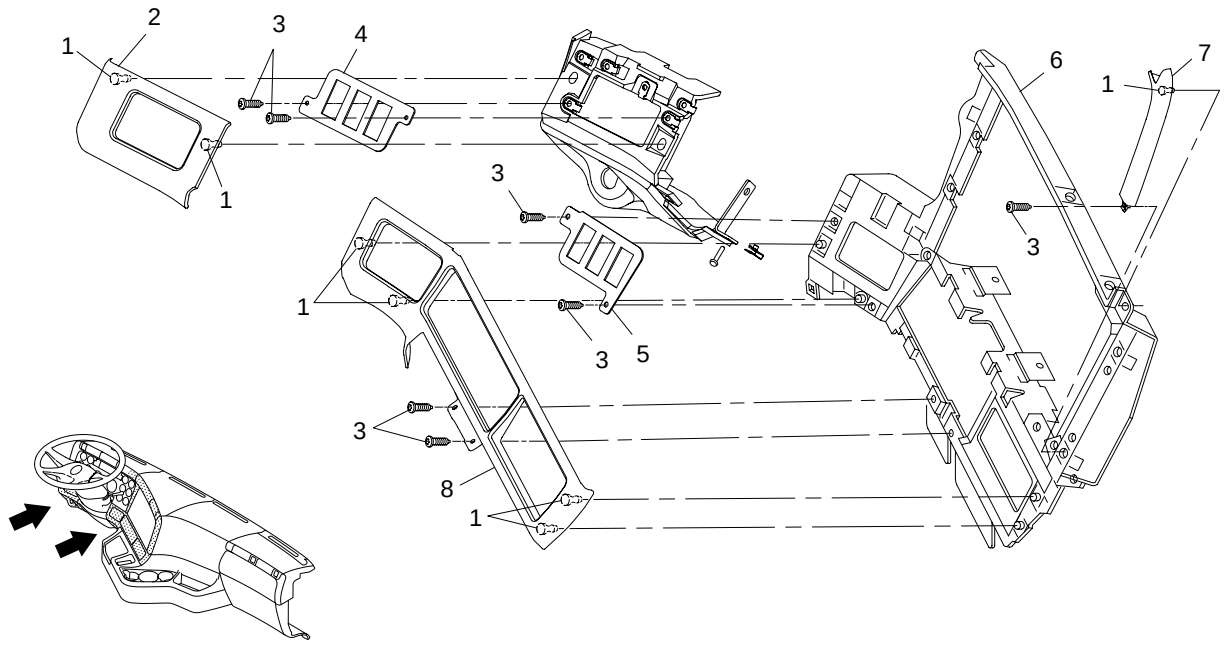
NOTE: When the dash is completely assembled (see **Fig. 8**), all dash fasteners are hidden from view.

UPPER DASH COMPONENTS

1. Install the upper dash assembly. See **Fig. 8**.

   NOTE: The upper dash assembly consists of three panels (left-hand, center, and right-hand) molded together.
   - 1.1 Fit the dash assembly into place along the edge of the windshield and over the top of the instrument panels.
   - 1.2 Install the six T25 dog-point screws in the recessed areas around the louvers along the edge of the windshield.
   - 1.3 Install the two screws attaching the upper dash panel to the inserts along the underside of the upper dash assembly (left-hand panel).
   - 1.4 Install the screw attaching the dash brace to the upper dash assembly (center panel).
   - 1.5 Install the two screws attaching the upper dash assembly (center panel) to the upper dash panel.
   - 1.6 Install the two screws attaching the upper dash assembly (right-hand panel) to the HVAC unit.
2. Install the right-hand dash panels, using the instructions below.
3. Install the keyswitch trimplate and left-hand dash endcap, using the instructions in "Left-Hand Dash Panels."

Dash Panels Removal and Installation, Argosy COE



1. Speed Clip
2. Keyswitch Trimplate
3. T25 Dog-Point Screw
4. Left-Hand Accessory Switch Panel
5. Right-Hand Accessory Switch Panel
6. Upper Dash Panel
7. Right-Hand Dash Trimcap
8. HVAC/Radio Trimplate

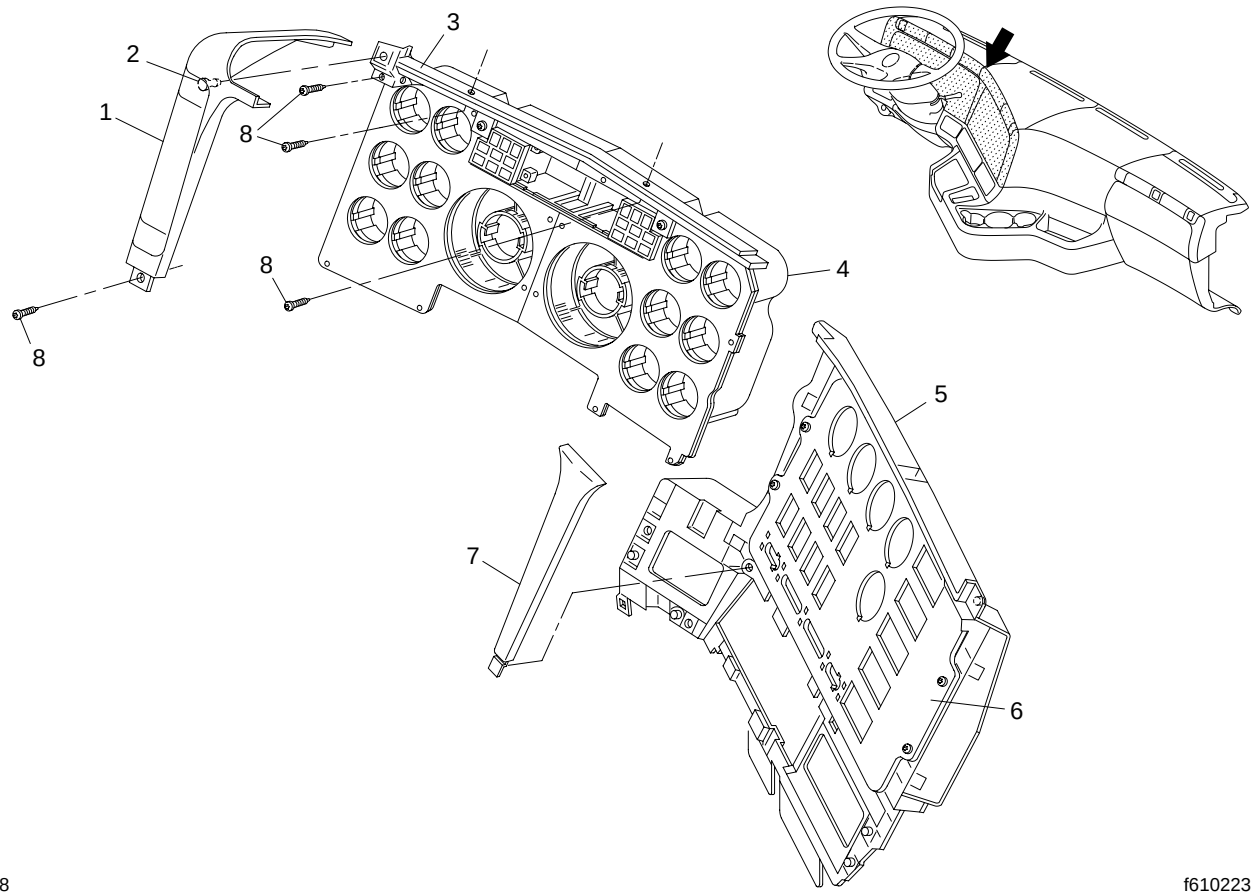
Fig. 6, Left-Hand Dash Trim Panels, Argosy COE

4. Install the two screws attaching the dash panel trimtop to the upper dash assembly.

LEFT-HAND DASH PANELS

1. Install the instrument panel trim. See **Fig. 7**.
   - 1.1 Insert the top edge of the instrument panel trim into its mating surface on the upper dash assembly. Insert the bottom edge of the instrument panel center trim down into the slot in the upper dash panel until it snaps into place.
   - 1.2 If removed, install the steering column cover (clamshell cover). For more information, refer to **Section 46.06**.
   - 1.3 Install the two screws attaching the dash panel trimtop to the upper dash assembly (left-hand panel).
   - 1.4 Snap the dash message center bezel into place.
   - 1.5 Install the speed clip attaching the left-hand dash endcap to the dash panel upper trimtop. Install the screw attaching the left-hand dash endcap to the keyswitch housing.
2. Install the left-hand dash trim panels. See **Fig. 3**.
   - 2.1 Install the screw and the speed clip attaching the right-hand dash trimcap to the upper dash panel.
   - 2.2 Install the two speed clips attaching the keyswitch trimplate to the keyswitch housing. If needed, replace the left-hand accessory/switch panel.
   - 2.3 Install the four speed clips and two screws attaching the HVAC/radio trimplate to the

Dash Panels Removal and Installation, Argosy COE



1. Left-Hand Dash End Cap
2. Speed Clip
3. Dash Panel Trimtop
4. Instrumentation Control Unit Housing
5. Upper Dash Panel
6. Auxiliary Instrument Panel
7. Instrument Panel Center Trim
8. T25 Dog-Point Screw

Fig. 7, Instrument Panel Trim, Argosy COE

upper dash panel. If needed, replace the right-hand accessory/switch panel.

2.4 Rotate the driver's cupholder down and into place, covering the screws on the HVAC/radio trimplate.

LOWER DASH CONSOLE

1. Position the console under the dash.
2. Install the eight fasteners.
3. Install the knee bolster. See **Fig. 5**.

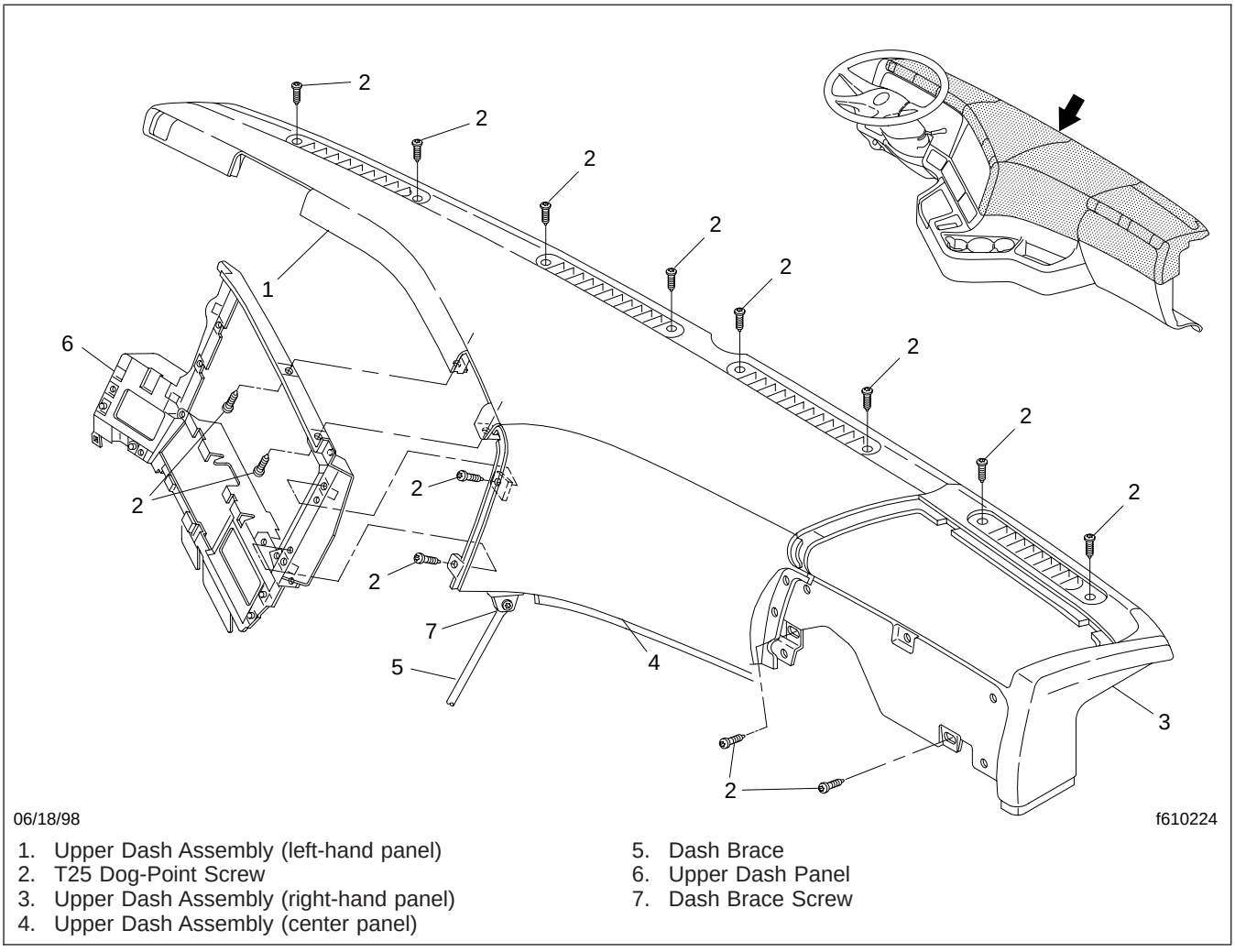
3.1 Install the hooks on the top of the knee bolster into the slots in the keyswitch housing and the upper dash panel.

3.2 Install the speed clips attaching the knee bolster to the keyswitch housing and the steering column bracket.

3.3 Press firmly against all four corners of the knee bolster to be sure all hooks and clips are firmly seated.

4. Install the transmission boot and the HVAC/radio assembly trimplate.

Dash Panels Removal and Installation, Argosy COE



1. Upper Dash Assembly (left-hand panel)
2. T25 Dog-Point Screw
3. Upper Dash Assembly (right-hand panel)
4. Upper Dash Assembly (center panel)
5. Dash Brace
6. Upper Dash Panel
7. Dash Brace Screw

Fig. 8, Upper Dash Assembly, Argosy COE

RIGHT-HAND DASH PANELS

1. Connect the electrical connector (see **Fig. 2**) on the footwell light.
2. Place the HVAC cover (see **Fig. 4**) into position over the upper dash assembly and install the two screws into the holes at the top of the HVAC cover.
3. Install the two screws at the bottom of the HVAC cover.
4. Install the electrical cover on the dash.
5. Attach the four speed clips on the right-hand upper dash cover to the HVAC cover. See **Fig. 2**.

Exterior Sun Visor Removal and Installation

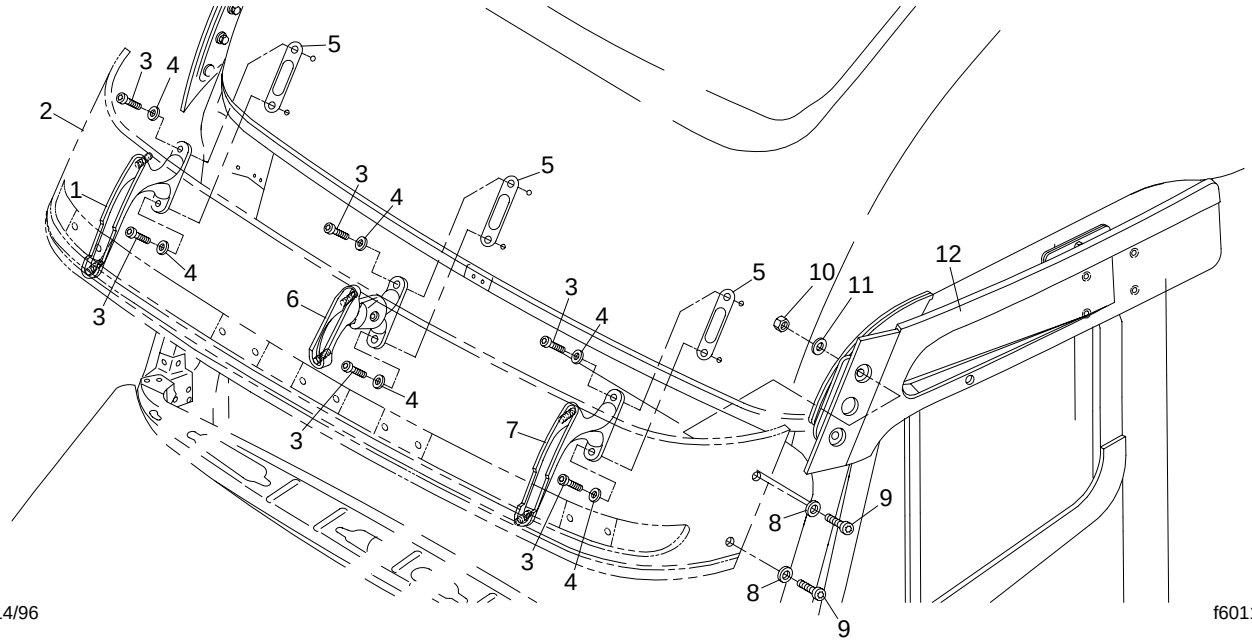
Sun Visor Removal

1. Park the vehicle, apply the parking brakes, then chock the tires.
2. Remove the front sun visor. See **Fig. 1** and **Fig. 2**.
   - 2.1 Remove the two 5/16–18 Torx®-head screws that hold both ends of the front sun visor to the side sun visors.
   - 2.2 Remove the 5/16–18 Torx-head screws and washers holding the front sun visor mounting brackets to the cab.
   - 2.3 Pull out the surplus wiring from the cab (where the right front mounting bracket was installed); then disconnect it.
   - 2.4 Remove the front sun visor, mounting brackets, and seals.
   - 2.5 If replacing the sun visor itself, remove the 5/16–18 hexnuts and washers that hold the three mounting brackets to the visor; then remove the brackets.
3. If replacing the marker lights, remove the wiring harness cover from the back of the sunvisor; then remove the two screws holding each marker light in place and remove the marker light.
4. Remove the side sun visors. See **Fig. 3**.
   - 4.1 Remove the remaining 5/16–18 hexnut and washer holding the left side sun visor to the forward outer mounting bracket.
   - 4.2 Remove the four 5/16–18 hexnuts and washers holding the left side sun visor to the rear outer mounting bracket.
   - 4.3 Remove the left side sun visor.
   - 4.4 Repeat the procedure for the right side sun visor.
5. If needed, remove the side sun visor mounting brackets. See **Fig. 4**.
   - 5.1 Remove the Torx-head screws and washers from the forward and rear outer mounting brackets.
   - 5.2 Remove the brackets and their seals from the side of the cab.

Sun Visor Installation

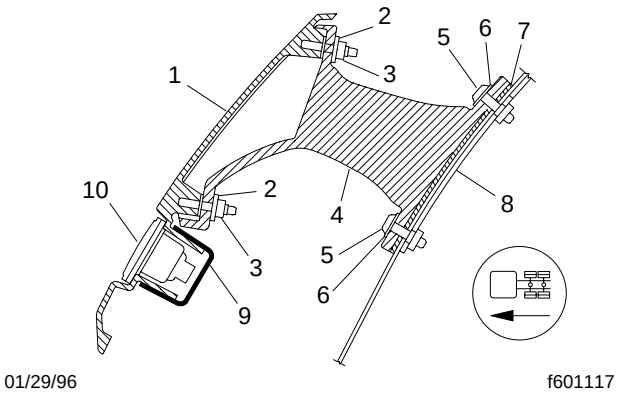
1. Install the side sun visors.
   - 1.1 If they were removed, install the forward and rear outer mounting brackets and their seals above the door frames.
   - 1.2 Align the left side sun visor with the forward and rear mounting brackets. Install the 5/16–18 hexnuts and washers. Tighten them firmly.
   - 1.3 Repeat the procedure for the right side sun visor.
2. Install the front sun visor.
   - 2.1 If they were removed, install the marker lights into the front sun visor. Install the wiring harness cover onto the back of the sun visor.
   - 2.2 If they were removed, install the three mounting brackets onto the front sun visor, using the 5/16–18 hexnuts and washers. Tighten the nuts firmly.
   - 2.3 Feed the wiring harness through the right mounting bracket
   - 2.4 Connect the marker light wiring to the cab harness, then push the extra length of wiring into the cab.
   - 2.5 Align the three mounting brackets with the holes in the cab roof. Make sure the holes on the ends of the front sun visor line up with those of the two side sun visors.
   - 2.6 Attach the front sun visor and mounting brackets to the cab roof, using 5/16–18 Torx-head screws. Tighten the screws firmly.
   - 2.7 Attach the ends of the front sun visor to the side sun visors, using the 5/16–18 Torx-head screws, hexnuts, and washers. Tighten the fasteners firmly.
3. Remove the chocks from the tires.

Exterior Sun Visor Removal and Installation



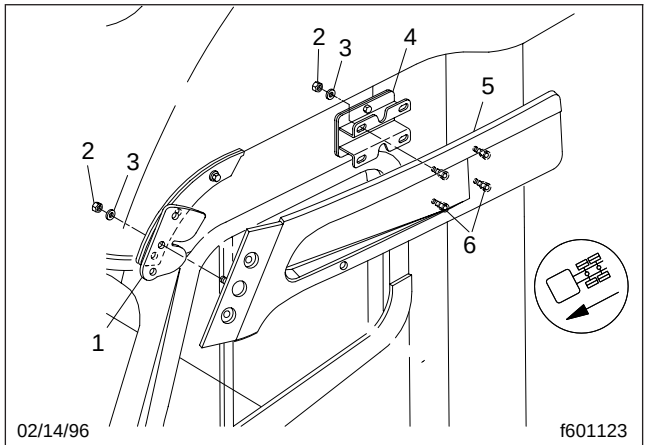
1. Side Mounting Bracket, Right
2. Front Sun Visor
3. 5/16–18 Torx®-Head Screw
4. Flatwasher
5. Seal
6. Center Mounting Bracket
7. Side Mounting Bracket, Left
8. Washer
9. Torx-Head Screw
10. Hexnut
11. Flatwasher
12. Side Sun Visor

Fig. 1, Front Exterior Sun Visor Installation



1. Front Sun Visor
2. Flatwasher
3. 5/16–18 Hexnut
4. Mounting Bracket
5. Torx-Head Screw
6. Washer
7. Seal
8. Cab Skin
9. Wiring Harness Cover
10. Parking Light

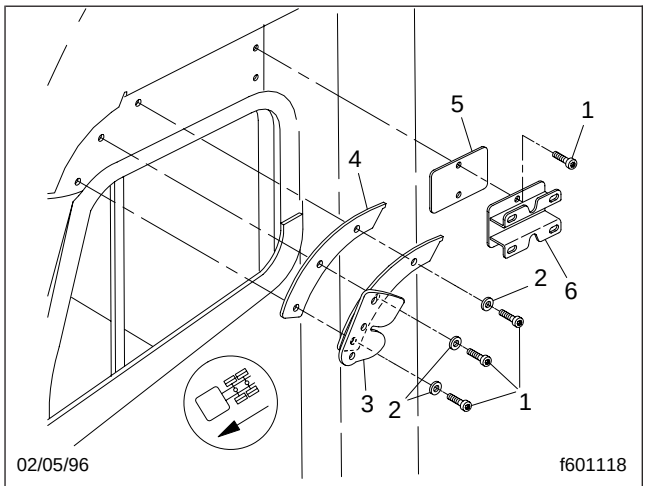
Fig. 2, Cross Section View



1. Front Outer Mounting Bracket
2. 5/16–18 Hexnut (4 qty.)
3. Flatwasher (4 qty.)
4. Rear Outer Mounting Bracket
5. Left Side Sun Visor
6. Threaded Stud (4 qty.)

Fig. 3, Side Sun Visor Installation

Exterior Sun Visor Removal and Installation



1. Torx-Head Screw
2. Washers
3. Front Outer Mounting Bracket
4. Seal
5. Seal
6. Rear Outer Mounting Bracket

Fig. 4, Side Sun Visor Mounting Brackets

IMPORTANT: Interior components are varied and optional. The following generalized information is intended for broad use, and should not be considered as a guide for a specific vehicle.

Wrap-Around Storage Side Cabinets

See **Fig. 1**.

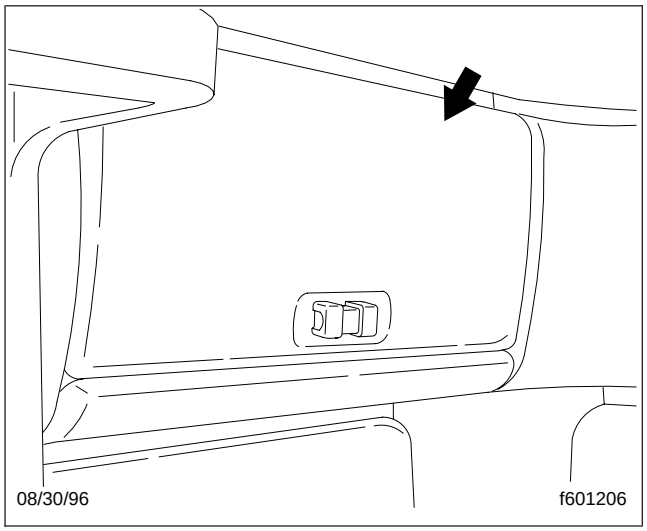


Fig. 1, Wrap-Around Storage Side Cabinet

Side Cabinet Removal

1. Park the vehicle on a level surface. Shut down the engine. Set the parking brake and chock the front tires.

IMPORTANT: The rear center cabinet must be removed before the side cabinets can be removed.

2. Remove the Torx® screws that hold the storage cabinet to the roof.

NOTE: The number of fasteners varies according to the type and style of interior components.

3. Lower the front edge of the cabinet, and disconnect the speaker wires behind it.
4. Lift up the rear of the cabinet so that the cabinet clears the edge of the side upholstery panel, then slide it out.
5. Repeat the procedure for the cabinet on the other side of the vehicle.

Side Cabinet Installation

IMPORTANT: The side cabinets must be installed before the rear center cabinet is installed.

NOTE: When installing the side cabinets, tip them in at the bottom so that the lips on the rear edge of the cabinets hook over the mounting channel behind the upholstery panels.

1. Slide the side cabinet in position, taking care to clear the side panel. Make sure the cabinet fully seats into the mounting channel.
2. Keeping the front edge of the cabinet lowered, connect the speaker wires behind it.
3. Attach the cabinet to the roof, using the Torx screws.
4. Repeat the procedure for the cabinet on the other side of the vehicle.

Wrap-Around Storage Rear Center Cabinet

See **Fig. 2**.

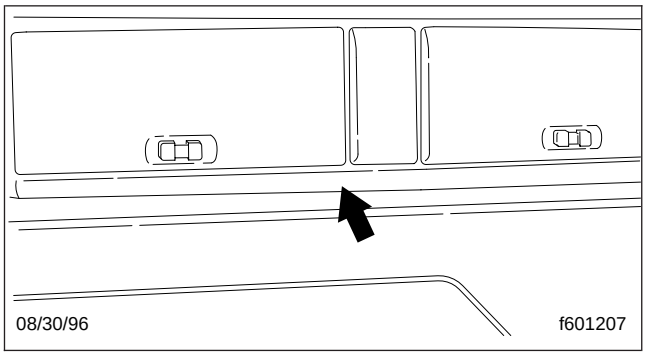


Fig. 2, Wrap-Around Storage Rear Center Cabinet

Rear Center Cabinet Removal

1. Park the vehicle on a level surface. Shut down the engine. Set the parking brake and chock the front tires.

Removal and Installation

IMPORTANT: The rear center cabinet must be removed before the side cabinets can be removed.

2. Remove the Torx screws that hold the storage cabinet to the rear headliner.

NOTE: The number of fasteners varies according to the type and style of interior components.

3. Maneuver the bottom of the storage cabinet to clear the rail above the rear wall upholstery panel. Allow the cabinet to drop down at the forward edge, then lift the rear of the cabinet.
4. Remove the storage cabinet from the vehicle.

Rear Center Cabinet Installation

IMPORTANT: The side cabinets must be installed before the rear center cabinet is installed.

NOTE: When installing the rear center cabinet, tip it in at the bottom so that the lip on the rear edge of the cabinet hooks over the mounting channel behind the upholstery panels. Make sure the cabinet fully seats into the rearwall extrusion.

1. Lift the storage cabinet into position.
2. Attach the cabinet in place using the Torx screws.

NOTE: The number of fasteners varies according to the type and style of interior components.

Upper Forward Side Storage Cabinet

See **Fig. 3**.

Removal

1. Park the vehicle on a level surface. Shut down the engine. Set the parking brake and chock the front tires.
2. Remove the two fasteners that attach the storage cabinet to the headliner and the roof.
3. Remove the fasteners that attach the storage cabinet to the side wall. If the interior configuration features a lower cabinet below, remove the four fasteners (typically located under an upholstery panel) that attach the bottom of the upper cabinet to the top of the lower cabinet.

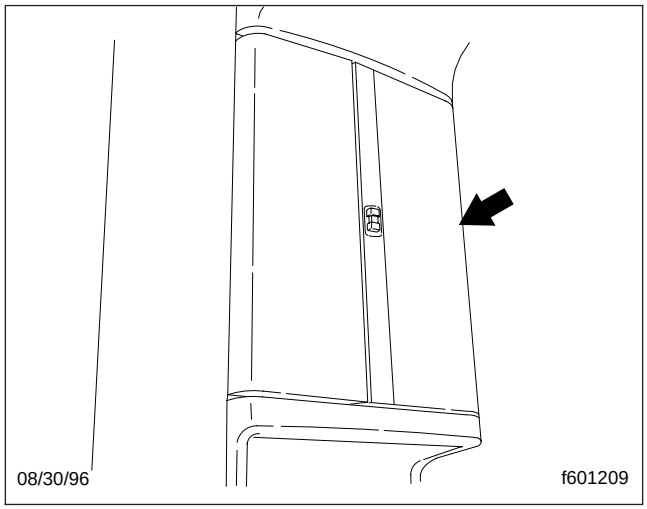


Fig. 3, Upper Forward Side Storage Cabinet

NOTE: The number of fasteners varies according to the type and style of interior components.

4. Remove the storage cabinet.

Installation

1. Position the side storage cabinet.
2. Attach the side storage cabinet to the side wall using the fasteners. Attach the upper cabinet to the lower cabinet, if so equipped, with the four fasteners.
3. Attach the side storage cabinet to the headliner and roof using the fasteners.

Front Overhead Side Consoles

See **Fig. 4**.

Removal

1. Park the vehicle on a level surface. Shut down the engine. Set the parking brake and chock the front tires.
2. Remove the privacy curtain and the curtain rail from the forward headliner. The fasteners are in the top track.

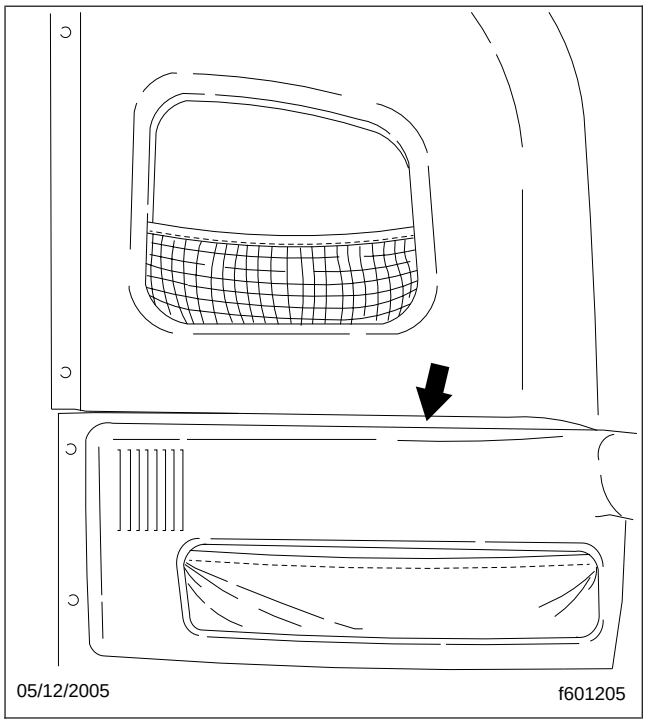


Fig. 4, Front Overhead Side Console

3. Remove the four fasteners that attach the side console in place.

Installation

1. Position the side console in place.
2. Attach the side console with the four fasteners.
3. Install the privacy curtain rail and the privacy curtain.

Front Overhead Center Storage Console

See **Fig. 5**.

Removal

1. Park the vehicle on a level surface. Shut down the engine. Set the parking brake and chock the front tires.
2. Remove the A-pillar inner covers.
3. Remove the passenger-side grab handle.

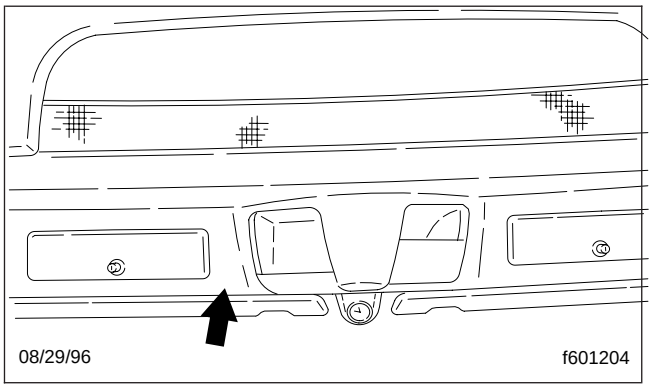


Fig. 5, Front Overhead Center Storage Console

4. Remove the privacy curtain and the curtain rail.
5. Remove the front overhead side consoles.
6. Remove the six fasteners that attach the center console to the windshield header.
7. Lower the center overhead console, then disconnect the wiring harness at the right-hand A-pillar.

Installation

1. Connect the wiring harness at the right-hand A-pillar.
2. Lift the center overhead console into position.
3. Attach the console with the six fasteners.
4. Install the front overhead side consoles.
5. Install the privacy curtain rail and the privacy curtain.
6. Install the upholstery panels on the A-pillar.
7. Install the passenger-side grab handle.

Side Wall Upholstery Panel

See **Fig. 6**.

Removal

1. Park the vehicle on a level surface. Shut down the engine. Set the parking brake and chock the front tires.
2. Remove the upper and lower forward side storage cabinets.

Removal and Installation

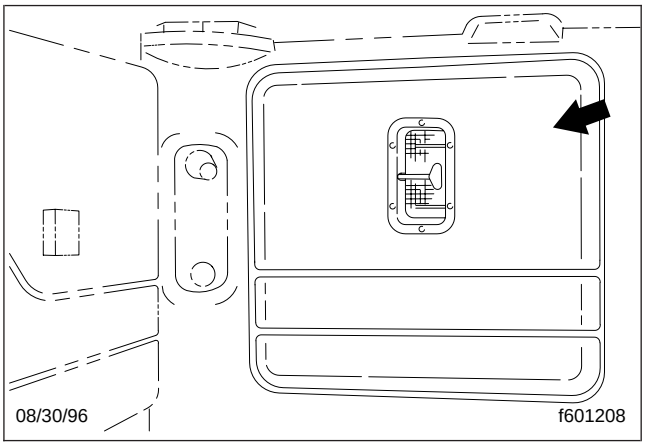


Fig. 6, Side Wall Upholstery Panel

3. Remove the upper rear side (wrap-around) storage cabinets.
4. Remove the trim from the sleeper vent.
5. On the left side, remove the HVAC control panel, and disconnect the wiring.
6. Remove the side panels, using care to keep the Christmas-tree fasteners attached to the panel.

Installation

1. Attach the side panels with the Christmas-tree fasteners.
2. Connect the wiring and install the HVAC control panel.
3. Install the sleeper vent trim.
4. Install the upper rear side (wrap-around) storage cabinets.
5. Install the upper and lower forward side storage cabinets.

Rear Headliner

Removal

1. Park the vehicle on a level surface. Shut down the engine. Set the parking brake and chock the front tires.
2. Remove the side storage (wrap-around) cabinets. Then remove the rear upper center cabinets.
3. Remove the upper forward side storage cabinets.
4. Remove the dome light by popping off the lens, removing the screw, and disconnecting the wiring.
5. Remove the moldings along the front edge of the headliner.
6. Remove the four Christmas-tree fasteners, then pry free the headliner.

Installation

1. Install the headliner, using the Christmas-tree fasteners.
2. Install the dome light.
3. Install the upper forward side storage cabinets.
4. Install the rear upper side storage cabinets, then the rear upper center (wrap-around) cabinets.
5. Install the moldings along the front edge of the headliner.

Forward Headliner

Removal

1. Park the vehicle on a level surface. Shut down the engine. Set the parking brake and chock the front tires.
2. Remove the privacy curtain and the privacy curtain rail.
3. Remove the sleeper curtain and the sleeper curtain rail.
4. Remove the dome light by popping off the lens, removing the screw, and disconnecting the wiring.
5. Remove the four Christmas-tree fasteners and pry free the forward headliner.

Installation

1. Install the forward headliner using the four Christmas-tree fasteners.
2. Install the dome light.
3. Install the privacy curtain rail and the privacy curtain.

4. Install the sleeper curtain rail and the sleeper curtain.

Day Cab Headliner

See **Fig. 7**.

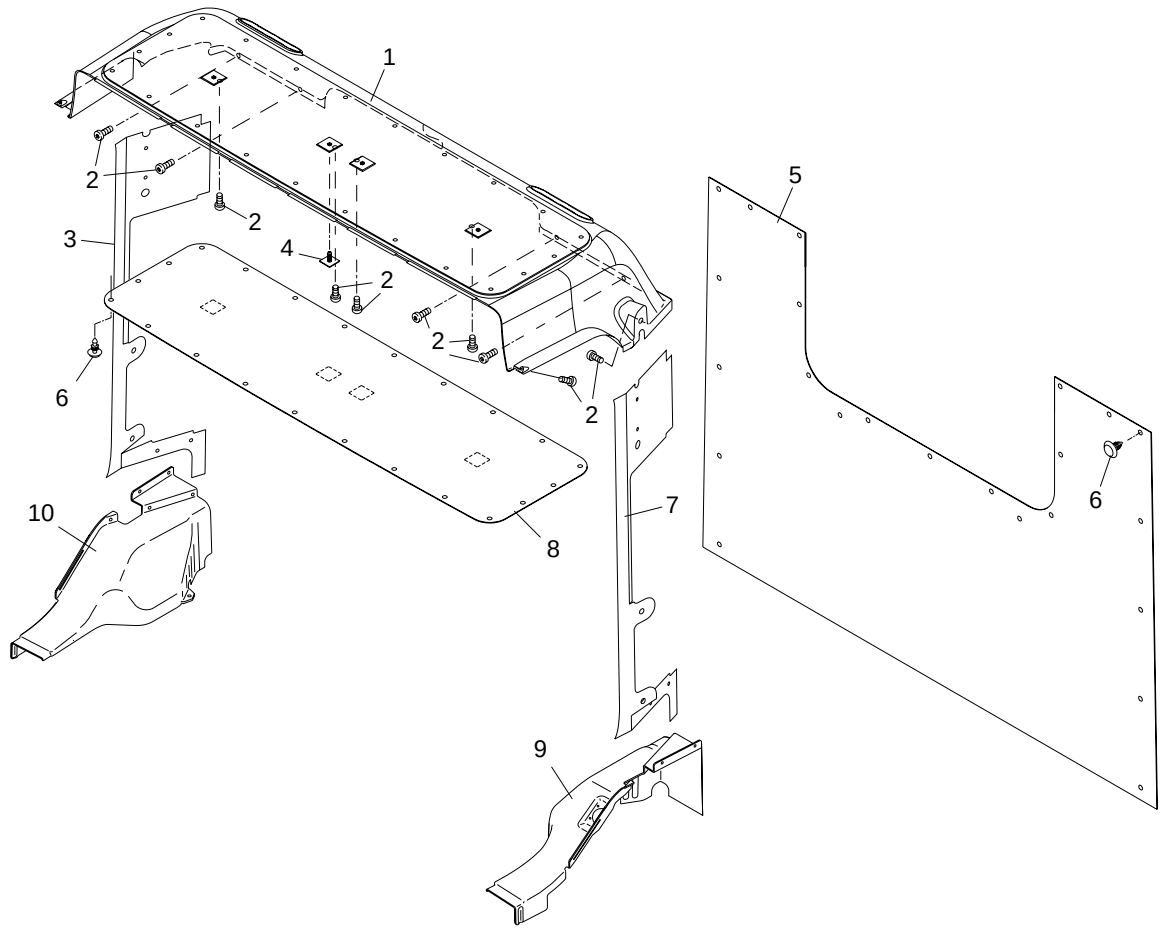
Removal

1. Park the vehicle on a level surface, apply the parking brake, shut down the engine, and chock the front and rear tires.
2. Remove the passenger seat from the cab. For instructions, see **Group 91** in this manual. Slide the driver seat forward out of the way.
3. Remove the left and right door sill tread plates by removing the three T20 Torx screws in each.
4. Remove the left and right lower B-pillar covers.
   - 4.1 Remove the diagnostic connector trim plate on the driver-side cover by prying it up.
   - 4.2 Pry loose the door trim molding along the rear edge of the door frame, from bottom to top. The edges of the lower B-pillar cover and the B-pillar upholstery panel are now exposed.
   - 4.3 Remove the clip that holds the cover to the door frame.
   - 4.4 Remove the T25 Torx screw located at the back of the cover. Remove the cover.
5. Remove the left and right B-pillar upholstery panels.
   - 5.1 Remove the interior grab handle by removing the two T40 Torx capscrews that hold it to the cab.
   - 5.2 Remove the two T50 Torx capscrews that hold the upper seat-belt mount to the cab. See **Fig. 8**. Lower the seat-belt mount to the cab floor.
   - 5.3 Remove the panel.
6. Remove the coat hanger hooks (if so equipped), each of which is attached with two T20 Torx screws.
7. Remove the first-aid box (if so equipped), which is attached with two T20 Torx screws.
8. Remove the rear upholstery panel by carefully prying free the upholstery fasteners that attach the panel to the cab rear wall. Remove the panel from the cab.
9. Remove the headliner upholstery insert panel by carefully prying free the upholstery fasteners that attach the insert panel to the headliner trim panel. Pull the panel free of the Velcro® fasteners, and remove it from the cab.
10. Remove the headliner trim panel.
    - 10.1 Remove the six T20 Torx screws along the lower back edge and sides of the panel.
    - 10.2 Remove the four T20 Torx screws, located next to the Velcro fasteners, that attach the panel to the cab roof.
    - 10.3 Remove the two T20 Torx screws, located above each door, that hold the panel to the forward overhead console.
    - 10.4 Remove the panel from the cab.

Installation

1. Install the headliner trim panel using the Torx screws.
2. Attach the headliner upholstery insert panel to the headliner trim panel using the Velcro and upholstery fasteners.
3. Install the first-aid box, if so equipped.
4. Install the coat hanger hooks, if so equipped.
5. Install the left and right B-pillar upholstery panels.
   - 5.1 Position the panel on the B-pillar.
   - 5.2 Install the upper seat-belt mount to the B-pillar using the two T50 Torx capscrews. See **Fig. 8**.
   - 5.3 Install the interior grab handle, using the T40 Torx capscrews.
6. Install the left and right lower B-pillar covers.
   - 6.1 Attach the back of the cover to the B-pillar using the T25 Torx screw.
   - 6.2 Install the clip to hold the cover to the door frame.

Removal and Installation



1. Headliner Trim Panel
2. Torx Screw, T20
3. B-Pillar Upholstery Panel, Right Side
4. Velcro Fastener
5. Rear Upholstery Panel
6. Upholstery Fastener
7. B-Pillar Upholstery Panel, Left Side
8. Headliner Upholstery Insert Panel
9. Lower B-Pillar Cover, Left Side
10. Lower B-Pillar Cover, Right Side

Fig. 7, Upholstery Panels, Day Cab

6.3 Press the loosened door trim molding onto the door frame.

6.4 Install the diagnostic connector trim plate on the driver-side cover.

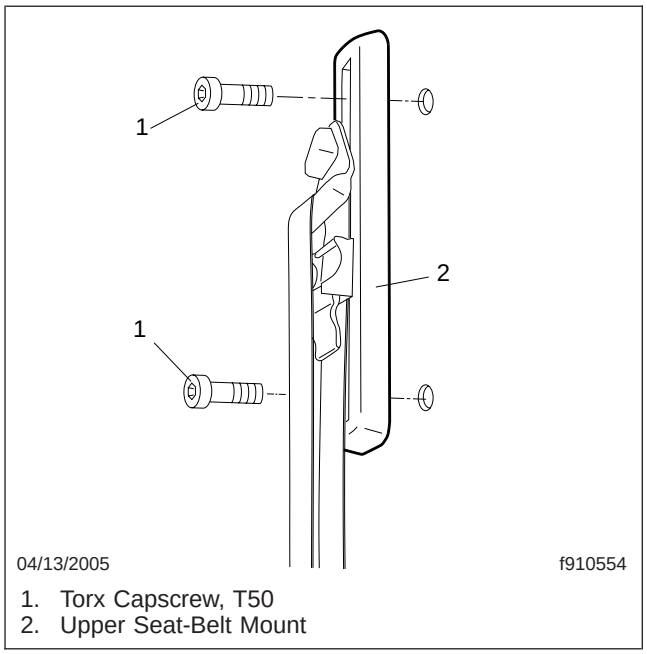
7. Install the left and right door sill plates using the T20 Torx screws.
8. Install the passenger seat in the cab. For instructions, see **Group 91** in this manual.

Back Wall Upholstery Panel

See **Fig. 9**.

Removal

1. Park the vehicle on a level surface. Shut down the engine. Set the parking brake and chock the front tires.



1. Torx Capscrew, T50
2. Upper Seat-Belt Mount

Fig. 8, Upper Seat-Belt Mount Installation

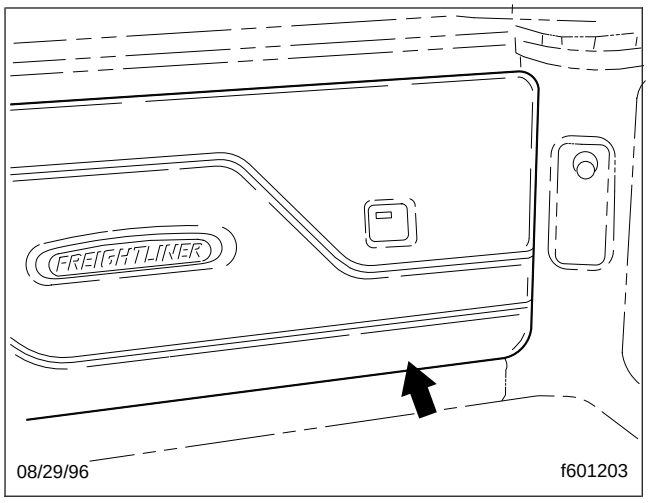


Fig. 9, Back Wall Upholstery Panel

2. Remove all of the upper (wrap-around) storage cabinets, beginning with the side storage cabinets.
3. Carefully pry free the Christmas-tree fasteners that attach the back wall upholstery panel.
4. Remove the back wall panel.

Installation

1. Position the back wall panel in place.
2. Install the back wall panel using the Christmas-tree fasteners.
3. Install the upper (wrap-around) storage cabinets.

General Description

BAGGAGE DOORS

On vehicles with sleeper compartments, baggage doors allow access to the storage compartments under the sleeper bunk.

The baggage doors have rounded corners, single-panel construction, a piano-style hinge, and a one-piece extruded aluminum door frame. A neoprene sponge bulb seal is set into the door frame. A door check cable limits opening the door beyond approximately 105 degrees.

Baggage doors have a keyed lock cylinder and a paddle handle. The same key used for the cab doors and the ignition is used for the baggage doors.

Baggage doors on Argosy COEs are opened by pulling a knob mounted inside the cab door. However, some Argosy COEs may be equipped with a keyed lock cylinder and paddle handle.

ACCESS DOOR

Access to sleeper compartments is provided by an access door, in addition to the walk-through opening at the back of the cab. The access door is on the passenger side of the vehicle. The access door is a rounded-corner, bulkhead-style door.

The door is flush with the outermost edge of the drip molding. A neoprene bulb seal fits into the inner flange of the door opening. There is a gas spring door check to prevent the door from opening too far.

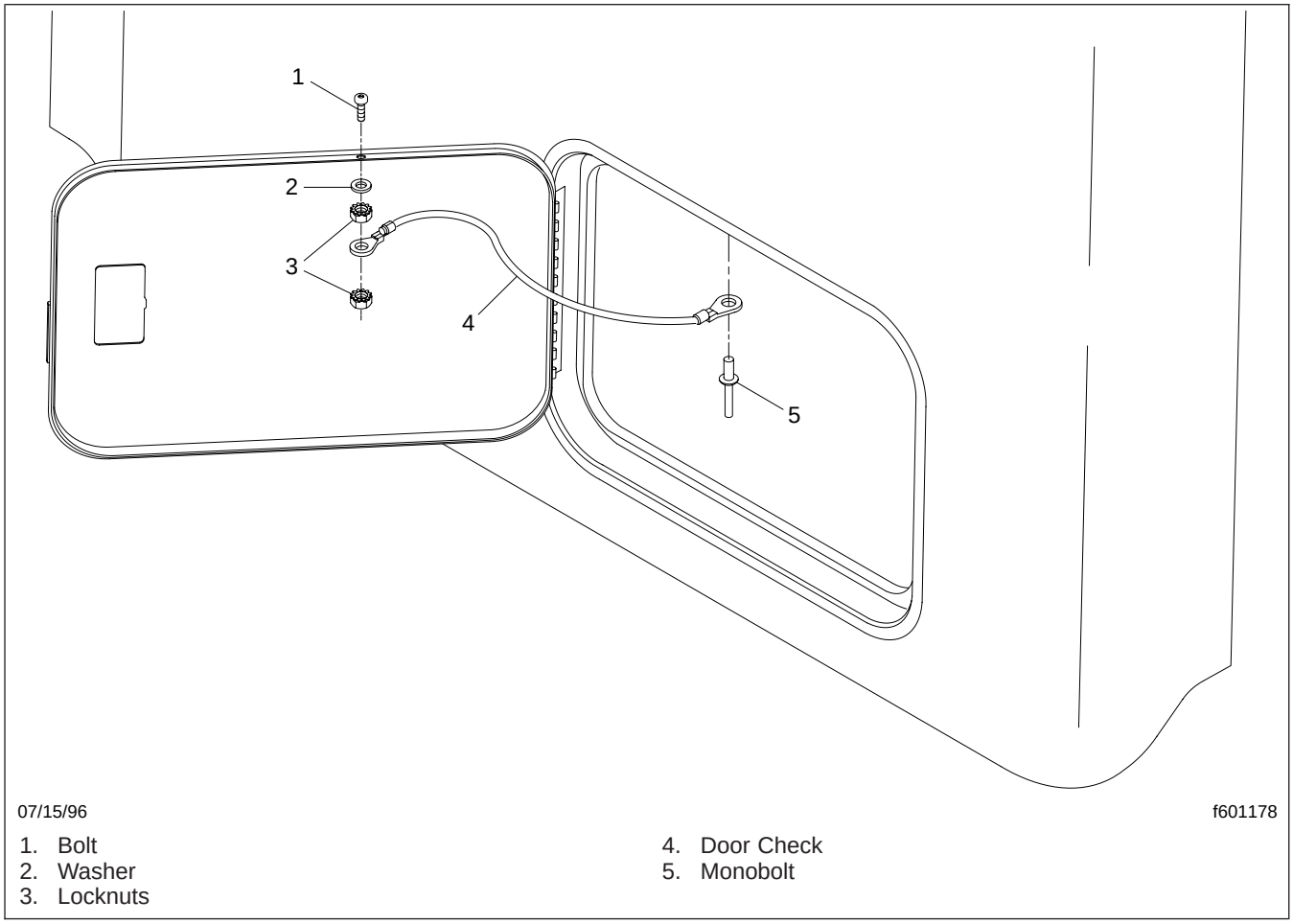
An optional lever handle releases the access door from inside the sleeper compartment.

Argosy COEs are not manufactured with access doors.

Baggage Door Replacement

Replacement

1. Park the vehicle on a flat surface. Shut down the engine. Set the parking brake. Chock the tires.
2. Open the baggage door.
3. Disconnect the door check cable. See **Fig. 1**.
8. Install the baggage door to the door hinge with fasteners, then buck rivet the door into place, removing the fasteners.
9. Attach the door check cable.
10. Install the baggage liner upholstery.



1. Bolt
2. Washer
3. Locknuts
4. Door Check
5. Monobolt

Fig. 1, Baggage Door

4. Partially remove the baggage liner upholstery.
5. Drill out the rivets attaching the door hinge to the door.
6. Remove the door from the vehicle.
7. Position the door to the vehicle.
11. Remove the chocks from the tires.

Replacement

1. At the seal seam located at the center of the bottom of the door frame, pull the entire length of the seal out of the door frame. See **Fig. 1**.
2. Clean and dry the seal area of the door frame. Remove any grease or dirt from the surface.
3. If not already done, cut a length of new door seal that is slightly longer than the total perimeter of the baggage door.
4. Using a soap-and-water solution, and beginning with one (squared off) end of the seal at the center of the bottom inside edge of the door frame, install the door seal, making sure that the contour of the seal is fitted to the curved lip of the door panel all the way around its perimeter. To avoid pulling the seal away from the corners of the door frame, do not stretch the seal.
5. Just prior to complete seating of the door seal, cut off (square) the excess length of the seal so that the two ends will form a hairline seam (butt joint) at the center of the bottom of the door panel. Press the seal ends together.
6. Test the door for ease of opening and closing.

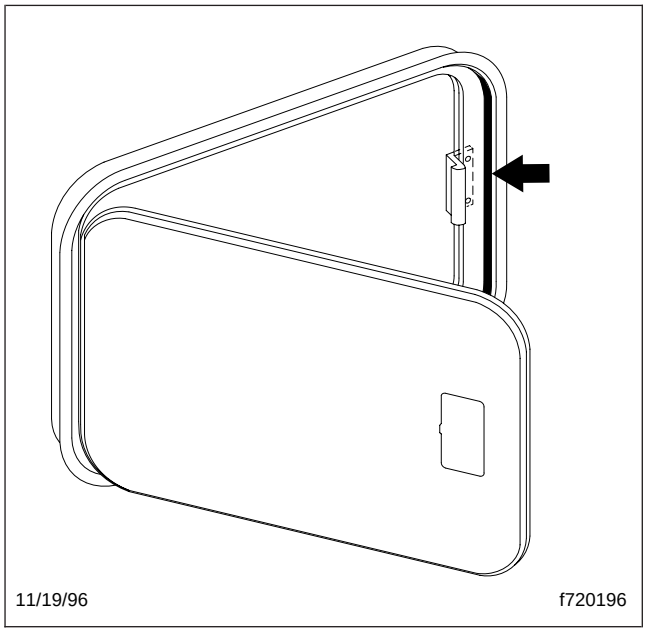
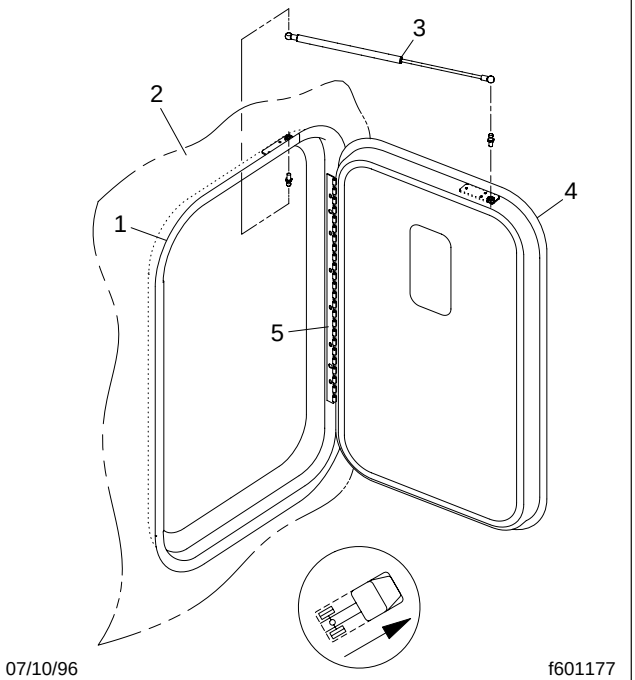


Fig. 1, Baggage Door Seal

Removal

1. Park the vehicle on a flat surface. Shut down the engine. Set the parking brake. Chock the tires.
2. Disconnect the door check strut at the top of the door by removing the clip cover that attaches the strut end to the door. See **Fig. 1**.



1. Door Frame
2. Cab Wall
3. Door Check Strut
4. Access Door
5. Hinge

Fig. 1, Access Door

3. Remove the interior cab trim for access to the fasteners that attach the door hinge to the cab.
4. Remove the door by removing the rivets holding the door in place.
5. To install the door, position the door into place on the door frame, then rivet into place.
6. Attach the clip cover connecting the door strut to the top of the door.
7. Close the door, and test for proper closing.
8. Install the interior cab trim.

Replacement

1. Gripping the end of the door seal, pull the entire length of the seal away from the inner door frame.
2. Remove any grease or dirt from the seal flange.
3. Using a soap-and-water solution, install the new seal onto the inner door frame so the bulb-portion of the seal is facing the door when the door is open. The ends of the seal should be located at the bottom of the door frame. To avoid pulling the seal away from the corners of the inner door frame, do not stretch the seal.
4. Just prior to complete seating of the door seal, cut off (square) any excess length of the seal so that the two ends will form a hairline seam (butt joint).
5. Test the door for ease of opening and closing.

Specifications

Torque Values	
Description	**Torque lbf·in (N·m)**
Sleeper Box Access Door Striker Pin	50 (68)

Table 1, Torque Values

Air Horn Valve Removal and Installation

Removal

1. Park the vehicle. Set the parking brake. Shut down the engine and chock the tires.
2. Drain the air supply, and disconnect the batteries.
3. Remove the overhead console. See **Section 60.13** for instruction.
4. Disconnect the air hoses from the air horn valve. Mark the hoses for later reference.
5. Remove the fasteners that attach the air horn valve to the mounting bracket.
6. Disconnect the air horn control cable from the air horn valve.
7. Remove the air horn valve.

Installation

1. Position the air horn valve.
2. Connect the control cable to the air horn valve.
3. Mount the valve on its brackets and secure it with the fasteners.
4. Connect the air hoses to the air horn valve.

CAUTION

CAUTION: Do not overtighten the air hose fittings. Hand-tighten the fittings 1/2-turn after tightening begins. Overtightening the fittings could cause the hoses to leak, to malfunction, and to affect the vehicle air system.

5. Install the overhead console. See **Section 60.13** for instruction.
6. Connect the batteries.
7. Remove the chocks from the tires. Start the engine, and refill the air supply.
8. Test the horn.

Overhead Console Removal and Installation, Century Class Conventional

Removal

1. Park the vehicle. Set the parking brake. Shut down the engine and chock the tires.
2. Drain the air supply, and disconnect the batteries.
3. Remove the curtains from the curtain rails.
4. Remove the Torq-head fasteners attaching the curtain rails to the underside of the overhead console. Then, remove the curtain rails.
5. Remove all items from the overhead console compartments.
6. Peel the door moldings from the inner door frames.
7. Remove the grab handle from the right A-pillar cover. Then, remove both A-pillar covers. Do so by pulling back on the pillar cover, which is held in place by three tabs.
8. Set aside the VORAD sensor device (if equipped) from the right A-pillar.
9. Remove the fasteners attaching the side front console panels above the driver and passenger seats. Remove the panels.
10. Remove the six fasteners holding the overhead console in place.
11. Remove the overhead console by pulling it out and then swinging it downward.
12. Disconnect the electrical wiring connectors.
13. Remove the overhead console from the vehicle.

Installation

1. Position and then slide the overhead console into place.
2. Connect the electrical wiring connectors.
3. Install the six fasteners that attach the console to the cab structure.
4. Attach the side front console panels.
5. Attach the VORAD sensor to the right A-pillar cover, if it was removed.
6. Install the A-pillar covers by snapping them into place.
7. Install the grab handle on the rightside A-pillar.
8. Attach the door moldings to the inner door frames.
9. Install both curtain rails.
10. Attach each curtain to the curtain rails.
11. Connect the batteries.
12. Remove the chocks from the tires.

Overhead Console Removal and Installation, Argosy COE

Removal

1. Park the vehicle on a level surface. Shut down the engine. Set the parking brake and chock the front and rear tires.
2. Drain the air supply, and disconnect the batteries.
3. Remove the curtains from the curtain rails.
   - 3.1 Remove the stopper at the aft ends of the curtain rails.
   - 3.2 Remove the curtains by pulling them out of the aft rail end.
4. Remove the eight Torq-head fasteners attaching the curtain rails to the underside of the overhead console. Then, remove the curtain rails.
5. Remove all items from the overhead console compartments.
6. Peel the door moldings from the inner door frames.
7. Remove the grab handle from the right A-pillar cover. Then, remove both A-pillar covers. Do so by pulling back on the pillar covers, which are held in place by three tabs.
8. Set aside the VORAD sensor device (if equipped) from the right A-pillar.
9. Remove the fasteners attaching the side front console panels above the driver and passenger seats.

NOTE: There is a Torx-head fastener in the bottom of the top shelf of the overhead console.

10. Remove each panel.
11. Remove the six fasteners holding the overhead console in place.
12. Remove the overhead console by pulling it out and then swinging it downward.
13. Disconnect the electrical wiring connectors.
14. Remove the overhead console from the vehicle.

Installation

1. Position and then slide the overhead console into place.

NOTE: It may be necessary to attach the overhead console beam cover.

2. Connect the electrical wiring connectors.
3. Install the six fasteners that attach the console to the cab structure.
4. Attach the side front console panels.
5. Attach the VORAD sensor to the right A-pillar cover, if necessary.
6. Install the A-pillar covers by snapping them into place.
7. Install the grab handle on the rightside A-pillar cover.
8. Attach the door moldings to the inner door frames.
9. Install both curtain rails.
10. Slide each curtain onto the curtain rails.
11. Attach the curtain stopper at the aft end of each curtain rail.
12. Connect the batteries.
13. Remove the chocks from the tires.

Safety Precautions

CAUTION

Before performing any electric welding on a vehicle, disconnect the battery power and ground cable, and any electronic control units or similar devices installed on the vehicle. Electric currents produced during electric welding can damage various electrical components on the vehicle, which could result in malfunction of the components.

1. Park the vehicle on a level surface. Shut down the engine. Set the parking brake, and chock the front and rear tires.
2. Tilt the hood.
3. Disconnect the batteries. Attach the welding ground strap as close to the work being done as safely possible.
4. Disconnect the following ECUs and other electronic devices:

ENGINE ELECTRONIC CONTROL UNIT (ECU)

The location of the engine ECU differs with the engine manufacturer. See **Fig. 1**, **Fig. 2**, **Fig. 3**, and **Fig. 4**.

INSTRUMENT CLUSTER UNIT (ICU)

The ICU includes the driver's instrument panel, the ICU housing, and the dash message center (all installed as one unit). To disconnect the ICU, see **Section 54.03** in this manual.

DATA LOGGING UNIT (DLU)

The DLU is one of several electronic modules mounted inside a compartment on the lefthand B-pillar, behind the driver's seat. See **Fig. 5**. The data logging unit is the top unit, and is mounted above the auxiliary power distribution module. Disconnect the electrical connector from the bottom of the unit.

AIR CONDITIONING PROTECTION UNIT (ACPU)

The ACPU connector is located near the bottom of the righthand side of the firewall in the engine compartment.

ANTILOCK BRAKE SYSTEM (ABS)

The ABS ECU is mounted in the B-pillar compartment. See **Fig. 5**.

AUXILIARY POWER DISTRIBUTION MODULE (APD)

The APD module is mounted in the B-pillar compartment. See **Fig. 5**.

VORAD SYSTEM

The ECU for the VORAD system is mounted in a small compartment on the righthand B-pillar, behind the driver's seat.

DAYTIME RUNNING LIGHTS

The ECU for the Daytime Running Lights is located in a small compartment on the righthand B-pillar, behind the driver's seat.

RADIO

Disconnect the electrical connection to the radio.

ALTERNATOR

Disconnect the ground strap, as previously mentioned, and this should serve to remove any chance for damage to the alternator.

WINDOW EXPRESS MODULE

The Window Express module is located beneath the driver's step threshold plate. Remove the plate to disconnect the module connection.

VEHICLE SECURITY SYSTEM

The vehicle's security system ECU is mounted in the righthand B-pillar compartment.

Safety Precautions

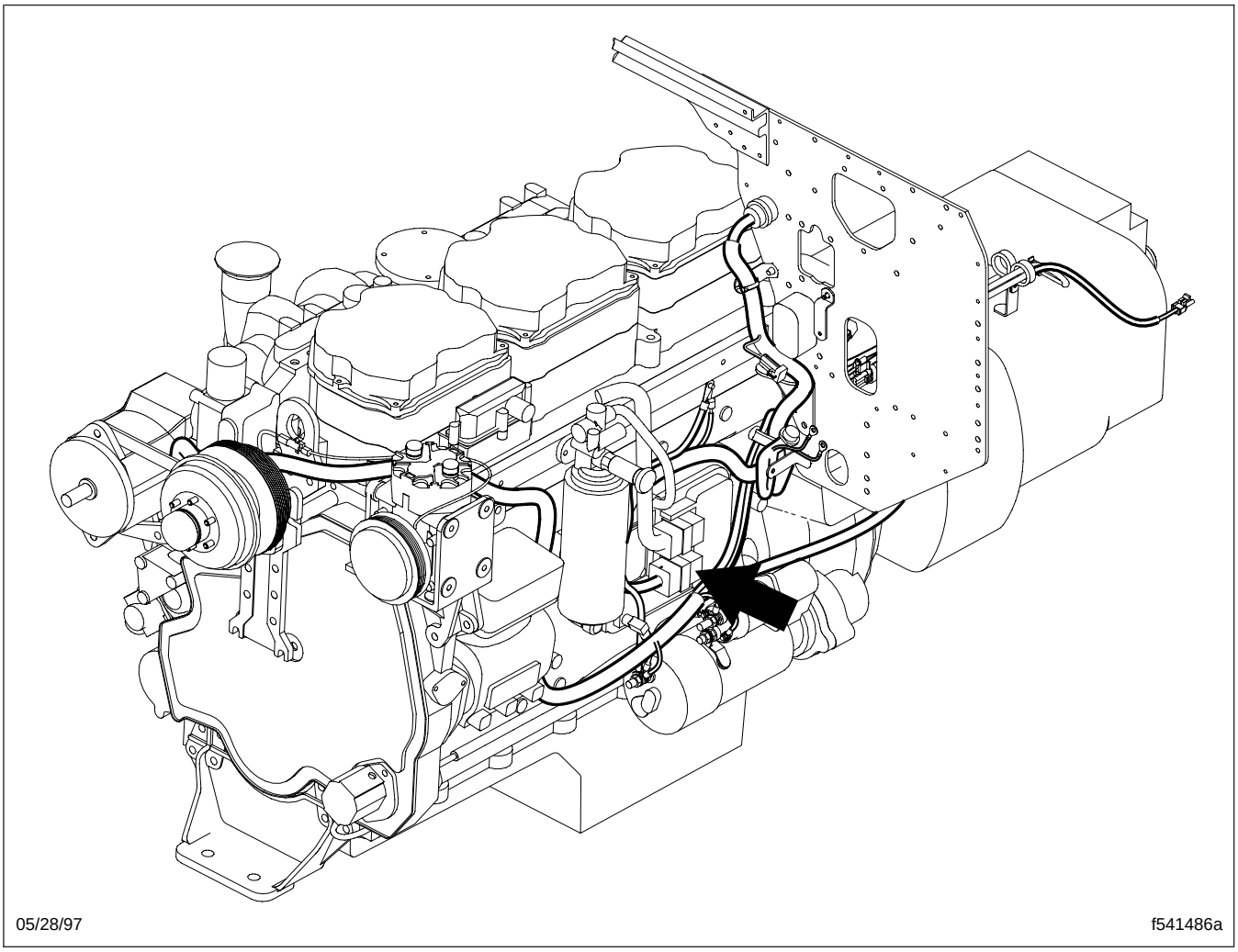


Fig. 1, Caterpillar C-10/C-12/3176 Engine ECU Location

SPACE SYSTEM

If the vehicle is so equipped, the SPACE system's ECU is disconnected by unplugging the wiring attached to the SPACE device mounted behind the operator's seat.

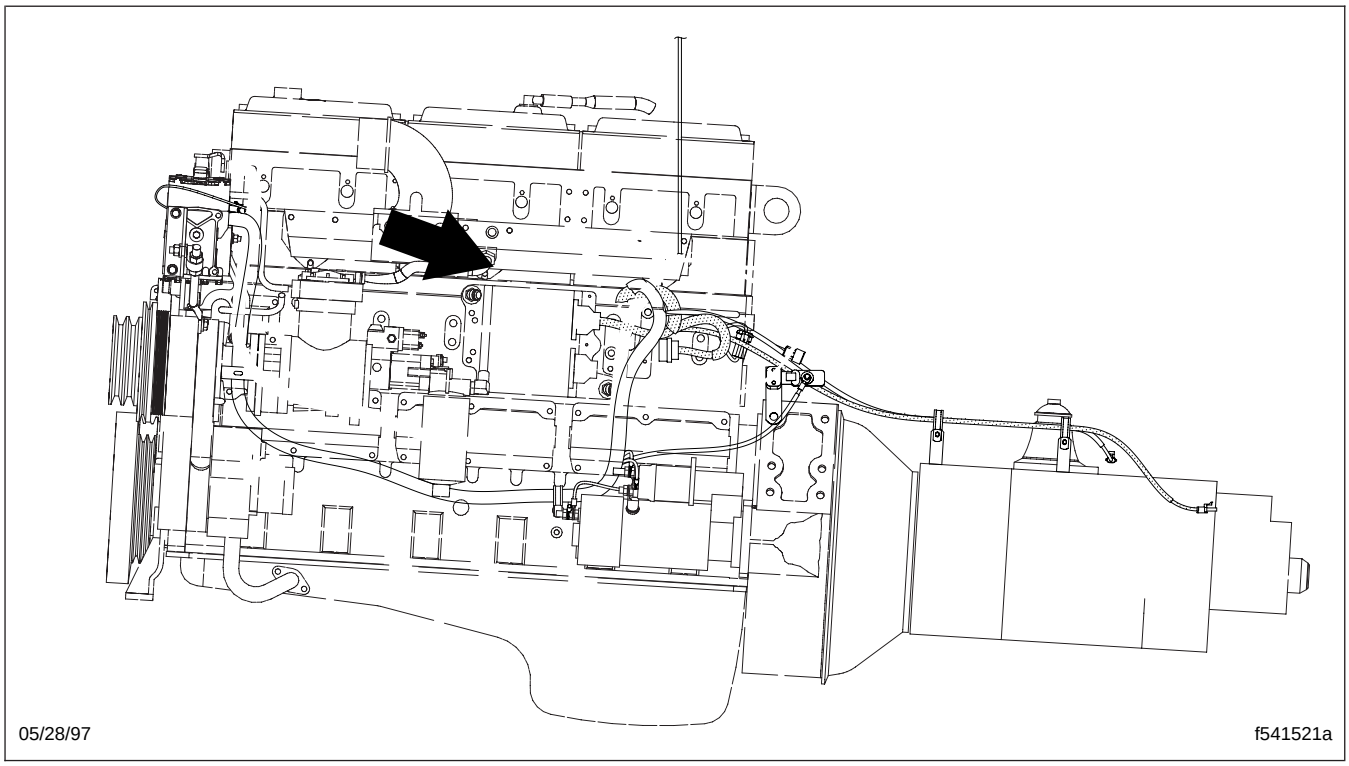


Fig. 2, Cummins N14 Engine ECU Location

Safety Precautions

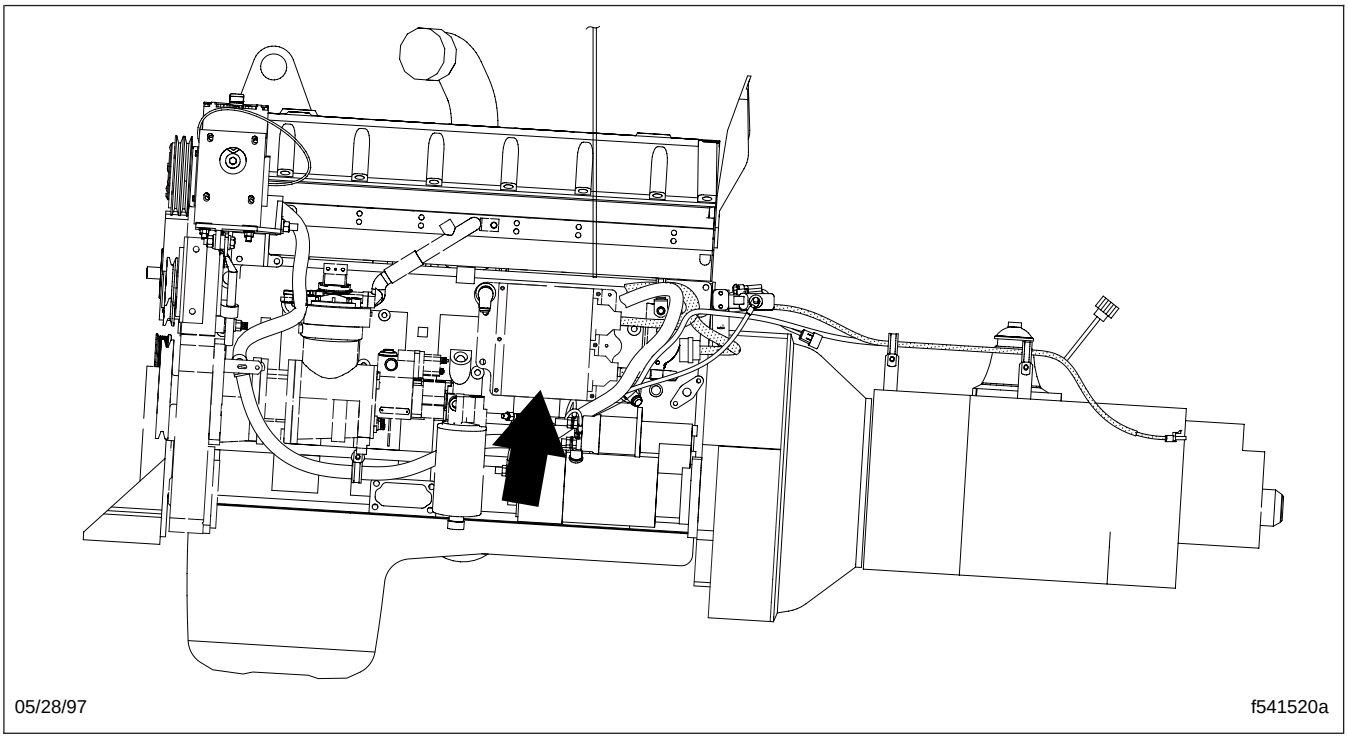


Fig. 3, Cummins M11 Engine ECU Location

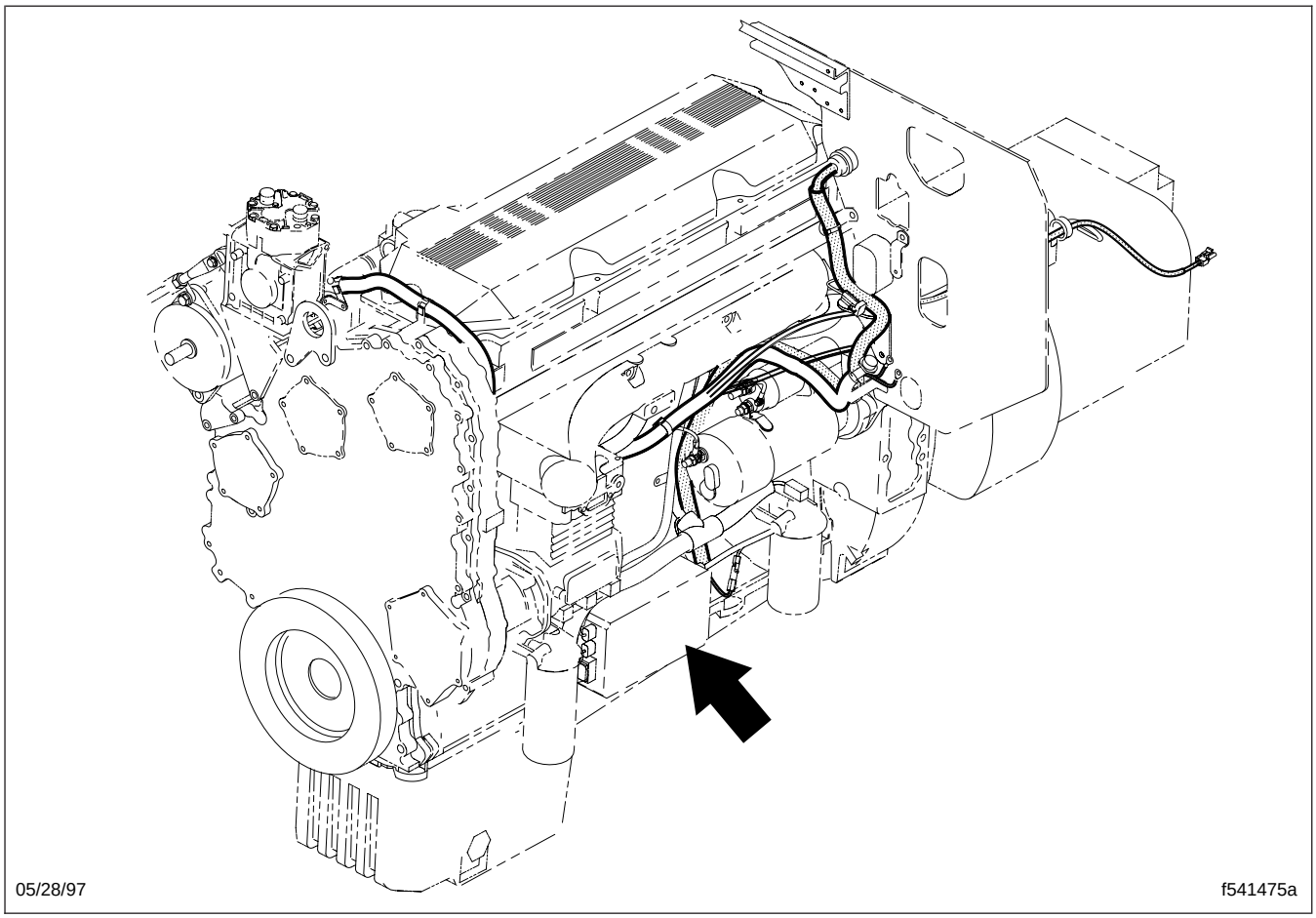
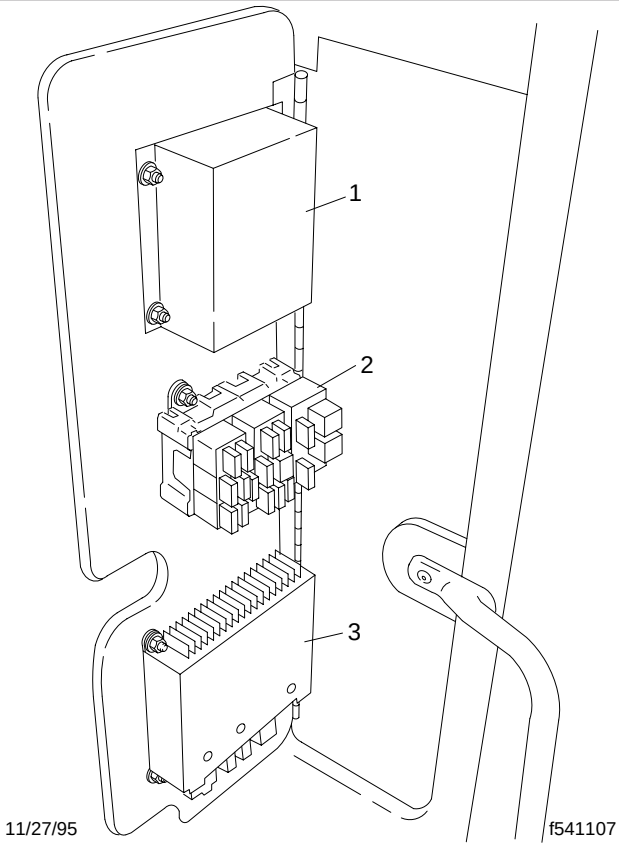


Fig. 4, Detroit Diesel Series 60 Engine ECU Location

Safety Precautions



1. Data Logging Unit
2. Auxiliary Power Distribution Module
3. ABS ECU

Fig. 5, Lefthand B-Pillar Electrical Compartment

General Description

The Power-Packer® cab-tilt system has four major parts:

- A hydraulic pump consisting of a pump body, a reservoir, and a pump control lever.
- Two hydraulic tilt cylinders that raise and lower the cab.
- A tilt safety stop on the right-side tilt cylinder, which must be used when working under a cab that has not been fully tilted.

The optional electric or air/hydraulic system has the same major parts as the hydraulic-only system, but has an additional motor assembly attached to the tilt pump. See **Fig. 1**. The electric or air/hydraulic motor normally operates the tilt pump in place of the manual pump control lever. If for any reason the motor isn't working, the tilt pump can be operated with the manual pump lever.

The tilt cylinders are connected to the pump by flexible high-pressure lines. Velocity fuses are built into the tilt cylinder ports. They act as check valves to prevent the cab from free falling in case of hydraulic system damage, such as a ruptured line.

Principles of Operation

There are two hydraulic circuits in the Power-Packer system: the *push* circuit raises the cab from the lowered position to the desired tilt position, and the *pull* circuit brings the cab from a fully tilted position up and over center. See **Fig. 2**.

Placing the control lever in the "Tilt" position opens the *push* circuit in the hydraulic system. When the pump is operated, hydraulic pressure builds up in the tilt cylinders. If equipped with hydraulic cab latches, hydraulic pressure releases the latches. Then the tilt cylinder piston rods extend, raising the cab. When the cab goes over center, it falls at a controlled rate to the full-tilt position, automatically relieving hydraulic system pressure.

When the control lever is placed in the "Return" position, the *pull* circuit in the hydraulic system opens. When the pump is operated, hydraulic pressure forces the cab back up and over top-dead-center. The cab then falls at a controlled rate until it settles onto the rear mounts.

NOTE: Whenever raising or lowering the cab, stop working the pump once the cab goes over center. The cab falls at a controlled rate and continued pumping could lock up the tilt cylinders. To slow the descent of the cab, reverse the lever.

HYDRAULIC LOCK-UP

Hydraulic lock-up can occur for the following reasons:

- Very cold weather
- Use of the wrong hydraulic fluid
- Air in the system
- Sudden cab movement
- A ruptured hydraulic line

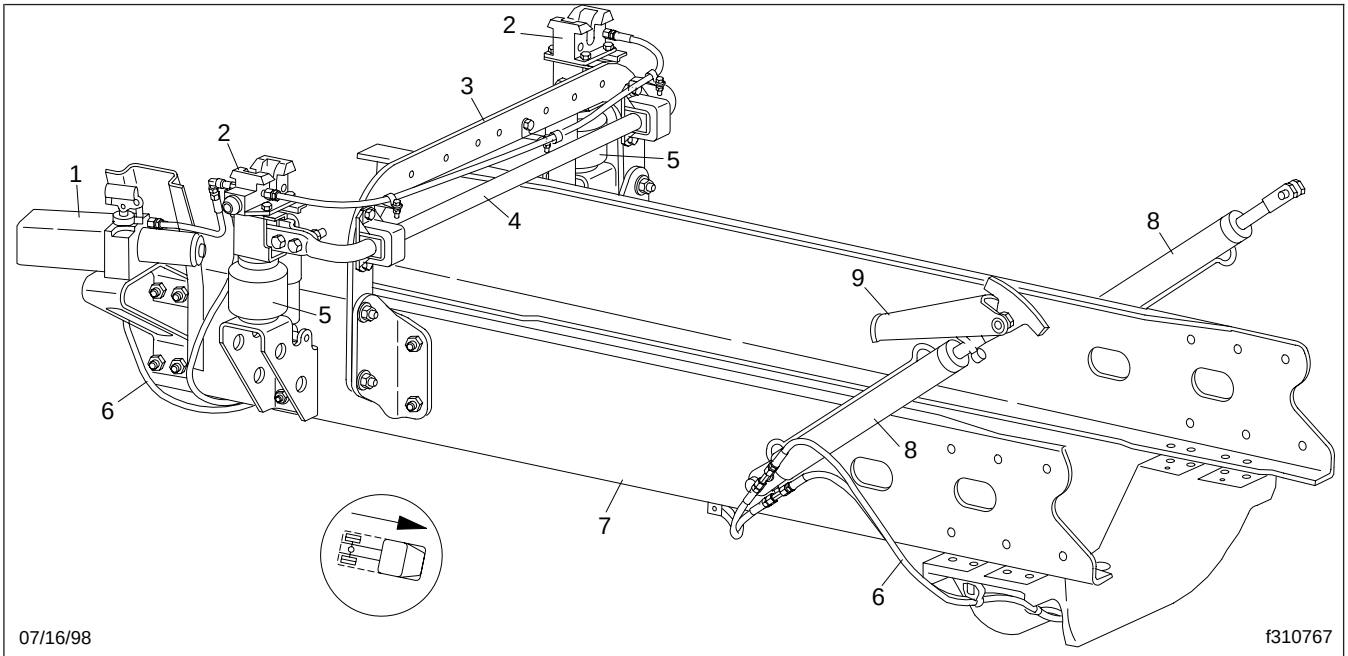
Any of the above situations will cause the velocity fuses to function as safety check valves, and lock up the tilt cylinders. To unlock the cylinders, the cab must be moved in the opposite direction of travel.

IMPORTANT: If the tilt cylinders lock up, check for a major problem (such as a ruptured line or leaking fitting) before trying to unlock the tilt cylinders. If such a problem is found, make any necessary repairs before unlocking the cylinder.

For example, if the cab is moving toward the full-tilt position when the lock-up occurs, move the control lever to "Return," and work the pump a few strokes. This will unlock the cylinders. Move the control lever to "Tilt," and allow the cab to descend to a full-tilt position.

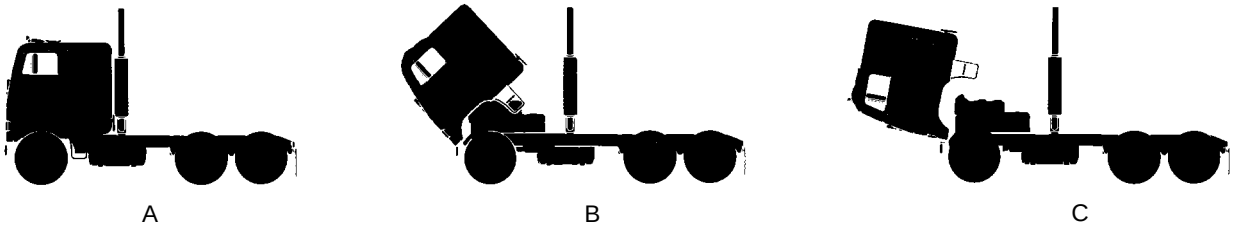
If the cab is moving toward the lowered (operating) position when the lock-up occurs, move the control lever to "Tilt," and work the pump a few strokes. This will unlock the cylinders. Move the control lever to "Return," and allow the cab to descend to the operating position.

General Information



1. Motor Assembly and Button
2. Cab Latch
3. Crossmember
4. Sway Bar
5. Air Bag
6. Hydraulic Line
7. Frame Rail
8. Tilt Cylinder
9. Tilt Safety Stop

Fig. 1, Cab Tilt System (equipped with hydraulic cab latches and cab air suspension)



A. Returned or in Operating Position
B. 45-Degree Tilted Position
C. Full-Tilt Position (75 Degrees)

Fig. 2, Cab Positions

Tilting the Cab

CAUTION

Before tilting the cab, make sure the vehicle is parked on level ground, both side-to-side and front-to-rear. Tilting the cab while the vehicle is parked on unlevel ground (such as a sloping highway shoulder) may damage the cab mounts and prevent you from returning the cab to the operating position.

1. Apply the parking brakes. Place the transmission shift lever in neutral. Shut down the engine if it is running.

WARNING

Before tilting the cab, make sure there is adequate clearance in front of the vehicle, and that the area is free of people and all objects.

Do not tilt the cab with the engine running. Tilting the cab could engage the transmission. If the engine is running, the vehicle can move, causing an accident that could result in personal injury or property damage.

2. Secure all loose articles in the cab and bunk, and make sure the doors are securely latched.

WARNING

Objects falling in the cab, or a door flying open, could damage the vehicle or cause personal injury.

3. Move the pump control lever to "Tilt."
4. Operate the pump (using the manual pump handle or the electric or air/hydraulic motor control button, if so equipped) to disengage the hold-down latches.

IMPORTANT: Check the indicator pin on each cab latch. The latches have disengaged if the pins are out. See **Fig. 1**.

If air is present in the hydraulic tilt system, pump operation will seem "spongy" or ineffective. If this happens, bleed the air from the system. For instructions, see **Subject 100**.

If the cab stops moving while it is being raised, do not force it to move with the tilt pump. The velocity fuses have locked up the tilt cylinder. To unlock them, see **Subject 050**.

WARNING

Make sure the tilt safety stop is pushed down onto the right tilt cylinder rod. If the tilt safety stop is not engaged, and the cab drops, the result could be serious injury or death.

5. When the cab reaches an approximately 30-degree angle, stop operating the pump. Push the free end of the tilt safety stop down onto the right tilt-cylinder rod. See **Fig. 2**. The tilt safety stop prevents the cab from accidently dropping below this position.

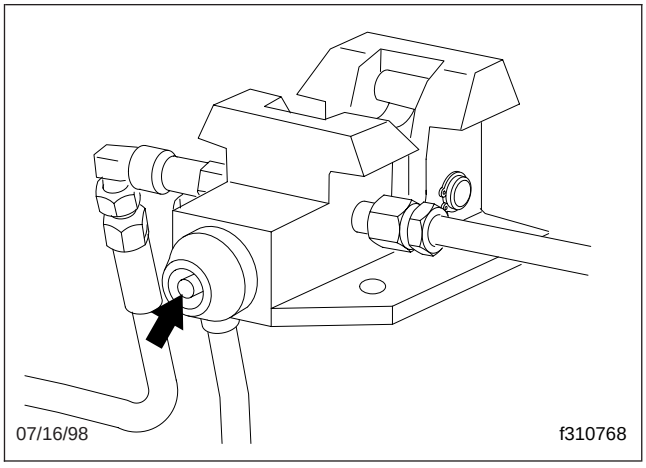
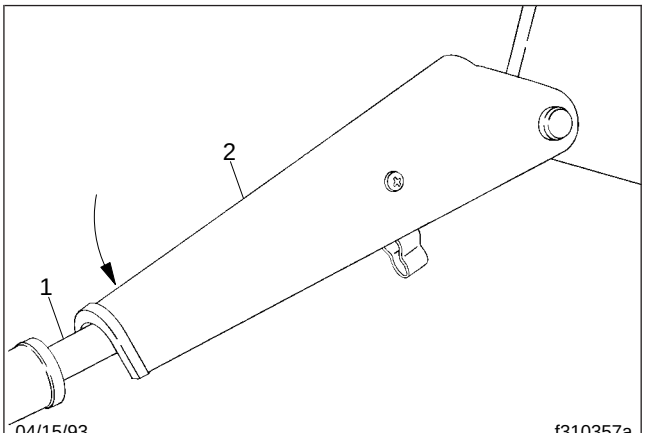


Fig. 1, Cab Latch Indicator Pin

6. To tilt the cab all the way, continue working the pump until the cab nears a 45-degree angle. Once the cab goes beyond 45 degrees, stop working the pump. The cab will gently descend to a full-tilt position. To slow the cab at any position between 45-degrees and full-tilt, move the control lever to "Return."

IMPORTANT: If the cab unintentionally stops after it has gone beyond 45 degrees, do not force it down with the tilt pump. The velocity fuses have locked the tilt cylinders. To unlock them, see **Subject 050**.

Cab Tilting



1. Tilt-Cylinder Rod
2. Tilt Safety Stop

Fig. 2, Tilt Safety Stop Positioning

Returning the Cab From a Tilted Position

DANGER

Stay completely clear of the cab's travel path at all times. Once the tilt safety stop has been released, do not lean over the frame rails, the engine, or the transmission for any reason. To do so could result in serious injury or death.

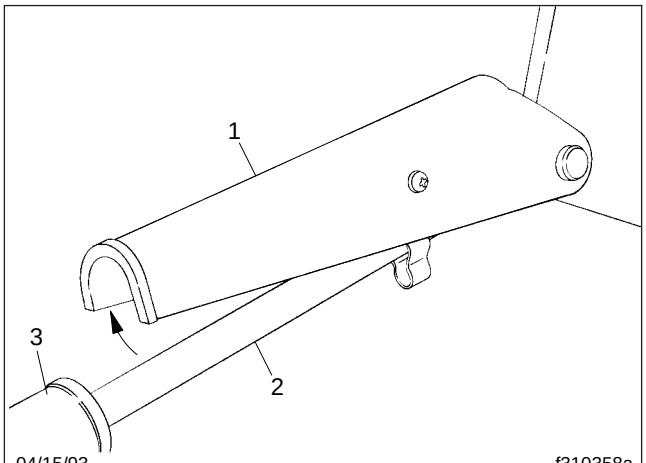
1. Move the tilt safety stop away from the right tilt-cylinder rod, and lock it in the spring catch.

   If the cab was not fully tilted, raise it enough to release the tilt safety stop. Move the tilt safety stop away from the tilt-cylinder rod, and lock it in the spring catch before returning the cab. See **Fig. 3**.

2. Set the pump control lever at "Return," and work the pump until the cab nears a 45-degree angle. Reduce pumping speed. Once the cab goes over center, stop working the pump. The cab will gently descend to the operating position.

   To stop the cab before completely returning it to its operating position, move the control lever to the "Tilt" position just prior to where the safety stop would engage the tilt cylinder if the cylinder were down. Then, lower the safety stop.

IMPORTANT: If the cab unintentionally stops after it has gone beyond 45 degrees, do not force it down with the tilt pump. The tilt strut is in the locked position, or the velocity fuses have locked the tilt cylinders. Release the tilt strut, or, to unlock the velocity fuses, see **Subject 050**.



1. Tilt Safety Stop
2. Tilt-Cylinder Rod
3. Tilt Cylinder

Fig. 3, Releasing the Tilt Safety Stop

3. When the cab is lowered all the way, make sure the pump control lever is set at "Return."
4. Check the indicator pin on each cab latch. See **Fig. 1**. The latches are locked when the pins have moved back into the piston and cylinder spring assembly.

NOTE: Maintain the hydraulic fluid level at the oil fill plug. Add fluid only when the cab is in the operating position. Use only Freightliner-approved hydraulic fluid, as indicated in **Specifications 400**.

Bleeding the System

A "spongy" feeling (cylinders do not move when the pump handle is operated) indicates air in the cab-tilt system. Use the following procedures to remove the air from the cab-tilt system.

IMPORTANT: With the exception of bleeding the *pull* port fittings on the tilt cylinders, and the hydraulic cab latches, never bleed any part of the system while the cab is tilted.

BLEEDING THE TILT CYLINDERS

DANGER

Before doing the work below, review the cab tilting information under Subject 060. Failure to read the warnings and to be aware of the dangers of tilting and returning the cab could result in serious injury or death.

1. With the cab completely returned and the tilt cylinders retracted, loosen the *push* port fitting on each tilt cylinder. Do not disconnect the hose from the fitting. Place the control lever in the "Tilt" position, and operate the tilt pump until a bubble-free stream of hydraulic fluid flows from the *push* ports on the tilt cylinders.
2. Tighten the *push* port fitting on each tilt cylinder.
3. Fill the tilt pump reservoir until hydraulic fluid appears in the fill port. Install and tighten the fill plug. Refer to **Specifications, 400** for the specified hydraulic fluid. Do not use engine oil, brake fluid, or automatic transmission fluid.
4. Tilt the cab to the full-tilt position. See **Subject 060** for cab tilting instructions.
5. Loosen the *pull* port fitting on each tilt cylinder. Place the control lever in the "Return" position, and operate the tilt pump until a bubble-free stream of hydraulic fluid flows from the *pull* port fitting on each cylinder.
6. Tighten the *pull* port fitting on each tilt cylinder.

DANGER

Stay completely clear of the cab's travel path at all times. Once the tilt safety stop has been released, do not lean over the frame rails, the engine, or the transmission for any reason. To do so could result in serious injury or death.

7. Return the cab to the operating position. For instructions, refer to **Subject 060**.
8. Fill the tilt pump reservoir until hydraulic fluid appears in the fill port. Install and tighten the fill plug. Refer to **Specifications, 400** for the specified hydraulic fluid. Do not use engine oil, brake fluid, or automatic transmission fluid.
9. Tilt the cab fully and return it to the lowered position. See **Subject 060** for instructions. Fill the tilt pump reservoir until hydraulic fluid appears in the fill port. Use only specified hydraulic fluid. Install and tighten the fill plug.

BLEEDING THE HYDRAULIC CAB LATCHES

DANGER

Before doing the work below, review the cab tilting information under Subject 060. Failure to read the warnings and to be aware of the dangers of tilting and lowering the cab could result in serious injury or death.

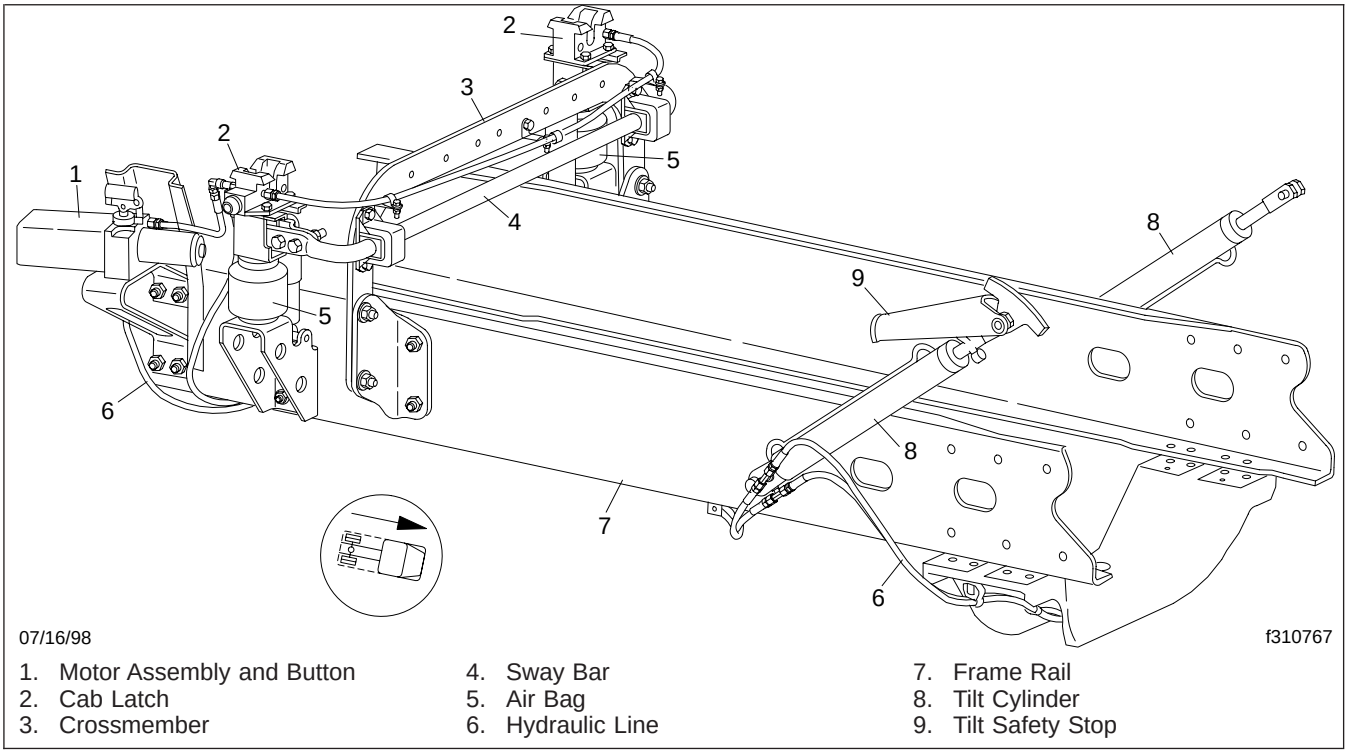
Since the hydraulic cab latches are mounted higher in the system than the tilt pump, air going to them will not discharge to the reservoir. See **Fig. 1**.

1. Tilt the cab to the full-tilt position. See **Subject 060** for cab tilting instructions.
2. Push the free end of the tilt safety stop down onto the rod of the right tilt cylinder.
3. Put the pump control lever into the "Return" position. Operate the tilt pump until the cab goes over-center. Let the cab settle onto the tilt safety stop.
4. Loosen the hydraulic fitting on the right cab latch.
5. Put the pump control lever in the "Tilt" position; then operate the tilt pump (using either the air motor or the pump lever) until a bubble-free stream of fluid flows from the fitting. Pump until

Bleeding the System

about 2 fl oz (60 mL) of fluid flows from the fitting to ensure the entire line is free of air.

6. Tighten the cab latch fitting.
7. Put the pump lever in the "Return" position.
8. Loosen the fitting on the left cab latch.
9. Put the pump control lever in the "Tilt" position; then operate the tilt pump (using either the air motor or the pump lever) until a bubble-free stream of fluid flows from the fitting. Pump until about 2 fl oz (60 mL) of fluid flows from the fitting to ensure the entire line is free of air.
10. Tighten the cab latch fitting.
11. With the pump control lever still in the "Tilt" position, operate the tilt pump just enough to take the weight off the tilt safety stop; then release the tilt safety stop, and lock it in the spring catch.
12. Return the cab. For instructions, refer to **Subject 060**.



1. Motor Assembly and Button
2. Cab Latch
3. Crossmember
4. Sway Bar
5. Air Bag
6. Hydraulic Line
7. Frame Rail
8. Tilt Cylinder
9. Tilt Safety Stop

Fig. 1, Cab Tilt System (equipped with hydraulic cab latches and cab air suspension)

13. Fill the tilt pump until hydraulic fluid appears in the fill port. See **Specifications 400** for specified hydraulic fluid. Don't use engine oil, brake fluid, or automatic transmission fluid.
14. Install the fill plug and tighten it firmly.

Tilt Cylinder Removal and Installation

Removal

NOTE: Remove the tilt cylinder assemblies from the vehicle only when the cab is in the lowered (operating) position.

1. Release the hydraulic pressure by alternately moving the control lever on the tilt pump to the "Tilt" and "Return" positions. Hold the control lever in each position for a few seconds. Return the control lever to the "Return" position before proceeding.
2. Disconnect the hydraulic lines from both tilt cylinders. Cover the ends of the lines to prevent dirt from entering the system.

If the hydraulic fluid is discolored, drain the cab-tilt system by placing a container under the tilt pump reservoir, then removing it. Install the reservoir; then add new, approved fluid. See **Specifications 400** for approved fluids.

3. Disconnect the right tilt cylinder at the clevis end by removing the cotter pin (**Fig. 1**, Ref. 5), and the clevis pin (Ref. 6).
4. Remove the tilt safety stop by removing the locknut (Ref. 3) and the machine screw (Ref. 1), then the tilt safety stop spring (Ref. 4).

   If the tilt-safety stop spring is installed with rivets and a retainer, squeeze the legs of the tilt-safety stop spring together; then remove the rivets from each side of the tilt safety stop. Remove the tilt safety stop spring and the tilt safety stop. Discard the rivets, and the retainer that is inside the tilt safety stop.
5. Loosen and remove the 5/8–11 bolt (Ref. 8) that holds the lower end of the tilt cylinder to the end spacer (Ref. 12) on the right-side frame rail.
6. Remove the right tilt cylinder from the vehicle.
7. Repeat the procedure for the left tilt cylinder.

NOTE: There is no tilt safety stop on the left tilt cylinder.

Installation

1. Install the right tilt cylinder assembly on the vehicle (see **Fig. 1**):

   1.1 Place the tilt safety stop (Ref. 2) over the clevis of the tilt cylinder, making sure the holes in both parts are aligned.

   1.2 Place the tilt cylinder clevis and tilt safety stop on the mounting flange of the cab, and insert the clevis pin through the aligned holes of all three parts.

   1.3 Place the washer over the end of the clevis pin, and install the cotter pin into the clevis pin hole. Lock the cotter pin.

   1.4 Install the tilt-safety stop spring (**Fig. 1**, Ref. 4).

   Place the tilt-safety stop spring (**Fig. 1**, Ref. 4) over the piston rod; then install it onto the tilt safety stop, using the machine screw and nylon locknut (Refs. 1 and 3).

   NOTE: If the tilt-safety stop spring was installed with rivets, replace them with two 10–24 machine screws (3/4-inch long) and nylon locknuts.

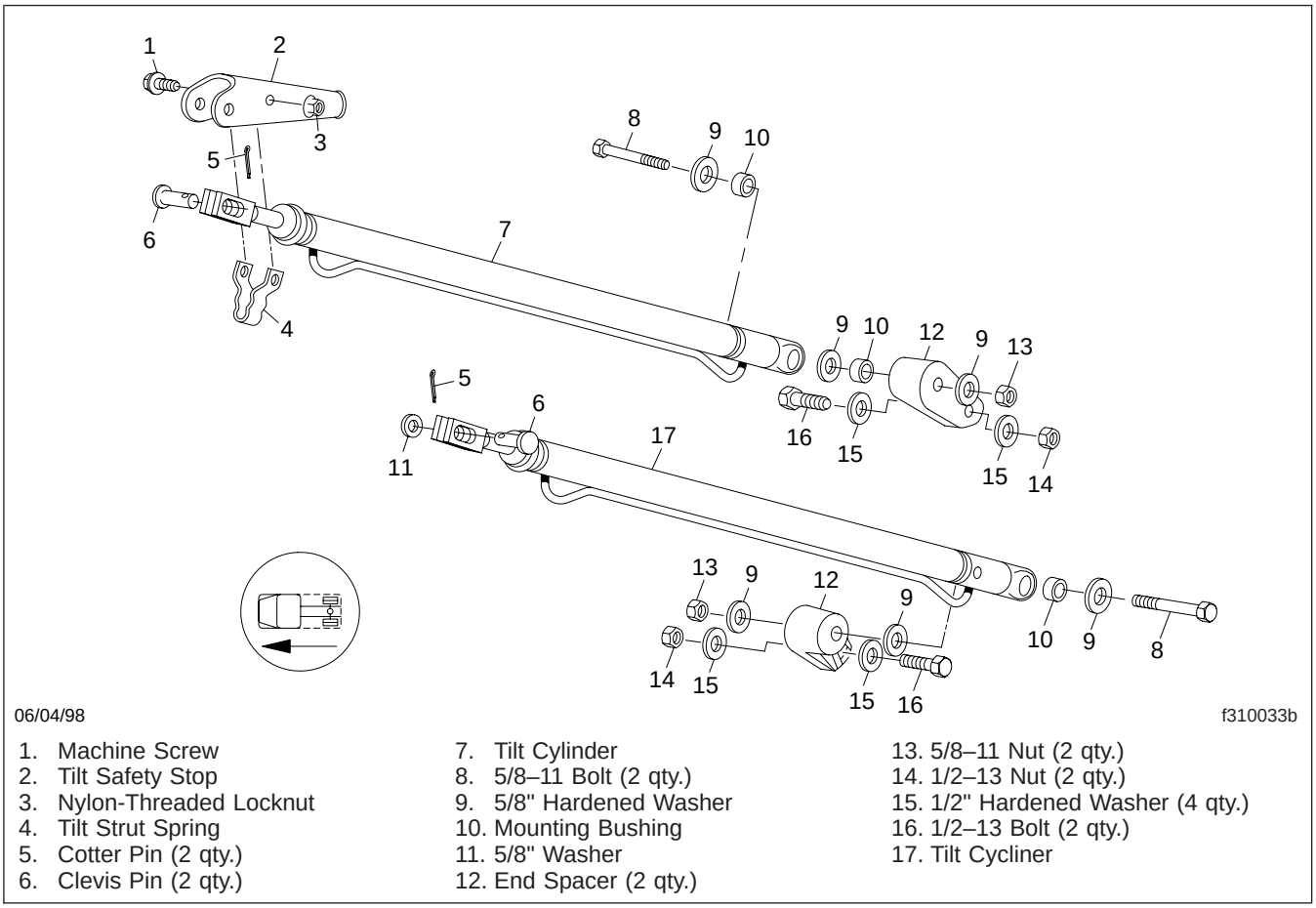
   1.5 Line up the mounting hole at the bottom end of the tilt cylinder with that on the right-side end spacer. See **Fig. 1**.

   1.6 Coat the outside of the mounting bushing (Ref. 10) with Never-Seez®; then install the 5/8–11 bolt and nut, and mounting bushing as shown in **Fig. 1**.

   1.7 Tighten the 5/8–11 bolt 135 lbf·ft (183 N·m).

   1.8 Check the end spacer mounting bolt (Ref. 16) for tightness, and tighten it 95 lbf·ft (129 N·m) if necessary.
2. Repeat the procedure for the left tilt cylinder. Note that there is no tilt safety stop on the left tilt cylinder.
3. Connect the hydraulic lines to the cylinder port fittings, but do not tighten them.
4. Bleed the hydraulic system as described in **Subject 100**.

Tilt Cylinder Removal and Installation

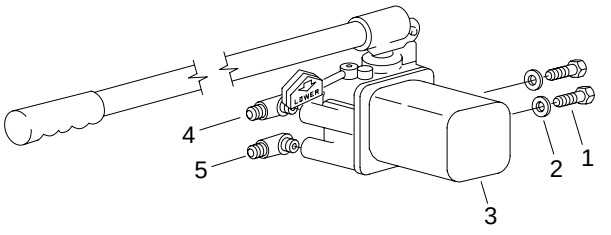


1. Machine Screw
2. Tilt Safety Stop
3. Nylon-Threaded Locknut
4. Tilt Strut Spring
5. Cotter Pin (2 qty.)
6. Clevis Pin (2 qty.)
7. Tilt Cylinder
8. 5/8–11 Bolt (2 qty.)
9. 5/8" Hardened Washer
10. Mounting Bushing
11. 5/8" Washer
12. End Spacer (2 qty.)
13. 5/8–11 Nut (2 qty.)
14. 1/2–13 Nut (2 qty.)
15. 1/2" Hardened Washer (4 qty.)
16. 1/2–13 Bolt (2 qty.)
17. Tilt Cycliner

Fig. 1, Tilt Cylinder Assembly, Exploded View

Removal

1. Release the hydraulic pressure in the lines and tilt cylinders by alternately moving the pump control lever to the "Tilt" and "Return" positions. Hold the control lever in each position for a few seconds. Return the control lever to the "Return" position.
2. On electric systems, disconnect the electrical connections, the two terminals at the bottom of the button assembly and the main electrical connector to the pump motor.
3. On air/hydraulic systems, drain the air tanks; then disconnect the air supply line from the air motor. Leave the air motor assembly attached to the tilt pump.
4. Mark the hydraulic lines and disconnect them at the *push* and *pull* ports on the tilt pump assembly. Place a container under the ends of the disconnected lines to catch any fluid remaining in them.
5. Cover the ends of the hydraulic lines to prevent the entry of dirt into the system.
6. Remove the two tilt pump mounting capscrews and washers. See **Fig. 1**.



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1. 3/8" Capscrew (2 qty.)
2. 3/8" Washer (2 qty.)
3. Tilt Pump Assembly
4. Push Port Fitting
5. Pull Port Fitting

Fig. 1, Hydraulic-Only System Shown

7. Remove the tilt pump assembly from the vehicle.

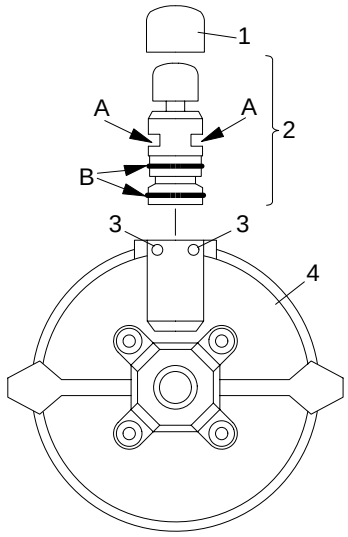
Installation

1. Using the two mounting capscrews and washers, install the assembled tilt pump on the vehicle. See **Fig. 1**, Refs. 2 and 3. Tighten the capscrews 23 lbf·ft (31 N·m).
2. Connect the hydraulic lines to the *push* and *pull* ports on the tilt pump assembly. Do not tighten the lines on the fittings until the system has been bled.
3. On electric systems, connect the electrical connections, the two terminals at the bottom of the button assembly and the main electrical connector to the pump motor.
4. On air/hydraulic systems, connect the air supply lines and fill the system with air.
5. Fill the reservoir with the specified hydraulic fluid, and install and tighten the fill plug. See **Specifications 400** for the specified hydraulic fluid. Do not use engine oil, brake fluid, or automatic transmission fluid.
6. Bleed the entire system. Refer to **Subject 100**. Tighten the hydraulic lines firmly.

Replacement

If the air button is sticking, and affecting the operation of the air motor, replace the air button assembly using this procedure.

1. Drain the air tanks.
2. Disconnect the air supply line from the air motor.
3. Remove the old air button assembly.
   - 3.1 Remove the rubber boot from the air button.
   - 3.2 Using a suitable punch, drive out the two roll pins holding the air button in place. See **Fig. 1.**



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A. Roll pins fit into these grooves.
B. Lubricate these O-rings.
1. Rubber Boot
2. Air Button Assembly
3. Roll Pins
4. Air Motor Assembly

Fig. 1, Air Button Assembly

   - 3.3 Using a twisting motion, pull the old air button assembly out of the air motor housing.
4. Clean out the cavity in the air motor housing.
5. Install the new air button assembly.
   - 5.1 Using clean motor oil or Lubri-Plate®, lubricate the O-rings on the new air button assembly. See **Fig. 1**.
   - 5.2 Using a slight twisting motion, push the new air button assembly into the air motor housing. If it doesn't go in correctly, remove it and lubricate the O-rings again.
   - 5.3 Turn the air button assembly so that the grooves in it are lined up with the holes for the roll pins. See **Fig. 1**.
   - 5.4 Install the roll pins. Make sure they are flush with the air motor housing.
   - 5.5 Install a new rubber boot over the button.
6. Connect the air supply line to the air motor assembly.
7. Build up the system air pressure; then check for air leaks around the button and the supply line.
8. Test the operation of the new air button.

   If there are still problems with the operation of the air motor, replace the entire air motor assembly, following the instructions in **Subject 140**.

Replacement

⚠ DANGER

Before doing the work below, review the cab tilting information under Subject 060. Failure to read the warnings and to be aware of the dangers of tilting and lowering the cab could result in serious injury or death.

⚠ CAUTION

Drain the air tanks before removing the air motor. Failure to do so could result in damage to the vehicle or the tilt system parts.

NOTE: The air motor can be removed from the hydraulic tilt pump without removing the tilt pump from the vehicle.

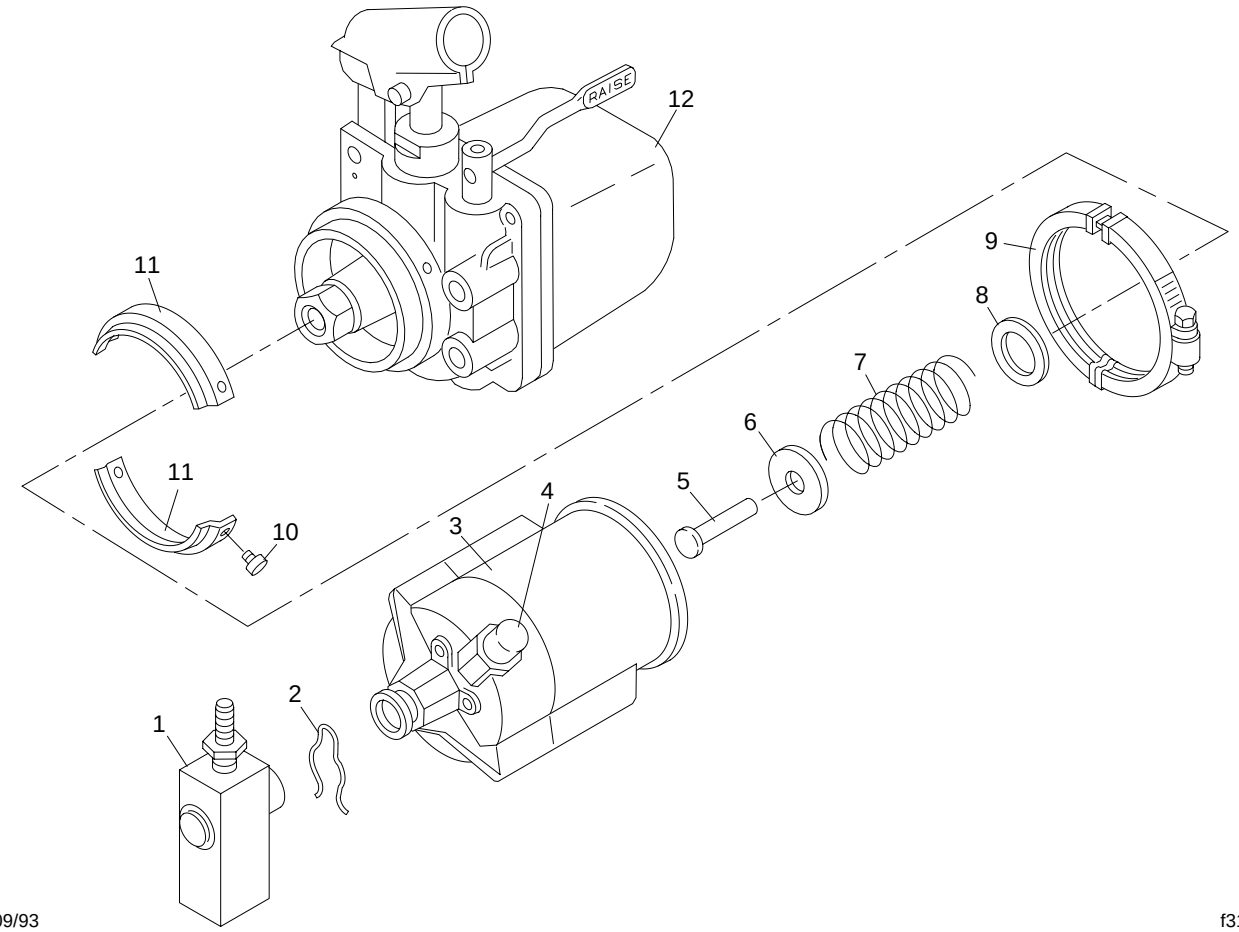
1. Tilt the cab. Refer to **Subject 060** for instructions.
2. Drain the air tanks.

⚠ WARNING

Hold the air motor housing firmly while you are removing it from the tilt pump. The spring inside the air motor could eject the air motor housing and other parts from the tilt pump, which could cause personal injury or parts damage.

3. Remove the air motor from the tilt pump. See **Fig. 1**.
   - 3.1 Remove the retaining clip (Ref. 2) from the air inlet assembly (Ref. 1). It isn't necessary to disconnect the air line from the air inlet assembly.
   - 3.2 While holding the air motor housing (Ref. 3) firmly, loosen the mounting clamp (Ref. 9 or 11) holding the air motor to the tilt pump.
   - 3.3 Slowly and carefully remove the air motor from the tilt pump. Hold on to the piston, spring, spool, and washer (Refs. 5, 7, 6, and 8), and save them for the installation of the new air body.
4. Check the piston, spring, spool, and washer. If they're not damaged or worn, use them on the new air motor; otherwise, replace them.
5. Remove the rubber boot from the air button (Ref. 4). If the boot isn't damaged, use it on the new air motor; otherwise, replace it.
6. Clean all the parts.
7. Install the new air motor onto the tilt pump.
   - 7.1 Install the rubber boot on the air button.
   - 7.2 Place the piston, spool, spring, and washer inside the new air motor housing, as shown in **Fig. 1**.
   - 7.3 Align the new air motor with the tilt pump, then push it in place.
   - 7.4 While holding the air motor in place, install and tighten the mounting clamp. Make sure the clamp is securely tightened before you let go of the air motor.
   - 7.5 Push the air inlet assembly onto the end of the air motor; then install the retaining clip.
8. Start the engine to build the air pressure.
9. When the air pressure is 120 psi (827 kPa), test the air motor by lowering the cab to the operating position. Refer to **Subject 060** for complete instructions on lowering the cab.

Air Motor Replacement



1. Air Inlet Assembly
2. Retaining Clip
3. Air Motor Housing
4. Air Button
5. Piston
6. Spool
7. Spring
8. Washer
9. New-Style Mounting Clamp
10. Screw
11. Old-Style Mounting Clamp
12. Tilt Pump

Fig. 1, Air Motor Assembly and Tilt Pump

Troubleshooting Tables

Problem—Cab Fails to Tilt or Fails to Return from Tilt When Using Manual Pump Lever, but Hydraulic Pressure Builds In System

Problem—Cab Fails to Tilt or Fails to Return from Tilt When Using Manual Pump Lever, but Hydraulic Pressure Builds In System	
Possible Cause	**Remedy**
Cab latch binding or failing to unlatch.	Check the cab latch release mechanism (either mechanical or hydraulic latches).
Plugged orifice at the bottom of the spool in the tilt pump.	Replace or rebuild the tilt pump.
Control lever in the wrong position.	Put the control lever in the correct position.
Worn seals or O-rings in the tilt pump.	Replace or rebuild the tilt pump.
Hoses blocked.	Replace the hoses.
Push and *pull* lines crossed.	Check for correct installation.
Internal leak in tilt pump.	Repair or replace the tilt pump.
Internal leak in tilt cylinder.	Repair or replace the tilt cylinder.
External leak.	Repair or replace the leaking part.
Air in hydraulic system.	Bleed the hydraulic system.

Problem—Cab Fails to Tilt or Fails to Return from Tilt When Using Electric or Air/Hydraulic Motor, but System Works When Using Manual Pump Lever

Problem—Cab Fails to Tilt or Fails to Return from Tilt When Using Electric or Air/Hydraulic Motor, but System Works When Using Manual Pump Lever	
Possible Cause	**Remedy**
Insufficient air supply to motor.	Build air system pressure, or repair/replace air or electric system parts as needed.
The motor is not working.	Repair or replace the motor.
The button assembly is not working.	Replace the air button assembly.

Problem—Cab Stops Moving When in Controlled Fall

Problem—Cab Stops Moving When in Controlled Fall	
Possible Cause	**Remedy**
Velocity fuses locked up.	Reverse the pump direction with the control lever, and operate the pump to unlock.
Plugged orifice.	Inspect, and clean or replace.
Tilt strut left engaged.	Disengage the tilt strut.

Troubleshooting

Problem—Cylinder Velocity Fuses Are Locked Up

Problem—Cylinder Velocity Fuses Are Locked Up	
Possible Cause	**Remedy**
Controlled fall rate is too fast.	Inspect the orifice in bottom of spool valve; replace or rebuild the tilt pump, if needed.
Air in the system.	Bleed the system.
Ruptured hydraulic line.	Replace the hydraulic line.

Problem—Hydraulic Fluid Leaking at Hand Pump Plunger or Around Spool Valve

Problem—Hydraulic Fluid Leaking at Hand Pump Plunger or Around Spool Valve	
Possible Cause	**Remedy**
Worn seals and O-rings.	Replace or rebuild the tilt pump.

Problem—Hydraulic Fluid Leaking at Air Motor Exhaust, and/or Between Air Motor and Tilt Pump

Problem—Hydraulic Fluid Leaking at Air Motor Exhaust, and/or Between Air Motor and Tilt Pump	
Possible Cause	**Remedy**
Seals between air motor and tilt pump leaking.	Replace the tilt pump, and the air motor plunger, spring and spool, if needed.

Problem—Hydraulic Fluid Leak at the Tilt-Cylinder Gland

Problem—Hydraulic Fluid Leak at the Tilt-Cylinder Gland	
Possible Cause	**Remedy**
Worn seal on the gland.	Replace or rebuild the tilt cylinder.

Problem—Tilt Pump Leaks Between the Pump Base and the Reservoir

Problem—Tilt Pump Leaks Between the Pump Base and the Reservoir	
Possible Cause	**Remedy**
Worn O-ring on the reservoir.	Replace the O-ring on the reservoir.
O-ring on the reservoir pinched.	Replace the O-ring, making sure it is properly positioned.

Problem—Cab Drifts When in the Half-Raised Position

Problem—Cab Drifts When in the Half-Raised Position	
Possible Cause	**Remedy**
Worn spool valve seals.	Replace the spool valve seals or rebuild the tilt pump.
Worn piston seals inside the tilt cylinders.	Replace the piston seals or rebuild the tilt cylinders.
Control lever not all the way in the correct position.	Place the control lever in the correct position.

Specifications

Torque Values				
Description	Size	Grade	Torque	
			lbf·in (N·cm)	lbf·ft (N·m)
Tilt Cylinder Mounting Bolts	5/8–11	8	—	135 (183)
End Spacer Mounting Bolts, 2 inches	1/2–13	8	—	95 (129)
Tilt Pump Cylinder	—	—	—	80 (108)
Tilt Pump Relief Valve	—	—	60 (680)	—
Tilt Pump Outlet Seat	—	—	—	19–21 (26–28)
Tilt Pump Reservoir Socket-Head Capscrews	1/4–20	7	96 (1080)	—
Push and Pull Port Fittings	—	—	96 (1080)	—
Tilt Pump Mounting Capscrews	3/8–16	5	—	23 (31)

Table 1, Torque Values

Hydraulic Fluid Types		
Component or Usage		Fluid Type
Tilt Pump Hydraulic Fluid	All Temperatures	Freightliner Tilt System Hydraulic Fluid * (part number 48-02207-200) (MIL-H-5606 equivalent)

* The following vendor lubricants are approved: Texaco 1537 Aircraft Hydraulic Oil 15; Union Arctic Low Pour (-65) Hydraulic Fluid 04617; Filmite 530 Hydraulic Oil

Table 2, Hydraulic Fluid Types

CAUTION

When directed to open the front-wall access panel in the procedures below, stand away from the panel when opening it. The access panel can open quickly and could hit a person, possibly resulting in personal injury.

Removal

NOTE: Argosy front fascia components are often mounted such that removal of one component is needed to permit removal of another; see **Fig. 1**.

Before performing these procedures, apply the parking brakes and chock the tires.

A-Pillar Interior and Exterior Covers

1. Remove the A-pillar interior cover by loosening the door seal, then pulling free the molded plastic panel.
2. Remove the A-pillar exterior cover, as follows.
   - 2.1 Inside the cab, remove the three nuts in the access holes through the A-pillar structure. Be careful not to drop the nuts inside the A-pillar during removal.
   - 2.2 Remove the capscrew from the top of the upper door frame.
   - 2.3 Remove the wiper arm, if necessary, then remove the capscrew that attaches the exterior cover to the cab near the wiper arm.
   - 2.4 Remove the exterior cover.

Cowl Side Panels

1. Open the front-wall access panel.
2. Remove the six fasteners that attach each cowl side panel to the cab.

Lower Grille Panel

Remove the lower grille panel by removing the six fasteners that attach it to the cab.

Headlight Fascias

1. With the front-wall access panel open, disconnect the electrical connections to the headlights and parking lights.
2. Remove the five fasteners that attach the headlight fascia to the cab.

Front-Wall Access Panel

1. Open the front-wall access panel.

WARNING

Support the front-wall access panel when disconnecting the gas struts. The front-wall access panel is supported by the gas struts and disconnecting them may cause the panel to swing downward, which could result in the panel hitting a person, possibly resulting in serious injury.

2. Disconnect the gas struts at the lower connection points.
3. Remove the roll pins from the panel hinges.
4. Remove the front-wall access panel.

Wiper/Handle Panel

1. Remove the wiper arms.
2. Disconnect the fluid hoses behind the wiper/handle panel.
3. Remove the hinge handles.
4. Remove the A-pillar exterior cover fasteners.
5. Remove the wiper/handle panel.

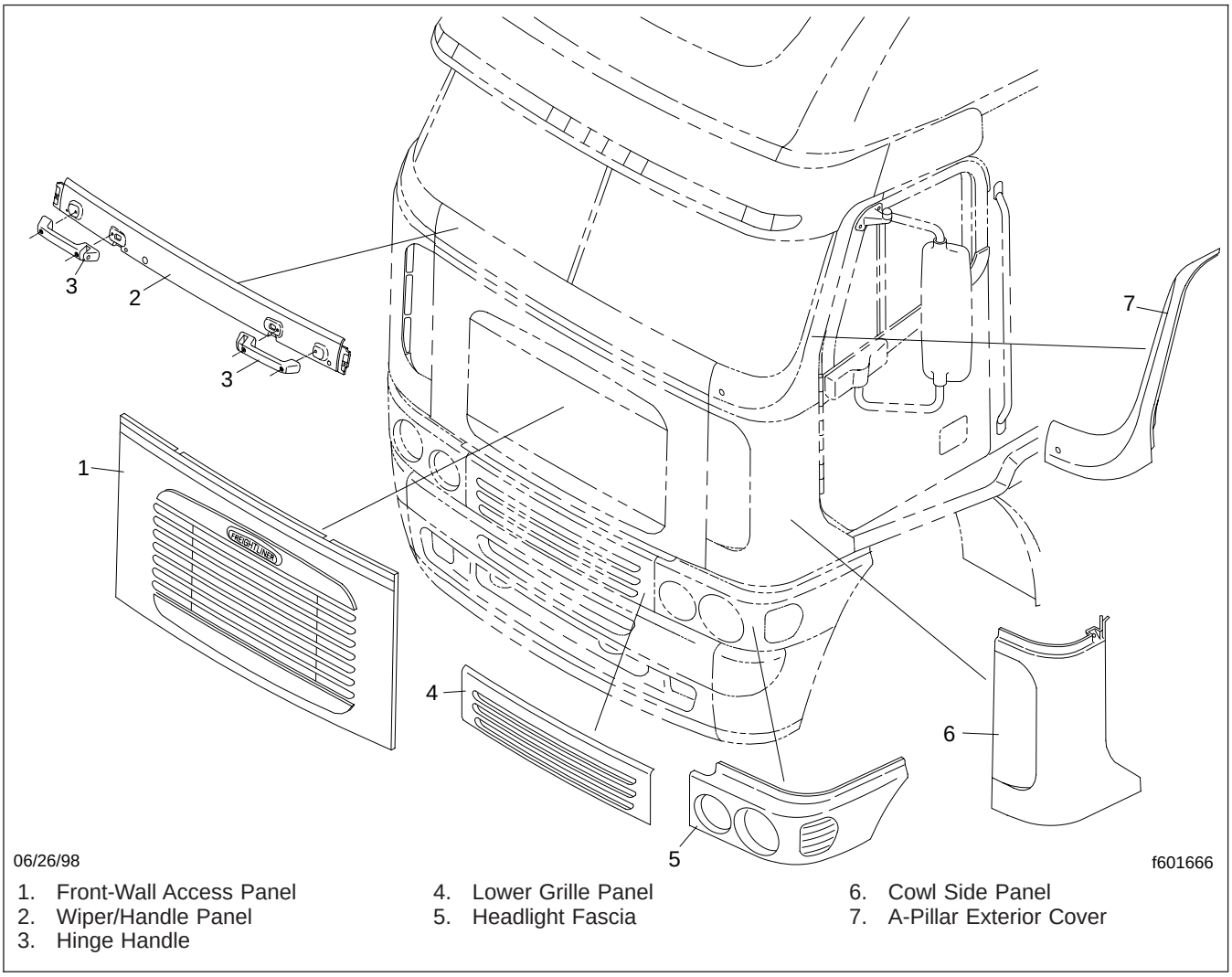
Installation

Make sure that the vehicle tires are chocked while performing the procedures described below.

Wiper/Handle Panel

1. Install the wiper/handle panel.
2. Install the A-pillar exterior cover fasteners.
3. Install the hinge handles.
4. Connect the fluid hoses behind the wiper/handle panel.
5. Attach the wiper arms.

Fascia Panels Removal and Installation



1. Front-Wall Access Panel
2. Wiper/Handle Panel
3. Hinge Handle
4. Lower Grille Panel
5. Headlight Fascia
6. Cowl Side Panel
7. A-Pillar Exterior Cover

Fig. 1, Front Fascia Assembly, Argosy COE

Front-Wall Access Panel

⚠ WARNING

Support the front-wall access panel during installation. The front-wall access panel is large and heavy; lifting it over your head could cause it to become unsteady, and hit a person or knock a person down, possibly resulting in serious injury.

1. Position the front-wall access panel in place.
2. Install the roll pins in the panel hinges.
3. Connect the gas struts at the lower connection points.
4. Close the front-wall access panel.

Headlight Fascias

1. With the front-wall access panel open, attach the headlight fascia on the cab with five fasteners.
2. Connect the electrical connections to the headlights and parking lights.

Lower Grille Panel

Position the lower grille panel, then install it using the six fasteners.

Cowl Side Panels

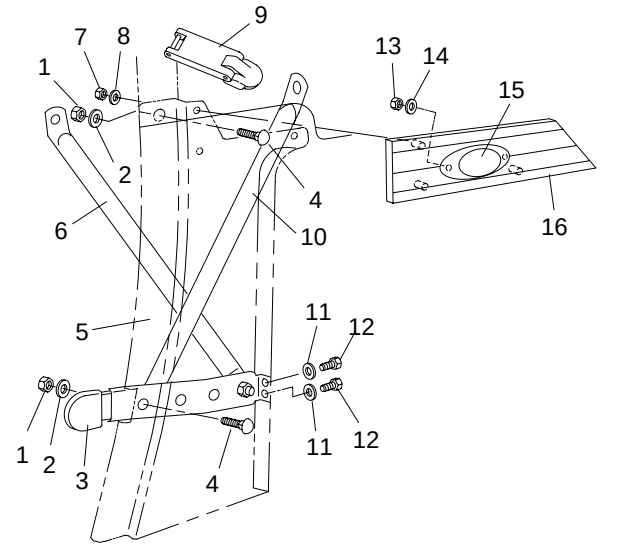
With the front-wall access panel open, attach each cowl side panel to the cab.

A-Pillar Interior and Exterior Covers

1. Install the A-pillar exterior cover, as follows.
    1.1 Position the exterior cover in place.
    1.2 Install the capscrew that attaches the exterior cover to the cab near the wiper arm. Then install the wiper arm.
    1.3 Install the capscrew that attaches the exterior cover to the top of the upper door frame.
    1.4 Inside the cab, attach the three nuts in the access holes, to secure the exterior cover to the A-pillar structure.
2. Install the A-pillar interior cover.
3. Install the door seal.

Removal

1. Park the vehicle on a level surface, shut down the engine, set the parking brake, and chock the front and rear tires.
2. Tilt the hood.
3. Remove the two Torx®-head screws holding the rear edge of the panel to the hood support bracket. See **Fig. 1**.



1. Hexnut
2. Hardened Washer
3. Support Bracket
4. Carriage Bolt
5. Cowl Panel
6. Rear Strut
7. Nylon Hexnut
8. Nylon Washer
9. Hood Latch Pin
10. Forward Strut
11. Washer
12. Torx-Head Screw
13. Stopnut
14. 1/4-inch Washer
15. Light Assembly
16. Chrome Strip

Fig. 1, Cowl Panel

4. From inside the cowl, remove the four stopnuts holding the top chrome strip.
5. Disconnect the wiring from the light.
6. Remove the strip and the light.
7. Remove the upper forward carriage bolts holding the panel to the cowl.
8. Remove the lower forward carriage bolt holding the panel to the hood bracket and the forward support strut.
9. Remove the panel.

Installation

1. Position the panel on the cowl.
2. Install the upper forward carriage bolt.
3. Install the Torx-head screws holding the rear edge of the panel to the hood bracket.
4. Install the lower forward carriage bolt, making sure the strut, bracket, and panel holes are aligned.
5. Install the top chrome strip and the light.

NOTE: The studs on the inner surface of the chrome strip are installed into grooves that allow them to slide back and forth. If necessary, position the studs so they align correctly.

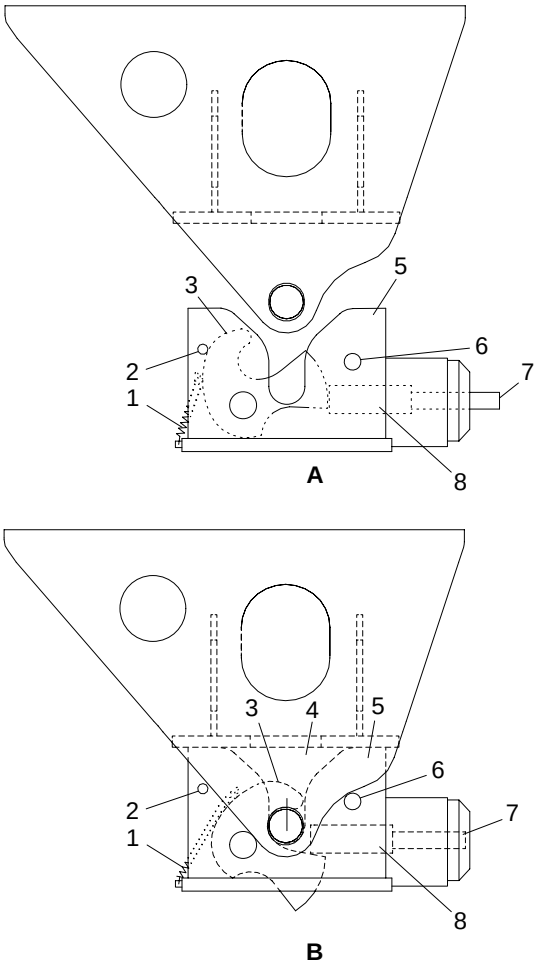
6. Connect the wiring to the light.
7. Tighten the four stopnuts securely.
8. Tighten all fasteners securely.
9. Remove the chocks from the tires.

General Information

A hydraulic cab latch assembly (**Fig. 1**) is located on each side of the cab, and is mounted on the cab suspension. The latches keep the cab secured to the frame and prevent any shifting or unwanted movement. When the latches are released (unlocked) the cab can be tilted. A latch pin assembly, mounted to the underside of the cab, fits into each cab latch assembly. The latch assembly consists of a body, a latch, a return spring, a piston, a piston spring (not shown), and an indicator pin.

The cab latches are plumbed into the cab-tilt hydraulic system. They automatically open when the cab is tilted, and close and lock when the cab is lowered.

When the cab is latched, a spring inside the housing keeps the piston pushed up against the cam part of the latch, preventing the latch from releasing. When the cab is tilted, hydraulic pressure moves the piston outward, which allows the latch to be pulled up by the return spring, releasing the latch pin assembly. The cab is then free to tilt. As the cab is lowered, hydraulic pressure is released, and the latch pin assembly pushes on the cam part of the latch. The latch swings around, captures the pin, and the spring inside the housing pushes the cylinder back out and against the cam part of the latch. This locks the latch in place, securing the cab. Indicator pins let the driver know whether or not the latches are locked. If the pins are flush with the latch housing ends, the latches are locked; if they're sticking out, the latches are not locked. See **Fig. 1**.

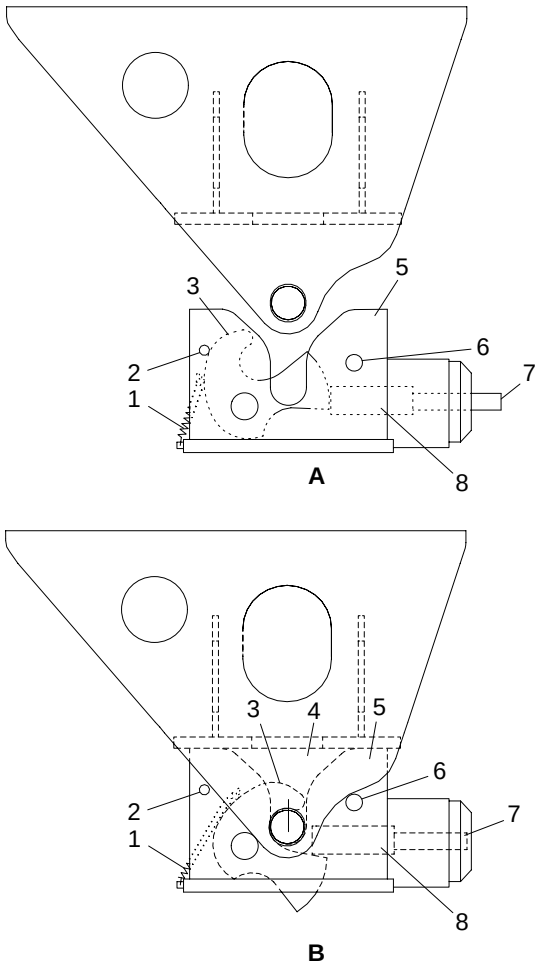


A. Unlocked
B. Locked
1. Return Spring
2. Pin
3. Latch
4. Latch Pin Assembly
5. Cab Latch Body
6. Hydraulic Port
7. Indicator Pin
8. Piston

Fig. 1, Cab Latch Assembly

Replacement (See Fig. 1)

1. Tilt the cab. For instructions, refer to **Section 60.15** in this workshop manual.



A. Unlocked
B. Locked
1. Return Spring
2. Pin
3. Latch
4. Latch Pin Assembly
5. Cab Latch Body
6. Hydraulic Port
7. Indicator Pin
8. Piston

Fig. 1, Cab Latch Assembly

2. Disconnect the batteries.
3. Loosen and remove the 3/8–16 capscrews, washers, and locknuts that attach the latches to the cab suspension.
4. Using a container to catch any hydraulic fluid, disconnect the hydraulic lines from the lower cab latch assemblies.
5. Remove the hydraulic cab latch from the vehicle.
6. Position the hydraulic cab latch in place on the cab suspension bracket.
7. Install the 3/8–16 capscrews, hardened washers, and locknuts. Tighten the nuts finger tight.
8. Connect the hydraulic lines to the cab latch.
9. Connect the batteries.
10. Bleed the cab-tilt system, following the instructions in **Section 60.15** of this workshop manual.
11. To align the cab latch in the proper location, lower the cab until the cab latch pins engage. For cab lowering instructions, refer to **Section 60.15** in this workshop manual.
12. Tilt the cab until the latch pins disengage. Make sure the tilt strut is pushed down over the right tilt-cylinder rod.
13. Tighten the nuts on the cab latch 28 lbf·ft (38 N·m).
14. Return the cab to the operating position. For instructions, refer to **Section 60.15** in this workshop manual.
15. Remove the chocks from the tires.

Replacement

1. Tilt the cab. For instructions, refer to **Section 60.15** in this workshop manual.
2. Remove the locknuts that attach the latch pin assembly to the underside of the cab. Remove the latch pin assembly.
3. Install the new latch pin assembly onto the studs on the underside of the cab.
4. Loosely Install the locknuts on the studs. Make sure the latch pin assembly can move from side-to-side.
5. Lower the cab. For instructions, refer to **Section 60.15** of this workshop manual. The latch pins will align with the cab latches and set into place on the cab mounting brackets.
6. Tighten one locknut firmly on the latch pin to hold it in place.
7. Tilt the cab far enough to engage the tilt strut. For instructions, refer to **Section 60.15** in this workshop manual.
8. Tighten all the locknuts 28 lbf·ft (38 N·m).
9. Return the cab to the operating position. For instructions, refer to **Section 60.15** in this workshop manual.

Roof Fairing Removal and Installation

Removal

1. With the vehicle parked, apply the parking brakes and chock the tires.
2. Place some padding, such as a blanket, on the roof to avoid damaging the surface.
3. Remove the bolts, nuts, and washers that attach the fairing to the fairing front brackets. See **Fig. 1**. Lower the front of the fairing onto the padding.
4. Remove the bolts, nuts, and washers that attach the roof fairing to the back-of-cab brackets.

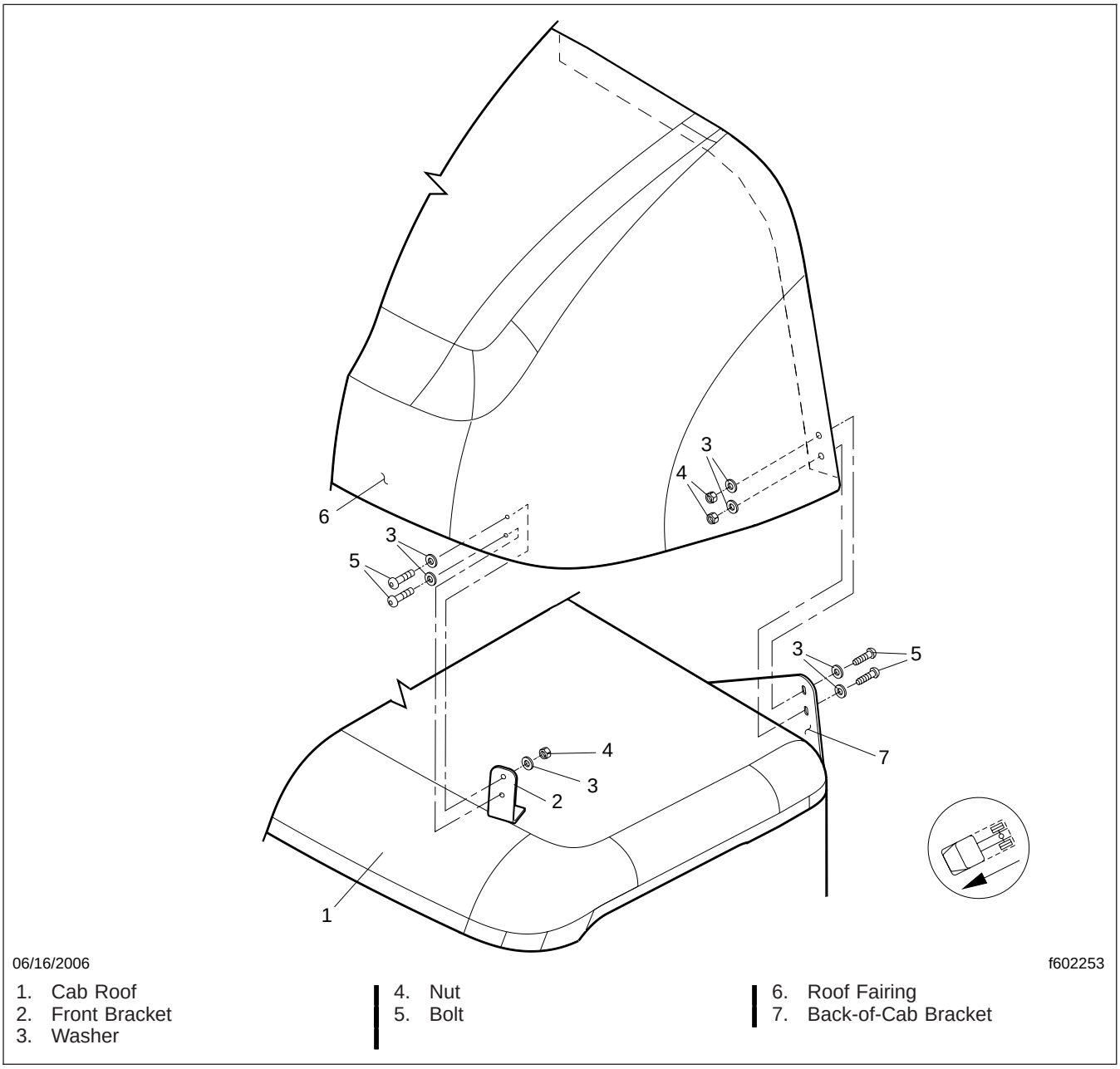


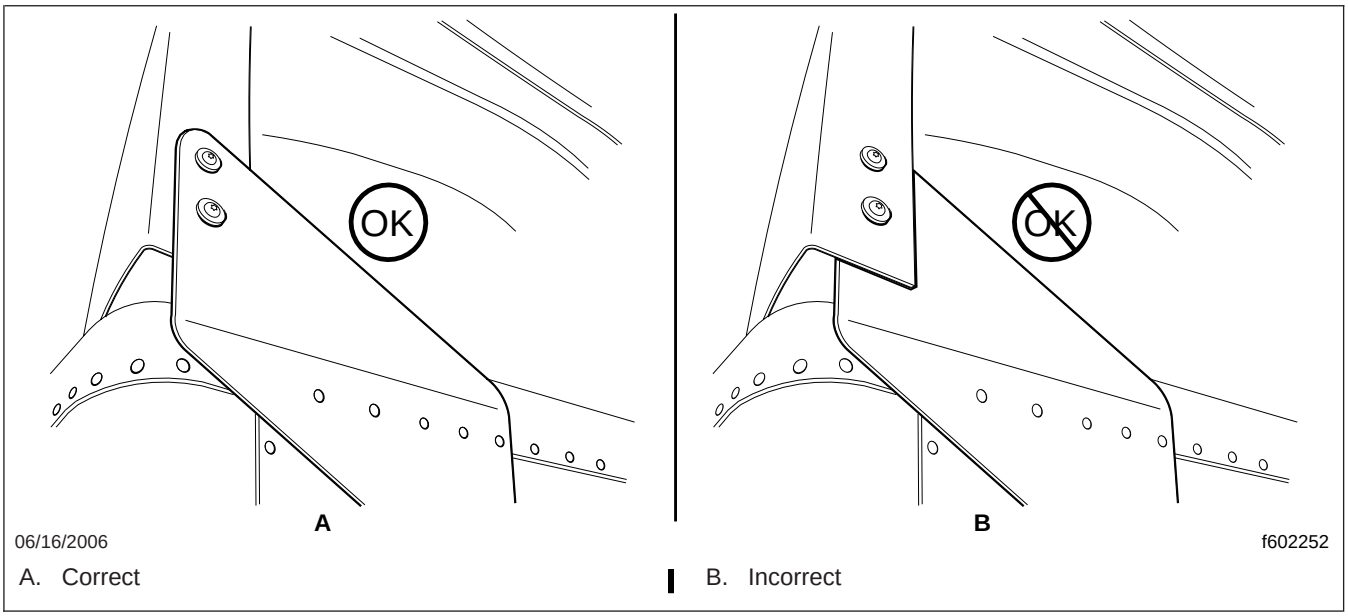
Fig. 1, Roof Fairing Installation

Roof Fairing Removal and Installation

5. Remove the fairing and the padding.

Installation

1. With the tires chocked, place some padding, such as a blanket, on the roof to avoid damaging the surface.
2. Place the fairing on the padding, taking care not to damage the roof surface. Position the fairing forward of both the front and back-of-cab brackets. See **Fig. 2**.
5. Install a washer and nut on each bolt that attaches the fairing to the brackets. Do not tighten the nuts.
6. Check the alignment of the fairing, adjusting it if necessary.
7. Tighten all the bolts.
8. Remove the chocks from the tires.



A. Correct

B. Incorrect

Fig. 2, Fairing Back-of-Cab Installation

⚠ CAUTION

Do not attach a roof fairing to the rearward sides of the back-of-cab brackets. Roof fairings should always be attached to the forward sides of the back-of-cab brackets. Attaching a roof fairing to the rearward sides of the brackets can result in damage to the fairing.

3. Start two bolts with washers through the back-of-cab brackets and the fairing. See **Fig. 1**.
4. While supporting the front of the fairing, remove the padding from the roof, and start two bolts with washers through the fairing into each of the fairing front brackets.

Driver's Lounge Under-Bunk Storage Bin

REMOVAL

NOTE: The Driver's Lounge consists of the driver's lounge lower bunk, the fold-down table, the under-bunk storage bin, and the side cushion chairs. See **Fig. 1** and **Fig. 2**.

1. Park the vehicle on a level surface.
2. Shut down the engine.
3. Set the parking brake and chock the front and rear tires.
4. With the driver's lounge table in the stowed position (latched to the underside of the lower bunk) raise and latch the lower bunk in its vertical position. See **Fig. 1**.
5. Press the push-button latch on the storage bin (**Fig. 2**, Ref. 2) and pull forward to gain access to the storage area.
6. Remove the shoulder bolt (Ref. 3) at each end of the storage bin and remove the bin.

INSTALLATION

1. With the driver's lounge table in the stowed position, raise and latch the lower bunk in its vertical position.
2. Place the storage bin into position between the side cushion chairs.
3. Install and tighten the passenger-side shoulder bolt and then the driver's side shoulder bolt.

NOTE: The shoulder bolts thread into mating clinch nuts in the seat box assemblies at each side.

4. Open and close the storage bin to ensure proper alignment of the bin and proper latch engagement.
5. Remove the chocks from the tires.

Driver's Lounge Table

REMOVAL

1. Park the vehicle on a level surface.
2. Shut down the engine.
3. Set the parking brake and chock the front and rear tires.
4. With the driver's lounge table in the stowed position, raise and latch the lower bunk in its vertical position. See **Fig. 1**.

NOTE: The next step is best performed with the aid of an assistant. Take note of the positions of the nylon bushing and flatwasher (Refs. 13 and 14) before removing them.

5. Have the assistant hold the table in position and remove the table link-to-table mounting bolts (Ref. 3) on both sides of the table.

NOTE: When the bolts are removed, the table will drop slightly as the table pins and nylon spacers (Ref. 12) come to rest in the bottoms of the table support casting (Ref. 9) guides.

6. Have the assistant hold the table. Then unlatch and place the table leg into position to support the table.

NOTE: Doing this will unlatch the table from the striker (Ref. 7) on the underside of the bunk, if it is still engaged.

7. Carefully lift and maneuver the table away from the bunk. Use care to disengage the table pins and nylon spacers from the table support casting guides at the same time.

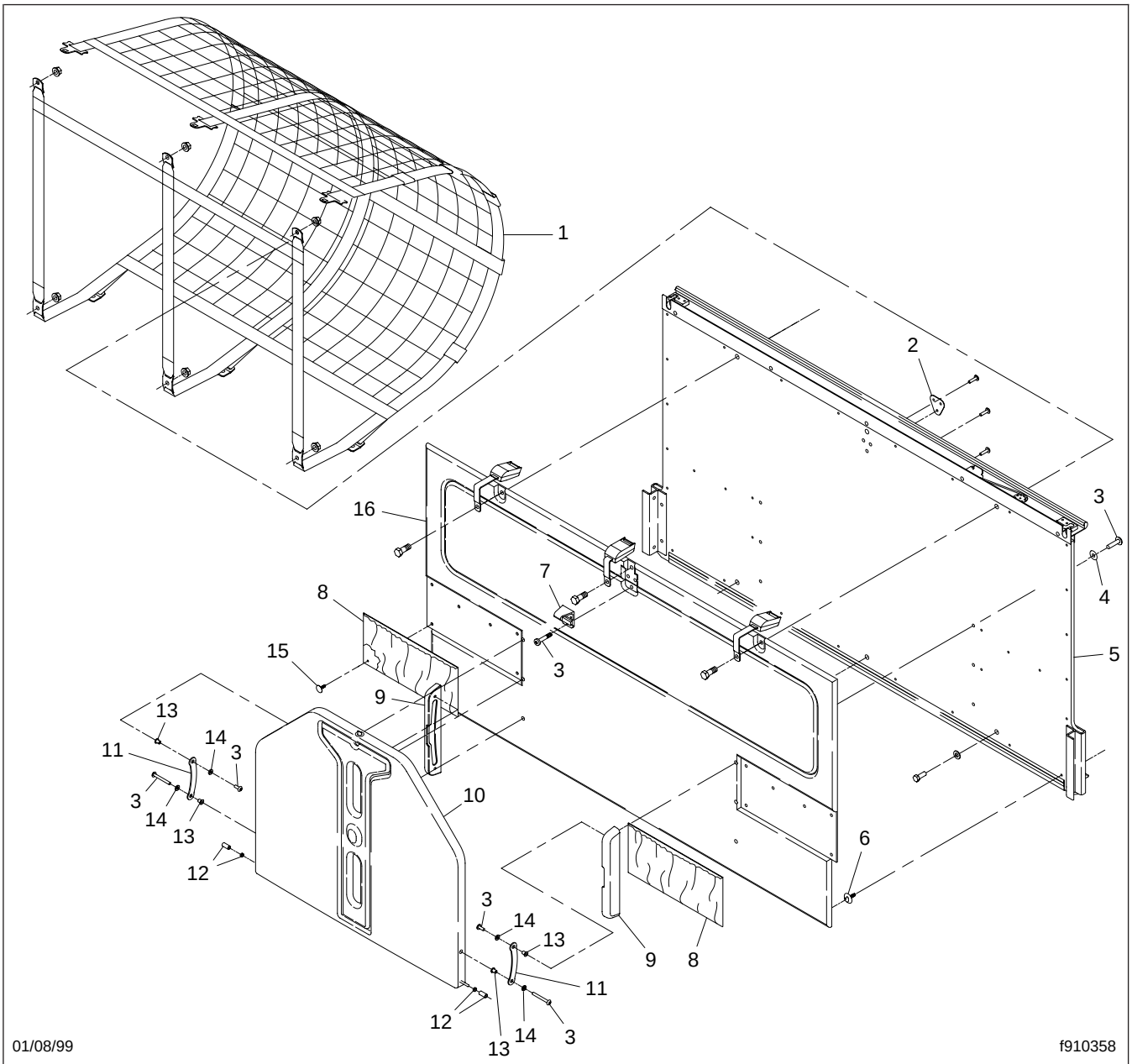
INSTALLATION

1. With the driver's lounge table in the stowed position, raise and latch the lower bunk in its vertical position.

NOTE: The next step is best performed with the aid of an assistant.

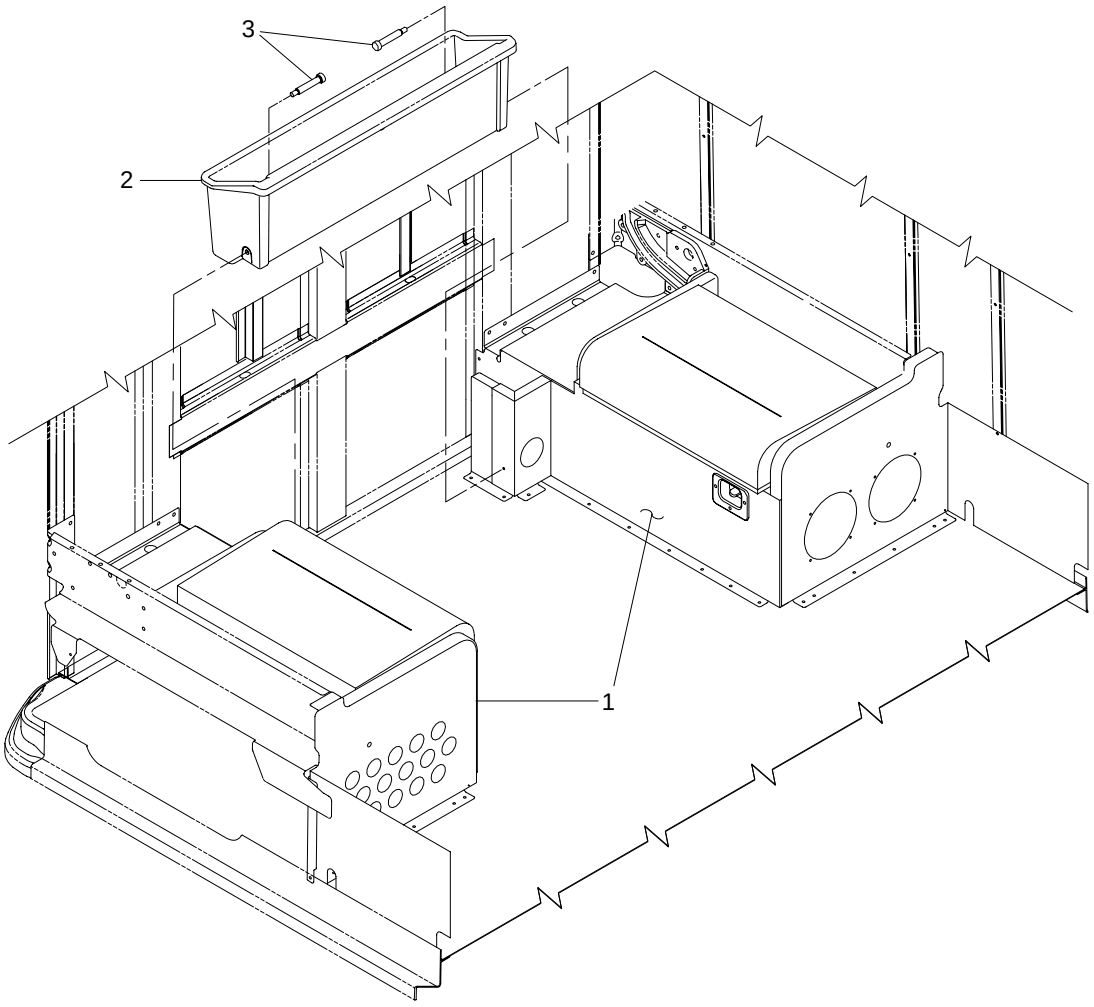
2. Carefully lift and maneuver the table (Ref. 10) into position. Use care to engage the table pins and nylon spacers into the table support casting guides at the same time. As the table pins and spacers enter the guides, carefully lower the

Removal and Installation



1. Bunk Restraint
2. Table Striker Mounting Plate
3. Mounting Bolt
4. Washer
5. Lower Bunk Assembly
6. 1/4-Turn Plastic Fastener
7. Table Striker Assembly
8. Pocket Assembly
9. Table Support Casting
10. Fold-Down Table
11. Table Link
12. Nylon Spacer
13. Nylon Bushing
14. Nylon Flatwasher
15. Plastic Christmas-Tree Fastener
16. Bunk Upholstery

Fig. 1, Driver's Lounge Table and Lower Bunk



1. Seat Box Assembly
2. Under-Bunk Storage Bin
3. Shoulder Bolt

Fig. 2, Driver's Lounge Under-Bunk Storage Bin and Chairs

table to allow the pins to rest in the bottoms of the guides.

3. Carefully raise one lower corner of the table and align the table link (Ref. 11) with its mounting hole in the table.
4. Ensure that the nylon bushing and flatwasher (Refs. 13 and 14) are in the same position as when removed. Then, install the mounting bolt through the flatwasher, table link, and bushing, into the table mounting hole.
5. On the opposite side, install the mounting bolt through the flatwasher, table link, and bushing, into the table mounting hole. Tighten both bolts securely.
6. While holding the table, unlatch and place the table leg into position to support the table.
7. Push the top of the table fully against the bunk striker and lower and latch the table leg to latch the table to the striker on the underside of the bunk.

Removal and Installation

8. Place the table in position for use and then in the stowed position several times to confirm proper operation.
9. Remove the chocks from the tires.

General Description

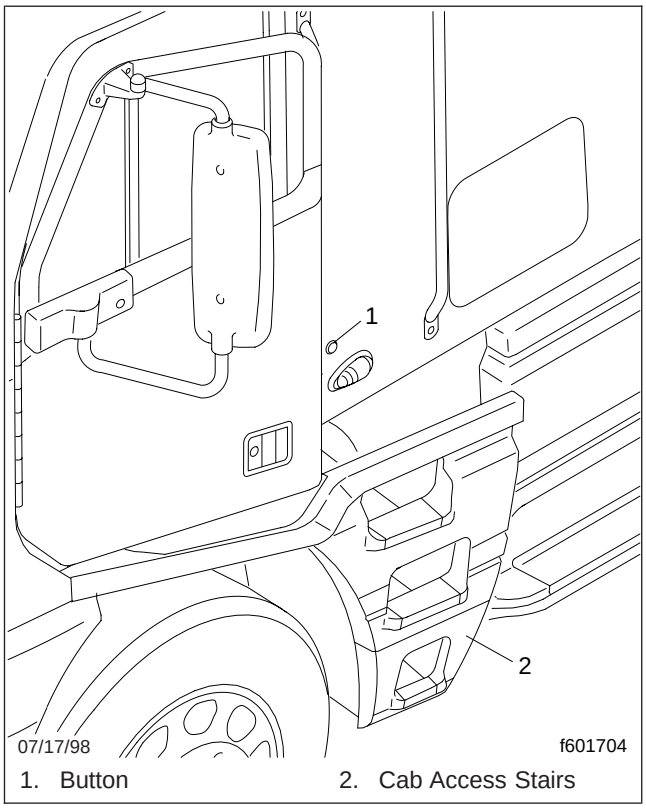
The optional cab access stairs will pivot outward from the cab when the cab door is opened from the inside or the outside, and will retract back under the cab when the door is closed from the inside or the outside. As the stairs move, an alarm outside the vehicle will sound. The stairs will stop moving if they come in contact with an obstruction. If an obstruction occurs, an interior buzzer will sound, and a light on the dash panel will activate.

The cab door can be opened without activating the stairs. From outside the cab, press the button on the side of the cab between the grab handles before opening the door. See **Fig. 1**. From inside the cab, press the rocker switch on the dash labeled RH STEP or LH STEP while opening the door.

NOTE: The button must be pressed each time the stairs are to be deactivated. Pressing the button will deactivate the stairs for one cycle of opening and closing the door. The next time the door is opened, the stairs will pivot outward unless the button is pressed again.

The cab access stairs will not move or will stop moving in the following conditions:

- The parking brake is not set.
- The vehicle is in motion. The stairs will automatically retract if the vehicle begins to move.
- There is weight on the stairs.
- The cab is tilted.
- The stairs come in contact with an obstruction.
- The button or rocker switch is pressed.



1. Button
2. Cab Access Stairs

Fig. 1, Cab Access Stairs

Cab Access Stairs Removal and Installation

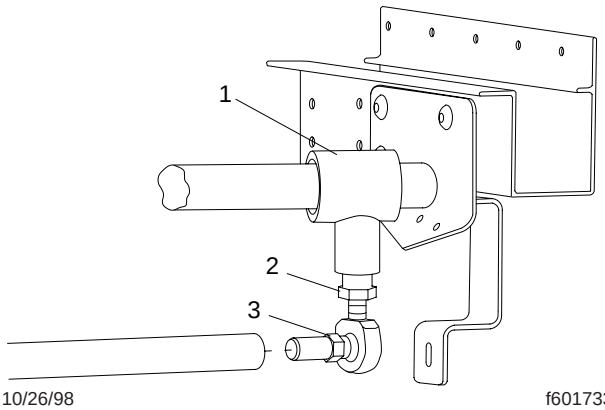
Removal

1. Turn off the engine, apply the parking brakes, disconnect the batteries, and chock the tires.
2. Remove the actuator pin.
   - 2.1 From under the front of the cab access stairs, open the quick-release access cover on the splash shield.
   - 2.2 Pull the handle on the actuator pin down, then turn the handle and remove the actuator pin from the access cover.

   NOTE: The stairs are now disconnected from the actuator.
3. Pull the step assembly out.

NOTE: Have an assistant support the steps before removing the linear bearing support bolt.

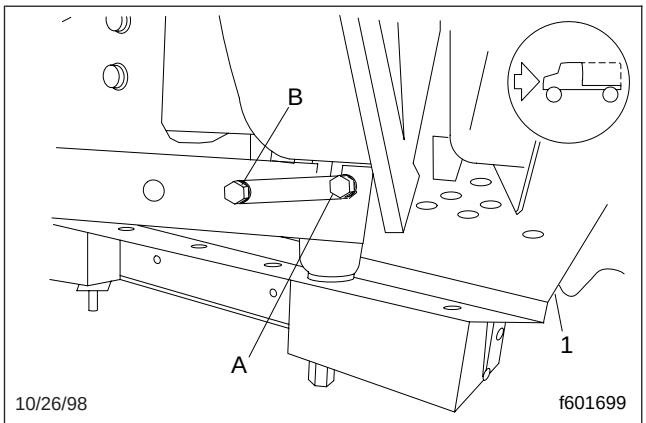
4. On the inboard side of the stairs, disconnect the ball stud of the rod end. See **Fig. 1**.



1. Linear Bearing
2. Adjusting Nut
3. Rod End with Ball Stud

Fig. 1, Linear Bearing

5. At the front of the stairs, remove the bolt on the outboard side of the vehicle, and loosen the bolt on the inboard side of the vehicle. See **Fig. 2**.
6. Remove the stairs.
   - 6.1 Support the back end of the stairs.
   - 6.2 At the front of the stairs, remove the bolt that was loosened earlier. See **Fig. 1**.



A. Remove this bolt.
B. Loosen this bolt.
1. Stair Platform

Fig. 2, Front End of Stairs

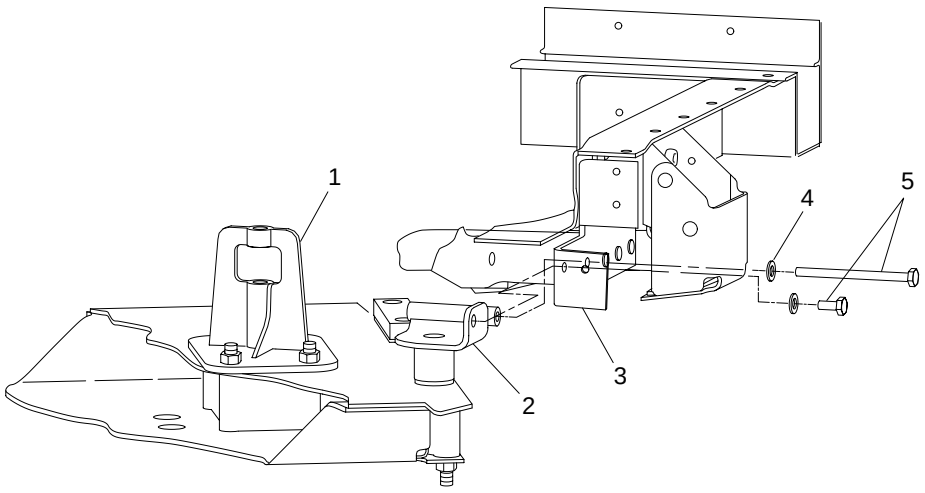
   - 6.3 Lower the front of the stairs, and remove the stairs.

Installation

1. Install the stairs.
   - 1.1 At the front of the vehicle, align the pivot bracket on the stairs with the pivot mounting bracket on the cab. Install the washers and the two bolts. See **Fig. 3**. Tighten the two bolts.
   - 1.2 On the inboard side of the stairs, connect the ball stud at the rod end. See **Fig. 1**.
   - 1.3 Move the actuator arm into the actuator mount. Install the actuator pin through the access cutout under the stairs. See **Fig. 4**.

   NOTE: After installing the actuator pin, push the handle back up to be sure the actuator pin remains in place. See **Fig. 4**.
2. Close the access cover, and connect the batteries.
3. Calibrate the cab access stairs. Refer to **Subject 150** for instructions.
4. Remove the chocks from the tires.

Cab Access Stairs Removal and Installation



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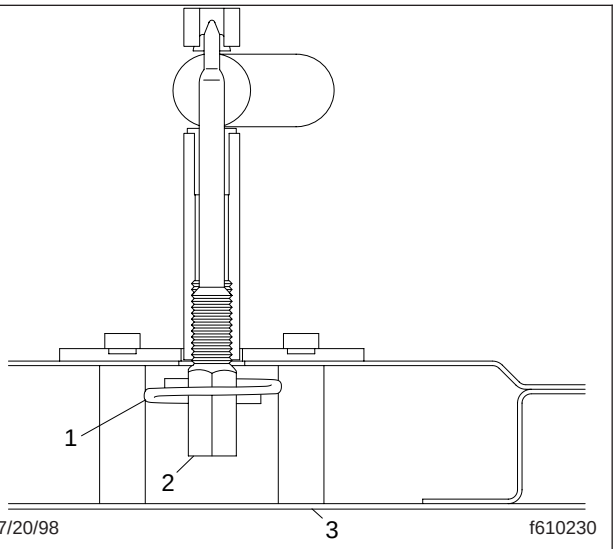
1. Actuator Mount
2. Pivot Bracket
3. Pivot Mounting Bracket
4. Washer
5. Bolts

Fig. 3, Pivot Bracket Installation



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1. Actuator Pin Handle
2. Actuator Pin
3. Underside of Cab Access Stairs

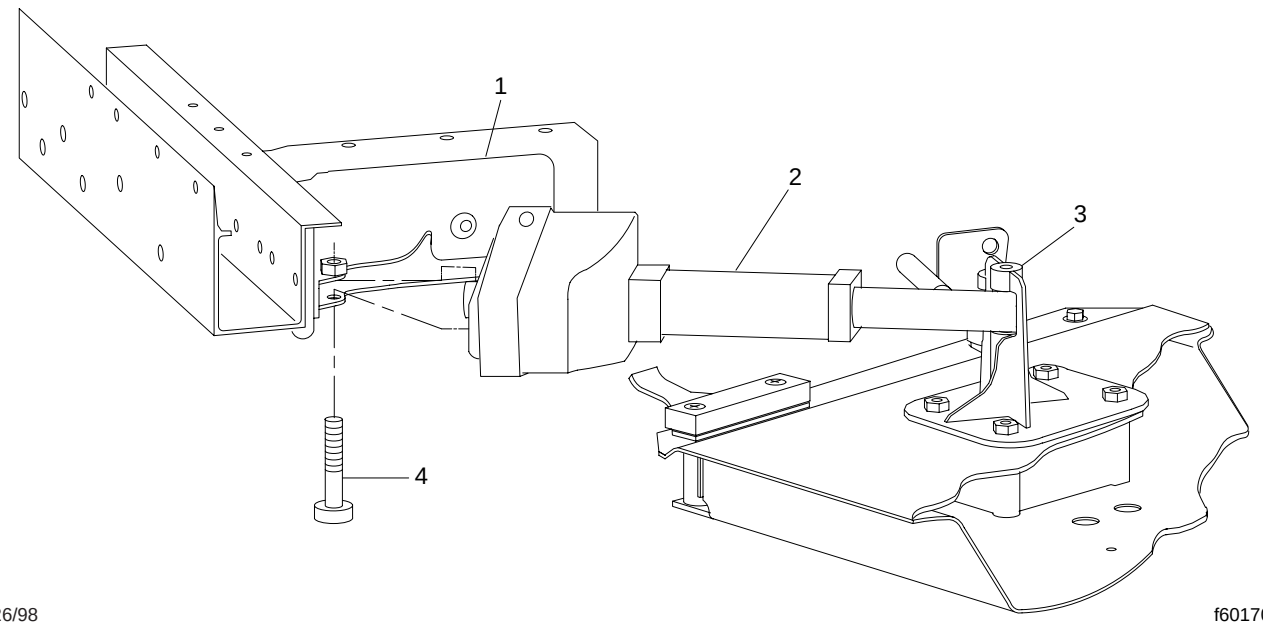
Fig. 4, Actuator Pin Installation

Replacement

1. Turn off the engine, apply the parking brakes, and chock the tires.
2. Disconnect the batteries.
3. Remove the actuator pin.
   - 3.1 From under the front of the cab access stairs, open the quick-release access cover on the splash shield.
   - 3.2 From the access cover, remove the actuator pin by pulling down, then turning, the actuator pin handle.

   NOTE: The stairs are now disconnected from the actuator.
4. Pull the stairs out.
5. Move the actuator arm out of the actuator mount. See **Fig. 1**.
6. Disconnect the two electrical connectors from the actuator.
7. Remove the bolt that attaches the actuator to the mounting bracket. See **Fig. 1**.
8. Install the new actuator.

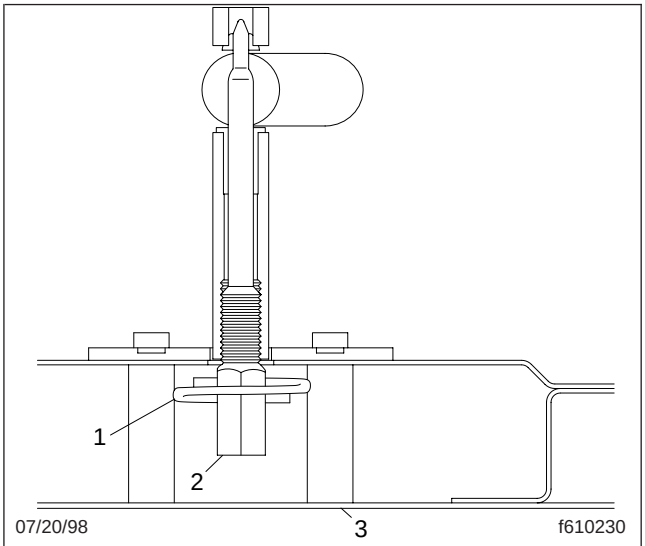
   IMPORTANT: The actuator arm needs to be extended about 3 inches (75 mm) out before being installed. Use a jumper wire and 12-volt battery to extend the actuator arm.
   - 8.1 Place the washer between the actuator and the lower shelf of the mounting bracket. Using the bolt and washer, attach the actuator to the mounting bracket.
   - 8.2 Move the actuator arm into the actuator mount. Reaching through the access cut-out under the stairs, install the actuator pin through the actuator arm and actuator mount.
9. After installing the actuator pin, push the handle up to secure the actuator pin. See **Fig. 2**.
10. Attach the two electrical connectors to the actuator.
11. Close the access cover on the splash shield.
12. Connect the batteries.



1. Mounting Bracket
2. Actuator Arm
3. Actuator Mount
4. Bolt

Fig. 1, Actuator Mounting

Actuator Replacement



1. Actuator Pin Handle
2. Actuator Pin
3. Underside of Cab Access Stairs

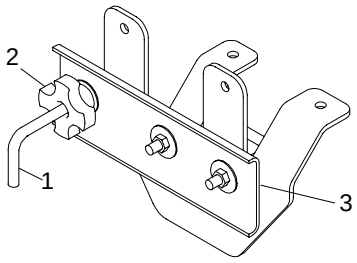
Fig. 2, Actuator Pin

13. Calibrate the cab access stairs. Refer to **Subject 150** in this section for instructions.
14. Remove the chocks from the tires.

Manual Storage

The cab access stairs can be manually stored under the cab if the stairs are open and cannot be moved.

1. Turn off the engine, apply the parking brakes, and chock the tires.
2. Remove the actuator pin. For instructions, see **Subject 100**.
3. Push the stairs under the cab.
4. Reach in through the top step to loosen the knob around the L-bar. See **Fig. 1**.



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1. L-Bar
2. Knob
3. Retainer Bracket

Fig. 1, Retainer Bracket

5. Turn the L-bar until the threads on the L-bar have engaged the stairs.
6. Tighten the knob to hold the L-bar in place.
7. Remove the chocks from the tires.

Step Deployment Unit Removal and Installation

Removal

There is an electronic control unit for each set of cab access stairs. The electronic control unit is mounted under the cab deck, directly above the cab access stairs.

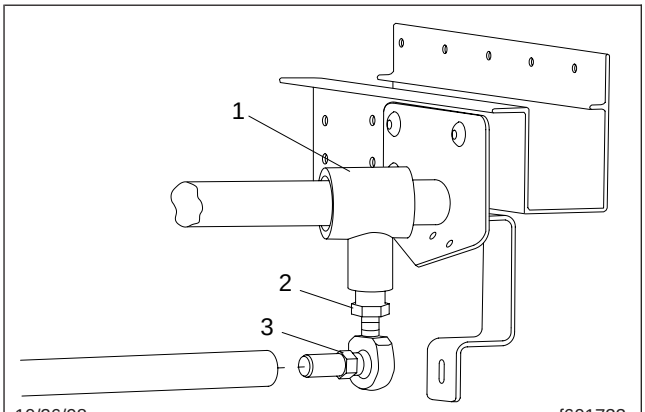
1. Turn off the engine, apply the parking brakes, and chock the tires.
2. Deploy the steps.
3. Disconnect the batteries.
4. Remove the fastener that attaches the connector to the electronic control unit.
5. Remove the four washers and bolts that attach the electronic control unit to the mounting bracket. Remove the electronic control unit.

Installation

1. Using four washers and bolts, attach the electronic control unit to the mounting bracket. Tighten the bolts 96 lbf·in (1080 N·cm).
2. Using the fastener, install the connector on the electronic control unit.
3. Connect the batteries.
4. Calibrate the cab access stairs. Refer to **Subject 150** for instructions.
5. Remove the chocks from the tires.

Removal (See Fig. 1)

1. Park the vehicle, apply the parking brakes, and chock the tires.



1. Adjusting Nut
2. Linear Bearing
3. Rod End with Ball Stud

Fig. 1, Linear Bearing

NOTE: Have an assistant support the access steps before removing the linear bearing.

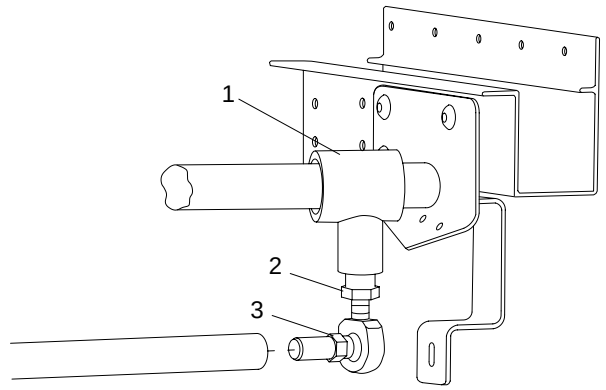
2. Remove the two fasteners on the inboard side of the linear bearing rod assembly.
3. Remove the three fasteners on the outboard side of the linear bearing rod assembly.
4. Loosen the nut at the base of the linear bearing.
5. Remove the support bar from the access step assembly, and remove the linear bearing.

Installation

1. Slide the linear bearing on to the support bar.
2. Position the linear bearing rod assembly on the access step assembly.
3. Attach the two fasteners on the inboard side of the linear bearing rod assembly, and tighten securely.
4. Attach the three fasteners on the outboard side of the linear bearing rod assembly, and tighten securely.
5. Tighten the nut at the base of the linear bearing.
6. Adjust the assembly as necessary. Refer to **Subject 150** for instructions.

Adjustment

1. Using the door frame as reference, verify that the cab access steps are parallel with the door frame, and maintain a constant gap.
2. Adjust the front to back level of the step by turning the adjusting nut on the linear bearing. See **Fig. 1**.



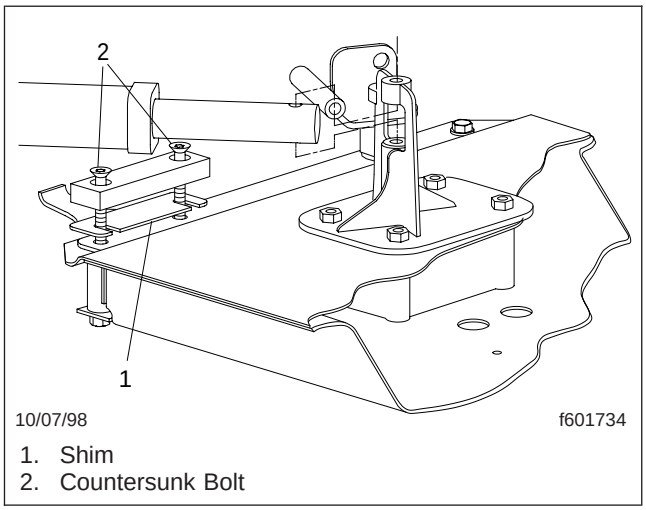
1. Linear Bearing
2. Adjusting Nut
3. Rod End with Ball Stud

Fig. 1, Linear Bearing

3. Adjust the side to side level of the step by loosening the bolts on the step retainer plate at the front of the access steps. See **Fig. 2**. Insert shims as necessary under the slider block to properly adjust the height. When the height is properly adjusted, tighten the bolts securely.

Calibrating the Cab Access Stairs Module

1. Calibrate the stairs using the DataLink Monitor.
   - 1.1 Open ServiceLink and connect to the vehicle.
   - 1.2 Click on the "Templates" icon on the ServiceLink menu.
   - 1.3 Under the J1708 heading, select "Recalibrate SDU" from the drop-down menu.
   - 1.4 Click the button for the side of the vehicle that requires calibration.



1. Shim
2. Countersunk Bolt

Fig. 2, Retainer Plate and Slider Block

2. Turn the ignition off and close the driver and passenger doors.
3. Press and hold for fifteen seconds the exterior disable switch on the side that is being recalibrated. Release the switch when the alarm sounds.

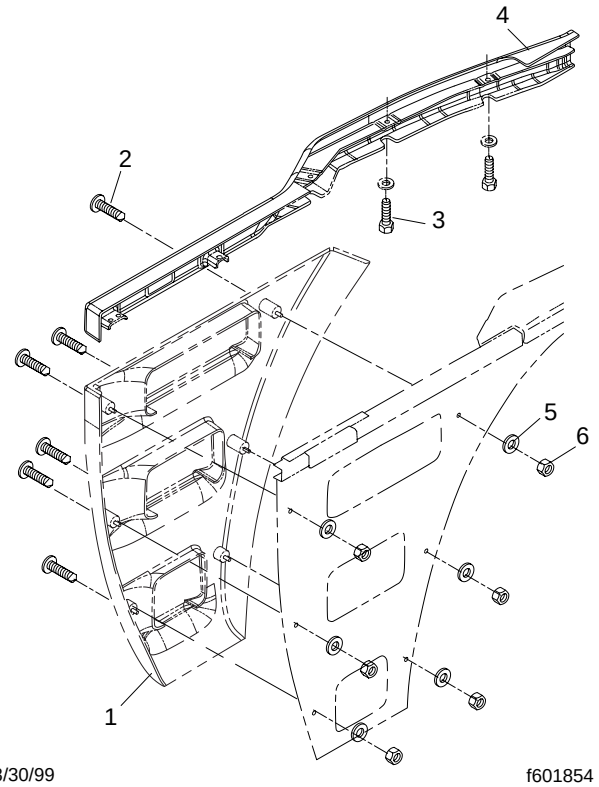
NOTE: The alarm will chirp while the SDU is in calibration mode.

4. Open the door to deploy the stairs. If the stairs do not completely deploy, press and release the exterior disable switch until the stairs are fully deployed.
5. Close the door. If the stairs do not stow completely, press and release the exterior disable switch until the stairs are fully stowed.
6. Repeat steps 4 and 5 two additional times, allowing the stairs to fully deploy and stow each time.
7. Open the door. The alarm will sound for several seconds and the stairs will not deploy.
8. Close and open the door. The stairs should deploy. The external alarm will no longer chirp.
9. Press and hold the interior disable switch for approximately fifteen seconds until the exterior alarm sounds.

Step Fairing Removal and Installation

Removal (See Fig. 1)

1. Park the vehicle, apply the parking brakes, and chock the tires.
2. Disconnect the batteries.



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1. Bottom Fairing
2. Bolt, 1/4–20, Grade 5
3. Capscrew, 1/4–20, Grade 5
4. Top Fairing
5. Flatwasher
6. Hexnut

Fig. 1, Cab Access Stairs Fairing

3. Deploy the stairs manually.
   - 3.1 Remove the actuator pin. For instructions, see **Subject 100**.
   - 3.2 Pull the stairs out to the deployed position.
4. Remove the three capscrews that secure the top fairing to the step assembly. Remove the fairing.
5. Remove the tread plates.
6. Remove the six bolts that secure the bottom fairing to the step assembly. Remove the fairing.

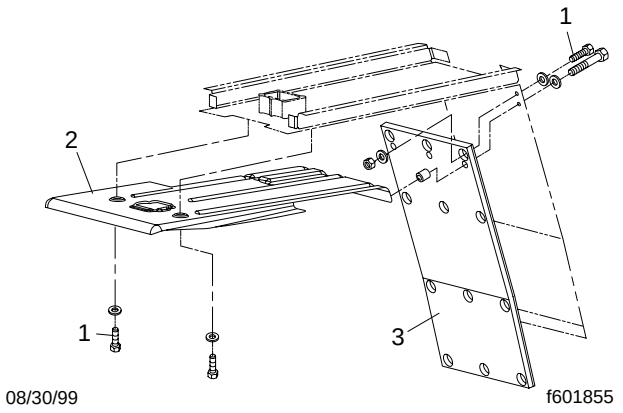
Installation

1. Install the bottom fairing on the step assembly.
   - 1.1 Install the three bolts on the left side of the bottom fairing, and tighten them securely.
   - 1.2 Install the three bolts on the right side of the bottom fairing, and tighten them securely.
   - 1.3 Tighten the bolts 15 lbf·ft (20 N·m).
2. Position the tread plates on the step assembly, and tighten the bolts 15 lbf·ft (20 N·m).
3. Position the top fairing on the step assembly. Install and tighten the capscrews 15 lbf·ft (20 N·m).
4. Push the stairs to the stowed position.
5. Install the actuator pin. For instructions, see **Subject 100**.
6. Connect the batteries.
7. Remove the chocks from the tires.

Mud Flap Removal and Installation

Removal (See Fig. 1)

1. Park the vehicle, apply the parking brakes, and chock the tires.



1. Bolt, 1/4–20, Grade 5
2. Splash Shield
3. Mud Flap

Fig. 1, Cab Access Stairs Mud Flap

2. Disconnect the batteries.
3. Deploy the stairs manually.
   - 3.1 Remove the actuator pin. For instructions, see **Subject 100**.
   - 3.2 Pull the stairs out to the deployed position.
4. Remove the two underdeck bolts and the top three step-mounted bolts that secure the splash shield to the step assembly. Remove the splash shield.
5. Remove the bolts that secure the mud flap to the step assembly. Remove the mud flap.

Installation

1. Position the mud flap on the step assembly, and install the nine lower bolts. Tighten the bolts 84 lbf·in (960 N·cm).
2. Position the splash shield on the step assembly. Install the two underdeck bolts and tighten 15 lbf·ft (20 N·m).

NOTE: Use an alignment tool, if necessary, to align the top three holes before installing the step-mounted bolts.

3. Install the top three step-mounted bolts. Tighten the bolts 84 lbf·in (960 N·cm).
4. Push the stairs to the stowed position.
5. Install the actuator pin. For instructions, see **Subject 100**.
6. Connect the batteries.
7. Remove the chocks from the tires.

See **Fig. 1** for a full view of the cab access stairs wiring diagram. See **Fig. 2** and **Fig. 3** for partial (detailed) views of the cab access stairs wiring diagrams.

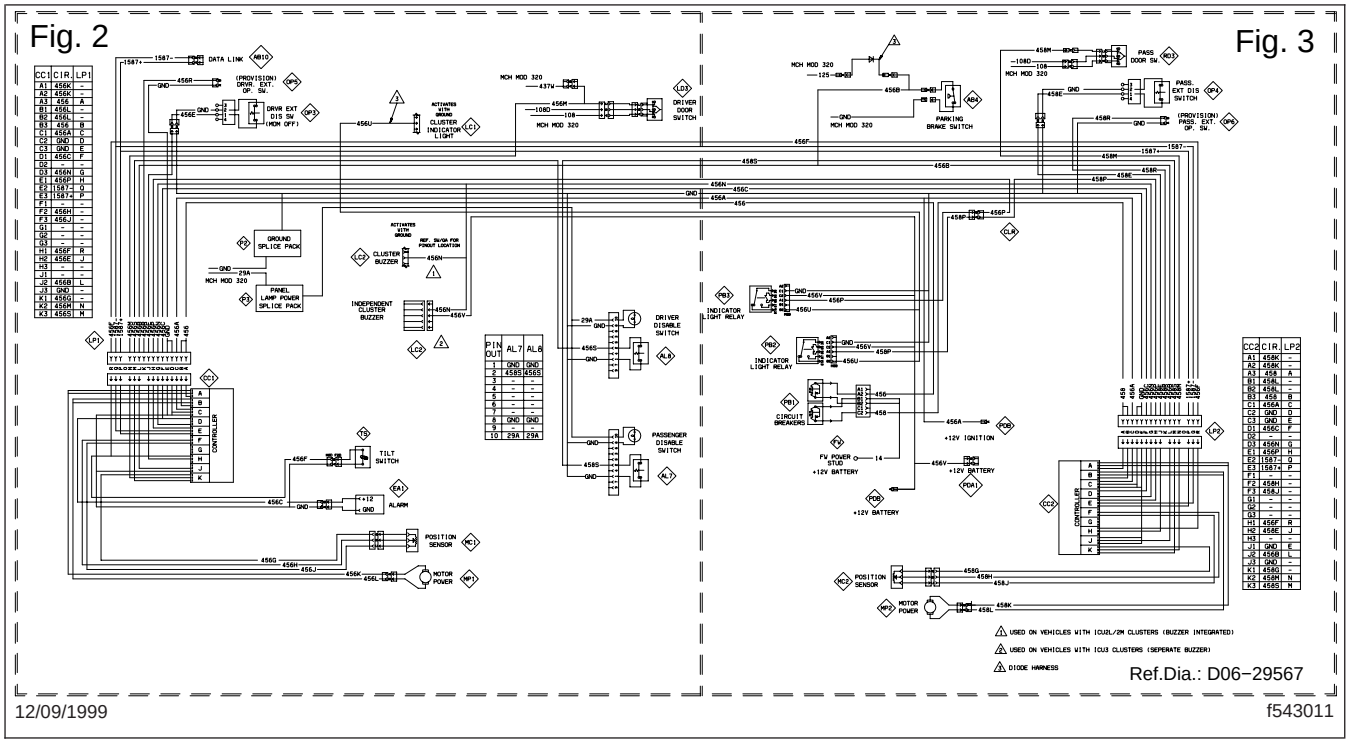


Fig. 1, Cab Access Stairs Wiring

Specifications

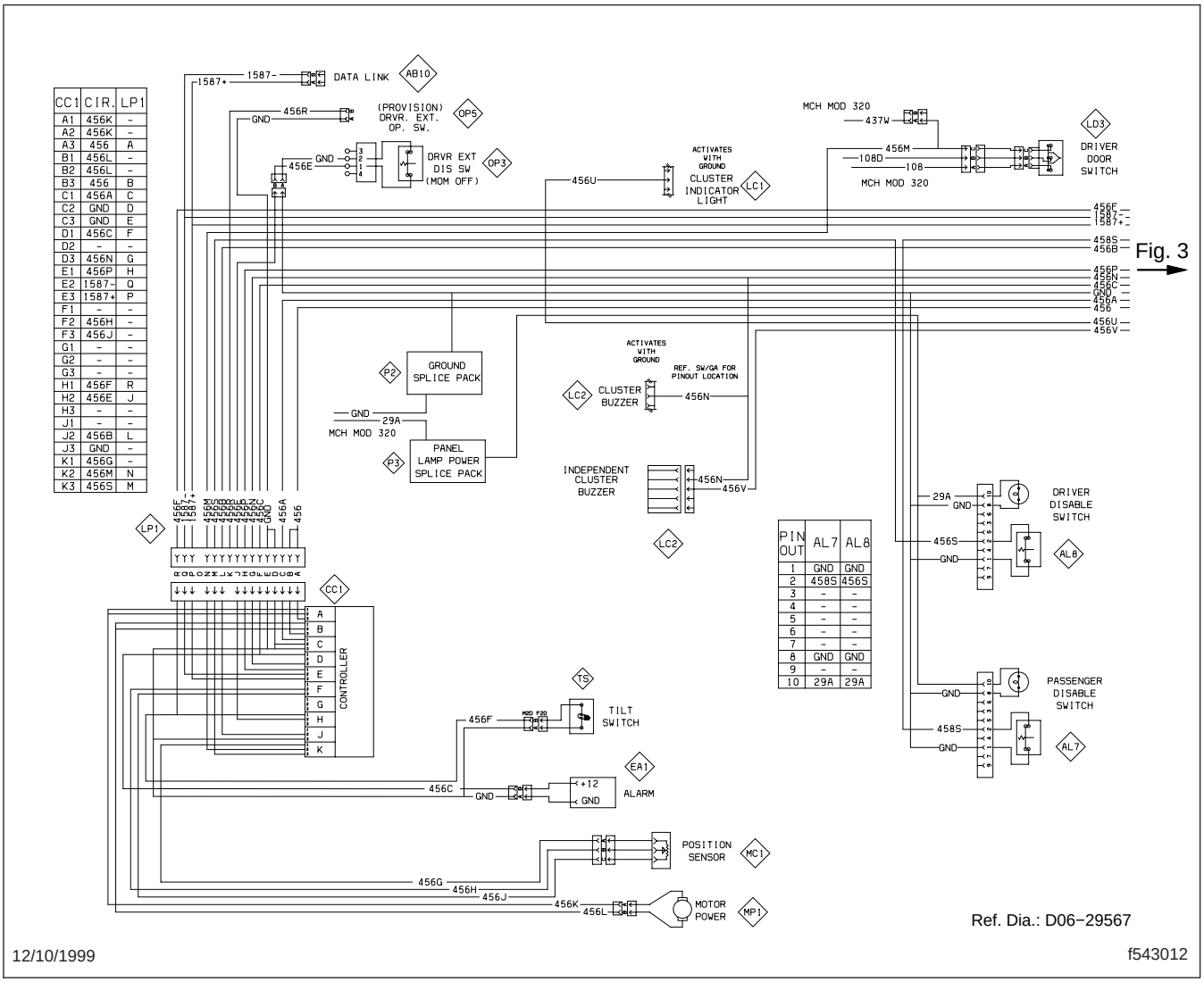
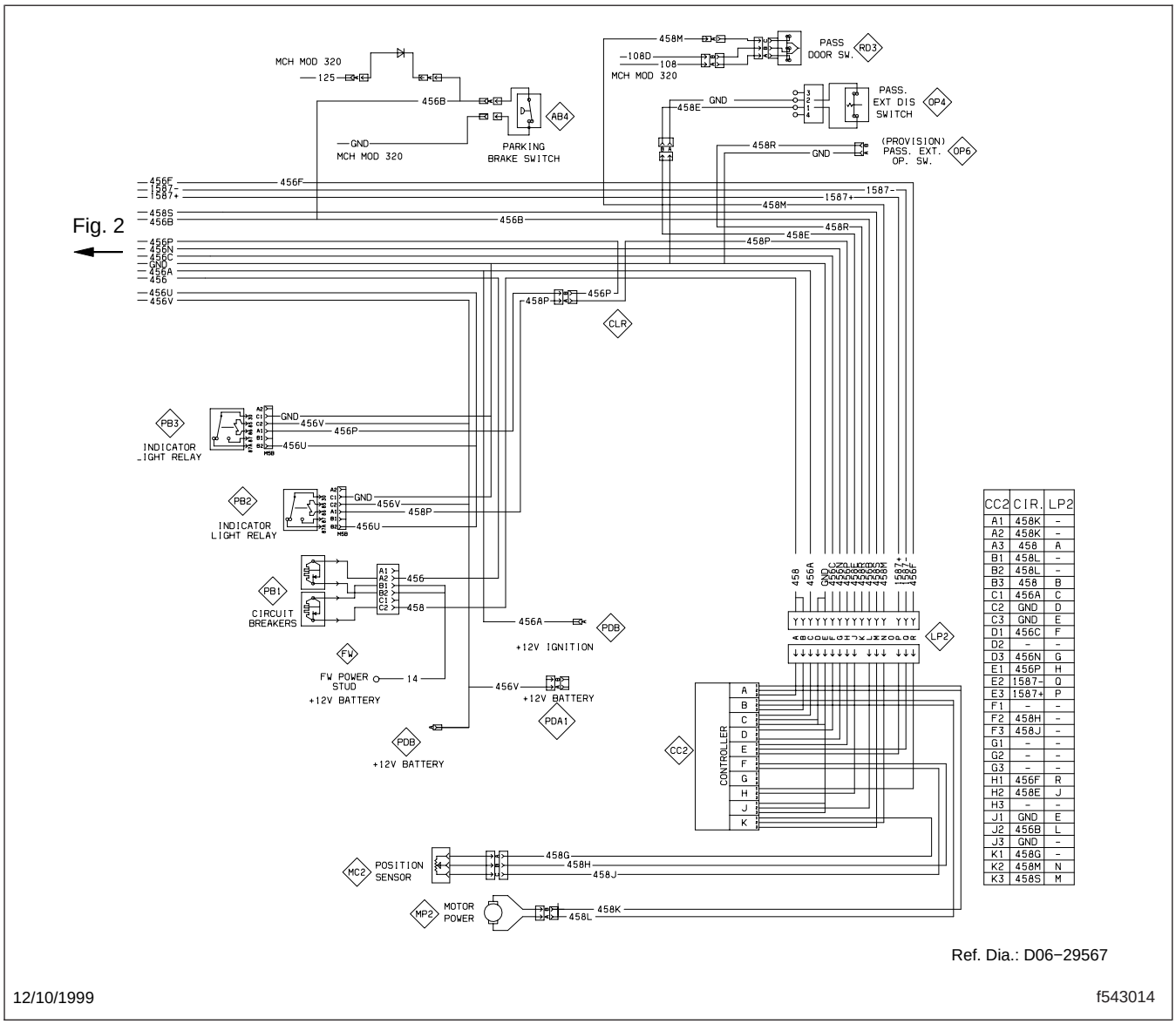


Fig. 2, Cab Access Stairs Wiring (partial view)



CC2	CIR.	LP2
A1	458K	–
A2	458K	–
A3	458	A
B1	458L	–
B2	458L	–
B3	458	B
C1	456A	C
C2	GND	D
C3	GND	E
D1	456C	F
D2	–	–
D3	456N	G
E1	456P	H
E2	1587-	Q
E3	1587+	P
F1	–	–
F2	458H	–
F3	458J	–
G1	–	–
G2	–	–
G3	–	–
H1	456F	R
H2	458E	J
H3	–	–
J1	GND	E
J2	456B	L
J3	GND	–
K1	458G	–
K2	458M	N
K3	458S	M

Fig. 3, Cab Access Stairs Wiring (partial view)

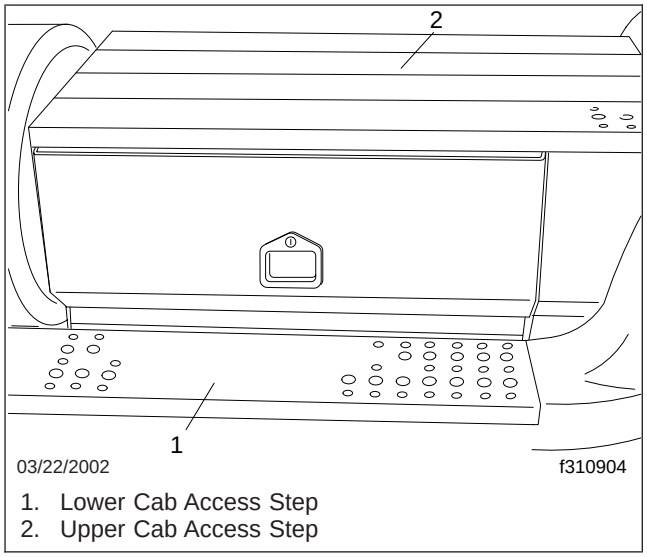
Lower Cab Access Step, Coronado

Removal

1. Park the vehicle on a level surface, apply the parking brake, shut down the engine, and chock the front and rear tires.

NOTE: The lower cab access step is positioned below the tool box. See **Fig. 1**.

2. Remove the bolts from the intermediate brace between the two lower step frame sections, and remove the brace.



1. Lower Cab Access Step
2. Upper Cab Access Step

Fig. 1, Cab Steps

3. Remove the bolts that attach the step to the step frame.
4. Remove the bolts attaching the rear section of the step to the internal frame.
5. Remove the step from the step risers.

Installation

1. Position the step on the quarter fender and rear tool box risers.
2. Install the rear mounting bolts on the internal frame.
3. Position the intermediate brace on the step frame and install the bolts.
4. Install the mounting bolts on the step frame.
5. Tighten all bolts securely.
6. Remove the chocks from the tires.

General Information

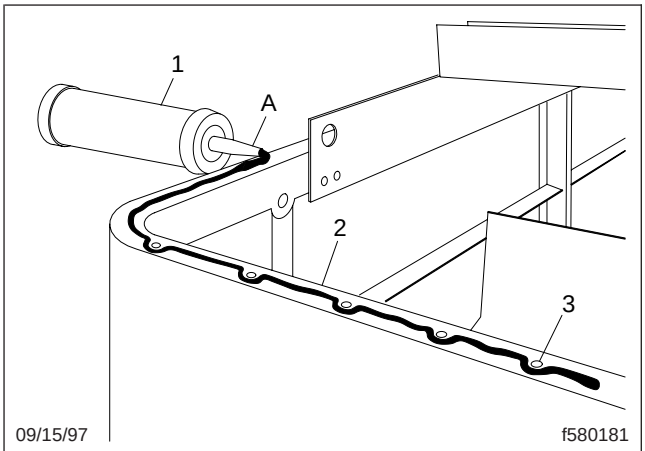
The installation of the coach joint and the roof cap changed in production on March 21, 2002. The revisions to the installation are as follows:

- The 58-inch and 70-inch raised roof assemblies are now bonded to the cabs.
- The quantity of roof cap joint fasteners is reduced from 46 to 20 (70-inch raised roof) and from 44 to 18 (58-inch raised roof).
- Seven 0.08-inch thick aluminum shims are removed.
- 19 countersunk rivets are removed.
- Four 18-gauge steel (adhesive backed) shims are removed.
- The roof cap near the corner headers and transition headers are removed.
- Side and rear roof cap headers are replaced with revised headers.
- The existing foam seating tape (.250-inch x .375-inch) is replaced with (0.188-inch by .312-inch) tape.
- The adhesive is replaced with blind rivets for attaching the window surround flange to the side headers.

Installation

The installation of the coach joint and the roof cap changed on March 21, 2002. Use the instructions in this section to install a new roof cap.

1. Park the vehicle, apply the parking brake, shut down the engine, and chock the front and rear tires.
2. Remove the roof cap. Refer to Section 60.07 of the *Century Class Trucks Workshop Manual* for instructions.
3. Fill the transitions around the top of the cab with Sika® 252 adhesive (48-25136-008) and smooth it out with a putty knife.
4. Use a glove and a lint-free rag to apply Sika Aktivator (48-25529-000). Use a quick single pass that fully wets the surface.
5. Apply a line of foam around the rim of the cab roof. See **Fig. 1**.



A. Apply adhesive around the top of the cab.
1. Adhesive Applicator
2. Cab Roof Rim
3. Fastener Hole

Fig. 1, Foam Application

NOTE: Apply adhesive 10 minutes after applying the foam, and no more than two hours after applying the Sika Aktivator.

6. Using the foam dam as a guide, apply Sika 252 adhesive. The bead should be 0.31-inch (8-mm) wide by 0.12-inch (3-mm) high.

NOTE: The adhesive should be inboard of the foam and should not spill over the top. If excess adhesive is applied, use a popsicle stick to spread it out.

7. Use bolts to align the back wall flanges.

IMPORTANT: The roof must be placed within 30 minutes after the adhesive bead is applied.

8. Install the roof cap. Refer to Section 60.07 of the *Century Class Trucks Workshop Manual* for instructions.
9. Make sure that the trim tabs and side extenders do not space out of the cap or the cab.

NOTE: Tighten the extenders only after the roof cap is bolted down.

10. Tighten the side extenders.
11. Before fully tightening all fasteners, inspect the roof cap to cab fit.
12. Remove the chocks from the tires.

General Description

The bulkhead-style cab door is an aluminum extrusion upper frame and a stamp-formed lower section with two aluminum billets inserted into the extrusion and lower section. The cab seal is mounted on the door.

The "bulkhead" description refers to the manner in which the door, when closed, seats inside the door opening; the outer panel surface of the door is then flush with the outermost edge of the stamped door opening frame.

The door opening frame has a small drip molding riveted to the cab skin above the door. Both the door opening and the drip molding are painted the predominant color of the cab exterior.

The door frame is the foundation of the door assembly (**Fig. 1**), serving as:

- the mount for the outer panel of the door
- the channel support for the window glass
- the hinge support
- the wing window mount
- the door latch mount

A cable-driven window regulator assembly raises and lowers the window on standard door assemblies. Some vehicles feature optional electric windows.

⚠ CAUTION

Before performing any electric welding on a vehicle, disconnect the battery power and ground cables and the window express module harness connectors behind the inner door panels. See Subject 110 in this section. Electric currents produced during electric welding can damage various electronic components on the vehicle.

The wiring harness for the turn signals, heated mirrors, and CB/radio antenna is routed inside the mirror support, and is not visible with the door closed.

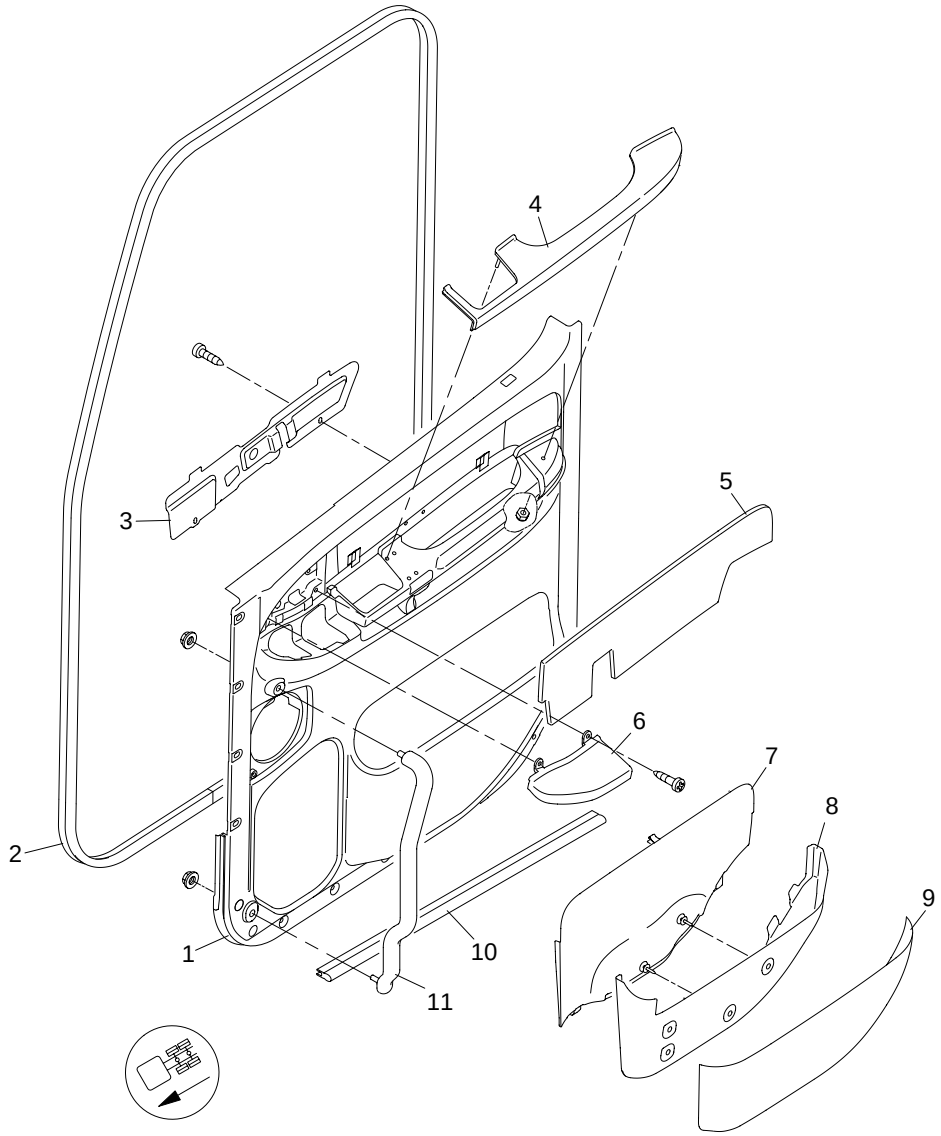
Most of the door parts are replaceable, with the exception of the outer panel (the exterior door skin). The outer panel is crimped to and bonded with structural adhesive to the door frame flange. If damaged, the outer panel and door frame assembly must be replaced as one assembly.

⚠ CAUTION

Do not attempt to replace the outer panel if it is structurally damaged. The entire portion of the panel that is crimped around the door frame is also bonded with a high-strength structural adhesive. In order to weaken this adhesive, a temperature of 400°F (204°C) is needed. If the aluminum door frame is heated to temperatures approaching 400°F (204°C), the door frame can crack or warp; accelerated aging of the metal may also occur.

Unless otherwise noted, all service operations can be done with the door attached to the vehicle. To reduce work time, don't remove the door unless told to do so.

General Description



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1. Inner Door Panel
2. Door Mounted Seal
3. Closure Panel
4. Arm Rest
5. Upholstery
6. Window Control Panel
7. Lower Door Trim Panel
8. Door Pocket Liner
9. Carpet
10. Weatherstrip
11. Grab Handle

Fig. 1, Cab Door Assembly, Exploded View

Removal

1. Apply the parking brakes, and chock the tires.
2. Lower the window.
3. Disconnect the batteries.
4. Disconnect the wiring connectors and harness leads.

IMPORTANT: As a safety precaution, bundle the loose wires, then temporarily tape them to the door.

5. Remove the door check, taking care to ensure the door does not swing out and damage the vehicle or the door. Also, do not allow the portion of the door check assembly mounted to the door opening to drop into the A-pillar.
6. Remove the inner A-pillar cover, the outer upper A-pillar cover, and the outer lower cowl A-pillar cover to provide access to the cabside of the door.

⚠ WARNING

WARNING: Do not attempt to lift the door. The door weighs approximately 110 pounds (50 kg). Lifting or dropping the door could result in personal injury or damage to the door assembly and other components.

7. Using a door support or another person, support the door frame from its bottom to prevent it from falling or tipping during removal. With the door open and supported, loosen the allen-bolts and hexhead fasteners that attach the door hinge to the cab.

Installation

1. If the door seal has been damaged or is weathered, replace it. For instructions, refer to **Subject 190**.

⚠ WARNING

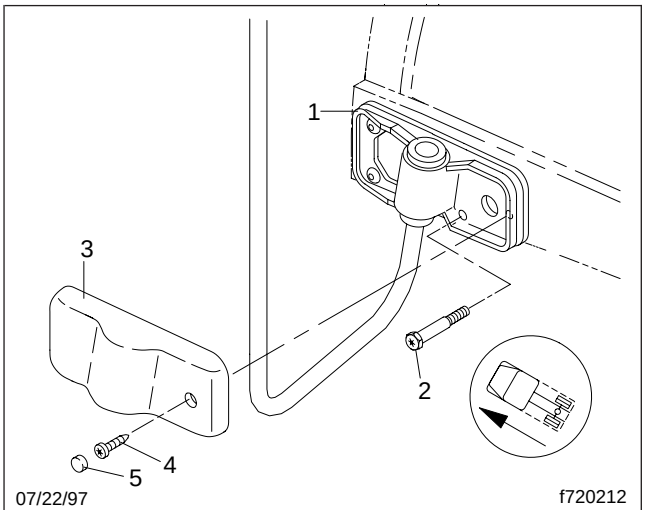
WARNING: Do not attempt to lift the door. The door weighs approximately 110 pounds (50 kg). Lifting or dropping the door could result in personal injury or damage to the door assembly and other components.

2. Using a door support or another person, support the door from its bottom to prevent it from falling or tipping during installation.
3. Insert and tighten the allen-bolts and hex head fasteners that attach the door hinge to the cab.
4. Unfasten the previously tied and bundled wires. Thread the wires through the bottom portion of the door opening frame and into the cab.
5. Install the door check, again taking care to keep the part mounted inside of the door opening from falling into the A-pillar.
6. As marked earlier, connect all electrical wiring to the door. The wires should be connected at the butt splices located just inside the cab, near the door opening frame.
7. Connect the batteries.
8. Check to be sure the door electrical components are operating correctly.
9. Install the outer lower cowl A-pillar cover, the outer upper A-pillar cover, and the inner A-pillar cover.

Inner Door Panel Removal and Installation

Removal

1. Apply the parking brakes and chock the tires.
2. Remove the mirror lower bracket cover; see **Fig. 1**. Using a T40 Torx® screwdriver, remove the door-panel retainer capscrew through the mirror bracket from outside of the cab; see **Section 60.06, Subject 110**.



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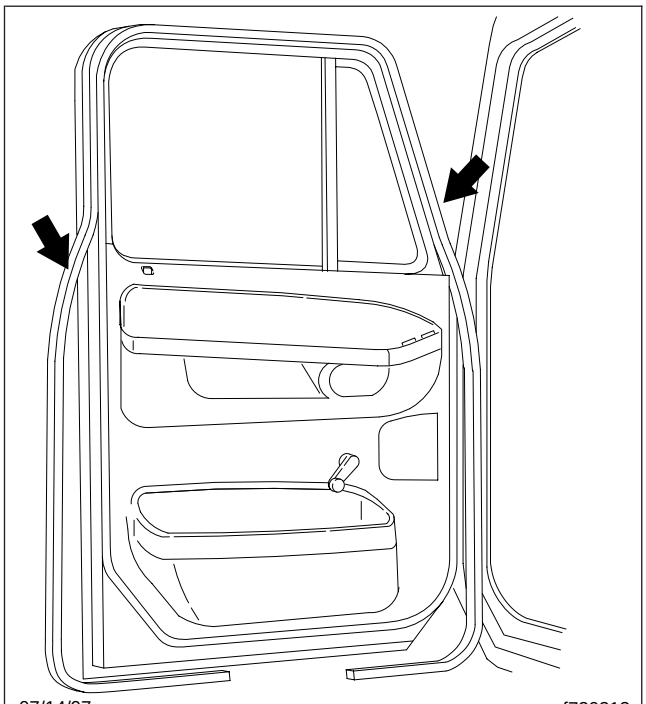
1. Mirror Lower Bracket
2. Door-Panel Retainer Capscrew
3. Mirror Bracket Cover
4. Bracket Mounting Screw
5. Plastic Plug

Fig. 1, Door-Panel Retainer Capscrew Removal

3. Starting at the bottom, partially remove the door seal to a point higher than the top of the inner panel. Leave the ends of the seal hanging down; see **Fig. 2**. Take care not to bend the seal in tight radius.
4. Remove the lower door trim panel (door pocket panel).
5. Roll down the window part way to expose the two window lift channel nuts through the opening in the inner door panel; see **Fig. 3**.
6. Remove the window crank, if installed (manual windows only).
7. Support the window glass.



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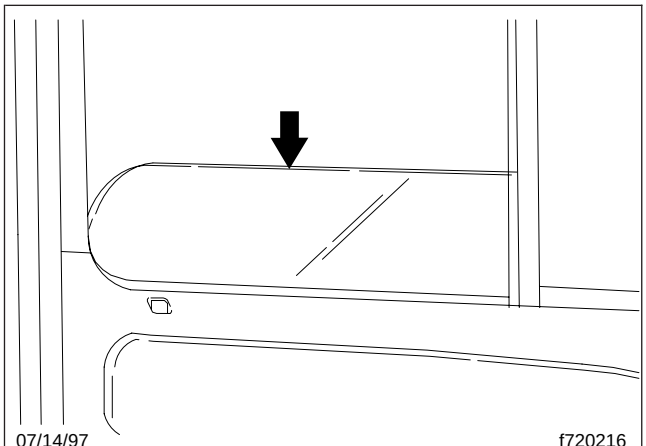
On both sides of the door, remove the seal to a point higher than the top of the inner door panel.

Fig. 2, Door Seal Partially Removed



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Lower the window glass about 2/3 of the way down; enough to expose the window lift channel nuts through the door pocket.

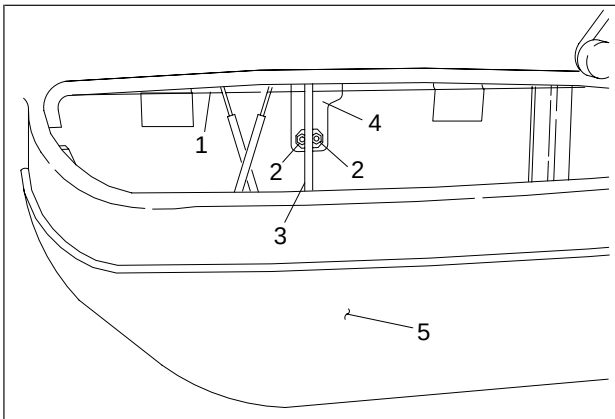
Fig. 3, Window Glass Lowered

Inner Door Panel Removal and Installation

NOTICE

To avoid damaging the window glass, make sure the window is rolled down and the window glass is supported from underneath.

8. Remove the two 1/4–20 window lift channel nuts; see **Fig. 4**.



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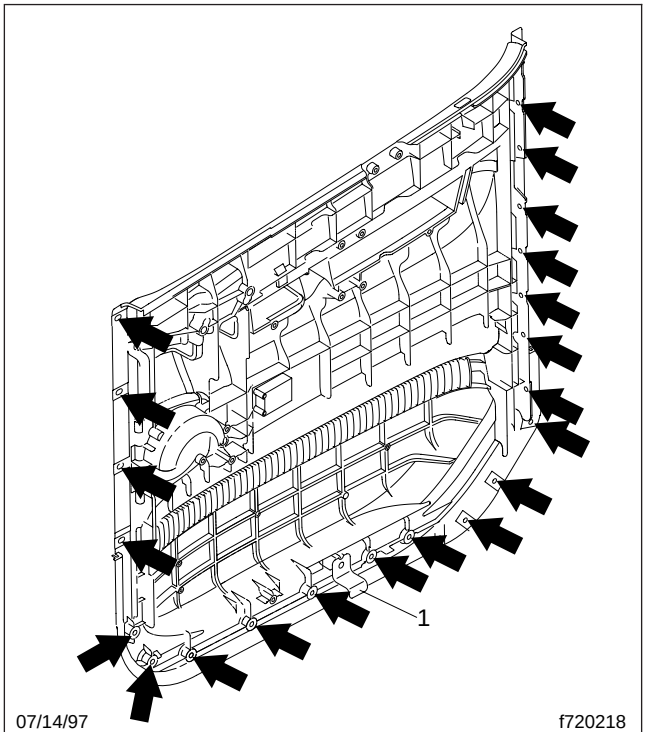
1. Window Glass
2. Lift Channel Nut
3. Regulator Shaft
4. Window Lift Channel
5. Inner Door Panel

Fig. 4, Lower Opening in Inner Door Panel

NOTE: Save all fasteners, plugs, and covers for later installation, when removing the inner door panel. Note that the screws are not all the same length. For ease of installation, keep the screws and other fasteners in a line in order of removal, so that each one can be installed in the correct hole.

9. Remove the inner door panel with the regulator and window glass installed, as follows; see **Fig. 5**.
   - 9.1 Remove the four plastic plugs on the rear door edge. Remove the four T25 screws, with washers, one underneath each plug; see **Fig. 6**.
   - 9.2 Remove the T40 Torx screw that holds the plastic cover on the rear door edge. Remove the T25 screw, with washer, underneath it.
   - 9.3 Remove the two exposed T25 Torx machine screws located on the door edge.



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The arrows indicate the location of T25 Torx screws (there are 21 in all).

1. Zee Bracket

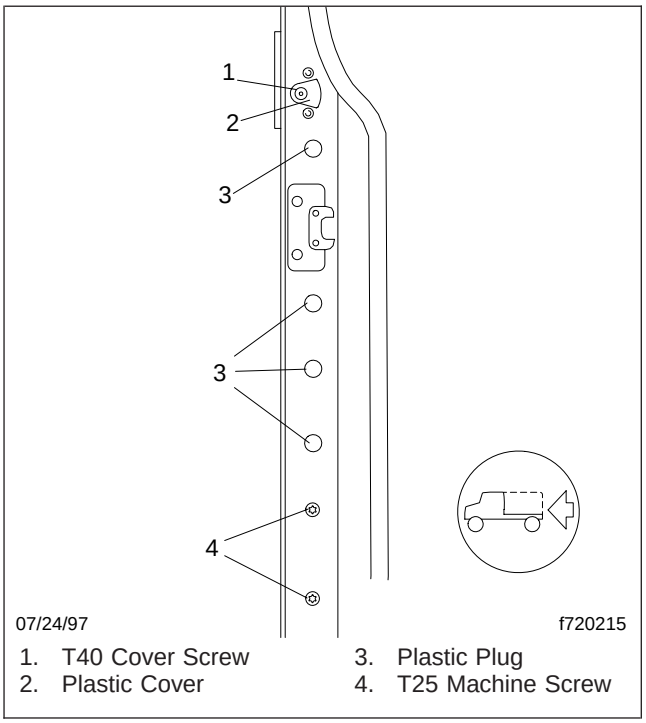
Fig. 5, Inner Door Panel Fasteners

   - 9.4 Remove all exposed screws on the front and rear of the door.
10. Lift the inner door panel up and over the door-lock button. Rest the panel on the edge of the door frame, using the zee bracket at the bottom of the panel.
11. Disconnect the door handle assembly. On manual door locks, tie the interior handle rod up and out of the way; see **Fig. 7**.
12. Disconnect the door electrical connectors (door harness, speakers, mirror switch harness, as installed). Loosen cables as necessary; see **Fig. 8**.
13. Lift the inner door panel out and remove it from the door.

Installation

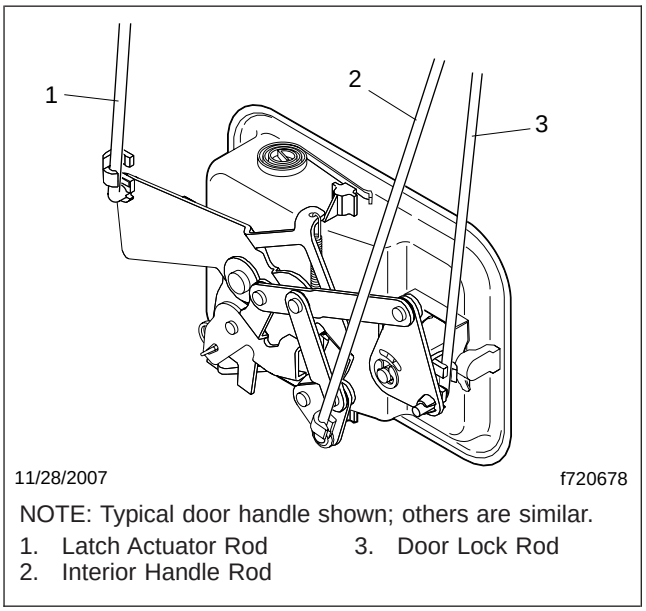
IMPORTANT: Make sure the interior handle rod is up and out of the way.

Inner Door Panel Removal and Installation



1. T40 Cover Screw
2. Plastic Cover
3. Plastic Plug
4. T25 Machine Screw

Fig. 6, Fasteners on Rear Edge of Door

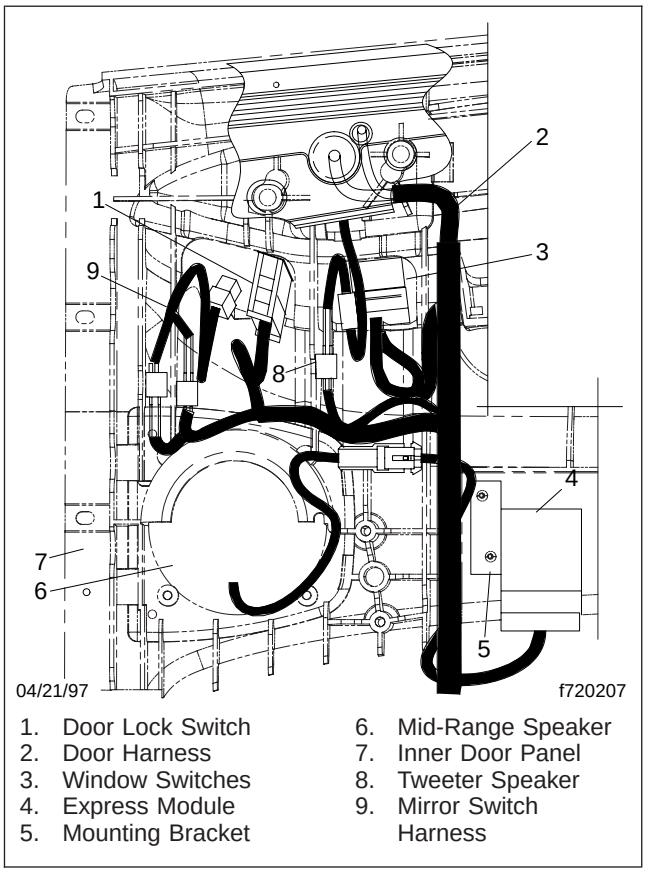


NOTE: Typical door handle shown; others are similar.

1. Latch Actuator Rod
2. Interior Handle Rod
3. Door Lock Rod

Fig. 7, Door Handle (inside view)

1. With the tires chocked, rest the inner door panel on the door frame, using the zee bracket on the bottom of the panel.



1. Door Lock Switch
2. Door Harness
3. Window Switches
4. Express Module
5. Mounting Bracket
6. Mid-Range Speaker
7. Inner Door Panel
8. Tweeter Speaker
9. Mirror Switch Harness

Fig. 8, Door Electrical Wiring (typical)

2. Connect the door handle assembly.
3. Attach all electrical connectors, as removed.
   - 3.1 Wrap tape on exposed connectors as needed.
   - 3.2 Feed any loosened cables into the door panel.
   - 3.3 Pack no-rattle foam into any empty spaces around the connectors.

CAUTION

It is possible to pinch fingers when moving the power window up and down.

- 3.4 Briefly press down the window switch and check that the window moves up and down easily, with no binding or slippage.

4. Install the inner door panel on the door as follows.

Inner Door Panel Removal and Installation

4.1 Attach two machine screws finger-tight, to loosely attach the inner door panel.

4.2 Check the panel all the way around the door for good seating and proper alignment.

NOTE: It may be helpful to use a magnetic screwdriver bit when installing these screws.

4.3 Install the five recessed machine screws on the door edge.

4.4 Install the rest of the machine screws and washers, as removed.

4.5 Tighten all machine screws 60 lbf·in (680 N·cm).

4.6 Install the plastic plugs and cover, as removed.

5. Install the lift channel nuts on the studs on the window lift channel. Tighten them 70 lbf·in (800 N·cm).
6. Install the window crank, if equipped with manual windows. Tighten the window crank screw 60 lbf·in (680 N·cm).
7. Install the door seal as removed; see **Subject 190**. Take care not to bend the seal in a tight radius.
8. Install the lower door trim panel (door pocket panel). Make sure it is firmly attached and not loose on either side.
9. Install the long door-panel retainer bolt through the mirror bracket from the outside of the cab. Tighten it 15 lbf·ft (20 N·m). Install the mirror bracket cover; see **Section 60.06, Subject 110**.

General Information

A newly installed door assembly must be adjusted for correct up-and-down, fore-and-aft, and in-and-out position relative to the door frame. The door assembly should also be adjusted whenever one or more of the following conditions exist (providing the door seal is correctly installed and is in good condition):

- wind or water leaks at the door frame
- premature wear of the door seal
- hard closing or opening of the door

The cab portion of the hinge has oversized holes. When the bolts that attach the hinge to the cab are loosened, the door can be adjusted forward or aft, and up and down within the door frame. The slotted holes along the door portion of the hinge area allow for in-and-out adjustment of the door.

Up-and-Down, Fore-and-Aft Adjustment

From outside the cab, check the alignment of the door with the cab door frame. The spaces around the top of the door should be uniform. If they are not, adjust the door.

1. With the vehicle parked, apply the parking brakes and chock the tires.
2. Remove three A-pillar covers (inner, outer upper, and outer lower-cowl) to provide access to the cab side of the door hinge.
3. Mark both the vertical and horizontal positions of the latch striker pin and the hinge before loosening them for adjustment. This will greatly simplify the procedure.
4. Using a no. 50 Torx® recess driver, loosen the striker pin, then tighten it finger-tight.
5. Loosen the bolts that attach the hinge to the cab door frame, but keep them tight enough to prevent unintentional hinge movement.
6. Carefully close the door, then raise or lower it until the space across the top is uniform.
    - The gap across the top should be about 3/8 inch (10 mm).
    - The gap at both the front and rear vertical edges of the door should be within 5/16 inch (8 mm).
7. Without disturbing the position of the hinge or striker pin, carefully open and support the door, then tighten the hinge bolts. Tighten the striker pin enough to hold it in place temporarily.
8. Install the three A-pillar covers, (outer lower-cowl, outer upper, and inner).
9. Follow the instructions in "Striker Pin Adjustment" below to correctly align and torque the striker pin.

In-and-Out Adjustment

The outer surface of the door should be flush with the surface of the cab skin at *both* its front and rear edges. If either edge is offset from the cab skin by more than ±5/64 inch (±2 mm), adjust the door.

Door Front Edge Adjustment

1. If the front edge of the door needs adjusting, with the tires chocked, mark the vertical and horizontal positions of the hinge before loosening them for adjustment. This will greatly simplify the procedure.
2. Loosen the bolts that attach the hinge to the door frame, but keep them tight enough to prevent unintentional hinge movement.
3. Carefully close the door. Move the front edge of the door in or out until its outer surface is flush, within ±5/64 inch (±2 mm), with the surface of the cab skin. Be careful not to disturb the up-and-down adjustment.
4. Without disturbing the positions of the hinge, carefully open and support the door, then tighten the hinge bolts.

Door Rear Edge Adjustment

1. If the rear edge of the door needs adjusting, with the tires chocked, mark the vertical and horizontal positions of the latch striker pin before loosening it for adjustment.
2. Loosen the striker pin, then tighten it finger-tight.
3. Carefully close the door. Move the rear edge of the door in or out until its outer surface is flush,

Door Adjustment

within ±5/64 inch (±2 mm), with the surface of the cab skin. Be careful not to disturb the up-and-down adjustment.

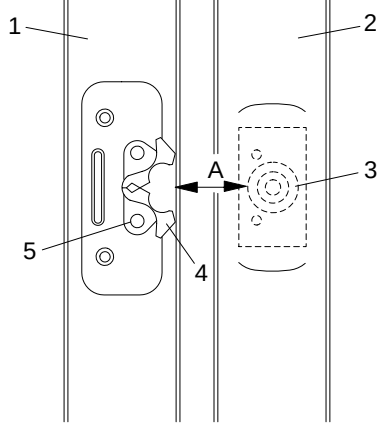
4. Without disturbing the position of the striker pin, carefully open the door and tighten the striker pin enough to hold it in place temporarily.
5. Follow the instructions in "Striker Pin Adjustment" below to correctly align and torque the striker pin.

Striker Pin Adjustment

For secure door closure, check the alignment of the latch jaws and striker pin even if the striker pin was not loosened.

1. With the tires chocked, from outside the cab, partially close the door until the latch jaws are about 1 to 2 inches (25 to 50 mm) from the striker pin. See **Fig. 1**. Check the alignment of the latch jaws and the striker pin.
   - In the up-and-down direction, the center of the latch must be level with the horizontal centerline of the striker pin.
   - Side-to-side, the latch jaws must contact the shaft of the striker pin so that when the door is closed, no part of the latch contacts the striker pin's outer flange or the conical washer. See **Fig. 2**.
2. As you close the door, check the movement of the door. It should not move up or down when the latch jaws engage the striker pin.
3. If the door latch does not engage correctly, adjust the striker pin. Using a no. 50 Torx® recess driver, loosen the striker pin and reposition it as required. If the striker pin needs to extend farther out from the door frame, add additional conical washers between the striker pin and the door frame.

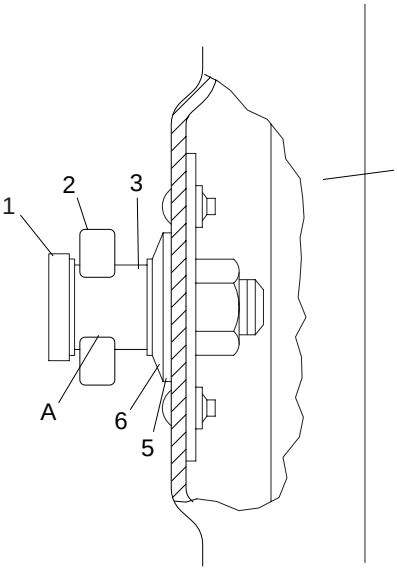
   Add only enough conical washers to allow correct engagement of the latch jaws around the striker pin shaft. Too many washers create interference between the striker pin washers and the capscrews on the latch assembly.
4. Repeat the above steps, as needed, until the striker pin contacts the middle of the latch rotors (jaws). When the striker pin is positioned correctly, tighten it 18 to 32 lbf·ft (24 to 43 N·m).



A. Check alignment with door latch jaws about 1–2 inches (25–50 mm) from striker pin.

1. Door Edge
2. Door Frame
3. Striker Pin
4. Door Latch Jaws
5. Capscrew, Hexhead

Fig. 1, Door Latch Alignment



A. Striker pin shaft must contact the middle of the door latch rotors (jaws).

1. Striker Pin Outer Flange
2. Door Latch Jaws
3. Striker Pin Shaft
4. Door Frame
5. Striker Pin Inner Flange
6. Conical Washer(s)

Fig. 2, Correct Latch Jaw Position on Striker Pin

5. Carefully close the door to the fully latched position (second click). From outside the cab, check the in-and-out, fore-and-aft, and up-and-down position of the door.
6. Remove the chocks from the tires.

Door Window Removal and Installation

Removal

WARNING

WARNING: Use care when working around or handling glass. Wear protective gloves and protective eyewear to eliminate the possibility of personal injury resulting from accidentally breaking or splintering the glass.

1. Apply the parking brakes. Lower the window glass.
2. For hand crank windows, remove the crank arm from the regulator assembly mounting spindle by removing the screw and carefully pulling the crank straight off the shaft.
3. Remove the inner door panel. See **Fig. 1**. For instructions, see **Subject 110**.
4. Remove the lower glass guide by removing two screws at the base of the guide and a bolt at the top.

IMPORTANT: Wear rubber gripper gloves during the removal of the window glass to ensure a secure grip on the glass.

5. If the window glass is not shattered, carefully remove the window glass and window lift channel assembly.

   Lean the window glass so that it is outside the window channel of the wing window mounting bracket, then carefully lift out the window glass assembly. If the window is broken, go to the next step.
6. Wearing protective gloves, remove all accessible shattered glass. Then, remove the window lift channel.

   Using a narrow extension accessory, vacuum out small glass fragments that may have fallen to the bottom of the door frame through the space behind the exterior door handle access cover attached to the inner panel. Failure to remove the glass fragments could cause plugged drain holes at the bottom of the door frame.
7. If necessary, remove the window glass-run channels. If the window glass was shattered, inspect the glass-run channels for cuts. Replace the glass-run channels, if damaged.
8. If the wing window assembly must be replaced, remove the fasteners that attach the window assembly to the door frame. Remove the window glass-run channel from the wing window.Remove the wing window assembly.

Installation

IMPORTANT: If the wing window assembly has been removed, carefully follow the first two steps below. Proper installation of the wing window seal will prevent water leaks from occurring when the vehicle is later placed in service.

If the wing window assembly has not been removed, skip the first two steps below.

1. Seat the wing window assembly in the door frame. Tilt the lower wing window guide toward the hinge. Make sure that the bottom seal flap on the outside of the door overlaps the belt rail (**Fig. 2**). The flap does not go under the belt rail.
2. Make sure that the flaps of the wing window side seal overlap onto the outside and inside surfaces of the door frame. If the seal flaps come between the door frame and the ventilator window mounting bracket, the holes for the panhead screws will not line up.

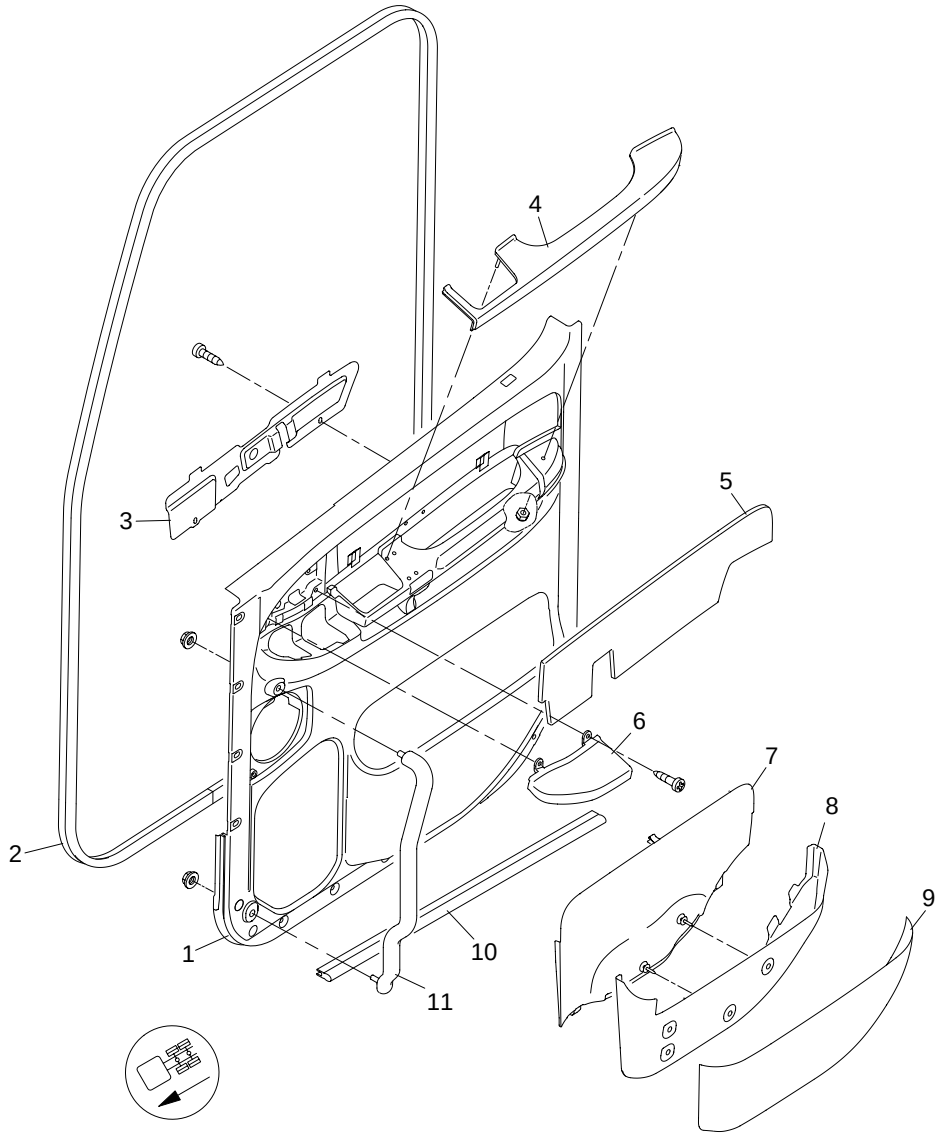
   Check the position (squareness) of the wing window in the door frame. The window channels should be parallel to one another, or binding of the window glass will occur as the window is raised. If necessary, adjust the position of the wing window. Tighten the panhead screws securely.
3. Carefully place the window glass assembly inside the door.

CAUTION

CAUTION: Failure to wear rubber gripper gloves while installing the window glass in the door could result in the glass slipping out of your hands and breaking.

IMPORTANT: Wear rubber gripper gloves when installing the window glass. Usually, service operations performed on the door will be done while the door is in a vertical position (that is,

Door Window Removal and Installation



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1. Inner Door Panel
2. Door Mounted Seal
3. Closure Panel
4. Arm Rest
5. Upholstery
6. Window Control Panel
7. Lower Door Trim Panel
8. Door Pocket Liner
9. Carpet
10. Weatherstrip
11. Grab Handle

Fig. 1, Cab Door Assembly, Exploded View

attached to the vehicle). Because of this, you will need a secure grip when handling the glass.

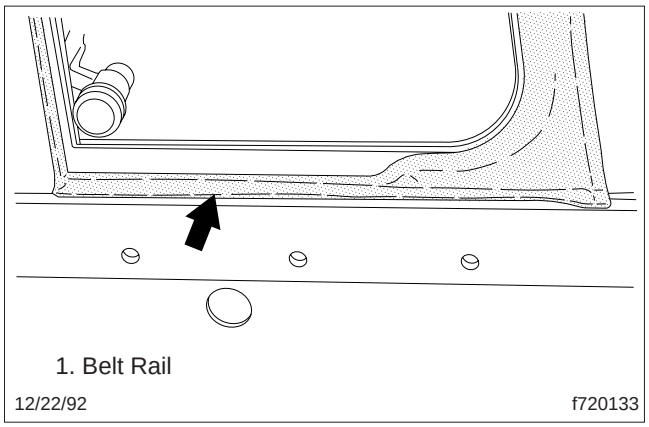
4. Install the window glass assembly in the window channel as follows:

4.1 Position the bottom (hinge side) corner of the window glass on the window stop block.

4.2 Position the top (hinge side) area of the window glass so that it is inside the win-

dow channel of the wing window mounting bracket. **See Fig. 2.**

4.3 Pull up on the top (latch side) corner of the window glass. As the top edge of the window is pulled up into a horizontal position, the bottom (latch side) corner of the window lift assembly will seat in the channel. See **Fig. 3**.



1. Belt Rail

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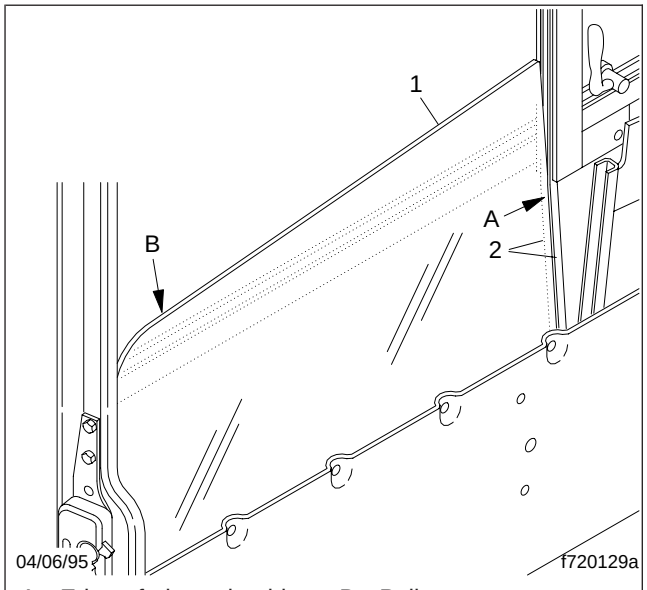
Fig. 2, Bottom Seal of the Wing Window Assembly



A. Edge of glass should be in channel
B. Pull up
1. Window Glass
2. Glass Run Channel

Fig. 3, Window Glass Installation

4.4 Tilt the lower wing window guide back to the vertical position. *Make sure that the guide remains in the vertical position.*

5. Install the lower glass guide by installing the two screws at the base and the bolt at the top.
6. Install the inner door panel. See **Fig. 1**. For instructions, see **Subject 110**.
7. Attach the crank arm to the regulator assembly mounting spindle. Test the window for up-and-down movement. Hard rolling usually means the window glass-run channels are not seated properly. Inspect the glass-run channels for seating.

Replacement

NOTE: The wing window glass can be replaced without disassembling the wing window mounting assembly.

IMPORTANT: Replacing the wing window mounting assembly requires the disassembly of most of the door assembly and mechanisms. See **Subject 120** for instructions.

1. Unlatch and open the wing window. **See Fig. 1.**

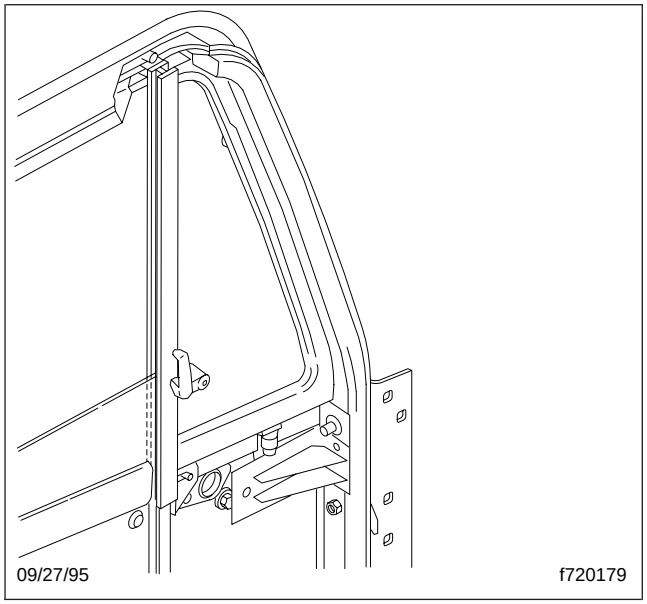


Fig. 1, Wing Window

2. Remove the window glass from the wing window assembly that is located inside of the wing window bracket.
3. Remove the window latch mounted to the glass by removing the roll pin, and then removing the nut.
4. Mount the window latch to the replacement glass.
5. Seat the window glass in the glass-run channel with rubber extrusion and adhesive.
6. Close the wing window and relatch.

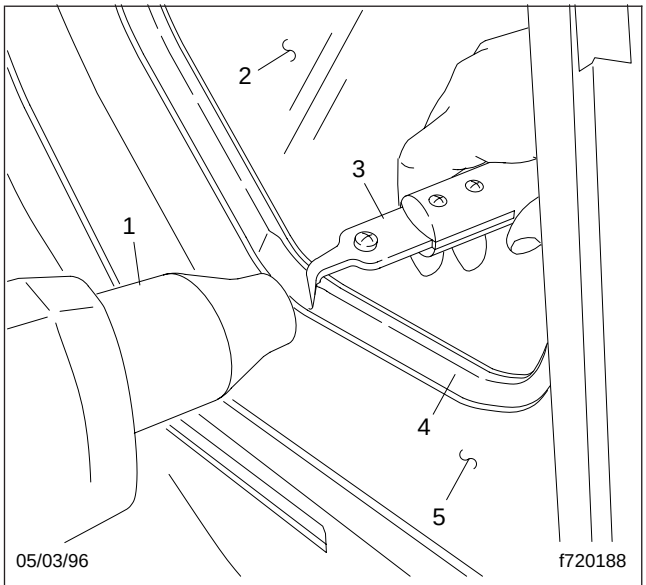
Lower Door Window Glass Replacement

Replacement

WARNING

WARNING: Use care when working around or handling glass. Wear protective gloves to eliminate the possibility of personal injury resulting from accidentally breaking or splintering the glass.

1. Park the vehicle on a flat surface. Shut down the engine, set the parking brake, and chock the tires.
2. Disconnect the batteries.
3. Remove the inner door panel. See "Inner Door Panel Removal and Installation" in **Subject 110** for instructions.
4. Loosen the window guide, if necessary.
5. Disconnect and move aside all electrical connections.
6. Remove the window (rubber) trim edge from between the window glass and the outer door panel.
7. Using a pull knife and a hand-held heat gun, loosen the window glass adhesive. From the inside of the door, heat the adhesive attaching the window glass to the inside of the outer door panel while simultaneously loosening the adhesive with the pull knife. See **Fig. 1**.
8. Remove the window glass.
9. Clean the surfaces of the window glass and the window opening in the door.
10. Mount double-sided tape to the edges of the replacement window glass.
11. Position the glass correctly, remove the tape covering, and then press the glass firmly around the edges to "set" the tape.
12. Insert the window (rubber) trim edge between the window and the door.
13. Connect all electrical connections, if necessary.
14. Install the inner door panel. See "Inner Door Panel Removal and Installation" in **Subject 110** for instructions.
15. Connect the batteries.



1. Heat Gun
2. Window Glass
3. Pull Knife
4. Adhesive
5. Door

Fig. 1, Heating Adhesive for Removal with Pull Knife

16. Remove the chocks from the tires.

Power Window Regulator

Removal

1. Apply the parking brakes and chock the tires.
2. Remove the interior door panel, with the regulator and window glass installed; see **Subject 110**.
3. Disconnect the door harness from the pigtail connector on the regulator motor; see **Fig. 1**.
4. Remove the cable clip from the pigtail connector.
5. Remove the two 10–24 machine screws from the upper mounting bracket.
6. Remove the regulator from the interior door panel, taking care not to bend the regulator shaft.

Installation

IMPORTANT: Before attempting to install the regulator, make sure the window glass is still supported from underneath and the window is rolled down.

1. With the tires chocked, position the regulator body, the regulator shaft, and upper mounting bracket on the interior door panel; see **Fig. 1**. Make sure all the fastener holes line up properly. Take care not to bend the regulator shaft.

IMPORTANT: Make sure the interior handle rod, if installed, is up and out of the way, and between the trim panel and the regulator shaft.

2. Install the upper mounting bracket on the inner door panel, using the two 10–24 machine screws, as removed.
3. Connect the door harness to the pigtail connector on the regulator motor.
4. Attach the cable clip to the pigtail connector.
5. Install the interior door panel, with the regulator and window glass, on the door; see **Subject 110**.

Manual Window Regulator

Removal

1. Apply the parking brakes and chock the tires.
2. Remove the interior door panel, with the regulator and window glass installed; see **Subject 110**.
3. Remove the two 10–24 machine screws from the face plate on the window crank; see **Fig. 2**.
4. Remove the spring clip from the regulator body.
5. Remove the two 10–24 machine screws from the upper mounting bracket.
6. Remove the regulator from the interior door panel, taking care not to bend the regulator shaft.

Installation

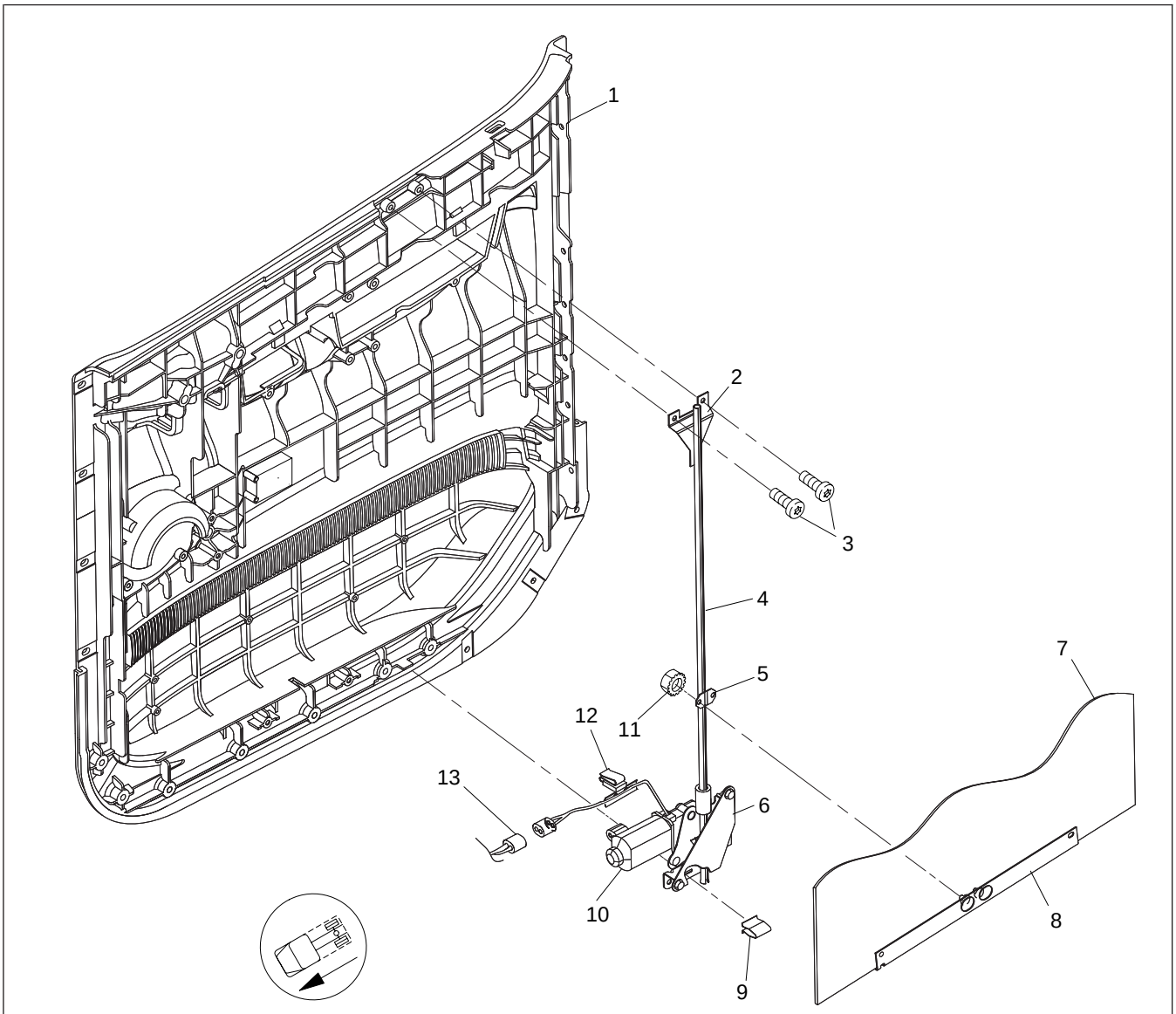
IMPORTANT: Before attempting to install the regulator, make sure the window glass is still supported from underneath and the window is rolled down.

1. With the vehicle tires chocked, position the regulator body, regulator shaft, upper mounting bracket, worm gear, and face plate on the interior door panel; see **Fig. 2**. Make sure all the fastener holes line up properly. Take care not to bend the regulator shaft.

IMPORTANT: Make sure the interior release rod, if installed, is up and out of the way.

2. Install the spring clip on the regulator body.
3. Install the face plate on the interior door panel using the two 10–24 machine screws, as removed.
4. Install the upper mounting bracket on the interior door panel using the two 10–24 machine screws, as removed.
5. Install the interior door panel, with the regulator and window glass, on the door; see **Subject 110**.
6. Install the window crank and check that the window moves up and down easily, without binding or slippage.

Window Regulator Removal and Installation

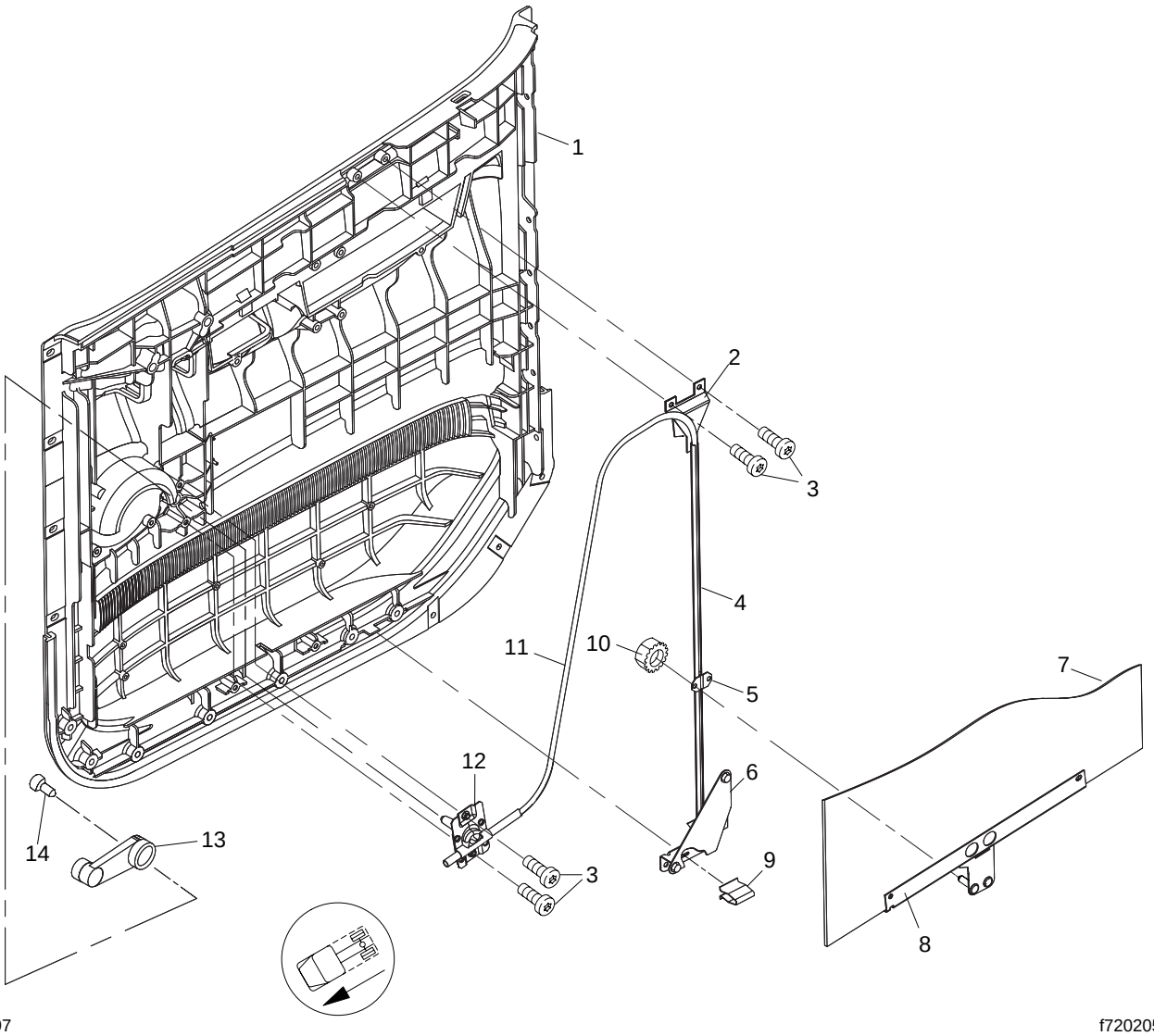


NOTE: Right-hand door is shown; left-hand door is similar.

1. Interior Door Panel
2. Upper Mounting Bracket
3. Machine Screws, 10–24
4. Regulator Shaft
5. Lift Cursor
6. Regulator Body
7. Window Glass
8. Window Lift Channel
9. Spring Clip
10. Regulator Motor
11. Window Lift Nut, 1/4–20
12. Cable Clip
13. Door Harness

Fig. 1, Power Window Regulator

Window Regulator Removal and Installation



NOTE: Right-hand door is shown; left-hand door is similar.

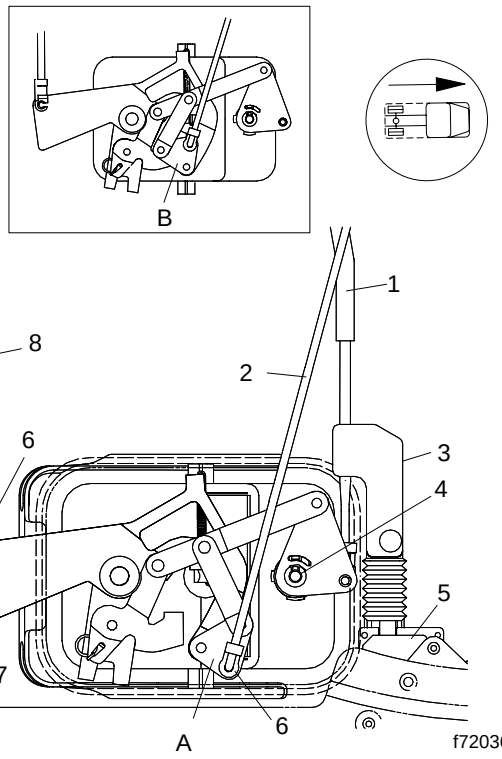
1. Interior Door Panel
2. Upper Mounting Bracket
3. Machine Screws, 10–24
4. Regulator Shaft
5. Lift Cursor
6. Regulator Body
7. Window Glass
8. Window Lift Channel
9. Spring Clip
10. Window Lift Nut, 1/4–20
11. Drive Shaft
12. Face Plate
13. Window Crank
14. Window Crank Screw, 10–24

Fig. 2, Manual Window Regulator

Exterior Door Handle and Rods Replacement

General Information

Century Class vehicles may have either of two different exterior door handle assemblies installed: one assembly is designed for a nonadjustable, one-piece interior handle rod (see **Fig. 1**), the other for an adjustable rod (see **Fig. 2**).



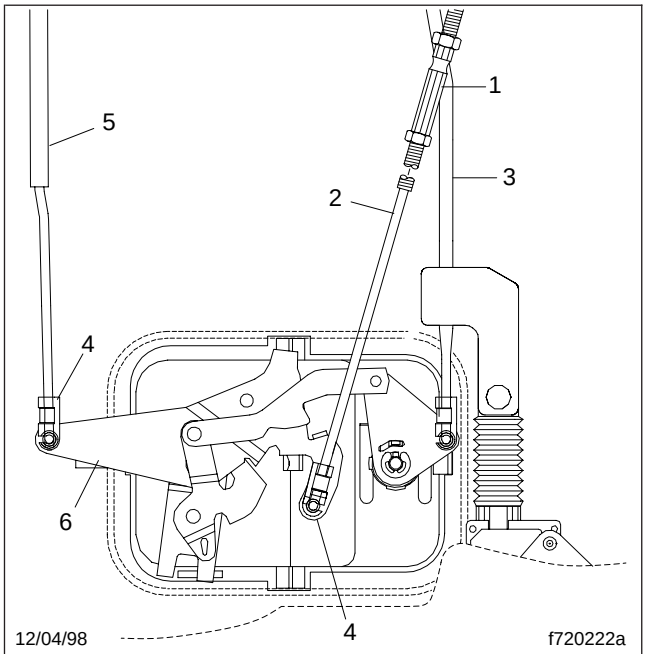
IMPORTANT: Rotate the top of the triangular link away from the paddle arm (interior handle rod in lowest position), as in A. Position B (interior handle rod in highest position) is incorrect.

NOTE: Inside view, LH door.

A. Correct orientation of triangular link.
B. Wrong orientation of triangular link.

1. Door Lock Rod
2. Interior Handle Rod
3. Electric Lock Actuator Bracket (option)
4. Snap Ring
5. Electric Lock Actuator (option)
6. Rod End Clip
7. Paddle Arm
8. Latch Actuator Rod

Fig. 1, Exterior Door Release Mechanism, Nonadjustable Rod



NOTE: Inside view, LH door.

1. Threaded Coupler with Jam Nuts
2. Interior Handle Rod
3. Door Lock Rod
4. Rod End Clip
5. Latch Actuator Rod
6. Paddle Arm

Fig. 2, Exterior Door Release Mechanism, Adjustable Rod

All new replacement door handle assemblies require a one-piece rod. A service kit is available for converting to the new design.

Control rods connect the latch, interior handle, and lock button to the door handle assembly. To avoid confusion, the names of the rods are listed below with other commonly used names shown in parentheses.

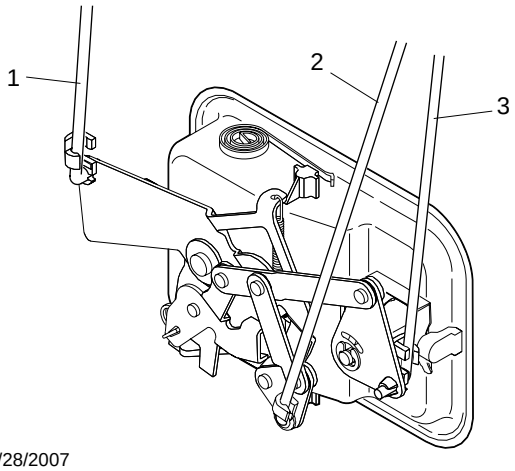
- Latch actuator rod (release latch rod)
- Interior handle rod (inner release rod)
- Door lock rod (lock button rod)

Handle Replacement

1. Apply the parking brakes and chock the tires.
2. Remove the window crank, if so equipped.
3. Remove the interior door panel; see **Subject 110**.

Exterior Door Handle and Rods Replacement

4. Reference the interior handle rod, latch actuator rod, and door lock rod attached to the door handle assembly. Release the lower ends of the rods from the clips on the door handle assembly; see **Fig. 3**.



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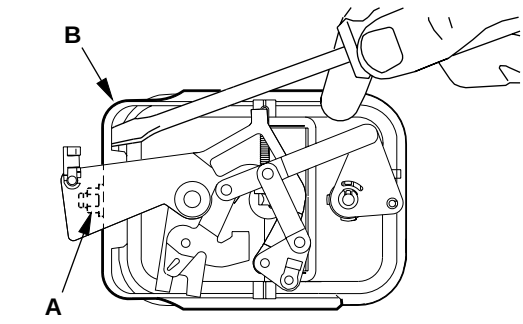
NOTE: Typical door handle shown; others are similar.

1. Latch Actuator Rod
2. Interior Handle Rod
3. Door Lock Rod

Fig. 3, Door Handle (inside view)

5. Remove the retaining nut that secures the fastening clip to the door handle assembly; see **Fig. 4**.



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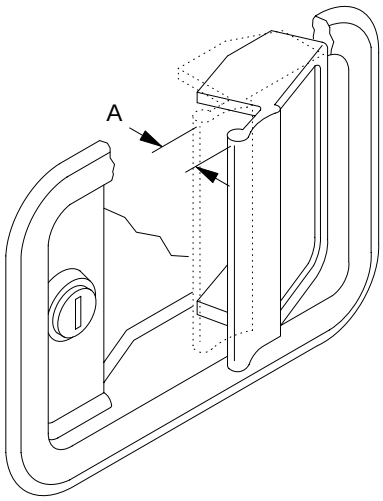
NOTE: Typical door handle shown; others are similar.

A. Remove retaining nut from bolt.
B. Push the fastening clip free.

Fig. 4, Removing Exterior Door Handle Fastening Clip

6. Using a pry tool, such as a screwdriver, push the fastening clip to the side until it clears the door handle bolt; see **Fig. 4**. Be careful not to let the door handle assembly drop as the fastening clip is pushed out of place. Remove the door handle assembly. It may be necessary to remove the lock cylinder (two clips) to fit the handle assembly through the door cutout.
7. Position the new door handle assembly in the door, then slide the fastening clip in place (reverse the procedure used to remove it).
8. Install the lock cylinder, if necessary.
9. Install the retaining nut that secures the fastening clip to the door handle assembly; see **Fig. 4**. Tighten the nut securely.
10. As referenced earlier, attach the lower ends of the interior handle rod, latch actuator rod, and door lock rod to the door handle assembly. Make sure the clips are locked in place.
11. With the cab door closed and unlocked, gradually pull on the paddle of the exterior door handle while measuring its travel. The paddle should move at least 3/8 inch (10 mm) before the door latch opens; see **Fig. 5**.



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A. Measurement: 3/8 inch (10 mm)

Fig. 5, Measurement of Paddle Travel

12. Make sure that the rod has been correctly installed by doing the following tests: Close the

latch jaws until they lock in place. Depress the lock button on the interior side of the door. Attempt to open the locked jaws using the exterior door handle. The jaws should not open. Attempt to open the locked jaws using the interior door handle. The jaws should open and the lock button should release. If adjustment is necessary, see **Subject 200**.

13. Attach the interior door panel; see **Subject 110**.
14. Install the window crank, if so equipped. Tighten the screw 60 lbf·in (680 N·cm).

Door Lock Rod Replacement

1. Apply the parking brakes and chock the tires.
2. Remove the window crank, if so equipped.
3. Remove the interior door panel; see **Subject 110**.
4. Release the lower end of the door lock rod from the clip on the door handle assembly; see **Fig. 3**.
5. Remove the lock rod from the door panel by pulling the bottom end down and out through the button hole, together with the door lock button, which is attached at the top end.
6. Install the door lock button on the new lock rod.
7. Install the lock rod in the interior door panel by inserting the end of the lock rod with the door lock button through the hole in the top of the interior door panel. Make sure the door lock rod is on the outboard side of the interior handle rod.
8. Attach the door lock rod to the door handle assembly; see **Fig. 3**. Make sure the clip is locked in place.
9. Install the interior door panel; see **Subject 110**.
10. Install the window crank, if so equipped. Tighten the screw 60 lbf·in (680 N·cm).

Interior Handle Rod and Latch Actuator Rod Replacement

NOTE: If you are replacing an adjustable interior handle rod with a nonadjustable, one-piece rod, you must also replace the door handle assembly and related components. The one-piece rod is not compatible with the old-style door handle assembly. A service kit is available for converting to the new design.

Use the following procedure only to replace an existing one-piece interior handle rod with a new one. To replace an adjustable rod, follow the service kit instructions.

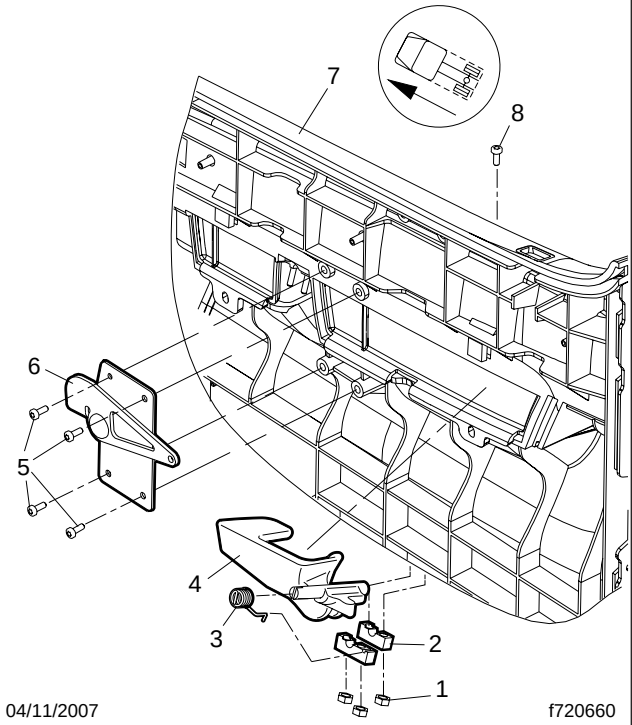
1. Apply the parking brakes and chock the tires.
2. Remove the window crank, if so equipped.
3. Remove the interior door panel; see **Subject 110**.
4. Remove the lower end of the interior handle rod by releasing the lower end from the clip on the door handle assembly; see **Fig. 3**. Remove the upper end from the clip on the bellcrank arm.
5. Remove the lower end of the latch actuator rod by releasing the lower end from the clip on the door handle assembly. Remove the upper end from the clip on the door latch.
6. Connect the upper end of the new latch actuator rod to the clip on the door latch, and the lower end to the clip on the door handle assembly; see **Fig. 3**.
7. Position the new interior handle rod between the door panel and the window regulator shaft. Make sure the interior handle rod is on the inboard side of the door lock rod. Connect the upper end of the rod to the clip on the bellcrank arm, and the lower end to the clip on the door handle assembly. Make sure that the clips are securely snapped on the the rod.
8. Install the interior door panel; see **Subject 110**.
9. Install the window crank, if so equipped. Tighten the screw 60 lbf·in (680 N·cm).

Inner Door Handle Replacement

Replacement

NOTE: Tighten all fasteners 35 lbf·in (400 N·cm).

1. Apply the parking brakes and chock the tires.
2. Remove the interior door panel; see **Subject 110**.
3. Lay the door panel on a clean, smooth work surface, with the inner side up.
4. Remove the four screws that secure the bell crank assembly to the interior door panel; see **Fig. 1**. Remove the bell crank assembly and interior release rod.
5. Remove the three interior door handle nuts; see **Fig. 2**.

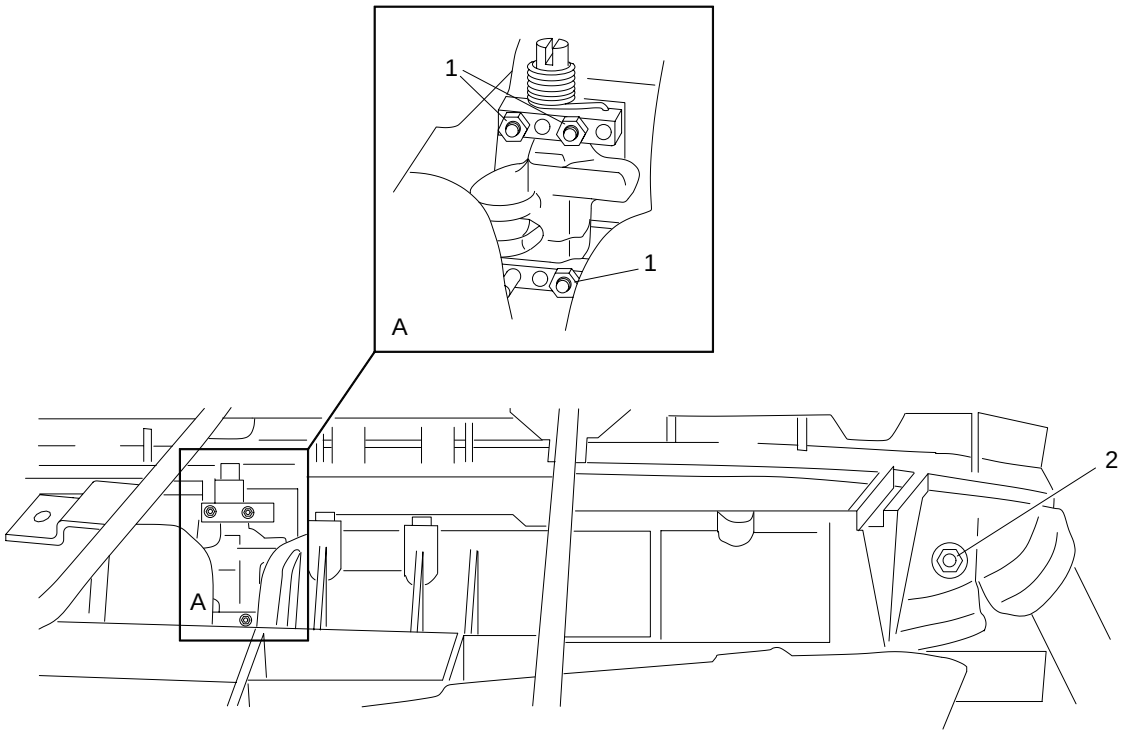


1. Nut
2. Handle Retainers
3. Door Handle Return Spring
4. Inner Door Handle
5. Screws
6. Bell Crank Assembly
7. Inner Door Panel
8. Retainer Screw

Fig. 1, Bell Crank Assembly and Inner Door Handle Installation

6. Remove the armrest support nut. Remove the arm rest.
7. Remove the interior door handle return spring.
8. From the outer side of the panel, remove the Torx® screw that secures the handle to the door panel; see **Fig. 3**. Remove the door handle.
9. Position a new handle on the door panel, and install the Torx screw on the outer side of the door panel; see **Fig. 3**.
10. Install the interior door handle return spring.
11. Install the armrest support nut; see **Fig. 2**. Install the armrest.
12. Install the interior door handle nuts.
13. Install the four screws that secure the bell crank assembly to the interior door panel; see **Fig. 1**. Install the bell crank assembly and interior release rod.
14. Install the interior door panel; see **Subject 110**.

Inner Door Handle Replacement



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1. Interior Door Handle Nuts
2. Armrest Support Nut

Fig. 2, Door Handle and Armrest Fasteners

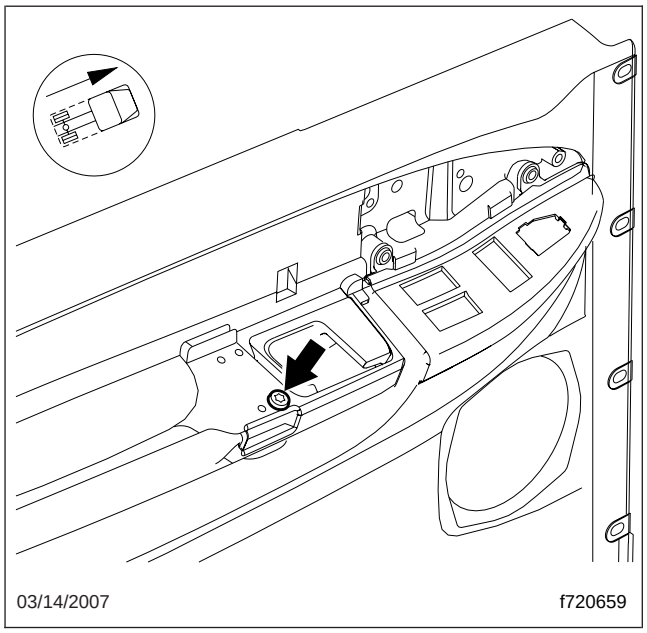


Fig. 3, Inner Door Handle Retainer Screw

Door Hinge Removal and Installation

Removal

1. Remove the door from the vehicle. For instructions, see **Subject 100**.
2. Remove the hinge from the door assembly.

Installation

1. Attach the hinge to the door assembly.
2. Install the door on the vehicle. For instructions, see **Subject 100**.
3. Adjust the door. For instructions, see **Subject 120**.
4. Some types of door hinges should not be lubricated. See **Group 72** of the *Century Class Trucks Maintenance Manual* to determine whether the hinge should be lubricated.

Replacement

1. Apply the parking brakes and chock the tires.
2. Remove the entire length of the seal from the channel that surrounds the upper door structure, as well as from the outer edge of the inner door panel.

NOTICE

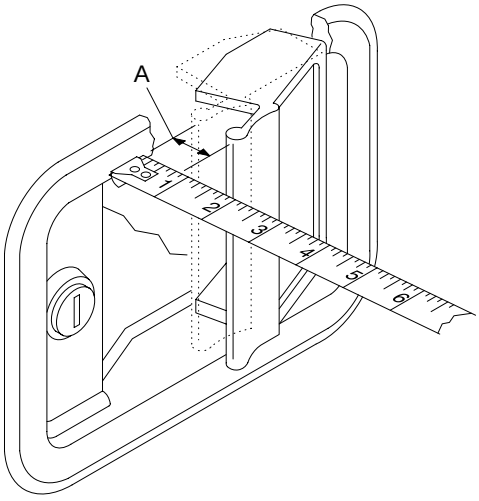
Do not stretch or bend the door seal in a tight radius during installation. To do so may reduce its sealing ability, which could result in water leaks.

3. Install the new door seal by pushing it firmly onto the channel, with the ends of the seal meeting at the bottom of the door, toward the front. Trim the seal to length as needed. Make sure the seal is pushed completely onto the channel all around the door. If necessary, use a rubber hammer to tap the seal into place. There should be no creases or buckles on the sealing surface.

Exterior Door Release Adjustment

1. Apply the parking brakes and chock the tires.
2. From outside the cab (with the cab entry door closed), place a tape measure or scale on the paddle handle chrome surround. Slowly pull the paddle handle. The horizontal measurement from the handle surround ridge to the inner finger-hold ridge on the inside of the paddle handle must be 3/8 to 13/16 inch (10 to 20 mm); see **Fig. 1**.

   If the movement of the exterior paddle handle is less than 3/8 inch (10 mm) before the door opens, the primary door latch releases too easily. If the measurement is more than 13/16 inch (20 mm), the primary door latch will be difficult to release from outside the cab. If the measurements are not within the specifications, adjust the linkage for the exterior release handle, as follows.



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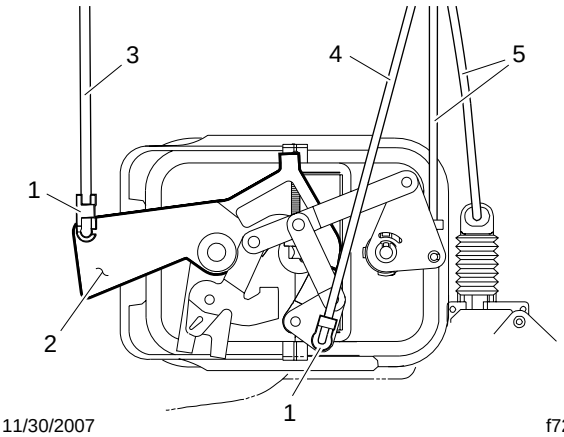
A. Door must open when handle is opened 3/8 to 13/16 inch (10 to 20 mm).

Fig. 1, Exterior Release Handle Measurement

3. Remove the interior door panel; see **Subject 110**.
4. Release the plastic clip and pull the latch actuator rod from the plastic bushing in the paddle arm of the exterior release handle; see **Fig. 2** or **Fig. 3**. Allow the latch actuator rod to hang freely near the paddle arm.



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1. Plastic Bushing with Clip
2. Paddle Arm
3. Latch Actuator Rod
4. Interior Handle Rod
5. Door Lock Rod

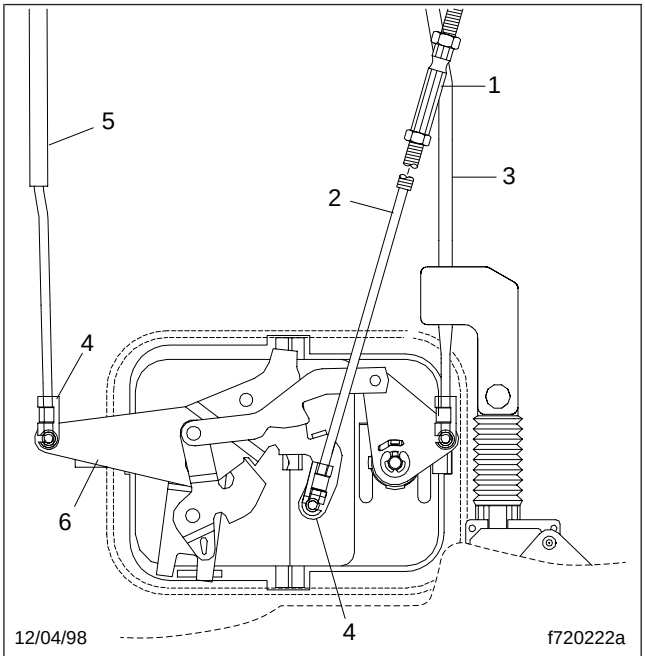
Fig. 2, Exterior Door Release Mechanism (vehicles with a non-adjustable interior door release)

5. The end of the latch actuator rod must be slightly below the hole in the plastic bushing in the paddle arm. Bend or straighten the latch actuator rod until the end is 1/8 inch (3 mm) below the hole. Make sure that the rod is aligned so that the door structure or the inner panel cannot interfere with the operation of the latch actuator rod.
6. Insert the latch actuator rod into the plastic bushing and rotate the plastic bushing to snap the clip onto the rod.
7. Make sure that the cab door opens correctly when the exterior paddle handle is pulled.
8. Install the interior door panel; see **Subject 110**.
9. Check that the rod does not rub or rattle against the inner door panel or door structure.

Interior Door Release Adjustment

NOTE: The following procedure applies to pre-2002 vehicles that are equipped with an adjustable interior release rod. If the interior release

Door Handle Adjustment



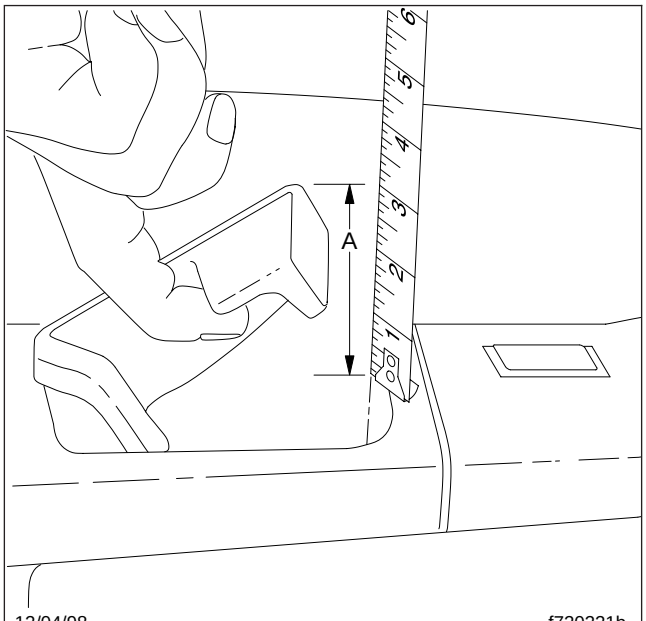
1. Threaded Coupler with Jam Nuts
2. Interior Handle Rod
3. Door Lock Rod
4. Plastic Bushing with Clip
5. Latch Actuator Rod
6. Paddle Arm

Fig. 3, Exterior Door Release Mechanism (vehicles with an adjustable interior door release)

rod does not have a threaded coupler, it is not adjustable; see **Fig. 2** (non-adjustable interior release rod) and **Fig. 3** (adjustable interior release rod).

IMPORTANT: Before checking the interior release handle adjustment, make sure that the exterior handle releases within the specified range, as described in the above procedure.

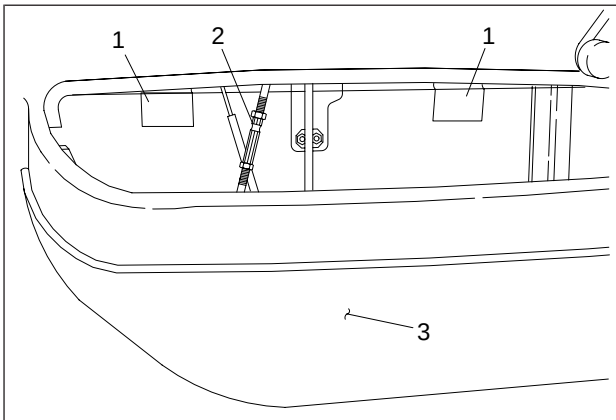
1. Apply the parking brakes and chock the tires.
2. With the cab entry door open, manually close the striker jaws to a fully closed position.
3. Place a tape measure vertically on the armrest, just forward of the interior release handle. Slowly pull up on the interior handle. The vertical measurement from the surface of the armrest to the top of the handle forward edge radius should be between 1-1/2 and 3 inches (38 and 76 mm) when the striker jaws snap open; see **Fig. 4**.



A. Door must open when handle is lifted 1-1/2 to 3 inches (38 to 76 mm).

Fig. 4, Interior Release Handle Measurement

4. If the striker jaws open with less than 1-1/2 inches (38 mm) of interior handle movement, the primary door latch releases too easily. If the measurement is more than 3 inches (76 mm), the primary latch will be difficult to release from inside the cab. This maladjustment could also cause the door lock to unlock if there is an impact to the outside of the door. Adjust the linkage for the interior release handle as follows if the measurements are not within the specifications.
5. If the interior release mechanism is out of adjustment, open the door and remove the cover located on the inner surface of the map pocket. This cover is retained by Velcro pads and can be removed by pulling at the top edge of the cover.
6. Lift the interior release handle and place a wood block under it, so that the handle is held up at the height specified in **Fig. 4**.
7. Loosen the two jam nuts on the threaded coupler for the interior release rod; see **Fig. 5**. Note that the lower jam nut has left-hand threads.
8. Close the latch striker jaws with your fingers; see **Fig. 6**. If the striker jaws will not stay closed with the wood block in place, turn the threaded cou-



1. Velcro Fasteners for Trim Cover
2. Threaded Coupler
3. Inner Door Panel

Fig. 5, Threaded Coupler for Interior Handle Adjustment

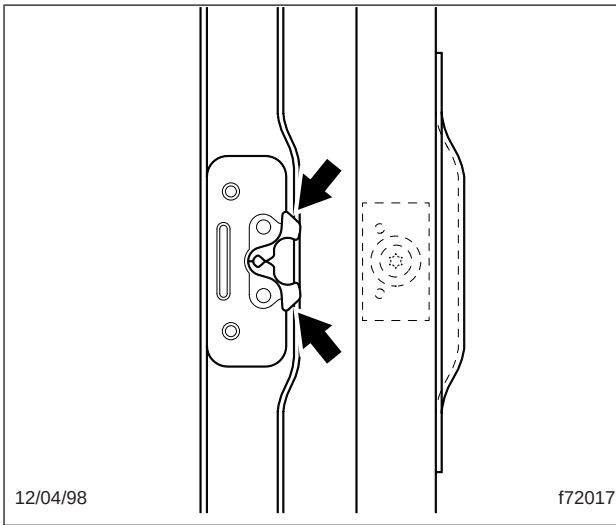


Fig. 6, Latch Striker Jaws

pler clockwise (looking from the top) to lengthen the rod. Manually close the latch jaws.

9. Turn the threaded coupler counterclockwise (looking from the top) until the striker jaws just open. Use your fingers to tighten the jam nuts with the threaded coupler in this position.
10. Tighten the jam nuts on the threaded coupler to 35 lbf·in (400 N·cm). Remove the wood block from underneath the interior handle, then check that the door releases when the handle is lifted between 1-1/2 and 3 inches (38 and 76 mm).
11. Install the trim cover in the map pocket of the door.

Specifications

For fastener torque values, see **Table 1**.

For a schematic of the electric windows on vehicles built before January 10, 1997, see **Fig. 1**. For a schematic of the electric windows on vehicles built from January 10, 1997, see **Fig. 2**.

For a schematic of the power door locks, see **Fig. 3**.

For a drawing of the main cab overlay harness, see **Fig. 4**.

For a drawing of the left-hand door harness, see **Fig. 5**.

For a drawing of the right-hand door harness, see **Fig. 6**.

Torque Values			
Description	**Grade**	**Size**	**Torque**
Allen-Head Capscrews	—	1/4–20	60 lbf·in (680 N·cm)
Door-Latch Hexhead Capscrews	5	1/4–20	60-84 lbf·in (680-940 N·cm)
	8	1/4–28	120 lbf·in (1360 N·cm)
Door-Panel Retainer Bolt	5	5/16–18	15 lbf·ft (20 N·m)
Hinge/Door-Frame Hexhead Capscrews	5	1/4–20	60-84 lbf·in (680-940 N·cm)
	8	1/4–28	120 lbf·in (1360 N·cm)
Hinge Self-Tapping Screws	8	1/4–20	120 lbf·in (1360 N·cm)
Inner Door Panel Machine Screws	—	10–24	60 lbf·in (680 N·cm)
Window Lift Channel Nuts	—	1/4–20	70 lbf·in (800 N·cm)
Sheet Metal Screws: Inner Panel to Door Frame	—	Type A, No. 10	30 lbf·in (340 N·cm)
Striker Pin	8	7/16–14	18-32 lbf·ft (24-43 N·m)
Window Crank Screw	—	10–24	60 lbf·in (680 N·cm)
Interior Handle Rod Threaded Coupler Nuts	—	—	35 lbf·in (400 N·cm)
Interior Door Handle Nuts	—	—	35 lbf·in (400 N·cm)
Armrest Support Nut	—	—	35 lbf·in (400 N·cm)
Inner Door Handle Retainer Screw	—	—	35 lbf·in (400 N·cm)

Table 1, Torque Values

Specifications

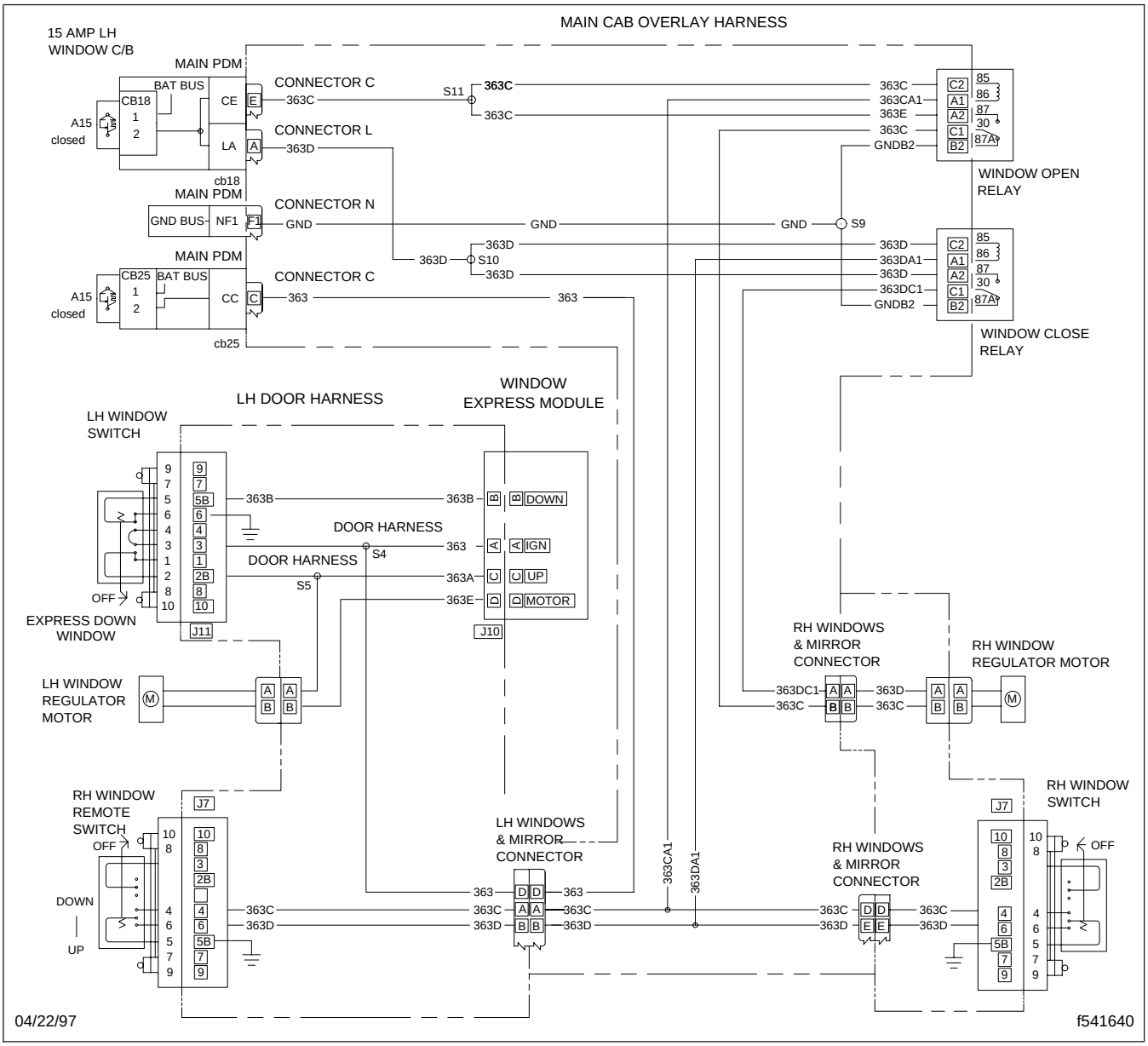


Fig. 1, Schematic, 1996 Electric Windows

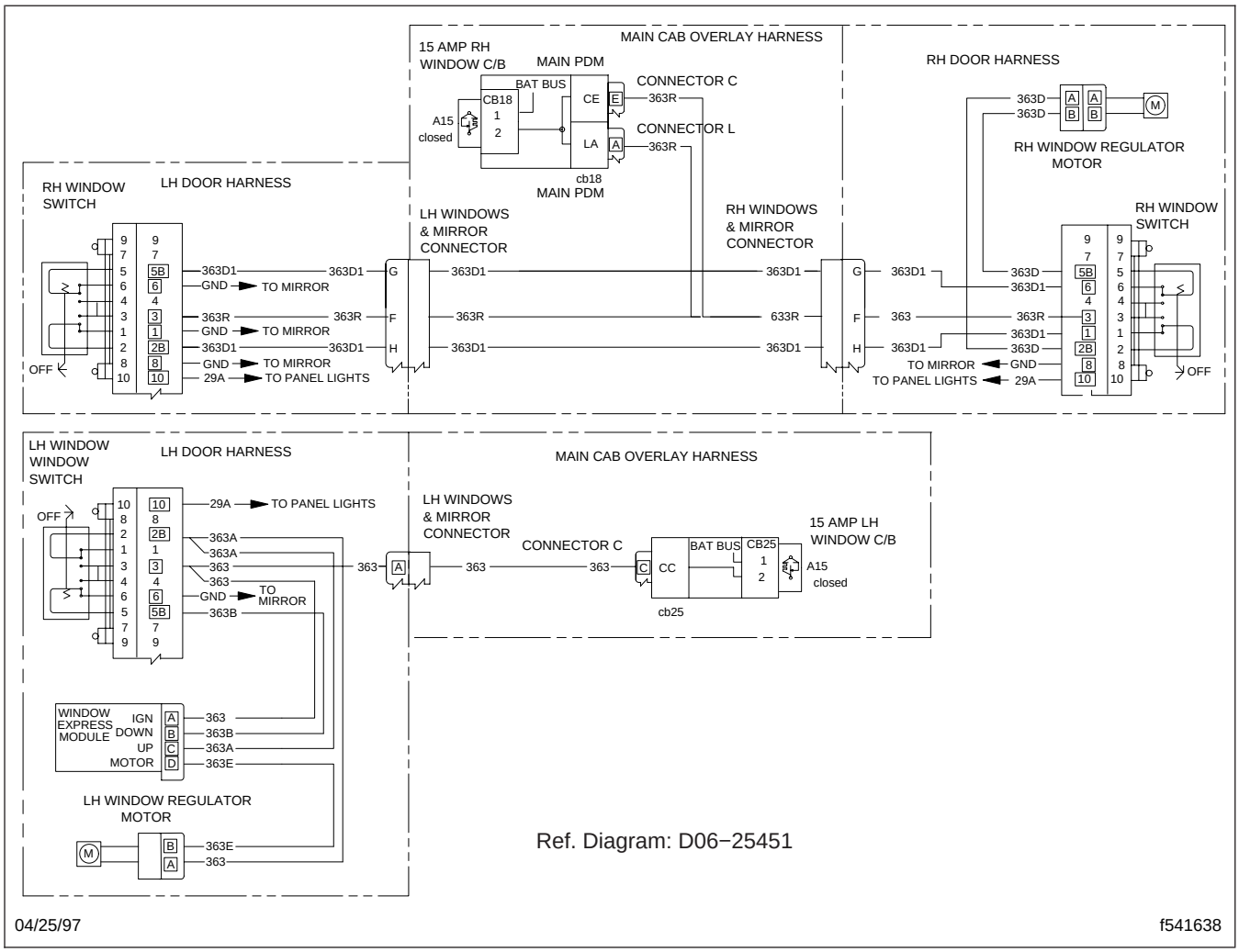


Fig. 2, Schematic, 1997 Electric Windows

Specifications

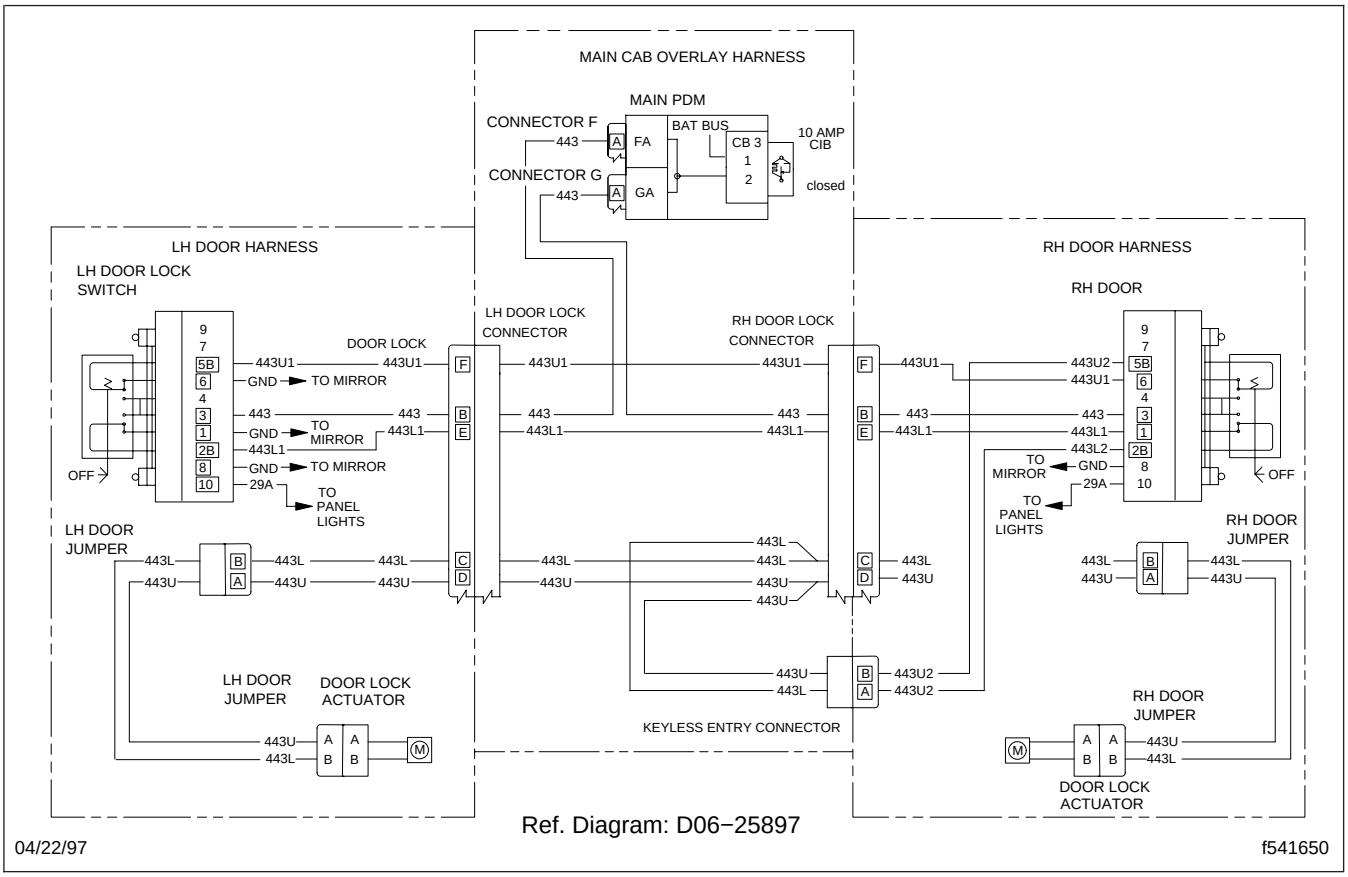


Fig. 3, Schematic, Power Door Locks

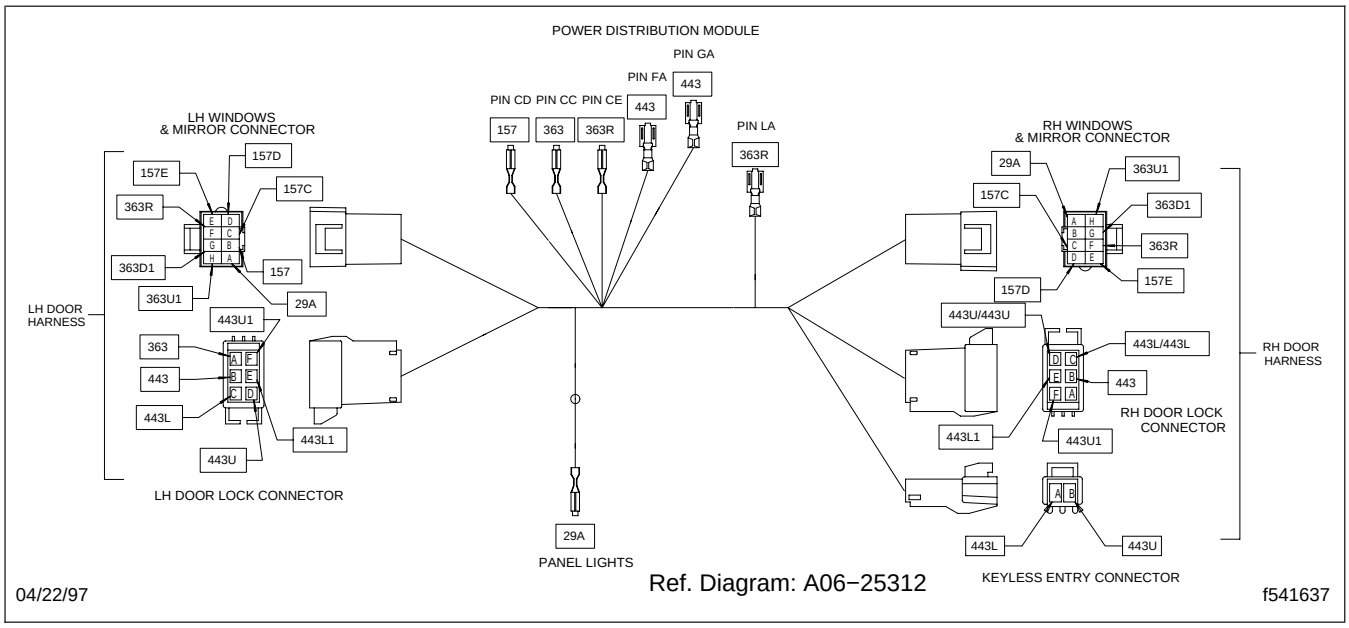


Fig. 4, Main Cab Overlay Harness

Specifications

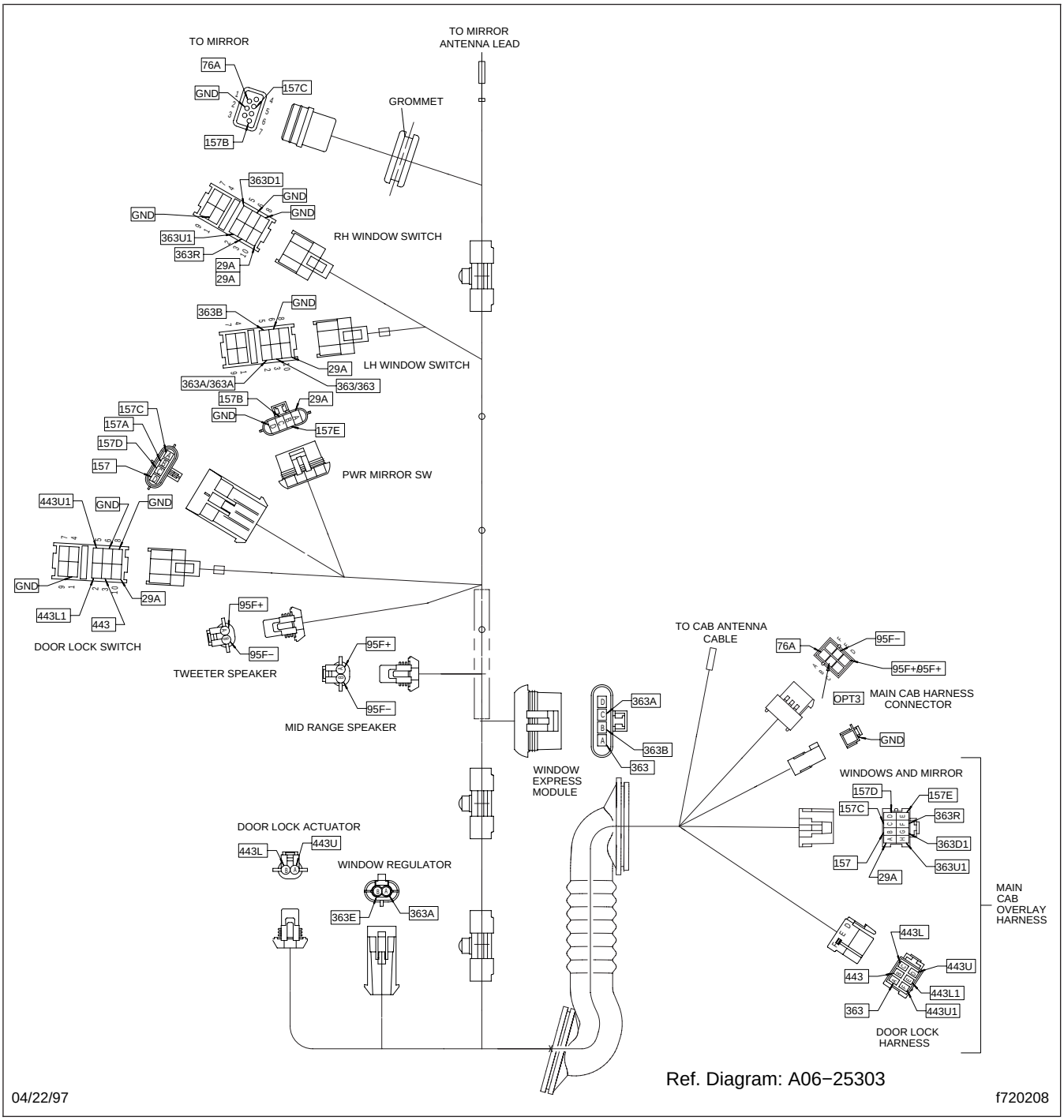


Fig. 5, Left-Hand Door Harness

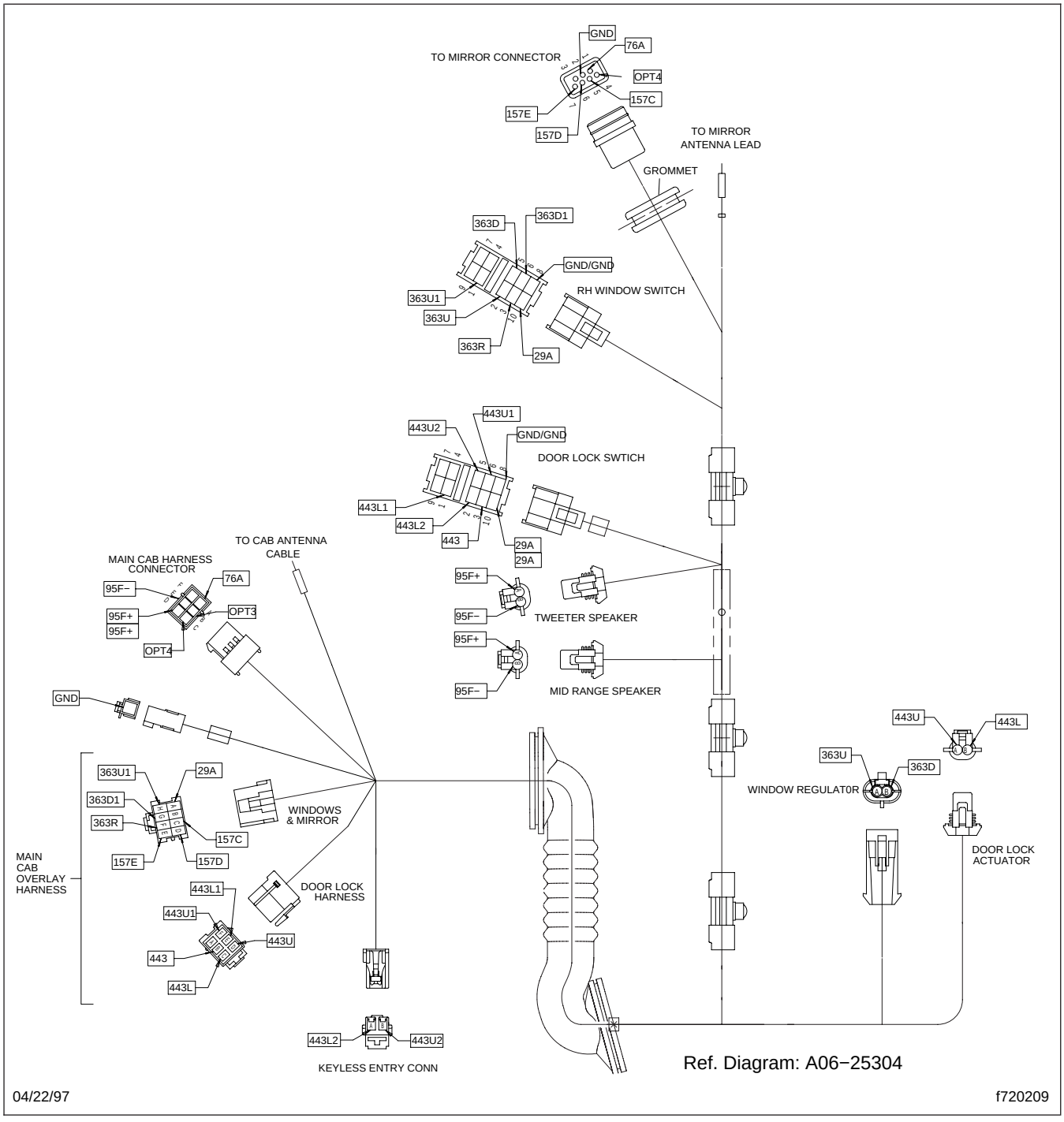
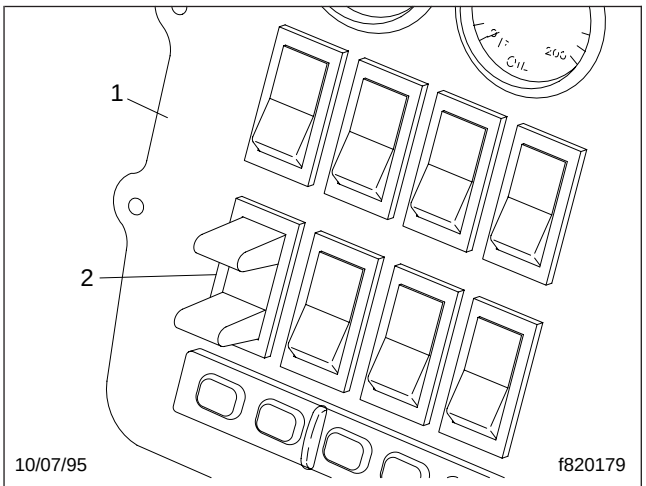


Fig. 6, Right-Hand Door Harness

This information applies only to a Century Class Conventional built before March 2000.

General Information

The windshield wipers and washers are operated by a double-paddle switch mounted on the auxiliary instrument panel; see **Fig. 1**. Each paddle can be pushed in, up, or down, for three different functions. For wiper switch functions and operation, see **Fig. 2**.



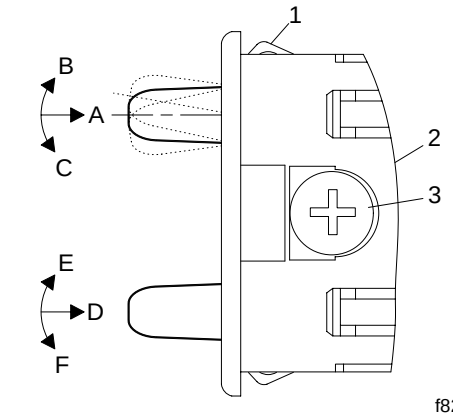
1. Auxiliary Instrument Panel
2. Wiper/Washer Switch

Fig. 1, Wiper/Washer Switch

The wipers have five cycles: fast, slow, mist, wash, and delay. There are six delay intervals, 3 seconds, 5 seconds (default fast), 8 seconds, 12 seconds, 17 seconds (default slow), and 23 seconds.

The top paddle, when pushed in, turns the wipers on (if they are off) or off (if they are on). When pushed up, the top paddle switches the wipers to high speed; when pushed down, it switches them to low speed.

The bottom paddle, when pushed in momentarily (for less than 1/2 second), turns the wipers on mist (one dry cycle at low speed). When pushed in and held in (for at least 1/2 second), the bottom paddle turns on the washers for a minimum of three cycles after release. For more wash cycles, hold the bottom paddle in longer (but it will always cycle three more times after release).



A. Push in to turn wipers on (low speed) or off.
B. Push up for high speed.
C. Push down for low speed.
D. Push in momentarily for mist cycle. Push in and hold in for wash cycle.
E. Push up for fast delay. If already in delay, push up for the next faster delay.
F. Push down for slow delay. If already in delay, push down for the next slower delay.

1. Locking Clip
2. Wiper/Washer Switch
3. Light Bulb Screw

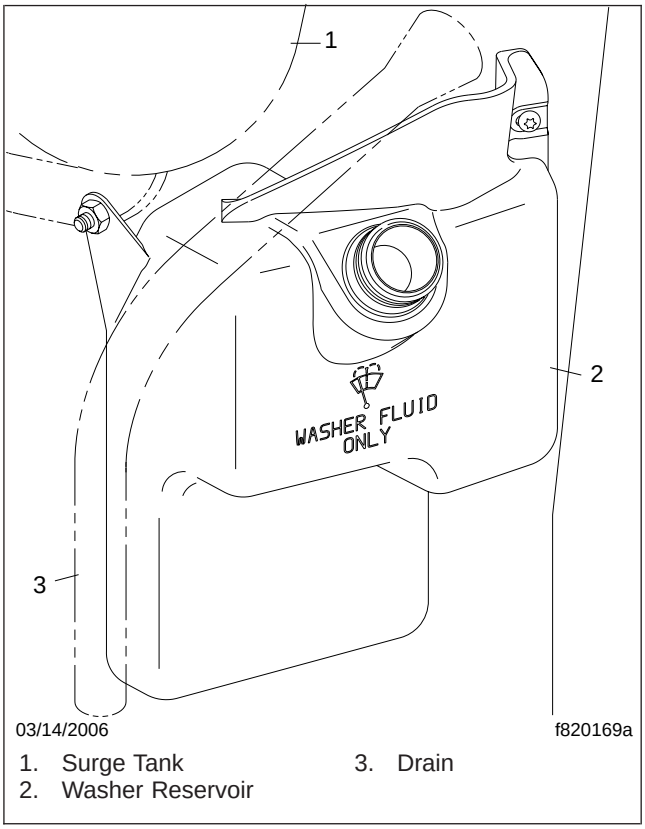
Fig. 2, Wiper/Washer Switch Operation

Pushing **the bottom paddle** up or down controls the delay cycle of the intermittent wipers. If the wipers are not in delay, push up for default fast delay (5 seconds) or down for default slow delay (17 seconds). If the wipers are already in delay, push up for the next faster delay or push down for the next slower delay.

A single wiper motor powers both wipers. It is mounted on the left-hand side of the firewall underneath the washer reservoir. The electric wiper motor is a sealed unit packaged together with a weather seal and drive crank. It is not serviceable. If a wiper motor does not work because of internal problems, replace it.

The windshield washer reservoir (**Fig. 3**) is located on the left-hand side of the firewall between the surge tank and the hood. A pump located in a recess in the bottom of the reservoir supplies washer fluid to each wiper arm. A purge mechanism empties the lines after use to prevent fluid from freezing in the lines during cold weather.

General Information



1. Surge Tank
2. Washer Reservoir
3. Drain

Fig. 3, Windshield Washer Reservoir

Wiper Linkage Removal and Installation

This procedure applies only to a Century Class Conventional built before March 2000.

Removal

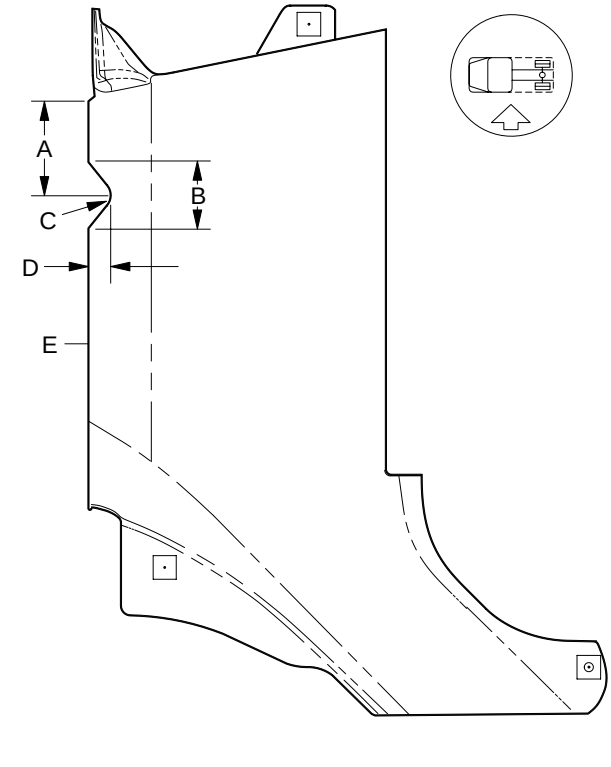
1. With the vehicle parked, apply the parking brakes and chock the tires.
2. Check that the wiper blades are parked. If necessary, park them by turning the wipers on and then off.
3. Tilt the hood.
4. Disconnect the wiper motor electrical connector.

⚠ WARNING

Disconnect the wiper motor electrical connector before working on the wiper linkage. This will keep the windshield wiper motor from cycling. The motor could cycle if the wiper linkage driveshaft is forced out of the parked position, which could result in personal injury.

NOTE: Before performing this procedure, check for a small notch in the left-hand cowl side cover. If the notch is not there, remove the cover and cut a notch in it, as shown in **Fig. 1**.

5. Remove the hood guide bracket, as follows. See **Fig. 2**.
   - 5.1 Remove the 5/16–18 capscrew located in the notch in the cowl side cover.
   - 5.2 Remove the 3/8–16 bolt, nut, and two washers that attach the hood guide to the rain tray.
   - 5.3 Remove the 3/8–16 locknut that attaches the hood guide to the surge tank upper mounting bracket.
6. Remove the 3/8–16 locknut that attaches the fan switch to the surge tank lower bracket located on the outboard side of the tank. See **Fig. 3**.
7. Using a T40 Torx® screwdriver, remove the 5/16–18 machine screw at the bottom of the washer reservoir. Loosen the washer reservoir, but do not remove it.
8. Remove the surge tank upper bracket, and loosen (do not remove) the surge tank, as follows. See **Fig. 4**.

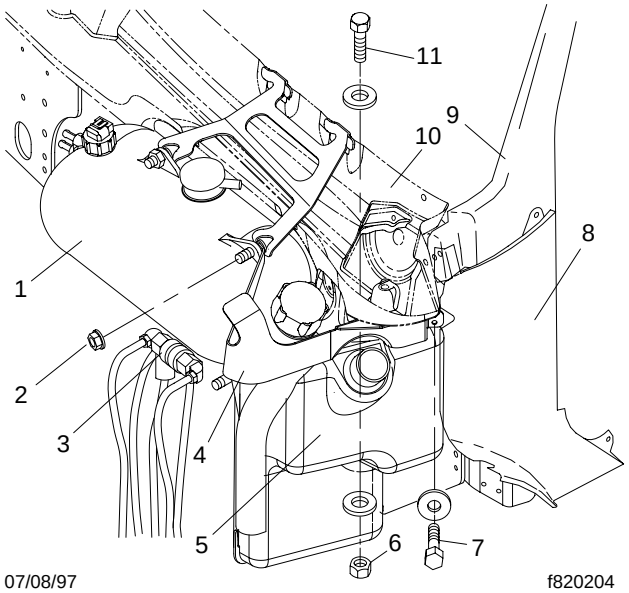


Notch the left-hand cowl side cover only.
A. 3-7/16 inch (87 mm)
B. 3-5/32 inch (80 mm)
C. 1-inch (25-mm) Radius
D. 1 inch (25 mm)
E. LH Cowl Side Cover

Fig. 1, Cowl Cover Modification, with Measurements

   - 8.1 Remove the two 5/16–18 machine screws that attach the aft end of the upper bracket to the cab front wall.
   - 8.2 Remove the two 3/8–16 locknuts that attach the surge tank to the forward end of the upper bracket.
   - 8.3 Partially remove the rain tray seal, then pull the studs on the forward end of the upper bracket out of the mounting holes in the surge tank, and remove the upper bracket from the vehicle.
9. Remove both wiper arms and washer hoses, as follows. See **Fig. 5**. For detail of the wiper arm lock, see **Fig. 6**.

Wiper Linkage Removal and Installation



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1. Surge Tank
2. Upper Mounting Locknut, 3/8–16
3. Fan Switch
4. Hood Guide
5. Washer Reservoir
6. Nut, 3/8–16
7. Capscrew, 5/16–18
8. Cowl Side Cover
9. A-Pillar Cover
10. Rain Tray
11. Bolt, 3/8–16

Fig. 2, Hood Guide Removal

9.1 The locking clip is spring-loaded. With the wiper pulled away from the windshield, push the locking piece toward the wiper blade.

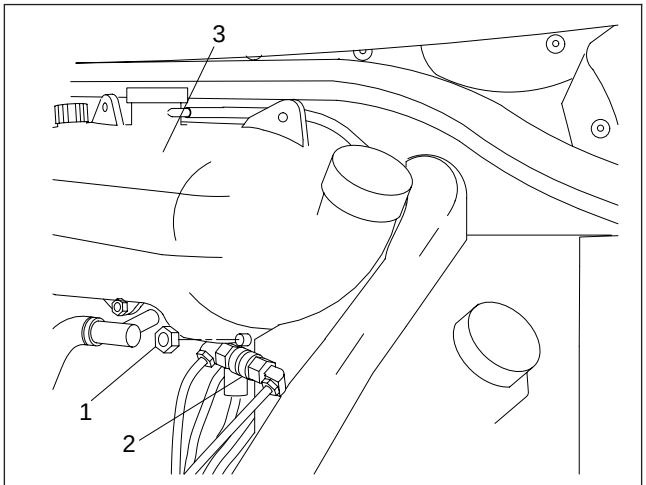
9.2 Carefully pull out on the base of each wiper arm until it comes free of the knurled drive knob at the end of the wiper shaft.

9.3 Disconnect the washer hose from each wiper arm.

10. Remove the rain tray, as follows. See **Fig. 7**.

10.1 Pop out the plastic rivet and remove the drain tube from the rain tray.

10.2 Remove the 5/16–18 machine screws from the rain tray. Five screws attach to the cab front wall. One screw on each end



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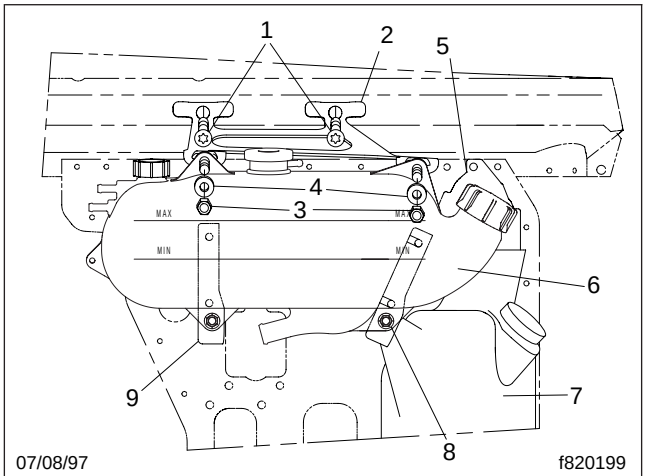
1. Lower Mounting Locknut, 3/8–16
2. Fan Switch
3. Surge Tank

Fig. 3, Fan Switch Removal



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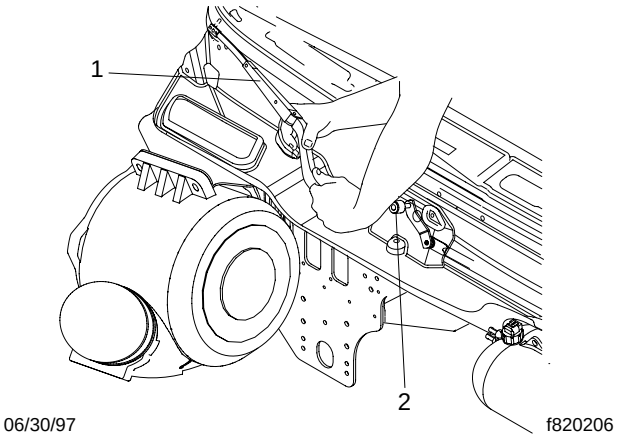
1. T40 Torx Machine Screw, 5/16–18
2. Surge Tank Upper Bracket
3. Upper Mounting Locknuts, 3/8–16
4. Washers
5. Wiper Motor Bracket
6. Surge Tank
7. Washer Reservoir
8. Lower Mounting Locknut (outboard), 3/8–16
9. Surge Tank Lower Bracket

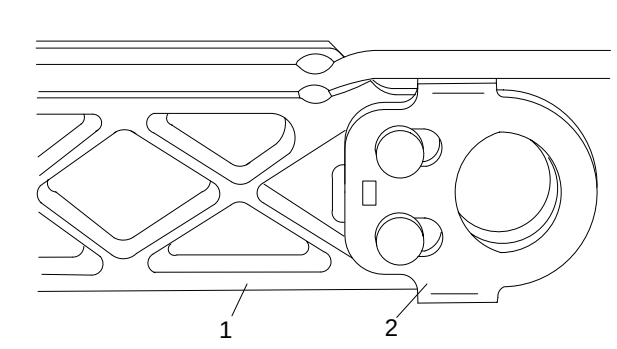
Fig. 4, Surge Tank Upper Bracket

attaches to the A-pillar cover and cowl



1. Wiper Arm 2. Wiper Post

Fig. 5, Wiper Arm Removal



1. Wiper Arm 2. Locking Clip

Fig. 6, Wiper Arm Lock

side cover, and one screw is mounted near each of the two wiper mounting posts.

10.3 If so equipped, remove the surge tank hose mounting clip from the center of the rain tray.

10.4 Disconnect the washer fluid hose from the rain tray.

10.5 Slip the rain tray off the wiper posts and remove it from the vehicle.

11. Disconnect the conlink from the idler bar (see **Fig. 8**) and the drive pivot bracket (see **Fig. 9**), as follows.

11.1 Carefully separate the conlink from the idler bar ball stud. Remove the rubber bellows.

11.2 Carefully separate the conlink from the drive pivot bracket front ball stud. Remove the rubber bellows.

12. Separate the drive pivot bar from the drive pivot bracket rear ball stud. Remove the rubber bellows.

13. Remove the drive pivot bar from the drive crank by carefully separating the drive pivot bar from the drive crank ball stud. Remove the rubber bellows.

Installation

1. With the tires chocked, connect the drive pivot bar to the drive crank and drive pivot bracket, and line it up correctly, with the flange facing the wiper motor.

1.1 Fill a rubber bellows with grease and install it onto the drive crank ball stud.

1.2 Line up the drive pivot bar in a straight line with the drive crank (see **Fig. 9**), and snap it onto the drive crank ball stud.

1.3 Using the same procedure, install a rubber bellows filled with grease and snap the other end of the drive pivot bar onto the drive pivot bracket rear ball stud.

IMPORTANT: Be sure to install the linkage with the drive pivot bar and drive crank lined up correctly as shown in **Fig. 9**. Otherwise, the wipers will not park properly.

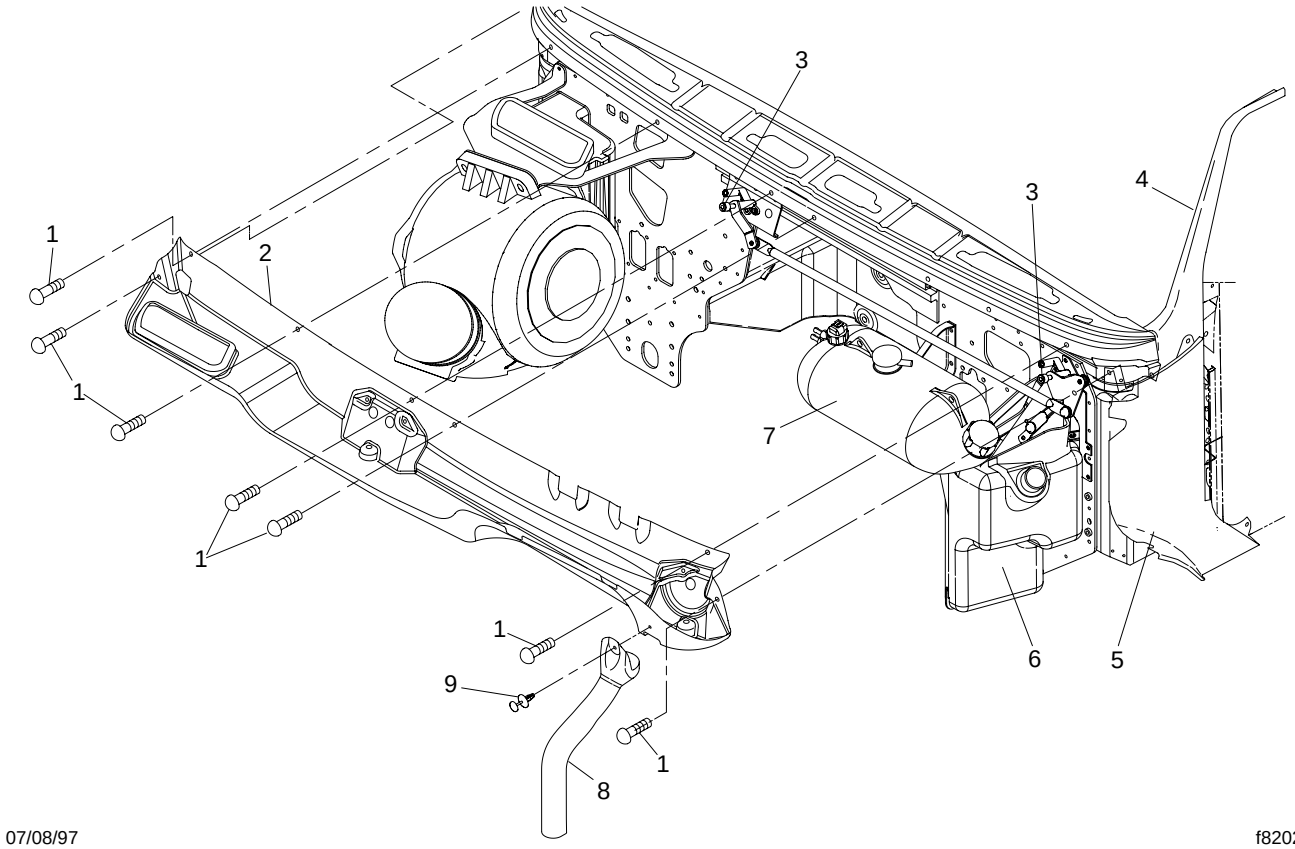
2. Connect the conlink to the idler bar (see **Fig. 8**) and drive pivot bracket (see **Fig. 9**), as follows.

2.1 Fill a rubber bellows with grease and install it onto the drive pivot bracket front ball stud.

2.2 Hold the conlink in place in front of the drive pivot bracket and snap it onto the drive pivot bracket front ball stud.

2.3 Using the same procedure, install a rubber bellows filled with grease and snap the other end of the conlink onto the idler bar ball stud.

Wiper Linkage Removal and Installation

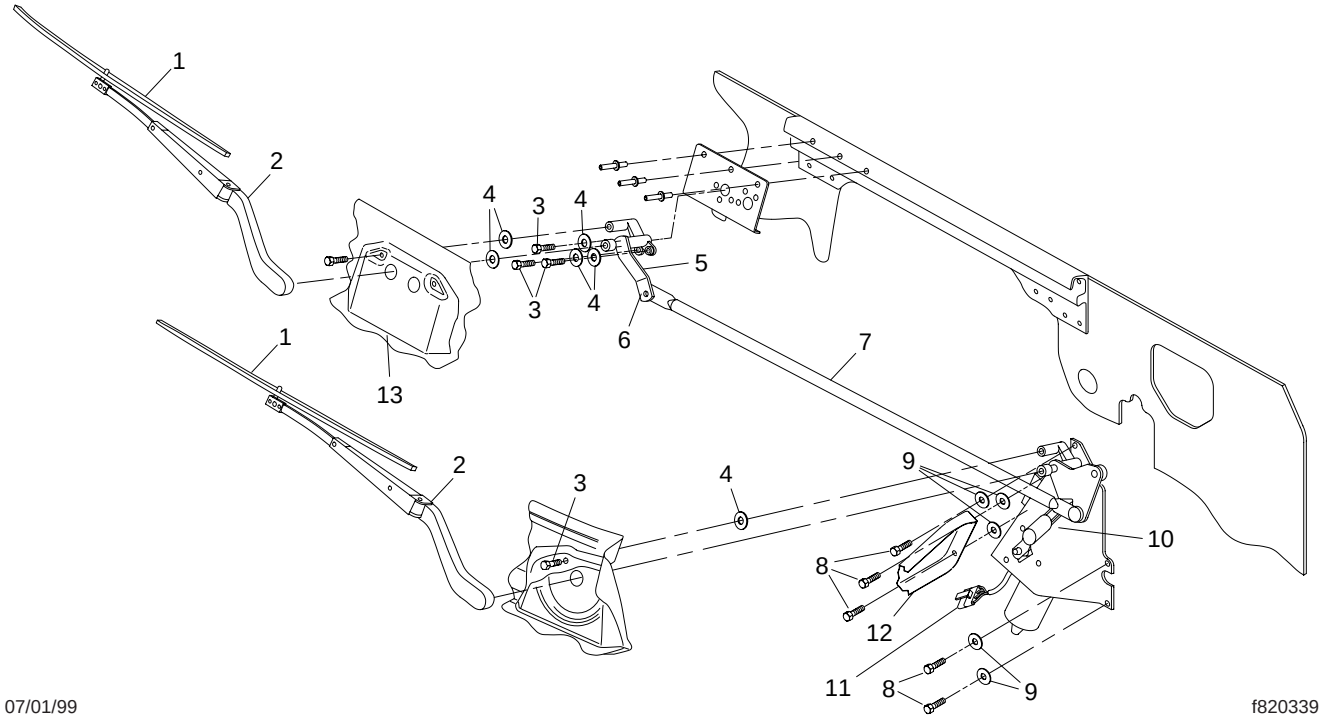


The RH A-pillar and cowl side covers are not shown. They are similar to the LH side, but the RH cowl side cover has no notch in it.

1. Capscrew
2. Rain Tray
3. Wiper Post
4. A-Pillar Cover
5. Cowl Side Cover
6. Washer Reservoir
7. Surge Tank
8. Drain Tube
9. Plastic Rivet

Fig. 7, Rain Tray Removal

3. Install the rain tray and tighten the machine screws finger-tight. If necessary, insert a screwdriver under the window glass lower molding and pry it up and over the edge of the rain tray. See **Fig. 10**. Install the drain tube, using a new plastic rivet, if necessary.
4. Install the upper surge tank bracket over the rain tray and insert the studs on the forward end of the bracket into the holes at the top of the surge tank. Install all the fasteners and tighten them finger-tight.
5. Install the rain tray seal. If removed, install the fasteners and tighten them until firm.
6. Install the fan switch onto the stud on the surge tank lower bracket. Install the locknut and tighten it finger-tight.
7. Install the machine screw on the bottom of the washer fluid reservoir, as removed, and reposition the reservoir. Tighten all the fasteners finger-tight.
8. Install the hood guide, as follows.
   - 8.1 On the outboard side of the surge tank upper bracket, remove the 3/8–16 locknut and insert the hood guide onto the stud. Install the locknut over the hood guide and tighten it finger-tight.



1. Wiper Blade
2. Wiper Arm
3. Capscrew, 1/4–20
4. Washer, 1/4-Inch
5. Idler Bar
6. Idler Bar Ball Stud
7. Conlink
8. Capscrew, 5/16–18
9. Washer, 5/16-Inch
10. Wiper Drive Linkage Assembly
11. Electrical Connector
12. Surge Tank Lower Bracket (outboard)
13. Rain Tray (partial view)

Fig. 8, Wiper Linkage

8.2 Install the 3/8–16 bolt, nut, and washers that attach the hood guide to the rain tray, and tighten them finger-tight.

8.3 Install the 5/16–18 capscrew that attaches the hood guide to the A-pillar cover and cowl side cover. Tighten it finger-tight.

9. Tighten all the assembly fasteners to specifications, as follows.

9.1 Tighten the uncoated 5/16–18 machine screws on the rain tray and surge tank upper bracket 13 lbf·ft (18 N·m).

9.2 Tighten the 3/8–16 locknuts on the surge tank upper and lower brackets 23 lbf·ft (31 N·m).

9.3 Tighten the three fasteners on the washer reservoir 15 lbf·ft (20 N·m).

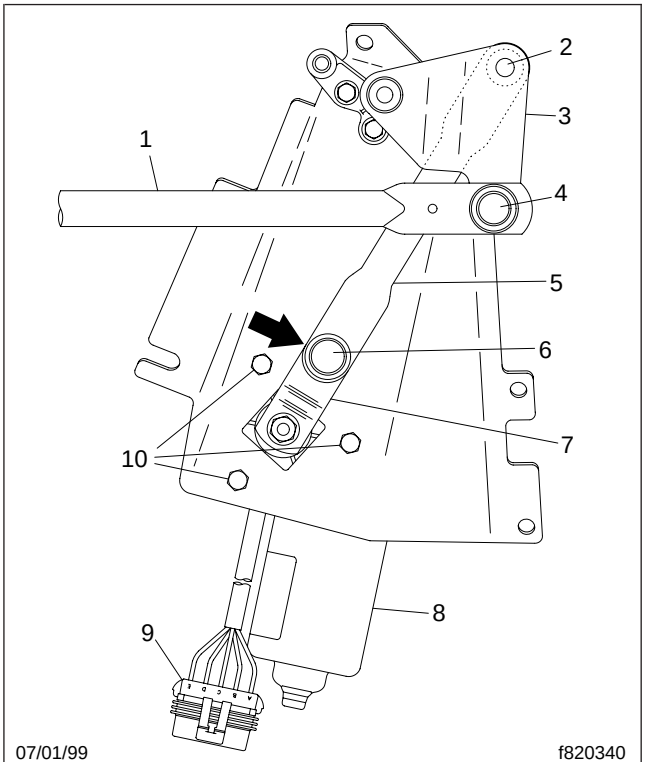
9.4 Tighten the 3/8–16 capscrew that attaches the hood guide to the rain tray 23 lbf·ft (31 N·m). Tighten the 5/16–18 capscrew that attaches the hood guide to the A-pillar cover and cowl side cover 15 lbf·ft (20 N·m).

9.5 If present, attach the surge tank hose mounting clip to the center of the rain tray.

10. Install both wiper arms and washer hoses, as follows.

10.1 Make sure each wiper arm is in the correct park position, at or near the edge of the darkened (tinted) area at the bottom of the windshield glass and far enough above the molding so as not to slap against it during normal low-speed operation. See **Fig. 11** for the correct wiper park position. If the wiper blades park incor-

Wiper Linkage Removal and Installation



Line up the drive pivot bar with the drive crank as shown (note arrow).

1. Conlink
2. Drive Pivot Bracket Rear Ball Stud
3. Drive Pivot Bracket
4. Drive Pivot Bracket Front Ball Stud
5. Drive Pivot Bar
6. Drive Crank Ball Stud
7. Drive Crank
8. Wiper Motor
9. Electrical Connector
10. M6 Capscrews

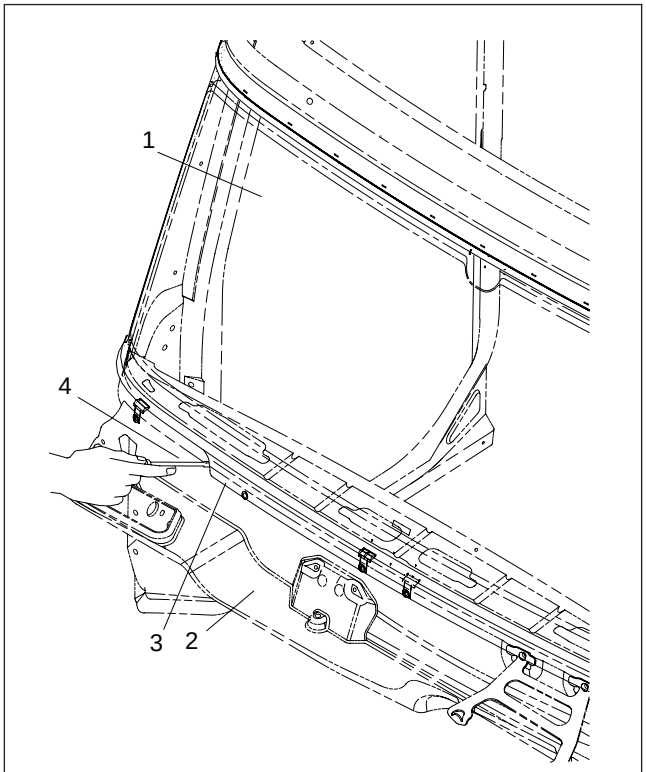
Fig. 9, Drive Linkage Assembly

rectly as in **Fig. 12**, remove the wiper arm and install it again.

10.2 Make sure each wiper arm fits snugly on the knurled drive knob. Pull gently against each wiper arm to make sure it is properly seated with the locking clip in place.

10.3 Connect a washer hose to each wiper arm.

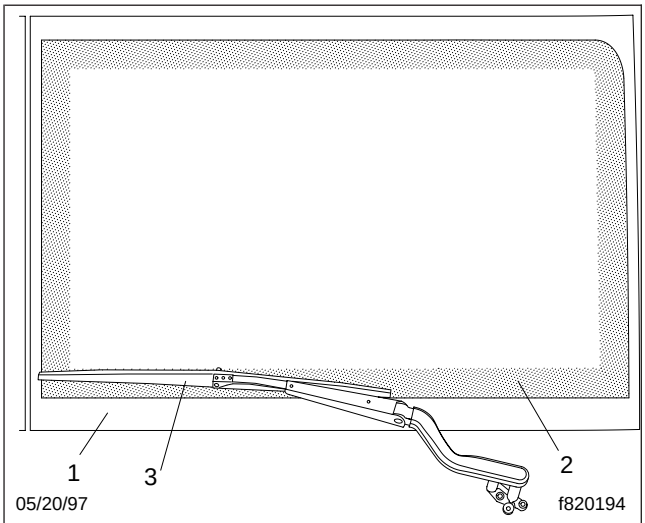
11. Connect the wiper motor electrical connector.



1. Windshield Glass
2. Rain Tray
3. Molding
4. Screwdriver

Fig. 10, Overlap the Molding onto the Rain Tray

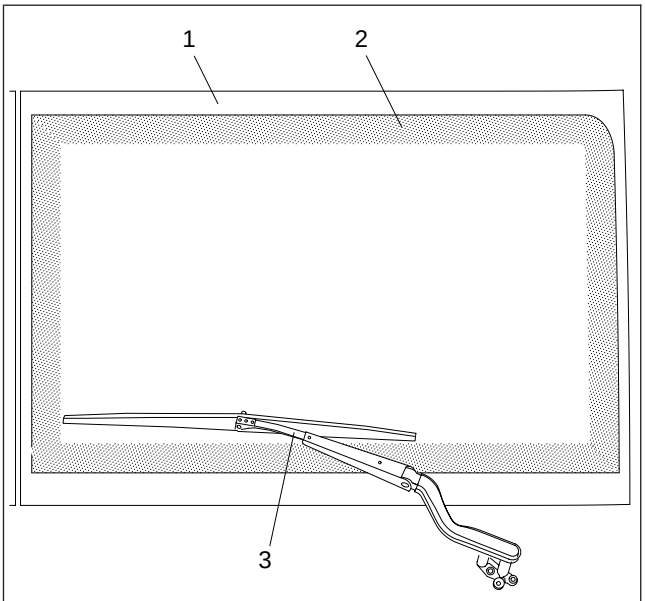
12. Test the wiper motor and washers. Operate the wipers at low speed and check that the blades do not slap against the molding around the edge of the window.
13. Close the hood.
14. Remove the chocks.



Rotate the arm on the shaft so that the blade parks in the darkened area at the bottom of the windshield.

1. Molding
2. Darkened Area of Glass
3. Wiper Blade

Fig. 11, Correct Windshield Wiper Park Position



If any part of the blade parks in the clear area of the windshield, adjust the wiper arm.

1. Molding
2. Darkened Area of Glass
3. Wiper Blade

Fig. 12, Incorrect Windshield Wiper Park Position

Wiper Motor Removal and Installation

This procedure applies only to a Century Class Conventional built before March 2000.

Removal

1. With the vehicle parked, apply the parking brakes and chock the tires.
2. Check that the wiper blades are parked. If necessary, park them by turning the wipers on and then off.
3. Tilt the hood.
4. Disconnect the wiper motor electrical connector.

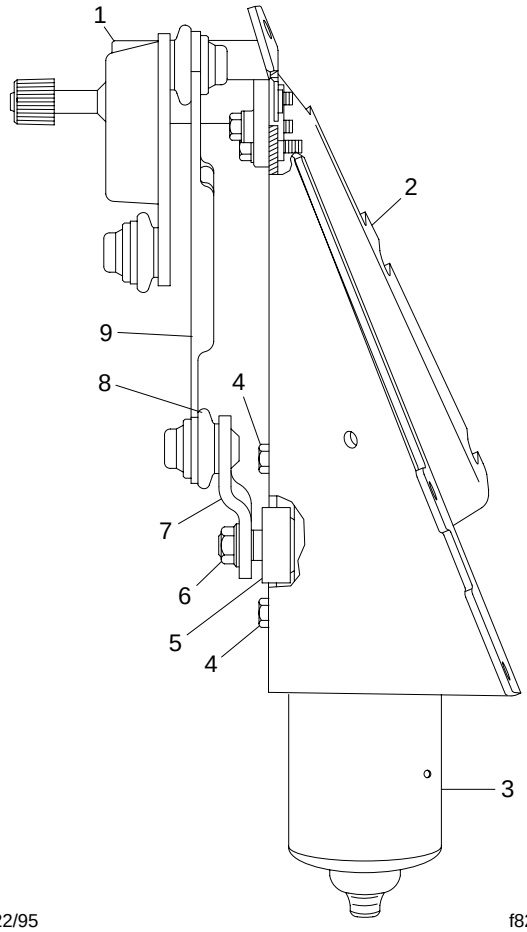
⚠ WARNING

Disconnect the wiper motor electrical connector before working on the wiper motor. Otherwise, the motor could cycle if the driveshaft is forced out of the parked position, which could result in personal injury.

5. Remove the hood guide bracket, fan switch, surge tank upper bracket, rain tray seal, rain tray, and wiper linkage. For detailed instructions, see **Subject 100**.
6. Remove the wiper motor and drive crank, as follows.
   - 6.1 Remove the M8 flanged locknut that attaches the drive crank to the wiper motor (see **Fig. 1**). Remove the drive crank from the vehicle.
   - 6.2 Remove the three M6 capscrews that hold the wiper motor to the mounting bracket.
   - 6.3 Remove the wiper motor from the motor mounting bracket.

Installation

1. With the tires chocked, install the wiper motor, as follows.
   - 1.1 Apply one drop of Loctite® 242 sealant, or an equivalent, to the threads of each of the three M6 mounting capscrews. Install them on the motor through the mounting bracket and tighten them 95 lbf·in (1080 N·cm).

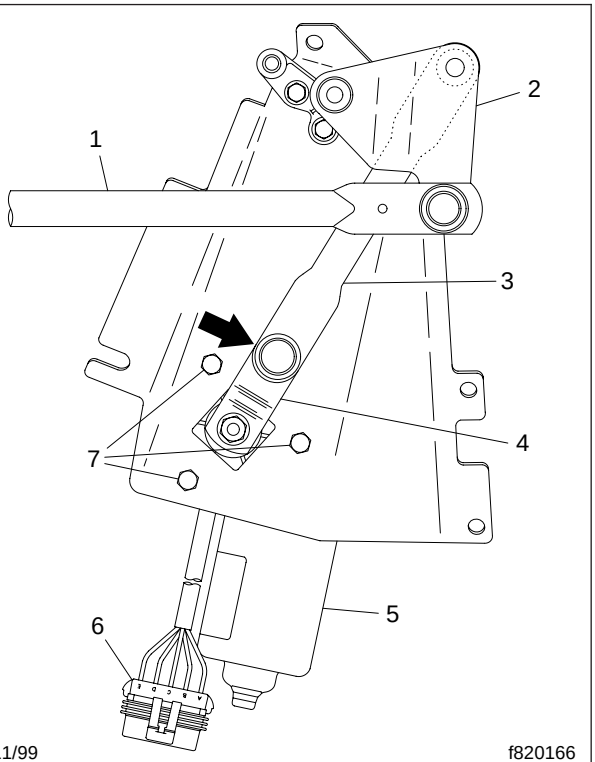


1. Drive Pivot Bracket
2. Motor Mounting Bracket
3. Wiper Motor
4. M6 Capscrews
5. Weather Seal
6. M8 Flanged Locknut
7. Drive Crank
8. Rubber Bellows
9. Drive Pivot Bar

Fig. 1, Wiper Motor Installation

   - 1.2 Install the drive crank on the motor drive shaft. Position the drive crank pointing up and to the right, roughly centered between the two upper mounting capscrews. See **Fig. 2**. Tighten the M8 flanged locknut 17 lbf·ft (23 N·m).

Wiper Motor Removal and Installation



Line up the drive pivot bar with the drive crank as shown (note arrow).

1. Conlink
2. Drive Pivot Bracket
3. Drive Pivot Bar
4. Drive Crank
5. Wiper Motor
6. Electrical Connector
7. M6 Capscrews

Fig. 2, Drive Linkage Assembly

2. For corrosion protection, pack the exposed ends of the connectors with pumpable dielectric grease, part number 48–02439–000.
3. Install the hood guide bracket, fan switch, surge tank upper bracket, rain tray seal, rain tray, and wiper linkage. For detailed instructions, see **Subject 100**.
4. Connect the wiper motor electrical connector.
5. Test the wiper motor and washers. Make sure the wiper blades park correctly. For instructions, see **Subject 100**.
6. Close the hood.
7. Remove the chocks.

Washer Reservoir Removal and Installation

This procedure applies only to a Century Class Conventional built before March 2000.

Removal

1. With the vehicle parked, apply the parking brakes and chock the tires.
2. Tilt the hood.
3. Remove the fasteners indicated by the arrows in **Fig. 1**, as follows.

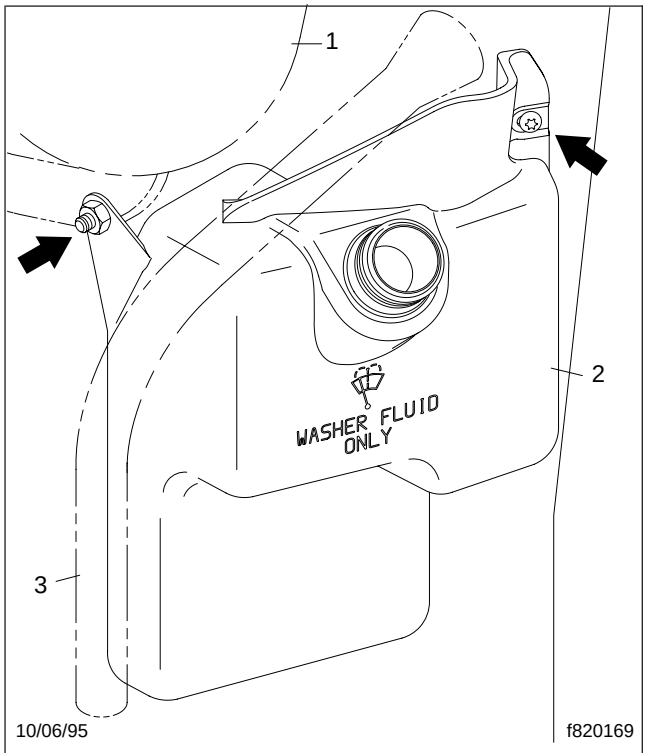


Fig. 1, Windshield Washer Reservoir

3.1 Remove the 5/16–18 Torx® screw that attaches the reservoir to the motor mounting bracket.

3.2 Remove the nut that attaches the reservoir and the surge tank to the lower left-hand surge tank bracket.

4. Remove the 5/16–18 Torx screw at the bottom of the reservoir. See **Fig. 2**.

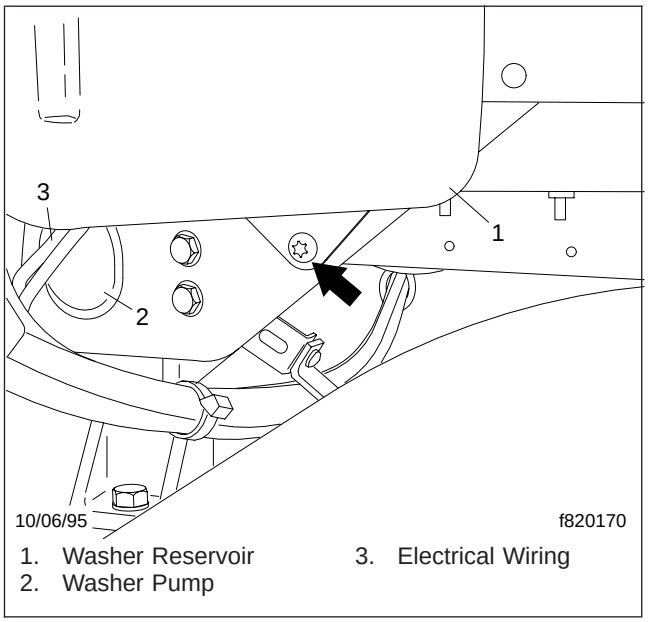


Fig. 2, Washer Reservoir Bottom Screw (arrow)

5. Pull the reservoir free of its mountings to expose the washer pump. Disconnect the electrical connector attached to the washer pump. Remove the washer fluid delivery line. To free the reservoir, remove the drain alongside it.

NOTE: If the reservoir contains washer fluid, removing the delivery line will cause washer fluid to flow out of the washer pump outlet.

6. Remove the washer reservoir from the vehicle.

Installation

1. With the tires chocked, connect the electrical connector to the washer pump. For corrosion protection, pack the exposed ends of the connectors with pumpable dielectric grease, part number 48-02439-000.
2. Attach the washer fluid delivery line to the washer pump.
3. Install the 5/16–18 Torx screw at the bottom of the reservoir. See **Fig. 2**.
4. Install the fasteners indicated by the arrows in **Fig. 1**, as follows.

4.1 Install the 5/16–18 Torx screw that attaches the reservoir to the motor mounting bracket.

Washer Reservoir Removal and Installation

4.2 Install the nut that attaches the reservoir and the surge tank to the lower left-hand surge tank bracket.

5. Tighten all the fasteners 15 lbf·ft (20 N·m) and install the drain.
6. Lower the hood.
7. Remove the chocks.

Troubleshooting

WARNING

Use caution when working on or near the wiper linkage, arms, and motor. An intermittent wiper system may swipe without warning, posing a risk of personal injury.

NOTICE

Make sure the ignition switch is off before disconnecting any wiper/washer harness connectors. Removing connectors with the ignition switch on may cause electrical arcing, which will damage the pins.

Preliminary Checks

Before beginning the troubleshooting procedures, verify the driver's complaint by checking the system components, and operating the wiper and washer to duplicate the problem.

1. Check the wiper arms, blades, and linkage for wear and damage.
2. Check the washer fluid level in the reservoir.
3. Turn the ignition switch to the ON position without starting the engine.
4. Test the wipers on low speed, high speed, and several intermittent speeds.
5. Test the windshield washers.
6. Turn the ignition switch to the OFF position.
7. Check the washer hoses for leaks and damage.

Diagnostic Procedures

Symptoms

The diagnostic procedures listed in **Table 1** are described in detail in the succeeding tables. When performing the diagnostic procedures, refer to the wiring diagram (**Fig. 1**) and the tables in this subject.

NOTICE

Use caution when backprobing sealed connectors. If the seal is damaged, water could intrude into the connection, resulting in corrosion and electrical failure.

IMPORTANT: The following wiper and washer diagnostic procedures are performed with the ignition switch in the ON position, and the engine NOT running.

Troubleshooting Procedures	
Symptom	**Table Number**
Wipers are inoperative in all modes.	**Table 2**
High-speed mode only is inoperative.	**Table 3**
Low-speed and all intermittent speed modes are inoperative, high-speed mode is OK.	**Table 4**
Wipers do not park in the proper position.	**Table 5**
Wipers stay on until ignition is turned off.	**Table 6**
Washers are inoperative.	**Table 7**
Washer spray does not correctly cover wipe area.	**Table 8**

Table 1, Troubleshooting Procedures

Wipers Are Inoperative In All Modes			
Step	**Test Procedure**	**Test Result**	**Action**
1	Turn the ignition switch to the ON position, and the wiper switch to low speed.	—	—

Troubleshooting

Wipers Are Inoperative In All Modes			
Step	**Test Procedure**	**Test Result**	**Action**
2	With the connector remaining connected, backprobe the wiper motor connector on pins A and C to measure for battery voltage; see **Table 9**. Is battery voltage present?	Yes	Make sure that the wiper linkage is not slipping or binding. Otherwise, replace the wiper motor; see **Subject 110**.
		Low or at zero	Go to **step 3**.
3	Verify that pin A of the wiper motor connector is at ground potential; see **Table 9**. Is pin A at ground potential?	Yes	Go to **step 4**.
		No	Repair the ground circuit.
4	Access the wiper switch (**Fig. 2**) connector, and backprobe pin 1 to measure the voltage, with the connector remaining connected to the module; see **Table 10**. Is battery voltage present on pin 1?	Yes	Go to **step 5**.
		Low or at zero	Check circuit breaker CB49 in the PDM. If the circuit breaker is open, determine if there is a shorted wire or component on circuit 315 that is drawing excess current.
5	With the ignition set to the ON position and the wipers switched to low speed, measure the voltage on pin 3 of the wiper switch connector. Is the measured voltage at or within a few tenths of a volt to ground?	Yes	Test for an open circuit through the speed switching relays R35 and R36. Troubleshoot circuits 315L and 315H from the PDM to the wiper motor.
		No	Replace the wiper switch.

Table 2, Wipers Are Inoperative In All Modes

High-Speed Mode Only Is Inoperative			
Step	**Test Procedure**	**Test Result**	**Action**
1	Turn the ignition switch to the ON position, and the wiper switch to high speed.	—	—
2	With the connector remaining connected, backprobe the wiper motor connector on pins A and B to measure for battery voltage; see **Table 9**. Is battery voltage present?	Yes	Make sure that the wiper linkage is not slipping or binding. Otherwise, replace the wiper motor; see **Subject 110**.
		Low or at zero	Go to **step 3**.
3	Access the wiper switch (**Fig. 2**) connector, and backprobe pin 4 to measure the voltage, with the connector remaining connected to the module, the ignition switch in the ON position, and the wipers set to high speed; see **Table 10**. Is the measured voltage at or within a few tenths of a volt to ground?	Yes	Test for an open circuit through relay R35 and its interconnecting wiring, including circuit 315H from the PDM to the wiper motor.
		No	Replace the wiper switch.

Table 3, High-Speed Mode Only Is Inoperative

Low Speed and All Intermittent Setting Modes Are Inoperative, High Speed Mode Is OK			
Step	**Test Procedure**	**Test Result**	**Action**
1	Turn the ignition switch to the ON position, and the wiper switch to low speed.	—	—

Low Speed and All Intermittent Setting Modes Are Inoperative, High Speed Mode Is OK			
Step	**Test Procedure**	**Test Result**	**Action**
2	With the connector remaining connected, backprobe the wiper motor connector on pins A and C to measure for battery voltage; see **Table 9**. Is battery voltage present?	Yes	Make sure that the wiper linkage is not slipping or binding. Otherwise, replace the wiper motor; see **Subject 110**.
		Low or at zero	Go to **step 3**.
3	Verify the voltage at pin A of the wiper motor connector. Is it at ground potential?	Yes	Go to **step 4**.
		No	Repair the ground circuit 320.
4	With the wiper switch (**Fig. 2**) remaining connected to the connector, the ignition switch in the ON position, and the wipers set to low speed, backprobe the wiper switch connector on pin 3 to measure for battery voltage; see **Table 10**. Is the measured voltage at or within a few tenths of a volt to ground?	Yes	Test for an open circuit through the speed switching relays R35 and R36, and the interconnected wiring. Troubleshoot circuit 315L from the PDM to the wiper motor.
		No	Replace the wiper switch.

Table 4, Low Speed and All Intermittent Setting Modes Are Inoperative, High Speed Mode Is OK

Wipers Do Not Park in Proper Position			
Step	**Test Procedure**	**Test Result**	**Action**
1	Turn the ignition switch to the ON position, and the wiper switch to low speed.	—	—
2	Turn the wiper switch off when the wipers are in mid-swipe. Do the wipers stop immediately, or continue traveling, then stop?	Immediately	Go to **step 3**.
		Continue traveling, then stop	Note the stopped position. Repeat the test to make sure that the wipers always stop in the same position. If the wipers always stop in the same position, regardless of where the switch was turned off, the linkage is improperly adjusted. Turn the ignition switch to OFF, disconnect the batteries, then adjust the wiper linkage to the correct position.
3	With the ignition switch in the ON position and the wipers switched off, measure the voltage on pin D of the wiper motor connector; see **Table 9**. Is battery voltage present?	Yes	Go to **step 4**.
		No	Locate and repair the open circuit on circuit 315C between the wiper motor and the PDM.
4	With the ignition in the ON position and the wipers switched to low speed, measure the voltage on pin F of the wiper motor connector; see **Table 9**. Battery voltage should be present except when the wipers travel through the park position and the circuit is momentarily at ground. Is battery voltage present?	Yes	Go to **step 5**.
		No	Replace the wiper motor; see **Subject 110**.

Troubleshooting

Wipers Do Not Park in Proper Position			
Step	**Test Procedure**	**Test Result**	**Action**
5	With the wipers switched on, measure the voltage at terminal 87A of relay R36. Is battery voltage present?	Yes	Test for an open R36 relay.
		No	Locate and repair the open circuit between relay R36 and the wiper motor in circuit 315P.

Table 5, Wipers Do Not Park in Proper Position

Wipers Stay On Until Ignition Is Turned Off			
Step	**Test Procedure**	**Test Result**	**Action**
1	Turn the ignition switch to the ON position. Leave the wiper switch in the OFF position. Do the wipers stay on at high speed or low speed?	High speed	Troubleshoot for circuit 315B shorted to ground, and for relay R35 shorted between terminals 87 and 30.
		Low speed	Go to **step 2**.
2	Backprobe pin F of the wiper motor connector to check the voltage through the wiper motor's internal park switch; see **Table 9**. When the wipers travel through the park position, pin F should be momentarily at ground. Most volt meters respond quickly enough to show this momentary voltage transition. Is the momentary voltage transition to ground present?	Yes	Troubleshoot and repair for circuit 315B shorted to ground, and for relay R36 shorted between terminals 87 and 30.
		No	The wiper motor internal park switch is not working. Replace the wiper motor; see **Subject 110**.

Table 6, Wipers Stay On Until Ignition Is Turned Off

Washers Are Inoperative			
Step	**Test Procedure**	**Test Result**	**Action**
1	Turn the ignition switch to the ON position, and the wiper switch to low speed. Do the wipers work?	Yes	Turn the wipers off. Go to **step 2**.
		No	Follow the troubleshooting procedure under "Wipers Are Inoperative In All Modes"; see **Table 2**.
2	Check the washer reservoir fluid level. Add fluid if needed, then test the washer operation. Hold the washer switch on for at least 5 seconds in case the hoses are leaking, or the system has lost its prime. Is the pump running?	Yes	Check the system for leaks. Also follow the troubleshooting procedure under "Washer Spray Does Not Correctly Cover Wipe Area"; see **Table 8**.
		No	Go to **step 3**.
3	If the system is not leaking, backprobe the connections at the washer pump, and test for battery voltage when the washer switch is activated; see **Table 11**. Is battery voltage present?	Yes	Replace the washer pump.
		No	Go to **step 4**.

Washers Are Inoperative			
Step	**Test Procedure**	**Test Result**	**Action**
4	With the wiper switch (**Fig. 2**) remaining connected to the connector, and the ignition switch in the ON position, backprobe pin 5 of the wiper switch to measure voltage; see **Table 10**. When the washers are activated, is the measured voltage at or within a few tenths of a volt to ground?	Yes	Troubleshoot for a wiring fault on circuit 320 between the wiper switch and the washer pump. Also troubleshoot circuit 315C to the washer pump.
		No	Replace the wiper switch.

Table 7, Washers Are Inoperative

Washer Spray Does Not Correctly Cover Wipe Area			
Step	**Test Procedure**	**Test Result**	**Action**
1	Make sure that the fluid level in the washer fluid reservoir is adequate. If needed, add fluid.	—	—
2	Test the washer operation. Hold the washer switch in the ON position for at least 5 seconds. Is the fluid flow adequate?	Yes	Troubleshooting is completed.
		No	Check the nozzles for damage, plugging, or improper installation. Check the hoses for kinks, or wire ties that may be too tight. Make sure that there are no breaks or disconnected fittings. Go to **step 3**.
3	Test the washer operation. Does the washer work properly?	Yes	Troubleshooting is completed.
		No	Replace the washer pump.

Table 8, Washer Spray Does Not Correctly Cover Wipe Area

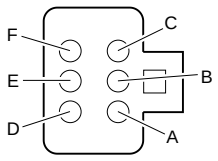
Terminal Identification of the Wiper Motor Harness Connector			
Wiper Motor Harness Connector	**Pin**	**Circuit Number**	**Circuit Description**
 f545385	A	GND	Ground
	B	315H	Wiper Motor High Speed
	C	315L	Wiper Motor Low Speed
	D	315C	Ignition Power
	E	—	Not used
	F	315P	Park Switch Signal

Table 9, Terminal Identification of the Wiper Motor Harness Connector

Troubleshooting

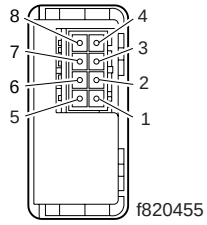
Terminal Identification of the Wiper/Washer Switch Connector			
Washer/Wiper Switch Connector	**Pin**	**Circuit Number**	**Circuit Description**
	1	315	Ignition Power
	2	29A	Backlighting
	3	315A	Wiper Motor Low Speed
	4	315B	Wiper Motor High Speed
	5	320	Washer Pump
	6	GND	Ground
	7	—	Not used
	8	—	Not used

Table 10, Terminal Identification of the Wiper/Washer Switch Connector

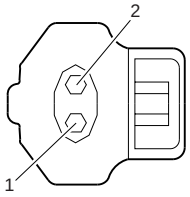
Terminal Identification of the Washer Pump Connector			
Washer Pump Connector	**Terminal**	**Circuit Number**	**Circuit Description**
	1	320	Washer Ground
	2	315C	Washer Power

Table 11, Terminal Identification of the Washer Pump Connector

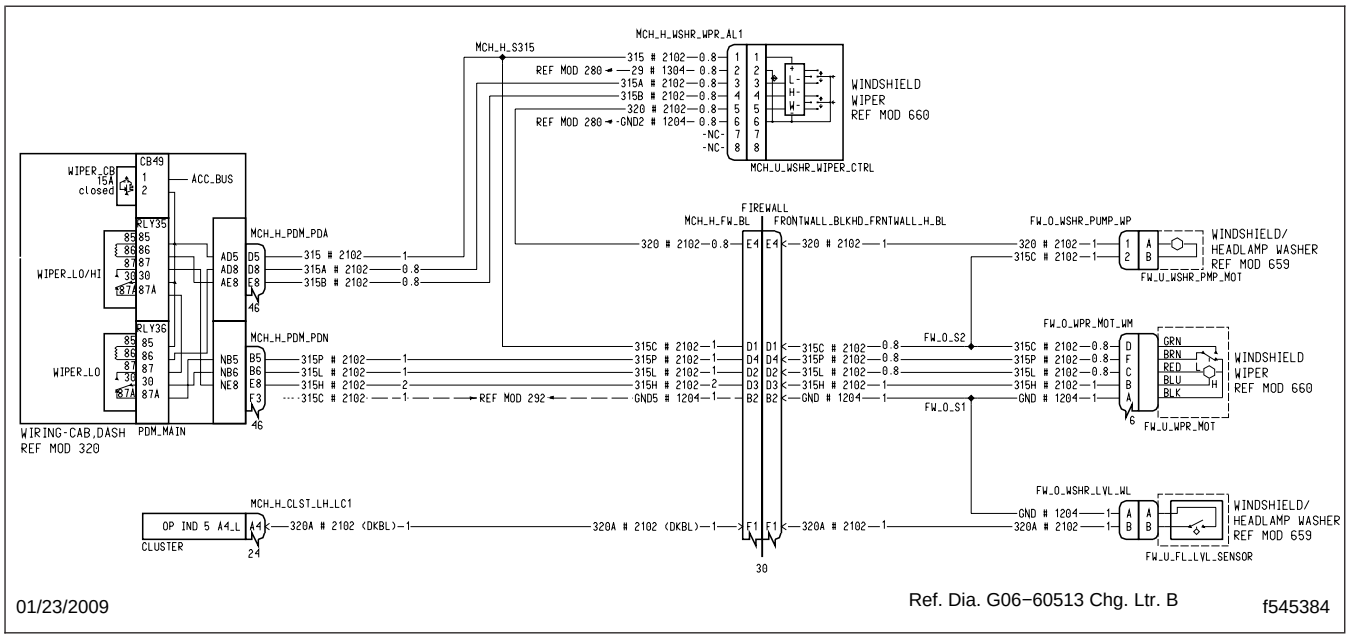
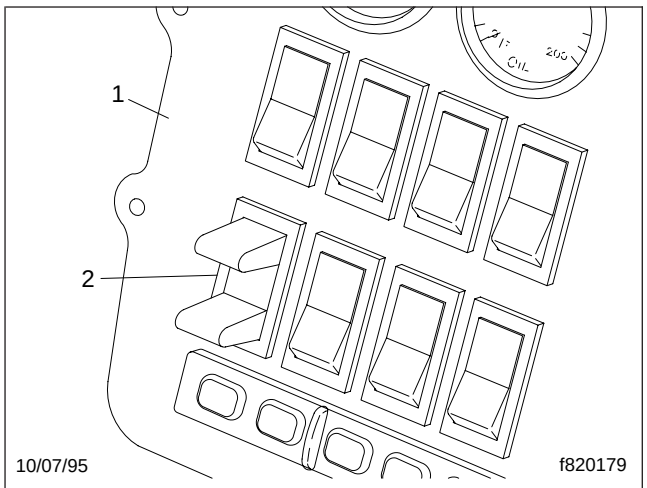


Fig. 1, Wiring Diagram, Wiper/Washer With a Dash-Mounted Switch



1. Auxiliary Instrument Panel
2. Wiper/Washer Switch

Fig. 2, Location of Dash-Mounted Wiper/Washer Switch

Specifications

Unless listed in **Table 1**, tighten all fasteners using the torque specifications found in **Section 00.05**.

Description	Size	Torque	
		lbf·ft (N·m)	lbf·in (N·cm)
Hood Guide Mounting Capscrew (to body)	5/16–18	15 (20)	—
Hood Guide Mounting Capscrew (to rain tray)	3/8–16	23 (31)	—
Machine Screws (Grade 5—uncoated)	5/16–18	13 (18)	—
Motor Mounting Capscrews	M6	—	95 (1080)
Pivot Bracket Mounting Capscrews (Grade 5)	5/16–18	15 (20)	—
Surge Tank Mounting Locknuts	3/8–16	23 (31)	—
Wiper Drive Flanged Locknut	M8	17 (23)	—
Washer Reservoir Mounting Screws (Grade 5)	5/16–18	15 (20)	—

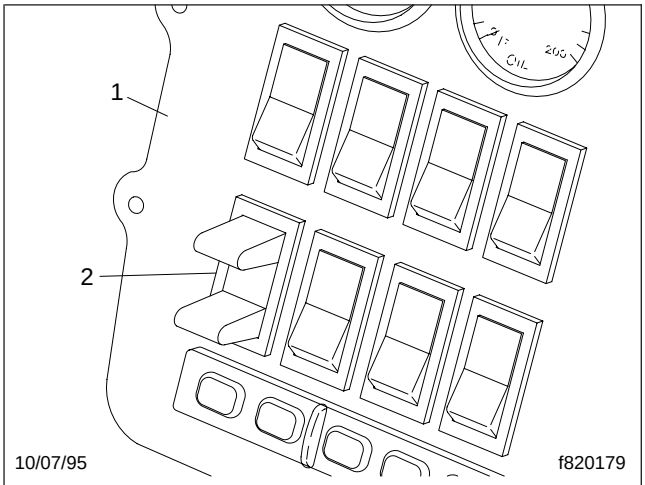
Table 1, Fastener Torque Values

This information applies to the following vehicle models, as specified:

- Century Class Conventional built during or after March 2000
- Argosy COE

General Information

The windshield wipers and washers are operated by a double-paddle switch mounted on the auxiliary instrument panel. See **Fig. 1**. Each paddle can be pushed in, up, or down, for three different functions. For wiper switch functions and operation, see **Fig. 2**.



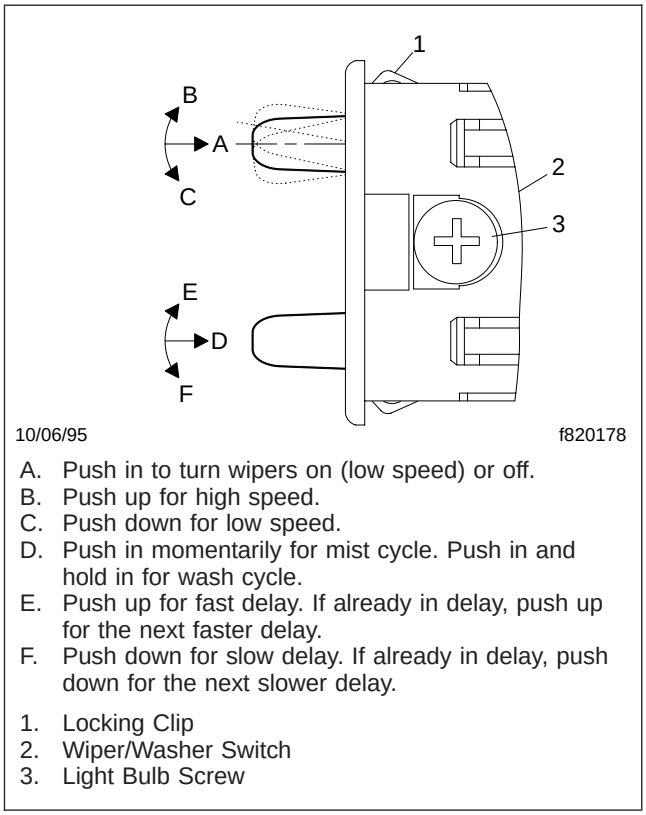
1. Auxiliary Instrument Panel
2. Wiper/Washer Switch

Fig. 1, Wiper/Washer Switch

The wipers have five cycles: fast, slow, mist, wash, and delay. There are six delay intervals, 3 seconds, 5 seconds (default fast), 8 seconds, 12 seconds, 17 seconds (default slow), and 23 seconds.

The top paddle, when pushed in, turns the wipers on (if they are off) or off (if they are on). When pushed up, the top paddle switches the wipers to high speed; when pushed down, it switches them to low speed.

The bottom paddle, when pushed in momentarily (for less than 1/2 second), turns the wipers on mist (one dry cycle at low speed). When pushed in and held in (for at least 1/2 second), the bottom paddle turns on the washers for a minimum of three cycles after release. For more wash cycles, hold the bottom paddle in longer (but it will always cycle three more times after release).



A. Push in to turn wipers on (low speed) or off.
B. Push up for high speed.
C. Push down for low speed.
D. Push in momentarily for mist cycle. Push in and hold in for wash cycle.
E. Push up for fast delay. If already in delay, push up for the next faster delay.
F. Push down for slow delay. If already in delay, push down for the next slower delay.

1. Locking Clip
2. Wiper/Washer Switch
3. Light Bulb Screw

Fig. 2, Wiper/Washer Switch Operation

Pushing **the bottom paddle** up or down controls the delay cycle of the intermittent wipers. If the wipers are not in delay, push up for default fast delay (5 seconds) or down for default slow delay (17 seconds). If the wipers are already in delay, push up for the next faster delay or push down for the next slower delay.

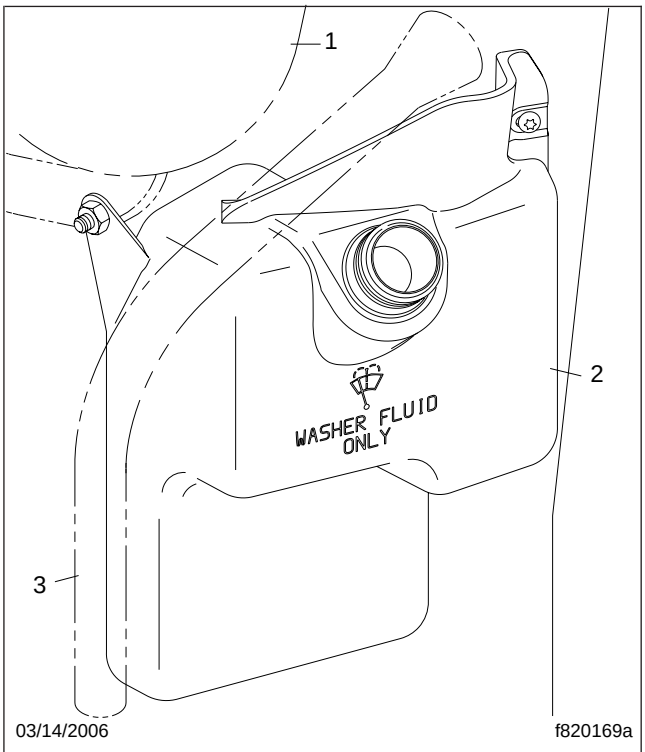
Vehicles may have a one-piece or two-piece windshield. All two-piece and most one-piece windshields are installed with two-pivot wiper systems. Argosy one-piece windshields are installed with three-pivot wipers.

A single wiper motor powers both wipers. It is mounted in the top center area of the cab front wall (behind the surge tank on vehicles with a front-wall mounted surge tank). The electric wiper motor is a sealed unit packaged together with a weather seal

General Information

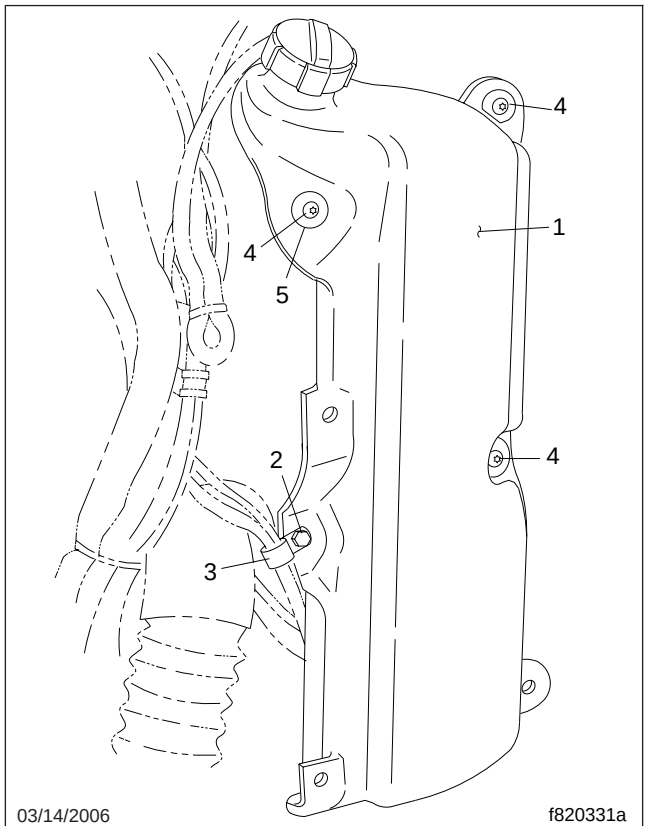
and drive crank. It is not serviceable. If a wiper motor does not work because of internal problems, replace it.

The windshield washer reservoir (see **Fig. 3** for a Century Class Conventional and **Fig. 4** for an Argosy COE) is located on the left-hand side of the cab front wall. A pump located in a recess in the bottom of the reservoir supplies washer fluid to each wiper arm. A purge mechanism empties the lines after use to prevent fluid from freezing in the lines during cold weather.



1. Surge Tank
2. Washer Reservoir
3. Drain

Fig. 3, Windshield Washer Reservoir (Century Class Conventional with front-wall mounted surge tank shown)



1. Washer Reservoir
2. Hexnut, 5/16–18
3. Support Clamp
4. Screw, 5/16–18
5. Plated Steel Washer

Fig. 4, Windshield Washer Reservoir (Argosy COE)

Procedures under these headings apply to the following vehicle models, as specified:

- Century Class Conventional with a radiator-mounted surge tank
- Century Class Conventional built during or after March 2000, with a cab front-wall mounted surge tank
- Argosy COE

Century Class Conventional with a Radiator-Mounted Surge Tank

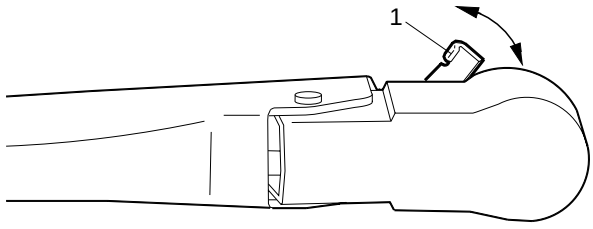
Removal

1. Apply the parking brakes and chock the tires.
2. Check that the wiper blades are parked. If necessary, park them by turning the wipers on and then off.
3. Open the hood.
4. Disconnect the wiper motor electrical connector.

⚠ WARNING

Disconnect the wiper motor electrical connector before working on the wiper linkage. This will prevent the windshield wiper motor from cycling. The motor could cycle if the wiper linkage driveshaft is forced out of the parked position, which could result in personal injury.

5. Remove each wiper arm and disconnect the washer hoses as follows.
   - 5.1 Disconnect the windshield washer hose from the rain tray.
   - 5.2 With the wiper blade pulled away from the windshield, pull up the locking tab near the pivot end of the wiper arm; see **Fig. 1**. Remove the wiper arm from the wiper shaft.
6. Remove the nut and washer that attach the fan switch mounting bracket to the washer reservoir mounting stud; see **Fig. 2**. Remove the fan switch mounting bracket.
7. Detach any wiring and hoses from the bottom of the rain tray.



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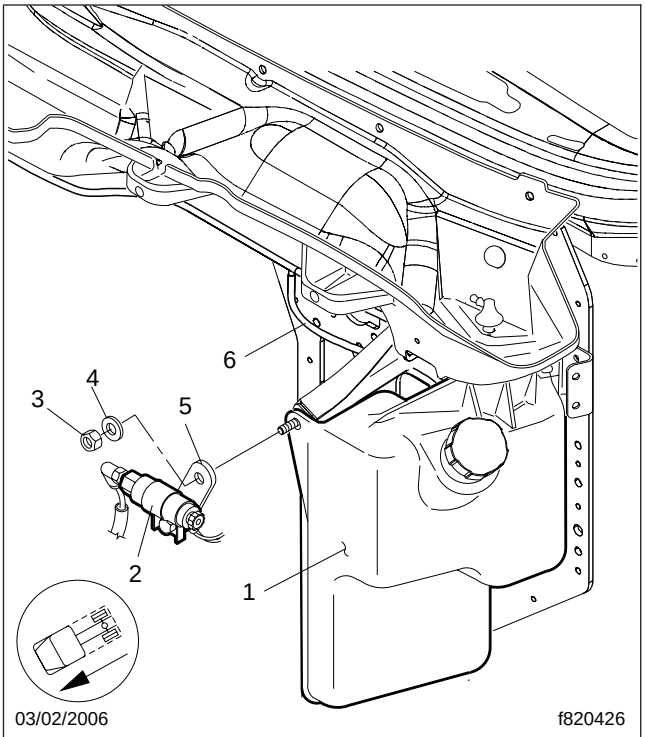
1. Locking Tab

Fig. 1, Wiper Arm Lock



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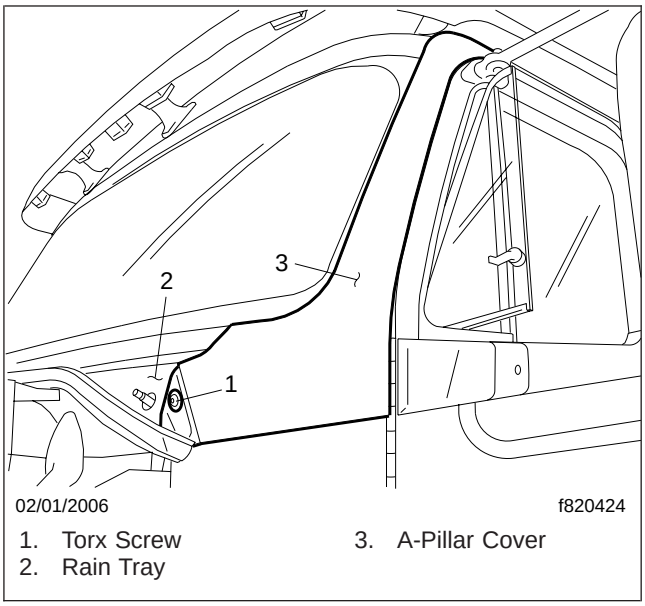
1. Washer Reservoir
2. Fan Switch
3. Nut
4. Washer
5. Fan Switch Mounting Bracket
6. Washer Fluid Line

Fig. 2, Fan Switch Installation

8. Remove the outboard drain tube from the rain tray. Remove the fastener that attaches the inboard drain tube to the rain tray, but leave the inboard drain tube in place.

Wiper Linkage Removal and Installation

9. Remove the T27 Torx® screws that attach the rain tray to the A-pillar covers on both sides of the vehicle; see **Fig. 3**.



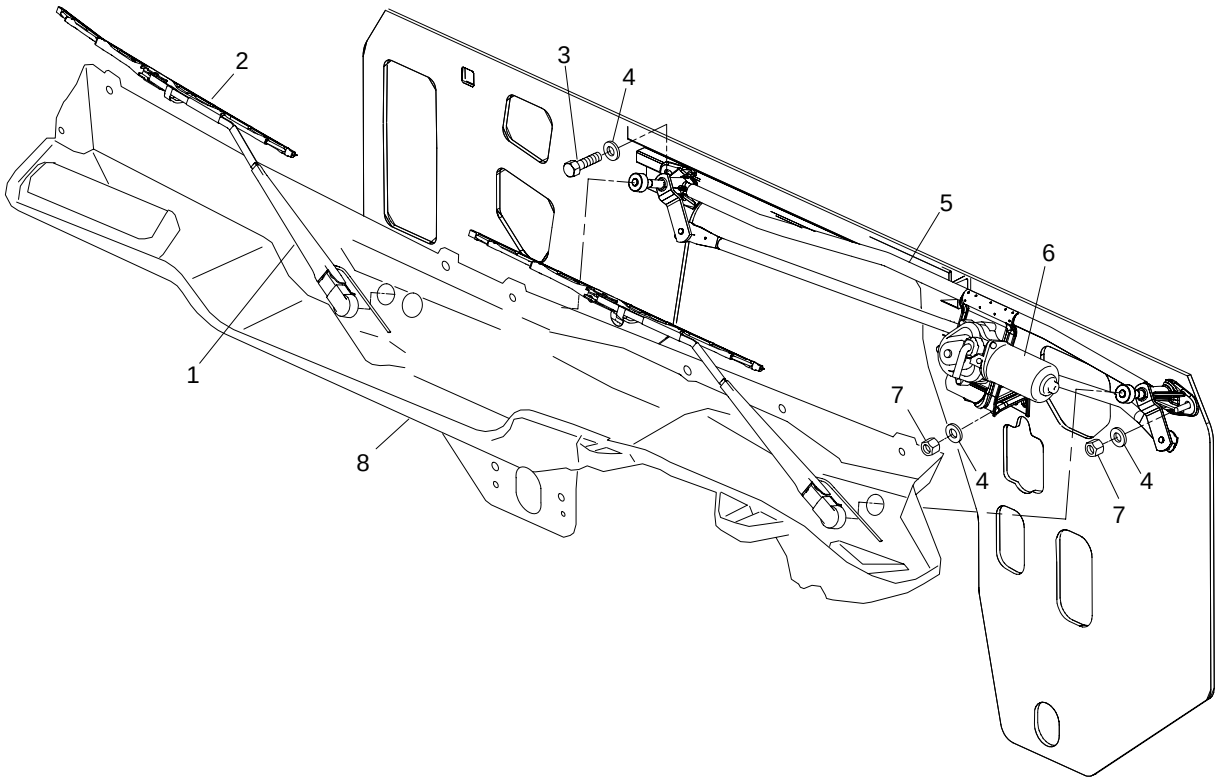
1. Torx Screw
2. Rain Tray
3. A-Pillar Cover

Fig. 3, A-Pillar Cover/Rain Tray Installation

10. Remove the T40 Torx capscrews that attach the rain tray to the cab front wall. Remove the rain tray.
11. Remove any hoses or wires that are attached to the wiper linkage assembly.
12. Remove the wiper linkage assembly from the cab front wall as follows; see **Fig. 4**.
    - 12.1 On the left side of the vehicle, remove the nut and washer that attach the wiper linkage mounting bracket to the front wall.
    - 12.2 On the right side of the vehicle, remove the capscrew and washer that attach the wiper linkage mounting bracket to the front wall.
    - 12.3 Remove the nut and washer that attach the wiper motor mounting bracket to the front wall. Remove the wiper linkage assembly.

Installation

1. Install the wiper linkage assembly on the cab front wall as follows; see **Fig. 4**.
    - 1.1 Using a nut and washer, attach the left-side mounting bracket of the wiper linkage assembly to the front wall.
    - 1.2 Using a capscrew and washer, attach the right-side mounting bracket of the wiper linkage assembly to the front wall.
    - 1.3 Using a nut and washer, attach the wiper motor bracket to the front wall.
2. Attach any hoses or wires that were disconnected from the wiper linkage assembly.
3. Using six T40 Torx capscrews, attach the rain tray to the cab front wall.
4. Attach any wiring or hoses that were detached from the bottom of the rain tray.
5. Install the outboard drain tube; hook the bottom of the drain tube on the washer reservoir. Install the fastener for the inboard drain tube.
6. Using T27 Torx screws, attach the rain tray to the A-pillar covers on both sides of the vehicle; see **Fig. 3**.
7. Using a nut and washer, attach the fan switch mounting bracket to the upper washer reservoir mounting stud; see **Fig. 2**.
8. Install each wiper arm as follows. For the correct wiper park position, see **Fig. 5**.
    - 8.1 Install the wiper arm on the wiper driveshaft, then hold it in place while pulling the wiper blade away from the windshield. The locking tab will snap into the locked position.
    - 8.2 Check that the wiper arm is securely attached by pulling gently on it.
    - 8.3 Connect the washer hose to the rain tray.
9. Connect the wiper motor electrical connector.
10. Test the wiper motor and washers. Operate the wipers at low speed and check that the blades do not slap against the mask around the edge of the window.



1. Wiper Arm
2. Wiper Blade
3. Capscrew
4. Washer
5. Wiper Linkage
6. Wiper Motor
7. Nut
8. Rain Tray

Fig. 4, Wiper Linkage Installation

Century Class Conventional Built during or after March 2000, with a Cab Front-Wall Mounted Surge Tank

Removal

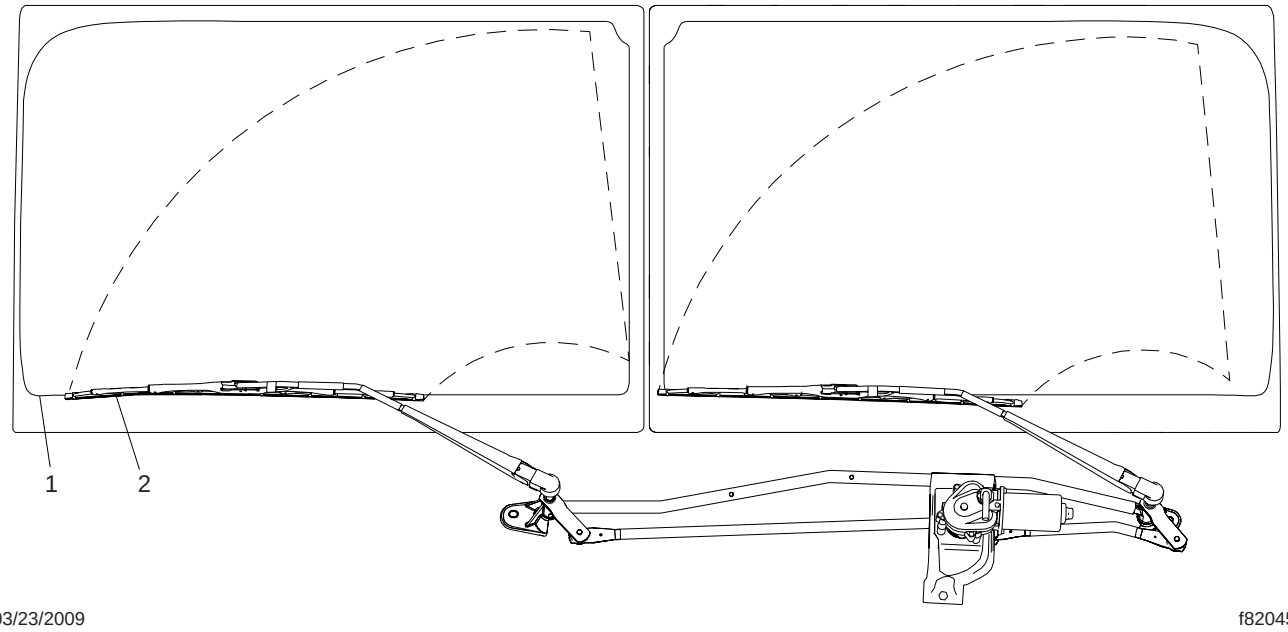
1. Apply the parking brakes and chock the tires.
2. Check that the wiper blades are parked. If necessary, park them by turning the wipers on and then off.
3. Open the hood.
4. Disconnect the wiper motor electrical connector.

⚠ WARNING

Disconnect the wiper motor electrical connector before working on the wiper linkage. This will prevent the windshield wiper motor from cycling. The motor could cycle if the wiper linkage driveshaft is forced out of the parked position, which could result in personal injury.

5. Remove each wiper arm and disconnect the washer hoses as follows.
   - 5.1 Disconnect the windshield washer hose from the rain tray.
   - 5.2 With the wiper blade pulled away from the windshield, pull up the locking tab near

Wiper Linkage Removal and Installation



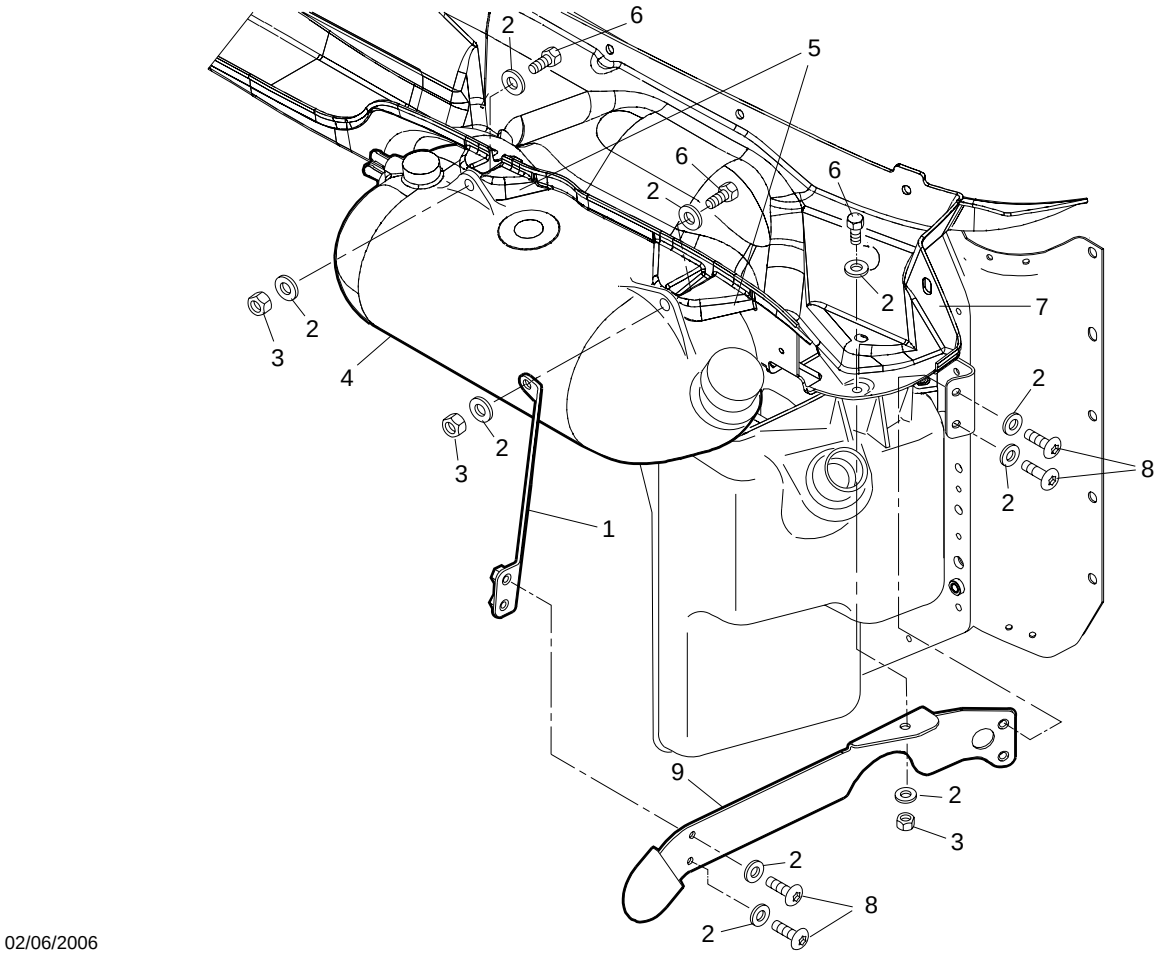
Park the blades within one spline's width of the edge of the dark band.

1. Edge of Dark Band
2. Wiper Blade

Fig. 5, Windshield Wiper Park Position, Two-Pivot Models

the pivot end of the wiper arm; see **Fig. 1**. Remove the wiper arm from the wiper shaft.

6. On vehicles with a hood guide mounted above the washer reservoir, remove the hood guide as follows; see **Fig. 6**.
   - 6.1 Remove the four T40 Torx capscrews and washers that attach the hood guide to the mounting brackets.
   - 6.2 Remove the bolt, nut, and washers that attach the hood guide to the rain tray.
7. Remove the surge tank and the fan switch as follows.
   - 7.1 Remove the bolts, nuts, and washers that attach the surge tank and the hood guide mounting bracket (if so equipped) to the surge tank upper mounting brackets; see **Fig. 6**.
   - 7.2 Remove the nut that attaches the hose clamp to the surge tank lower mounting stud; see **Fig. 7**. Remove the hose clamp. Remove the second nut and washer that attach the surge tank to the same mounting stud.
   - 7.3 Remove the nut and washer that attach the fan switch mounting bracket to the surge tank lower left-side mounting stud; see **Fig. 7**. Remove the fan switch mounting bracket.
   - 7.4 Remove the surge tank.
8. Detach any wiring and hoses from the bottom of the rain tray.
9. Remove the outboard drain tube from the rain tray. Remove the fastener that attaches the inboard drain tube to the rain tray, but leave the inboard drain tube in place.
10. Remove the T27 Torx screws that attach the rain tray to the A-pillar covers on both sides of the vehicle; see **Fig. 3**.
11. On the driver side only, remove the exterior covers from the upper A-pillar and the side cowl.



1. Hood Guide Mounting Bracket
2. Washer
3. Nut
4. Surge Tank
5. Surge Tank Mounting Brackets
6. Bolt
7. Rain Tray
8. T40 Torx Capscrew
9. Hood Guide

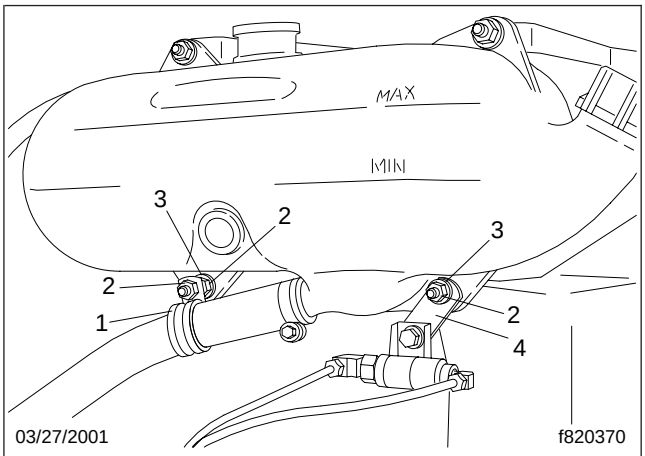
Fig. 6, Hood Guide Installation

12. Remove the T40 Torx capscrews that attach the rain tray to the cab front wall. Remove the rain tray.
13. Remove any hoses or wires that are attached to the wiper linkage assembly.
14. Remove the wiper linkage assembly from the cab front wall as follows; see **Fig. 4**.
    - 14.1 On the left side of the vehicle, remove the nut and washer that attach the wiper linkage mounting bracket to the cab front wall.
    - 14.2 On the right side of the vehicle, remove the capscrew and washer that attach the wiper linkage mounting bracket to the cab front wall.
    - 14.3 Remove the nut and washer that attach the wiper motor mounting bracket to the cab front wall. Remove the wiper linkage assembly.

Installation

1. Install the wiper linkage assembly on the cab front wall as follows; see **Fig. 4**.

Wiper Linkage Removal and Installation



1. Hose Clamp
2. Nut
3. Washer
4. Fan Switch Mounting Bracket

Fig. 7, Surge Tank Installation

1.1 Using a nut and washer, attach the left-side mounting bracket of the wiper linkage assembly to the cab front wall.

1.2 Using a capscrew and washer, attach the right-side mounting bracket of the wiper linkage assembly to the cab front wall.

1.3 Using a nut and washer, attach the wiper motor bracket to the cab front wall.

2. Attach any hoses or wires that were disconnected from the wiper linkage assembly.
3. Using six T40 Torx capscrews, attach the rain tray to the cab front wall.
4. Attach any wiring or hoses that were detached from the bottom of the rain tray.
5. Install the outboard drain tube; hook the bottom of the drain tube on the washer reservoir. Install the fastener for the inboard drain tube.
6. Install the driver-side upper A-pillar exterior cover and the side cowl exterior cover.
7. Using T27 Torx screws, attach the rain tray to the A-pillar covers on both sides of the vehicle; see **Fig. 3**.
8. Install the surge tank and the fan switch as follows.

8.1 Position the surge tank on the mounting brackets and studs. Using a bolt, nut, and washer, install the hood guide mounting bracket (if so equipped) on the left-side upper mounting bracket; see **Fig. 6**.

8.2 Using a bolt, nut, and washer, secure the surge tank to the right-side upper mounting bracket.

8.3 Using a nut and washer, secure the surge tank to the lower right-side mounting stud. Install the hose clamp on the same mounting stud and secure the hose clamp with a nut; see **Fig. 7**.

8.4 Using a nut and washer, attach the fan switch mounting bracket to the lower left-side mounting stud.

9. On vehicles with a hood guide mounted above the washer reservoir, install the hood guide as follows; see **Fig. 6**.

9.1 Using a bolt, nut, and washer, attach the hood guide to the rain tray.

9.2 Using four T40 Torx capscrews, attach the hood guide to the mounting brackets.

10. Install each wiper arm as follows. For the correct wiper park position, see **Fig. 5**.

10.1 Install the wiper arm on the wiper driveshaft, then hold it in place while pulling the wiper blade away from the windshield. The locking tab will snap into the locked position.

10.2 Check that the wiper arm is securely attached by pulling gently on it.

10.3 Connect the washer hose to the rain tray.

11. Connect the wiper motor electrical connector.
12. Test the wiper motor and washers. Operate the wipers at low speed and check that the blades do not slap against the mask around the edge of the window.

Argosy COE

NOTE: If an Argosy COE one-piece windshield is replaced with a two-piece windshield, replace the existing three-pivot wiper linkage with a two-pivot linkage.

Wiper Linkage Removal and Installation

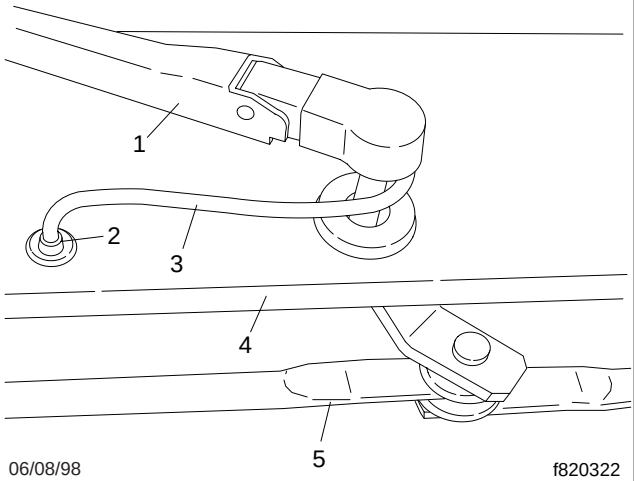
Removal

1. Apply the parking brakes and chock the tires.
2. Check that the wiper blades are parked. If necessary, park them by turning the wipers on and then off.
3. Open the grille.
4. Disconnect the wiper motor electrical connector.

⚠ WARNING

Disconnect the wiper motor electrical connector before working on the wiper linkage. This will prevent the windshield wiper motor from cycling. The motor could cycle if the wiper linkage driveshaft is forced out of the parked position, which could result in personal injury.

5. Remove each wiper arm (three on vehicles with one-piece windshields, two on vehicles with two-piece windshields) and disconnect the washer hoses as follows; see **Fig. 8**.



1. Wiper Arm
2. Nipple
3. Washer Hose
4. Wiper/Handle Panel
5. Wiper Linkage

Fig. 8, Wiper Arm and Washer Hose

5.1 Disconnect the windshield washer hose from the nipple on the wiper/handle panel.

5.2 With the wiper blade pulled away from the windshield, pull up the locking tab near the pivot end of the wiper arm; see **Fig. 1**. Remove the wiper arm from the wiper shaft.

6. Remove the wiper/handle panel from the front of the vehicle; see **Section 60.16, Subject 100**.
7. Disconnect the drive link from the ball stud on the motor crank (see **Fig. 9** for two-pivot wipers and **Fig. 10** for three-pivot wipers).
8. Remove the pivot brackets, one for each wiper pivot as follows.

8.1 Remove the three 5/16–18 capscrews, with washers, that hold each wiper pivot bracket in place.

8.2 Remove the drive link assembly from the vehicle.

NOTE: To remove the drive crank and wiper motor, see **Subject 110**.

Installation

1. With the wiper motor and drive crank installed, install each wiper pivot bracket on the wiper motor mounting bracket, using the fasteners previously removed. Using a 1/2-inch wrench, tighten the 5/16–18 capscrews 15 lbf·ft (20 N·m).
2. Apply a small amount of water-resistant grease to both the ball stud and the drive link socket. Connect the drive link to the ball stud on the end of the drive crank.
3. Install the wiper/handle panel, as removed; see **Section 60.16, Subject 100**.
4. Install each wiper arm as follows. For the correct wiper park position, see **Fig. 5** for two-pivot models, and **Fig. 11** for three-pivot models.

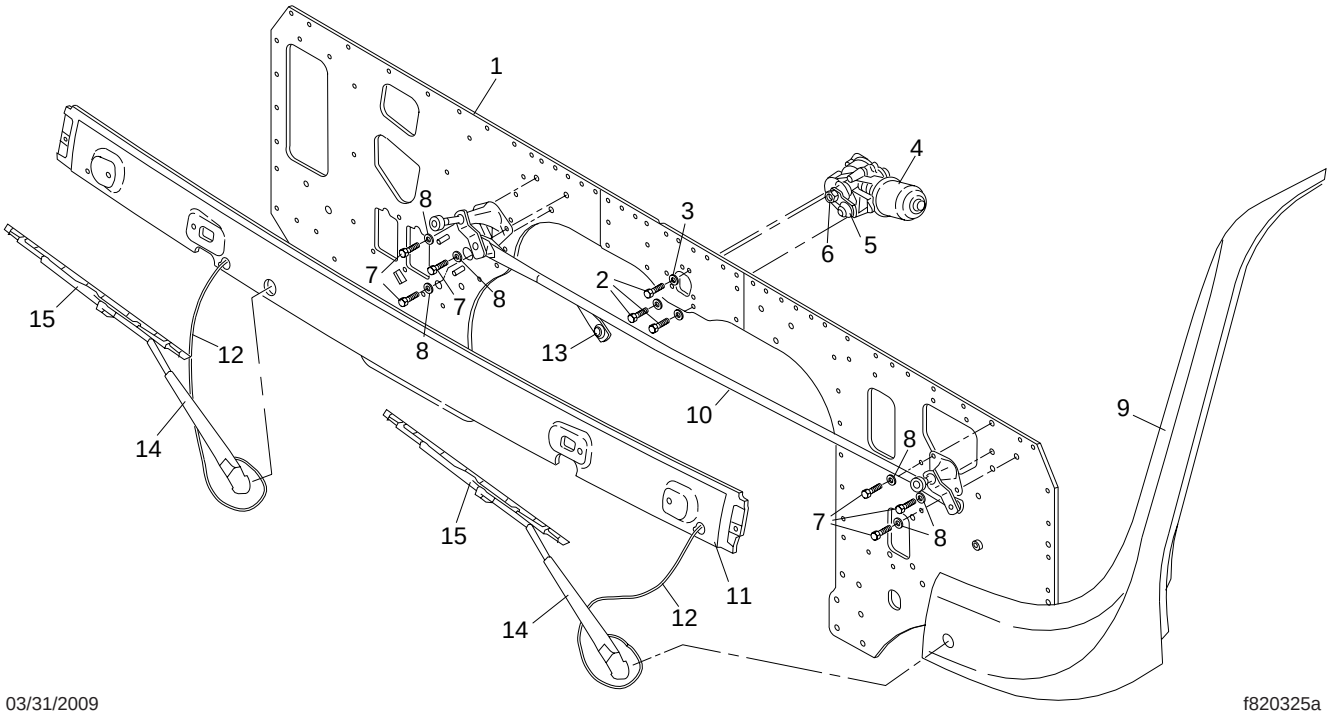
4.1 Install the wiper arm on the wiper driveshaft, then hold it in place while pulling the wiper blade away from the windshield. The locking tab will snap into the locked position.

4.2 Check that the wiper arm is securely attached by pulling gently on it.

4.3 Connect the washer hose to the nipple on the wiper/handle panel.

5. Test the wiper motor and washers. Operate the wipers at low speed and check that the blades do not slap against the mask around the edge of

Wiper Linkage Removal and Installation



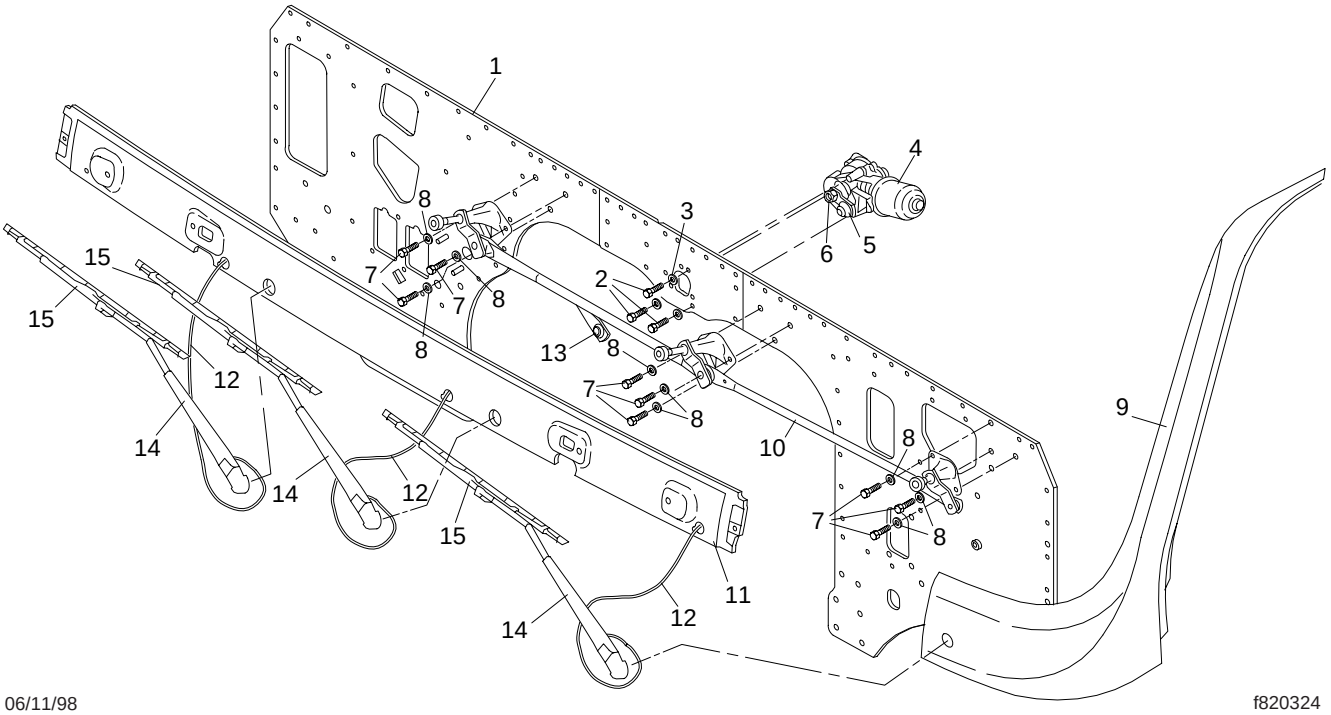
1. Front Wall
2. M6 Capscrew
3. Washer, 1/4-Inch
4. Wiper Motor
5. Ball Stud
6. Drive Nut
7. Capscrew, 5/16–18
8. Washer, 5/16-Inch
9. A-Pillar Side Panel
10. Wiper Linkage
11. Wiper/Handle Panel
12. Washer Hose
13. Drive Link
14. Wiper Arm
15. Wiper Blade

Fig. 9, Wiper Linkage, Two-Pivot Wipers

the window. See **Fig. 11** for three-pivot models, and **Fig. 5** for two-pivot models.

6. Close and latch the grille.

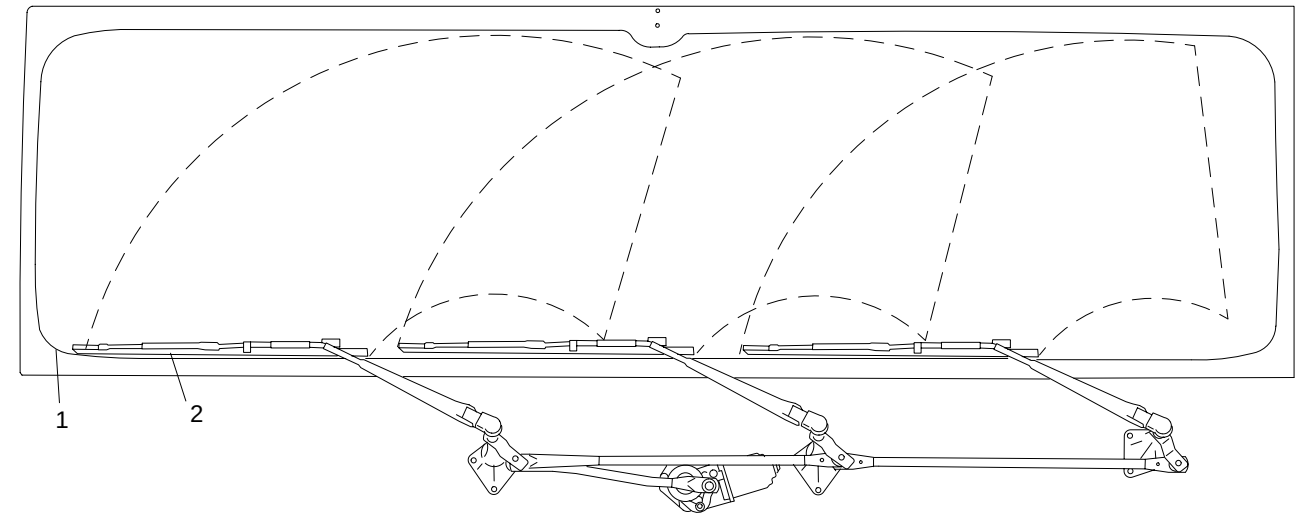
Wiper Linkage Removal and Installation



1. Front Wall
2. M6 Capscrew
3. Washer, 1/4-Inch
4. Wiper Motor
5. Ball Stud
6. Drive Nut
7. Capscrew, 5/16–18
8. Washer, 5/16-Inch
9. A-Pillar Side Panel
10. Wiper Linkage
11. Wiper/Handle Panel
12. Washer Hose
13. Drive Link
14. Wiper Arm
15. Wiper Blade

Fig. 10, Wiper Linkage, Three-Pivot Wipers

Wiper Linkage Removal and Installation



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Park the blades within one spline's width of the edge of the dark band.

1. Edge of Dark Band
2. Wiper Blade

Fig. 11, Windshield Wiper Park Position, Three-Pivot Models

Procedures under these headings apply to the following vehicle models, as specified:

- Century Class Conventional built during or after March 2000
- Argosy COE

Century Class Conventional Built during or after March 2000

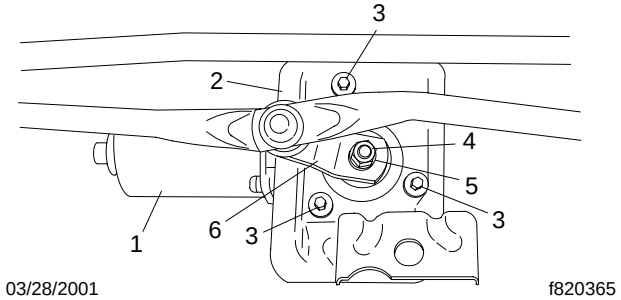
Replacement

1. With the vehicle parked, apply the parking brakes and chock the tires.
2. Check that the wiper blades are parked. If necessary, park them by turning the wipers on and then off.
3. Open the hood.
4. Disconnect the wiper motor electrical connector.

⚠ WARNING

Disconnect the wiper motor electrical connector before working on the wiper motor. Otherwise, the motor could cycle if the driveshaft is forced out of the parked position, which could result in personal injury.

5. Remove the wiper linkage assembly. For instructions, see **Subject 100**.
6. Remove the nut and lockwasher that attach the motor lever to the driveshaft. See **Fig. 1**.



1. Wiper Motor
2. Mounting Bracket
3. Capscrew
4. Nut
5. Lockwasher
6. Motor Lever

Fig. 1, Wiper Motor Assembly

7. Remove the three capscrews that attach the motor to the mounting bracket.
8. Using three capscrews, attach a new motor to the mounting bracket.
9. Using a nut and lockwasher, attach the motor lever to the drive shaft.
10. Install the wiper linkage assembly. For instructions, see **Subject 100**.
11. Connect the wiper motor electrical connector.
12. Test the wiper motor and washers.
13. Close and latch the hood.
14. Remove the chocks.

Argosy COE

Replacement

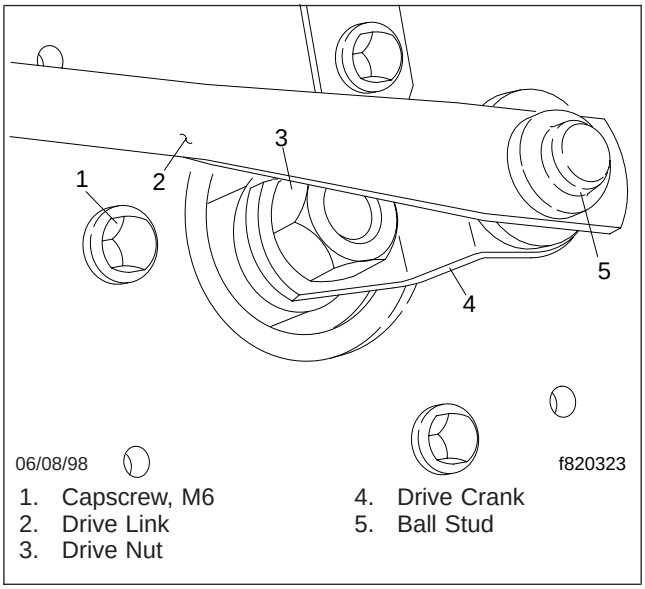
1. With the vehicle parked, apply the parking brakes and chock the tires.
2. Make sure the wiper blades are parked. If needed, park them by turning them on, then off.
3. Open the grille.
4. Disconnect the batteries.

⚠ WARNING

Disconnect the batteries before working on the wiper motor. Otherwise, the motor could cycle if the driveshaft is forced out of the parked position, which could result in personal injury.

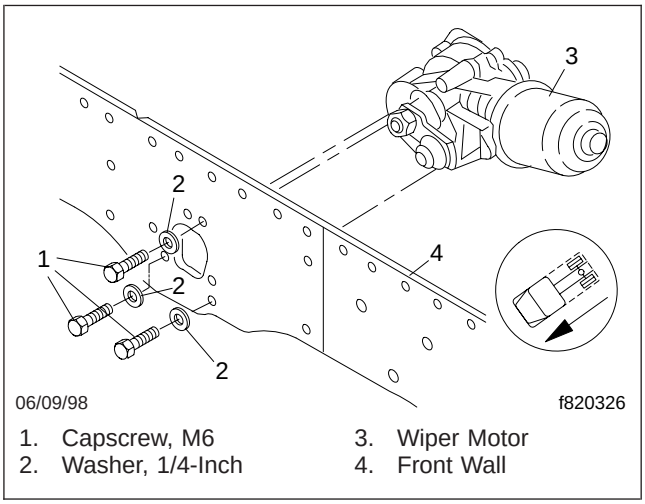
5. Gently pry the plastic end of the drive link off the ball stud. See **Fig. 2**.
6. Remove the three M6 capscrews and 1/4-inch plated steel washers that attach the motor to the front wall. See **Fig. 3**.
7. Remove the electrical connector from the back of the wiper motor.
8. To remove the motor from the vehicle, twist it around until it fits through the opening between the surge tank and the front wall.
9. Install the new wiper motor, as follows.

Wiper Motor Replacement



1. Capscrew, M6
2. Drive Link
3. Drive Nut
4. Drive Crank
5. Ball Stud

Fig. 2, Wiper Drive



1. Capscrew, M6
2. Washer, 1/4-Inch
3. Wiper Motor
4. Front Wall

Fig. 3, Wiper Motor

9.1 Position the new wiper motor so that the threaded holes in the motor housing line up with the mounting holes in the front wall.

9.2 Install the three M6 mounting capscrews and tighten them 88 lbf·in (1000 N·cm).

9.3 Use your finger to apply a small amount of water-resistant grease to both the ball stud and the drive link socket. Position the drive link on the ball stud.

9.4 Snap the plastic end of the drive link onto the ball stud.

10. Connect the wiper motor electrical connector.
11. For corrosion protection, pack the exposed ends of the connectors with pumpable dielectric grease, part number 48–02439–000.
12. Connect the batteries.
13. Test the wiper motor and washers. Make sure the wiper blades park correctly. For instructions, see **Subject 100**.
14. Close and latch the grille.
15. Remove the chocks.

Washer Reservoir Removal and Installation

Procedures under these headings apply to the following vehicle models, as specified:

- Century Class Conventional with a radiator-mounted surge tank
- Century Class Conventional built during or after March 2000, with a cab front-wall mounted surge tank
- Argosy COE

Century Class Conventional with a Radiator-Mounted Surge Tank

Removal

1. With the vehicle parked, apply the parking brakes and chock the tires.
2. Open the hood.
3. Remove the nut and washer that attach the fan switch mounting bracket and washer reservoir to the mounting stud. See **Fig. 1**. Remove the fan switch mounting bracket.
4. Remove the outboard drain tube from the rain tray.
5. Disconnect the electrical connector from the washer pump.
6. Disconnect the washer fluid hose from the washer pump.

NOTE: Washer fluid will flow out of the washer pump outlet if the reservoir contains washer fluid.

7. Remove the two T40 Torx capscrews and washers that attach the washer reservoir to the mounting bracket and front wall. See **Fig. 1**.
8. Remove the washer reservoir.

Installation

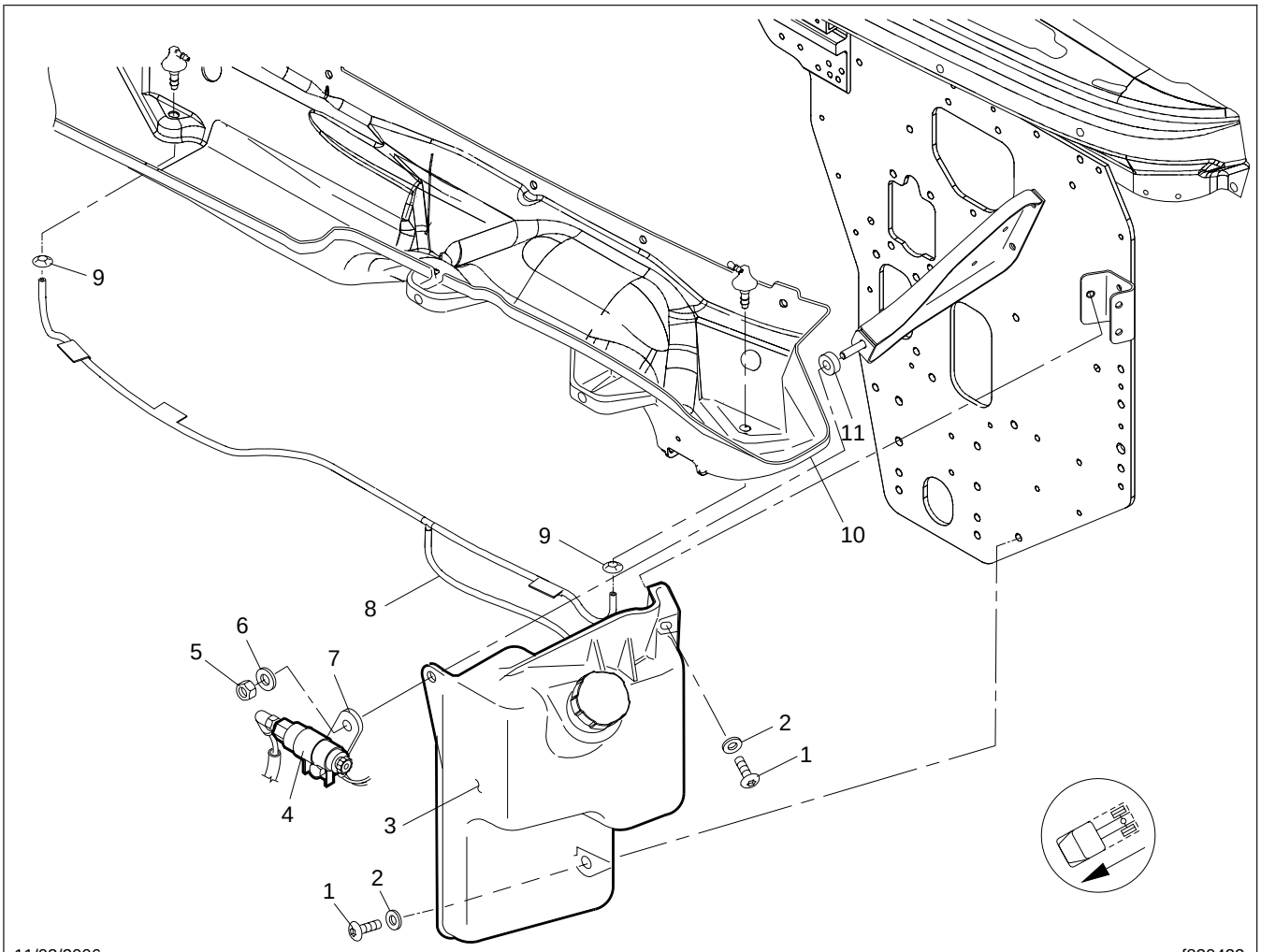
1. With the tires chocked, using two T40 Torx capscrews and washers, attach the washer reservoir to the mounting bracket and front wall. See **Fig. 1**.
2. Attach the washer fluid hose to the washer pump.
3. Attach the electrical connector to the washer pump.
4. Install the fan switch mounting bracket on the mounting stud. Using a nut and washer, secure the fan switch bracket and the washer reservoir to the mounting stud. See **Fig. 1**.
5. Install the outboard drain tube on the rain tray; hook the drain tube on the washer reservoir.
6. Close and latch the hood.
7. Remove the chocks.

Century Class Conventional Built during or after March 2000, with a Cab Front-Wall Mounted Surge Tank

Removal

1. With the vehicle parked, apply the parking brakes and chock the tires.
2. Open the hood.
3. On vehicles with a hood guide mounted above the washer reservoir, remove the hood guide, as follows. See **Fig. 2**.
   - 3.1 Remove the four T40 Torx capscrews and washers that attach the hood guide to the mounting brackets.
   - 3.2 Remove the bolt, nut, and washers that attach the hood guide to the rain tray.
4. Remove the surge tank and the fan switch, as follows.
   - 4.1 Remove the bolts, nuts, and washers that attach the surge tank and the hood guide mounting bracket (if so equipped) to the upper surge tank mounting brackets. See **Fig. 2**.
   - 4.2 Remove the nut that attaches the hose clamp to the lower surge tank mounting stud. See **Fig. 3**. Remove the hose clamp. Remove the second nut and washer that attach the surge tank to the same mounting stud.
   - 4.3 Remove the nut and washer that attach the fan switch mounting bracket to the

Washer Reservoir Removal and Installation



1. T40 Torx Capscrew
2. Washer
3. Washer Reservoir
4. Fan Switch
5. Nut
6. Washer
7. Fan Switch Mounting Bracket
8. Washer Fluid Hose
9. Pushnut
10. Rain Tray
11. Spacer

Fig. 1, Washer Reservoir Installation (Century Class Conventional with Radiator-Mounted Surge Tank)

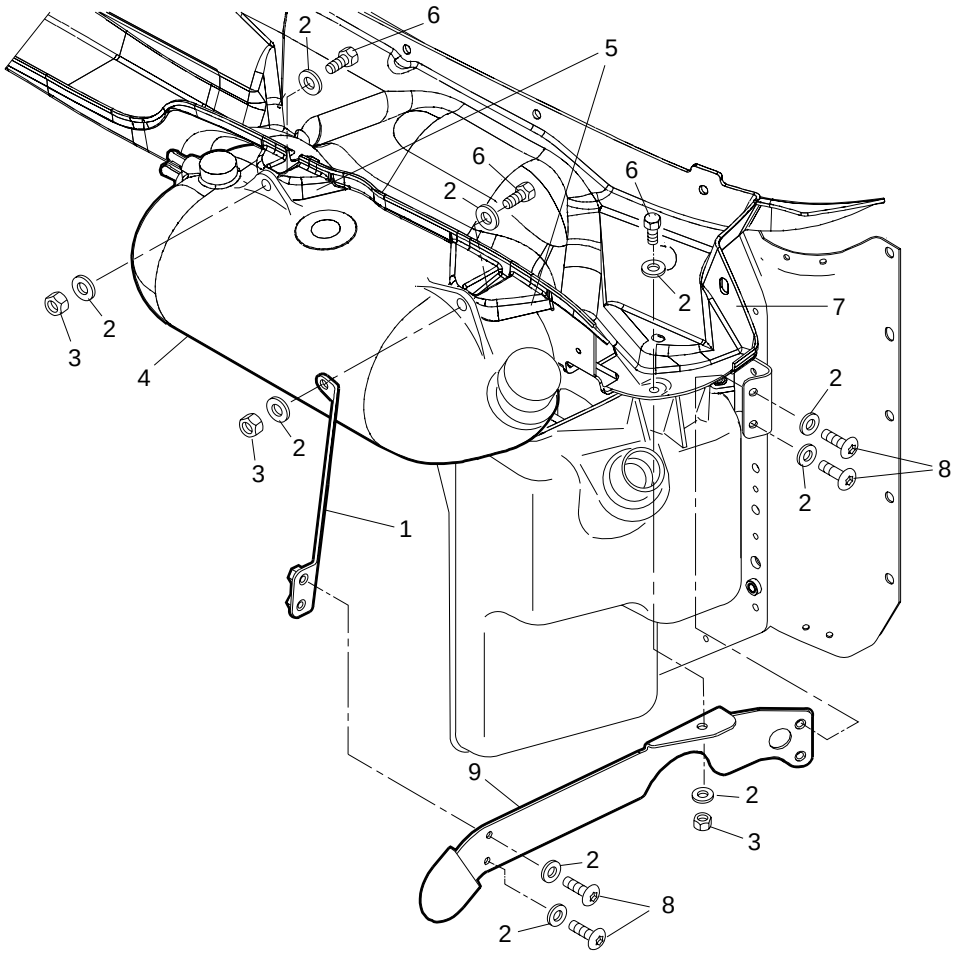
lower surge tank mounting stud. See **Fig. 3**. Remove the fan switch mounting bracket.

4.4 Remove the surge tank.

5. Remove the outboard drain tube from the rain tray.
6. Disconnect the electrical connector from the washer pump.
7. Disconnect the washer fluid hose from the washer pump.

NOTE: Washer fluid will flow out of the washer pump outlet if the reservoir contains washer fluid.

8. Move the surge tank off of the lower mounting stud and upper mounting brackets.



1. Hood Guide Mounting Bracket
2. Washer
3. Nut
4. Surge Tank
5. Surge Tank Mounting Brackets
6. Bolt
7. Rain Tray
8. T40 Torx Capscrew
9. Hood Guide

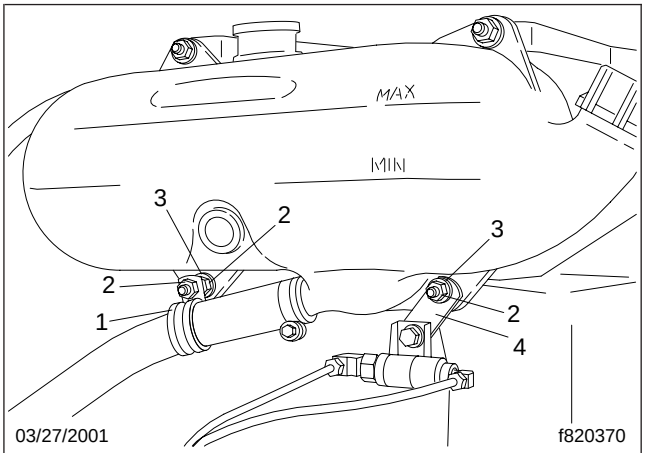
Fig. 2, Hood Guide Installation

9. Remove the two T40 Torx capscrews and washers that attach the washer reservoir to the mounting bracket and front wall. See **Fig. 4**.
10. Remove the washer reservoir.

Installation

1. With the tires chocked, position the washer reservoir in place on the mounting stud. Using two T40 Torx capscrews and washers, attach the reservoir to the mounting bracket and front wall. See **Fig. 4**.
2. Attach the washer fluid hose to the washer pump.
3. Attach the electrical connector to the washer pump.
4. Install the surge tank and the fan switch, as follows.
   - 4.1 Position the surge tank on the mounting brackets and studs. Using a bolt, nut, and washer, install the hood guide mounting bracket (if so equipped) on the upper right-side mounting bracket. See **Fig. 2**.

Washer Reservoir Removal and Installation



1. Hose Clamp
2. Nut
3. Washer
4. Fan Switch Mounting Bracket

Fig. 3, Surge Tank Installation

4.2 Using a bolt, nut, and washer, secure the surge tank to the upper left-side mounting bracket.

4.3 Using a nut and washer, secure the surge tank to the lower right-side mounting stud. Install the hose clamp on the same mounting stud and secure the hose clamp with a nut. See **Fig. 3**.

4.4 Using a nut and washer, attach the fan switch mounting bracket to the left-side mounting stud.

5. On vehicles with a hood guide mounted above the washer reservoir, install the hood guide, as follows. See **Fig. 2**.

5.1 Using a bolt, nut, and washer, attach the hood guide to the rain tray.

5.2 Using four T40 Torx capscrews, attach the hood guide to the mounting brackets.

6. Install the outboard drain tube; hook the bottom of the drain tube on the washer reservoir. Install the fastener for the inboard drain tube.
7. Close and latch the hood.
8. Remove the chocks.

Argosy COE

Removal

1. With the vehicle parked, apply the parking brakes and chock the tires.
2. Open the grille.
3. Remove the A-pillar side panel. For detailed instructions, see **Section 60.16, Subject 100**.
4. Remove the left-hand cowl side panel. For detailed instructions, see **Section 60.16, Section 100**.
5. Remove the four fasteners that attach the washer reservoir to the front wall. See **Fig. 5**.
6. Disconnect the pump, as follows. See **Fig. 6**.

6.1 Pull the reservoir free of its mountings and turn it over to expose the washer pump.

6.2 Disconnect the electrical connector attached to the washer pump and cut the tie strap that attaches the electrical conduit to the strap holder on the back of the reservoir.

6.3 Remove the washer fluid delivery line from the pump.

NOTE: Washer fluid will flow out of the washer pump outlet if the reservoir contains washer fluid.

Installation

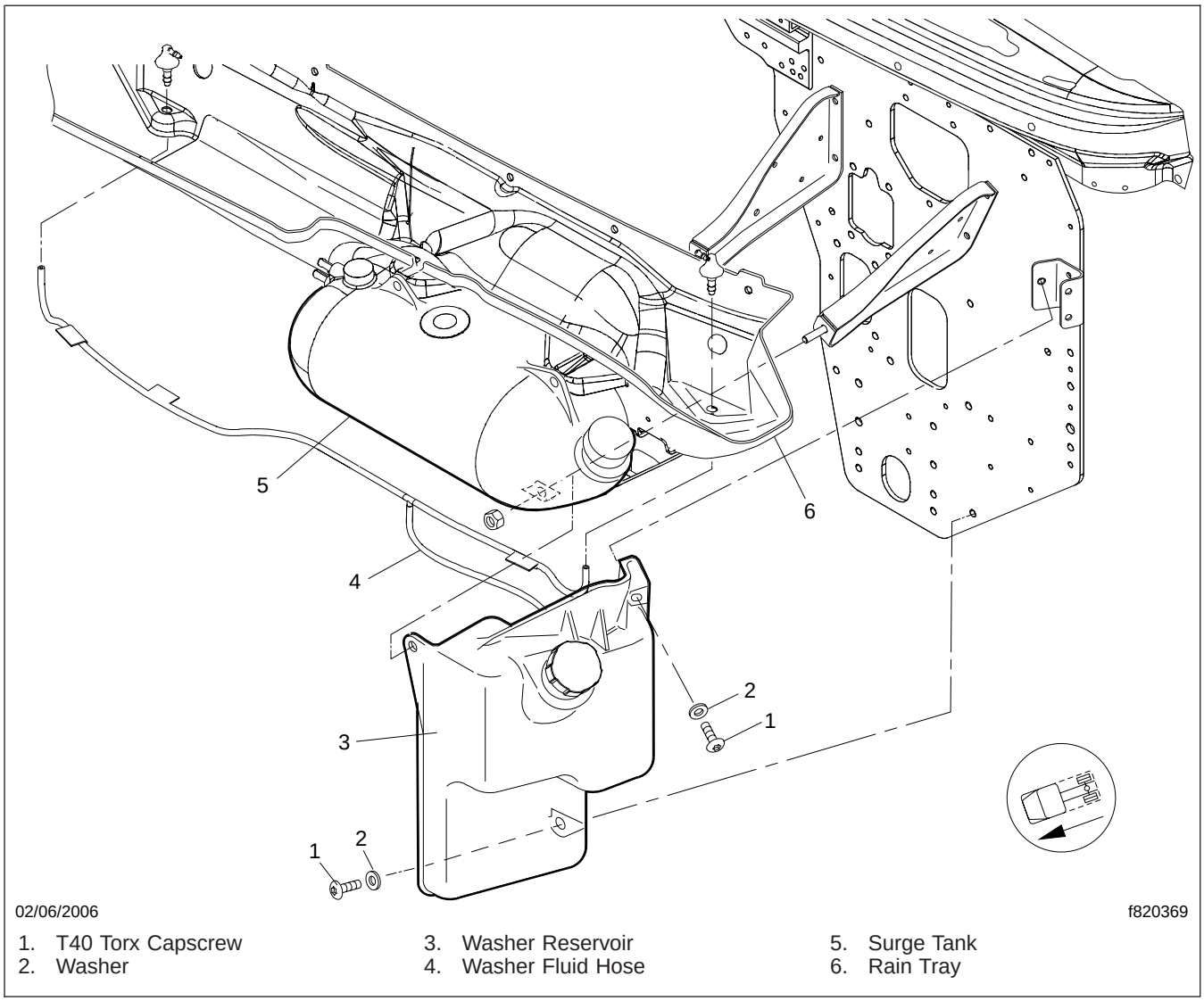
1. With the tires chocked, connect the pump to its electrical connector and fluid line, as follows. See **Fig. 6**.

1.1 Connect the electrical connector to the washer pump. For corrosion protection, pack the exposed ends of the connector with pumpable dielectric grease, part number 48–02439–000.

1.2 Insert a new tie strap through the tie strap holder and around the electrical conduit.

1.3 Attach the washer fluid delivery line to the washer pump.

2. Install the washer fluid reservoir onto the front-wall, as follows. See **Fig. 5**.



1. T40 Torx Capscrew
2. Washer
3. Washer Reservoir
4. Washer Fluid Hose
5. Surge Tank
6. Rain Tray

Fig. 4, Washer Reservoir Installation (Century Class Conventional with Front-Wall Mounted Surge Tank)

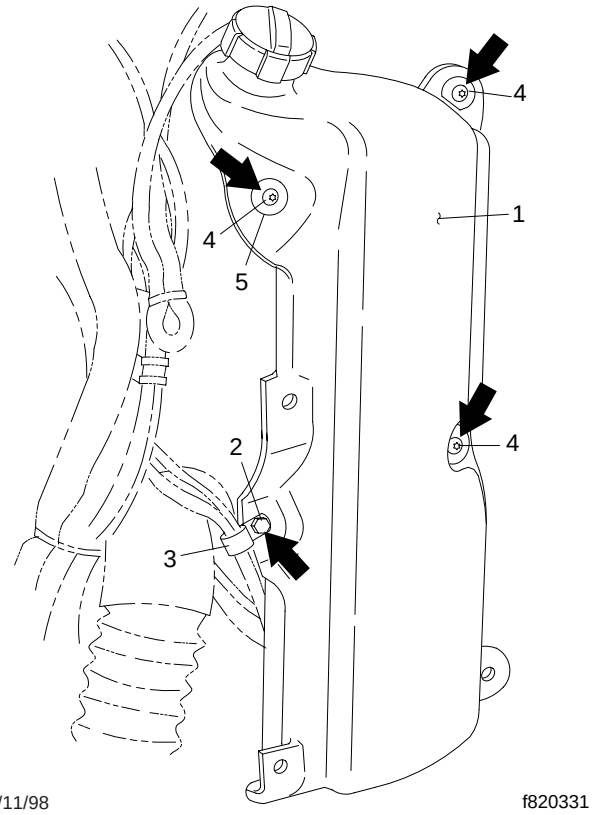
2.1 Position the reservoir on the front wall and line up the mounting holes.

2.2 Install the 5/16–18 hexnut and the two washers on the upper right-hand corner of the reservoir, as removed.

2.3 Install the three 5/16–18 screws, as removed.

3. Tighten all the fasteners 15 lbf·ft (20 N·m).
4. Install the left-hand cowl side panel. For detailed instructions, see **Section 60.16, Subject 100**.
5. Install the A-pillar side panel. For detailed instructions, see **Section 60.16, Subject 100**.
6. Close and latch the grille.
7. Remove the chocks.

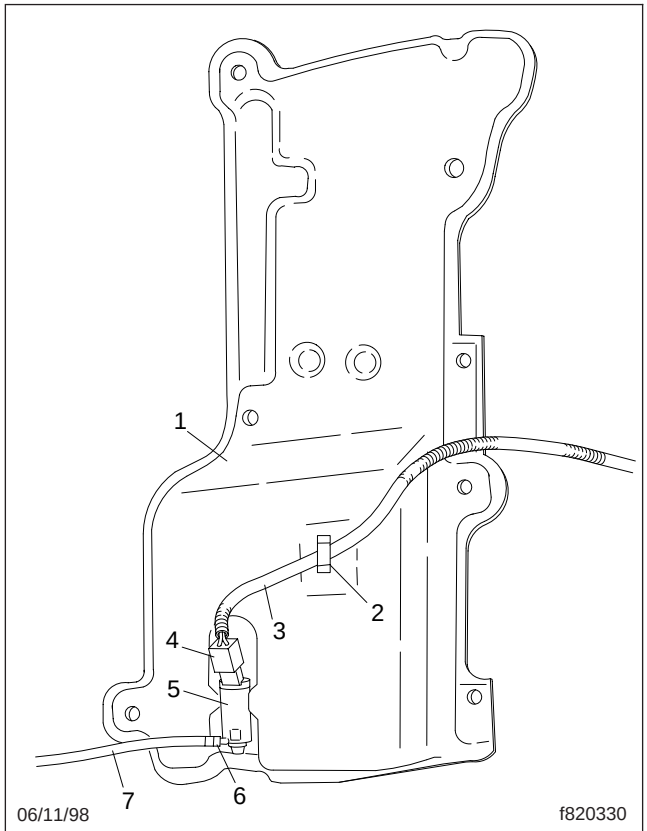
Washer Reservoir Removal and Installation



Remove the fasteners shown by the arrows.

1. Washer Reservoir
2. Hexnut, 5/16–18
3. Support Clamp
4. Screw, 5/16–18
5. Plated Steel Washer

Fig. 5, Washer Reservoir Mounting (Argosy COE)



1. Washer Reservoir
2. Tie Strap Holder
3. Electrical Conduit
4. Electrical Connector
5. Washer Pump
6. Hose Connector
7. Fluid Delivery Hose

Fig. 6, Washer Pump (Argosy COE)

Troubleshooting

WARNING

Use caution when working on or near the wiper linkage, arms, and motor. An intermittent wiper system may swipe without warning, posing a risk of personal injury.

NOTICE

Make sure the ignition switch is off before disconnecting any wiper/washer harness connectors. Removing connectors with the ignition switch on may cause electrical arcing, which will damage the pins.

Preliminary Checks

Before beginning the troubleshooting procedures, verify the driver's complaint by checking the system components, and operating the wiper and washer to duplicate the problem.

1. Check the wiper arms, blades, and linkage for wear and damage.
2. Check the washer fluid level in the reservoir.
3. Turn the ignition switch to the ON position without starting the engine.
4. Test the wipers on low speed, high speed, and several intermittent speeds.
5. Test the windshield washers.
6. Turn the ignition switch to the OFF position.
7. Check the washer hoses for leaks and damage.

Diagnostic Procedures

Symptoms

The diagnostic procedures listed in **Table 1** are described in detail in the succeeding tables. When performing the diagnostic procedures, refer to the wiring diagram (**Fig. 1**) and the tables in this subject.

NOTICE

Use caution when backprobing sealed connectors. If the seal is damaged, water could intrude into the connection, resulting in corrosion and electrical failure.

IMPORTANT: The following wiper and washer diagnostic procedures are performed with the ignition switch in the ON position, and the engine NOT running.

Troubleshooting Procedures	
Symptom	**Table Number**
Wipers are inoperative in all modes.	**Table 2**
High-speed mode only is inoperative.	**Table 3**
Low-speed and all intermittent speed modes are inoperative, high-speed mode is OK.	**Table 4**
Wipers do not park in the proper position.	**Table 5**
Wipers stay on until ignition is turned off.	**Table 6**
Washers are inoperative.	**Table 7**
Washer spray does not correctly cover wipe area.	**Table 8**

Table 1, Troubleshooting Procedures

Wipers Are Inoperative In All Modes			
Step	**Test Procedure**	**Test Result**	**Action**
1	Turn the ignition switch to the ON position, and the wiper switch to low speed.	—	—

Troubleshooting

Wipers Are Inoperative In All Modes			
Step	**Test Procedure**	**Test Result**	**Action**
2	With the connector remaining connected, backprobe the wiper motor connector on pins A and C to measure for battery voltage; see **Table 9**. Is battery voltage present?	Yes	Make sure that the wiper linkage is not slipping or binding. Otherwise, replace the wiper motor; see **Subject 110**.
		Low or at zero	Go to **step 3**.
3	Verify that pin A of the wiper motor connector is at ground potential; see **Table 9**. Is pin A at ground potential?	Yes	Go to **step 4**.
		No	Repair the ground circuit.
4	Access the wiper switch (**Fig. 2**) connector, and backprobe pin 1 to measure the voltage, with the connector remaining connected to the module; see **Table 10**. Is battery voltage present on pin 1?	Yes	Go to **step 5**.
		Low or at zero	Check circuit breaker CB49 in the PDM. If the circuit breaker is open, determine if there is a shorted wire or component on circuit 315 that is drawing excess current.
5	With the ignition set to the ON position and the wipers switched to low speed, measure the voltage on pin 3 of the wiper switch connector. Is the measured voltage at or within a few tenths of a volt to ground?	Yes	Test for an open circuit through the speed switching relays R35 and R36. Troubleshoot circuits 315L and 315H from the PDM to the wiper motor.
		No	Replace the wiper switch.

Table 2, Wipers Are Inoperative In All Modes

High-Speed Mode Only Is Inoperative			
Step	**Test Procedure**	**Test Result**	**Action**
1	Turn the ignition switch to the ON position, and the wiper switch to high speed.	—	—
2	With the connector remaining connected, backprobe the wiper motor connector on pins A and B to measure for battery voltage; see **Table 9**. Is battery voltage present?	Yes	Make sure that the wiper linkage is not slipping or binding. Otherwise, replace the wiper motor; see **Subject 110**.
		Low or at zero	Go to **step 3**.
3	Access the wiper switch (**Fig. 2**) connector, and backprobe pin 4 to measure the voltage, with the connector remaining connected to the module, the ignition switch in the ON position, and the wipers set to high speed; see **Table 10**. Is the measured voltage at or within a few tenths of a volt to ground?	Yes	Test for an open circuit through relay R35 and its interconnecting wiring, including circuit 315H from the PDM to the wiper motor.
		No	Replace the wiper switch.

Table 3, High-Speed Mode Only Is Inoperative

Low Speed and All Intermittent Setting Modes Are Inoperative, High Speed Mode Is OK			
Step	**Test Procedure**	**Test Result**	**Action**
1	Turn the ignition switch to the ON position, and the wiper switch to low speed.	—	—

Low Speed and All Intermittent Setting Modes Are Inoperative, High Speed Mode Is OK			
Step	**Test Procedure**	**Test Result**	**Action**
2	With the connector remaining connected, backprobe the wiper motor connector on pins A and C to measure for battery voltage; see **Table 9**. Is battery voltage present?	Yes	Make sure that the wiper linkage is not slipping or binding. Otherwise, replace the wiper motor; see **Subject 110**.
		Low or at zero	Go to **step 3**.
3	Verify the voltage at pin A of the wiper motor connector. Is it at ground potential?	Yes	Go to **step 4**.
		No	Repair the ground circuit 320.
4	With the wiper switch (**Fig. 2**) remaining connected to the connector, the ignition switch in the ON position, and the wipers set to low speed, backprobe the wiper switch connector on pin 3 to measure for battery voltage; see **Table 10**. Is the measured voltage at or within a few tenths of a volt to ground?	Yes	Test for an open circuit through the speed switching relays R35 and R36, and the interconnected wiring. Troubleshoot circuit 315L from the PDM to the wiper motor.
		No	Replace the wiper switch.

Table 4, Low Speed and All Intermittent Setting Modes Are Inoperative, High Speed Mode Is OK

Wipers Do Not Park in Proper Position			
Step	**Test Procedure**	**Test Result**	**Action**
1	Turn the ignition switch to the ON position, and the wiper switch to low speed.	—	—
2	Turn the wiper switch off when the wipers are in mid-swipe. Do the wipers stop immediately, or continue traveling, then stop?	Immediately	Go to **step 3**.
		Continue traveling, then stop	Note the stopped position. Repeat the test to make sure that the wipers always stop in the same position. If the wipers always stop in the same position, regardless of where the switch was turned off, the linkage is improperly adjusted. Turn the ignition switch to OFF, disconnect the batteries, then adjust the wiper linkage to the correct position.
3	With the ignition switch in the ON position and the wipers switched off, measure the voltage on pin D of the wiper motor connector; see **Table 9**. Is battery voltage present?	Yes	Go to **step 4**.
		No	Locate and repair the open circuit on circuit 315C between the wiper motor and the PDM.
4	With the ignition in the ON position and the wipers switched to low speed, measure the voltage on pin F of the wiper motor connector; see **Table 9**. Battery voltage should be present except when the wipers travel through the park position and the circuit is momentarily at ground. Is battery voltage present?	Yes	Go to **step 5**.
		No	Replace the wiper motor; see **Subject 110**.

Troubleshooting

Wipers Do Not Park in Proper Position			
Step	**Test Procedure**	**Test Result**	**Action**
5	With the wipers switched on, measure the voltage at terminal 87A of relay R36. Is battery voltage present?	Yes	Test for an open R36 relay.
		No	Locate and repair the open circuit between relay R36 and the wiper motor in circuit 315P.

Table 5, Wipers Do Not Park in Proper Position

Wipers Stay On Until Ignition Is Turned Off			
Step	**Test Procedure**	**Test Result**	**Action**
1	Turn the ignition switch to the ON position. Leave the wiper switch in the OFF position. Do the wipers stay on at high speed or low speed?	High speed	Troubleshoot for circuit 315B shorted to ground, and for relay R35 shorted between terminals 87 and 30.
		Low speed	Go to **step 2**.
2	Backprobe pin F of the wiper motor connector to check the voltage through the wiper motor's internal park switch; see **Table 9**. When the wipers travel through the park position, pin F should be momentarily at ground. Most volt meters respond quickly enough to show this momentary voltage transition. Is the momentary voltage transition to ground present?	Yes	Troubleshoot and repair for circuit 315B shorted to ground, and for relay R36 shorted between terminals 87 and 30.
		No	The wiper motor internal park switch is not working. Replace the wiper motor; see **Subject 110**.

Table 6, Wipers Stay On Until Ignition Is Turned Off

Washers Are Inoperative			
Step	**Test Procedure**	**Test Result**	**Action**
1	Turn the ignition switch to the ON position, and the wiper switch to low speed. Do the wipers work?	Yes	Turn the wipers off. Go to **step 2**.
		No	Follow the troubleshooting procedure under "Wipers Are Inoperative In All Modes"; see **Table 2**.
2	Check the washer reservoir fluid level. Add fluid if needed, then test the washer operation. Hold the washer switch on for at least 5 seconds in case the hoses are leaking, or the system has lost its prime. Is the pump running?	Yes	Check the system for leaks. Also follow the troubleshooting procedure under "Washer Spray Does Not Correctly Cover Wipe Area"; see **Table 8**.
		No	Go to **step 3**.
3	If the system is not leaking, backprobe the connections at the washer pump, and test for battery voltage when the washer switch is activated; see **Table 11**. Is battery voltage present?	Yes	Replace the washer pump.
		No	Go to **step 4**.

Washers Are Inoperative			
Step	**Test Procedure**	**Test Result**	**Action**
4	With the wiper switch (**Fig. 2**) remaining connected to the connector, and the ignition switch in the ON position, backprobe pin 5 of the wiper switch to measure voltage; see **Table 10**. When the washers are activated, is the measured voltage at or within a few tenths of a volt to ground?	Yes	Troubleshoot for a wiring fault on circuit 320 between the wiper switch and the washer pump. Also troubleshoot circuit 315C to the washer pump.
		No	Replace the wiper switch.

Table 7, Washers Are Inoperative

Washer Spray Does Not Correctly Cover Wipe Area			
Step	**Test Procedure**	**Test Result**	**Action**
1	Make sure that the fluid level in the washer fluid reservoir is adequate. If needed, add fluid.	—	—
2	Test the washer operation. Hold the washer switch in the ON position for at least 5 seconds. Is the fluid flow adequate?	Yes	Troubleshooting is completed.
		No	Check the nozzles for damage, plugging, or improper installation. Check the hoses for kinks, or wire ties that may be too tight. Make sure that there are no breaks or disconnected fittings. Go to **step 3**.
3	Test the washer operation. Does the washer work properly?	Yes	Troubleshooting is completed.
		No	Replace the washer pump.

Table 8, Washer Spray Does Not Correctly Cover Wipe Area

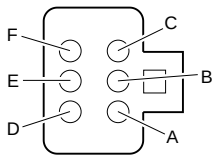
Terminal Identification of the Wiper Motor Harness Connector			
Wiper Motor Harness Connector	**Pin**	**Circuit Number**	**Circuit Description**
 f545385	A	GND	Ground
	B	315H	Wiper Motor High Speed
	C	315L	Wiper Motor Low Speed
	D	315C	Ignition Power
	E	—	Not used
	F	315P	Park Switch Signal

Table 9, Terminal Identification of the Wiper Motor Harness Connector

Troubleshooting

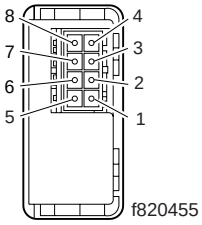
Terminal Identification of the Wiper/Washer Switch Connector			
Washer/Wiper Switch Connector	**Pin**	**Circuit Number**	**Circuit Description**
	1	315	Ignition Power
	2	29A	Backlighting
	3	315A	Wiper Motor Low Speed
	4	315B	Wiper Motor High Speed
	5	320	Washer Pump
	6	GND	Ground
	7	—	Not used
	8	—	Not used

Table 10, Terminal Identification of the Wiper/Washer Switch Connector

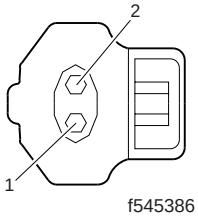
Terminal Identification of the Washer Pump Connector			
Washer Pump Connector	**Terminal**	**Circuit Number**	**Circuit Description**
	1	320	Washer Ground
	2	315C	Washer Power

Table 11, Terminal Identification of the Washer Pump Connector

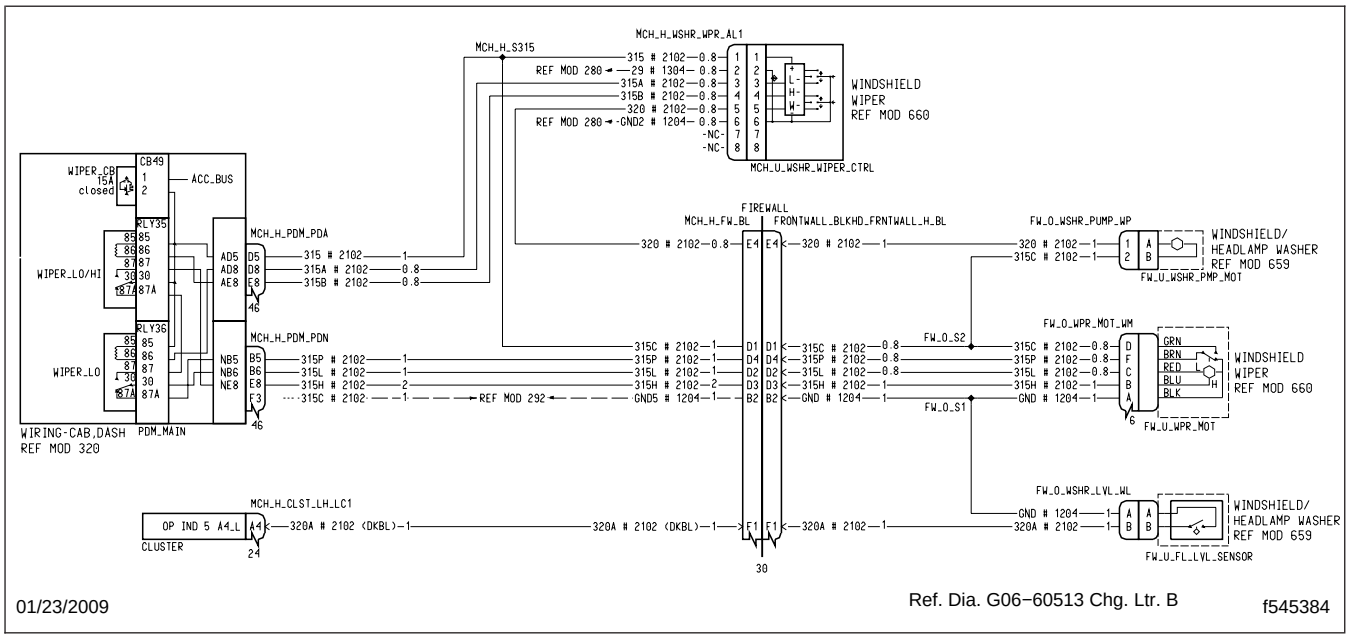
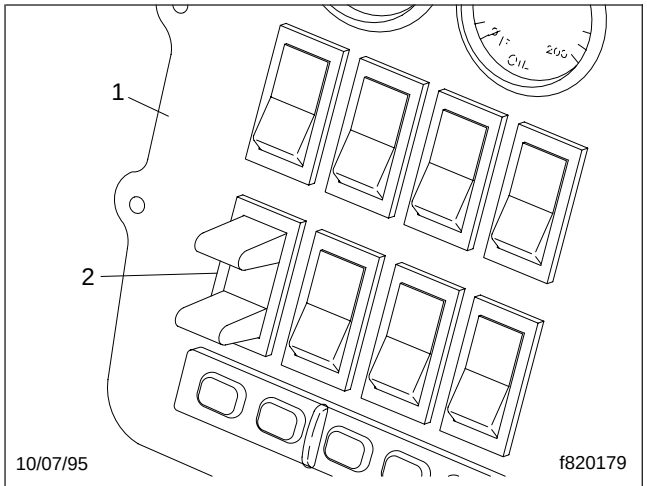


Fig. 1, Wiring Diagram, Wiper/Washer With a Dash-Mounted Switch



1. Auxiliary Instrument Panel
2. Wiper/Washer Switch

Fig. 2, Location of Dash-Mounted Wiper/Washer Switch

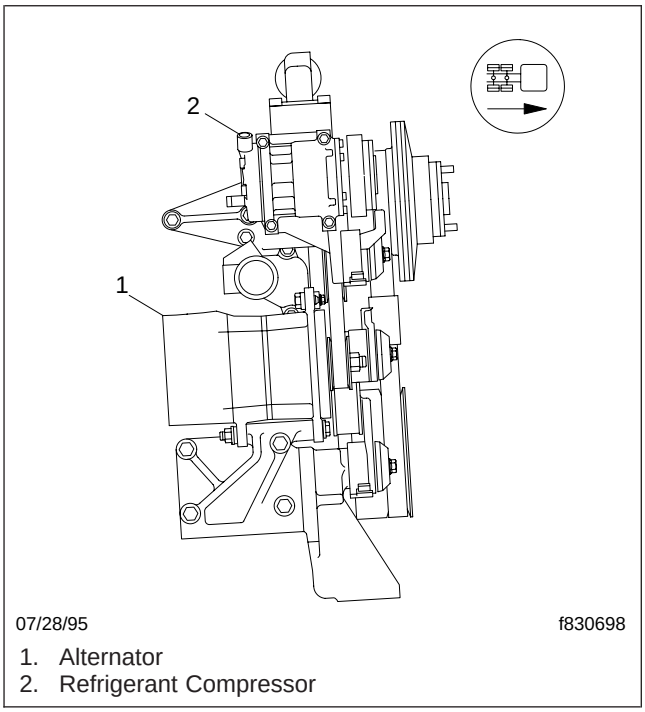
Specifications

Unless listed in **Table 1**, tighten all fasteners using the torque specifications found in **Section 00.05**.

Fastener Torque Values			
Description	**Size**	**Torque**	
		lbf·ft (N·m)	**lbf·in (N·cm)**
Motor Mounting Capscrews	M6	—	88 (1000)
Pivot Bracket Mounting Capscrews (Grade 5)	5/16–18	15 (20)	—
Washer Reservoir Mounting Screws (Grade 5)	5/16–18	15 (20)	—

Table 1, Fastener Torque Values

General Information



1. Alternator
2. Refrigerant Compressor

Fig. 1, Compressor Mounting

The Sanden SD7 Series compressor is installed on vehicles equipped with Detroit Diesel Series 55, Caterpillar C10 and C12, and Cummins ISX engines. See **Fig. 1**.

The main purpose of the refrigerant compressor is to draw refrigerant gas from the evaporator and squeeze it into high-pressure gas. High pressure raises the condensation point of refrigerant gas, which allows the condenser to change it to a liquid so that it can be used for cooling again. A second purpose of the compressor is to move refrigerant through the air conditioning system.

On vehicles built before April 16, 1999, the compressor is monitored by the Air Conditioning Protection Unit (ACPU), which consists of an electronic control module, high- and low-pressure switches, and a thermostatic switch.

During operation, the clutch is energized, engaging the compressor. When the cab temperature drops sufficiently, the ACPU system breaks the circuit to the compressor clutch, disengaging the clutch. See **Section 83.02** in this manual for more information on the ACPU system.

The control module registers fault codes that warn of existing or impending problems with the compressor and the air-conditioning system. For further information on system fault codes, see **Section 54.03** in this manual, which discusses the Instrumentation Control Unit. If ServicePro is available, consult the technician diagnostic routine covering the ACPU system.

Safety Precautions

Whenever repairs are made to any air conditioner parts that hold R–134a refrigerant, you must recover, purge or flush (if contaminated), evacuate, charge, and leak test the system. In a good system, refrigerant lines are always under pressure and you should disconnect them only after the refrigerant charge has been recovered (discharged) at the service valves.

Refrigerant R–134a is safe when used under the right conditions. Always wear safety goggles and non-leather gloves while recovering, evacuating, charging, and leak testing the system. Do not wear leather gloves; when refrigerant gas or liquid contacts leather, the leather will stick to your skin.

⚠ WARNING

WARNING: Use care to prevent refrigerant from touching your skin or eyes, because liquid refrigerant, when exposed to the air, quickly evaporates and will freeze skin or eye tissue. Serious injury or blindness could result if you come into contact with liquid refrigerant.

Refrigerant splashed in the eyes should be rinsed with lukewarm water, not hot or cold. Do not rub the eyes. Apply a light bandage and contact a physician right away.

Refrigerant splashed on the skin should be rinsed with lukewarm water, not hot or cold. Do not rub the skin. Apply a light coat of a nonmedicated ointment, such as petroleum jelly. Contact a physician right away.

R–134a refrigerant does not burn at ambient temperatures and atmospheric pressure. However, it can be combustible at pressures as low as 5.5 psig (139 kPa absolute) at 350°F (177°C) when mixed with air concentrations that are greater than 60 percent.

⚠ WARNING

WARNING: R–134a air conditioning systems should not be pressure tested or leak tested with compressed air. Combustible mixtures of air and R–134a may form, resulting in a fire or explosion, which could cause personal injury or property damage. R–134a may be safely pressured with dry nitrogen.

Always work in an area where there is a constant flow of fresh air when the system is recovered, evacuated, charged, and leak tested. R–134a vapors have a slightly sweet odor that is difficult to detect. Frequent leak checks and air monitoring equipment are recommended to ensure a safe working environment.

IMPORTANT: When servicing an R–134a air conditioning system, use only service equipment certified to meet the requirements of SAE J2210 (R–134a recycling equipment). The equipment should be operated only by qualified personnel who are familiar with the recycling station manufacturer's instructions.

Because of its very low boiling point, refrigerant must be stored under pressure. To prevent the refrigerant containers from exploding, never expose them to temperatures higher than 125°F (52°C).

On R–134a refrigerant systems, polyalkylene glycol (PAG) oil is used in the compressor. When handling PAG oil, observe the following:

- keep the oil free of contaminants
- do not expose the air conditioning system or the PAG oil container to air for long periods of time; PAG oil has a high moisture absorption capacity and the oil container should be immediately sealed after each use
- use care when handling: spilled oil could damage painted surfaces, plastic parts, and other components (drive belts)
- never mix PAG oil with other types of refrigerant oil

Pre-Service Checks

WARNING

WARNING: Before doing any work, read the information under Safety Precautions, 100. Failure to read the safety precautions, and to be aware of the dangers involved when working with refrigerant, could lead to serious personal injury.

Some special tools are needed for doing repair work on the compressor. Refer to the special tools table in **Specifications, 400.** Tool kits can be bought from the distributor listed under the special tools table in **Specifications, 400.**

NOTE: Compressor problems usually show in one of four ways: abnormal noise; seizure; leakage; or low suction and discharge pressures. Resonant compressor noises are not causes for alarm; irregular noise or rattles are likely to be caused by broken parts. To check for seizure, de-energize the magnetic clutch and see if the drive plate can be turned. If it won't turn, the compressor has seized.

Do the following checks whenever the air conditioner system is not cooling enough and the causes are unknown.

IMPORTANT: The Air Conditioning Protection Unit (APADS™) registers fault codes that warn of existing or impending problems with the compressor and the air conditioning system. For further information on system fault codes, refer to the section in **Group 54** in the vehicle service manual which discusses the Instrument Cluster Unit.

1. Be sure to check the moisture indicator, to see if moisture is the cause of the problems. The air conditioner should be on when checking the indicator; it is better to check it at the end of a day's run.
2. Check the drive belt and mounting:
   - 2.1 On the drive belt, look for wear, damage, or oil. If worn, oil-soaked, or damaged, remove it and install a new one. Refer to the drive belt section in **Group 01** of this manual for instructions.
   - 2.2 Check the compressor mounting parts for loose fasteners, cracks, or other damage. Tighten loose fasteners to the torque value in the torque specifications table under **Specifications, 400.** Repair or replace cracked or damaged brackets.
   - 2.3 Check the tension of the compressor drive belt. Refer to the drive belt section in **Group 01** of this manual for instructions.
   - 2.4 Check the compressor oil level. Refer to **Subject 130** for instructions.
3. Check the wiring and connections to the compressor clutch. Replace damaged wiring and tighten loose connections.
4. Check for road debris build-up on the condenser coil fins. Using air pressure and a whiskbroom or a solution of soap and water, carefully clean the condenser; be careful not to bend the fins.
5. Check the refrigerant charge in the air conditioner system; for instructions, refer to the section on the cab heater and air conditioner system in this group.
6. Check the valve plate and cylinder gasket **(Subject 160),** and the shaft seal **(Subject 150)** for damage. Replace as needed.

NOTE: For other possible causes of air conditioner problems, refer to the heater and air conditioner section in this group and to the applicable fan clutch section in **Group 20** of this manual.

Refrigerant Compressor Removal and Installation

Removal

WARNING

Before doing any of the work below, read the information under Safety Precautions 100. Failure to read the safety precautions and to be aware of the dangers involved when working with refrigerant, could lead to serious personal injury.

1. Park the vehicle on a level surface, turn off the engine, apply the parking brakes, and chock the tires.
2. Raise the hood, or on Argosy COEs, tilt the cab. For cab tilt instructions, see **Group 60**.
3. Begin recovery of the refrigerant from the air conditioning system; for instructions, see **Section 83.02, Subject 250**.
4. Remove the drive belt. Do not pry or roll the belt off the pulleys.
5. Disconnect the wiring harness from the compressor.
6. After the refrigerant has been fully recovered, disconnect the discharge and suction lines from the compressor. Cap the discharge and suctions ports and the refrigerant lines.

IMPORTANT: Under no circumstances should the ports on the compressor or the refrigerant lines remain uncapped for longer than five minutes. Water and dirt can damage the refrigerant system. Do not blow shop air through refrigerant lines since shop air is wet (humid).

7. Being careful not to spill any refrigerant oil, remove the capscrews and washers that attach the refrigerant compressor to the engine and remove the compressor.

Installation

IMPORTANT: A new compressor is filled with refrigerant oil and nitrogen gas. The oil quantity is printed on a label attached to the compressor.

When installing a new compressor on the vehicle, gently release the nitrogen gas from the discharge side of the compressor.

1. Adjust the refrigerant oil level in the compressor; for instructions, see **Subject 130**.
2. Install the compressor on the mounting bracket.
3. Uncap the discharge and suction ports and the refrigerant lines. Check the refrigerant lines and the discharge and suction ports. They must be clean and free of nicks, gasket residue, and other foreign material.
4. On refrigerant line connections that have threaded fittings, replace the O-rings in the fittings. Lubricate the O-rings with mineral oil before installing.

   On refrigerant line connections that have Mini Stat-O-Seals, replace the seals. **Do not** lubricate the Mini Stat-O-Seals prior to installation. Use only a Mini Stat-O-Seal on a Mini Stat-O-Seal assembly.
5. Connect the refrigerant lines to the compressor.
6. Connect the wiring harness to the compressor.
7. Install the drive belt.
8. If installing a new compressor, or if the system was without any refrigerant pressure before repairs were started, replace the receiver-drier; for instructions, see **Section 83.02, Subject 200**.
9. Evacuate, charge, and leak test the refrigerant system; for instructions, see **Section 83.02, Subject 250**.
10. Return the hood or cab to the operating position. For cab tilt instructions, see **Group 60**.

Oil Check and Adding Oil to the Compressor

WARNING

Before doing any of the work below, read the information under Safety Precautions 100. Failure to read the safety precautions and to be aware of the dangers involved when working with refrigerant, could lead to serious personal injury.

General Information

Compressors are charged with 10 fl oz (296 mL) of refrigerant oil. When the air conditioning system is operating, some refrigerant oil leaves the compressor and is circulated through the system with the refrigerant, but the refrigerant oil cannot leave the system except when there is a leak, when the refrigerant is recovered, or when a system part is replaced.

It is important that the air conditioning system has the correct amount of refrigerant oil for proper operation. Too little oil will result in compressor failure. Too much oil will degrade the performance of the air conditioner and may cause damage to the compressor.

IMPORTANT: Whenever the air conditioning system is discharged or recovered, the recovered oil, from the charging machine, must be measured in order to know how much oil must be returned to the system. When a system component is replaced, a quantity of new oil equal to the recovered oil plus the oil coating the inside of the component must be returned to the system. New oil must be from a container that has not been opened or that has been tightly sealed since its last use.

Order Sanden PAG oil SKI 7803 1997 (type SP–20) for an 8.45-ounce (250-mL) can of refrigerant oil from your local Daimler Trucks North America Parts Distribution Center. Tubing, funnels, or other equipment used to transfer the oil should be very clean and dry.

When handling refrigerant oil:

- Be sure that the oil is free of water, dust, metal powder, and other foreign substances;
- Do not mix the refrigerant oil with other types or viscosities of oil;
- Quickly seal the oil container after use. Refrigerant oil absorbs moisture when exposed to the air for any period of time.

Checking and Adding Refrigerant Oil

WARNING

Do not remove the oil fill plug on the refrigerant compressor without first recovering the system. Failure to recover the system could cause uncontrolled release of high-pressure refrigerant, which can freeze skin and eye tissue causing serious injury or blindness.

1. Before beginning the refrigerant recovery process, make sure that the oil accumulator and oil drain bottle on the recovery/recycle machine are emptied of oil from previous repairs.
2. Recover all of the refrigerant from the system. For instructions, see **Section 83.04, Subject 220**.
3. Drain the recovered oil into the calibrated drain bottle of the recovery/recycle machine. Record the amount of oil recovered.
4. Inspect the refrigerant oil. If the oil has any of the following characteristics, flush and charge the system with 10 fl oz (296 mL) of oil.
   - silver or black oil—indicates metal in the air conditioning system due to compressor wear
   - milky oil—may indicate moisture in the system
   - grit or debris in the oil
5. Properly dispose of the recovered oil.
6. After repairs are finished, refer to **Table 1** and use the following equation to determine the quantity of refrigerant oil that needs to be added to the system.

   [Quantity Recovered] + [Quantity for All Replaced Components] = [Quantity to add to the System]

   Table 1 provides the quantities of oil that need to be added to the system for each component that was replaced. Add the quantities listed in the table for each component that was replaced. Use the sum of the quantities or 6 fl oz (177 mL), whichever is less.

Oil Check and Adding Oil to the Compressor

Refrigerant Oil Quantities for Replaced Components	
Add the quantities listed in this table for each component that was replaced. Use the sum of the quantities or 6 fl oz (177 mL), whichever is less.	
Component	**Quantity: oz (mL)**
High Pressure Line (main A/C)	1 (30)
Low Pressure Line (main A/C)	2 (59)
High Pressure Line (auxiliary A/C)	1 (30)
Low Pressure Line (auxiliary A/C)	3 (89)
Condenser	1 (30)
Evaporator (main A/C)	3 (89)
Evaporator (auxiliary A/C)	2 (59)
Receiver-Drier	3 (89)
Minor Leak at Connector Only	0.5 (15)
Major Leak at Connector Only	2 (59)

Table 1, Refrigerant Oil Quantities for Replaced Components

7. Remove the oil fill plug on the refrigerant compressor and add the refrigerant oil. Never add more than 8 fl oz (237 mL) to the system unless the system has been flushed.
8. Evacuate, charge, and leak test the refrigerant system. See **Section 83.04, Subject 220** for instructions.

Adjusting the Refrigerant Oil Level in a New Compressor

Sanden refrigerant compressors are charged with 10 fl oz (296 mL) of refrigerant oil. If the air conditioning system has been flushed, the compressor will need a 10-ounce charge. If the system has not been flushed, use the following procedure to adjust the oil level in the compressor.

Use the "Worksheet for Adjusting the Refrigerant Oil Level in a New Compressor" shown in **Fig. 1** to adjust the refrigerant oil level in a new compressor.

Worksheet for Adjusting the Refrigerant Oil Level in a New Compressor

1. Drain the oil from the old compressor.
   - 1.1 Remove the oil plug and drain as much oil as possible into a clean, calibrated container.
   - 1.2 If there are caps on the suction and discharge ports, remove them.
   - 1.3 Drain the oil from the suction and discharge ports into the container while turning the shaft clockwise using a socket wrench on the armature retaining nut.
   - 1.4 Enter the amount of oil that was drained from the compressor. 1. ☐
2. See Table 1 of this subject to determine the total amount of refrigerant oil that is needed for each component that was replaced. Enter the amount, up to 6 fl oz (177 mL), here. 2. ☐
3. Add the amounts from steps 1 and 2 and enter the total. 3. ☐
4. Subtract the total in step 3 from 10 and enter that number. For example, if the total in line 3 was six, the calculation would be 10 − 6 = 4. 4. ☐
5. Refer to the table below for the amount of oil that must be drained from the new compressor.

If the number in step 4 is:	Drain this amount from the new compressor:
a negative number(−)	2 fl oz (59 mL)
0	2 fl oz (59 mL)
1	2 fl oz (59 mL)
2	2 fl oz (59 mL)
3	3 fl oz (89 mL)
4	4 fl oz (118 mL)
5	4 fl oz (118 mL)
6	4 fl oz (118 mL)
7	4 fl oz (118 mL)
8	4 fl oz (118 mL)
9	4 fl oz (118 mL)
10	4 fl oz (118 mL)

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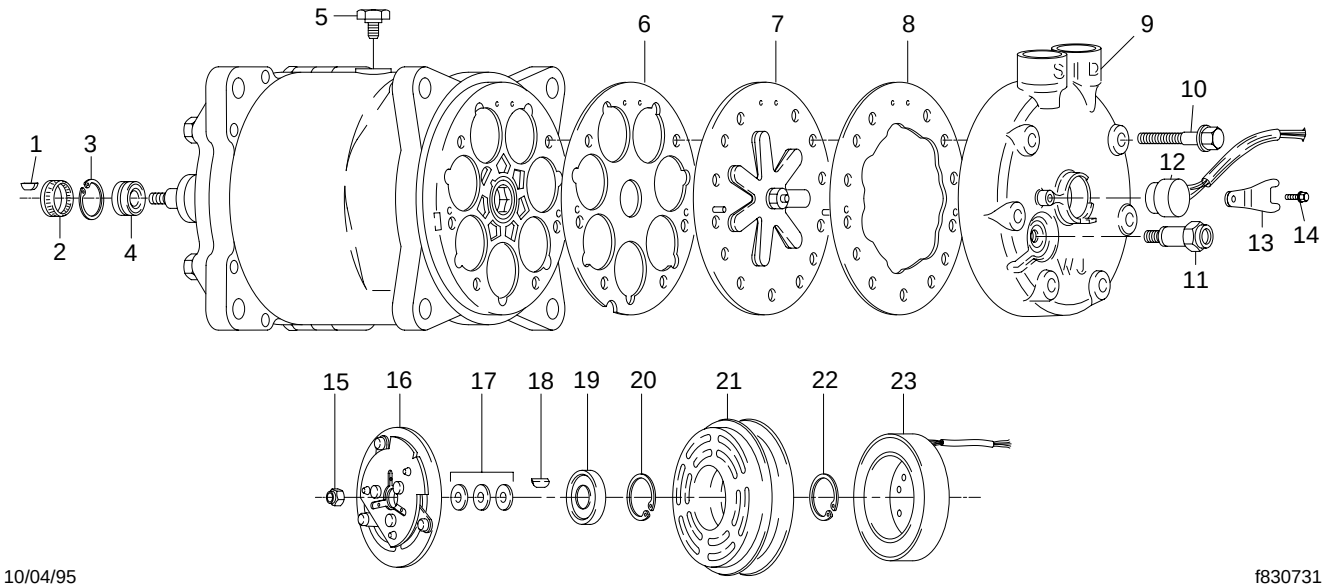
Fig. 1, Worksheet for Adjusting the Refrigerant Oil Level in a New Compressor

Clutch Assembly Removal, Inspection, and Installation

Removal (See Fig. 1)

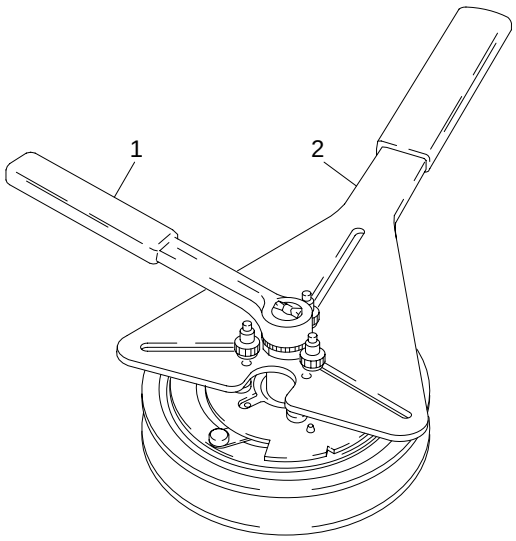


1. Shaft Key
2. Felt Ring
3. Shaft Seal Snap Ring
4. Shaft Seal (with O-ring)
5. Oil Plug
6. Block Gasket
7. Valve Plate Assembly
8. Head Gasket
9. Cylinder Head
10. Cylinder Head Bolt
11. Pressure Relief Valve
12. Thermal Protector Switch, TPS (optional)
13. TPS Clip (optional)
14. TPS Screw (optional)
15. Shaft Nut
16. Drive Plate
17. Clutch Shims
18. Shaft Key
19. Pulley Bearing Dust Cover
20. Pulley Snap Ring
21. Pulley Assembly
22. Field Coil Assembly Snap Ring
23. Field Coil Assembly

Fig. 1, Refrigerant Compressor (exploded view)

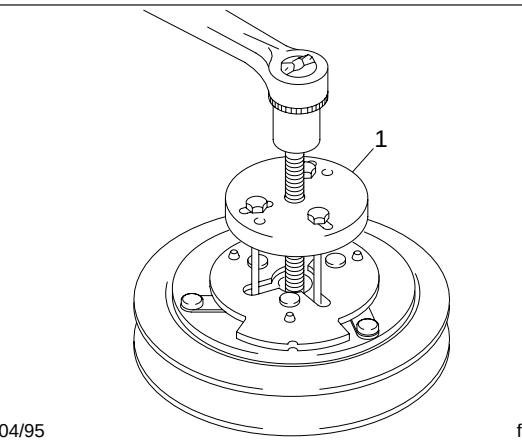
1. Remove the compressor from the vehicle. For instructions, refer to **Subject 120.**
2. Remove the six bolts that attach the drive plate cover and remove the cover.
3. Insert the pins of the drive plate spanner into the threaded holes of the drive plate. Hold the drive plate securely while removing the retaining nut. **See Fig. 2 .**
4. Using the drive-plate puller, thread the three puller bolts into the drive plate. Turn the center screw clockwise to loosen and remove the drive plate. **See Fig. 3.**
5. Remove the pulley bearing dust cover (if equipped), the shaft key, and the clutch shims. Use a slotted screwdriver and hammer to tap the shaft key loose. **See Fig. 4 .**
6. Using external snap-ring pliers, remove the pulley assembly snap ring.
7. Remove the pulley assembly.
   - 7.1 Insert the lip of the pulley puller jaws into the snap ring groove. **See Fig. 5.**
   - 7.2 Place the puller shaft protector over the exposed shaft.
   - 7.3 Align the thumb screws to the puller jaws. Tighten the screws finger tight.
   - 7.4 Using a socket wrench, turn the puller center bolt clockwise and remove the pulley.
8. Remove the coil assembly.
   - 8.1 Remove the coil's lead wire from the wire holder on the compressor.

Clutch Assembly Removal, Inspection, and Installation



1. Socket Wrench
2. Drive Plate Spanner

Fig. 2, Remove the Retaining Nut



1. Puller

Fig. 3, Remove the Drive Plate

8.2 Disconnect the wiring harness.

8.3 Remove the snap ring **Fig. 6**; then, remove the coil assembly.

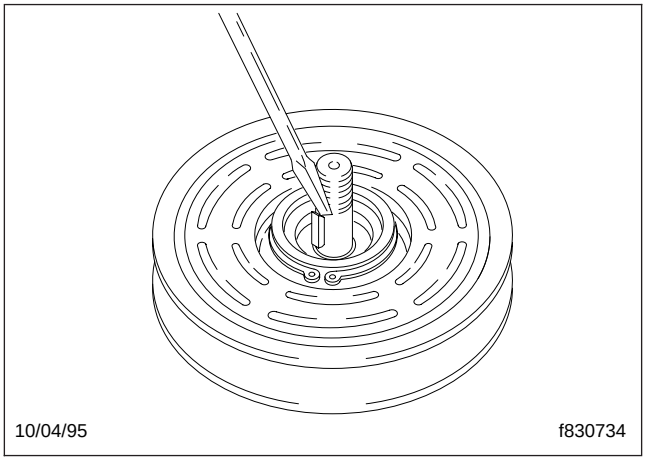
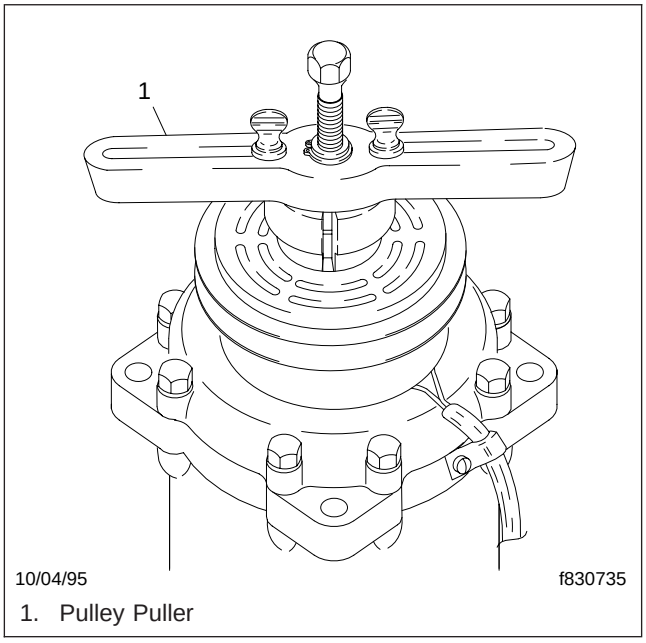


Fig. 4, Remove the Shaft Key



1. Pulley Puller

Fig. 5, Position the Pulley Puller Jaws

Inspection

1. Inspect the drive plate. If the frictional surface shows signs of damage due to too much heat, replace the drive plate and pulley assembly.
2. Check the appearance of the pulley assembly. If the friction surface of the pulley shows signs of too much grooving due to slippage, replace both the pulley and drive plate. Clean the friction surfaces of the pulley assembly before installing it.

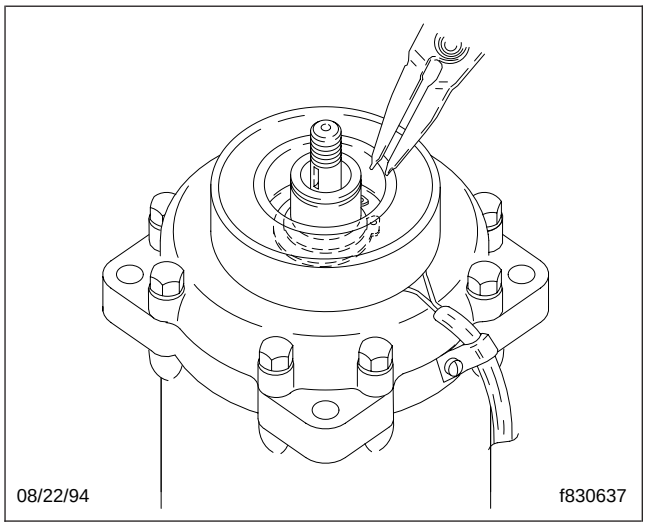


Fig. 6, Remove the Snap Ring

3. Check the coil for a loose connector and for cracked insulation. Replace it if necessary.

Installation

NOTE: When supporting the compressor in a vise, clamp only on the mounting ears, never on the body of the compressor.

1. Install the coil assembly.
   - 1.1 Position the coil assembly on the compressor.
   - 1.2 Install the snap ring.
   - 1.3 Attach the coil's lead wire to the wire holder on the compressor.
   - 1.4 Connect the wiring harness.
2. Install the pulley assembly.
   - 2.1 Position the pulley over the boss of the front housing.
   - 2.2 Place the pulley installer ring into the bearing bore. Make sure that the edge rests only on the inner race of the bearing, not on the seal, pulley, or outer race of the bearing.
   - 2.3 Place the driver into the ring. Using a hammer or arbor press, drive the pulley down against the front housing step. **See Fig. 7.**

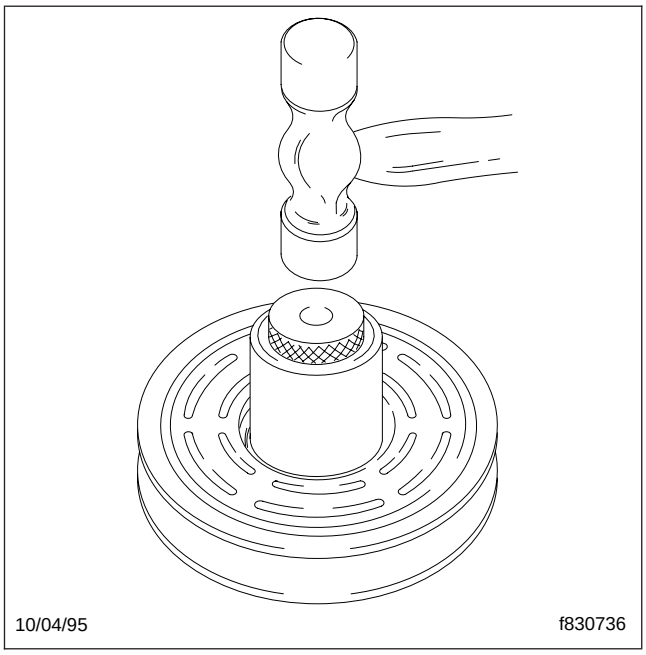


Fig. 7, Drive the Pulley Down Against the Front Housing Step.

   - 2.4 Using internal snap ring pliers, install the pulley bearing snap ring.
   - 2.5 Using external snap ring pliers, install the pulley snap ring. If a bevel is present on the snap ring, make sure that it is facing up (away from the body of the compressor).
   - 2.6 Install the pulley bearing dust cover by gently tapping it into place.
3. Install the drive plate assembly.
   - 3.1 Using pliers, install the shaft key. **See Fig. 8.**
   - 3.2 Install the shims.
   - 3.3 Align the keyway in the drive plate assembly with the shaft key. Using a driver, and a hammer or an arbor press, drive the assembly down over the shaft until it bottoms on the shims. **See Fig. 9.**
   - 3.4 Install the retaining nut. Tighten the nut to the torque in **Specifications, 400.**
4. Using a feeler gauge, check that the clutch clearance is 0.02 to 0.03 inch (0.4 to 0.8 mm). **See Fig. 10**. Adjust the clearance by gently tap-

Clutch Assembly Removal, Inspection, and Installation

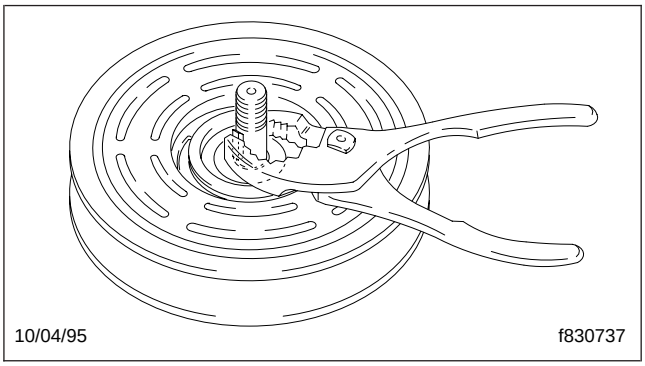


Fig. 8, Install the Shaft Key

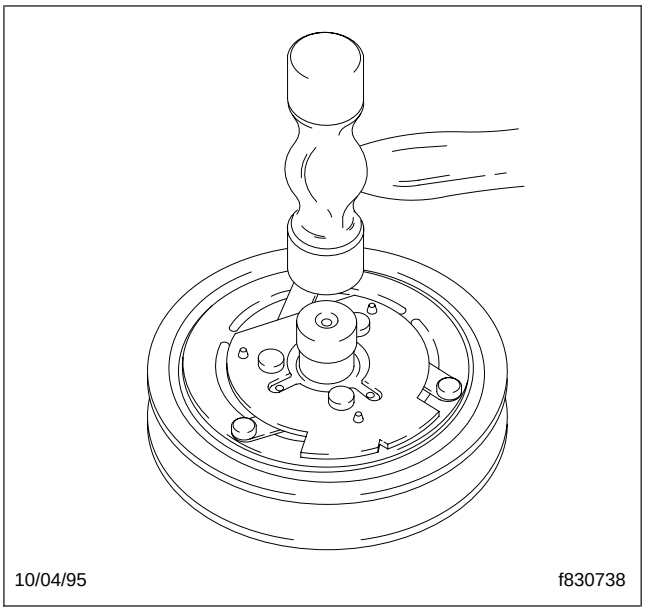


Fig. 9, Install the Drive Plate Assembly

ping down on the front plate at the high spots, or gently prying up at the low spots.

5. Install the drive plate dust cover. Tighten the bolts to the torque in **Specifications, 400.**
6. Install the compressor on the vehicle. For instructions, refer to **Subject 120.**

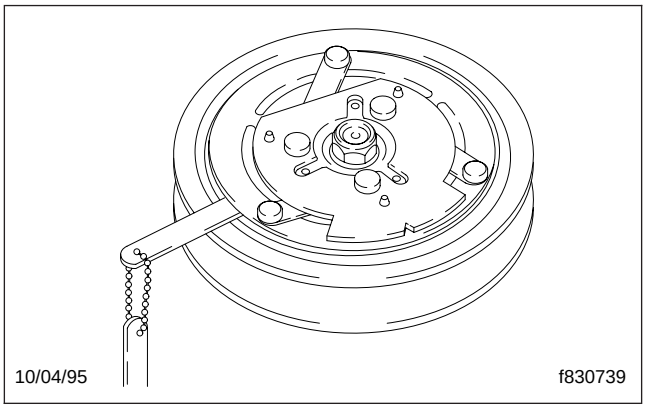


Fig. 10, Check the Clutch Clearance

Replacement

1. Remove the drive plate and pulley assemblies. For instructions, refer to **Subject 140.**
2. Using snap ring pliers, remove the felt ring retainer. **See Fig. 1.** Then remove the felt ring.

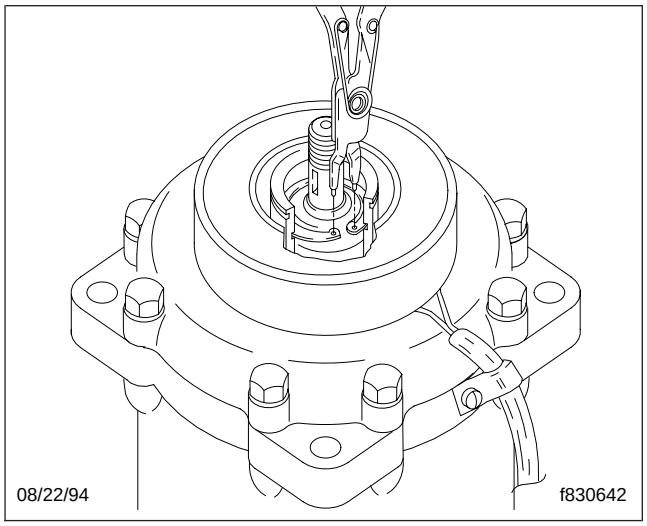
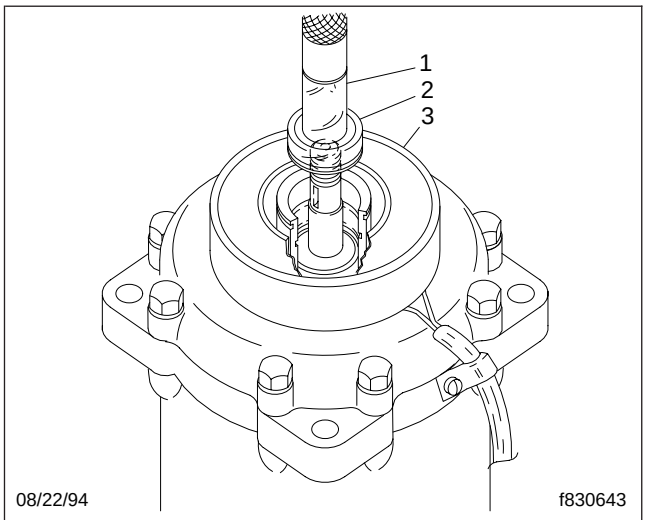


Fig. 1, Remove the Felt Ring Retainer and the Felt Ring

3. Using snap ring pliers, remove the shaft seal snap ring.
4. Position the shaft seal removal and installation tool on the shaft seal. Twist the tool until the hooks on the tool engage the slots in the shaft seal housing, then pull the seal out with a twisting motion. **See Fig. 2.**

NOTE: The shaft seal and felt ring should not be reused. Always use a new seal kit. Be very careful that the lip of the shaft seal to be installed is not scratched or damaged in any way. Make sure the shaft seal is free of lint and dirt, which could damage the shaft seal surface.

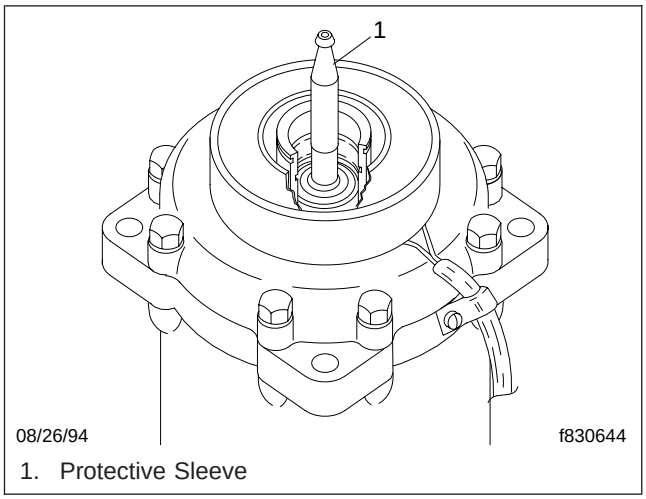
5. Using a non-petroleum based solvent and a lint-free cloth, clean the shaft seal cavity. Then, use dry compressed air to blow out the shaft seal cavity.
6. Position the shaft seal protective sleeve over the compressor shaft. **See Fig. 3** . Make sure that the sleeve has no scratches so that the shaft seal will not be damaged. Also, make sure that



1. Shaft Seal Removal and Installation Tool
2. Shaft Seal
3. Coil Assembly

Fig. 2, Remove the Shaft Seal

there is no gap between the end of the sleeve and the seal surface of the shaft.



1. Protective Sleeve

Fig. 3, Position the Shaft Seal Protective Sleeve

7. Position the shaft seal removal and installation tool until the hooks on the tool engage the slots in the new shaft seal housing.
8. Place the entire assembly into clean 5GS refrigerant oil. **See Fig. 4.**
9. Insert the shaft seal over the protective sleeve, then press it down as far as possible. Twist the

Shaft Seal Replacement

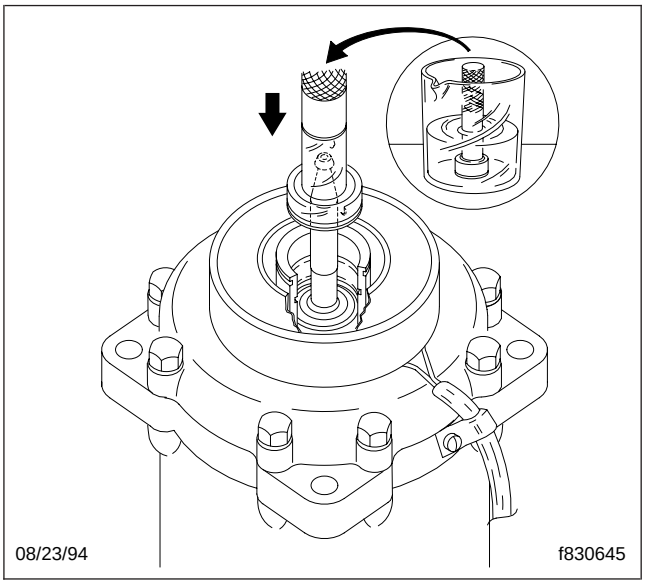


Fig. 4, Place the Shaft Seal Assembly into Clean Refrigerant Oil

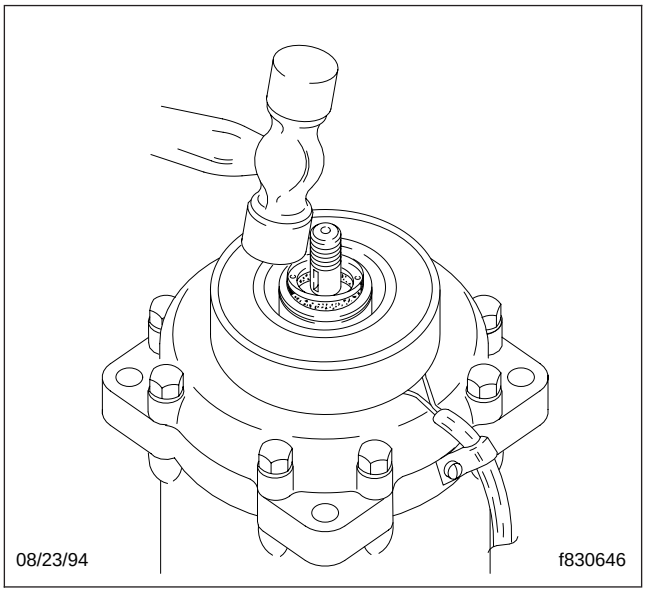


Fig. 5, Tap the New Felt Ring in Place

removal and installation tool to remove it from the seal. Remove the tool and the protective sleeve.

10. Using internal snap-ring pliers, install the snap ring. **See Fig. 1.** If needed, gently tap the snap ring to ensure that it is seated in the groove.

NOTE: When installing the snap ring, the beveled end of the snap ring must face away from the compressor body.

11. Gently tap the new felt ring in place. **See Fig. 5.**
12. Install the drive plate and pulley assemblies. For instructions, refer to **Subject 140.**

Removal

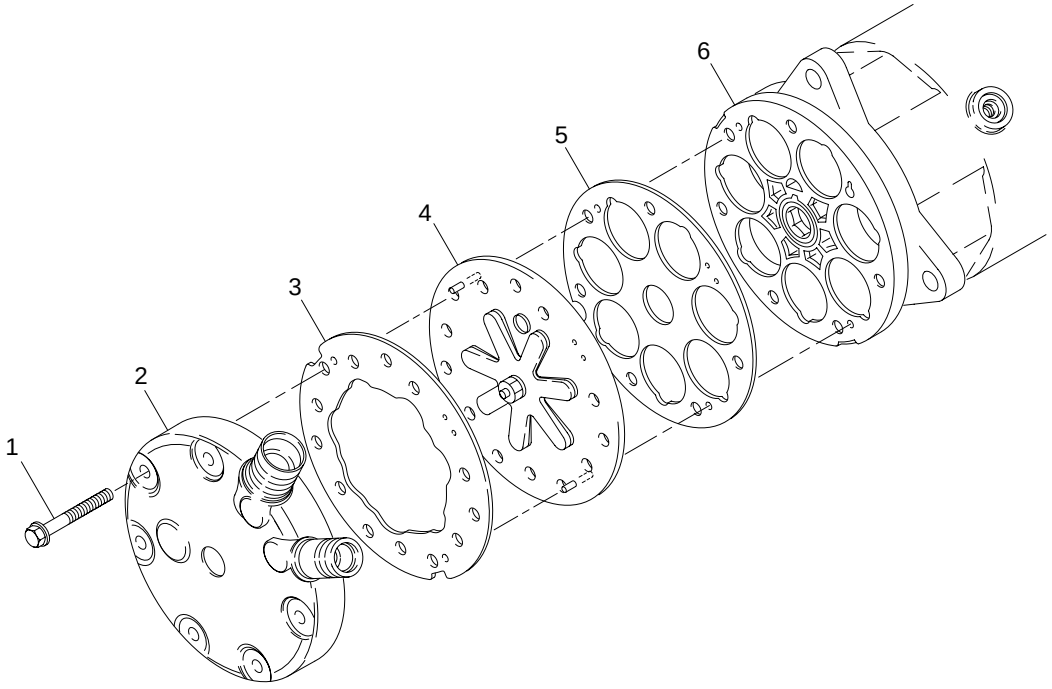
NOTE: Before doing any work on the head and valve plate, open both service valves to release any gas pressure in the compressor.

1. Remove the bolts from the cylinder head. **See Fig. 1.**

⚠ CAUTION

CAUTION: Do not hit or tap the head to separate it from the valve plate. Damage to the head may result.

NOTE: It is recommended that the head gasket (located between the cylinder head and the valve plate) and the block gasket (located between the valve plate and the cylinder block) be replaced any time the cylinder head is removed.



1. Cylinder Head Bolt
2. Cylinder Head
3. Head Gasket
4. Valve Plate Assembly
5. Block Gasket
6. Compressor Body

Fig. 1, Head and Valve Plate Assembly

2. Remove the valve plate assembly and the cylinder head from the compressor. Use a gasket scraper to separate the cylinder head from the valve plate. **See Fig. 2**. Use care not to scratch the gasket surface of the cylinder head.
3. Being careful not to scratch or nick the machined sealing surfaces, remove all gasket material adhering to the head, valve plate, or compressor block.

Head and Valve Plate Removal and Installation

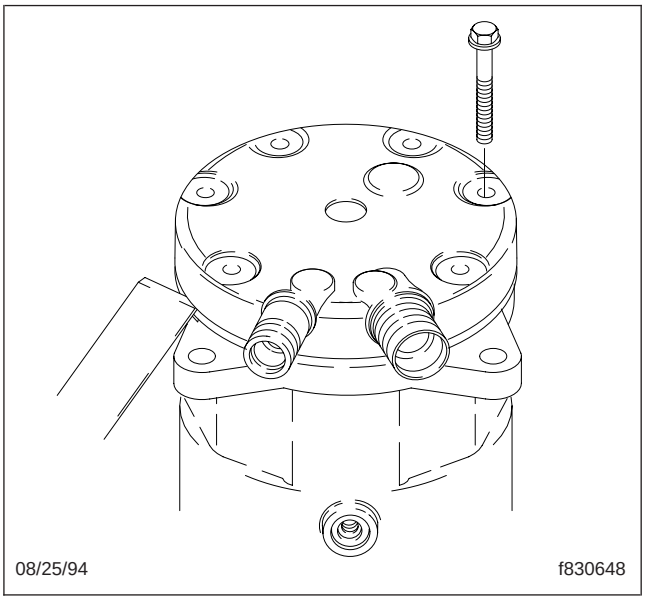


Fig. 2, Separate the Cylinder Head from the Valve Plate

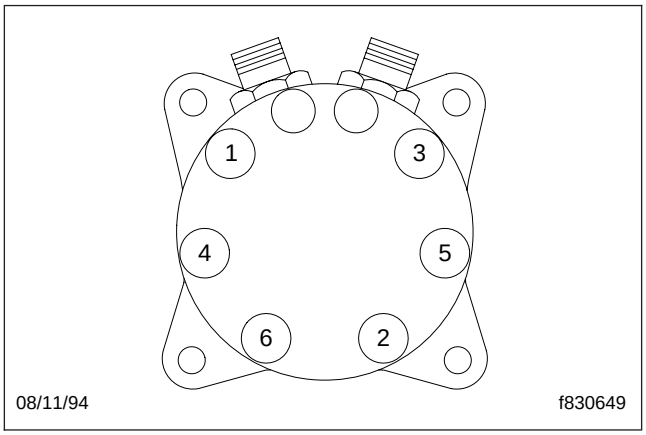


Fig. 3, Tightening Sequence

Installation

1. Apply a thin film of clean 5GS refrigerant oil to the new block gasket. Place the block gasket in position on the compressor so that the pin holes in the compressor block line up with the pin holes in the block gasket.
2. Place the valve plate assembly in position on the block gasket so that the discharge valve, retainer, and the nut are facing up (away from the cylinder block). Make sure that the locating pins on the valve plate go through the pin holes in the gasket.
3. Remove all residual oil from each bolt hole on the cylinder block.
4. Apply a thin film of clean 5GS refrigerant oil to the new head gasket. Place the gasket in position over the valve plate locating pins. Make sure that the locating pins on the valve plate go through the pin holes in the gasket.
5. Place the head on the cylinder head gasket so that the dowel pins go into the dowel pin holes in the head.
6. Install the head bolts. Tighten the bolts in sequence to the values given in **Specifications 400. See Fig. 3** for the tightening sequence.

Special tools can be purchased from the following independent suppliers:

Classic Tool Design
31 Walnut St.
New Windsor, NY 12550
(914)–562–8700

Mastercool USA Inc.
216 Route 10, Bldg. 3
Randolph, NJ 07869
(201)–366–1101

Torque Values		
Description	**Torque**	
	lbf·in (N·cm)	**lbf·ft (N·m)**
Adjusting Rod Jam Nut	—	140 (190)
Compressor Mounting Fasteners	—	20 to 25 (27 to 34)
Clutch Retaining Nut (1/2")	—	22 (30)
Clutch Retaining Nut (M8)	—	13 (18)
Oil Drain Plug	—	15 (20)
Cylinder Head Bolts, M6	—	10 (14)
Cylinder Head Bolts, M8	—	25 (34)
Pressure Relief Valve	11 (120)	—
Dust Cover Screws, M5	78 (880)	—
Clutch Lead Wire Clamp Screw	132 (1500)	—
Rotalock Valve	—	27 (37)

Table 1, Torque Values

SlimLine Seal Assembly Bolt Torques	
HVAC Component	**Torque**
A/C Compressor	11 to 15 lbf·ft (15 to 20 N·m)
Condenser	11 to 15 lbf·ft (15 to 20 N·m)
Receiver-Drier	11 to 15 lbf·ft (15 to 20 N·m)
Thermal Expansion Valve	11 to 15 lbf·ft (15 to 20 N·m)
Evaporator	11 to 15 lbf·ft (15 to 20 N·m)
Junction Block	11 to 15 lbf·ft (15 to 20 N·m)

Table 2, SlimLine Seal Assembly Bolt Torques

O-Ring Fitting Torques	
Hose Size	**Torque**
#6	20–25 lbf·ft (27–34 N·m)
#8	30–35 lbf·ft (41–47 N·m)
#10/12	35–40 lbf·ft (47–54 N·m)

Specifications

O-Ring Fitting Torques	
Hose Size	**Torque**
One-Inch Fittings on Compressor	21–27 lbf·ft (28–37 N·m)

Table 3, O-Ring Fitting Torques

General Information

The heating and air conditioning unit is mounted behind the dash. It consists of a heater core, evaporator, blower motor, control valves, and air ducts. The system is controlled by a dash-mounted climate control panel. See **Fig. 1**. The panel controls heating, air conditioning, defrosting, and ventilation of the cab. By regulating the following things, an even cab temperature is maintained:

- Fresh air intake.
- Speed of the blower motor.
- Coolant flow through the heater core.
- Refrigerant flow through the evaporator.

See the vehicle driver's manual for heater and air conditioner operating instructions.

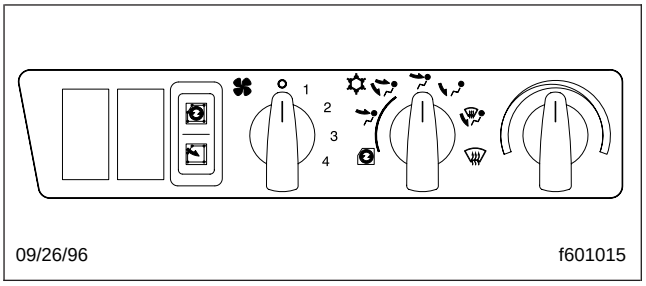


Fig. 1, Climate Control Panel

Thermodynamic Principles

Air conditioning is the cooling (or refrigeration) of the air in the passenger compartment. Refrigeration is accomplished by making practical use of three thermodynamic principles. These principles and their practical application are described below.

Heat Transfer

If two objects of different temperatures are placed near each other, the heat in the warmer object will always travel to the cooler object, until both are of equal temperature.

For example, a block of ice in a refrigerator does not transfer its coldness to a nearby warm container. Instead, the heat in the warm container flows to the ice.

The British Thermal Unit (BTU) is used to determine the amount of heat transferred from one object to another. One BTU is the amount of heat required to raise the temperature of 1 pound (0.45 kg) of water 1°F (0.55°C).

For example, to raise the temperature of 1 pound (0.45 kg) of water from 32°F to 212°F (0°C to 100°C), one BTU of heat must be added for 1°F (0.55°C) rise in temperature, or a total of 180 BTUs of heat. Conversely, in order to lower the temperature of 1 pound (0.45 kg) of water from 212°F to 32°F (100°C to 0°C), 180 BTUs of heat must be removed from the water.

Latent Heat of Vaporization

When a liquid boils, it absorbs heat without raising the temperature of the resulting gas. When the gas condenses (changes back to a liquid), it gives off heat without lowering the temperature of the resulting liquid.

For example, when a container holding 1 pound (0.45 kg) of water at 32°F (0°C) is heated, the temperature of the water rises 1°F (0.55°C) with each BTU of heat energy that the water absorbs. After it absorbs 180 BTUs of heat, raising its temperature 180°F (100°C), the water reaches a temperature of 212°F (100°C). This is the boiling point of water at standard sea level conditions.

Even as more heat is absorbed by the water, the temperature of the water can not go above 212°F (100°C). The water starts to boil, to change from a liquid to a gas. It continues to boil until the water has passed off into the atmosphere as vapor. Under normal conditions the vapor rapidly gives off its heat to the surrounding air, but it rises from the water at a temperature of 212°F (100°C).

In other words, the water and vapor temperatures can rise only 180°F (from 32°F to 212°F [0°C to 100°C]) at sea level pressure, even though many more than 180 BTUs of heat are absorbed. The heat absorbed by the liquid in the process of boiling dissipates from the vapor into the surrounding air, and the vapor condenses back to water.

The transfer of heat as substances change their physical state, such as water boiling to vapor, and vapor condensing back to water, is called the latent (hidden) heat of vaporization.

Water has a latent heat of vaporization of 970 BTUs and a boiling point of 212°F (100°C). This means that 1 pound (0.45 kg) of water at 212°F (100°C), will

General Information

absorb 970 BTUs of heat when changing to vapor at 212°F (100°C). Conversely, the vapor will give off 970 BTUs of heat when condensing back to water at 212°F (100°C).

This heat energy transfer, occurring when a liquid boils or a vapor condenses, forms the basic principle of all conventional refrigerant systems.

For a liquid to be a refrigerant, it must also have a low boiling point. That is, the temperature at which it boils must be lower than the temperature of the substance to be cooled.

R–134a is a non-CFC refrigerant. Its temperature/pressure relationship makes it suitable for mobile air conditioning systems.

Effect of Pressure on Boiling or Condensation

Refrigerant passes through an air conditioning system under high-pressure conditions. It expands to a low-pressure vapor between the evaporator orifice and the refrigerant return port in the refrigerant compressor. As pressures in the closed refrigerant circuit vary, the temperature of the refrigerant also varies. As pressure increases, temperatures increase; as the pressure decreases, temperatures also decrease:

- First, as a high-pressure vapor between the refrigerant compressor and the condenser
- Then, as a high-pressure liquid between the condenser and the evaporator orifice.

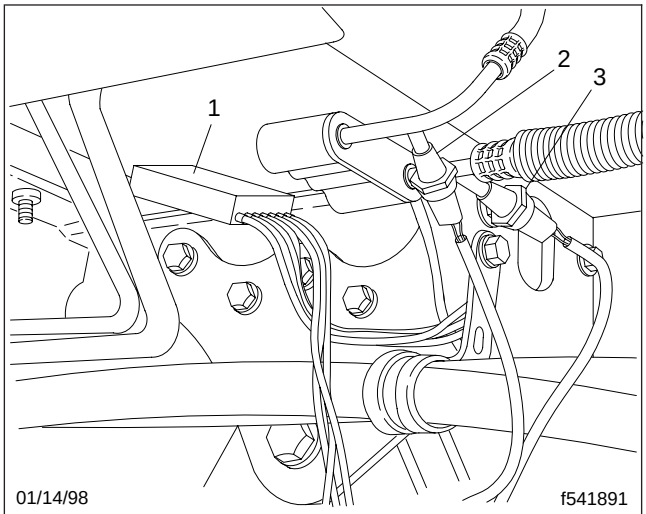
Description of Components

Air Conditioning Protection Unit (ACPU)

The ACPU is installed on vehicles built before April 16, 1999.

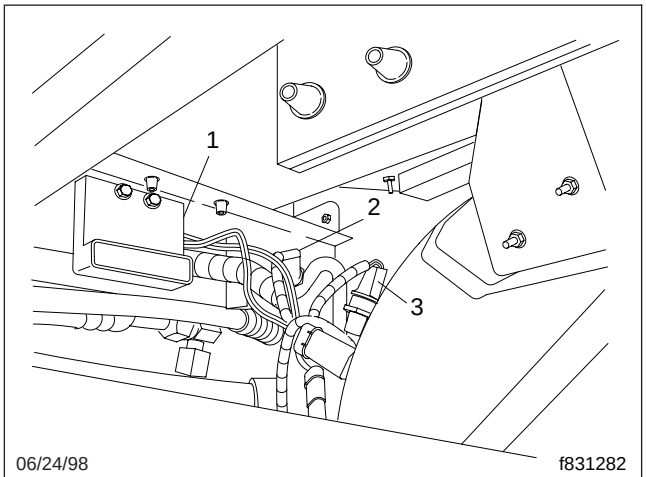
The ACPU system consists of an electronic control module, high and low-pressure switches, and the thermostatic switch. The control module monitors system conditions (low or high refrigerant charge), and controls the operation of the refrigerant compressor and the on-off fan drive. See Principles of Operation for more information on this system.

On a Century Class Conventional, the ACPU control module is located under the hood on the right side of the frontwall. See **Fig. 2**. On an Argosy COE, the ACPU control module is located on the right side of the vehicle behind the bumper. See **Fig. 3**.



1. ACPU Control Module
2. high-pressure Switch
3. low-pressure Switch

Fig. 2, ACPU Mounting, Century Class Conventional



1. ACPU Control Module
2. low-pressure Switch
3. high-pressure Switch

Fig. 3, ACPU Mounting, Argosy COE

The control module registers fault codes that warn of existing or impending problems in the air conditioning system. The control module displays these fault

codes on the Instrumentation Control Unit (ICU) message display screen.

For further information on system fault codes, see **Troubleshooting 300**. Also, if ServicePro is available, a technician diagnostic routine is available covering the ACPU system.

CAUTION

Before performing any electric welding on a vehicle, disconnect the battery power, ground cables, and the ACPU. Electric currents produced during electric welding can damage various electric components on the vehicle.

At the high and low pressure switches at the discharge and suction service ports, disconnect the harness connectors. See Subject 210 in this section for instructions.

The air conditioning protection unit (ACPU) is a micro controller-based device used to control the air conditioning system and help in diagnosing air conditioning system problems. It uses the vehicle's J1587 serial data bus to communicate with other electronic devices on the vehicle, and with off-board diagnostic tools.

ACPU System Components

The system components include the ACPU control module and the pressure switches.

- On a Century Class Conventional, the ACPU control module is located under the hood on the right side of the frontwall. On an Argosy COE, the ACPU control module is located on the right side of the vehicle behind the bumper.
- The pressure switches include one high-side pressure switch and one low-side pressure switch. The pressure switches are located near the ACPU control module on both the Century Class Conventional and Argosy COE models.

ACPU System Inputs

The two system inputs are the thermostat and the pressure switches.

- The HVAC thermostat switch (circuit 97T) is the primary control unit. It is connected in series with the main air conditioning on/off switch and the evaporator thermostat (circuit 97T). The ACPU will cycle the air conditioning compressor on and off in response to the thermostat input, but will not do so more than once every 15 seconds. The thermostat contacts close when the evaporator temperature exceeds 38°F (3°C) on the rise, and open when the temperature decreases below about 32°F (0°C) on the fall. The thermostat turns off the compressor whenever frost begins to form on the evaporator.
- The ACPU high and low-pressure switches monitor air conditioning system pressure. Both switches are closed at low-pressure and opened on increasing pressure. See **Table 1** for opening and closing pressures for the ACPU high and low-pressure switches. Both switches have a 2490 ohm resistor in parallel with the contacts, allowing the ACPU module to detect an open circuit (broken wire) condition.

  The static pressure in a properly charged air conditioning system will cause the low-pressure switch to be normally opened (2490 ohms) and the high-pressure switch to be normally closed.(0 ohms). A closed low-pressure switch is usually indicative of a partial or complete loss of refrigerant. However, at very low ambient temperatures the air conditioning system pressure may drop low enough to close the low-pressure switch, even if the refrigerant charge is adequate. The air conditioning system will not operate if this happens.

ACPU System Outputs

The two ACPU system outputs are the fan request to the engine ECM (circuit 234A) and the refrigerant compressor clutch.

- Although the engine fan is actually controlled by the electronic control module (ECM), the manufacturers provide a fan request input so that other systems, such as air conditioning, may request fan operation. A fan request is sent to the ECM via circuit 234A on pin G of the 8-way ACPU connector. The fan request input is connected to electrical ground to turn the fan off, and is disconnected from ground to request fan operation. The actual fan behavior in a vehicle will depend on the engine installation. The details about fan operation are given later in this subject under the heading "ACPU Control Rules."

General Information

Opening and Closing Pressures for the ACPU Pressure Switches			
ACPU Pressure Switch	**Opens psi (kPa)**	**Closes psi (kPa)**	**Color of Cap**
Low Pressure Switch	34 (234)	10 (69)	—
High Pressure Switch (on vehicles built before December 11, 1998)	290 to 310 (1999 to 2137)	250 to 270 (1724 to 1862)	blue
High Pressure Switch (on vehicles built from December 11, 1998)	340 to 375 (2344 to 2586)		red

Table 1, Opening and Closing Pressures for the ACPU Pressure Switches

- Operation of the refrigerant compressor clutch is directly controlled by the ACPU module via circuit 97C on pin E of the 8-way ACPU connector. It will discontinue operation of the compressor clutch if it detects a short or open circuit condition. The clutch coil has a nominal resistance of 3.5 ohms. The ACPU calculates actual coil resistance from current and voltage measurements. If the calculated resistance is less than about 2 ohms or greater than about 12 ohms, the ACPU will de-energize the clutch coil circuit. It will make another attempt after 15 seconds. Then, if the coil resistance is still out of limits the circuit will be latched off until the next ignition cycle, and a fault message will broadcast on the J1587 databus.

ACPU Data Communications (J1587/J1708 Serial Databus)

The ACPU uses the following data transmitted by other electronic devices to control the air conditioning system. In the event the ACPU becomes disconnected from the databus it will assume default values for these parameters that will allow the air conditioning system to continue operating. The default values are shown in **Table 2**.

Parameter Defaults	
Missing Parameter	**Default Value**
Ambient Air Temperature	48°F (9°C)
Road Speed	32 mph (51 km/h)
Engine Speed	384 rpm
Park Brake Status	Not Set
Air Pressure	Okay

Table 2, Parameter Defaults

These parameters include:

- Ambient Air Temperature: The ACPU uses ambient air temperature data broadcast by the Instrumentation Control Unit (MID 140, PID 171) in determining whether or not to transmit a low-pressure fault message if the low-pressure switch closes. Below a certain preset temperature the low-pressure fault message is suppressed, since the low-pressure may simply be the result of the low ambient temperature. For details, refer to information under the heading "High and low-pressure Switches" in this subject. Note that if this is the case, air conditioning function will still be disabled, but no fault message will be broadcast on the J1587 bus. Pressing the TEMP key on the keypad will display the ambient temperature being broadcast by the ICU.
- Road Speed: The ACPU uses road speed data from the data bus (MID 128, PID 84) to determine how long to keep the fan running in response to a high-pressure condition. The actual length of time the fan operates depends on the engine installation. The details about fan operation are given later in this subject under the heading "ACPU Control Rules."
- Engine Speed: The ACPU reads engine RPM data from the data bus (MID 128, PID 190) and disables air conditioning operation if the engine speed is below 300 rpm. Once the engine speed exceeds 300 rpm, there is a delay of 15 seconds before air conditioning operation is allowed.
- Park Brake Status: Park Brake status is broadcast by the ICU (MID 140, PID 70). The ACPU uses different control rules to govern fan-on time when the truck is parked. The details

about fan operation are given later in this subject under the heading "ACPU Control Rules."

- Low Air Pressure: A low air pressure message is broadcast by the ICU if system air pressure drops below about 60 psi (414 kPa). This is a Freightliner proprietary message broadcast under MID 142, PID 254. When this happens the LOW AIR warning will also be activated on the ICU. To prevent possible damage to the fan clutch, the ACPU will not operate the air conditioning system when the LOW AIR warning is active.
- Transmitted Messages: The ACPU periodically transmits the following information on the data bus for use by other electronic devices on the vehicle.
  - Diagnostic Fault Codes. When the ACPU senses a fault condition, it broadcasts a fault code which will be received and displayed by the ICU. A list of fault messages as they would appear on the message display screen is included later in this subject. The ACPU broadcasts a list of faults once every fifteen seconds. Although some fault messages continue to be broadcast after a fault becomes inactive, only active faults are displayed on the message display screen.
  - Local Battery Voltage. The ACPU broadcasts locally sensed battery voltage once per second (MID 190, PID 168).

ACPU Control Rules

The ACPU uses the following logic rules to control the air conditioning system.

NOTE: After the first two rules have been completed, the ACPU will go into its normal operating mode in which the remaining two rules apply.

1. Air conditioning start delay: The air conditioning compressor is not allowed to run under any circumstances until the engine has been running for at least 15 seconds, and is turning over 300 rpm.
2. After the ignition has been switched on, and the engine has been running over 300 rpm for 15 seconds, the air conditioning compressor engages for 15 seconds, this provides compressor lubrication, provided the following additional conditions are satisfied:
   - The high and low-pressure switches do not indicate out-of-limits or fault conditions.
   - No low air pressure message is being received from the ICU.
   - Battery voltage sensed by the ACPU module is at least 11 volts and less than 16 volts.
   - There are no active fault codes which would disable air conditioning operation. These faults are: low-pressure, Open Clutch Circuit, Shorted Clutch Circuit.
3. For basic fan operation, the ACPU signals the engine ECU when the high-side pressure exceeds 290 to 310 psi (1999 to 2137 kPa) on vehicles built before December 11, 1998, or 340 to 375 psi (2344 to 2586 kPa) on vehicles built from December 11, 1998. The signal opens the high-pressure switch, turning the fan on. After the high-pressure condition no longer exists, the high-pressure switch closes. The ACPU fan request to the ECU remains active for a variable length of time, as described below. The actual length of time the fan runs depends on the engine installation and ECU programming.

   The basic fan operating times are as follows:
   - If the high-pressure switch indicates a high-pressure condition, and if road speed is less than 5 mph (8 km/h), the fan request remains active for three minutes after the high-pressure condition no longer exists.
   - If the high-pressure switch indicates a high-pressure condition and if road speed is 5 mph (8 km/h) or greater, but less than 30 mph (48 km/h), the fan request remains active for one minute and 30 seconds after the high-pressure condition no longer exists.
   - If the high-pressure switch indicates a high-pressure condition and if road speed is 30 mph (48 km/h) or greater, the fan request remains active for 45 seconds after the high-pressure condition no longer exists.
   - If the ACPU fan request has been active for at least 20 seconds and road speed

increases from less than 30 mph (48 km/h) to more than 30 mph (48 km/h), the ACPU turns the fan request off.

- If the high-pressure switch indicates a high-pressure condition and if the parking brake is set, the ACPU fan request remains on indefinitely once it has been activated.

  Please note the following exceptions based on the engine installed in the vehicle:

  For a vehicle equipped a with a Caterpillar engine, the ECU has a minimum programmable fan time of 30 seconds, meaning that it will keep the fan clutch engaged for an additional 30 seconds after the fan request from the ACPU has been discontinued. Therefore, the total length of time that the engine fan runs after the ACPU high-pressure switch closes will be 30 seconds longer than the basic fan operating times listed above.

  For a vehicle equipped with a Cummins engine, the ECU can be programmed for zero fan delay time. Therefore, the time the fan actually runs in response to a fan request input from the ACPU will be equal to the basic fan operating times listed above.

  For a vehicle equipped with a Detroit Diesel DDEC III engine, the ECU fan timing is set to one second, which is the minimum allowable time. This means it will keep the fan clutch engaged for one additional second after the fan request from the ACPU has been discontinued.

4. The ACPU turns the air conditioning clutch on and off in response to the thermostat switch input, subject to the following conditions:
   - The air conditioning clutch will not engage if data received from the databus indicates that engine speed is less than 300 rpm.
   - The air conditioning clutch will not engage more than once every 15 seconds.
   - The air conditioning clutch will turn off if the low-pressure switch closes.
   - If the high-pressure switch opens, the air conditioning clutch will turn off after a length of time equal to the time the clutch was turned on before the high-pressure switch opened, or after 10 seconds, whichever occurs first.
   - The air conditioning clutch will turn off if the locally sensed battery voltage is less than 11.0 volts.
   - The air conditioning clutch will turn off if an overcurrent or undercurrent condition is detected in the clutch coil circuit (low or high coil resistance, respectively). If this happens, the ACPU will wait for 15 seconds, then attempt to energize the clutch coil circuit again. If the overcurrent or undercurrent condition is still present, air conditioning operation will be disabled until the next ignition cycle.

Air Conditioning Protection Unit High-Pressure Switch

This switch is located on the discharge side of the service ports (small refrigerant line). If the pressure becomes too high, it signals the control module to turn on the fan. Too much pressure may be caused by blocked air flow through the condenser, a plugged expansion valve or receiver-drier, or too much refrigerant in the system.

If the compressor cylinder head pressure reaches unsafe levels above 290 to 310 psi (1999 to 2137 kPa) on vehicles built before December 11, 1998 or 340 to 375 psi (2344 to 2586 kPa) on vehicles built from December 11, 1998, the module shuts off the compressor and turns on the fan. When the pressure returns to 250 to 270 psi (1724 to 1862 kPa) the compressor resumes operation, and the control module turns off the fan.

Air Conditioning Protection Unit Low-Pressure Switch

Located on the suction side of the service ports (large refrigerant line), this switch signals the control module to disengage the refrigerant compressor, to protect it from harmful operating conditions.

If refrigerant is lost or the outside temperature is too low, the switch continually signals the module to keep the compressor from operating. The control module disengages the compressor when falling pressure goes below 10 psi (69 kPa); normal com-

pressor operation resumes when rising pressure reaches 34 psi (234 kPa).

Binary Switch

A binary switch disengages the refrigerant compressor clutch to protect the compressor from harmful operating conditions. It performs two functions.

- If the refrigerant system pressure is too low, the binary switch will keep the compressor from operating. The switch disengages the compressor clutch when falling pressure drops below 25.6 to 31.2 psig (177 to 215 kPa). Normal compressor operation resumes when rising pressure reaches 25.7 to 34.3 psig (177 to 236 kPa).
- If the refrigerant system pressure increases above 426.5 to 483.5 psig (2941 to 3334 kPa), the binary switch shuts off the compressor clutch. When system pressure falls back to 313 to 426 psig (2158 to 2937 kPa), the compressor resumes operation.

Blower Motor Resistor Block Assembly

The blower motor draws air over the evaporator, and forces it through the heater core, into the cab. The resistor block assembly controls the speed of the blower motor by reducing the voltage to the motor, and has a thermal cutout which shuts off current to the blower motor, if the circuit overheats.

Condenser

A condenser turns hot refrigerant gas, coming from the compressor, into liquid. Mounted in front of the radiator, it is made up of coiled tubes covered with cooling fins. Because of its location, the condenser transfers heat to air that is drawn in by the engine fan, and to ram air, which is forced into the engine compartment by the vehicle's forward motion.

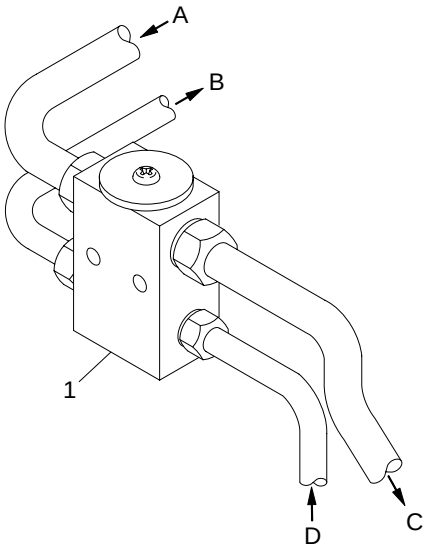
Evaporator

Because the evaporator holds an area of low-pressure in the system, the boiling point of the refrigerant falls, which causes it to absorb heat from the tubing walls and fins of the coils. As it absorbs heat, liquid refrigerant quickly boils and turns into a gas.

As heat is absorbed through the outside surfaces of the evaporator, air passing over the unit loses its heat to these cooler surfaces. Moisture in the air condenses on the outside of the evaporator and drains off as water, dehumidifying the air in the cab.

Expansion Valve

The expansion valve is a dividing point between the high- and low-pressure parts of the refrigerant system. High-pressure liquid refrigerant from the receiver-drier passes through the expansion valve and moves into the low-pressure area of the evaporator. See **Fig. 4** and **Fig. 5**.



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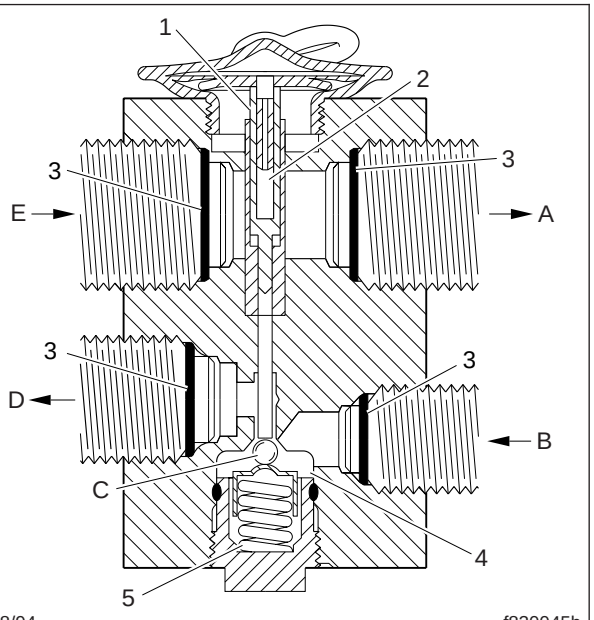
A. From the evaporator
B. To the evaporator
C. To the refrigerant compressor
D. From the receiver-drier

1. Expansion Valve

Fig. 4, Expansion Valve Refrigerant Lines

The expansion valve proportions the flow rate of refrigerant according to the rate of evaporation in the evaporator. If the amount of liquid in the evaporator drops off, the temperature of the gas going to the compressor rises. This causes a sensor tube in the expansion valve to react to the temperature changes, which causes an orifice in the valve to open or close. Through the orifice, liquid refrigerant is metered into the evaporator.

General Information



A. To the compressor
B. From the receiver-drier
C. Bleed at the ball seat
D. To the evaporator
E. From the evaporator

1. Internal Equalization Passage
2. Temperature Sensor
3. O-Ring
4. Metering Orifice
5. Ball and Spring

Fig. 5, Expansion Valve

Heater Core

The heater core is a series of tubes covered with fins. When the water valve is open, warm engine coolant flows through the heater core tubes, heating the tubes and fins. The blower motor blows air through the finned tubes and into the cab, to heat the cab.

Receiver-Drier

The receiver-drier is a reservoir and filter for liquid refrigerant. It also removes water and acids from the refrigerant. The water-absorbing material (desiccant) in the unit helps stop blockages caused by moisture forming in the expansion valve and other parts of the system.

Refrigerant

Refrigerant is the chemical substance that is used to absorb heat from the air in the cab and release it to the air outside the cab.

During compressor operation, refrigerant constantly changes from a gas to a liquid, then back to a gas, depending on whether it is absorbing heat (boiling) in the low-pressure evaporator, or releasing absorbed heat in the high-pressure condenser.

Refrigerant Compressor

"Heat" in the low-pressure gas of the evaporator does not feel like heat to the touch, because liquid refrigerant boils at a temperature much lower than the temperature at which water turns to ice. By touch, the "heated" gas in the coils is very cold. As a result, there is the problem of how to remove heat from subfreezing gas using outside air that may be higher than 100°F (38°C).

With a refrigerant compressor, low-pressure gas from the evaporator can be squeezed into a much smaller space. When the gas is compressed, the heat it contains becomes concentrated. In this way, the gas is made hotter than the outside air without adding heat.

If the system pressure rises above 550 ± 50 psi (3792 ± 345 kPa), a pressure relief valve will vent, disengaging the compressor clutch until the pressure drops to 400 psi (2758 kPa).

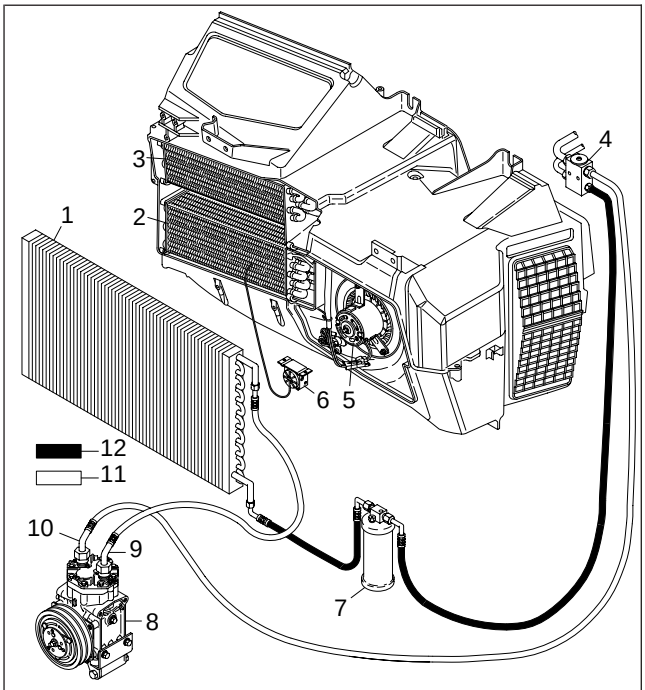
A second purpose of the compressor is to move refrigerant through the system.

Thermostatic Switch

A thermostatic switch signals the ACPU to engage and disengage the refrigerant compressor. See **Fig. 6**. From the thermostatic switch, a sensing tube extends to the evaporator where it monitors the temperature near the coil tubes. As air passes through the evaporator, water vapor can condense and freeze on the evaporator, blocking airflow. If the coil temperature drops too low, the thermostatic switch disengages the refrigerant compressor clutch until a temperature just above freezing is reached, to prevent the formation of ice.

Water Regulating Valve

The water regulating valve is controlled by the temperature control knob on the dash panel. On vehicles



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1. Condenser
2. Evaporator
3. Heater Core
4. Expansion Valve
5. Blower Motor
6. Thermostatic Switch
7. Receiver-Drier
8. Refrigerant Compressor
9. Discharge Side
10. Suction Side
11. Vapor
12. Liquid

Fig. 6, Air Conditioning Refrigerant Plumbing

equipped with a mechanically controlled water regulating valve, a cable opens and closes the valve, regulating the amount of coolant flowing through the heater core. See **Fig. 7** and **Fig. 8**. On vehicles equipped with an electronically controlled water regulating valve, the amount of coolant flowing through the heater core is regulated electronically. See **Fig. 9**.

Definition of Terms

Refer to the following terms for a better understanding of the heater and air conditioning system.

Air Conditioner A system used to control the temperature, humidity, and movement of air in the cab.

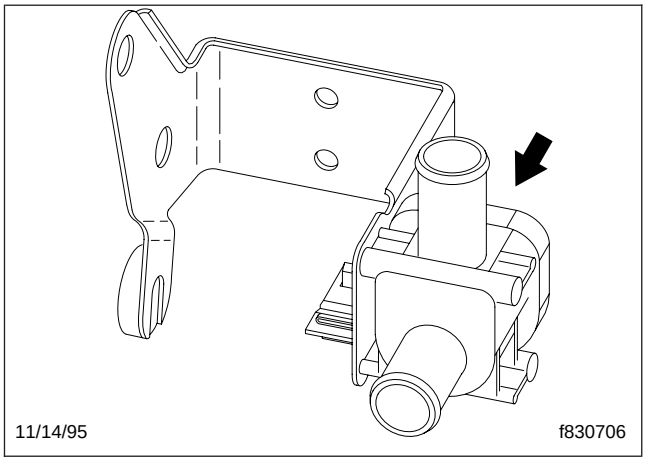

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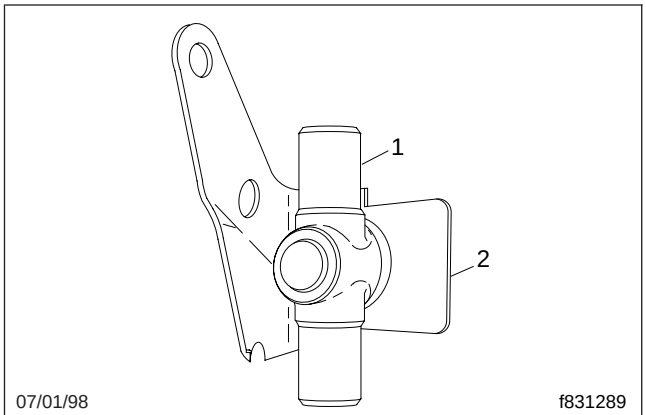
Fig. 7, Mechanically Controlled Water Regulating Valve, Century Class Conventional



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1. Water Regulating Valve
2. Mounting Bracket

Fig. 8, Mechanically Controlled Water Regulating Valve, Argosy COE

Air Cylinder Air-operated device used to open or close vents through which air is pushed into the cab by the blower.

Ambient Air Temperature The temperature of air around an object or the outside temperature.

Air Conditioning Protection Unit (ACPU) A system that monitors heater and air conditioner conditions (low or high refrigerant charge) and controls the refrigerant compressor and the on-off fan drive. Impending or existing problems are registered as fault codes through the Instrumentation Control Unit. The ACPU was installed on vehicles built before April 16, 1999.

General Information

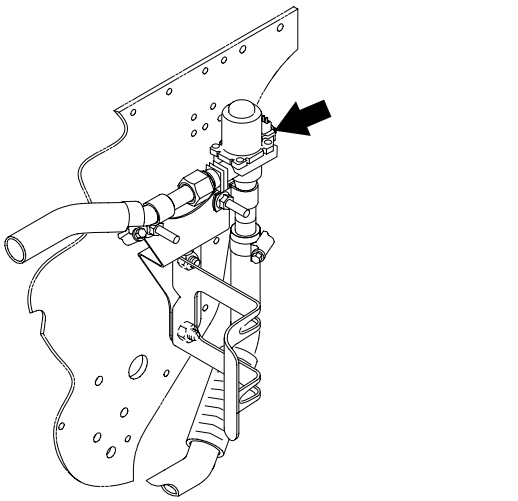


Fig. 9, Electronically-Controlled Water Regulating Valve

Binary Switch This switch disengages the refrigerant compressor clutch to protect the compressor from harmful operating conditions.

Blower Motor A blower motor forces air through the HVAC assembly and through the duct work.

Blower Resistor Block Assembly Inline resistors that control the amount of voltage going to the blower motor. By controlling the voltage, you can control the fan speed.

Boiling Point The temperature at which a liquid changes to a gas. The boiling point varies with pressure.

Bulk Charging Use of large containers of refrigerant for charging a refrigerant system. Normally used for charging empty systems.

Charge A specific amount of refrigerant or oil by volume or weight. Also the act of placing an amount of refrigerant or oil into the air conditioning system.

Clutch Cycling Switch (Thermostatic Switch) Engages or disengages the compressor depending on changes in evaporator temperature.

Condensate Water taken from the air, which forms on the outer surface of the evaporator.

Condenser A heat exchanger that is used to remove heat from refrigerant, changing it from a high-pressure hot gas to a high-pressure warm liquid. Typically the condenser is mounted in front of the radiator.

Contaminants Anything other than refrigerant or refrigerant oil in the system. Usually means water, dirt, or air in the system.

Dehumidify To remove water from the air at the evaporator.

Dehydrate To remove all traces of moisture from the refrigerant system. This process occurs during evacuation.

Desiccant A drying agent used in the receiver-drier to remove moisture and create an extremely dry condition.

Discharge Line Connects the refrigerant compressor outlet to the condenser inlet.

Discharge Pressure High-side pressure or condensing pressure of the refrigerant being discharged from the compressor.

Discharge Service Valve A device that allows high-side pressure to be checked and other service operations to be performed. This valve is located between the receiver-drier and the expansion valve.

Drive Pulley A pulley attached to the front of the engine crankshaft. It drives the compressor clutch pulley with a belt.

Duct A passageway for the transfer of air from one point to another.

Evacuate To place a high vacuum in the refrigeration system to remove air and dehydrate or remove traces of moisture.

Evaporate A change of state from a liquid to a gas.

Evaporator A component in which liquid refrigerant changes to a gas after it absorbs heat from the air. Also removes some moisture from the cab air.

Expansion Valve A device that causes a pressure-drop of the refrigerant and also regulates its flow.

Flooding A condition caused by too much liquid refrigerant going into the evaporator. Usually caused by an expansion valve that is stuck open.

Flushing A process of passing liquid refrigerant through an air conditioner component to remove dirt and water from the part. Liquid refrigerant removes heavy contamination, such as gritty dirt and large dirt buildup.

Freeze-Up Failure of a unit to operate properly because of ice forming at the expansion valve orifice or on the evaporator.

Heater Core A part of the heating system through which hot engine coolant flows to provide heat to the cab, or to adjust the temperature produced by the air conditioner.

High-Pressure Switch (Air Conditioning Protection Unit) Located on the discharge side of the service ports (small refrigerant line), this switch signals the electronic control module to turn the fan on or off, depending on refrigerant pressure. Additionally, if the high-pressure condition does not return to normal within a programmed period of time, the control module will turn off the compressor.

Humidity The amount of water vapor in the air.

Hydraulic Lock The return of liquid refrigerant to the compressor, which could destroy the unit.

Leak Detector Any device used to detect refrigerant leaks in a refrigerant system.

Liquid Line high-pressure liquid refrigerant is carried back to the evaporator from the condenser by the liquid line to repeat the evaporation/condensation cycle.

Liquid Pressure Pressure of refrigerant in the liquid line from the condenser to the expansion device.

Low Head Pressure High-side pressure that is lower than normal due to a system problem.

Low-Pressure Switch (Air Conditioning Protection Unit) Located on the suction side of the service ports (large refrigerant line), this switch signals the electronic control module to disengage the refrigerant compressor to protect it from harmful operating conditions.

Low Suction Pressure Low-side pressure that is lower than normal due to a system problem.

Magnetic Clutch An electrical coupling device used to engage or disengage the compressor.

Manifold Designed to control refrigerant flow for system test purposes. It is used with manifold gauges.

Manifold Gauge A calibrated instrument used for measuring system pressures.

Manifold Gauge Set A manifold that is complete with gauges and charging hoses and is used to measure or test pressure.

Micron A metric unit of length equal to one-millionth of a meter. This unit of measure is used to measure vacuum drawn from a refrigerant system by a vacuum pump.

Nitrogen A colorless, odorless, dry, inert gas that can be used to remove light contaminants, such as dust, from air conditioner parts.

Opacity A measure of contamination of refrigerant oil in the compressor. Fresh refrigerant oil is clear; when contaminated, it appears cloudy or may have fine particles held in suspension.

Overcharge Too much refrigerant or oil in the system.

Polyalkylene Glycol (PAG) A highly refined synthetic oil used in R–134a air conditioning systems.

Polyol Ester (POE) A highly refined synthetic oil used in R–134a air conditioning systems.

Purge To remove damp air, traces of refrigerant, and loose dirt from a system or part, by flushing with a dry inert gas, such as nitrogen.

PSIA Pounds per square inch, absolute pressure. Pressure exerted by the air at sea level. Atmospheric pressure is usually measured with a mercury barometer.

PSIG Gauge pressure, relative to the local atmosphere. At sea level, 0 PSIG is about 14.7 PSIA, which is standard atmospheric pressure. But in Denver, which is at about 5000 feet altitude, standard atmospheric pressure and PSIG are about 12.5 PSIA. It is possible to have a negative gauge pressure, indicating a vacuum.

Receiver-Drier A combination desiccant, filter, and storage container for liquid refrigerant.

Recovery Removal of the refrigerant from the air conditioning system.

Recycling Removal of contaminants and moisture from R–134a using a recovery and recycling station.

Refrigerant–134a (R–134a) The cooling agent used in automotive air conditioning systems. The chemical name for R–134a is tetrafluoroethane.

Refrigerant Compressor A device used to draw low-pressure refrigerant gas from the evaporator and squeeze it into a high-temperature, high-pressure gas. A second purpose of the compressor is to move refrigerant through the system.

Refrigeration Cycle The complete circulation of refrigerant through an air conditioning system, accompanied by changes in temperature and pressure.

General Information

Relative Humidity The actual water content of the air in relation to the total water the air can hold at a given temperature.

Resistor A voltage-dropping device, usually wire wound, for controlling fan speed.

Sensor A temperature- or pressure-sensing unit that is used to sense air temperatures or pressures, and provide a control voltage for operation of automatic temperature control units.

Suction Line The line connecting the evaporator outlet to the compressor inlet.

Suction Pressure Compressor inlet pressure or the system's low-side pressure.

Suction Service Valve A device that allows low-side pressure to be checked and other service operations to be performed. This valve is located between the evaporator and the compressor.

Suction Side The low-pressure area of the system, extending from the expansion valve to the compressor inlet.

Thermistor A vacuum pressure sensor that is used to measure, in microns of mercury, the internal system vacuum level after evacuation.

Thermostatic Vacuum Gauge A high-vacuum gauge sensitive to pressures ranging from atmospheric pressure to less than 1 micron of mercury, with scales reading from 25,000 microns to 1 micron of mercury.

Thermostatic Switch A temperature-sensitive switch used to control system temperature and prevent evaporator freeze-up. It does this by controlling the compressor's clutch operation.

Undercharge A system low on refrigerant resulting in lack of cooling and possible compressor damage.

Vacuum Refers to pressure that is less than atmospheric pressure.

Vacuum Pump A mechanical device used to evacuate and create a high vacuum in the refrigerant system.

Vacuum Pump Oil Water soluble oil used in some vacuum pumps to absorb moisture from the refrigerant system.

Vapor The gaseous state of a material.

Water Regulating Valve The mechanically or electronically controlled valve, used for controlling the flow of coolant to the heater core.

Principles of Operation

Air Conditioner

The refrigerant compressor crankshaft actuates the pistons and connecting rods, drawing in and compressing the low-pressure refrigerant gas into a high-pressure, high-temperature gas. high-pressure raises the condensation point of refrigerant gas, which allows the condenser to change it to a liquid.

After it is compressed, refrigerant gas moves out of the discharge port of the compressor and on to the condenser. At the condenser, air passing over the fins absorbs heat from the hot refrigerant gas and causes it to change into a liquid. The liquid moves to the receiver-drier, which filters it and removes traces of moisture and acids, then stores the refrigerant until it is needed by the system.

From the receiver-drier, liquid refrigerant moves to the expansion valve, which meters the flow into the evaporator and acts as a boundary between the high- and low-pressure sides of the system. The metered release of the expansion valve greatly drops the liquid's pressure causing it to expand. The pressure drop lowers the boiling point of the refrigerant and causes it to quickly evaporate as it absorbs heat from air passing over the coil. The resulting cool air is forced into the cab by the blower. The heated refrigerant gas is drawn back into the compressor, where the cycle is repeated.

Air Conditioning Protection Unit (ACPU)

The ACPU was installed on vehicles built before April 16, 1999.

After the engine is started, the electronic control module holds off compressor activation for about fifteen seconds. After the fifteen second delay, the compressor comes on for about fifteen seconds. This start-up cycle is accomplished with the control module ignoring all input from the thermostatic switch. The purpose of this activity is to circulate lubricant within the compressor, which is beneficial to the system especially when it is not used frequently.

The ACPU controls the length of time the engine fan remains engaged after a system high-pressure condition returns to normal. The length of time it stays on depends on vehicle speed. Basically, the fan stays on longer if the vehicle is parked or the speed is low. If the parking brake is on and the fan engages (high system pressure is sensed), it is held on until either the air conditioning is turned off for more than about two minutes, the parking brake is released, or the engine is shut down.

Additional air conditioning system controls performed by the ACPU include automatic shutdown of the air conditioning system if pressure drops below 60 psi (414 kPa). If an air conditioning fault occurs that causes the system to turn off the air conditioning, the refrigerant compressor clutch will not operate until the vehicle is shut down, then restarted. All of these controls are designed into the ACPU system to reduce air conditioning maintenance and increase the life of air conditioning components.

Heater

Turning the temperature control knob from COOL to WARM opens the water regulating valve, which allows engine-heated coolant to flow through the heater core. Air heated by the air passing over the heater core fins is forced through ducts and into the cab.

Safety Precautions

Whenever repairs are made to any air conditioner parts that hold R–134a refrigerant, you must recover, purge or flush (if contaminated), evacuate, charge, and leak test the system. In a good system, refrigerant lines are always under pressure and you should disconnect them only after the refrigerant charge has been recovered (discharged) at the service valves.

Refrigerant R–134a is safe when used under the right conditions. Always wear safety goggles and non-leather gloves while recovering, evacuating, charging, and leak testing the system. Do not wear leather gloves; when refrigerant gas or liquid contacts leather, the leather will stick to your skin.

⚠ WARNING

Use care to prevent refrigerant from touching your skin or eyes, because liquid refrigerant, when exposed to the air, quickly evaporates and will freeze skin or eye tissue. Serious injury or blindness could result if you come into contact with liquid refrigerant.

Refrigerant splashed in the eyes should be rinsed with lukewarm water, not hot or cold. Do not rub the eyes. Apply a light bandage and contact a physician right away.

Refrigerant splashed on the skin should be rinsed with lukewarm water, not hot or cold. Do not rub the skin. Apply a light coat of a nonmedicated ointment, such as petroleum jelly. Contact a physician right away.

R–134a refrigerant does not burn at ambient temperatures and atmospheric pressure. However, it can be combustible at pressures as low as 5.5 psig (139 kPa absolute) at 350°F (177°C) when mixed with air concentrations that are greater than 60 percent.

⚠ WARNING

R–134a air conditioning systems should not be pressure tested or leak tested with compressed air. Combustible mixtures of air and R–134a may form, resulting in a fire or explosion, which could cause personal injury or property damage. R–134a may be safely pressured with dry nitrogen.

You must work in an area where there is a constant flow of fresh air when the system is recovered, evacuated, charged, and leak tested. R–134a vapors have a slightly sweet odor that is difficult to detect. Frequent leak checks and air monitoring equipment are recommended to ensure a safe working environment.

IMPORTANT: When servicing an R–134a air conditioning system, use only service equipment certified to meet the requirements of SAE J2210 (R-134a recycling equipment). The equipment should be operated only by qualified personnel who are familiar with the recycling station manufacturer's instructions.

Because of its very low boiling point, refrigerant must be stored under pressure. To prevent the refrigerant containers from exploding, never expose them to temperatures higher than 125°F (52°C).

On R–134a refrigerant systems, polyalkylene glycol (PAG), or polyol ester (POE) oil is used in the compressor. When handling these oils, observe the following:

- keep the oil free of contaminants
- do not expose the a/c system or the oil container to air for long periods of time; PAG and POE oils absorb moisture quickly
- use care when handling: painted surfaces, plastic parts, and other components (drive belts) could be damaged if the oil is spilled on them
- never mix the oils with other types of refrigerant oil

Replacement

1. Turn off the engine, apply the brakes, and chock the tires.
2. Access the receiver-drier. The fan cycling switch is mounted to the port on the receiver-drier. See **Fig. 1**.

   On Century Class vehicles, open the hood. On Argosy COEs, open the access panel on the front of the vehicle.
3. If the wiring harness is secured to the receiver-drier with a tie-strap, remove the tie-strap. Disconnect the wiring harness from the fan cycling switch.
4. Remove the fan cycling switch, and remove and discard the O-ring on the port.

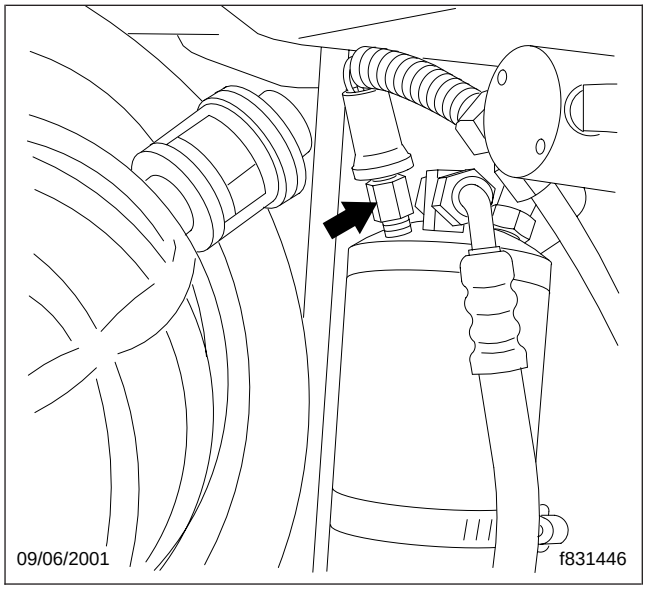


Fig. 1, Fan Cycling Pressure Switch

5. Lubricate a new O-ring with mineral oil and install the O-ring on the port.
6. Install a new fan cycling switch on the receiver-drier port. Torque the switch 60 to 72 lbf·in (678 to 813 N·cm).
7. Connect the wiring harness to the fan cycling switch. Using a tie-strap, make sure the wiring harness is kept away from the rain tray by securing the wiring harness to the receiver-drier on Century Class vehicles.
8. On Century Class vehicles, close the hood. On Argosy COEs, close the access panel on the front of the vehicle.
9. Remove the chocks from the tires.

Heater and Air Conditioner Removal and Installation

Removal

1. Turn off the engine, apply the brakes, and chock the tires.
2. Disconnect the batteries.

NOTE: When the dash is completely assembled, all dash fasteners are hidden from view. See **Fig. 1**, **Fig. 2** and **Fig. 3**.

3. Remove the right-hand dash panels, the left-hand dash panels as needed, and the upper dash panels to access the heater and air conditioner assembly. See **Fig. 4**, **Fig. 5**, **Fig. 6**, **Fig. 7** and **Fig. 8**. For instructions, refer to **Group 60**.

NOTE: On right-hand-drive (RH DR) vehicles, the dash panels are in the reverse position from the left-hand-drive (LH DR) vehicle.

4. At the climate control panel, disconnect the air lines and unplug the electrical connector.
5. Remove the air distribution duct that runs across the top of the power distribution module.
6. Remove the two fasteners holding the vertical air duct that is located along the kick panel. Remove the duct.
7. Remove the power distribution module. See **Fig. 9**. For instructions, refer to **Group 54**.
8. Remove the air distribution duct located on top of the heater and air conditioner assembly.
9. On Century Class Conventionals, remove the rain gutter and the air intake duct in the engine compartment.
10. On Century Class Conventionals, remove the air cleaner. For instructions, refer to **Group 09**.
11. At the frontwall (just above the expansion valve), disconnect the heater core supply and return lines. Clamp off the lines to prevent coolant loss.
12. Remove the mastic insulating tape from around the expansion valve.
13. Remove the refrigerant from the air conditioning system. For instructions, see **Subject 250**.
14. At the expansion valve, disconnect the refrigerant lines that are routed to the junction block (then on to the receiver-drier and the refrigerant compressor). See **Fig. 10**. Quickly cap the expansion valve ports and plug the fittings.

IMPORTANT: Under no circumstances should the expansion valve ports remain uncapped or the fittings remain unplugged for longer than five minutes total. Water and dirt can damage the refrigerant system. Do not blow shop air through refrigerant lines since shop air is wet (humid).

15. Remove the drain tubes that pass through the frontwall.
16. Remove the two capscrews and the four nuts that hold the heater and air-conditioner unit in place. Remove the heater and air conditioner.

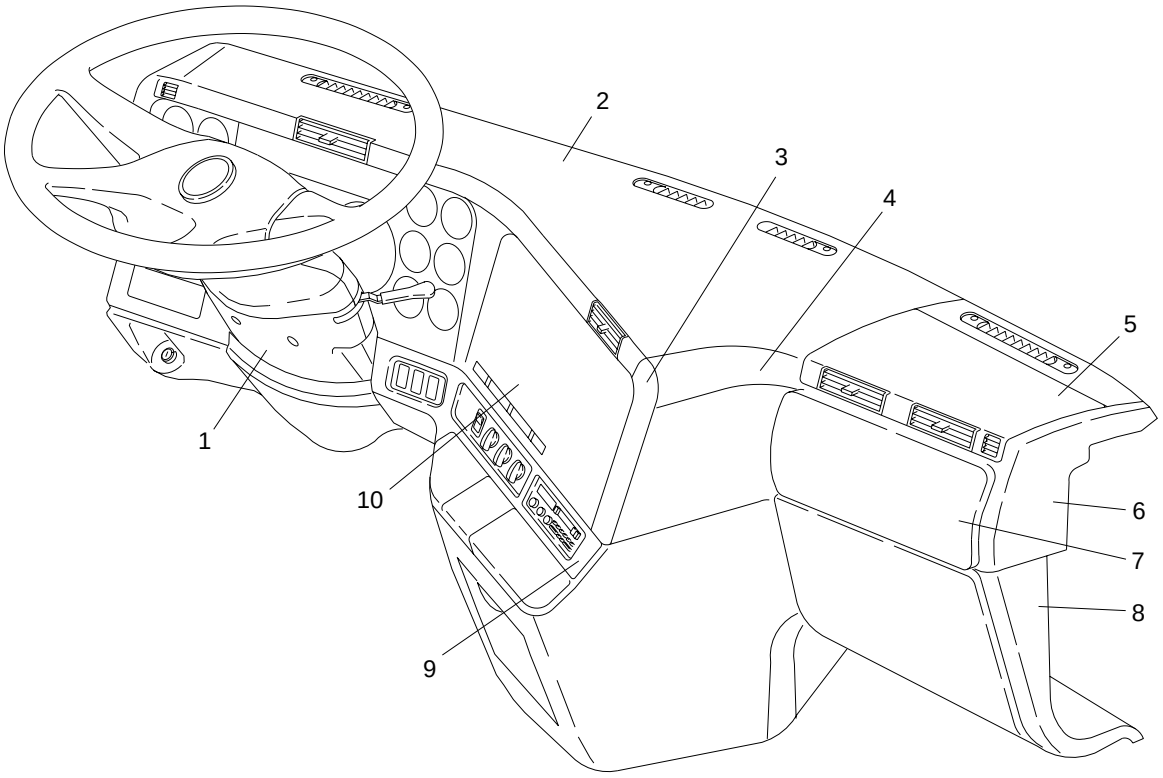
NOTE: Pull out the lower right-hand side of the heater and air conditioner first.

Installation

1. Align the left side of the heater and air conditioner in the cab. Make sure that the ducts on the left side mate with their respective cavities in the dash structure.
2. Check that the left-hand heat duct slides into position and that all gaskets are flush against the frontwall.
3. Install the capscrews and nuts that secure the heater and air conditioner. Tighten them 16 lbf·ft (22 N·m).
4. Feed the drain tubes through the frontwall.
5. Uncap the expansion valve ports and unplug the fittings. Check the fittings and the ports. They must be clean and free of nicks, gasket residue, and other foreign material.
6. On hose connections that have threaded fittings, replace the O-rings in the fittings. Lubricate the O-rings with mineral oil before installing.

   On hose connections that have a SlimLine seal assembly (**Fig. 11**), replace the seals. **Do not** lubricate SlimLine seals prior to installation. Use **only** a SlimLine seal on a SlimLine seal assembly.
7. Install the refrigerant lines to the expansion valve.

Heater and Air Conditioner Removal and Installation



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1. Steering Column Cover
2. Upper Dash Assembly (left-hand panel)
3. Dash Trim Cap, Right-Hand
4. Upper Dash Assembly, Center Panel
5. Electrical Cover
6. Upper Dash Assembly, Right-Hand
7. Upper Dash Cover, Right-Hand
8. Heater and Air Conditioner Cover
9. Waste Bin Outer Wall
10. Console Cover, Right-Hand
11. HVAC/Radio Trim Plate
12. Auxiliary Gauge Panel

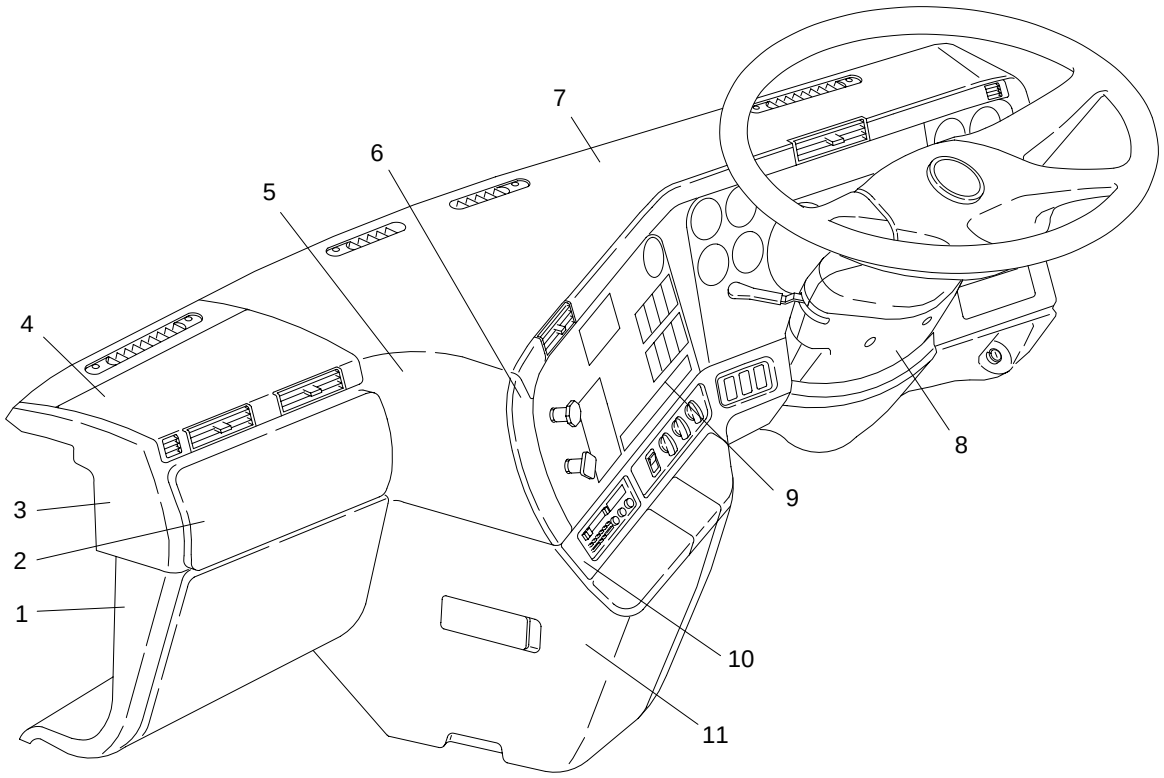
Fig. 1, Dash Panels, Century Class Conventional, LH DR

On hose connections that have threaded fittings, torque the large line 35 to 40 lbf·ft (47 to 54 N·m). Torque the small line 20 to 25 lbf·ft (27 to 34 N·m).

On hose connections that have a SlimLine seal assembly, torque the bolt on the SlimLine seal assembly 11 to 15 lbf·ft (15 to 20 N·m).

8. Evacuate and charge the system with refrigerant. Refer to **Subject 250** for instructions. Be sure to add refrigerant oil to the compressor to replace that which is lost when the system is discharged. For instructions, refer to the applicable refrigerant compressor section in this group.
9. Cover the expansion valve with mastic insulating tape.
10. Connect the heater inlet and outlet hoses to the heater core pipe elbows. Tighten the clamps securely.
11. On Century Class Conventionals, install the air intake duct and the rain gutter in the engine compartment. Tighten the fasteners securely.
12. On Century Class Conventionals, install the air cleaner. For instructions, refer to **Group 09**.
13. Install the power distribution module. For instructions, refer to **Group 54**.

Heater and Air Conditioner Removal and Installation



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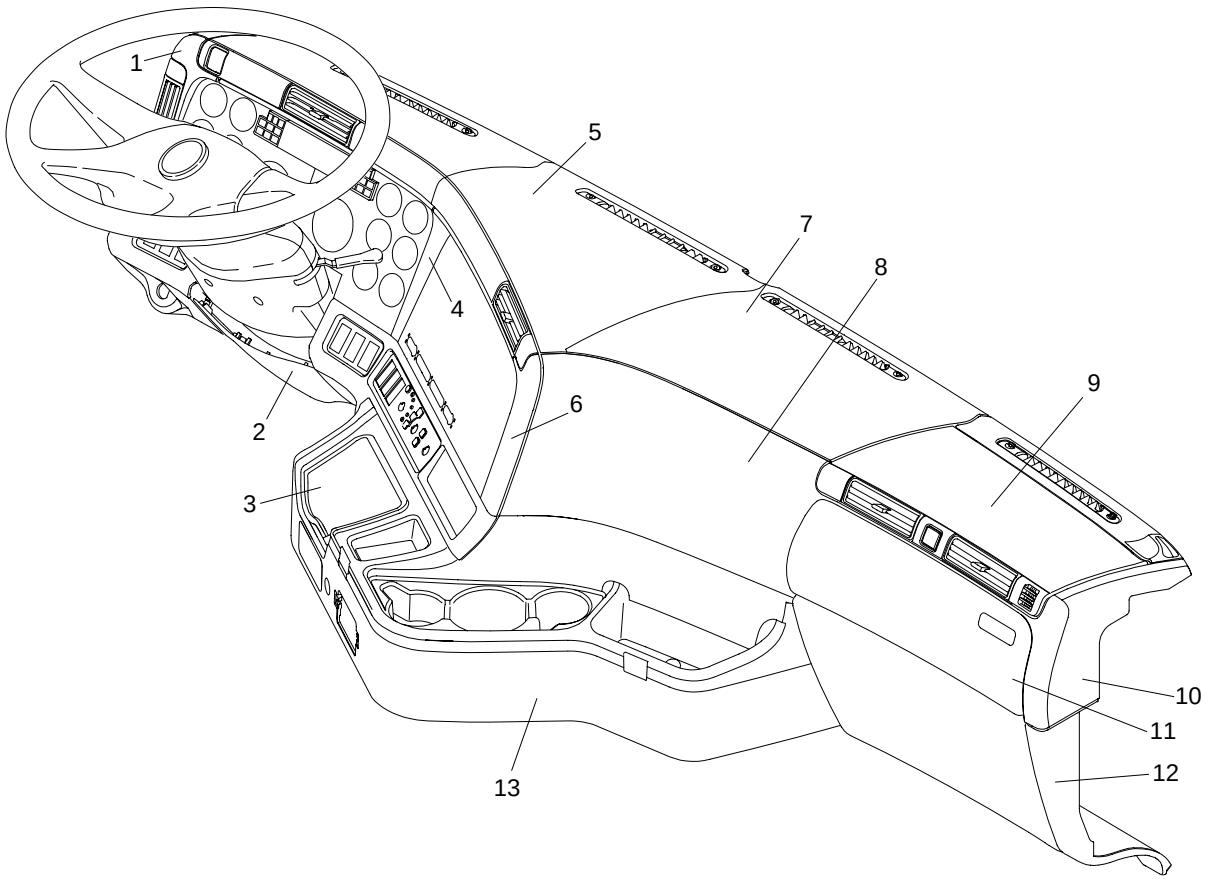
1. Heater and Air Conditioner Cover
2. Upper Dash Cover, Left-Hand
3. Upper Dash Assembly, Left-Hand
4. Electrical Cover
5. Upper Dash Assembly, Center Panel
6. Dash Trim Cap, Left-Hand
7. Upper Dash Assembly (right-hand panel)
8. Steering Column Cover
9. Auxiliary Gauge Panel
10. HVAC/Radio Trim Plate
11. Console Cover, Left-Hand

Fig. 2, Dash Panels, Century Class Conventional, RH DR

14. Install the vertical air duct along the right-hand side kick panel using the two fasteners removed earlier.
15. Install the air distribution duct across the top of the power distribution module.
16. Securely fasten the unit to the windshield support bracket (near the center of the windshield).
17. Connect the electrical connector to the climate control panel. Install the air lines.
18. Install the dash panels. For instructions, refer to **Group 60**.
19. Connect the batteries.
20. Start the engine. Turn the heat control knob to hot (this opens the water valve). When the engine thermostat(s) opens, air will be forced from the heater core as the coolant circulates. Check the coolant level and fill as needed.
21. Remove the chocks from the tires.

Heater and Air Conditioner Removal and Installation



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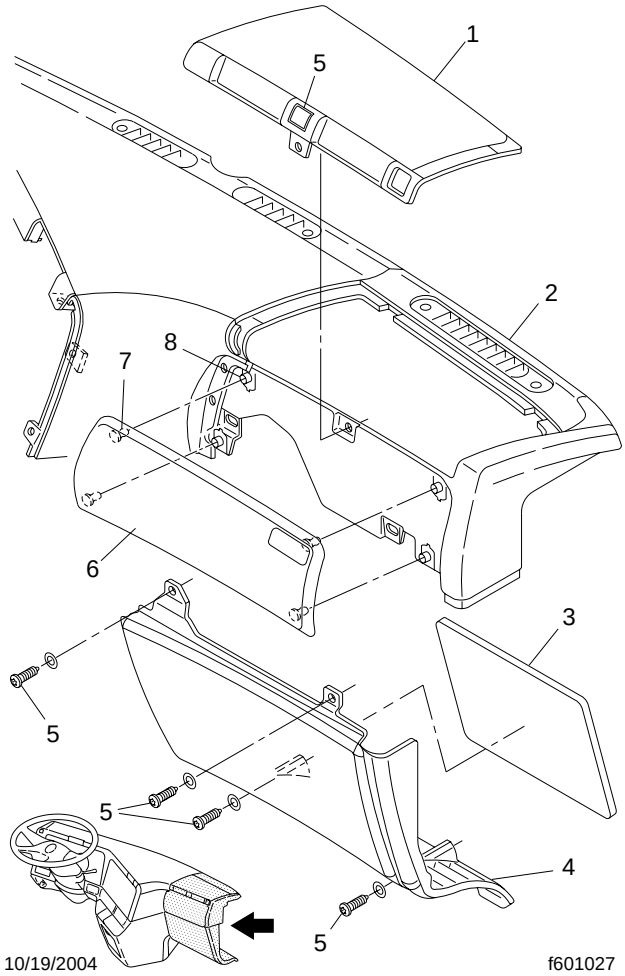
1. Dash End Cap
2. Steering Column Cover
3. Transmission Opening
4. Instrument Panel Center Trim
5. Upper Dash Assembly (left-hand panel)
6. Right-Hand Dash Trimcap
7. Upper Dash Assembly (right-hand panel)
8. Upper Dash Assembly (center panel)
9. Upper Dash Electrical Access Panel
10. Dash Assembly, Right-Hand
11. Dash Cover
12. HVAC Cover
13. Lower Dash Console

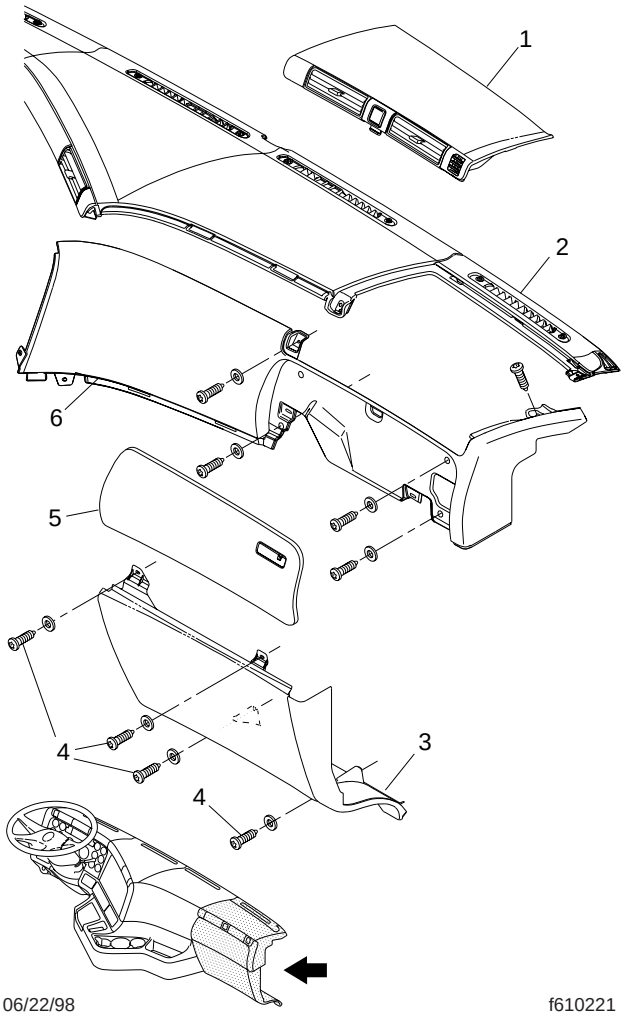
Fig. 3, Dash Panels, Argosy COE

Heater and Air Conditioner Removal and Installation



1. Electrical Cover
2. Upper Dash Assembly, Right-Hand
3. Cover Seal
4. Heater and Air Conditioner Cover
5. T25 Dog-Point Screw
6. Upper Dash Cover, Right-Hand
7. Speed Clip
8. Speed Nut

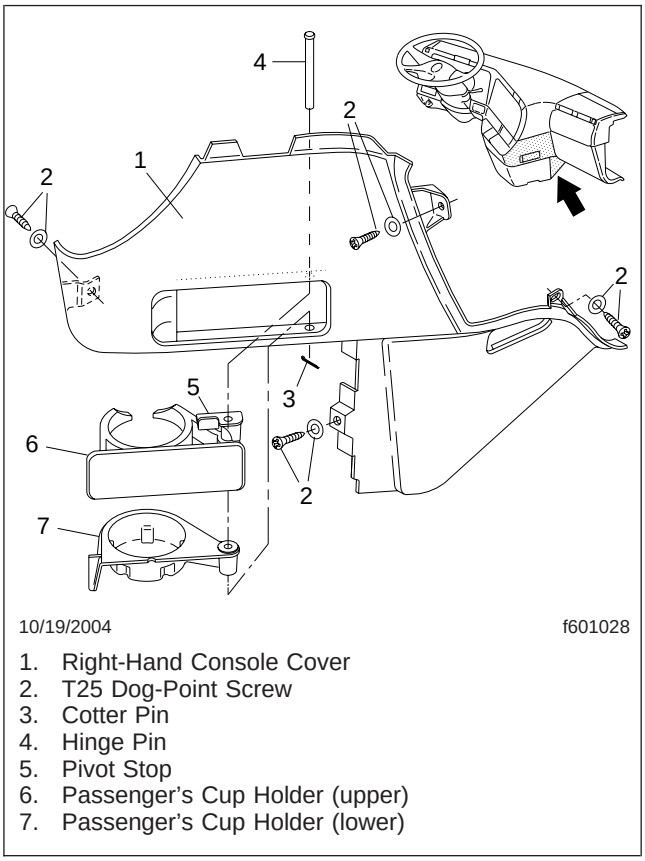
Fig. 4, Right-Hand Dash Panels, Century Class Conventional, LH DR



1. Electrical Cover
2. Upper Dash Assembly
3. HVAC Cover
4. T25 Dog-Point Screw
5. Dash Cover
6. Upper Dash Assembly (center panel)

Fig. 5, Right-Hand Dash Panels, Argosy COE

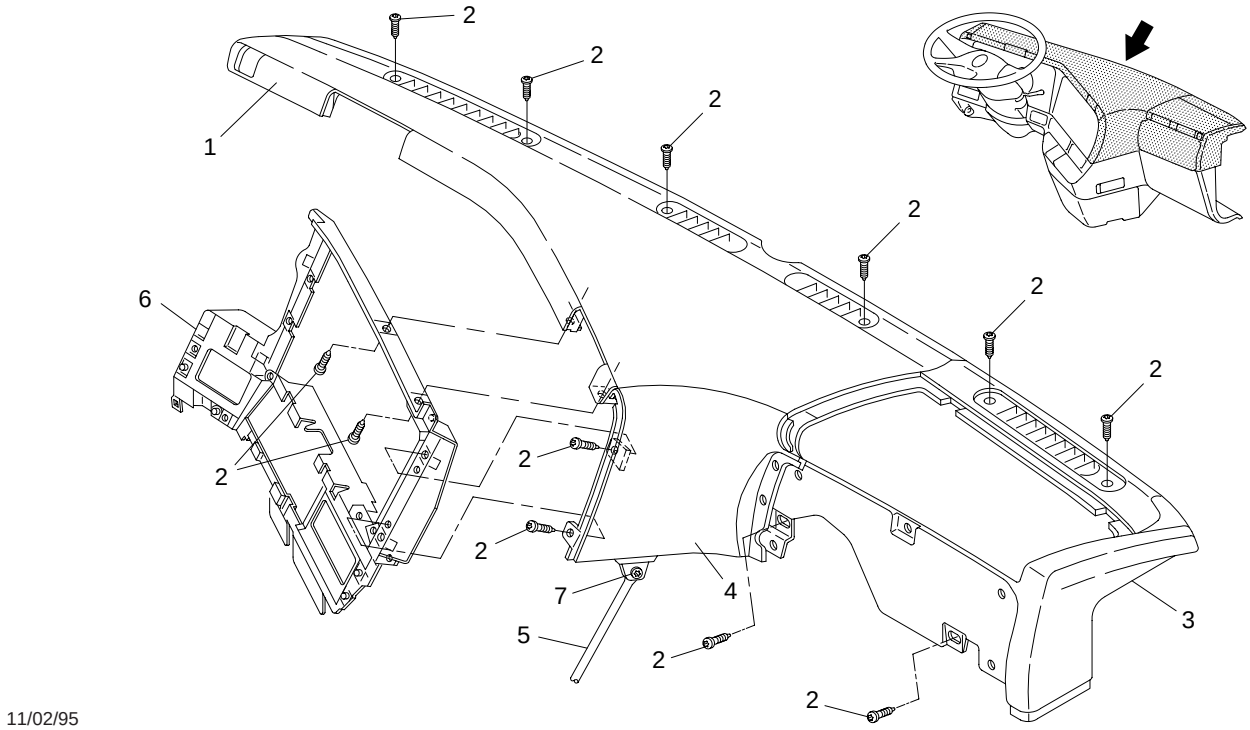
Heater and Air Conditioner Removal and Installation



1. Right-Hand Console Cover
2. T25 Dog-Point Screw
3. Cotter Pin
4. Hinge Pin
5. Pivot Stop
6. Passenger's Cup Holder (upper)
7. Passenger's Cup Holder (lower)

Fig. 6, Right-Hand Console Cover, Century Class Conventional, LH DR

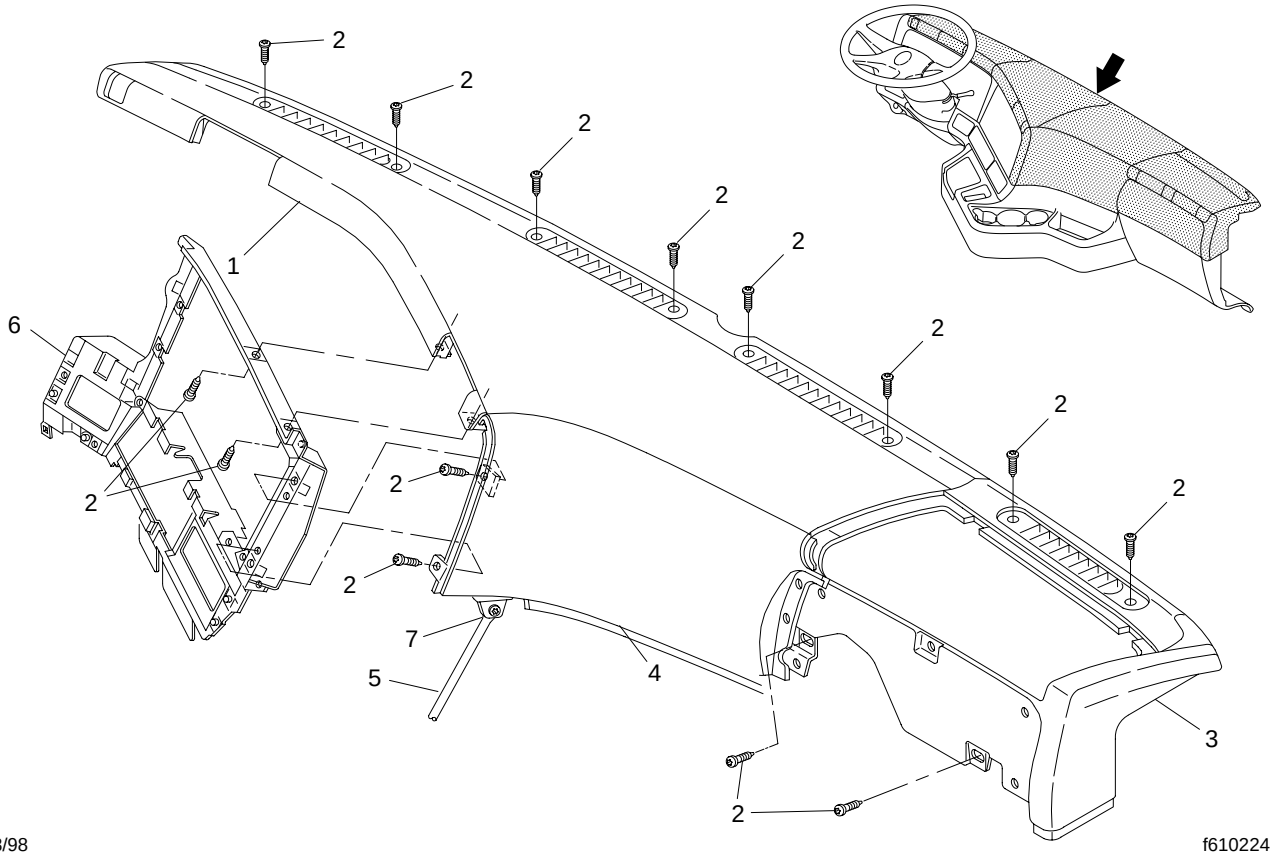
Heater and Air Conditioner Removal and Installation



1. Upper Dash Assembly, Left-Hand
2. T25 Dog-Point Screw
3. Upper Dash Assembly, Right-Hand
4. Upper Dash Assembly, Center Panel
5. Dash Brace
6. Upper Dash Panel
7. Dash Brace Screw

Fig. 7, Upper Dash Panels, Century Class Conventional, LH DR

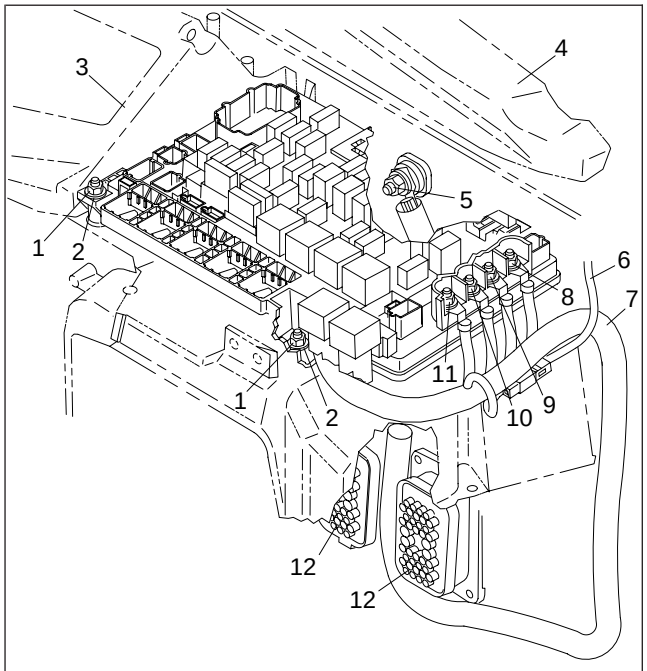
Heater and Air Conditioner Removal and Installation



1. Upper Dash Assembly (left-hand panel)
2. T25 Dog-Point Screw
3. Upper Dash Assembly (right-hand panel)
4. Upper Dash Assembly (center-hand panel)
5. Dash Brace
6. Upper Dash Panel
7. Dash Brace Screw

Fig. 8, Upper Dash Panels, Argosy COE

Heater and Air Conditioner Removal and Installation



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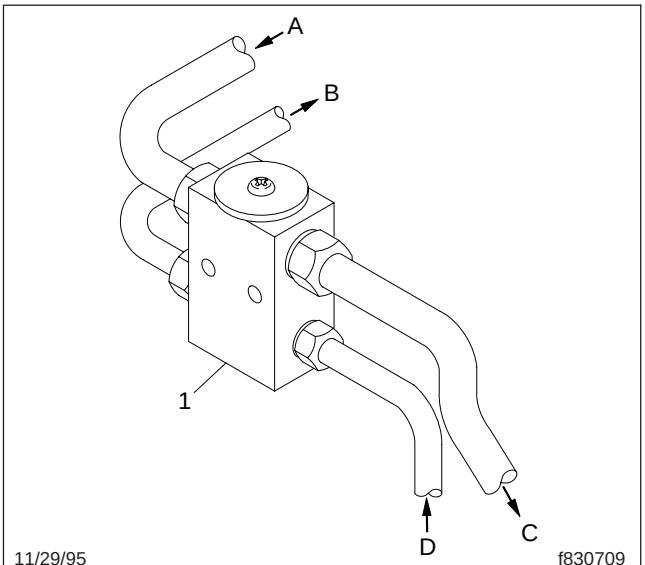
1. 1/4–20 Hold-Down Nut
2. 1/4-Inch Hold-Down Washer
3. Dash Panel
4. Main Defrost Duct
5. Cab Power Stud
6. Breakout from Main Dash Harness
7. Power Distribution Module Power Harness
8. ACC Ring Terminal
9. IGN Ring Terminal
10. ISO Ring Terminal
11. BAT Ring Terminal
12. Cannon Plugs

Fig. 9, Power Distribution Module Installation



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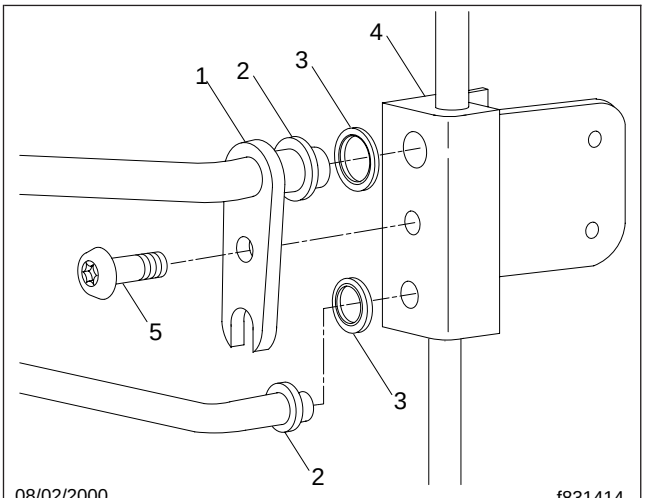
A. From the evaporator coil
B. To the evaporator coil
C. To the refrigerant compressor
D. From the receiver-drier

1. Expansion Valve

Fig. 10, Expansion Valve Refrigerant Lines



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1. Plate
2. Fitting
3. Seal
4. Block
5. Bolt

Fig. 11, A Typical SlimLine Seal Assembly

Removal

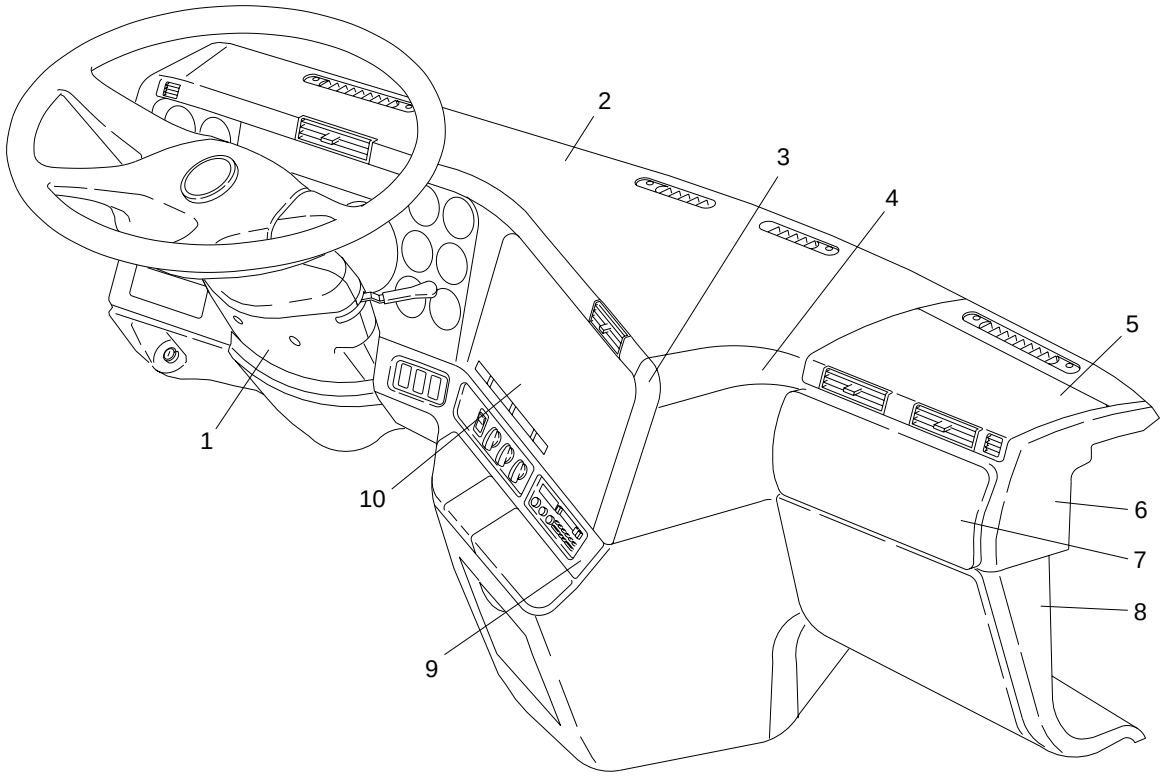
1. Turn off the engine, apply the brakes, and chock the tires.
2. Disconnect the batteries.

NOTE: When the dash is completely assembled, all dash fasteners are hidden from view. See **Fig. 1**, **Fig. 2**, and **Fig. 3**.

3. Remove the right-hand dash panels as needed to access the heater core. See **Fig. 4**, **Fig. 5** and **Fig. 6**. For instructions, refer to **Group 60**.

NOTE: On right-hand-drive (RH DR) vehicles, the dash panels are in the reverse position from the left-hand-drive (LH DR) vehicle.

4. Remove the air duct that runs across the top of the power distribution module.
5. Disconnect the harness from the thermostatic switch. See **Fig. 7**.
6. Remove the two screws attaching the thermostatic switch to the heater core and evaporator coil cover. Remove the switch and the sensor tube.



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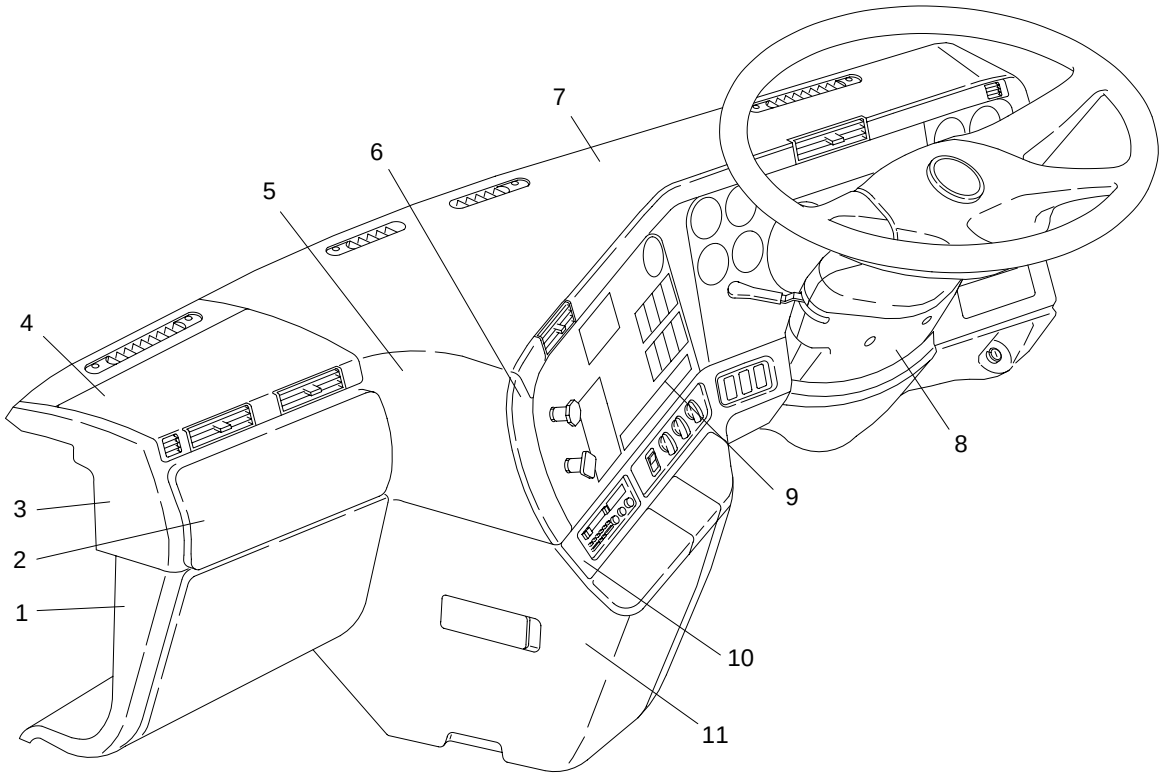
1. Steering Column Cover
2. Upper Dash Assembly (left-hand panel)
3. Dash Trim Cap, Right-Hand
4. Upper Dash Assembly, Center Panel
5. Electrical Cover
6. Upper Dash Assembly, Right-Hand
7. Upper Dash Cover, Right-Hand
8. Heater and Air Conditioner Cover
9. Waste Bin Outer Wall
10. Console Cover, Right-Hand
11. HVAC/Radio Trim Plate
12. Auxiliary Gauge Panel

Fig. 1, Dash Panels, Century Class Conventional, LH DR

Heater Core Removal and Installation



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1. Heater and Air Conditioner Cover
2. Upper Dash Cover, Left-Hand
3. Upper Dash Assembly, Left-Hand
4. Electrical Cover
5. Upper Dash Assembly, Center Panel
6. Dash Trim Cap, Left-Hand
7. Upper Dash Assembly (right-hand panel)
8. Steering Column Cover
9. Auxiliary Gauge Panel
10. HVAC/Radio Trim Plate
11. Console Cover, Left-Hand

Fig. 2, Dash Panels, Century Class Conventional, RH DR

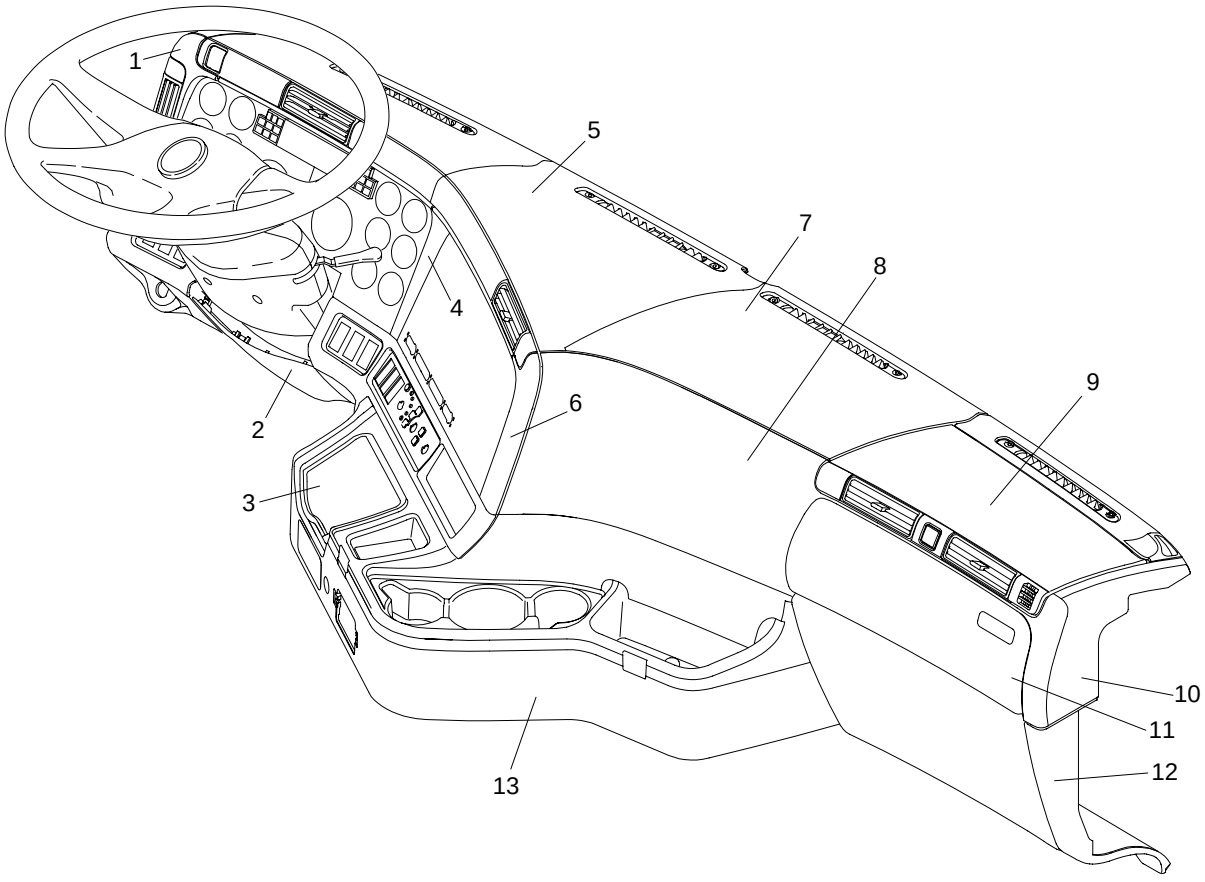
7. Remove the air duct located just above the thermostatic switch and sensor tube.
8. Remove the fasteners from the heater core and evaporator coil cover. See **Fig. 8**.
9. On Century Class Conventionals, open the hood and remove the air cleaner. For instructions, refer to **Group 09**.
10. At the frontwall (just above the expansion valve), disconnect the heater core supply and return lines. Clamp off the lines to prevent coolant loss.

⚠ WARNING

Failure to wear protective gloves could result in serious skin cuts due to the sharp edges on the heater core fins.

IMPORTANT: A small amount of antifreeze may be present in the heater core. Protect the interior of the vehicle to prevent any damage from antifreeze spillage.

11. Wearing protective gloves, slide the heater core out of the housing. See **Fig. 9**.



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1. Dash End Cap
2. Steering Column Cover
3. Transmission Opening
4. Instrument Panel Center Trim
5. Upper Dash Assembly (left-hand panel)
6. Right-Hand Dash Trimcap
7. Upper Dash Assembly (right-hand panel)
8. Upper Dash Assembly (center panel)
9. Upper Dash Electrical Access Panel
10. Dash Assembly, Right-Hand
11. Dash Cover
12. HVAC Cover
13. Lower Dash Console

Fig. 3, Dash Panels, Argosy COE

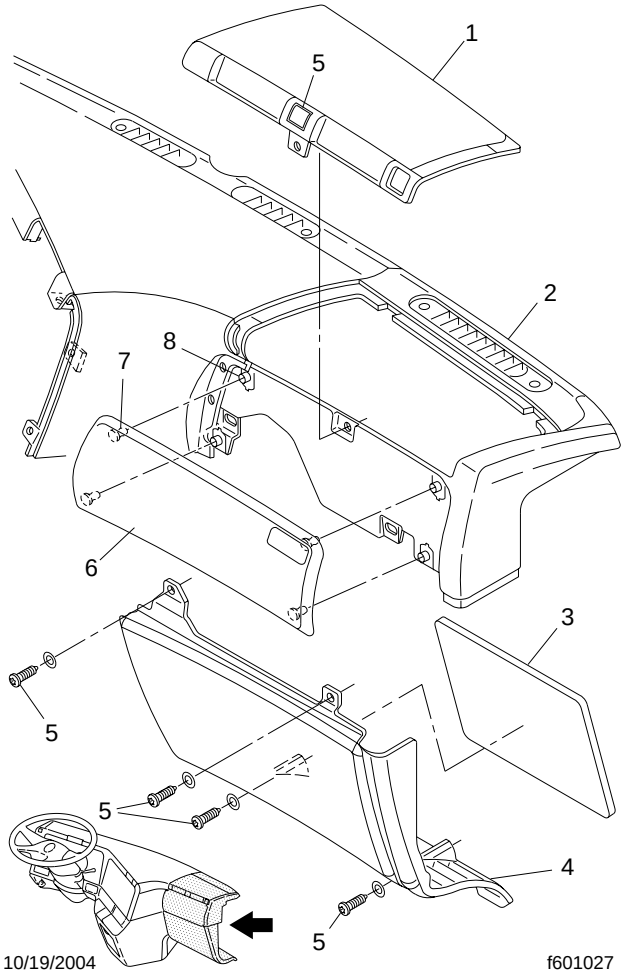
Installation

1. Wearing protective gloves, slide the new heater core into the housing. Make sure that the heater core gasket is flush against the frontwall. Connect the heater inlet and outlet hoses to the heater core pipe elbows. Tighten the clamps securely.
2. On Century Class Conventionals, install the air cleaner. For instructions, refer to **Group 09**.
3. Install the heater core and evaporator coil cover.

⚠ CAUTION

Be careful when installing the thermostat sensor tube. Using too much force will bend the tube, which could damage it.

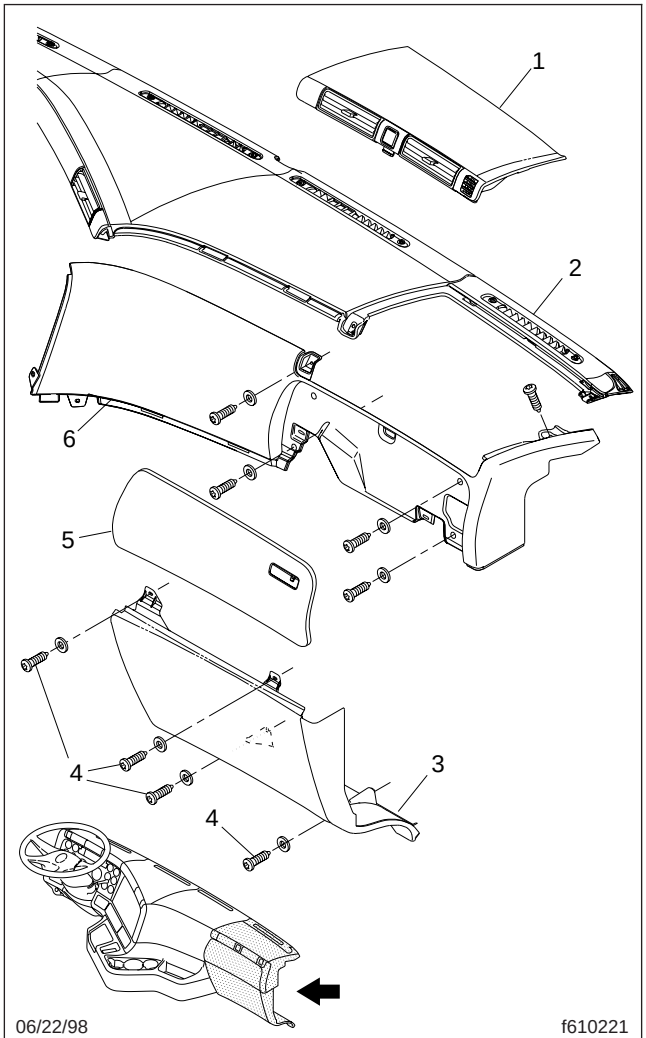
Heater Core Removal and Installation



1. Electrical Cover
2. Upper Dash Assembly, Right-Hand
3. Cover Seal
4. Heater and Air Conditioner Cover
5. T25 Dog-Point Screw
6. Upper Dash Cover, Right-Hand
7. Speed Clip
8. Speed Nut

Fig. 4, Right-Hand Dash Panels, Century Class Conventional, LH DR

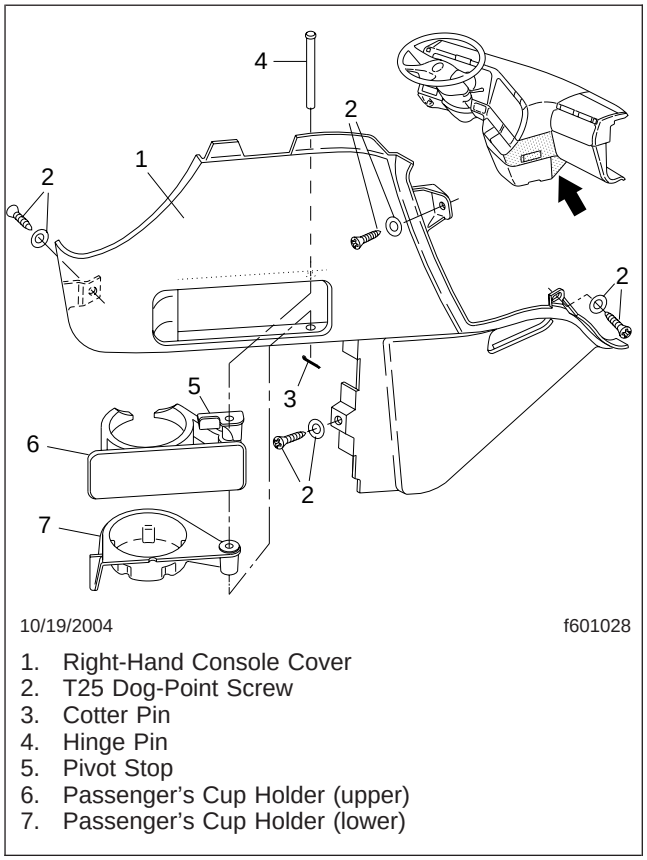
4. Carefully insert the thermostatic switch sensor tube into the same hole from which it was removed. The tip of the sensor tube must be in direct contact with an evaporator coil fin and be inserted at least 6 inches (15 cm) into the evaporator coil.



1. Electrical Cover
2. Upper Dash Assembly
3. HVAC Cover
4. T25 Dog-Point Screw
5. Dash Cover
6. Upper Dash Assembly (center panel)

Fig. 5, Right-Hand Dash Panels, Argosy COE

5. Using the two screws removed previously, install the thermostatic switch.
6. Connect the wire harness to the thermostatic switch.
7. Install the air duct above the thermostatic switch.
8. Install the right-hand dash panels. For instructions, refer to **Group 60**.



1. Right-Hand Console Cover
2. T25 Dog-Point Screw
3. Cotter Pin
4. Hinge Pin
5. Pivot Stop
6. Passenger's Cup Holder (upper)
7. Passenger's Cup Holder (lower)

Fig. 6, Right-Hand Console Cover, Century Class Conventional, LH DR

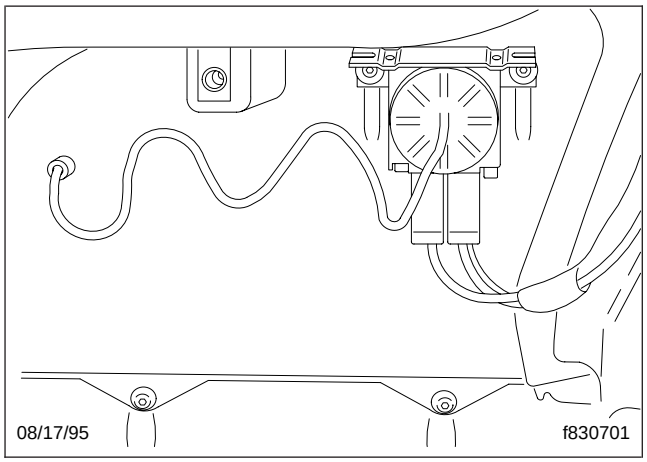


Fig. 7, Thermostatic Switch Mounting

9. Start the engine. Turn the heat control knob to hot (this opens the water valve). When the engine thermostat(s) opens, air will be forced from the heater core as the coolant circulates. Check the coolant level and fill as needed.

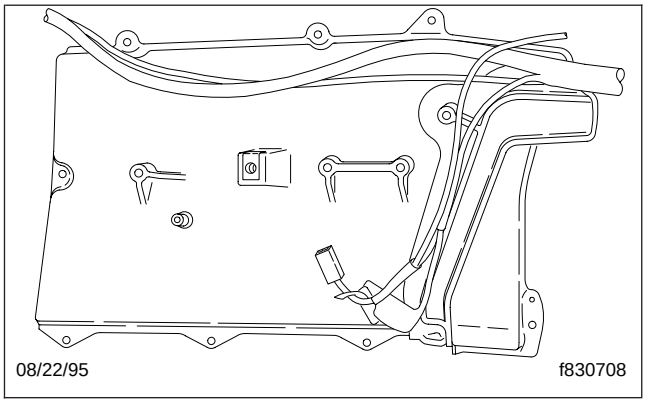
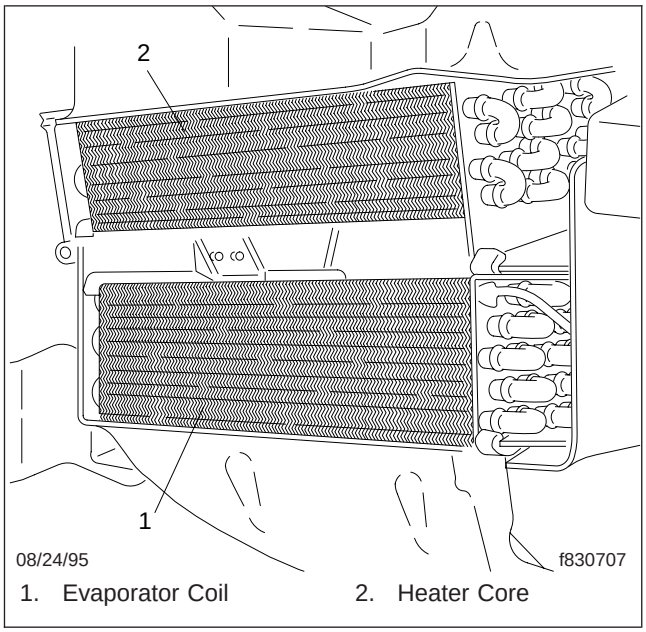


Fig. 8, Heater Core and Evaporator Coil Cover



1. Evaporator Coil
2. Heater Core

Fig. 9, Remove the Heater Core

10. On Century Class Conventionals, return the hood to the operating position.
11. Remove the chocks from the tires.

Removal

⚠ WARNING

Failure to turn off the ignition switch could allow the blower motor to operate during repairs. This could result in personal injury or electrical shock.

1. Turn off the engine, apply the brakes, and chock the tires.

NOTE: When the dash is completely assembled, all dash fasteners are hidden from view. See **Fig. 1**, **Fig. 2**, and **Fig. 3**.

2. Remove the right-hand dash panels as needed to access the blower motor. See **Fig. 4** and **Fig. 5**. For instructions, refer to **Group 60**.

NOTE: On right-hand-drive (RH DR) vehicles, the dash panels are in the reverse position from the left-hand-drive (LH DR) vehicle.

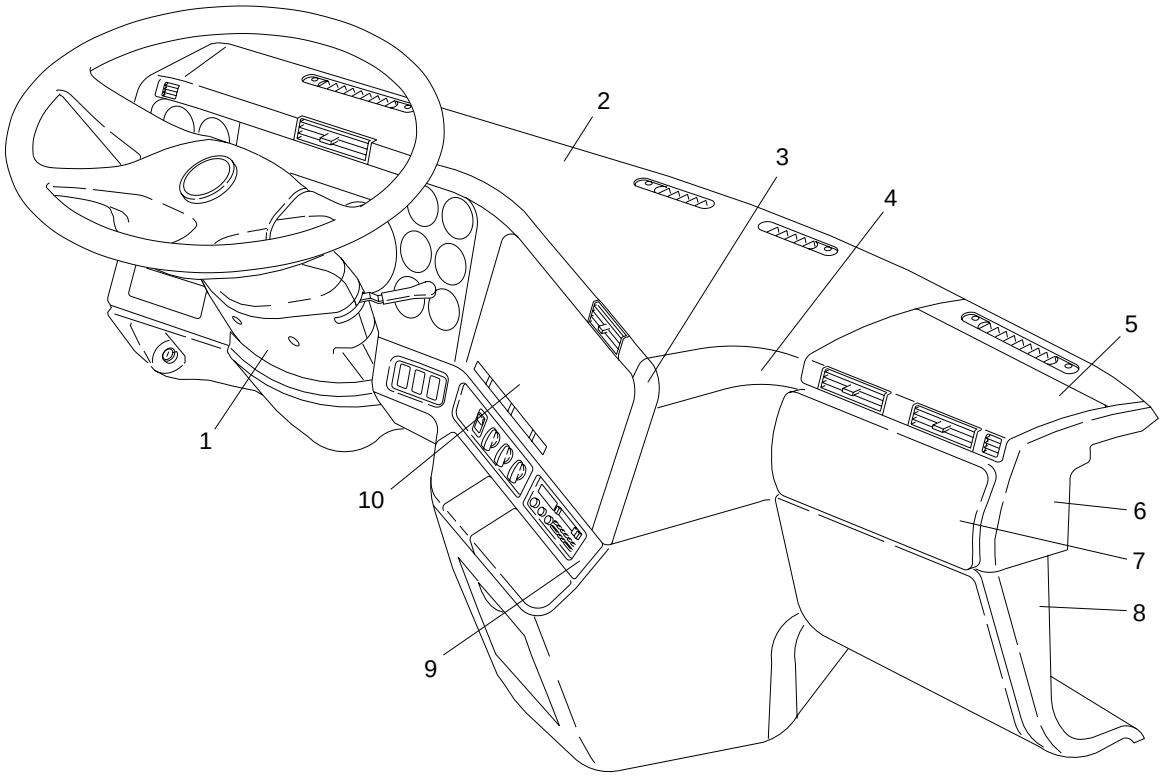
3. Disconnect the blower motor wires. See **Fig. 6**.
4. Remove the three screws from the blower motor bracket, then lift the blower motor out of the housing.

Installation

IMPORTANT: Make sure that the wiring exiting the motor is positioned at 4 o'clock to prevent excess slack in the harness.

1. Position the blower motor on the mounting bracket in the housing. Install the screws and tighten them securely.
2. Connect the blower motor wires.
3. Install the right-hand dash panels. For instructions, refer to **Group 60** of this manual.
4. Turn on the ignition key and test the blower motor.
5. Remove the chocks from the tires.

Blower Motor Removal and Installation



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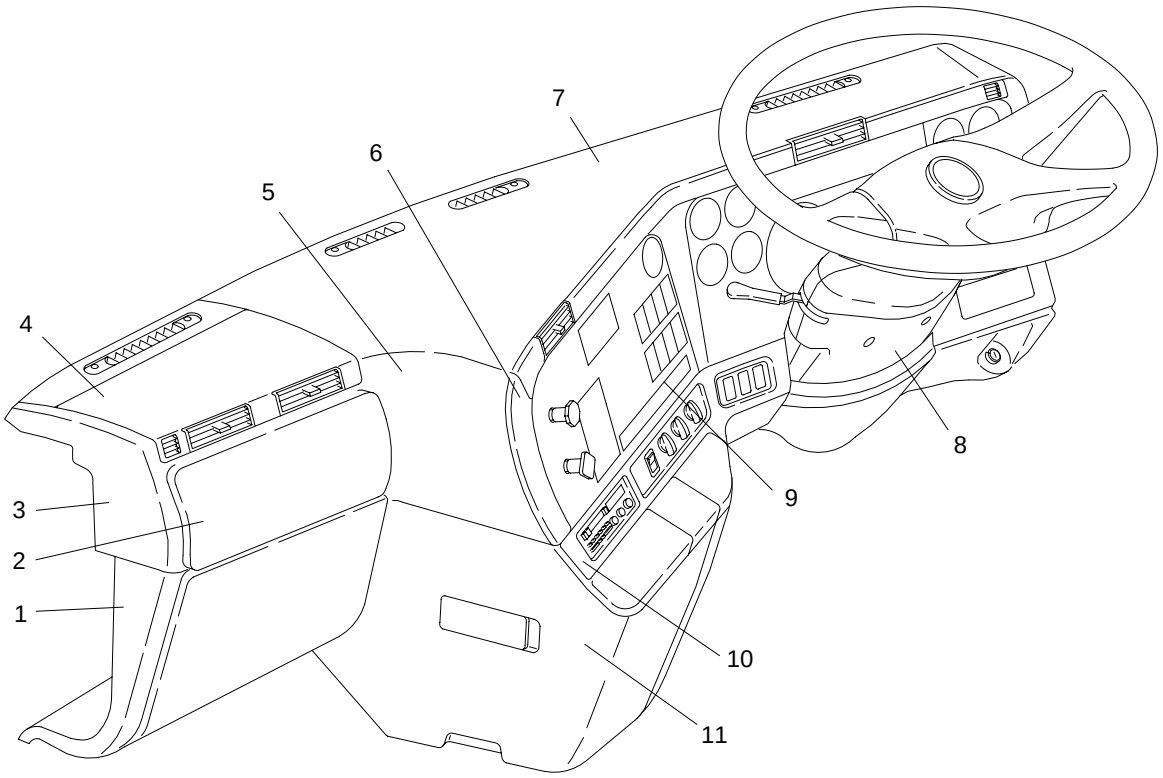
1. Steering Column Cover
2. Upper Dash Assembly (left-hand panel)
3. Dash Trim Cap, Right-Hand
4. Upper Dash Assembly, Center Panel
5. Electrical Cover
6. Upper Dash Assembly, Right-Hand
7. Upper Dash Cover, Right-Hand
8. Heater and Air Conditioner Cover
9. Waste Bin Outer Wall
10. Console Cover, Right-Hand
11. HVAC/Radio Trim Plate
12. Auxiliary Gauge Panel

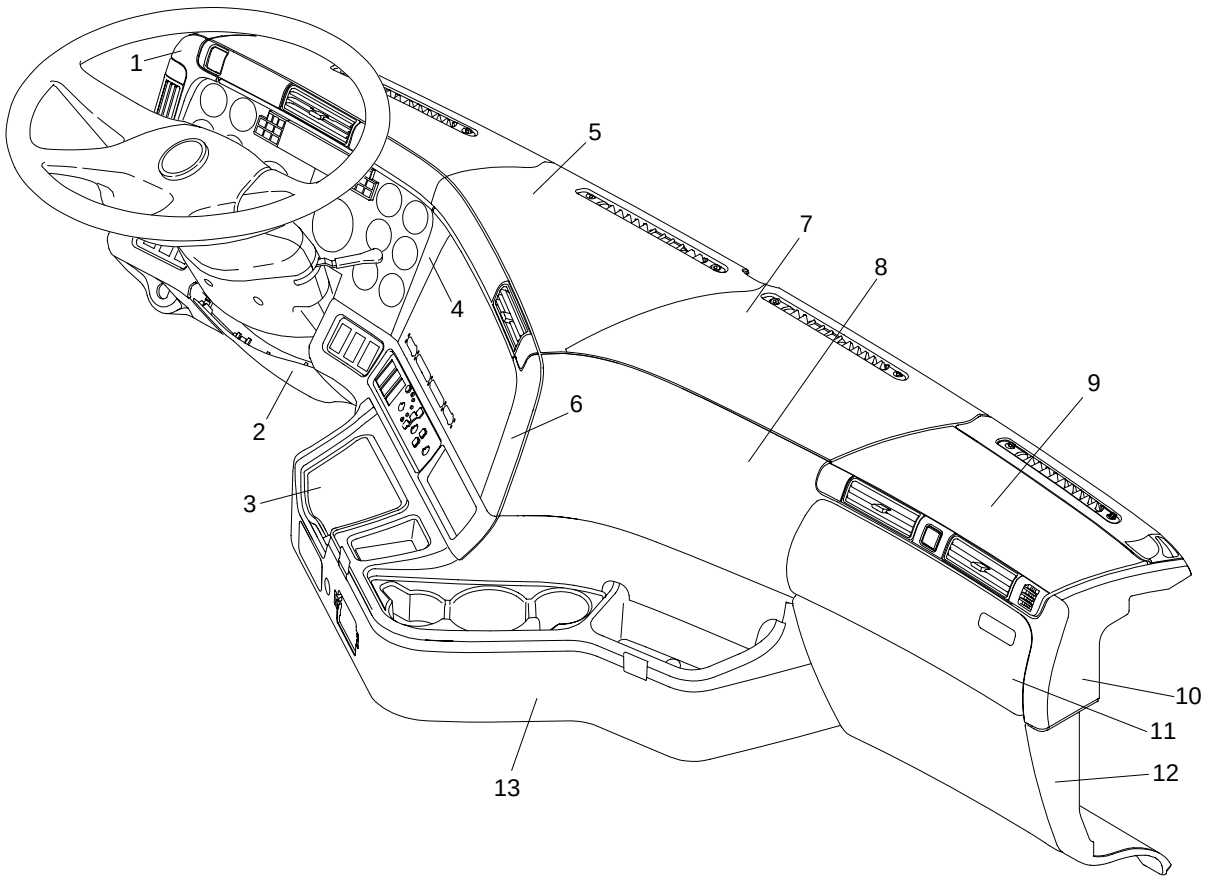
Fig. 1, Dash Panels, Century Class Conventional, LH DR



1. Heater and Air Conditioner Cover
2. Upper Dash Cover, Left-Hand
3. Upper Dash Assembly, Left-Hand
4. Electrical Cover
5. Upper Dash Assembly, Center Panel
6. Dash Trim Cap, Left-Hand
7. Upper Dash Assembly (right-hand panel)
8. Steering Column Cover
9. Auxiliary Gauge Panel
10. HVAC/Radio Trim Plate
11. Console Cover, Left-Hand

Fig. 2, Dash Panels, Century Class Conventional, RH DR

Blower Motor Removal and Installation



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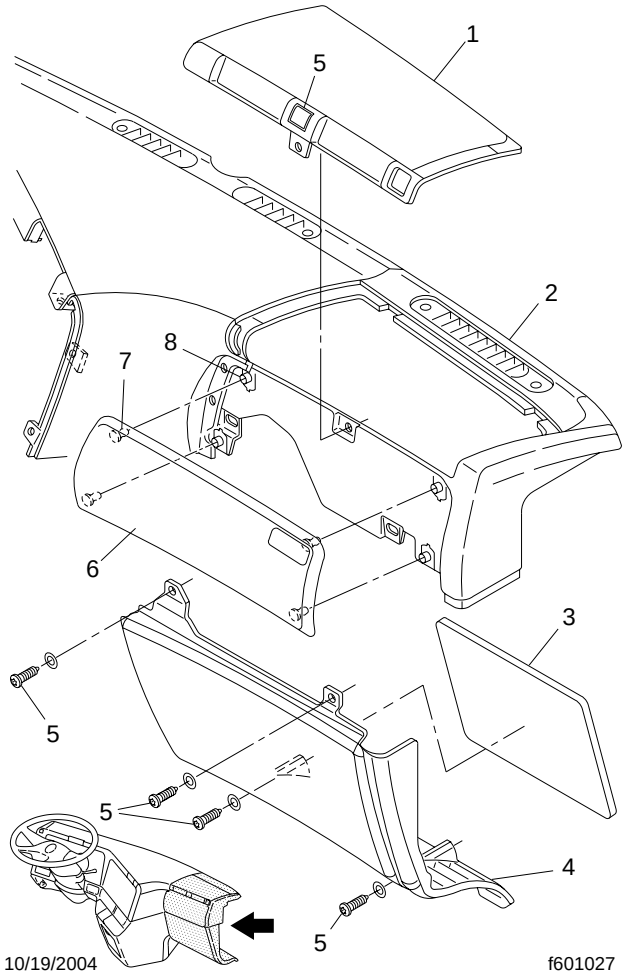
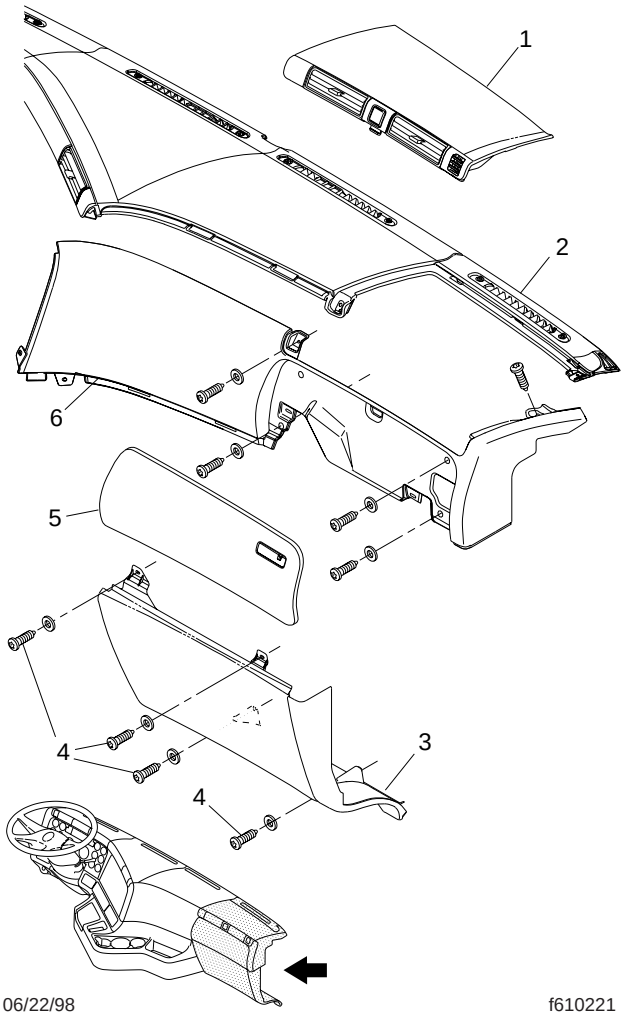
1. Dash End Cap
2. Steering Column Cover
3. Transmission Opening
4. Instrument Panel Center Trim
5. Upper Dash Assembly (left-hand panel)
6. Right-Hand Dash Trimcap
7. Upper Dash Assembly (right-hand panel)
8. Upper Dash Assembly (center panel)
9. Upper Dash Electrical Access Panel
10. Dash Assembly, Right-Hand
11. Dash Cover
12. HVAC Cover
13. Lower Dash Console

Fig. 3, Dash Panels, Argosy COE



1. Electrical Cover
2. Upper Dash Assembly, Right-Hand
3. Cover Seal
4. Heater and Air Conditioner Cover
5. T25 Dog-Point Screw
6. Upper Dash Cover, Right-Hand
7. Speed Clip
8. Speed Nut

Fig. 4, Right-Hand Dash Panels, Century Class Conventional, LH DR



1. Electrical Cover
2. Upper Dash Assembly
3. HVAC Cover
4. T25 Dog-Point Screw
5. Dash Cover
6. Upper Dash Assembly (center panel)

Fig. 5, Right-Hand Dash Panels, Argosy COE

Blower Motor Removal and Installation

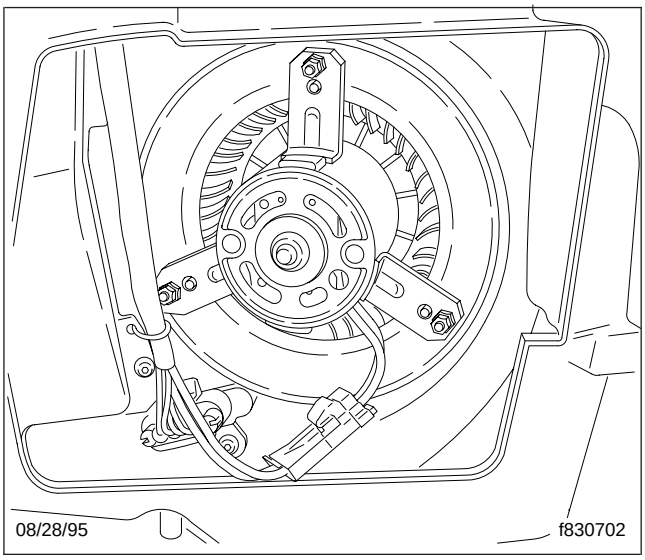


Fig. 6, Blower Motor Mounting and Electrical Connector

Replacement

CAUTION

Never try to bypass the fuse in the blower motor resistor block. To do so could cause the blower motor to overheat, resulting in serious damage to the heater and air-conditioning system.

WARNING

Failure to turn off the ignition switch could allow the blower motor to operate during repairs. This could result in personal injury or electrical shock.

1. Turn off the engine, apply the brakes, and chock the tires.

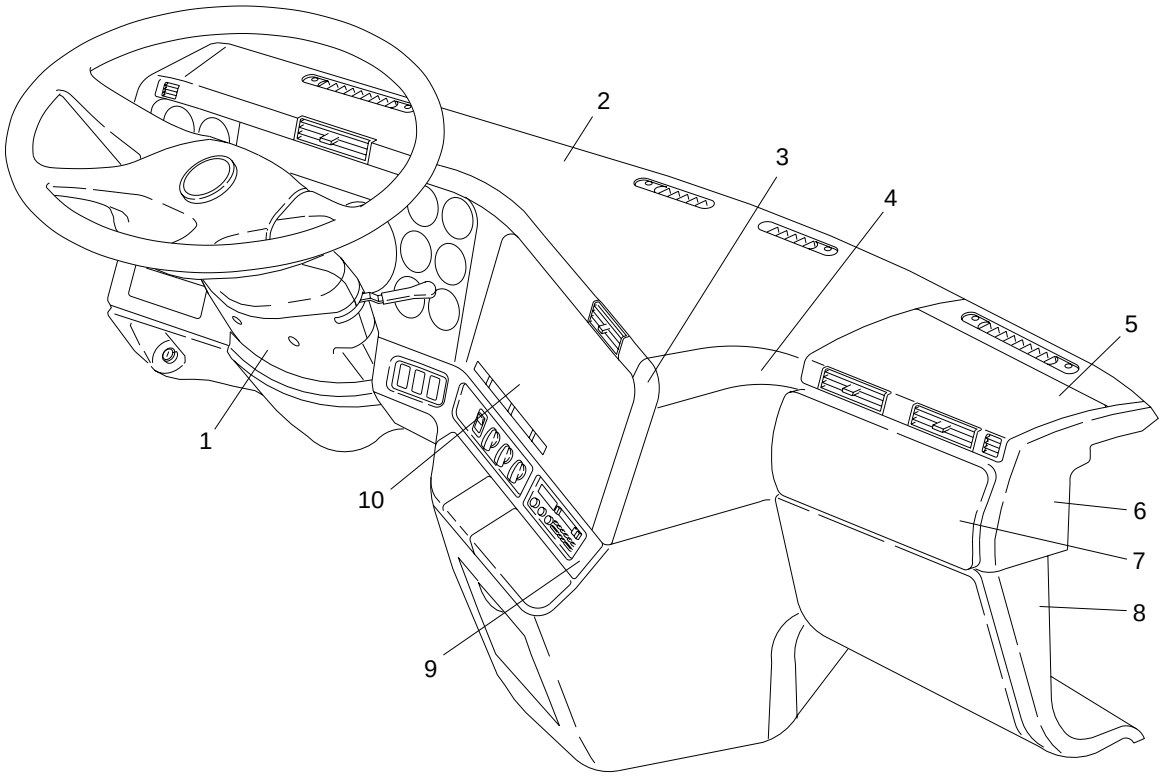
NOTE: When the dash is completely assembled, all dash fasteners are hidden from view. See **Fig. 1**, **Fig. 2**, and **Fig. 3**.

2. Remove the right-hand dash panels as needed to access the resistor block. See **Fig. 4** and **Fig. 5**. For instructions, see **Group 60**.

NOTE: On right-hand-drive (RH DR) vehicles, the dash panels are in the reverse position from the left-hand-drive (LH DR) vehicle.

3. Disconnect the harness from the resistor block. See **Fig. 6**.
4. Remove the two screws and lift out the resistor block.
5. Position the new resistor block and install the mounting screws firmly.
6. Connect the wire harness.
7. Turn on the ignition key and test the blower motor.
8. Install the right-hand dash covers. For instructions, see **Group 60**.
9. Remove the chocks from the tires.

Resistor Block Replacement



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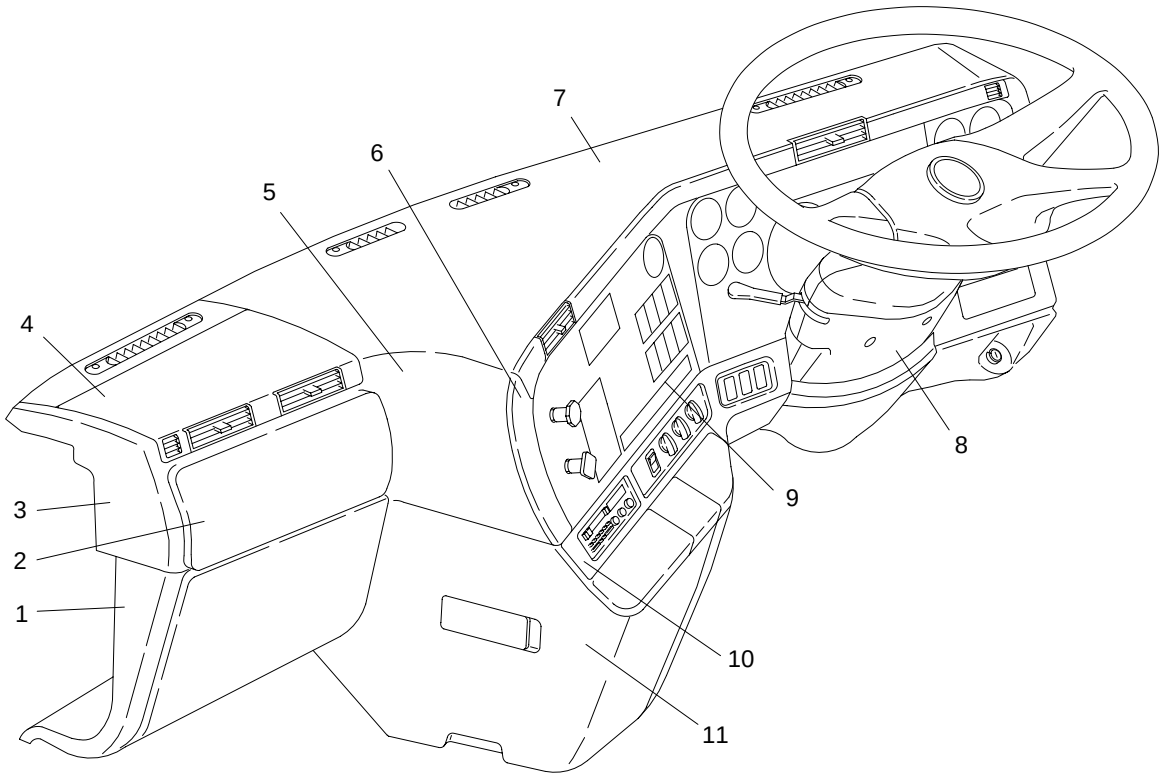
1. Steering Column Cover
2. Upper Dash Assembly (left-hand panel)
3. Dash Trim Cap, Right-Hand
4. Upper Dash Assembly, Center Panel
5. Electrical Cover
6. Upper Dash Assembly, Right-Hand
7. Upper Dash Cover, Right-Hand
8. Heater and Air Conditioner Cover
9. Waste Bin Outer Wall
10. Console Cover, Right-Hand
11. HVAC/Radio Trim Plate
12. Auxiliary Gauge Panel

Fig. 1, Dash Panels, Century Class Conventional, LH DR



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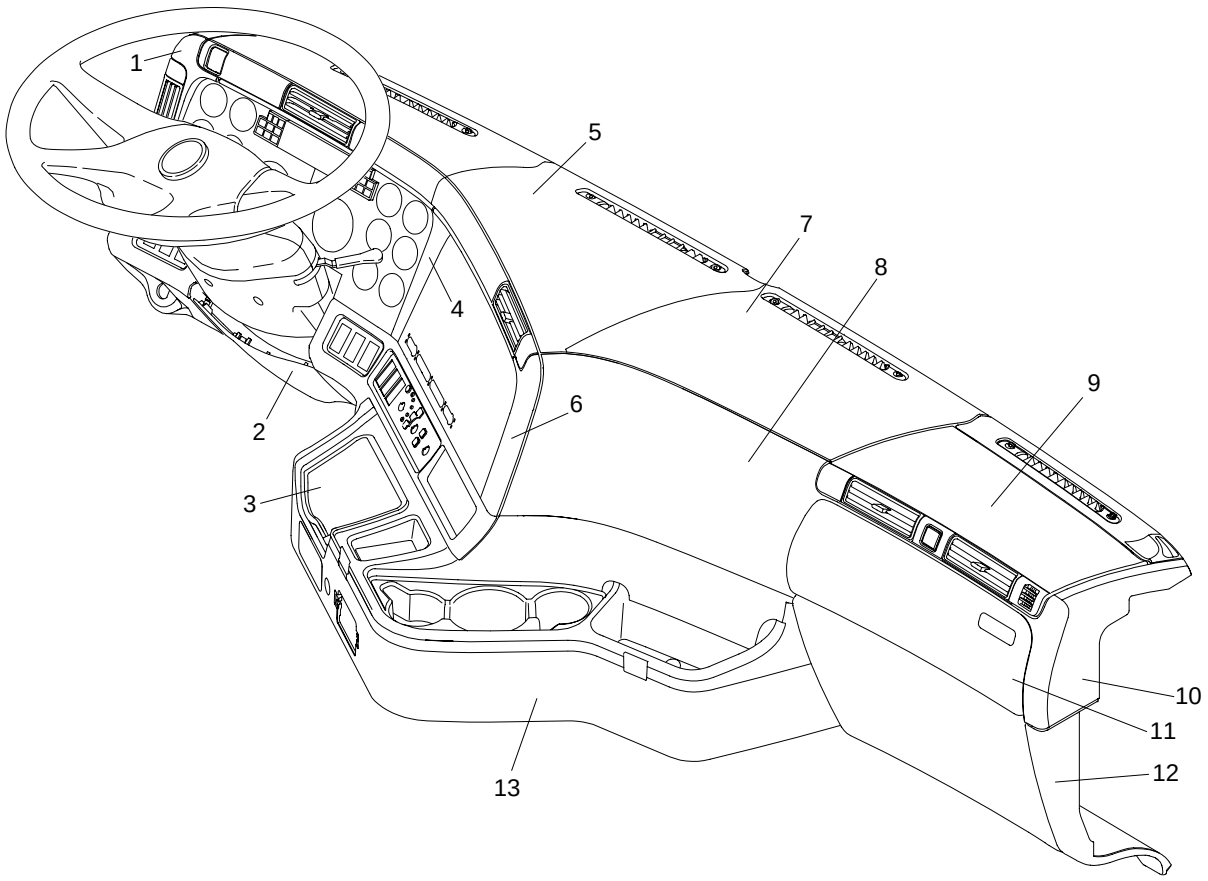
1. Heater and Air Conditioner Cover
2. Upper Dash Cover, Left-Hand
3. Upper Dash Assembly, Left-Hand
4. Electrical Cover
5. Upper Dash Assembly, Center Panel
6. Dash Trim Cap, Left-Hand
7. Upper Dash Assembly (right-hand panel)
8. Steering Column Cover
9. Auxiliary Gauge Panel
10. HVAC/Radio Trim Plate
11. Console Cover, Left-Hand

Fig. 2, Dash Panels, Century Class Conventional, RH DR

Resistor Block Replacement



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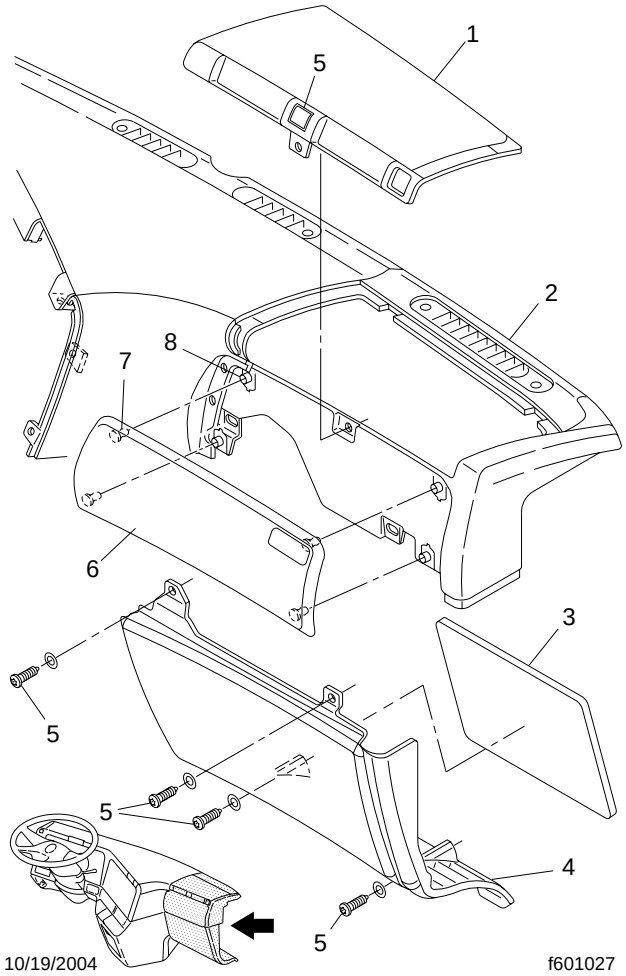
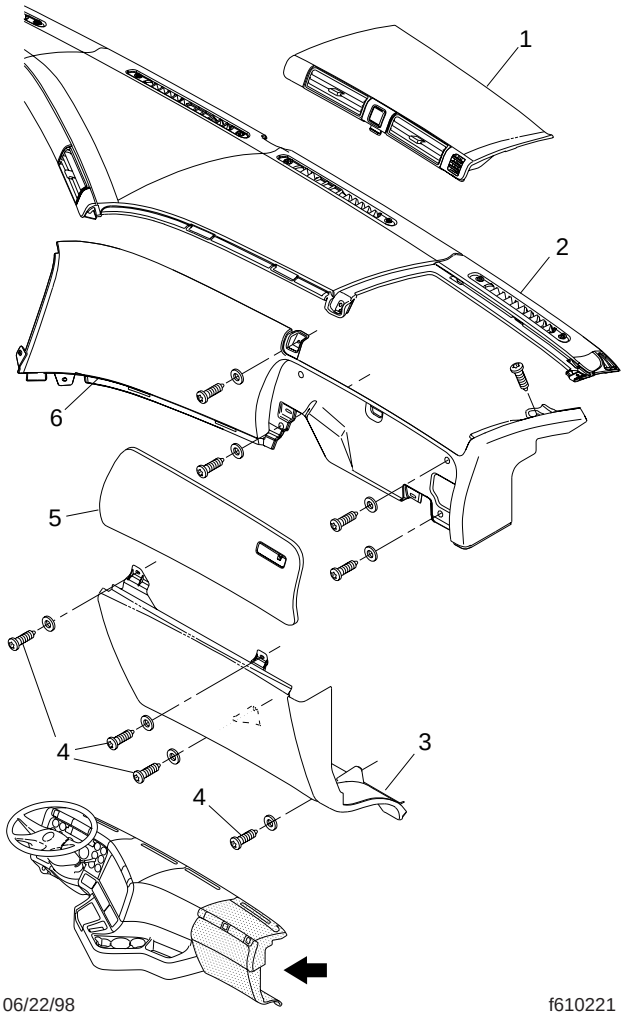
1. Dash End Cap
2. Steering Column Cover
3. Transmission Opening
4. Instrument Panel Center Trim
5. Upper Dash Assembly (left-hand panel)
6. Right-Hand Dash Trimcap
7. Upper Dash Assembly (right-hand panel)
8. Upper Dash Assembly (center panel)
9. Upper Dash Electrical Access Panel
10. Dash Assembly, Right-Hand
11. Dash Cover
12. HVAC Cover
13. Lower Dash Console

Fig. 3, Dash Panels, Argosy COE



1. Electrical Cover
2. Upper Dash Assembly, Right-Hand
3. Cover Seal
4. Heater and Air Conditioner Cover
5. T25 Dog-Point Screw
6. Upper Dash Cover, Right-Hand
7. Speed Clip
8. Speed Nut

Fig. 4, Right-Hand Dash Panels, Century Class Conventional, LH DR



1. Electrical Cover
2. Upper Dash Assembly
3. HVAC Cover
4. T25 Dog-Point Screw
5. Dash Cover
6. Upper Dash Assembly (center panel)

Fig. 5, Right-Hand Dash Panels, Argosy COE

Resistor Block Replacement

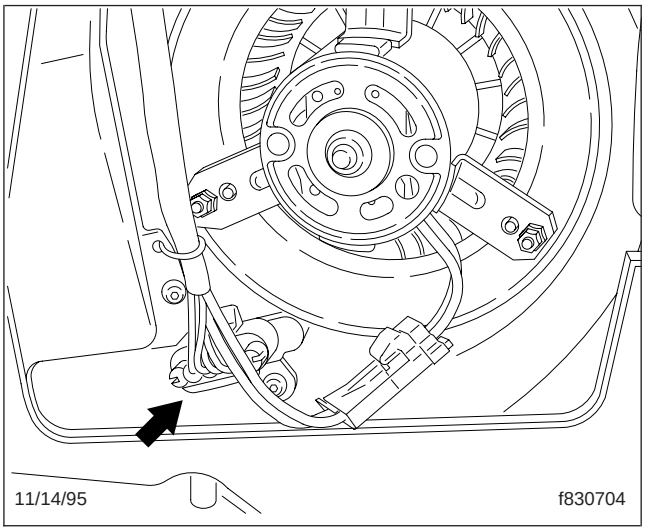
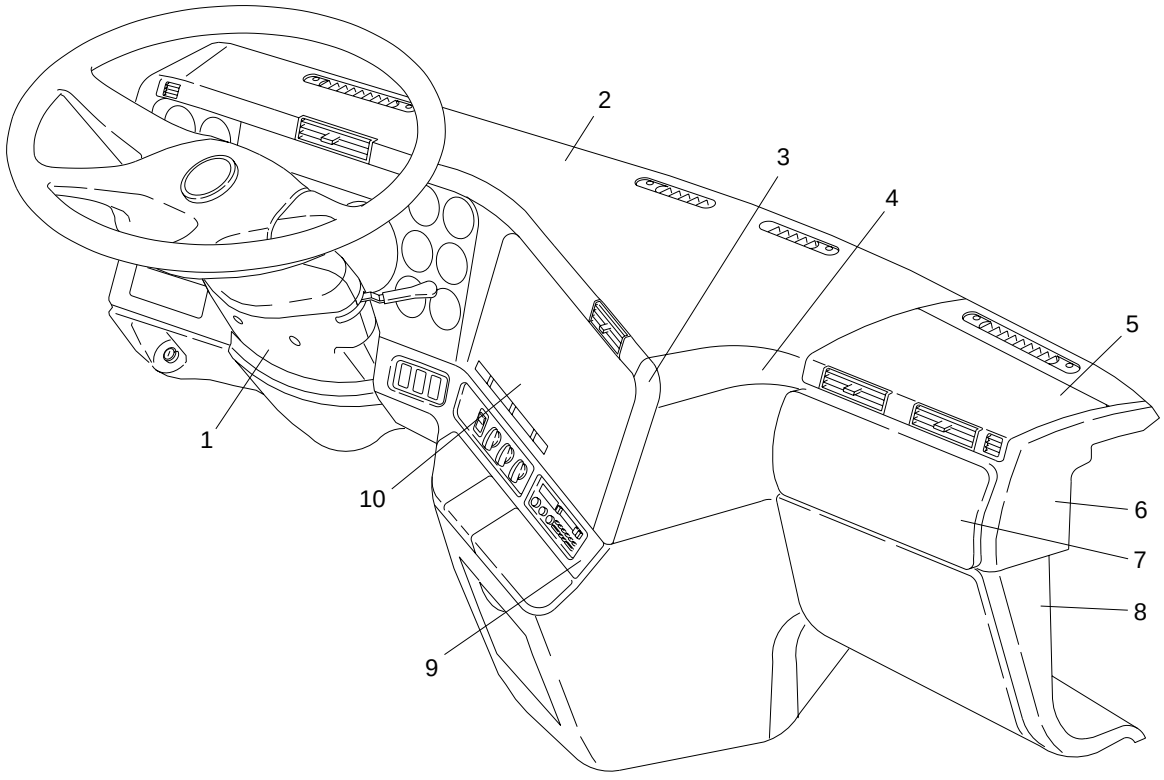


Fig. 6, Resistor Block

Replacement

NOTE: When the dash is completely assembled, all dash fasteners are hidden from view. See **Fig. 1**, **Fig. 2**, and **Fig. 3**.

2. Disconnect the air line from the cylinder by pushing in the collar and pulling out the air line. See **Fig. 5**.
3. Remove the attachment clips, then remove the air cylinder.



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1. Steering Column Cover
2. Upper Dash Assembly (left-hand panel)
3. Dash Trim Cap, Right-Hand
4. Upper Dash Assembly, Center Panel
5. Electrical Cover
6. Upper Dash Assembly, Right-Hand
7. Upper Dash Cover, Right-Hand
8. Heater and Air Conditioner Cover
9. Waste Bin Outer Wall
10. Console Cover, Right-Hand
11. HVAC/Radio Trim Plate
12. Auxiliary Gauge Panel

Fig. 1, Dash Panels, Century Class Conventional, LH DR

Inlet Air Cylinder

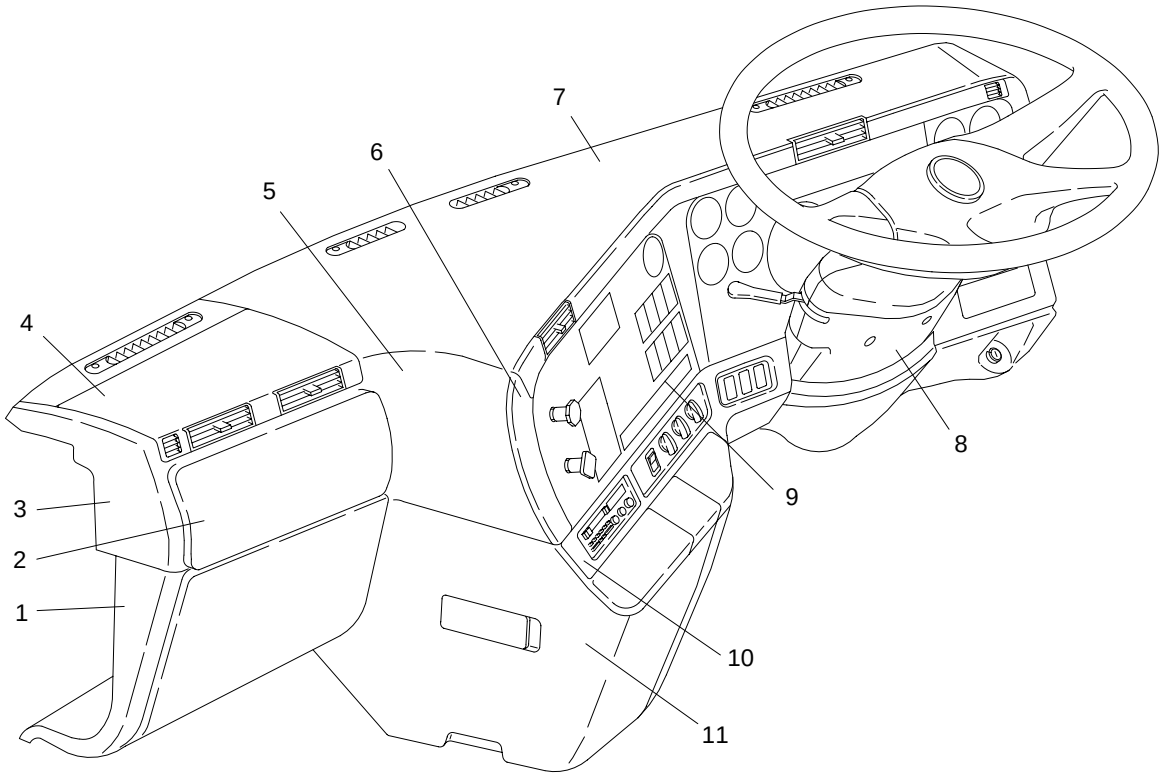
1. Remove the right-hand dash panels as needed to access the air cylinder. See **Fig. 4**. For instructions, refer to **Group 60**.

NOTE: On right-hand-drive (RH DR) vehicles, the dash panels are in the reverse position from the left-hand-drive (LH DR) vehicle.

NOTE: During installation, use a socket to ensure even pressure on the clips.

4. Using new attachment clips, install the new air cylinder.
5. Install the right-hand dash panels. For instructions, refer to **Group 60**.

Air Cylinder Replacement



1. Heater and Air Conditioner Cover
2. Upper Dash Cover, Left-Hand
3. Upper Dash Assembly, Left-Hand
4. Electrical Cover
5. Upper Dash Assembly, Center Panel
6. Dash Trim Cap, Left-Hand
7. Upper Dash Assembly (right-hand panel)
8. Steering Column Cover
9. Auxiliary Gauge Panel
10. HVAC/Radio Trim Plate
11. Console Cover, Right-Hand

Fig. 2, Dash Panels, Century Class Conventional, RH DR

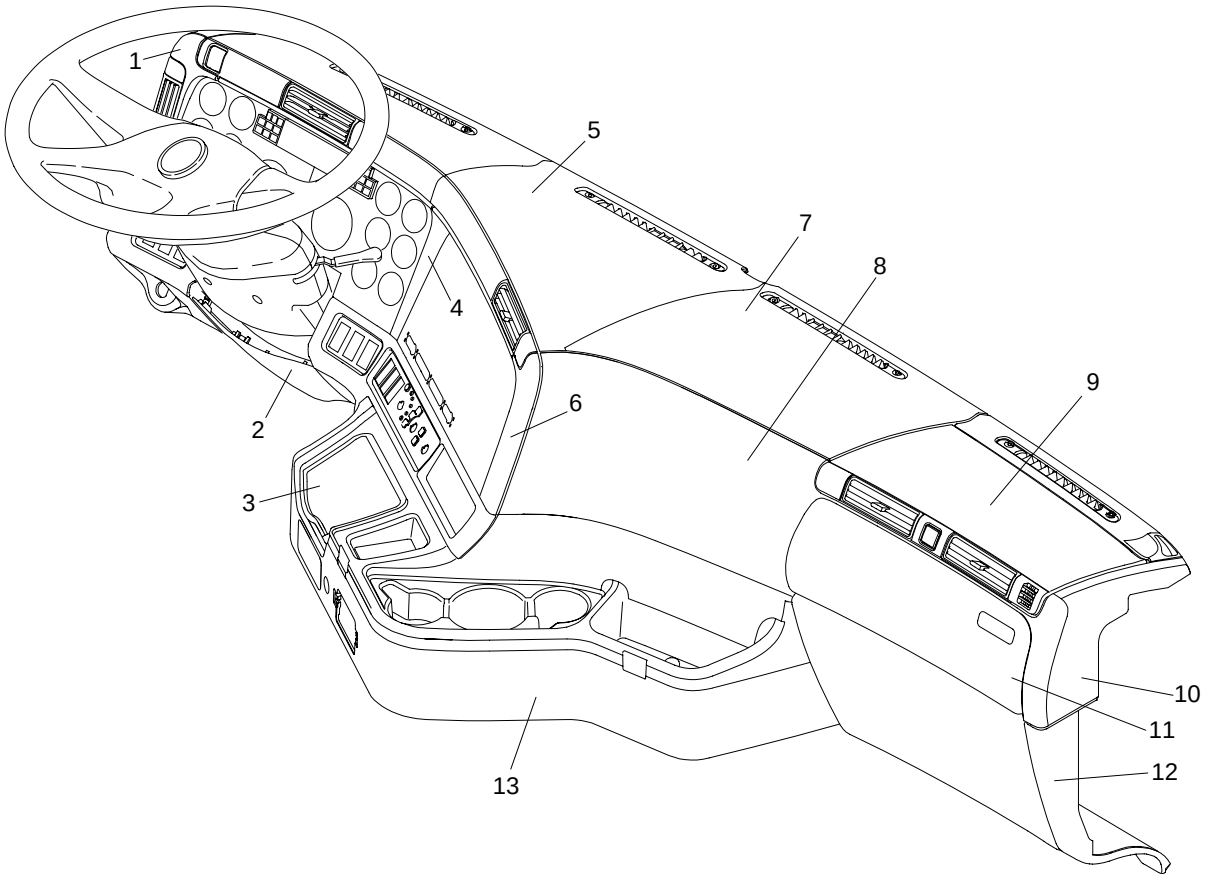
Face and Heat/Defrost Air Cylinder

NOTE: The face and heat/defrost air cylinder is located near the center of the dash assembly. See **Fig. 6**.

1. Remove the right-hand dash panels, left-hand dash panels, and upper dash panels as needed to access the air cylinder. See **Fig. 7**, **Fig. 8**, **Fig. 9**, **Fig. 10** and **Fig. 11**. For instructions, refer to **Group 60**.
2. Move the wiring harness trough out of the way.
3. Disconnect the air lines from the cylinder by pushing in the collar and pulling out the air line. See **Fig. 5**.
4. Remove the attachment clips, then remove the air cylinder.

NOTE: During installation, use a socket to ensure even pressure on the clips.

5. Using new attachment clips, install the new air cylinder.
6. Move the wiring harness trough into position in the dash.
7. Install the dash panels. For instructions, refer to **Group 60**.



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1. Dash End Cap
2. Steering Column Cover
3. Transmission Opening
4. Instrument Panel Center Trim
5. Upper Dash Assembly (left-hand panel)
6. Right-Hand Dash Trimcap
7. Upper Dash Assembly (right-hand panel)
8. Upper Dash Assembly (center panel)
9. Upper Dash Electrical Access Panel
10. Dash Assembly, Right-Hand
11. Dash Cover
12. HVAC Cover
13. Lower Dash Console

Fig. 3, Dash Panels, Argosy COE

Heat/Defrost Air Cylinder

NOTE: The heat/defrost air cylinder is located under the upper dash panels near the center of the windshield. See **Fig. 6**.

1. Remove the right-hand dash panels, left-hand dash panels, and upper dash panels as needed to access the air cylinder. See **Fig. 7**, **Fig. 8**, **Fig. 9**, **Fig. 10**, and **Fig. 11**. For instructions, refer to **Group 60**.
2. Disconnect the air lines from the cylinder by pushing in the collar and pulling out the air line. See **Fig. 5**.
3. Remove the attachment clips, then remove the air cylinder.

NOTE: During installation, use a socket to ensure even pressure on the clips.

Air Cylinder Replacement

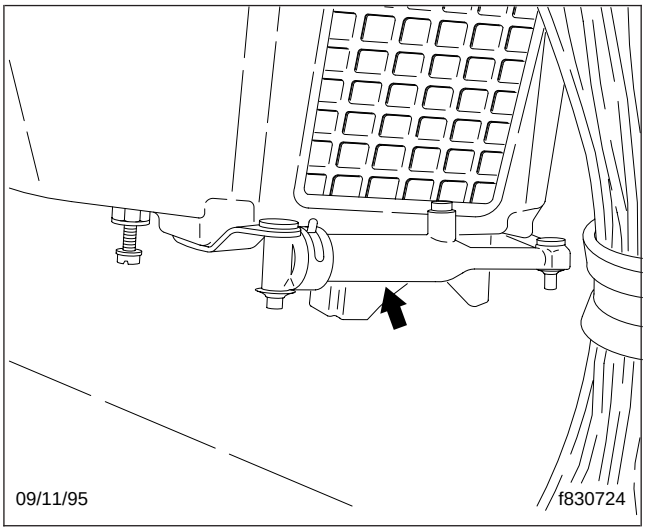
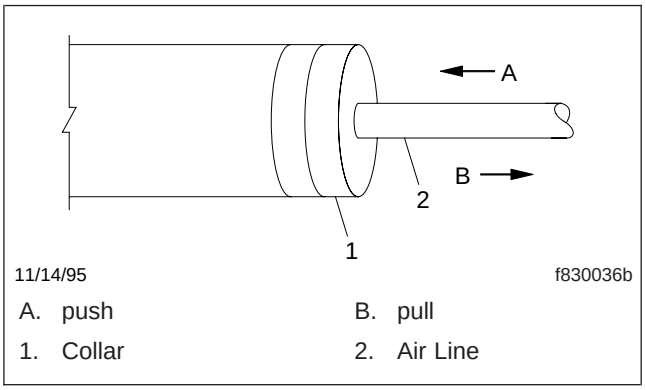


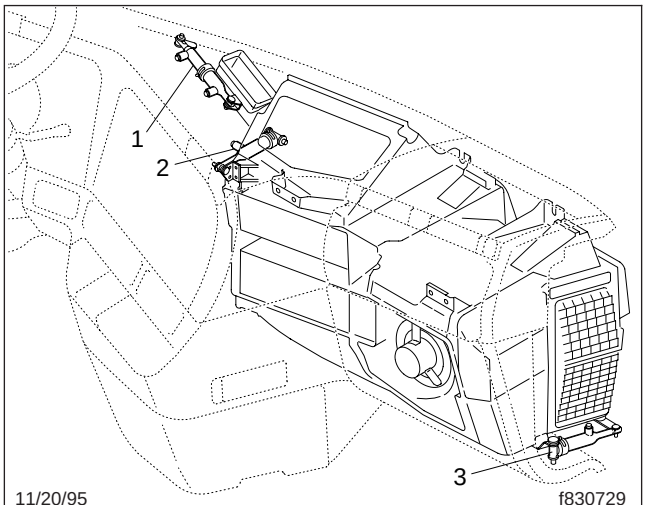
Fig. 4, Inlet Air Cylinder (located under the blower motor)



A. push
B. pull
1. Collar
2. Air Line

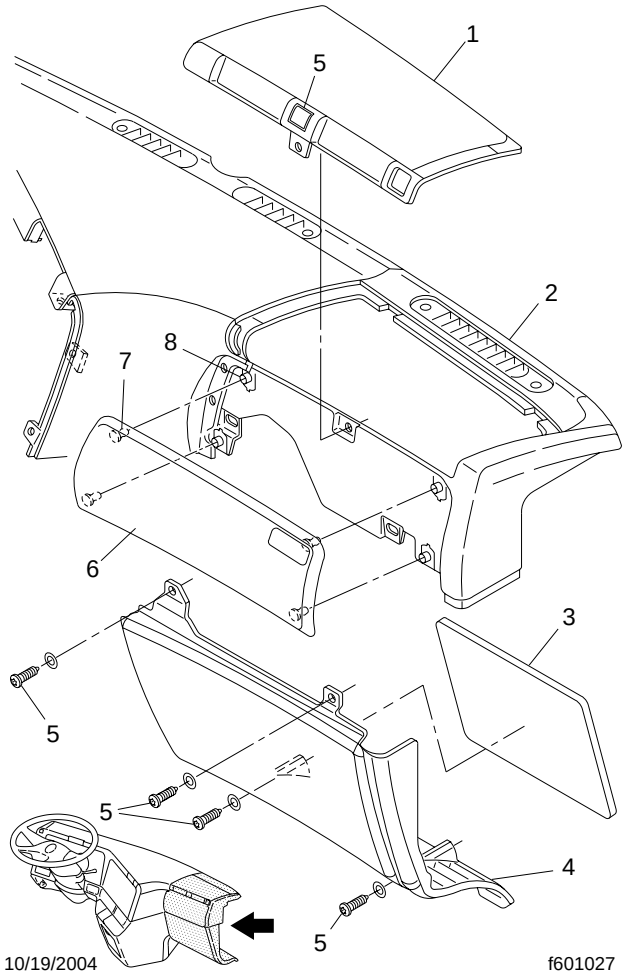
Fig. 5, Air Line

4. Using new attachment clips, install the new air cylinder.
5. Install the dash panels. For instructions, refer to **Group 60**.



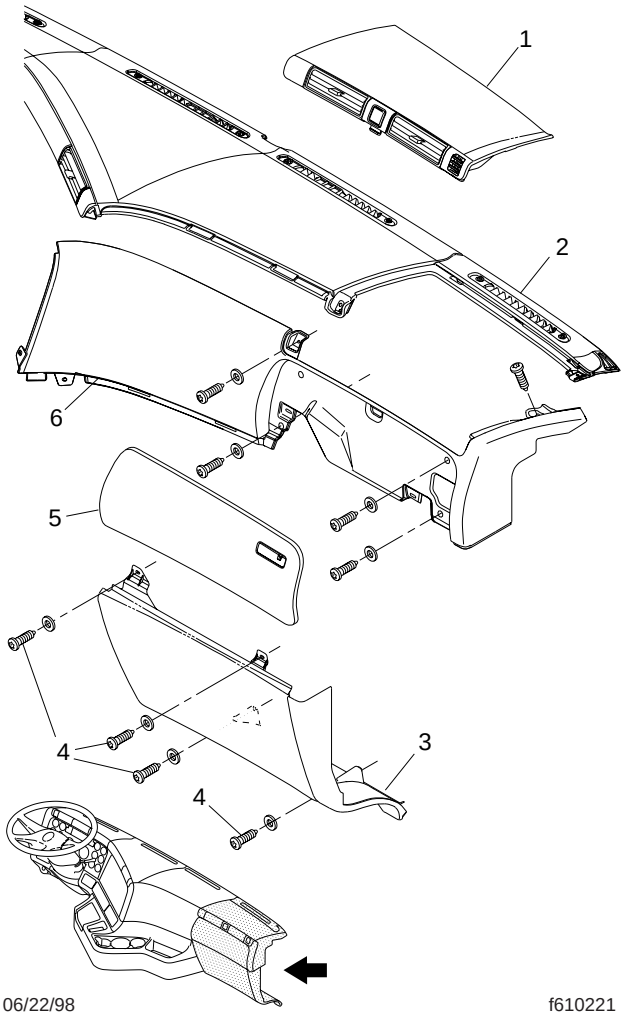
1. Heat/Defrost Air Cylinder
2. Face and Heat/Defrost Air Cylinder
3. Inlet Air Cylinder

Fig. 6, Air Cylinder Locations



1. Electrical Cover
2. Upper Dash Assembly, Right-Hand
3. Cover Seal
4. Heater and Air Conditioner Cover
5. T25 Dog-Point Screw
6. Upper Dash Cover, Right-Hand
7. Speed Clip
8. Speed Nut

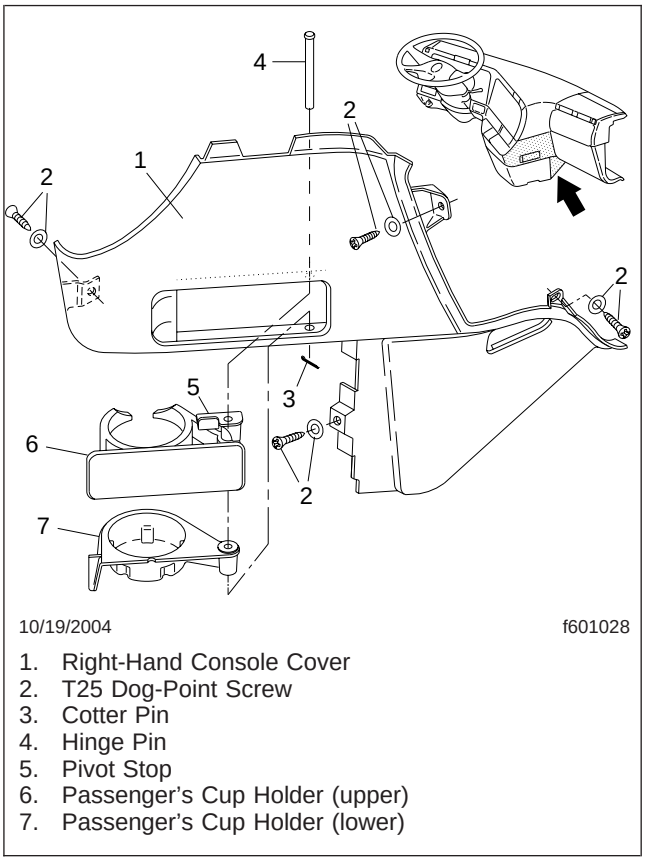
Fig. 7, Right-Hand Dash Panels, Century Class Conventional, LH DR



1. Electrical Cover
2. Upper Dash Assembly
3. HVAC Cover
4. T25 Dog-Point Screw
5. Dash Cover
6. Upper Dash Assembly (center panel)

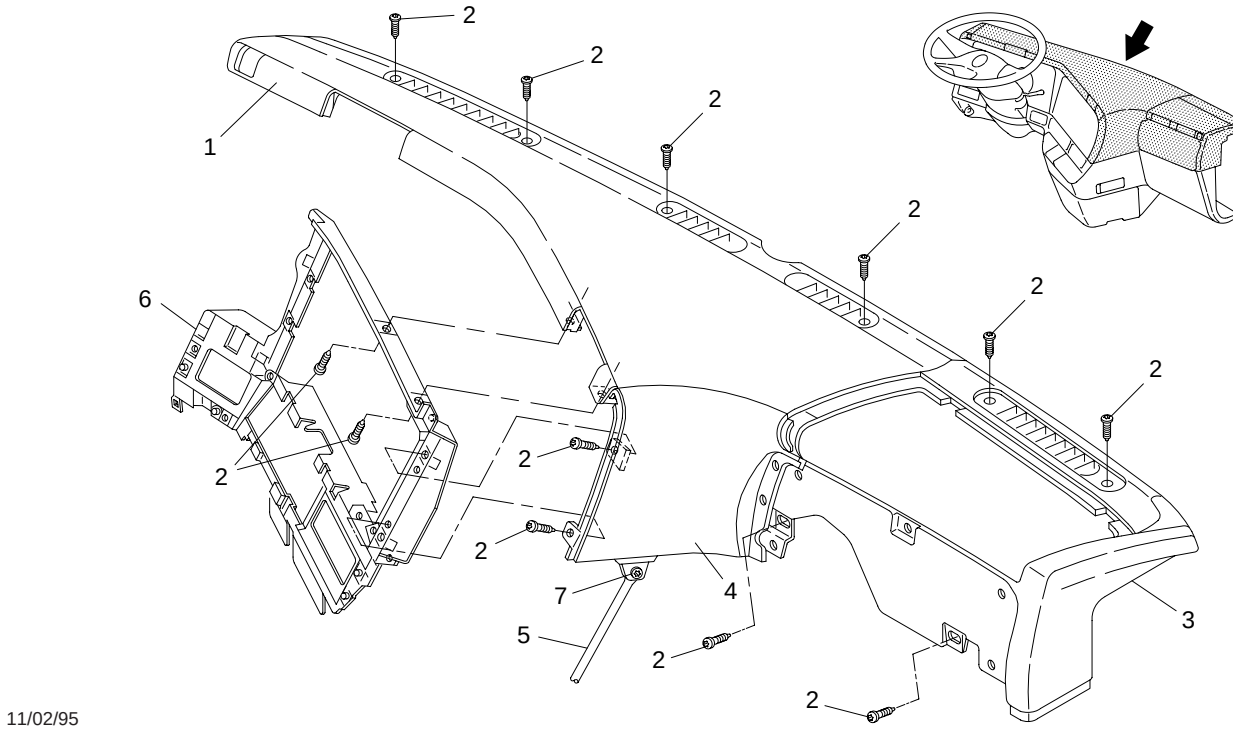
Fig. 8, Right-Hand Dash Panels, Argosy COE

Air Cylinder Replacement



1. Right-Hand Console Cover
2. T25 Dog-Point Screw
3. Cotter Pin
4. Hinge Pin
5. Pivot Stop
6. Passenger's Cup Holder (upper)
7. Passenger's Cup Holder (lower)

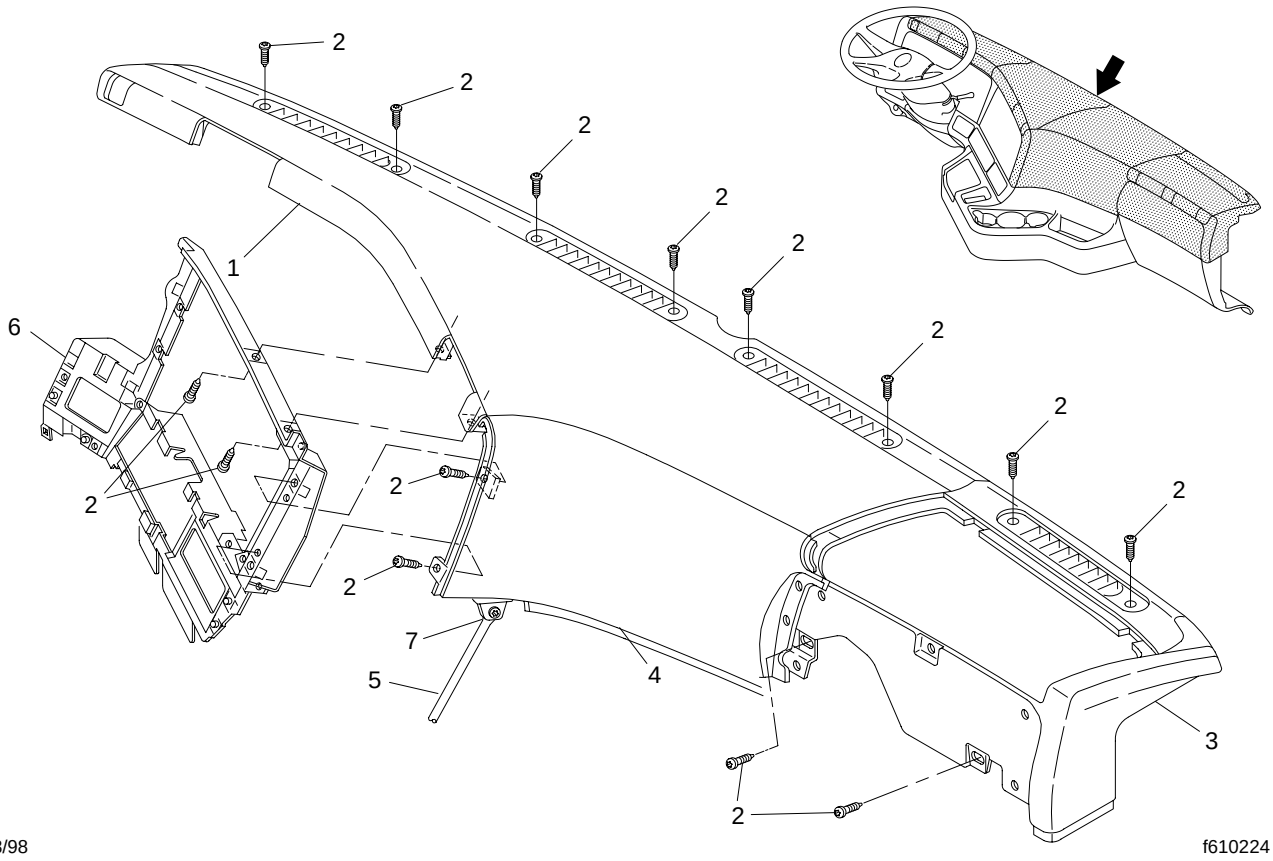
Fig. 9, Right-Hand Console Cover, Century Class Conventional, LH DR



1. Upper Dash Assembly, Left-Hand
2. T25 Dog-Point Screw
3. Upper Dash Assembly, Right-Hand
4. Upper Dash Assembly, Center Panel
5. Dash Brace
6. Upper Dash Panel
7. Dash Brace Screw

Fig. 10, Upper Dash Panels, Century Class Conventional, LH DR

Air Cylinder Replacement



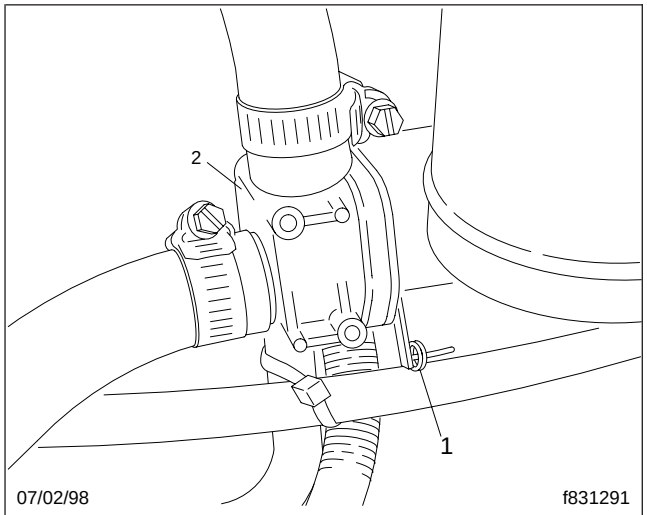
1. Upper Dash Assembly (left-hand panel)
2. T25 Dog-Point Screw
3. Upper Dash Assembly (right-hand panel)
4. Upper Dash Assembly (center-hand panel)
5. Dash Brace
6. Upper Dash Panel
7. Dash Brace Screw

Fig. 11, Upper Dash Panels, Argosy COE

Water Regulating Valve Replacement, Mechanically-Controlled

Replacement

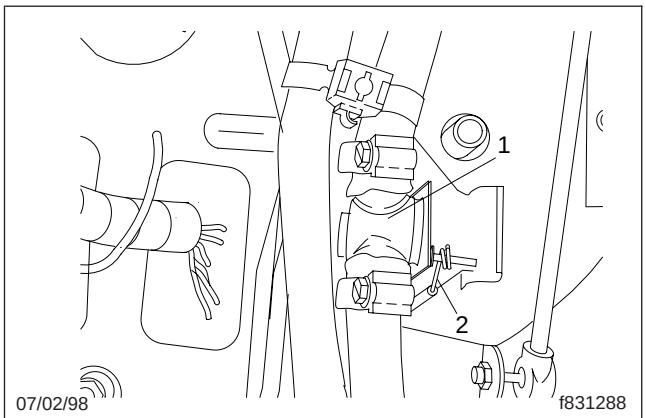
1. Turn off the engine, apply the brakes, and chock the tires.
2. On Century Class Conventionals, open the hood. On Argosy COEs, open the access panel on the front of the vehicle.
3. On Century Class Conventionals, remove the air cleaner. For instructions, refer to **Group 09**.
4. Clamp off the heater hoses to prevent coolant loss.
5. Remove the hoses from the water regulating valve. See **Fig. 1** and **Fig. 2**.



1. Control Cable
2. Water Regulating Valve

Fig. 1, Water Regulating Valve, Century Class Conventional

6. Slip the control cable off the end of the rod. See **Fig. 1** and **Fig. 2**. Remove the control cable from the cable bracket.
7. Remove the nuts and washers that attach the water regulating valve mounting bracket to the frontwall. Remove the valve and mounting bracket.
8. Remove the water regulating valve from the valve mounting bracket. See **Fig. 3** and **Fig. 4**.
9. Place a new water regulating valve on the valve bracket.



1. Water Regulating Valve
2. Control Cable

Fig. 2, Water Regulating Valve, Argosy COE

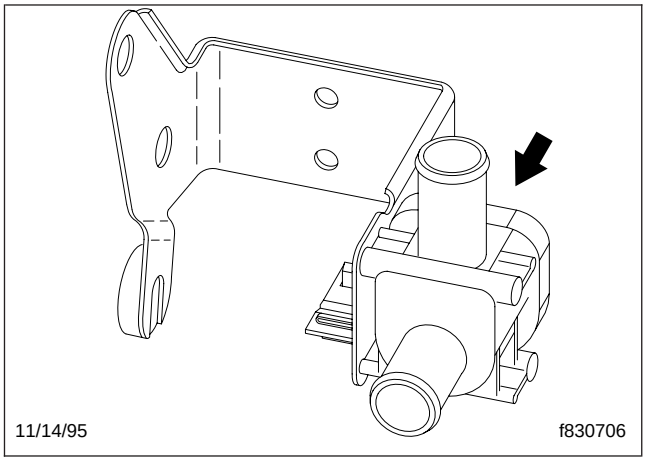
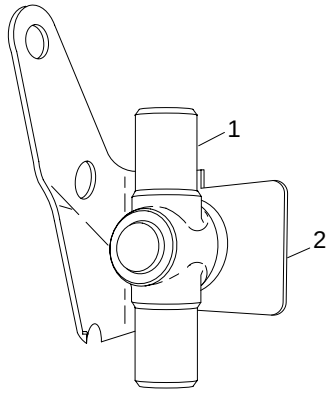


Fig. 3, Water Regulating Valve, Century Class Conventional

10. Place the water regulating valve and mounting bracket on the frontwall. Install the washers and nuts that attach the valve and mounting bracket to the frontwall. Tighten the nuts securely.
11. Place the control cable through the valve mounting bracket, and slip the end of the control cable over the valve rod.
12. Connect the heater hoses to the water regulating valve. Tighten the hose clamps securely.
13. Move the temperature control knob to COOL. The water regulating valve should close completely. Move the control knob to WARM. The valve should open. The travel of the knob should

Water Regulating Valve Replacement, Mechanically-Controlled



1. Water Regulating Valve
2. Mounting Bracket

Fig. 4, Water Regulating Valve, Argosy COE

be smooth. If it isn't, adjust the turnbuckle following the instructions in **Subject 170**.

14. Start the engine. Turn the heat control knob to hot (this opens the water valve). When the engine thermostat(s) opens, air will be forced from the heater core as the coolant circulates. Check the coolant level and fill as needed.
15. Check for leaks around the water regulating valve and correct the cause.
16. On Century Class Conventionals, install the air cleaner. For instructions, refer to **Group 09**.
17. On Century Class Conventionals, return the hood to the operating position. On Argosy COEs, close the access panel
18. Remove the chocks from the tires.

Replacement

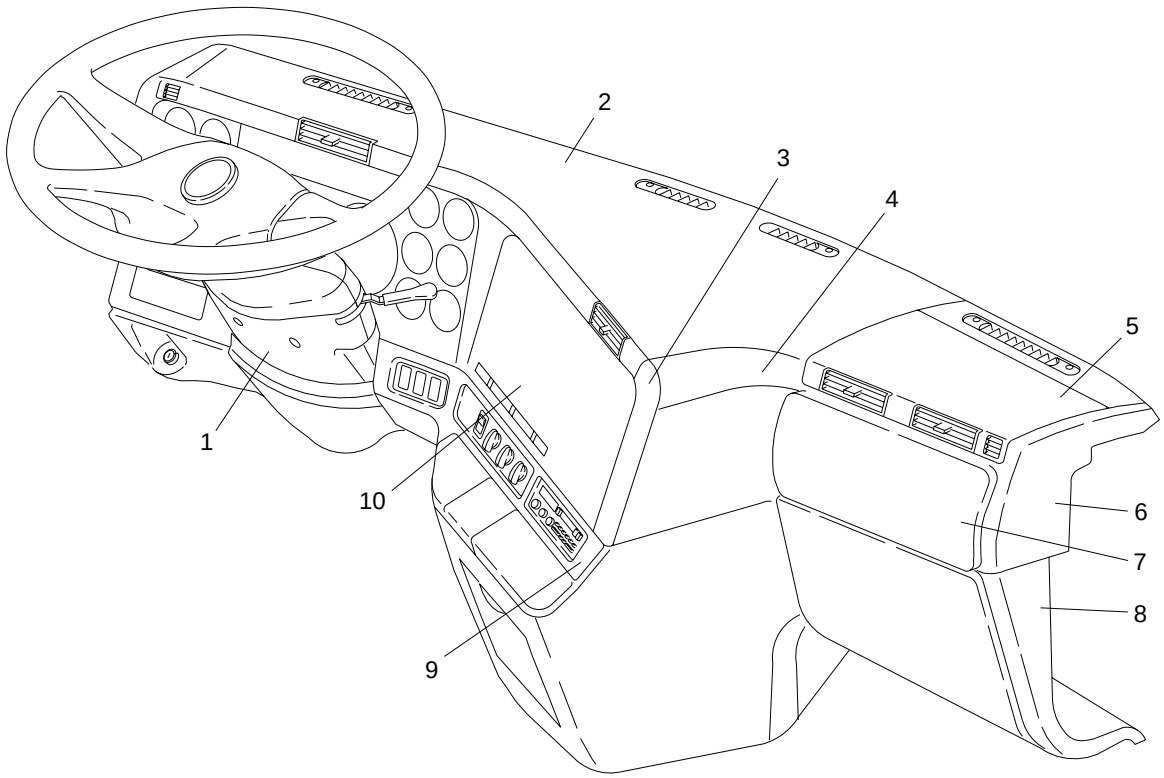
1. Turn off the engine, apply the brakes, and chock the tires.

NOTE: When the dash is completely assembled, all dash fasteners are hidden from view. See **Fig. 1**, **Fig. 2**, and **Fig. 3**.

2. Remove the right-hand dash panels as needed to replace the water regulating valve cable. See **Fig. 4**, **Fig. 5** and **Fig. 6**. For instructions, refer to **Group 60**.

NOTE: On right-hand-drive (RH DR) vehicles, the dash panels are in the reverse position from the left-hand-drive (LH DR) vehicle.

3. Unhook the water regulator valve cable from the temperature control switch assembly.
4. Cut the tie strap that secures the cable to the dash brace.
5. On Century Class Conventionals, open the hood and remove the air cleaner. For instructions, see **Group 09**.
6. Access the water regulating valve.



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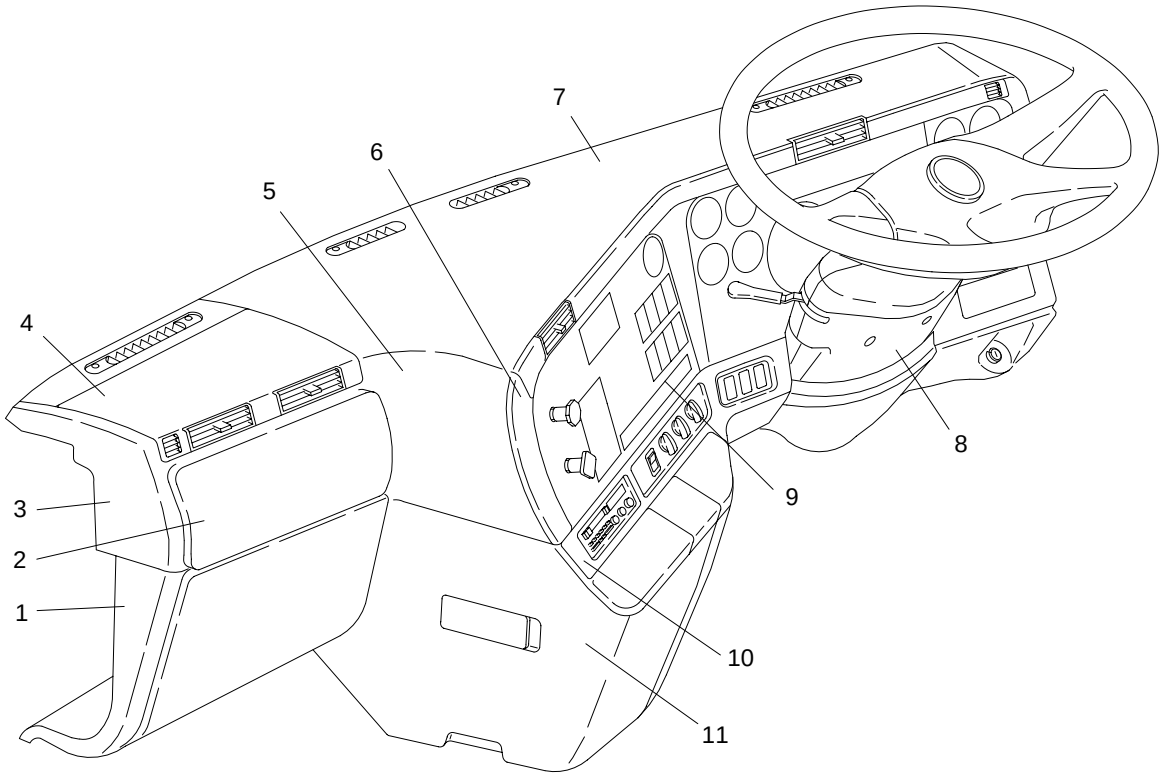
1. Steering Column Cover
2. Upper Dash Assembly (left-hand panel)
3. Dash Trim Cap, Right-Hand
4. Upper Dash Assembly, Center Panel
5. Electrical Cover
6. Upper Dash Assembly, Right-Hand
7. Upper Dash Cover, Right-Hand
8. Heater and Air Conditioner Cover
9. Waste Bin Outer Wall
10. Console Cover, Right-Hand
11. HVAC/Radio Trim Plate
12. Auxiliary Gauge Panel

Fig. 1, Dash Panels, Century Class Conventional, LH DR

Water Regulating Valve Cable Replacement



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1. Heater and Air Conditioner Cover
2. Upper Dash Cover, Left-Hand
3. Upper Dash Assembly, Left-Hand
4. Electrical Cover
5. Upper Dash Assembly, Center Panel
6. Dash Trim Cap, Left-Hand
7. Upper Dash Assembly (right-hand panel)
8. Steering Column Cover
9. Auxiliary Gauge Panel
10. HVAC/Radio Trim Plate
11. Console Cover, Left-Hand

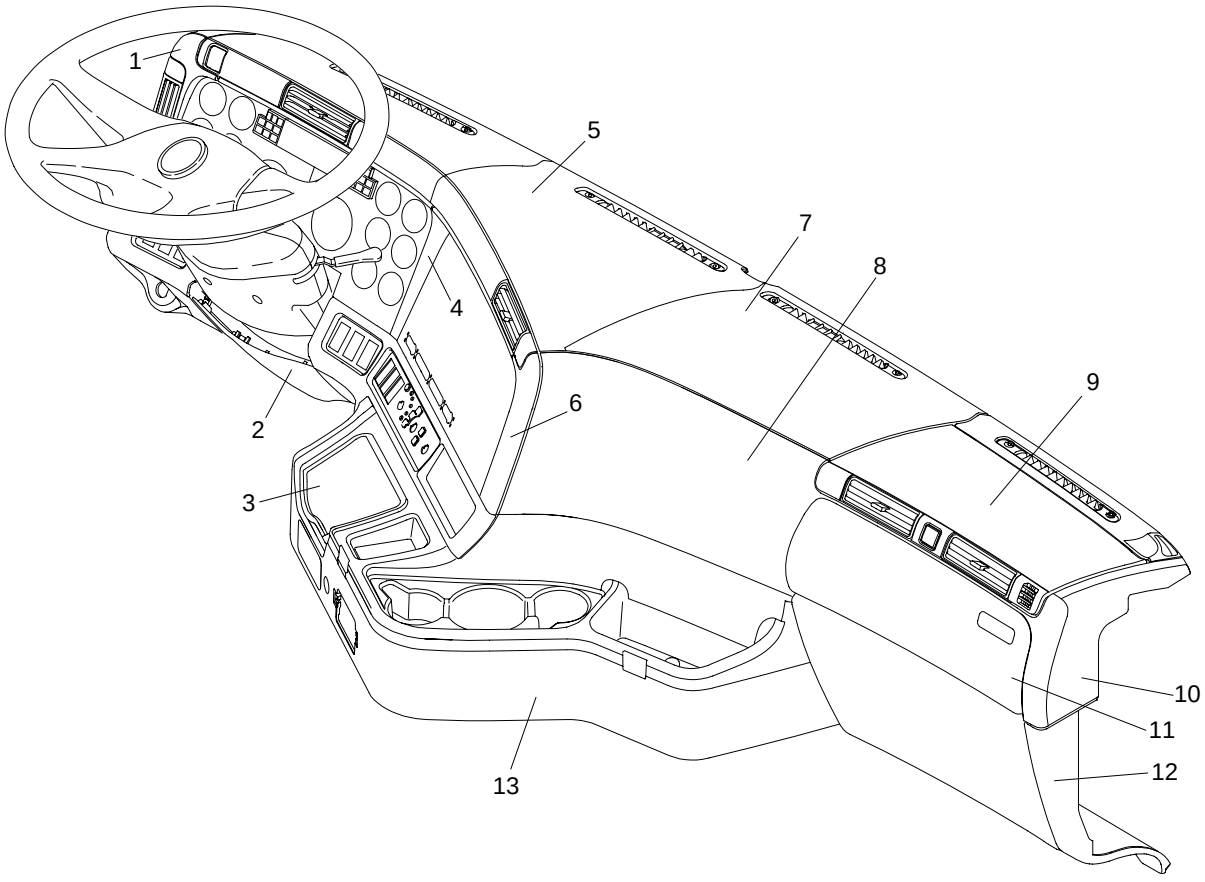
Fig. 2, Dash Panels, Century Class Conventional, RH DR

On Century Class Conventionals, open the hood.

On Argosy COEs, open the access panel on the front of the vehicle.

7. Slip the control cable off the end of the rod on the water regulating valve. See **Fig. 7** and **Fig. 8**. Remove the cable from the cable bracket.
8. Inside the cab, pull the cable out of the engine compartment.
9. Inside the cab, feed the replacement cable through the frontwall and through the clamp. Slip the end of the cable over the water regulating valve rod. Place the cable in the cable bracket and secure it to the valve mounting bracket.
10. At the other end of the cable, feed the end of the cable through the cable clamp and hook the end on the temperature control switch.
11. Tie strap the cable to the dash brace.
12. On Century Class Conventionals, install the air cleaner. For instructions, see **Group 09**.
13. Position the control panel on the dash.
14. Adjust the cable.

    The temperature control knob should spring back from the full-hot and full-cold positions. The amount of spring back should be equal at each of these positions. If it isn't, turn the adjustment turnbuckle as needed to correct.



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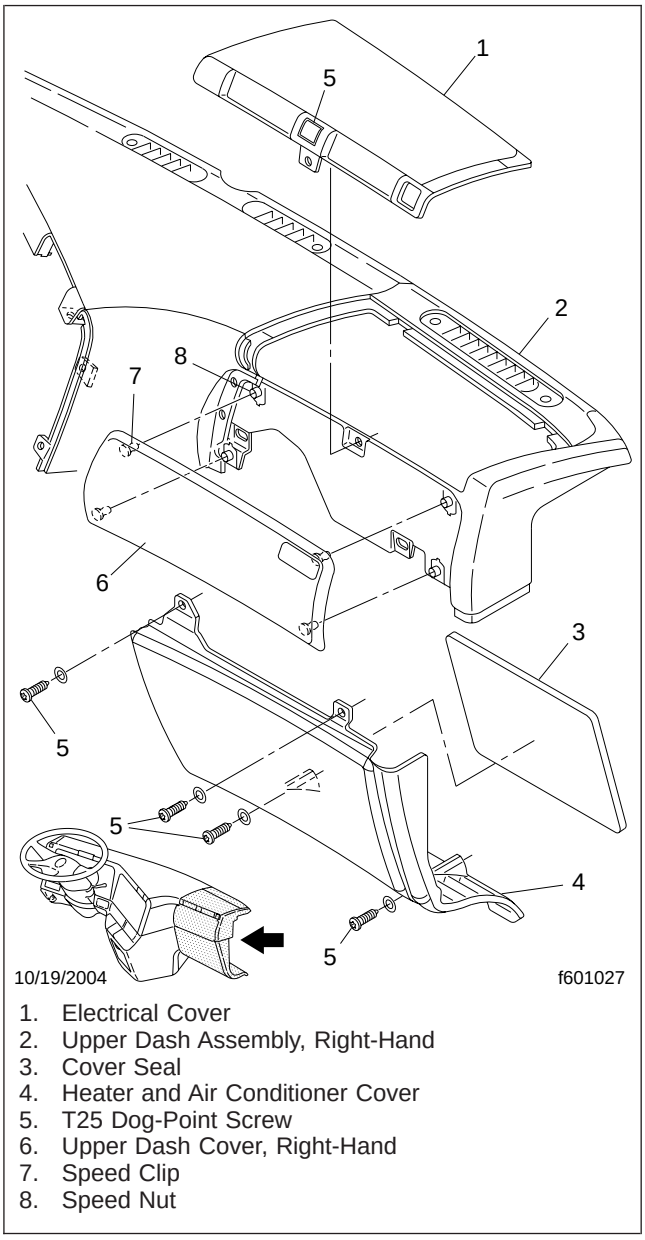
1. Dash End Cap
2. Steering Column Cover
3. Transmission Opening
4. Instrument Panel Center Trim
5. Upper Dash Assembly (left-hand panel)
6. Right-Hand Dash Trimcap
7. Upper Dash Assembly (right-hand panel)
8. Upper Dash Assembly (center panel)
9. Upper Dash Electrical Access Panel
10. Dash Assembly, Right-Hand
11. Dash Cover
12. HVAC Cover
13. Lower Dash Console

Fig. 3, Dash Panels, Argosy COE

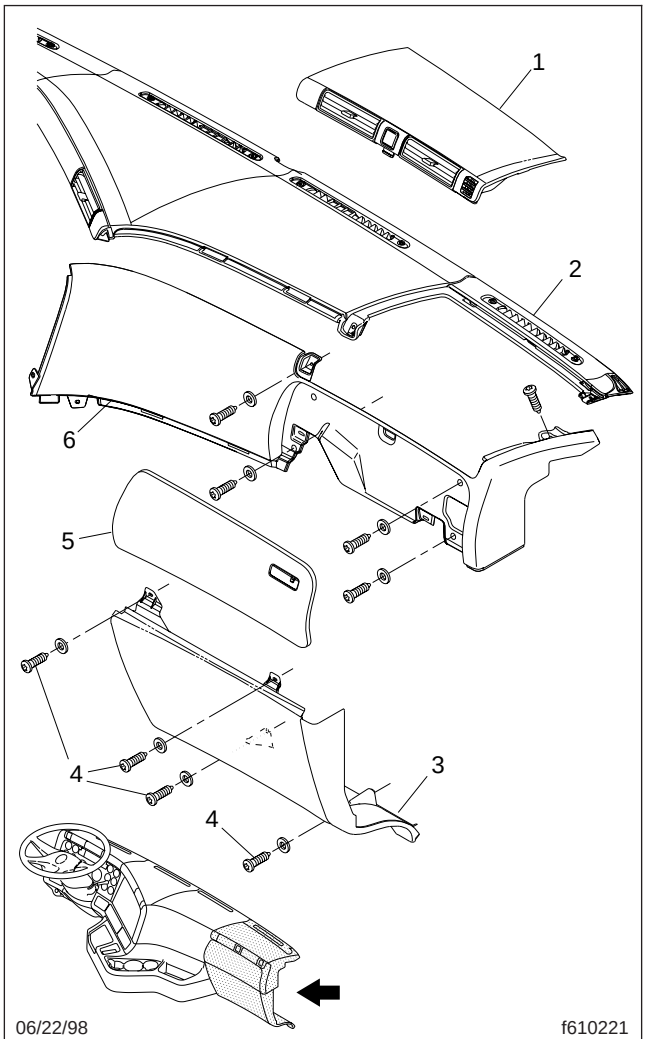
15. On Century Class Conventionals, close the hood to the operating position. On Argosy COEs, close the access panel
16. Install the dash panels. For instructions, see **Group 60**.
17. Remove the chocks from the tires.

Water Regulating Valve Cable Replacement



1. Electrical Cover
2. Upper Dash Assembly, Right-Hand
3. Cover Seal
4. Heater and Air Conditioner Cover
5. T25 Dog-Point Screw
6. Upper Dash Cover, Right-Hand
7. Speed Clip
8. Speed Nut

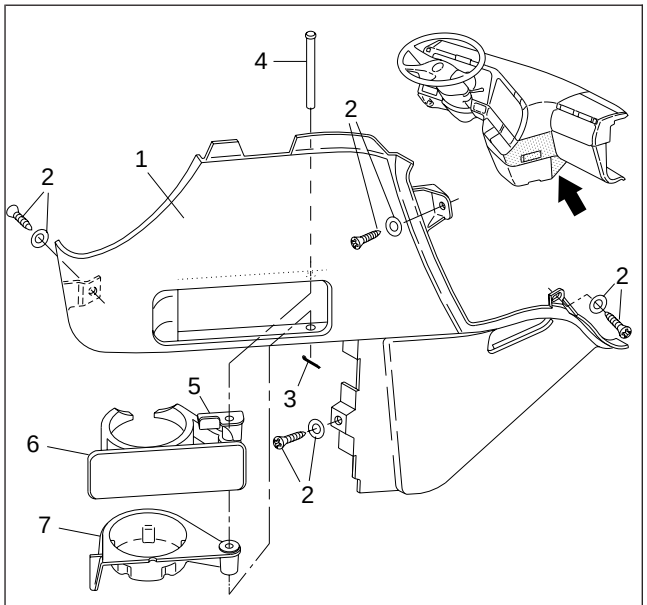
Fig. 4, Right-Hand Dash Panels, Century Class Conventional, LH DR



1. Electrical Cover
2. Upper Dash Assembly
3. HVAC Cover
4. T25 Dog-Point Screw
5. Dash Cover
6. Upper Dash Assembly (center panel)

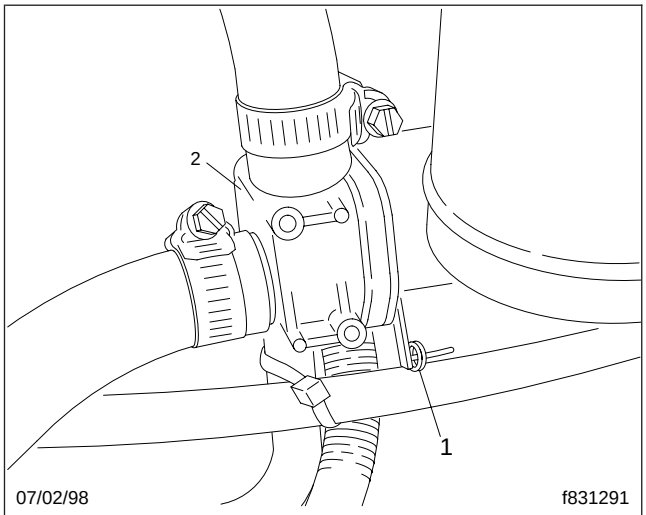
Fig. 5, Right-Hand Dash Panels, Argosy COE

Water Regulating Valve Cable Replacement



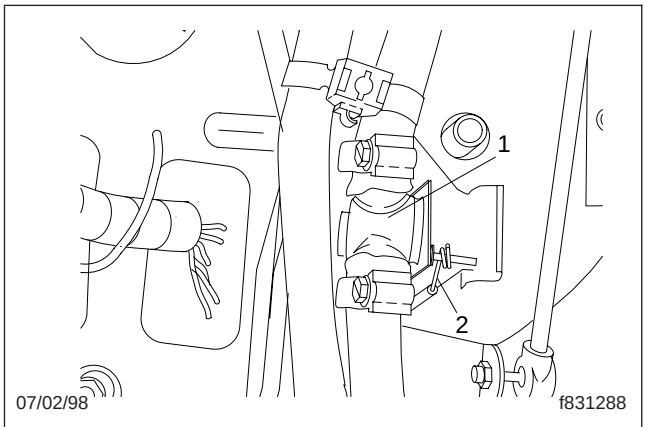
1. Right-Hand Console Cover
2. T25 Dog-Point Screw
3. Cotter Pin
4. Hinge Pin
5. Pivot Stop
6. Passenger's Cup Holder (upper)
7. Passenger's Cup Holder (lower)

Fig. 6, Right-Hand Console Cover, Century Class Conventional, LH DR



1. Control Cable
2. Water Regulating Valve

Fig. 7, Water Regulating Valve, Century Class Conventional



1. Water Regulating Valve
2. Control Cable

Fig. 8, Water Regulating Valve, Argosy COE

Removal

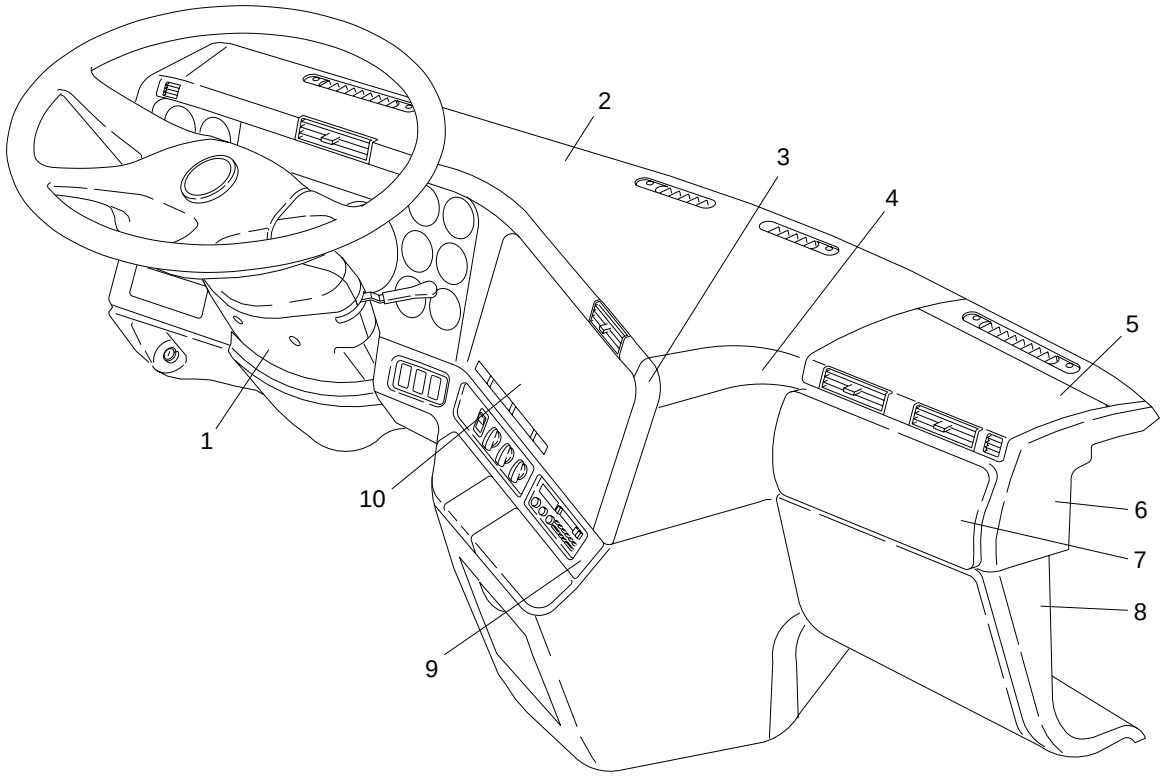
1. Turn off the engine, apply the brakes, and chock the tires.
2. Disconnect the batteries.

NOTE: When the dash is completely assembled, all dash fasteners are hidden from view. See **Fig. 1**, **Fig. 2**, and **Fig. 3**.

3. Remove the right-hand dash panels as needed to access the evaporator coil. See **Fig. 4**, **Fig. 5** and **Fig. 6**. For instructions, see **Group 60**.

NOTE: On right-hand-drive (RH DR) vehicles, the dash panels are in the reverse position from the left-hand-drive (LH DR) vehicle.

4. Remove the air duct that is located on top of the power distribution module.
5. Disconnect the harness from the thermostatic switch. See **Fig. 7**.
6. Remove the two screws attaching the thermostatic switch to the heater core and evaporator coil cover. Remove the switch and the sensor tube.



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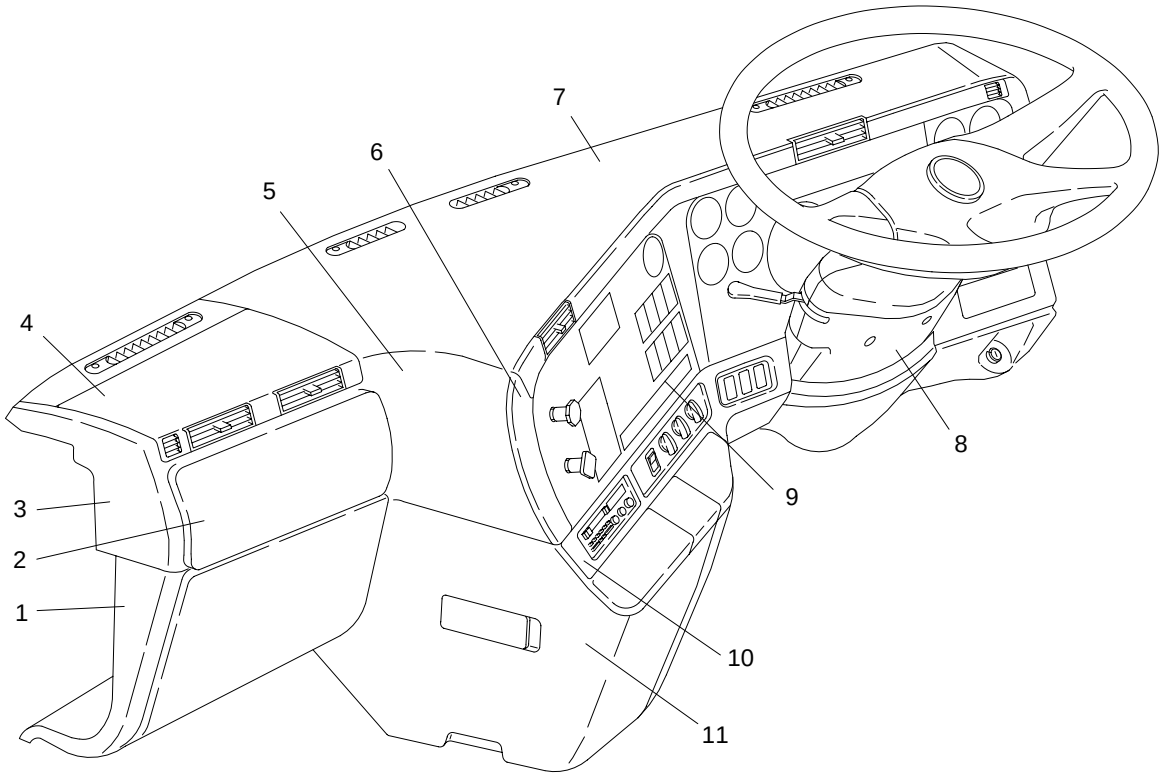
1. Steering Column Cover
2. Upper Dash Assembly (left-hand panel)
3. Dash Trim Cap, Right-Hand
4. Upper Dash Assembly, Center Panel
5. Electrical Cover
6. Upper Dash Assembly, Right-Hand
7. Upper Dash Cover, Right-Hand
8. Heater and Air Conditioner Cover
9. Waste Bin Outer Wall
10. Console Cover, Right-Hand
11. HVAC/Radio Trim Plate
12. Auxiliary Gauge Panel

Fig. 1, Dash Panels, Century Class Conventional, LH DR

Evaporator Coil Removal and Installation



1. Heater and Air Conditioner Cover
2. Upper Dash Cover, Left-Hand
3. Upper Dash Assembly, Left-Hand
4. Electrical Cover
5. Upper Dash Assembly, Center Panel
6. Dash Trim Cap, Left-Hand
7. Upper Dash Assembly (right-hand panel)
8. Steering Column Cover
9. Auxiliary Gauge Panel
10. HVAC/Radio Trim Plate
11. Console Cover, Left-Hand

Fig. 2, Dash Panels, Century Class Conventional, RH DR

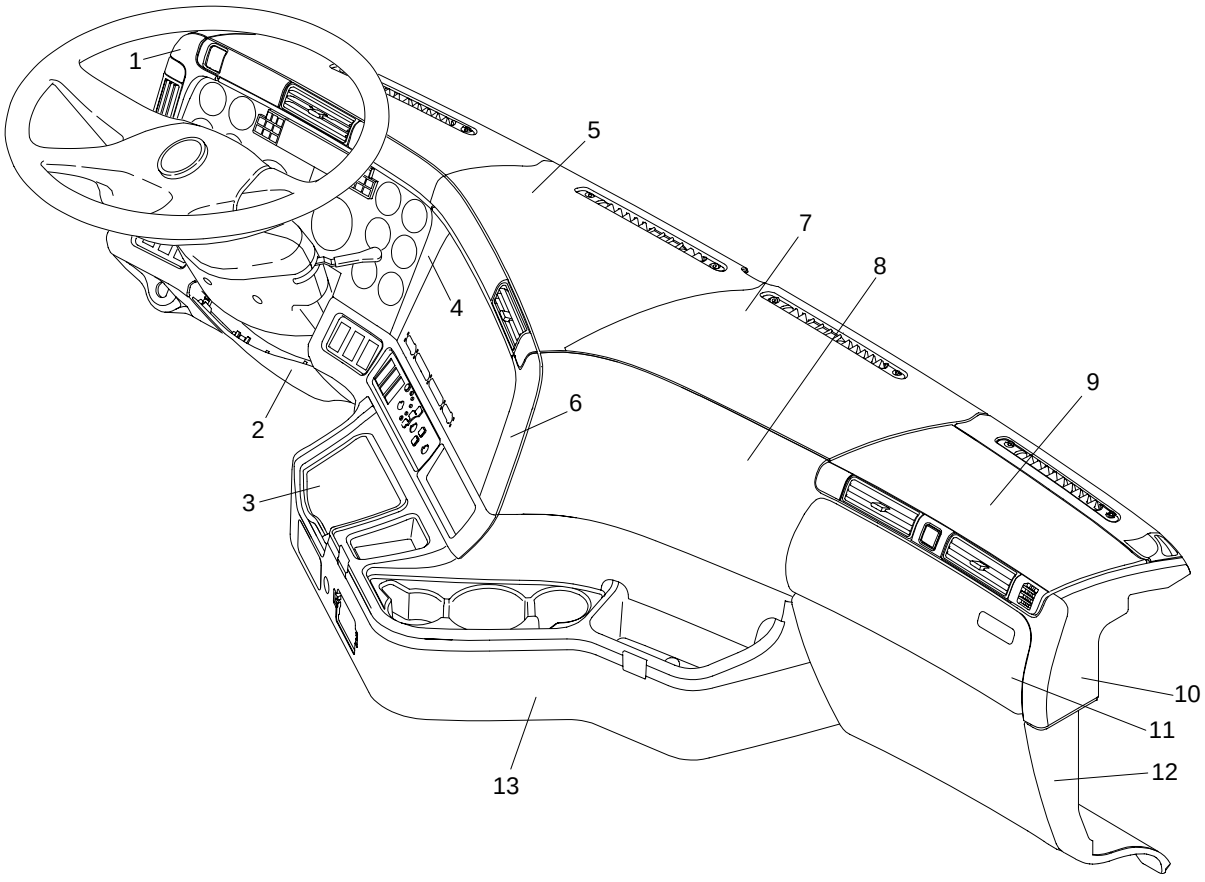
7. Remove the fasteners from the heater core and evaporator coil cover. See **Fig. 8**.
8. On Century Class Conventionals, open the hood and remove the air cleaner. For instructions, see **Group 09**.
9. Remove the mastic insulating tape from around the expansion valve.
10. Remove the refrigerant from the air conditioning system. For instructions, see **Subject 250**.
11. At the expansion valve, disconnect the refrigerant lines that are routed to the junction block (then on to the receiver-drier and the refrigerant compressor). See **Fig. 9**. Quickly cap the expansion valve ports and plug the fittings

IMPORTANT: Under no circumstances should the expansion valve ports remain uncapped or the fittings remain unplugged for longer than five minutes total. Water and dirt can damage the refrigerant system. Do not blow shop air through refrigerant lines since shop air is wet (humid).

⚠ WARNING

Failure to wear protective gloves could result in serious skin cuts due to the sharp edges on the evaporator coil fins.

12. Wearing protective gloves, slide the evaporator coil out of the housing. See **Fig. 10**.



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1. Dash End Cap
2. Steering Column Cover
3. Transmission Opening
4. Instrument Panel Center Trim
5. Upper Dash Assembly (left-hand panel)
6. Right-Hand Dash Trimcap
7. Upper Dash Assembly (right-hand panel)
8. Upper Dash Assembly (center panel)
9. Upper Dash Electrical Access Panel
10. Dash Assembly, Right-Hand
11. Dash Cover
12. HVAC Cover
13. Lower Dash Console

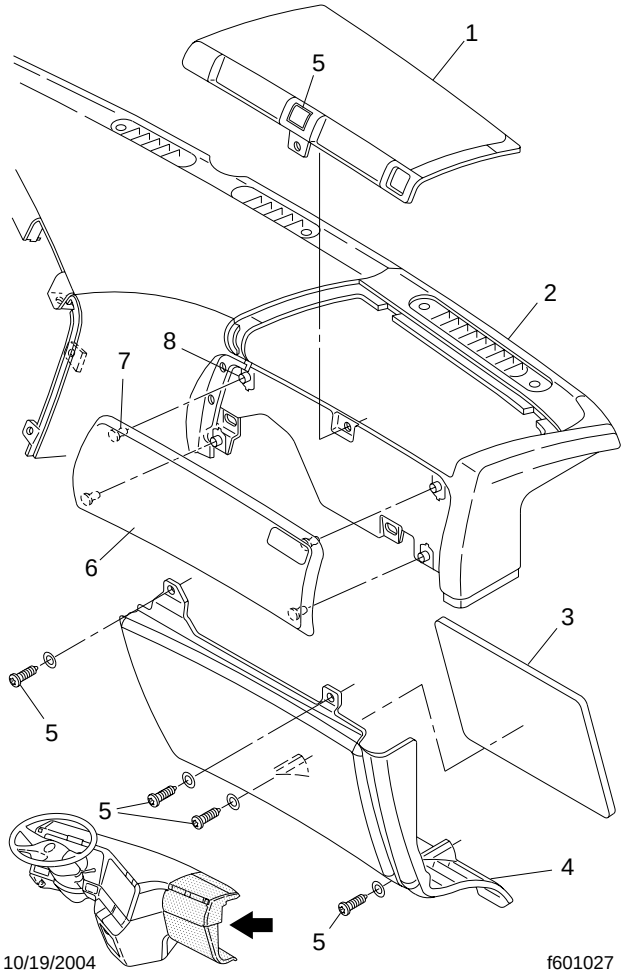
Fig. 3, Dash Panels, Argosy COE

Installation

1. Wearing protective gloves, slide the evaporator coil into the housing.
2. Uncap the expansion valve ports and unplug the fittings. Check the fittings and the ports. They must be clean and free of nicks, gasket residue, and other foreign material.
3. On hose connections that have threaded fittings, replace the O-rings in the fittings. Lubricate the O-rings with mineral oil before installing.

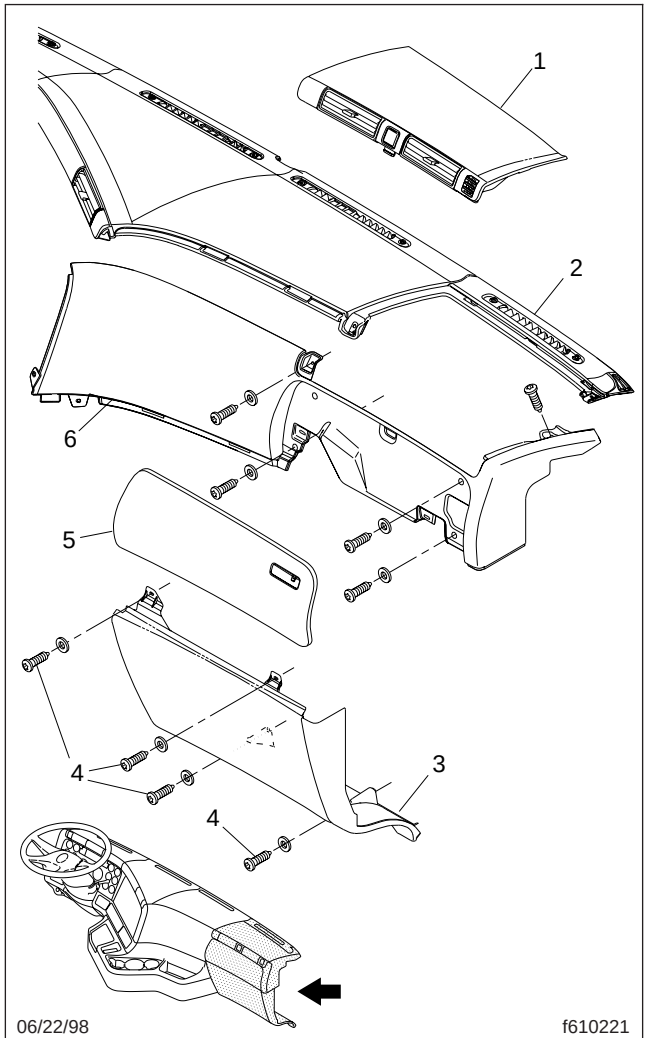
   On hose connections that have a SlimLine seal assembly (**Fig. 11**), replace the seals. **Do not** lubricate SlimLine seals prior to installation. Use **only** a SlimLine seal on a SlimLine seal assembly.

Evaporator Coil Removal and Installation



1. Electrical Cover
2. Upper Dash Assembly, Right-Hand
3. Cover Seal
4. Heater and Air Conditioner Cover
5. T25 Dog-Point Screw
6. Upper Dash Cover, Right-Hand
7. Speed Clip
8. Speed Nut

Fig. 4, Right-Hand Dash Panels, Century Class Conventional, LH DR



1. Electrical Cover
2. Upper Dash Assembly
3. HVAC Cover
4. T25 Dog-Point Screw
5. Dash Cover
6. Upper Dash Assembly (center panel)

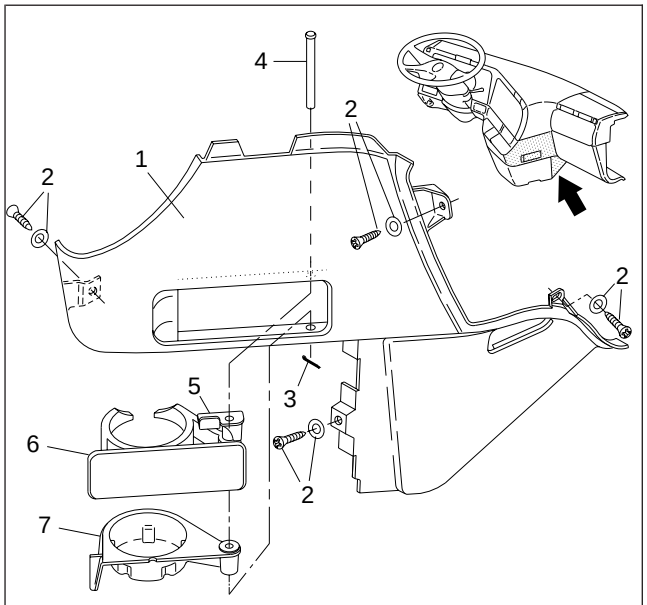
Fig. 5, Right-Hand Dash Panels, Argosy COE

4. Connect the refrigerant lines to the expansion valve.

   On hose connections that have threaded fittings, torque the large line 35 to 40 lbf·ft (47 to 54 N·m) Torque the small line 20 to 25 lbf·ft (27 to 34 N·m).

   On hose connections that have a SlimLine seal assembly, torque the bolt on the SlimLine seal assembly 11 to 15 lbf·ft (15 to 20 N·m).

5. Evacuate and charge the system with refrigerant. See **Subject 250** for instructions. Be sure to add refrigerant oil to the compressor to replace that which is lost when the system is discharged.



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1. Right-Hand Console Cover
2. T25 Dog-Point Screw
3. Cotter Pin
4. Hinge Pin
5. Pivot Stop
6. Passenger's Cup Holder (upper)
7. Passenger's Cup Holder (lower)

Fig. 6, Right-Hand Console Cover, Century Class Conventional, LH DR

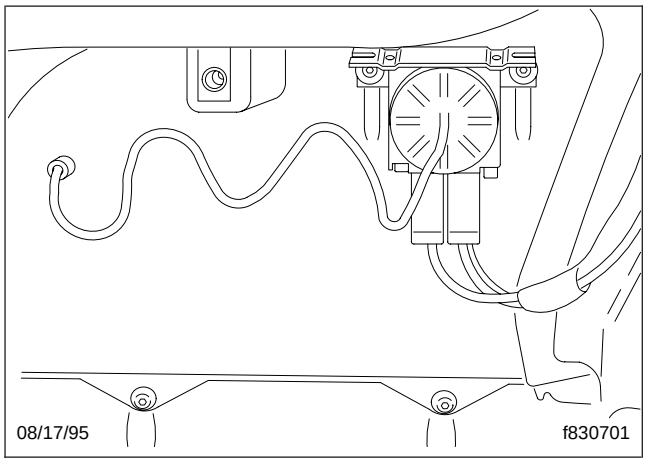

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Fig. 7, Thermostatic Switch Mounting

Refer to the applicable refrigerant compressor section in this group.

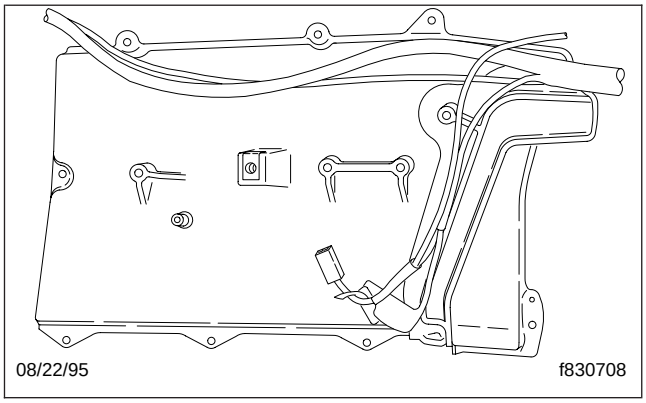

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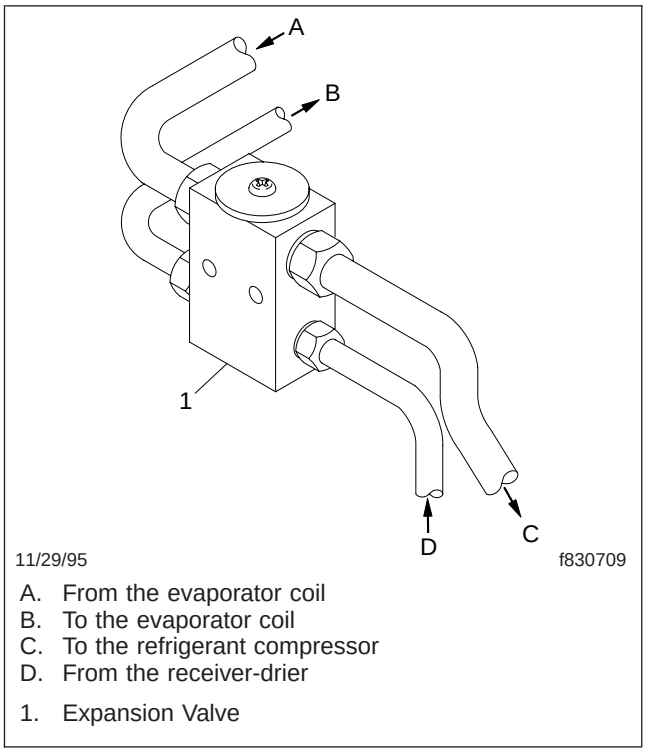
Fig. 8, Heater Core and Evaporator Coil Cover



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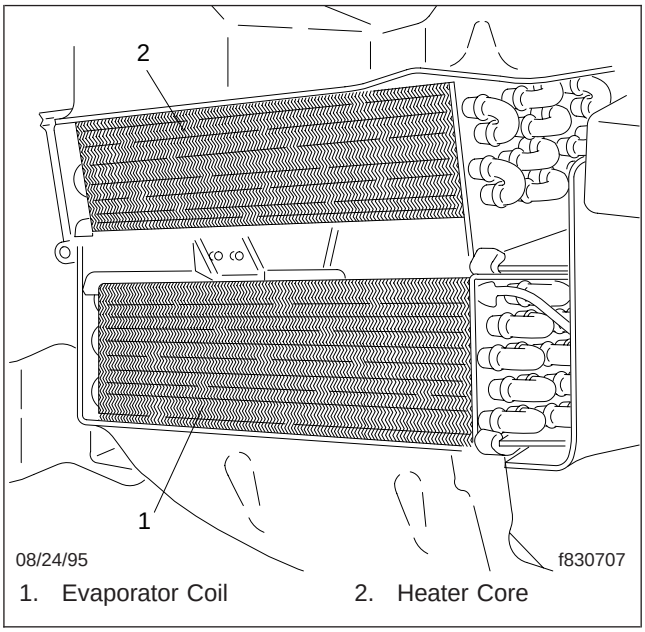
A. From the evaporator coil
B. To the evaporator coil
C. To the refrigerant compressor
D. From the receiver-drier

1. Expansion Valve

Fig. 9, Expansion Valve Refrigerant Lines

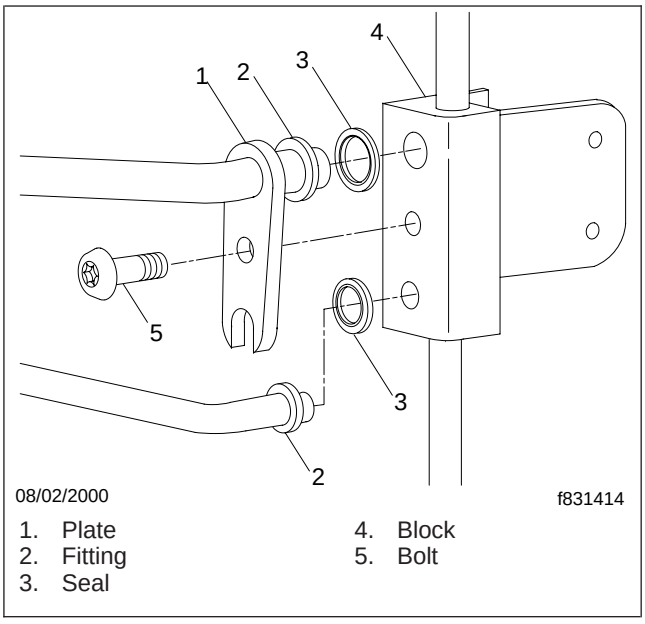
6. Wipe the expansion valve and refrigerant line connections clean, and wrap them with mastic insulating tape.
7. On Century Class Conventionals, install the air cleaner. For instructions, see **Group 09**.
8. Install the heater core and evaporator coil cover.

Evaporator Coil Removal and Installation



1. Evaporator Coil
2. Heater Core

Fig. 10, Remove the Evaporator Coil



1. Plate
2. Fitting
3. Seal
4. Block
5. Bolt

Fig. 11, A Typical SlimLine Seal Assembly

⚠ CAUTION

Be careful when installing the thermostat sensor tube. Using too much force will bend the tube, which could damage it.

9. Carefully insert the thermostatic switch sensor tube into the same hole from which it was removed. The tip of the sensor tube must be in direct contact with an evaporator coil fin and be inserted at least 6 inches (15 cm) into the evaporator coil.
10. Using the two screws removed previously, install the thermostatic switch.
11. Connect the wire harness to the thermostatic switch.
12. Install the air duct on top of the power distribution module.
13. Install the right-hand dash panels. For instructions, see **Group 60**.
14. Connect the batteries.
15. On Century Class Conventionals, return the hood to the operating position. On Argosy COEs, close the access panel.
16. Remove the chocks from the tires.

Replacement

1. Turn off the engine, apply the parking brakes, and chock the tires.
2. On Century Class Conventionals, open the hood. On Argosy COEs, open the access panel on the front of the vehicle.
3. Remove the refrigerant from the air conditioning system. For instructions, see **Subject 250**.
4. On Century Class Conventionals, remove the air cleaner. For instructions, refer to **Group 09**.
5. Remove the mastic insulating tape from around the expansion valve.
6. Disconnect the four lines from the expansion valve. See **Fig. 1**. Quickly cap the expansion valve ports, and plug the fittings.

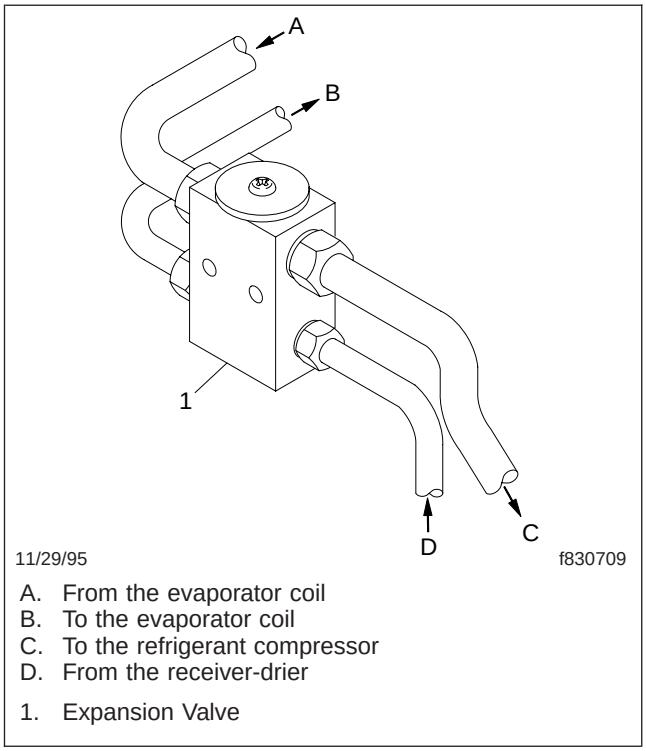
IMPORTANT: Under no circumstances should the expansion valve ports remain uncapped or the fittings remain unplugged for longer than five minutes total. Water and dirt can damage the refrigerant system. Do not blow shop air through refrigerant lines since shop air is wet (humid).

7. Remove the expansion valve.
8. Install a new expansion valve.
9. Uncap the inlet and outlet ports on the expansion valve. Unplug the fittings. Check the fittings, and the inlet and outlet ports. They must be clean and free of nicks, gasket residue, and other foreign material.
10. On hose connections that have a SlimLine seal assembly (**Fig. 2**), replace the seals. **Do not** lubricate SlimLine seals prior to installation. Use **only** a SlimLine seal on a SlimLine seal assembly.

    On hose connections that have threaded fittings, replace the O-rings in the fittings. Lubricate the O-rings with mineral oil before installing.
11. Attach the four lines to the expansion valve.

    On hose connections that have a SlimLine seal assembly, torque the bolt on the SlimLine seal assembly 11 to 15 lbf·ft (15 to 20 N·m).

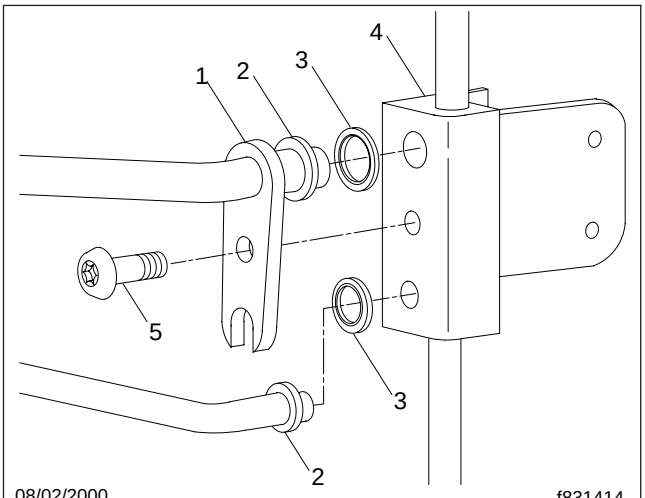
    On hose connections that have threaded fittings, tighten the fittings to the following specs. See **Fig. 1**.



A. From the evaporator coil
B. To the evaporator coil
C. To the refrigerant compressor
D. From the receiver-drier

1. Expansion Valve

Fig. 1, Expansion Valve



1. Plate
2. Fitting
3. Seal
4. Block
5. Bolt

Fig. 2, A Typical SlimLine Seal Assembly

- A. 35 to 40 lbf·ft (47 to 54 N·m)

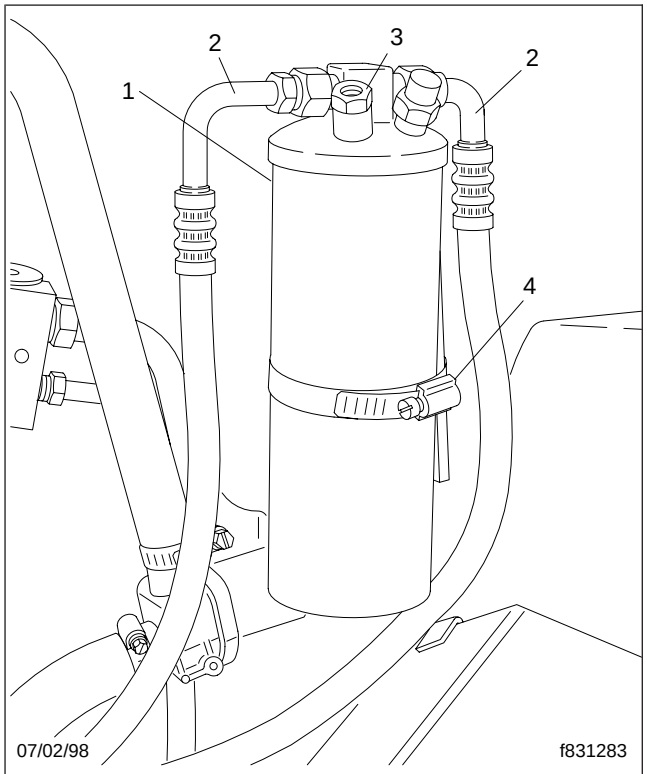
Expansion Valve Replacement

- B. 30 to 35 lbf·ft (41 to 47 N·m)
- C. 35 to 40 lbf·ft (47 to 54 N·m)
- D. 20 to 25 lbf·ft (27 to 34 N·m)

12. Evacuate and charge the air conditioning system with refrigerant. For instructions, see **Subject 250**.
13. Be sure to add refrigerant oil to the compressor to replace that which is lost when the system is discharged. Refer to the applicable refrigerant compressor section in this group.
14. Wipe the expansion valve and refrigerant line connections clean, and wrap them with mastic insulating tape.
15. On Century Class Conventionals, install the air cleaner. For instructions, refer to **Group 09**.
16. On Century Class Conventionals, return the hood to the operating position. On Argosy COEs, close the access panel.
17. Remove the chocks from the tires.

Replacement

1. Turn off the engine, apply the brakes, and chock the tires.
2. On Century Class vehicles, open the hood. On Argosy COEs, open the access panel on the front of the vehicle.
3. Remove the refrigerant from the air conditioning system. For instructions, see **Subject 250**.
4. On Argosy COEs, tilt the cab. For cab tilt instructions, see **Group 60**.
5. Disconnect the refrigerant lines from the receiver-drier. See **Fig. 1**. Quickly plug the fittings.



1. Receiver-Drier
2. Refrigerant Line
3. Moisture Indicator
4. Clamp

Fig. 1, Receiver-Drier

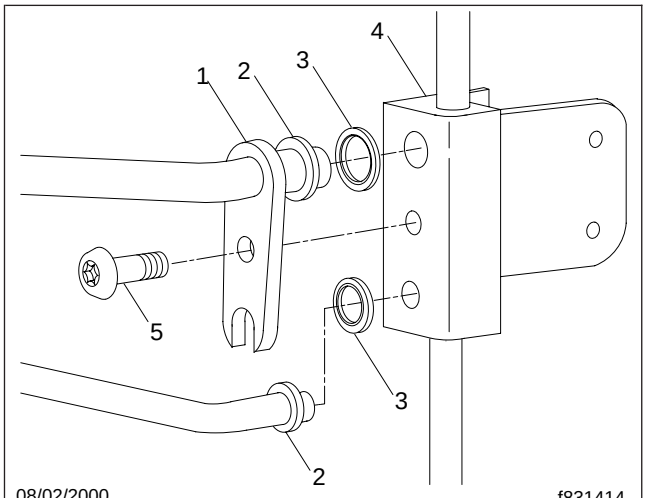
IMPORTANT: Under no circumstances should the fittings remain unplugged for longer than five minutes. Water and dirt can damage the refrigerant system. Do not blow shop air through refrigerant lines since shop air is wet (humid).

6. Loosen the clamp that attaches the receiver-drier to the mounting bracket. Remove the receiver-drier.

IMPORTANT: If the desiccant cartridge inside the receiver-drier has fallen apart, evacuate the system and replace the expansion valve and the refrigerant compressor (desiccant matter can't be removed from these parts). A cartridge may fall apart from too much moisture in the system, because of poor evacuation of the system, or lack of maintenance.

7. Place a new receiver-drier on the mounting bracket and tighten the clamp securely.
8. Unplug the fittings.
9. On hose connections that have threaded fittings, replace the O-rings in the fittings. Lubricate the O-rings with mineral oil before installing.

   On hose connections that have a SlimLine seal assembly (**Fig. 2**), replace the seals. **Do not** lubricate SlimLine seals prior to installation. Use **only** a SlimLine seal on a SlimLine seal assembly.



1. Plate
2. Fitting
3. Seal
4. Block
5. Bolt

Fig. 2, A Typical SlimLine Seal Assembly

10. Connect the refrigerant lines to the receiver-drier.

Receiver-Drier Replacement

On hose connections that have threaded fittings, tighten the fittings to the torque specifications in **Table 1**.

On hose connections that have a SlimLine seal assembly, torque the bolt on the SlimLine seal block and plate assembly 11 to 15 lbf·ft (15 to 20 N·m).

A/C Threaded Fitting Torque Specifications *	
Hose Size	**Torque lbf·ft (N·m)**
#6	20–25 (27–34)
#8	30–35 (41–47)
#10 and #12	35–40 (47–54)

* One-inch fittings on the A/C compressor need to be torqued 21 to 27 lbf·ft (28 to 37 N·m) regardless of hose size.

Table 1, A/C Threaded Fitting Torque Specifications

11. Charge the system with refrigerant. Refer to **Subject 250** for instructions. Be sure to add refrigerant oil to the compressor to replace that which is lost when the system is recovered. Refer to the applicable refrigerant compressor section.
12. On Century Class Conventionals, return the hood to the operating position. On Argosy COEs, close the access panel and tilt the cab. For cab tilt instructions, see **Group 60**.
13. Remove the chocks from the tires.

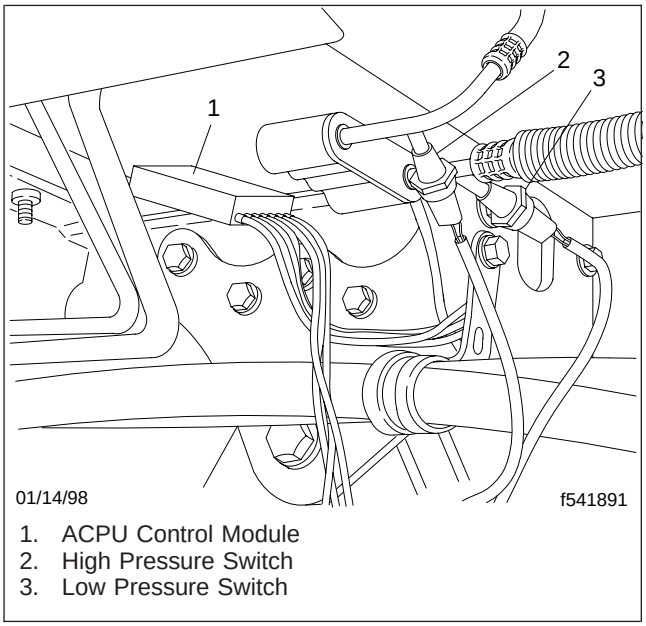
Air Conditioning Protection Unit Pressure Switch Replacement

Replacement

1. Turn off the engine, apply the brakes, and chock the tires.
2. Open the hood or tilt the cab. For cab tilt instructions, see **Group 60**.
3. Access the ACPU pressure switches.

   On Century Class Conventionals, the ACPU pressure switches are located under the hood on the right-hand side of the vehicle near the front-wall. See **Fig. 1**.

   On Argosy COEs, the ACPU pressure switches are located on the right-hand side of the vehicle behind the bumper. See **Fig. 2**.

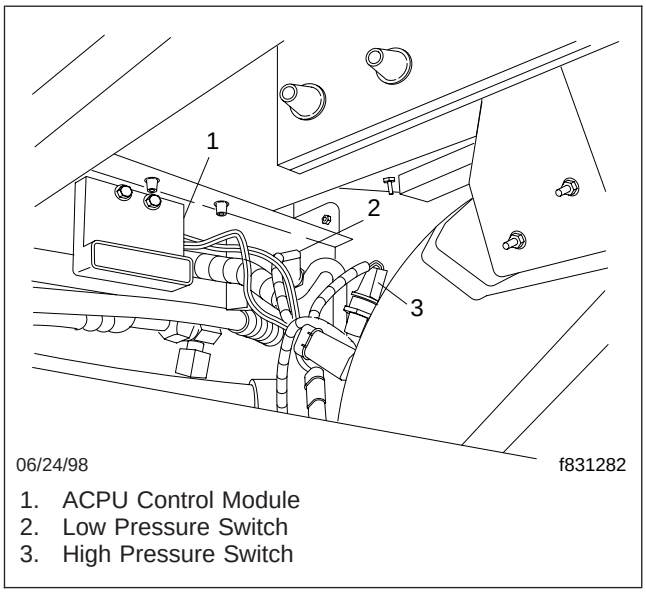


1. ACPU Control Module
2. High Pressure Switch
3. Low Pressure Switch

Fig. 1, ACPU Pressure Switches, Century Class Conventional

4. Disconnect the wiring harness from the pressure switch.
5. Remove the pressure switch.
6. Replace the O-ring on the fitting. Lubricate the O-ring with mineral oil before installing.
7. Install a new pressure switch on the fitting and tighten 20 to 25 lbf·ft (27 to 34 N·m).

IMPORTANT: After replacing the high pressure switch, reset the high pressure cycle to zero.



1. ACPU Control Module
2. Low Pressure Switch
3. High Pressure Switch

Fig. 2, ACPU Pressure Switches, Argosy COE

For more information on setting this parameter, refer to the Freightliner ServiceLink on-line help program.

8. Connect the wiring harness to the pressure switch.
9. Return the hood or cab to the operating position. For cab tilt instructions, see **Group 60**.
10. Remove the chocks from the tires.

Removal

1. Turn off the engine, apply the parking brakes, and chock the tires.
2. Open the hood or tilt the cab. For cab tilt instructions, refer to **Group 60**.
3. Recover the refrigerant from the A/C system. For instructions, refer to **Subject 250**.
4. Disconnect the refrigerant lines from the condenser. Quickly cap the condenser inlet and outlet ports if the condenser will be reinstalled, and plug the fittings.

IMPORTANT: Under no circumstances should the ports remain uncapped or the fittings remain unplugged for longer than five minutes total. Water and dirt can damage the refrigerant system. Do not blow shop air through refrigerant lines since shop air is wet (humid).

5. Remove the fasteners that attach the condenser to the radiator, and remove the condenser.

Installation

1. Place the condenser on the radiator. Install and tighten the fasteners 108 lbf·in (1220 N·cm).
2. Uncap the inlet and outlet ports on the condenser. Unplug the fittings.
3. On hose connections that have threaded fittings, replace the O-rings in the fittings. Lubricate the O-rings with mineral oil before installing.

   On hose connections that have a SlimLine seal assembly (**Fig. 1**), replace the seals. **Do not** lubricate SlimLine seals prior to installation. Use **only** a SlimLine seal on a SlimLine seal assembly.
4. Install the refrigerant lines on the condenser.

   On hose connections that have threaded fittings, tighten the fittings to the torque specifications in **Table 1**.

   On hose connections that have a SlimLine seal assembly, tighten the bolt on the SlimLine seal assembly 11 to 15 lbf·ft (15 to 20 N·m).
5. If needed, add refrigerant oil to the compressor to replace that which is lost in the old condenser.

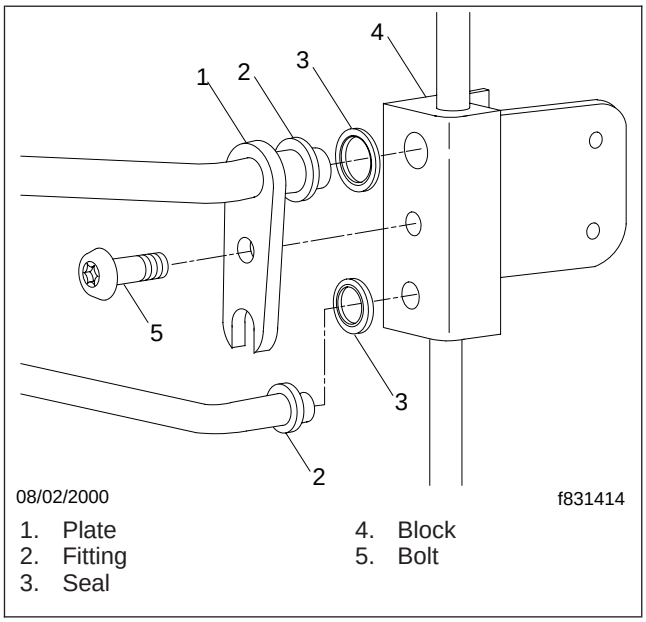


Fig. 1, Typical SlimLine Seal Assembly

   For instructions, refer to the applicable refrigerant compressor section.
6. Evacuate and charge the system with refrigerant. For instructions, refer to **Subject 250**.

A/C Threaded Fitting Torque Specifications*	
Hose Size	**Torque lbf·ft (N·m)**
#6	20–25 (27–34)
#8	30–35 (41–47)
#10 and #12	35v40 (47–54)

* One-inch fittings on the A/C compressor need to be tightened 21 to 27 lbf·ft (28 to 37 N·m) regardless of hose size.

Table 1, A/C Threaded Fitting Torque Specifications

7. Return the hood or cab to the operating position. For cab tilt instructions, see **Group 60**.

Thermostatic Switch Removal and Installation

Removal

1. Turn off the engine, apply the brakes, and chock the tires.

⚠ WARNING

Failure to turn off the ignition switch could result in personal injury or electrical shock.

2. Turn off the ignition switch.

NOTE: When the dash is completely assembled, all dash fasteners are hidden from view. See **Fig. 1**, **Fig. 2**, and **Fig. 3**.

3. Remove the right-hand dash panels as needed to access the thermostatic switch. See **Fig. 4** and **Fig. 5**. For instructions, refer to **Group 60**.

NOTE: On right-hand-drive (RH DR) vehicles, the dash panels are in the reverse position from the left-hand-drive (LH DR) vehicle.

4. Disconnect the harness from the thermostatic switch. See **Fig. 6**.
5. Remove the two screws attaching the thermostatic switch to the heater core and evaporator coil cover. Remove the switch and the sensor tube.

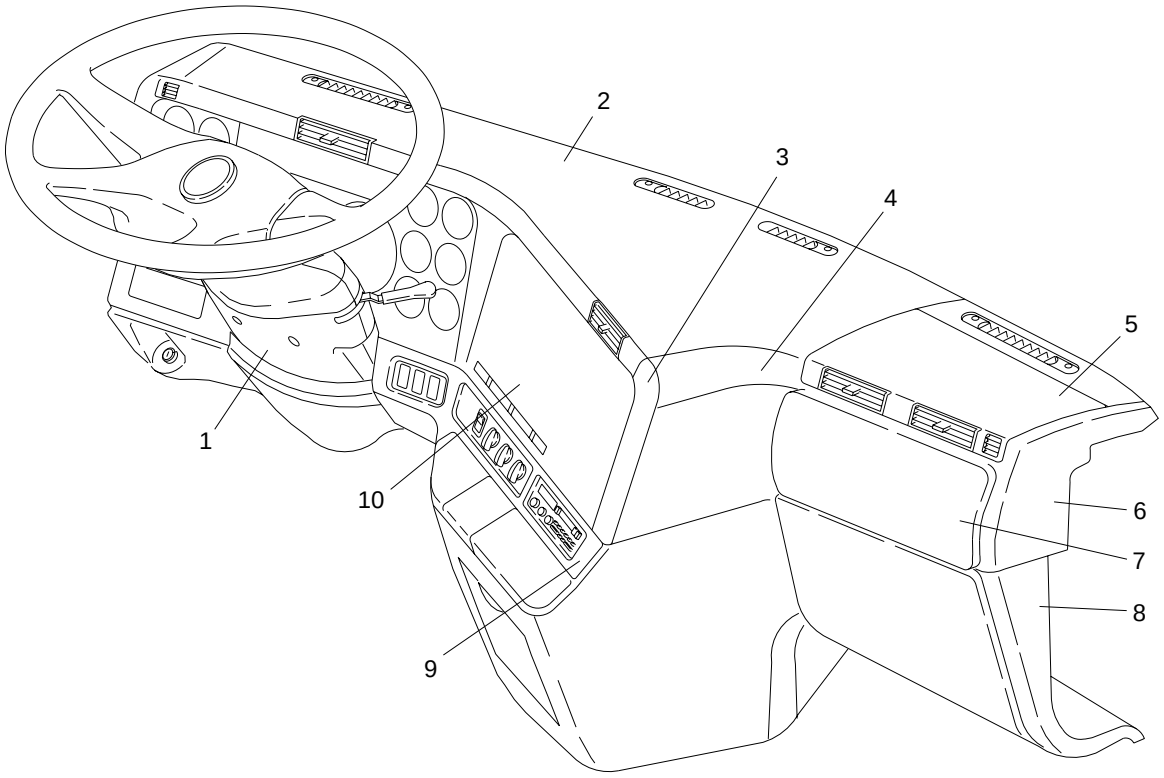
Installation

⚠ CAUTION

Be careful when installing the thermostat sensor tube. Using too much force will bend the tube, which could damage it.

1. Carefully insert the thermostatic switch sensor tube into the same hole from which it was removed. The tip of the sensor tube must be in direct contact with an evaporator coil fin and be inserted at least 6 inches (15 cm) into the evaporator.
2. Using the two screws removed previously, install the new thermostatic switch.
3. Connect the wire harness to the thermostatic switch.
4. Install the right-hand dash covers. For instructions, refer to **Group 60**.
5. Remove the chocks from the tires.

Thermostatic Switch Removal and Installation



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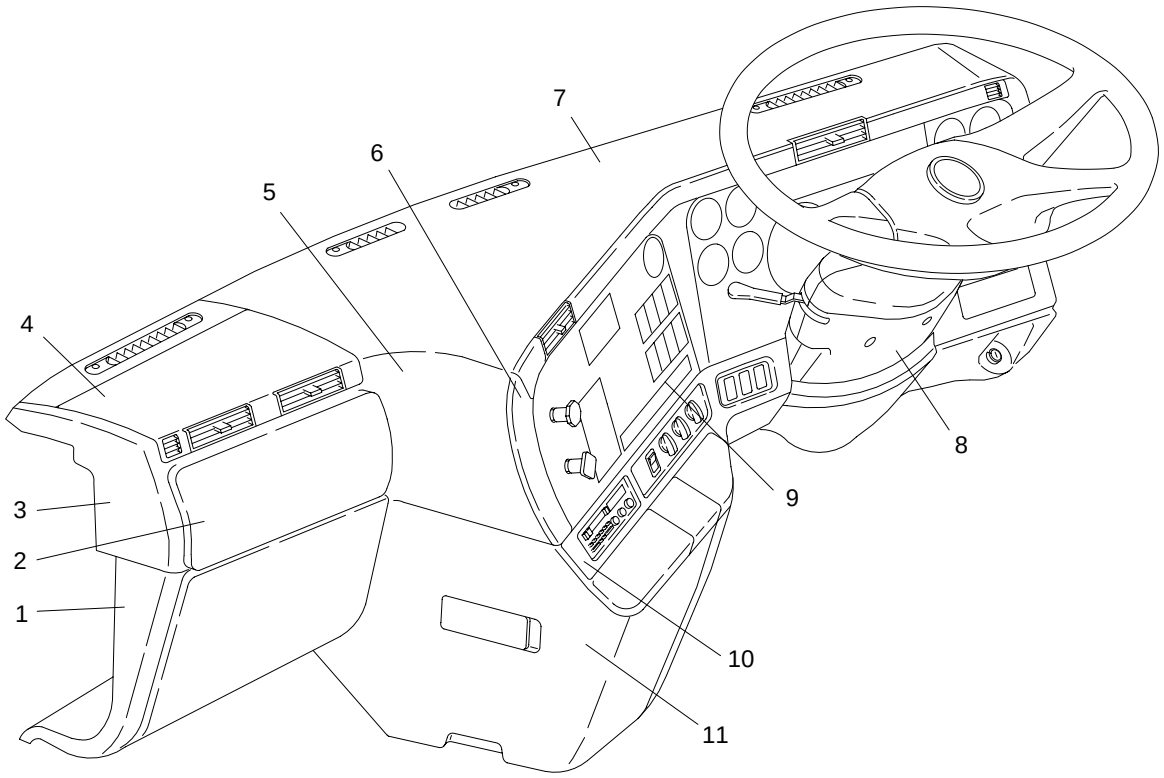
1. Steering Column Cover
2. Upper Dash Assembly (left-hand panel)
3. Dash Trim Cap, Right-Hand
4. Upper Dash Assembly, Center Panel
5. Electrical Cover
6. Upper Dash Assembly, Right-Hand
7. Upper Dash Cover, Right-Hand
8. Heater and Air Conditioner Cover
9. Waste Bin Outer Wall
10. Console Cover, Right-Hand
11. HVAC/Radio Trim Plate
12. Auxiliary Gauge Panel

Fig. 1, Dash Panels, Century Class Conventional, LH DR



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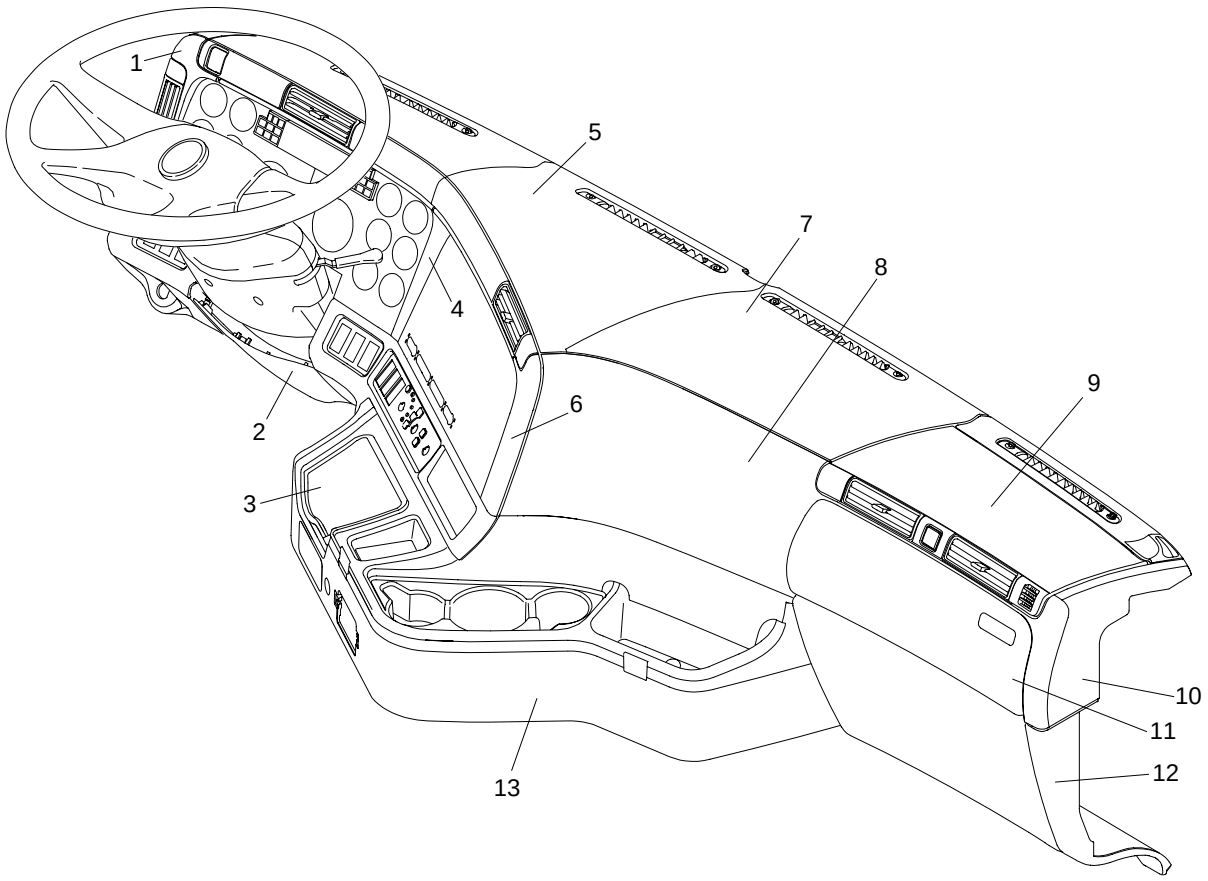
1. Heater and Air Conditioner Cover
2. Upper Dash Cover, Left-Hand
3. Upper Dash Assembly, Left-Hand
4. Electrical Cover
5. Upper Dash Assembly, Center Panel
6. Dash Trim Cap, Left-Hand
7. Upper Dash Assembly (right-hand panel)
8. Steering Column Cover
9. Auxiliary Gauge Panel
10. HVAC/Radio Trim Plate
11. Console Cover, Left-Hand

Fig. 2, Dash Panels, Century Class Conventional, RH DR

Thermostatic Switch Removal and Installation



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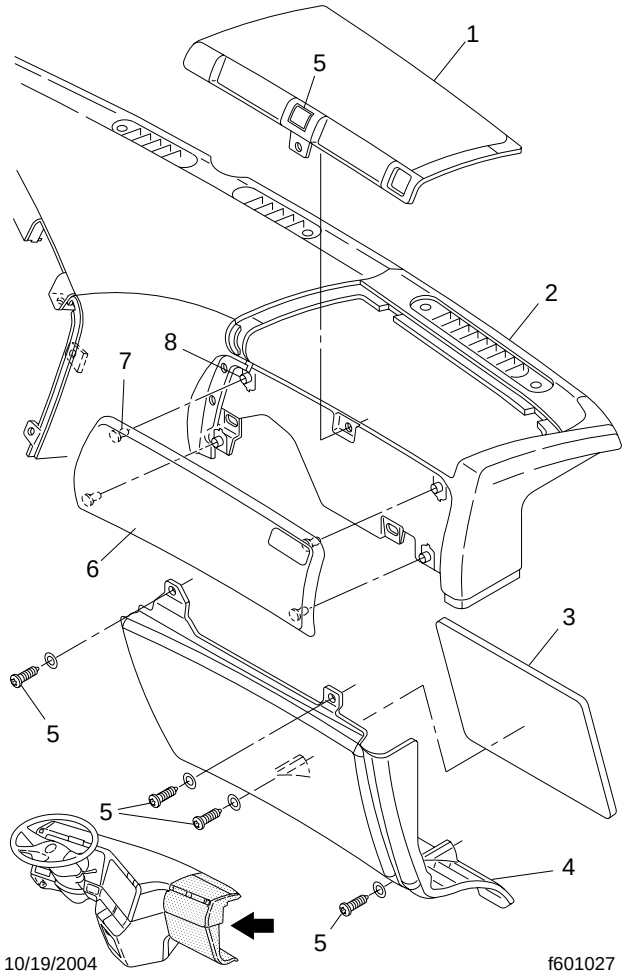
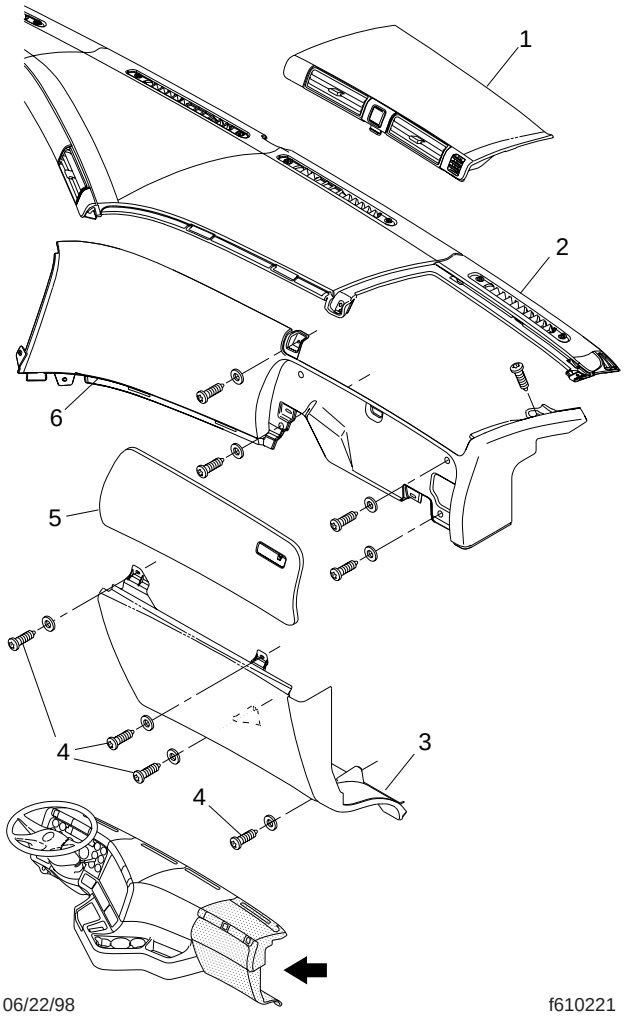
1. Dash End Cap
2. Steering Column Cover
3. Transmission Opening
4. Instrument Panel Center Trim
5. Upper Dash Assembly (left-hand panel)
6. Right-Hand Dash Trimcap
7. Upper Dash Assembly (right-hand panel)
8. Upper Dash Assembly (center panel)
9. Upper Dash Electrical Access Panel
10. Dash Assembly, Right-Hand
11. Dash Cover
12. HVAC Cover
13. Lower Dash Console

Fig. 3, Dash Panels, Argosy COE



1. Electrical Cover
2. Upper Dash Assembly, Right-Hand
3. Cover Seal
4. Heater and Air Conditioner Cover
5. T25 Dog-Point Screw
6. Upper Dash Cover, Right-Hand
7. Speed Clip
8. Speed Nut

Fig. 4, Right-Hand Dash Panels, Century Class Conventional, LH DR



1. Electrical Cover
2. Upper Dash Assembly
3. HVAC Cover
4. T25 Dog-Point Screw
5. Dash Cover
6. Upper Dash Assembly (center panel)

Fig. 5, Right-Hand Dash Panels, Argosy COE

Thermostatic Switch Removal and Installation

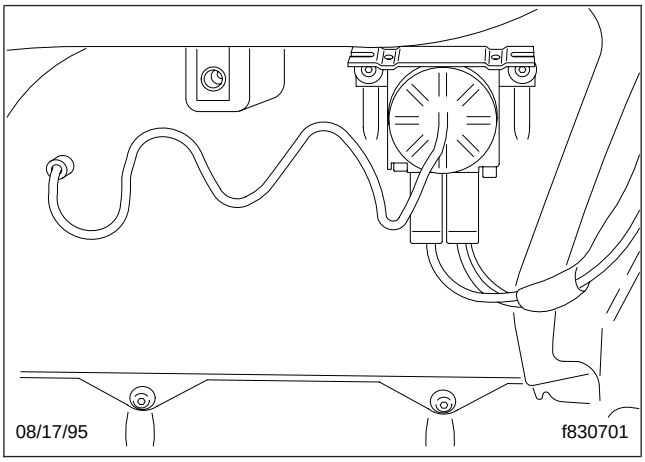
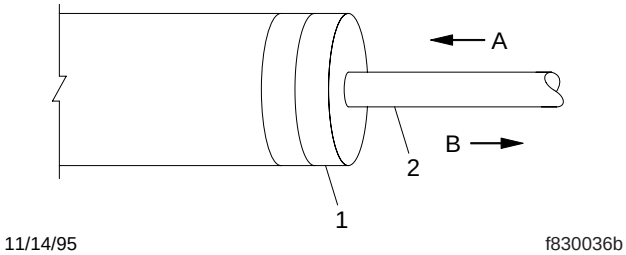


Fig. 6, Thermostatic Switch Mounting

Replacement

1. Turn off the engine, apply the brakes, and chock the tires.
2. Disconnect the batteries.
3. Remove the HVAC/radio trimplate from the dash. For instructions, see **Section 60.08**.
4. Remove the fasteners that attach the HVAC control panel to the dash. Move the control panel away from the dash to service it.
5. Disconnect the pigtail connectors from the rear of the control panel. Disconnect the electrical connectors from the control panel harness.
6. If the vehicle is equipped with a mechanically controlled water regulating valve, unhook the water regulator valve cable from the temperature control switch assembly.

   If the vehicle is equipped with an electronically controlled water regulating valve, disconnect the connector from the potentiometer behind the temperature control switch.
7. Disconnect the air lines from the control panel by pushing in the cover ring and pulling out the air line. See **Fig. 1**.



A. push
B. pull
1. Collar
2. Air Line

Fig. 1, Air Line

8. Remove the control panel from the dash.
9. Position the new control panel and connect the air lines by pushing them into the fittings as far as they will go. Then, give the air line a slight tug so the line will lock in to place.

NOTE: The color of the air lines should match the colored collar at the back of the control panel.

10. Insert the control panel and connect pig-tail connectors at the back of the panel.
11. Connect the electrical connectors to the control panel harness.
12. If the vehicle is equipped with a mechanically controlled water regulating valve, hook the end of the water regulating valve control cable onto the temperature control switch assembly.

    If the vehicle is equipped with an electronically controlled water regulating valve, attach the connector to the potentiometer behind the temperature control switch.
13. If the vehicle is equipped with a mechanically-controlled water regulating valve, check the cable adjustment. For instructions, see **Subject 170**.
14. Position the control panel and install the fasteners that attach it to the dash.
15. Connect the batteries.
16. Turn on the ignition switch and test the blower motor.
17. Install the HVAC/radio trimplate. For instructions, see **Section 60.08**.
18. Remove the chocks from the tires.

Identification, Recovery, Evacuating, Purging and Flushing, Charging, and Leak Testing

Required Equipment

You will need a machine, or machines, to identify the refrigerant and to recover, evacuate, flush, and charge the refrigerant system. Ideally, one machine should do all the following functions:

- Identification–The machine must be able to verify the purity of the refrigerant in the refrigerant system, and the presence of hydrocarbon-based refrigerants or other unapproved refrigerants.
- Recovery–The machine must be able to recover the refrigerant fully, from the refrigerant system.
- Evacuation–Ideally, the machine should have a vacuum pump rated at 6 cfm (170 liters per minute) and be maintenance-free. (A machine that requires maintenance is acceptable, as long as it has been properly maintained.)
- Charging–The scale used in charging should be accurate to within ±1 ounce (30 mL).
- Flushing–Adaptors for the compressor(s), expansion device(s), and receiver-drier should be purchased or fabricated, to flush the system with refrigerant.

Refrigerant Identification

⚠ WARNING

Before doing any of the work below, read the information in Safety Precautions 100. Failure to read and understand the safety precautions, and to take necessary precautions against the dangers involved when working with refrigerant could lead to serious personal injury.

IMPORTANT: Identify the refrigerant in the refrigerant system if you suspect one of the following conditions:

- Noncondensable gas, such as nitrogen or air, is in the system.
- An unapproved refrigerant is in the system.
- The history of refrigerant system repairs is unknown.

1. Using a high-quality refrigerant identifier and the manufacturer's instructions, attach the identifier to the vehicle and perform the test.
2. If the system passes the test, it is safe to recover the refrigerant.
3. If the vehicle failed the test due to an excessive amount of noncondensable gas, recover the refrigerant system, then purge the recovery tank of the noncondensable gas.
4. If the vehicle failed the test due to the presence of a hydrocarbon-based refrigerant or a refrigerant other than R-134a, **do not recover the refrigerant into the general-use machine.** To recover the refrigerant, put it into a separate container that contains refrigerant for recycling by a qualified recycling center. It is best to refer the customer to the place where the vehicle was last serviced.

Recovery

⚠ WARNING

Before doing any of the work below, read the information in Safety Precautions 100. Failure to read and understand the safety precautions, and to take necessary precautions against the dangers involved when working with refrigerant could lead to serious personal injury.

The recovery process removes most of the refrigerant charge in the system.

1. Turn off the engine, apply the parking brakes, chock the tires, and open the hood.
2. Remove the caps from the suction and discharge service valves.
3. If the history of refrigerant system repairs is unknown, or if you suspect that the system is charged with an unapproved refrigerant, identify the refrigerant using the "Refrigerant Identification" procedures.
4. Wearing protective goggles and nonleather gloves, attach the refrigerant recovery and charging machine hoses to the valves.

IMPORTANT: Push down firmly on the hose connectors until they click into engagement. This will ensure that the coupler is locked.

Identification, Recovery, Evacuating, Purging and Flushing, Charging, and Leak Testing

5. Follow the refrigerant recovery and charging machine manufacturer's instructions, and recover all of the refrigerant from the refrigerant system.

IMPORTANT: Always comply with all federal and local regulations regarding refrigerant recovery and disposal. There are substantial penalties for using improper procedures.

6. Measure the oil recovered during the recovery process. The refrigerant system will have to be filled with the same quantity of new refrigerant oil. If the system is contaminated with moisture, all of the compressor oil must be replaced with clean oil. If the system is heavily contaminated with desiccant or grit, replace the compressor, expansion valve, and receiver-drier, and flush the condenser and evaporator(s). After the system is charged, perform a performance check to ensure that the heat exchangers are not plugged.

Evacuating

The main purpose in evacuating the refrigerant system is to remove noncondensable gases (NCG), such as nitrogen and air. The secondary purpose is to boil off free water molecules.

In rare cases, water forms ice crystals at the expansion valve. Ice crystals retard or stop the flow of refrigerant, causing a reduction or complete loss of cooling. As the expansion valve warms due to the lack of refrigerant, the ice melts and passes through the expansion valve. Then refrigerant will flow again until the ice crystals re-form. The result is intermittent cooling.

Refrigerant oil has an extremely high moisture absorption capacity. Typically, the moisture picked up by the oil is passed on to the receiver-drier. If excessive moisture exists in the system, the lubricating ability of the oil is reduced, which could damage the compressor and other components.

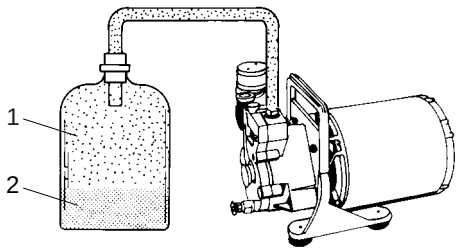
Effects of Pressure on the Boiling Point of Water

⚠ WARNING

Before doing any of the work below, read the information in Safety Precautions 100. Failure to read and understand the safety precautions, and to take necessary precautions against the dangers involved when working with refrigerant could lead to serious personal injury.

Water boils at 212°F (100°C) at an atmospheric pressure of 14.7 psi (101 kPa) at sea level. At higher elevations the atmospheric pressure is lower, which allows water to boil at lower temperatures. See **Table 1** for boiling temperatures of water at converted pressures.

Similarly you can boil and remove water from the air conditioning system by lowering the system pressure to a vacuum to cause the moisture to vaporize at normal ambient temperatures. A vacuum pump can reduce the pressure in the system. Since the pressure is lowest at the pump, NCG and water vapor are pulled out of the system. This process is called evacuation or dehydration. See **Fig. 1**.



1. Vapor 2. Water

Fig. 1, Water to Vapor

Measuring Vacuum

Vacuum should be measured with an electronic thermistor vacuum gauge, which is designed for use with high vacuum pumps and can accurately read as low as 100 microns. This gauge can have an analog scale or a digital (LED or LCD) display.

The location of the vacuum gauge will affect the reading. The closer to the vacuum source, the lower the reading will be. Follow the manufacturer's instructions for proper use of the vacuum gauge.

If the pressure will not stabilize, it is an indication of a leak. If it does stabilize at a vacuum that is too high, for example 1500 microns Hg, it is an indication of moisture and more evacuation is required.

Boiling Temperatures of Water at Converted Pressures		
Boiling Temperature of Water: °F (°C)	**Absolute Pressure: psi (microns Hg)**	**Vacuum: inHg (mmHg)**
212 (100)	14.696 (759993.4)	0 (0)
205 (96)	12.770 (660400.0)	3.92 (99.6)
194 (90)	10.169 (523881.6)	9.22 (234.2)
176 (80)	6.8699 (355269.8)	15.93 (404.6)
158 (70)	4.5207 (233786.7)	20.72 (526.3)
140 (60)	2.8900 (149580.7)	24.04 (610.6)
122 (50)	1.7987 (92555.1)	26.28 (667.5)
104 (40)	1.0700 (55336.4)	27.74 (704.6)
89 (30)	0.61540 (31826.2)	28.67 (728.2)
86 (27)	0.57010 (26220.4)	28.89 (733.8)
76 (24)	0.44435 (22979.9)	29.02 (737.1)
72 (22)	0.38856 (20094.7)	29.13 (739.9)
69 (21)	0.35084 (18143.7)	29.21 (741.9)
64 (18)	0.29505 (15258.5)	29.32 (744.7)
59 (15)	0.24720 (12783.8)	29.42 (747.3)
53 (12)	0.19888 (10285.0)	29.52 (749.8)
45 (7)	0.14746 (7625.8)	29.62 (752.3)
32 (0)	0.08858 (4579.6)	29.74 (755.4)
21 (–6)	0.05293 (2738.1)	29.81 (757.2)
6 (–14)	0.02521 (1304.0)	29.87 (758.7)
–24 (–31)	0.004905 (253.7)	29.911 (759.74)
–35 (–37)	0.002544 (131.6)	29.915 (759.84)
–60 (–51)	0.0004972 (25.7)	29.9200 (759.968)
–70 (–57)	0.0002443 (12.69)	29.92050 (759.9807)
–90 (–68)	0.0000526 (2.72)	29.92089 (759.9906)

Table 1, Boiling Temperatures of Water at Converted Pressures

Holding a vacuum is only an indication that there are not any leaks that are present under a vacuum. Other leaks may exist when the system is pressurized, so a proper leak test must be performed in conjunction with holding a vacuum.

Maintaining an Oil-Lubricated Vacuum Pump

Maintenance is important for a high-vacuum pump. The oil must be changed at regular intervals to prevent moisture buildup, which will cause decreased pump performance and eventual pump failure.

Pumping down for extremely wet air conditioning systems can completely saturate the pump oil, which will require the replacement of the vacuum pump oil.

⚠ CAUTION

Flush the vacuum pump every fourth time it is used, and before storing for long periods of time.

Identification, Recovery, Evacuating, Purging and Flushing, Charging, and Leak Testing

Acid will form and corrode the pump, if water-laden oil remains in the pump for an extended period.

Vacuum pump oil is water soluble. This aids the pump in reaching a high vacuum by absorbing water and sealing the pump.

Use only vacuum pump oil as a lubricant. Do not use any solvent or any other oil. Clean oil should be run through the pump until it runs out clear. Oil should be added to the fill level indicated on the pump. Check the oil level before each use.

Evacuation Procedure

1. The system must have been recovered and the refrigerant compressor filled with the correct amount of refrigerant oil. Replace the receiver-drier if the system conditions require it.
2. Make sure the vacuum pump has been properly maintained.
3. Wearing protective goggles and nonleather gloves, attach the refrigerant recovery and charging machine hoses, or a vacuum pump, to the valves.

IMPORTANT: Push down firmly on the hose connectors until a clicking sound is heard. This will ensure that the coupler is locked.

4. Follow the refrigerant recovery and charging machine manufacturer's instructions and evacuate the refrigerant system.
5. The system should be evacuated a minimum of 10 minutes with a 6-cfm (170 liter per minute) pump. Evacuate the system for a longer time, if using a smaller pump. Make sure that the vacuum level reaches the point where water would boil, and does not go back toward zero, then proceed with charging and leak testing the system.

Purging and Flushing

⚠ WARNING

Before doing any of the work below, read the information in Safety Precautions 100. Failure to read and understand the safety precautions, and to take necessary precautions against the dangers involved when working with refrigerant could lead to serious personal injury.

Purging removes damp air, traces of refrigerant, and loose particles from refrigerant parts by passing a stream of inert, dry nitrogen gas through the parts. If left in the system, these contaminants have an adverse effect on the life and operation of the air conditioning system.

Flushing removes moisture-laden oil and some types of contamination, such as dirty oil and some particles, that cannot be removed by purging with nitrogen. When a part is flushed, liquid refrigerant is forced through it. The liquid picks up the contaminants, and flushes them out.

Whether to purge, flush, or replace a part depends on how much contamination there is, as previously described.

Normally, the system always has pressure in it. Some loss of refrigerant from one season to the next is normal, and does not mean that the system is dirty. If refrigerant parts show signs of internal corrosion and grit, the system is contaminated.

If the system is contaminated with moisture, purge all sections of the system. Then change the oil in the compressor and replace the receiver-drier, prior to evacuating and charging the system.

If the system is heavily contaminated or if desiccant has circulated through the system, replace the receiver-drier and expansion valve(s), and inspect the compressor.

Do not purge the receiver-drier or the compressor.

Flush the system in segments, to lessen the chance of blowing deposits against a port.

Purge or flush the system in the opposite direction of refrigerant flow. In other words, backflush the sections.

Flushing parts with refrigerant requires a refrigerant recovery and charging machine.

Purging Procedure

NOTE: Dry nitrogen gas is required for purging. A pressure regulator is required to regulate between 0 and 200 psi (0 and 1379 kPa). Commercial cylinders of nitrogen contain pressures in excess of 2000 psi (13 790 kPa). This pres-

sure must be reduced to 200 psi (1379 kPa) for use in the air conditioning system.

1. Recover the refrigerant from the air conditioning system.
2. Disconnect both ends of the line or part being purged. Tightly cap the rest of the system.
3. Make sure the nitrogen bottle control valve, the purging control valve, and the supply line valve are closed.
4. Connect the supply line valve to the outlet end of the part or line.
5. Connect the drain line to the inlet end of the part or line.
6. Place the outlet of the drain line into a container to collect the oil and debris that may come out of the part that is being flushed.
7. Adjust the nitrogen bottle regulator to 200 psi (1379 kPa). Open the nitrogen bottle control valve and the purging control valve. Then slowly open the supply line valve. Check the drain line for gas flow.
8. Let the nitrogen flow at 200 psi (1379 kPa) for 25 to 30 seconds.
9. Lower the pressure to 4 psi (28 kPa), and let it flow for one to two minutes. If the line or part was very wet, allow it to flow until there is no trace of refrigerant oil, or solid bits of dirt or grit flowing from the drain tube.
10. Close the nitrogen bottle control valve and the purging control valve first, then close the supply line valve.
11. Disconnect the supply line valve and the drain line. Tightly cap both ends of the part or line.

Flushing Procedure

Method 1

NOTE: Use this method when the recovery and charging machine is equipped with a flush cycle.

1. Recover the refrigerant from the air conditioning system.
2. Disconnect both ends of the line or part(s) being flushed. Tightly cap the lines to the rest of the system.

NOTE: You must remove the expansion device(s), receiver-drier, and compressor(s) when flushing. These components must be removed and bypassed when performing a system flush.

3. Install the flushing adaptors and an inline filter, and follow the instructions from the manufacturer of the recovery and charging machine to perform the flush. When flushing the entire system, use an adaptor that fits where the compressor was located, and backflush.
4. Remove the adaptors and bypass devices and install the expansion device(s), the compressor, and a new receiver-drier.
5. If installing the existing compressor, remove the oil in it, and replace the oil with new oil. New compressors may or may not have a full charge of oil.
6. Charge the system with refrigerant and check the system performance.

Method 2

NOTE: Use this method when two recovery and charging machines are available.

1. Recover the refrigerant from the air conditioning system.
2. Disconnect both ends of the line or part(s) being flushed. Tightly cap the lines to the rest of the system.

NOTE: You must remove the expansion device(s), receiver-drier, and compressor(s) when flushing. These components must be removed and bypassed when performing a system flush.

3. Install the flushing adaptors and an inline filter. When flushing the entire system, use an adaptor that fits where the compressor was located and backflush.
4. Charge the part with 2 pounds (0.9 kg) of refrigerant or the system with 5 pounds (2.3 kg) of refrigerant, then recover the refrigerant with a second machine. It is desirable to start the recovery slightly before the charge cycle is done since this helps to pull fluid through the system. Repeat the process several times, until you think that all the oil has been removed.

5. Remove the adaptors and bypass devices. Install the expansion device(s), the compressor(s), and a new receiver-drier.
6. If installing the existing compressor, remove the oil in it and replace the oil with new oil. New compressors may or may not have a full charge of oil.
7. Charge the system with refrigerant and check the system performance.

Charging

WARNING

Before doing any of the work below, read the information in Safety Precautions 100. Failure to read and understand the safety precautions, and to take necessary precautions against the dangers involved when working with refrigerant could lead to serious personal injury.

NOTE: Before charging, the system must be recovered and evacuated with the recovery and charging machine connected to the service and discharge port connections.

1. Obtain enough refrigerant to fully charge the system. To determine the amount of refrigerant needed to fully charge the system, read the Air Conditioner label on the vehicle or see **Specifications 400**.
2. Charge the system on the high side following the refrigerant recovery and charging machine manufacturer's instructions.
3. While the compressor is engaged, check the duct temperature and operating pressures at the suction and discharge ports. Compare the temperature and pressures to those in **Specifications 400**. If the operating pressures are not acceptable, see **Subject 300** for troubleshooting procedures.
4. Disconnect the hoses.
5. Shut down the engine.
6. Recover the refrigerant that is in the hoses.

Leak Testing Methods

General Information

WARNING

Before doing any of the work below, read the information under Safety Precautions 100. Failure to read the safety precautions, and to take precautions against the dangers involved when working with refrigerant, could lead to serious personal injury.

Refrigerant is nearly odorless. As a result, it may leak away and not be noticed, until the system stops cooling. All vehicle refrigerant systems lose some refrigerant. Higher loss rates signal a need to locate and repair the leaks.

Leaks are most often found at the compressor hose connections and at the various fittings and joints in the system. If unapproved replacement hoses are installed, refrigerant can be lost through hose permeation.

There are two leak testing methods that can be used to detect leaks in the refrigerant system: UV (ultraviolet) dye leak detection and electronic leak detection. Daimler Trucks North America LLC recommends using the UV dye leak detection method whenever possible, even though there are some limitations to using this method. A leak on the front seal of the compressor **must** be verified using a heated diode leak detector and the instructions under "Electronic Leak Detection" in this subject. Visible dye on the front of the compressor clutch **does not** verify that there is a repairable leak at the front seal. Evaporator leaks may not show up with dye, and must be checked using a heated diode leak detector if dye is not present at the condensate drain.

UV Dye Leak Detection

IMPORTANT: When using the UV dye leak detection method, always wear protective eyewear that blocks UV rays and enhances the appearance of the dye. Always wear nonleather gloves and protective eyewear, when servicing the air conditioning system.

1. Inspect the refrigerant system for leaks using a UV lamp.

Identification, Recovery, Evacuating, Purging and Flushing, Charging, and Leak Testing

1.1 Inspect the entire refrigerant system under low lighting using a UV lamp. Low lighting will increase the apparent brightness of the UV dye at leak sites.

1.2 Move the UV lamp along the entire refrigerant system, looking for signs of damage or corrosion on the fittings, hose-to-line crimps, switch ports, service ports with caps installed (dye inside the port is not an indication of a leak), brazed or welded areas, and around all connections. Check for evaporator leaks by illuminating the condensate drain tube or hole using the UV lamp.

1.3 Move the UV lamp along the refrigerant system following a continuous path, so that no potential leak sites are missed. If a leak is found, continue to check the remainder of the system since other leaks may be present.

2. After repairing a leak, remove all UV dye residue remaining on the outside of the refrigerant system using the cleaner provided by the dye manufacturer, or a comparable cleaner. Use a spray bottle of cleaner, a toothbrush, and a spray bottle of clean water for hard-to-reach areas.

NOTE: Minor UV dye residue, or residue that is impossible to reach, will lose its fluorescence over time.

3. See **Table 2** for a list of products that have been tested and approved for use by Freightliner dealers.

Approved Products for UV Dye Leak Detection				
Type of Refrigerant Oil	**Product Description**	**Vendor Part Number**	**Freightliner Part Number**	**Website Address**
PAG	Tracerline BigEZ Kit—Can be injected without discharging the system. • Each kit includes one 4-oz (118-mL) cartridge and an injection tool.	TP-9741CS	ABP N83 327911	www.tracerline.com
	• A 4-oz (118-mL) replacement cartridge services 16 vehicles.	TP-9760-0004CS	ABP N83 327961	
	• An 8-oz (237-mL) replacement cartridge services 32 vehicles.	TP-9760-0108	ABP N83 327951	
POE/ universal	Tracerline BigEZ Kit—Can be injected without discharging the system. • Each kit includes one 4-oz (118-mL) cartridge and an injection tool.	TP-9742CS	ABP N83 327910	www.tracerline.com
	• A 4-oz (118-mL) replacement cartridge services 16 vehicles.	TP-9770-0004CS	ABP N83 327950	
	• An 8-oz (237-mL) replacement cartridge services 32 vehicles.	TP-9770-108	ABP N83 327960	
—	Tracerline Optimax UV Lamp	TP-8680	ABP N83 327985	www.tracerline.com
—	Bright Solutions UV Lamp	BSL760	ABP N83 327967	www.brightsol.com
—	Service Valve Cap	—	PH 660412	—

Table 2, Approved Products for UV Dye Leak Detection

Identification, Recovery, Evacuating, Purging and Flushing, Charging, and Leak Testing

Electronic Leak Detection

NOTE: Do not try to use a leak tester immediately after connecting or disconnecting service hoses. Traces of refrigerant at the fittings can falsely indicate a leak. Always verify a leak by blowing shop air into the area of the suspected leak, and checking the area again.

When checking for leaks, move the probe all the way around the fitting or suspected leak.

Daimler Trucks North America LLC recommends using only certain makes of the heated diode and infrared (IR) types of electronic leak detectors.

Recommended electronic heated diode type leak detectors are available from their manufacturers. See **Table 3**.

Another type of detector, the corona discharge type, is specifically **not recommended**.

Use the following procedures to locate refrigerant system refrigerant gas leaks using an electronic leak detector.

1. Operate the electronic leak detector in accordance with the manufacturer's instructions. Occasionally use a leak reference bottle of R-134a to ensure that the detector is working properly.
2. Leak test with the engine turned off.
3. Charge the air conditioning system with sufficient refrigerant to indicate a gauge pressure of at least 50 psi (345 kPa) with the system not operating. Typically, one-half pound (0.22 kg) of refrigerant is sufficient to create 50 psi (345 kPa) of pressure. It may not be possible to produce this amount of pressure and measure leakage if the ambient temperature is less than 59°F (15°C).
4. Be careful not to contaminate the detector probe tip if the part being tested is not clean. Wipe the part off with a dry shop towel or blow it off with shop air. Do not use cleaners or solvents as many detectors are sensitive to their chemical ingredients.
5. Visually inspect the entire refrigerant system. Look for air conditioning lubricant leakage and corrosion or damage to lines, hoses, and all other components. Inspect each questionable location carefully with the detector probe.

   Areas to inspect include:

   - All fittings.
   - Couplings.
   - Refrigerant controls.
   - Service ports (with caps installed).
   - Brazed or welded areas.
   - Areas around attachment points and hold-downs.
   - Any other areas of stress or sharp bends.
6. Follow the path of the refrigerant system methodically, so that no leaks are missed. If a leak is found, continue to test the rest of the system.
7. Inspect an area of possible leakage slowly and close to the part, moving completely around the part. Move the probe no faster than one to two inches (25 to 50 mm) per second and no farther away than 1/4 inch (6.4 mm) from the part.
8. If there is a large leak of refrigerant in either the system being serviced or the service equipment, the surrounding air will be saturated with refrigerant gas. Refrigerant in the surrounding air makes the leak detector operate erratically, and will give false indications of leaks. To reduce this possibility, place a large fan so that a light breeze blows through the work area. Verify a leak by blowing shop air into the suspected leak site and repeating the inspection. Blow out the area often, to pinpoint a large leak.
9. You can test the evaporator core without removing it from its housing. Turn on the blower motor for a minimum of 15 seconds. Shut off the blower and wait for refrigerant gas to accumulate in the housing. Follow the detector instructions for the specific length of time to wait for the gas to accumulate. Insert the detector probe into the blower resistor block, or condensate drain tube if no water is present. If this is not possible, insert the probe into the closest opening to the evaporator, such as a heater or vent duct.

Identification, Recovery, Evacuating, Purging and Flushing, Charging, and Leak Testing

Electronic Leak Detectors		
Designation	**Manufacturer**	**Comments**
D-TEK, D-Tek Select, and TekMate	Leybold Inficon 2 Technology Place East Syracuse NY 13057 (315) 434–1144	• Rechargeable battery • Hand-held design • Simple to operate
H–10 Professional	Bacharach Inc. c/o Yokogawa Corp. of America 2 Dart Road Newnan GA 30265 (800) 850–0044	• Rechargeable battery • Carrying case with strap • Calibration leak bottle • Manual sensitivity control • Most sensitive available
J 39400	SPX Kent-Moore 28635 Mound Road Warren MI 48092–3499 (800) 328–6657	• 12V DC or 120V AC • Carrying case with strap • Calibration leak bottle • Manual sensitivity control • Manual balance control

Table 3, Electronic Leak Detectors

NOTE: The end opening of the condensate drain tube should be free of water, when the probe tip is inserted into it. To determine whether there is water in the condensate drain tube, insert the eraser end of a pencil in the drain tube. Inserting the pencil will break the surface tension of any water near the opening of the drain tube, and allow the water to drain out before inserting the probe tip. It is only necessary to break the plane of the drain tube with the probe tip. It does not need to be inserted far into the tube.

10. Leak test the front seal area of the compressor. Blow shop air into the cavities in and around the clutch for at least 15 seconds, to clear out any residual gas. Let the compressor stand for one minute, then test for leakage. Inspect axial-type compressors (Sanden or Sel-Tec) by placing the probe near the holes at the front of the clutch. See **Fig. 2**. Inspect two-cylinder reciprocating type compressors (Climate Control) by placing the probe between the clutch coil and the compressor. See **Fig. 3**.

IMPORTANT: Be careful not to damage the clutch bearing seal with high pressure shop air.

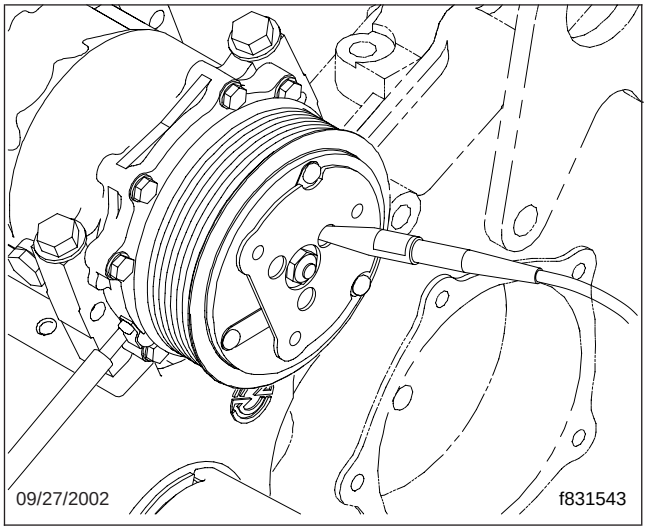


Fig. 2, Axial Type Compressor

11. Leak test the repaired areas of the system, after any repairs have been performed. Leak test the service ports (with caps installed) after any service which disturbs the refrigerant system.

Identification, Recovery, Evacuating, Purging and Flushing, Charging, and Leak Testing

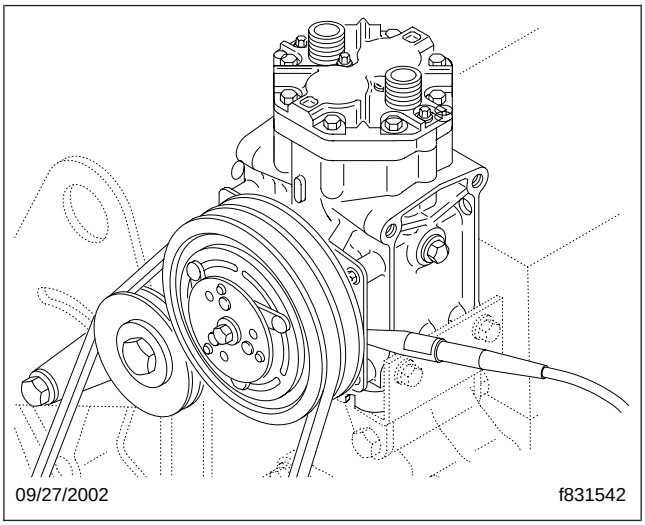


Fig. 3, Two-Cylinder Reciprocating Compressor

Replacement

1. Turn off the engine, apply the brakes, and chock the tires.
2. Open the hood or tilt the cab. For cab tilt instructions, see **Group 60**.
3. Access the binary switch.

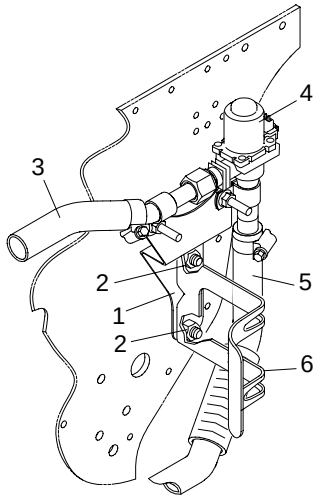
   On Century Class Conventionals, the binary switch is located under the hood on the right-hand side of the frontwall.

   On Argosy COEs, the binary switch is located on the right-hand side of the vehicle behind the bumper.
4. Disconnect the wiring harness from the binary switch.
5. Remove the binary switch.
6. Install a new binary switch and tighten 20 to 25 lbf·ft (27 to 34 N·m).
7. Connect the wiring harness to the binary switch.
8. Return the hood or cab to the operating position. For cab tilt instructions, see **Group 60**.
9. Remove the chocks from the tires.

Water Regulating Valve Replacement, Electronically-Controlled

Replacement

1. Turn off the engine, apply the brakes, and chock the tires.
2. Disconnect the batteries.
3. Open the hood to access the water regulating valve.
4. Remove the air cleaner. For instructions, refer to **Group 09**.
5. Clamp off the heater hoses to prevent coolant loss.
6. Remove the hoses from the water regulating valve. See **Fig. 1**.



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1. Water Regulating Valve Mounting Bracket
2. Nut
3. Outlet Hose
4. Water Regulating Valve
5. Inlet Hose
6. Receiver-Drier Mounting Bracket

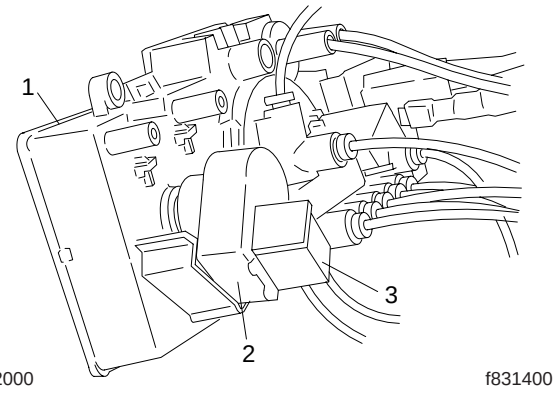
Fig. 1, Water Regulating Valve

7. Disconnect the connector on the water regulating valve.
8. Remove the nuts that attach the water regulating valve and mounting bracket and the receiver-drier mounting bracket to the frontwall. Remove the valve and mounting bracket.
9. Position a new water regulating valve and mounting bracket on the frontwall. Attach the receiver-drier mounting bracket to the front wall and install the nuts and tighten them securely.
10. Attach the connector on the water regulating valve to the mating connector.
11. Connect the heater hoses to the water regulating valve. Tighten the hose clamps 40 lbf·in (452 N·cm).
12. Remove the clamps from the heater hoses.
13. Install the air cleaner. For instructions, refer to **Group 09**.
14. Return the hood to the operating position.
15. Connect the batteries.
16. Remove the chocks from the tires.

Constant Discharge Temperature Control Potentiometer Replacement

Replacement

1. Turn off the engine, apply the brakes, and chock the tires.
2. Disconnect the batteries.
3. Remove the HVAC/radio trimplate from the dash. For instructions, see **Section 60.08**.
4. Remove the four screws that attach the HVAC control panel to the dash.
5. Disconnect the connector on the potentiometer behind the temperature control switch. See **Fig. 1**.



1. Control Panel
2. Potentiometer
3. Connector

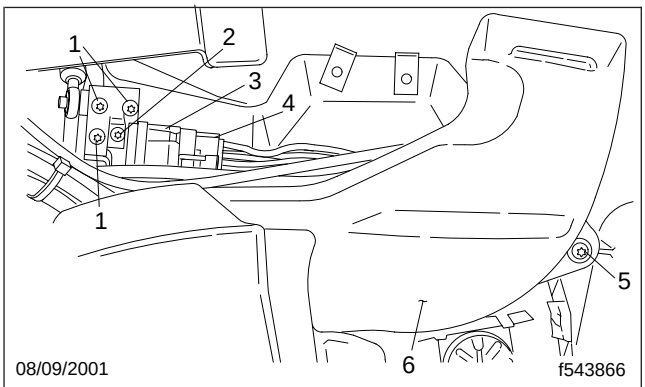
Fig. 1, HVAC Control Panel

6. Remove the temperature control knob from the control panel.
7. Remove the nut that attaches the potentiometer to the control panel and remove the potentiometer.
8. Install a new potentiometer and secure it to the control panel using a nut.
9. Attach the connector to the potentiometer.
10. Using four screws, attach the control panel to the dash.
11. Attach the temperature control knob to the control panel.
12. Attach the HVAC/radio trimplate to the dash. For instructions, see **Section 60.08**.
13. Connect the batteries.
14. Remove the chocks from the tires.

CDTC Controller With Sensor Replacement

Replacement

1. Turn off the engine, apply the brakes, and chock the tires.
2. Disconnect the batteries.
3. Remove the following dash panels. For instructions, see **Section 60.08**, Subject 100.
   - electrical cover
   - right-hand upper dash cover
   - HVAC cover
   - HVAC/radio trimplate
   - right-hand dash trimcap
4. Remove the HVAC duct that is above the power distribution module.
5. Remove the screws that secure the upper dash assembly. Lift the upper dash assembly to access the CDTC controller. See **Fig. 1**.



1. Air Cylinder Mounting Bracket Capscrew
2. CDTC Controller Capscrew
3. CDTC Controller
4. Connector
5. HVAC Duct Capscrew
6. HVAC Duct

Fig. 1, CDTC Controller With Sensor

6. Remove the capscrew that attaches the HVAC duct to the HVAC unit. See **Fig. 1**.
7. Remove the 7-pin connector from the CDTC controller.
8. Remove the capscrew that attaches the CDTC controller to the mounting bracket.
9. Loosen the three capscrews that attach the air cylinder mounting bracket to the HVAC unit.
10. Remove the CDTC controller.
11. Using a capscrew, attach a new CDTC controller to the mounting bracket.
12. Tighten the three air cylinder mounting bracket capscrews.
13. Attach the 7-pin connector to the CDTC controller.
14. Using a capscrew, attach the HVAC duct to the HVAC unit.
15. Lower the upper dash assembly back in place and secure it using screws.
16. Install the HVAC duct above the power distribution module.
17. Install the following dash panels. For instructions, see **Section 60.08**, Subject 100.
    - right-hand dash trimcap
    - HVAC/radio trimplate
    - HVAC cover
    - right-hand upper dash cover
    - electrical cover
18. Connect the batteries.
19. Remove the chocks from the tires.

Preliminary Checks

Before testing the operation of the air conditioning system, make the following checks:

1. Make sure the drive belt on the refrigerant compressor is not damaged and is correctly tensioned. Also check the compressor mountings for tightness. For instructions and other information, refer to the applicable refrigerant compressor section in this group.
2. Using a feeler gauge, check for correct refrigerant compressor clutch clearance. For instructions, refer to the applicable refrigerant compressor section in this group.
3. Check for broken, burst, or cut hoses. Also check for loose fittings on all parts.
4. Check for road debris buildup on the condenser coil fins. Using air pressure and a whiskbroom or a soapy spray of water, carefully clean off the condenser. Be careful not to bend the fins.
5. Check the color of the moisture indicator sight glass. If the color is blue, the refrigerant charge is dry. If the indicator is not blue, the system is contaminated with moisture. Recover the refrigerant, evacuate the system, replace the receiver-drier, and add a full refrigerant charge.
6. If there is not enough airflow, make sure that leaves or other debris have not entered the fresh air ports under the windshield. If debris have entered, it could clog the fins of the evaporator core and block airflow.

   Also be sure that all ducts are connected to the dash louvers and that the air-control flaps in the heater housing are moving properly.

Performance Tests

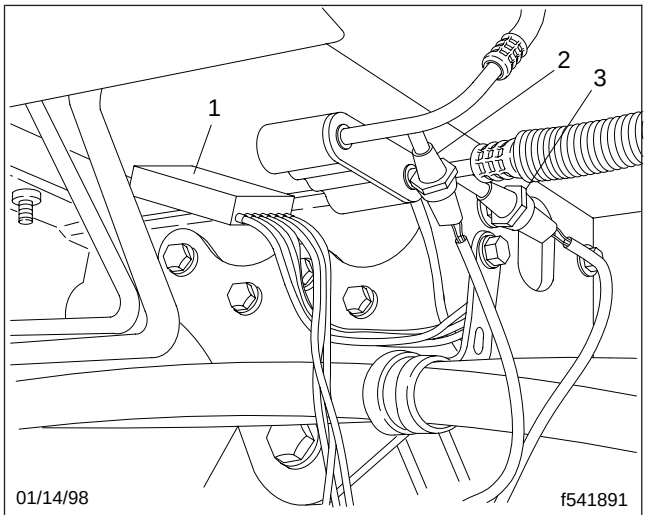
Following is a brief description of symptoms or conditions that could exist if something goes wrong with a refrigerant part.

Air Conditioning Protection Unit (ACPU)

NOTE: For more information about the ACPU, see **Subject 050**. The ACPU was installed on vehicles built before April 16, 1999.

IMPORTANT: The ACPU control system consists of an electronic control module, high and low pressure switches, and the thermostatic switch. The control module monitors system conditions (low or high refrigerant charge) and controls the operation of the refrigerant compressor and the on-off fan drive.

On Century Class Conventionals, the ACPU is located under the hood on the right side of the front-wall. On Argosy COEs, the ACPU is located on the right side of the vehicle behind the bumper. See **Fig. 1** and **Fig. 2**.



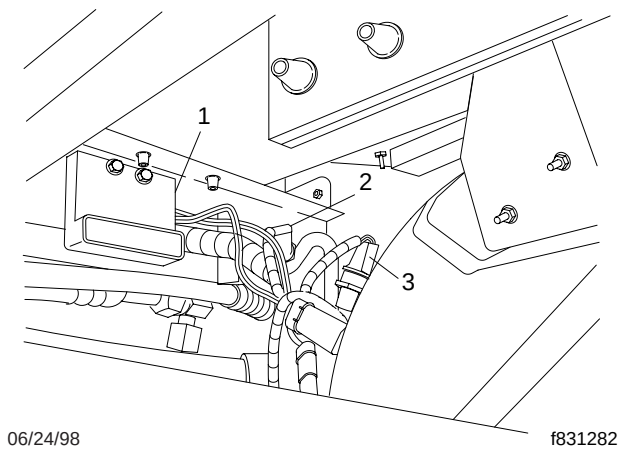
1. ACPU Control Module
2. High Pressure Switch
3. Low Pressure Switch

Fig. 1, ACPU Mounting, Century Class Conventional

The control module registers fault codes that warn of existing or impending problems in the air conditioning system. **Table 1** provides a list of ACPU messages broadcast to the Instrumentation Control Unit (ICU) message display screen. Additionally, corresponding fault codes are provided. Use **Table 1** to assist in troubleshooting the ACPU control system.

For further information on system fault codes, see the section in **Group 54** that discusses the Instrumentation Control Unit. Additionally, if ServicePro is available, a technician diagnostic routine is available covering the ACPU system.

Troubleshooting



1. ACPU Control Module
2. Low Pressure Switch
3. High Pressure Switch

Fig. 2, ACPU Mounting, Argosy COE

Cooling Check

When outside temperature and humidity are high, it will take longer to cool the cab, especially if the fresh air vents are left open.

To determine if the air conditioner is cooling enough:

1. Set the engine speed at 1500 rpm. The engine fan should be on.
2. On Century Class Conventionals, open the hood. On Century Class Conventionals and Argosy COEs, open the cab doors.
3. Turn on the cab air conditioner. Set the controls at air conditioning (not max AC), fresh air (not recirculated air), and maximum blower speed. The compressor must be engaged during this test.
4. In the sleeper (if equipped), turn the temperature control knob all the way counterclockwise to COOL. Turn the fan control knob to position 3 (high).
5. Allow the system to run for at least 10 minutes (longer on hot and humid days).
6. In the cab, place a thermometer inside the center dash outlet. In the sleeper, place a thermometer inside the lower outlet. Make sure the controls are set so that air flows out of the duct being tested.
7. Record the temperatures and take pressure readings at the service valves. Record the readings again after three minutes. If the temperature readings have not stabilized, run the system for an additional three minutes and record the readings again.
8. Compare the measured temperature readings to the readings in the temperature/pressure tables in **Specifications 400**. If the duct's air temperature is higher than normal readings, the system isn't cooling enough. For possible causes, see the troubleshooting chart.

Receiver-Drier

The receiver-drier is normally at outside temperature. To the touch, the entire length of the unit should be the same temperature. If noticeable cool spots exist, replace the receiver-drier.

A blockage at the inlet of the unit will cause high head pressures. Outlet blockages will cause low head pressures and little or no cooling.

If the moisture indicator is pink or white (showing that the system is wet), the receiver-drier is saturated with moisture and must be replaced.

Cooling System

Although they are not physically connected, there is a close tie between a vehicle's air conditioner and its cooling system. Poor air conditioner cooling can be the result of a problem in the cooling system.

If the cooling system does not work correctly, the heat of the engine will rise to abnormal levels. The added heat will transfer to the air conditioner, other underhood parts, and maybe make its way into the cab. The added heat makes it necessary for the air conditioner to work harder and, at the same time, it reduces the air conditioner's ability to cool down the air in the cab. Also, if the water regulating valve isn't closing all the way, heat will enter the cab, giving the impression that the air conditioning system is not working.

Refer to **Group 20** for cooling system troubleshooting and to the engine manufacturer's service manual for other details about cooling system problems.

ACPU Fault Codes and Tests					
ICU Text Message	**Problem**	**MID**	**SID**	**FMI**	**Remedy**
REFRIG PRES HIGH	Refrigerant charge above normal, high pressure	190	1	00	Condenser is clogged, or the system is overcharged. Clean the condenser, then check system pressure. If okay, start the engine. After system pressure reaches 290 to 310 psi (1999 to 2137 kPa) on vehicles built before December 11, 1998 or 340 to 375 psi (2344 to 2586 kPa) on vehicles built from December 11, 1998 the fan should come on. If it doesn't, the fan hub could be damaged.
REFRIG PRES LOW	Refrigerant charge is below normal, low pressure	190	1	01	Check system pressure. If the low-side pressure is below 35 psi (241 kPa) there is a loss of refrigerant charge. Perform a leak test. Repair any leaks, evacuate the system, replace the receiver-drier, and add a full charge of refrigerant. If the pressure is okay, use an ohmmeter to measure the resistance between the low pressure switch wires. Replace the switch if resistance is not 2.25–2.75 kilo ohms.
CLUTCH CIR OPEN	Open circuit	190	6	05	Check the wiring to the compressor clutch. Repair or replace as needed.
CLUTCH CIR SHORT	Short circuit	190	6	06	Check the wiring to the compressor clutch. Repair or replace as needed.
BAT VOLTAGE LOW	Low battery voltage	190	168	04	Check for excessive electrical loads, a damaged alternator, or a discharged battery. Repair or replace as needed.
LO PRES SW OPEN	Low pressure switch, open circuit	190	5	05	Check that the correct switches are installed. Check the switch wiring. Repair or replace as needed. Use an ohmmeter to measure the resistance between the low pressure switch wires. Replace the switch if resistance is not 2.25–2.75 kilo ohms when the switch is open.
HI PRES SW OPEN	High pressure switch, open circuit	190	228	05	Check that the correct switches are installed. Check the switch wiring. Repair or replace as needed. Use an ohmmeter to measure the resistance between the high pressure switch wires. Replace the switch if resistance is not 2.25–2.75 kilo ohms when the switch is open.
HI PRES SW CALIBRT	High pressure switch, life cycle exceeded	190	228	13	Replace the high pressure switch. After replacing the high pressure switch, reset the high pressure cycle to zero. For more information on resetting this parameter, see the Freightliner ServiceLink on-line help program.

Troubleshooting

ACPU Fault Codes and Tests					
ICU Text Message	**Problem**	**MID**	**SID**	**FMI**	**Remedy**
TSTAT CIR ERRATIC	Evaporator coil thermostatic switch	190	7	02	Test the thermostatic switch following the instructions provided elsewhere in this subject.

Table 1, ACPU Fault Codes and Tests

Expansion Valve

Problems that start in the expansion valve show up as follows: when stuck closed, the evaporator coil and the expansion valve will be at outside temperature; when stuck open, both the coil and the valve will be extremely cold with frost or ice buildup.

Because the expansion valve channels are very small, blockages in the system tend to be found here (the valve is very sensitive to contamination). Usually, the contaminant is water; less than a drop of water is all it takes to make the valve inoperative. When water reaches the valve, the extreme cold that results from the pressure drop freezes the water, forming a block of ice in the valve. After the system shuts down and the valve warms up, the ice melts, and the valve operates again, only to freeze-up when the moisture returns.

On-and-off operation of the expansion valve means that the receiver-drier is not removing moisture from the system. These contaminants should cause the moisture indicator to turn white and then pink.

Refrigerant Compressor

Compressor problems usually show in one of four ways: abnormal noise, seizure, leakage, or low suction and discharge pressures.

Resonant compressor noises are not causes for alarm. Irregular noise or rattles are likely to be caused by broken parts. To check for seizure, de-energize the magnetic clutch and see if the drive plate can be turned. If it won't turn, the compressor has seized.

Low discharge pressure may be caused by not enough refrigerant, not enough belt tension, or a blockage somewhere in the system. These things should be checked before servicing the compressor.

Evaporator

The evaporator coils are basically trouble-free when airflow over the fins is not blocked. External or, less often, internal blockages will cause low suction pressure as well as little or no cooling.

If a leak exists in the system, and it cannot be traced to other parts or fittings, suspect damage to one of the evaporator coils.

Condenser

The condenser is usually trouble-free. Normally, the temperature of the condenser outlet line is noticeably cooler than the inlet line. However, when road debris, such as leaves or dirt, build up, airflow over the condenser fins is blocked. Air is not able to absorb enough heat to turn the hot refrigerant gas into a liquid. High head pressures will result. In these cases, carefully clean off the outer surfaces of the condenser with compressed air or a soap and water solution. Be careful not to bend the fins.

High head pressures will also occur if the condenser's tubing is abnormally bent, blocking the flow of refrigerant. Frost will appear at the point where the flow is restricted.

Less common internal blockages (bits of foreign material or metallic grit buildup) will stop the flow of refrigerant.

A quick test to check that poor system performance is caused by the condenser is to direct a spray of water onto the condenser while the system is running. If the air conditioner cools better because of the assist provided by the water, it is a sign that the condenser is not working.

When troubleshooting a suspected condenser problem, remember that the problem may be caused by the radiator transferring high levels of heat to the condenser. Refer to **Group 20** of this manual for cooling system troubleshooting and to the engine

manufacturer's service manual for other details about cooling system problems.

Thermostatic Switch

IMPORTANT: Before troubleshooting the thermostatic switch, be sure there is a full charge of refrigerant in the system. The compressor will not operate or will cycle too often if there is not enough refrigerant in the system.

Quick or delayed cycling of the compressor may be caused by a thermostatic switch that is working, but is out of adjustment. If, after doing the tests below, the switch seems to be out of adjustment, replace it (the thermostatic switch cannot be recalibrated).

1. Be sure the compressor clutch is operating correctly. See the applicable refrigerant compressor section in this group.
2. Expose the evaporator coil. See **Subject 180** for instructions.
3. Start the engine. Place the air conditioner control at its coldest setting. Turn on the air conditioner and the fan.
4. Place an accurate thermometer in contact with a tube on the evaporator coil. Be sure the thermometer is in good contact with the tube or you will get a wrong reading.

   When the temperature drops below 31 to 36°F (–1 to 2°C), the compressor clutch should disengage and remain this way until the temperature rises to 39 to 44°F (4 to 7°C).
5. If the compressor did not engage when the temperature was above the accepted high range, do the following test:

   5.1 Connect a voltmeter or a test light from one of the terminals on the thermostatic switch to ground. Repeat this test with the other terminal on the switch.

   5.2 With the engine running and the air conditioner and blower on, both terminals will show voltage when the compressor should be engaged. One terminal will show voltage when the compressor should be disengaged.

   If there is no voltage, there is a problem in the electrical system from the batteries to the thermostatic switch. Check all circuits for the cause, and repair or replace the wiring or parts.

   In all other cases where the compressor is not engaging and disengaging properly, the thermostatic switch is the cause. Replace it with a new switch.
6. Shut down the engine and, to prevent accidental electric shock or shorting during dash assembling, disconnect the batteries.
7. Assemble the dash. See **Subject 180** for instructions.

Discharge Temperature Control (DTC) System Troubleshooting

The water regulating valve clicks when it opens and closes. The clicks can be used to confirm operation of the water valve. The valve is normally open (NO). When the potentiometer is turned to full cold and the cab is warm, the controller should send electricity to the solenoid that closes the water valve and stops coolant flow through the heater core. By listening for the sound of the valve opening and closing, the technician can determine if the water valve is operating.

See **Fig. 3** for the wiring schematic for the cab Discharge Temperture Control (DTC) module.

See **Table 2** for the electrical pinout descriptions of the DTC module.

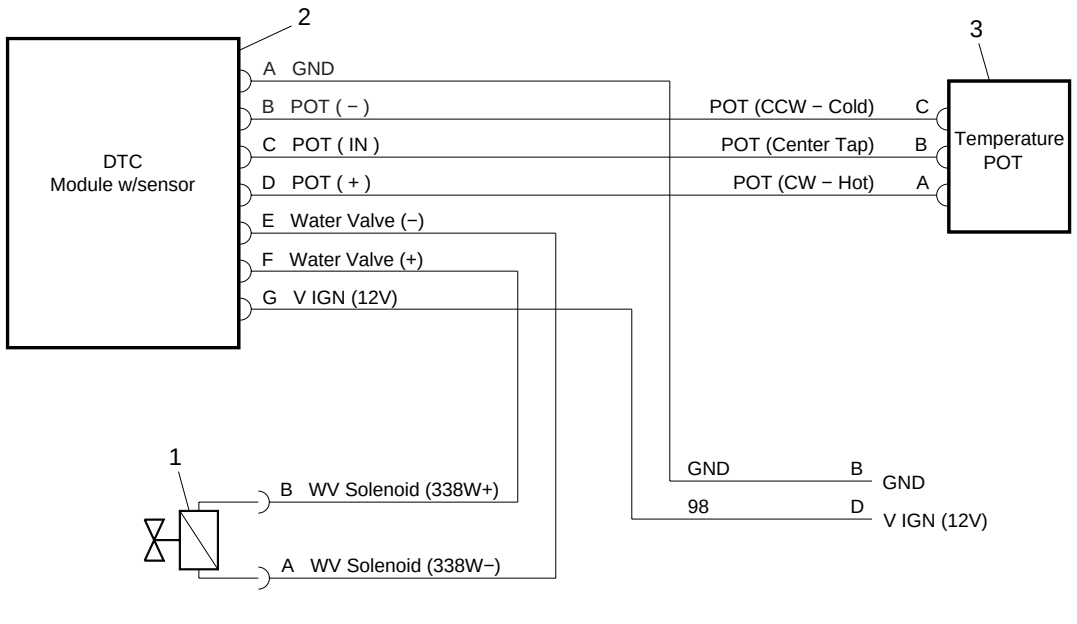
DTC Module Pinout	
Pin	**Electrical Function**
A	Ground
B	Potentiometer Input (–) Cold
C	Potentiometer Input (wiper)
D	Potentiometer Input (+) Hot
E	Solenoid Valve Output (–)
F	Solenoid Valve Output (+)
G	Ignition +12V

Table 2, DTC Module Pinout

Use the troubleshooting procedures in **Table 3** first.

Use the troubleshooting procedures in **Table 3** before using the procedures in **Table 4**.

Troubleshooting



1. Water Valve Solenoid (NO)
2. DTC Module With Sensor
3. Potentiometer

Fig. 3, Cab Discharge Temperature Control Schematic

CDTC System Initial Electrical Diagnosis				
Test No.	**Test Procedure**	**Test Criteria**	**Test Result**	**Action**
1	Measure voltage at the water valve by backprobing the connector. Voltage should be approximately 12V.	• Engine running • Engine at normal operating temperature • Temperature setting at **full cold**	OK	**Go to test no. 2.**
			Not OK	**Go to test no. 3.**

CDTC System Initial Electrical Diagnosis				
Test No.	**Test Procedure**	**Test Criteria**	**Test Result**	**Action**
2	Measure voltage at the water valve by backprobing the connector. Voltage should be approximately 0V.	• Engine running • Engine at normal operating temperature • Temperature setting at **full hot**	OK	There are no apparent electrical problems with the system. With the engine at normal operating temperature, hot air should come from the vents when the temperature setting is **full hot**. When switched to **full cold**, cooler air should come from the vents within approximately 10 minutes. If the system does not operate as stated above, refer to one of the following: • For little or no heat symptom, see **Table 6**. • For blowing warm/hot air symptom, see **Table 7**.
			Not OK	Perform tests in **Table 4**, CDTC System Temperature Potentiometer Test.
3	Repeat test no. 1 using a known good ground instead of water valve ground wire. Voltage should be approximately 12V.	• Engine running • Engine at normal operating temperature • Temperature setting at **full cold**	OK	**Go to test no. 4.**
			Not OK	Perform tests in **Table 4**, CDTC System Temperature Potentiometer Test.
4	Check the ground wire to the controller (terminal A).	—	OK	Perform tests in **Table 4**, CDTC System Temperature Potentiometer Test.
			Not OK	Repair controller ground circuit.

Table 3, CDTC System Initial Electrical Diagnosis

CDTC System Temperature Potentiometer Test			
Test No.	**Test Procedure**	**Test Result**	**Action**
1	Disconnect the temperature potentiometer from the harness. Using an ohmmeter, measure the potentiometer resistance as follows: • A to B (knob full CCW) 8000 to 12,000 ohms • A to B (knob full CW) 40 to 60 ohms • B to C (knob full CCW) 40 to 60 ohms • B to C (knob full CW) 8000 to 12,000 ohms NOTE: Resistance ranges are approximate.	OK	**Go to test no. 2.**
		Not OK	Replace temperature potentiometer.

Troubleshooting

CDTC System Temperature Potentiometer Test			
Test No.	**Test Procedure**	**Test Result**	**Action**
2	Connect the potentiometer. Disconnect the harness from the controller. Using an ohmmeter, measure the potentiometer resistance through the harness pins at the controller as follows: • C to D (knob full CCW) 8000 to 12,000 ohms • C to D (knob full CW) 40 to 60 ohms • B to C (knob full CCW) 40 to 60 ohms • B to C (knob full CW) 8000 to 12,000 ohms NOTE: Resistance ranges are approximate.	OK	Temperature potentiometer and wires are okay. Perform tests in the table titled CDTC System Controller Test.
		Not OK	Repair wiring between temperature potentiometer and CDTC controller.

Table 4, CDTC System Temperature Potentiometer Test

Use the troubleshooting procedures in **Table 3** and **Table 4** before using the procedures in **Table 5**.

CDTC System Controller Test				
Test No.	**Test Procedure**	**Test Criteria**	**Test Result**	**Action**
1	Disconnect the harness from the CDTC controller. Measure voltage across pins A and G. Voltage should be approximately 12V.	• Ignition on • CDTC controller disconnected	OK	**Go to test no. 2.**
			Not OK	Check power supply wire and fuse to CDTC controller. Check CDTC controller ground circuit. Repair as necessary.
2	Connect the harness to the CDTC controller. Measure voltage by backprobing one meter lead to pin F and placing the other lead to a known good ground. Voltage should be approximately 12V.	• Ignition on • CDTC controller connected	OK	**Go to test no. 3.**
			Not OK	Replace the CDTC controller.

CDTC System Controller Test				
Test No.	**Test Procedure**	**Test Criteria**	**Test Result**	**Action**
3	Measure voltage by backprobing pins F and E of the CDTC controller connector. Voltage readings should be: • Slightly less than 12V when the control knob is **full cold** (CCW) • 0V when the control knob is **full hot** (CW).	• Ignition on • CDTC controller connected	OK	No problem found. Repeat tests **Table 3**.
			Not OK	Replace the CDTC controller.

Table 5, CDTC System Controller Test

Use the troubleshooting procedures in **Table 3** before using the procedures in **Table 6**.

CDTC System Special Test-Symptom: Little or No Heat and Passes All Electrical Tests			
Test No.	**Test Procedure**	**Test Result**	**Action**
1	Check to make sure that the coolant source from the engine is connected to the inlet pipe on the water valve.	OK	**Go to test no. 2.**
		Not OK	Route hose to correct connections.
2	Check to make sure that the water inlet hose at the water valve is hot.	OK	Check for blocked heater core and repair as necessary.
		Not OK	Check for closed heater hose shutoff valve. If okay or not present, repair engine cooling system as necessary.

Table 6, CDTC System Special Test-Symptom: Little or No Heat and Passes All Electrical Tests

Use the troubleshooting procedures in **Table 3** before using the procedures in **Table 7**.

Troubleshooting

CDTC System Special Test-Symptom: Blows Warm/Hot Air and Passes All Electrical Tests			
Test No.	**Test Procedure**	**Test Result**	**Action**
1	Remove the water valve and visually inspect the inside of the outlet tube to see if the plunger is broken or if debris is preventing the plunger from seating properly.	OK	If the vehicle: • Has a 2002 or newer Detroit Diesel engine, **or** • Has an MBE engine, **or** • If water pump pressure or flow is higher than a standard truck, **then** Install a water flow restrictor, part number RCV H43 1000 000 (available in the PDCs). Install the flow restrictor in the heater hose between the engine and the inlet side of the water valve. IMPORTANT: Make sure the flow restrictor is installed so that the flow direction arrow is toward the water valve, which is the direction of coolant flow.
		Not OK	If plunger is broken, replace the water valve. If debris is present, clean the cooling system.

Table 7, CDTC System Special Test-Symptom: Blows Warm/Hot Air and Passes All Electrical Tests

See **Table 8** for the electrical pinout descriptions of the DTC module.

DTC Module Pinout	
Pin	**Electrical Function**
A	Ground 2
B	Potentiometer (CCW–cold) 98U
C	Potentiometer (center tap) 98T
D	Potentiometer (CW–hot) 98J
E	Water Valve (–) 98X
F	Water Valve (+) 98W
G	Ignition Power (12V) 98N

Table 8, DTC Module Pinout

Line Restrictions

A restricted suction line causes low suction pressure at the compressor and little or no cooling. A restriction in a line between the compressor and the expansion valve can cause high discharge and low suction pressure, and insufficient cooling.

Usually, areas of ice or frost buildup mean a blockage. Parts that often freeze-up are probably corroded or inoperative and should be replaced. Parts (such as the expansion valve) that freeze-up once in a while may do so because of moisture in the system, which will cause the moisture indicator to turn white or pink. If this happens, recover the refrigerant charge, evacuate/recycle the system refrigerant, replace the receiver-drier, and install a new charge.

Fault Analysis Flow Chart

See **Fig. 4** for the fault analysis flow chart.

System Troubleshooting Tables

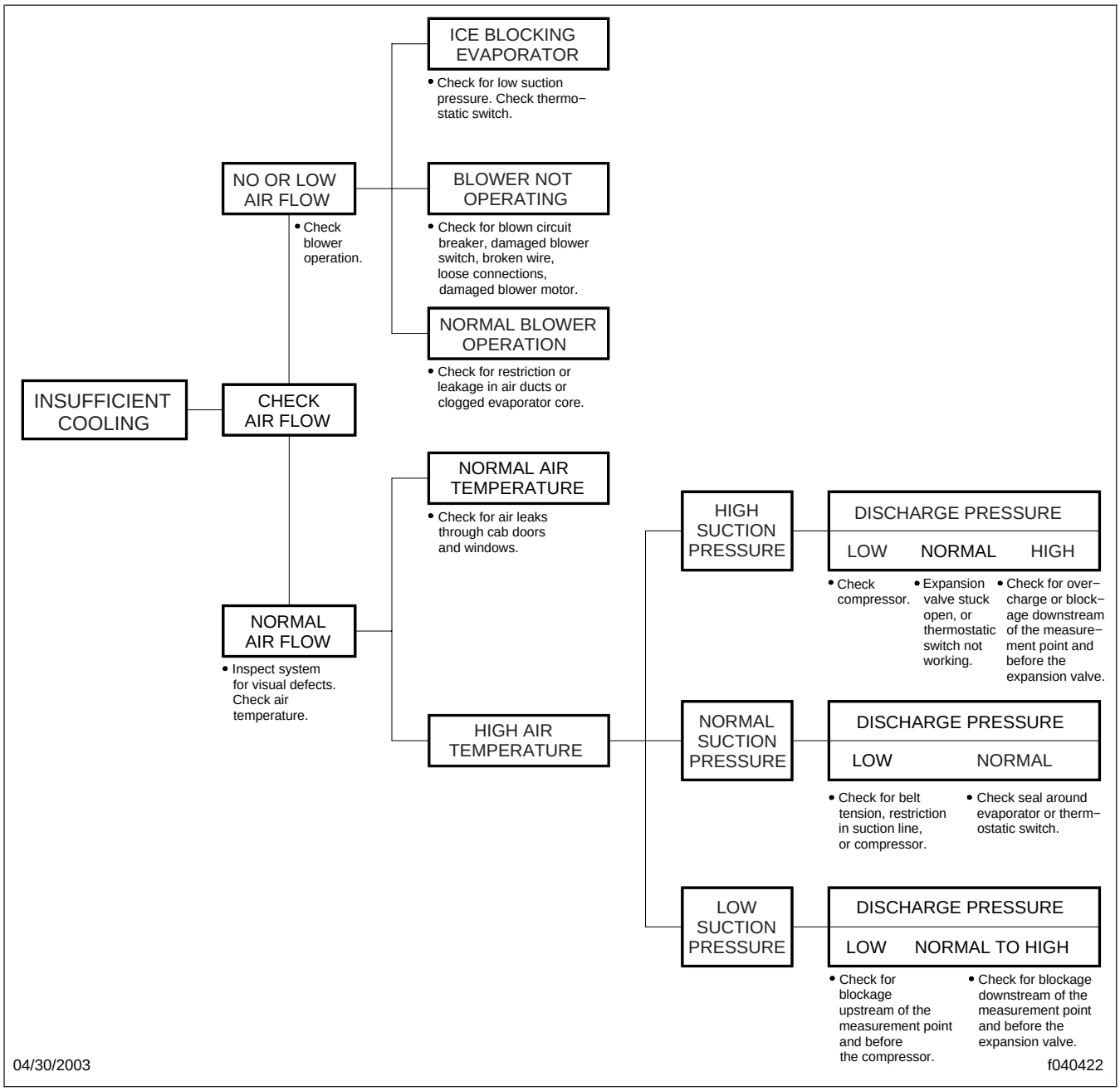


Fig. 4, Fault Analysis Flow Chart

Troubleshooting

Problem—Little or No Airflow

Problem—Little or No Airflow	
Possible Cause	**Remedy**
The blower is not operating.	Check for an open circuit breaker. An open circuit indicates a short in the electrical system, which must be located and repaired.
	Check the air conditioner relays for operation. Replace, as necessary.
	Make sure the blower motor switch is working. Replace, if necessary.
	Check the wiring to the blower motor. If any connections are loose, securely tighten them. Make sure the wiring conforms to the applicable diagram under **Specifications 400**.
	Check the blower motor for operation. Replace if sticking or otherwise inoperative.
	Check the resistor block. Replace, if necessary. **CAUTION** **Never try to bypass the fuse in the resistor block. To do so could cause the blower motor to overheat, resulting in serious damage to the heater/ air-conditioning system.**
There are restrictions or leaks in the air ducts.	Examine all air ducts and remove any blockages. Stop any leaks or replace any portion where the leaks cannot be stopped.
Ice has formed on the evaporator coil.	Defrost the evaporator coil before resuming operation of the air conditioner. Review "Performance Tests" in this subject for possible causes and corrective action.

Problem—Warm Airflow When the Air Conditioner Is On

Problem—Warm Airflow When the Air Conditioner Is On	
Possible Cause	**Remedy**
There is no refrigerant charge in the system.	Perform a leak test. Repair any leaks, evacuate the system, replace the receiver-drier, and add a full charge of refrigerant.
Moisture in the system.	If moisture is in the system, ice crystals may form at the expansion valve, blocking the flow of refrigerant (off and on). Recover the refrigerant charge, replace the receiver-drier, evacuate the system, and add a full charge of refrigerant.
The refrigerant compressor is not operating.	If the refrigerant charge is low, charge and leak test the system. Repair any leaks.
	The refrigerant compressor clutch or drive belt needs repair or replacement. For instructions, see the applicable refrigerant compressor section elsewhere in this group.
Ice has formed on the evaporator coil.	Defrost the evaporator coil before resuming operation of the air conditioner. Review "Performance Tests" in this subject for possible causes and corrective action.

Problem—Low Evaporator Coil Outlet Pressure (Low Compressor Suction Pressure)

Problem—Low Evaporator Coil Outlet Pressure (Low Compressor Suction Pressure)	
Possible Cause	**Remedy**
The expansion valve is not working.	Replace the expansion valve.
There are restrictions in the line to the expansion valve.	Remove the line restrictions.
There is an insufficient refrigerant charge in the system.	Locate the leak. Recover the charge, replace the receiver-drier, and add a full refrigerant charge.

Problem—High Compressor Discharge Pressure

Problem—High Compressor Discharge Pressure	
Possible Cause	**Remedy**
The shutters are not opening.	Replace the shutter solenoid valve, Air Conditioning Protection Unit high pressure switch, or both.
Airflow through the condenser is restricted.	Remove the debris from the condenser.
There is an internal restriction in the condenser. Ice buildup on the condenser or a cool spot on the line from the condenser to the receiver-drier.	Replace the condenser.
Air is present in the system.	Perform a leak test. Repair any leaks, evacuate the system, and add a full charge of refrigerant.
Heavy frosting on the suction line suggests that the evaporator coil is flooded.	Defrost the evaporator coil before resuming operation of the air conditioner.
The engine is overheated.	See the engine manufacturer's operations manual for corrective measures.
Restriction in the compressor discharge line.	Repair or replace the line.

Problem—Evaporator Outlet Air Temperature Increases as the Compressor Discharge Pressure Drops

Problem—Evaporator Outlet Air Temperature Increases as the Compressor Discharge Pressure Drops	
Possible Cause	**Remedy**
There are leaks in the system.	Leak test the system.
The expansion valve setting is too low.	Replace the expansion valve. Add a full charge of refrigerant.
Too much oil is in the system. An indication of this is clutch or belt slippage at governed engine speed.	Check and remove excess refrigerant oil. For instructions, see the applicable refrigerant compressor section elsewhere in this group.

Problem—Compressor Operates Too Often or Continuously

Problem—Compressor Operates Too Often or Continuously	
Possible Cause	**Remedy**
There is too little refrigerant in the system.	Perform a leak test. Repair any leaks, and add a full charge of refrigerant.

Troubleshooting

Problem—Compressor Operates Too Often or Continuously	
Possible Cause	**Remedy**
Ice has formed on the evaporator coil.	Defrost the evaporator coil before resuming operation of the air conditioner. Check the operation of the thermostatic switch, and replace as necessary.
There is a restriction in the refrigerant system.	Remove the restriction from the line.
Dirt and debris are clogging the condenser fins.	Remove all dirt and debris from the condenser fins.
The thermostatic switch isn't working.	Replace the thermostatic switch.

Problem—Quick or Delayed Cycling of the Compressor

Problem—Quick or Delayed Cycling of the Compressor	
Possible Cause	**Remedy**
The thermostatic switch operates, but is out of adjustment.	Replace the thermostatic switch. Do not attempt to adjust it.
Loss of refrigerant is causing a delayed cycling of the compressor.	Leak test and add a full charge of refrigerant.

Problem—Temperature in the Cab Too Low or No Heat

Problem—Temperature in the Cab Too Low or No Heat	
Possible Cause	**Remedy**
The water regulating valve is not opened.	Move the temperature control knob toward warm.
The water regulating valve is not opening all the way.	Adjust the water regulating valve cable.
The water regulating valve is not working.	Replace the water regulating valve.
A heater hose is pinched or twisted.	Repair or replace the heater hose.
Coolant is leaking from the system.	Check for leakage at the heater core, and at all hose connections from the heater core to the engine. Check the radiator coolant level, as instructed in the vehicle driver's manual, and add coolant, if necessary. Check and repair any leaks at the radiator.
Dust or dirt is clogging the heater core fins.	Remove and clean the heater core.

Problem—Condensed Water Is Leaking from the Air Conditioner

Problem—Condensed Water Is Leaking from the Air Conditioner	
Possible Cause	**Remedy**
The drain tubes are plugged.	Clean the drain holes and drain tubes.

Troubleshooting the Refrigerant System Using ACPU Fault Codes

For ACPU faults accompanied by fault messages, **Fig. 5** and **Table 9** list faults that the ACPU is capable of detecting. The wording of the fault message display may vary depending on the level of software installed in the instrument cluster. Use ServicePro to clear fault codes.

See **Fig. 6** for the ACPU system schematic.

Troubleshooting Fault Code Definitions

High Pressure: The high pressure condition is detected by monitoring high pressure switch activity after the fan has been engaged. This fault can be caused by fan drive failure, condenser airflow blockage, or refrigerant overcharging.

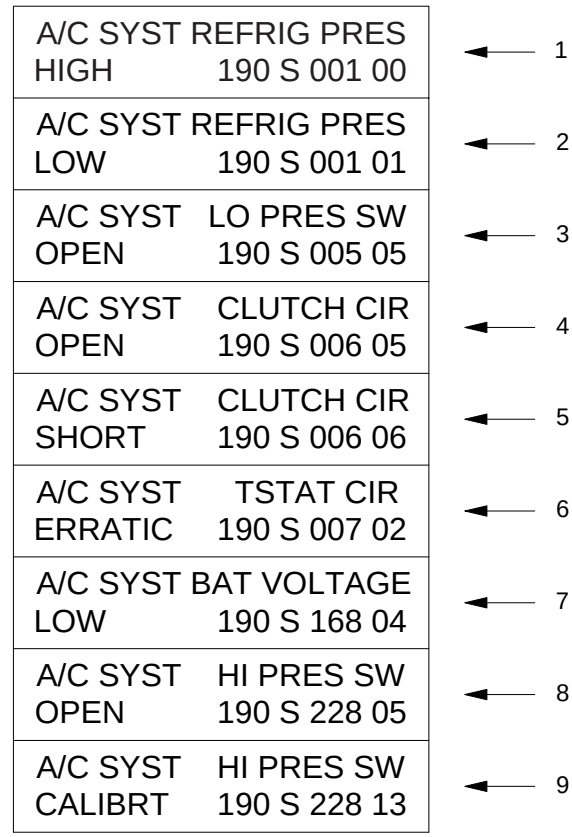
High Pressure Switch Open: Indicates that the wiring to the high pressure switch is an open circuit. This can be caused by an unseated connector, a break in the wiring harness, or moisture intrusion into the connectors or switch. When continuity to the switch resumes, this fault becomes inactive.

High Voltage: Indicates a high supply voltage condition (greater than 16 volts). This can be caused by a defective alternator, voltage regulator or surges on the supply line. The high voltage warning goes away when the supply voltage returns to normal (below 16 volts).

Low Pressure: This is detected by monitoring the ambient temperature and activity of the low pressure switch. It indicates a loss of refrigerant.

Low Pressure Switch Open: Indicates that the wiring to the low pressure switch is an open circuit. This can be caused by an unseated connector, break in the wiring harness, or moisture intrusion into the connectors or switch. When continuity to the switch resumes, this fault code becomes inactive.

Low Voltage: Indicates a low supply voltage condition. This can be caused by a defective alternator, discharged batteries or excessive loads. The low voltage warning goes away when the supply voltage returns to normal (above 11 volts).



1. High Pressure Fault
2. Low Pressure Fault
3. Low Pressure Switch Open
4. Open Wire to Clutch
5. Shorted Clutch
6. Erratic Thermostatic Switch
7. Low Battery Voltage
8. High Pressure Switch Open
9. High Pressure Switch Life has Exceeded 260,000 Cycles

Fig. 5, ACPU Fault Messages

Open Clutch: If no current is sensed when the AC clutch is engaged, an open connection to the clutch coil is inferred. When continuity to the clutch resumes, this fault becomes inactive. If this fault is detected, the AC is held off for the remainder of the ignition cycle.

Shorted Clutch: This is detected by excessive current flowing to the compressor clutch. This indicates

Troubleshooting

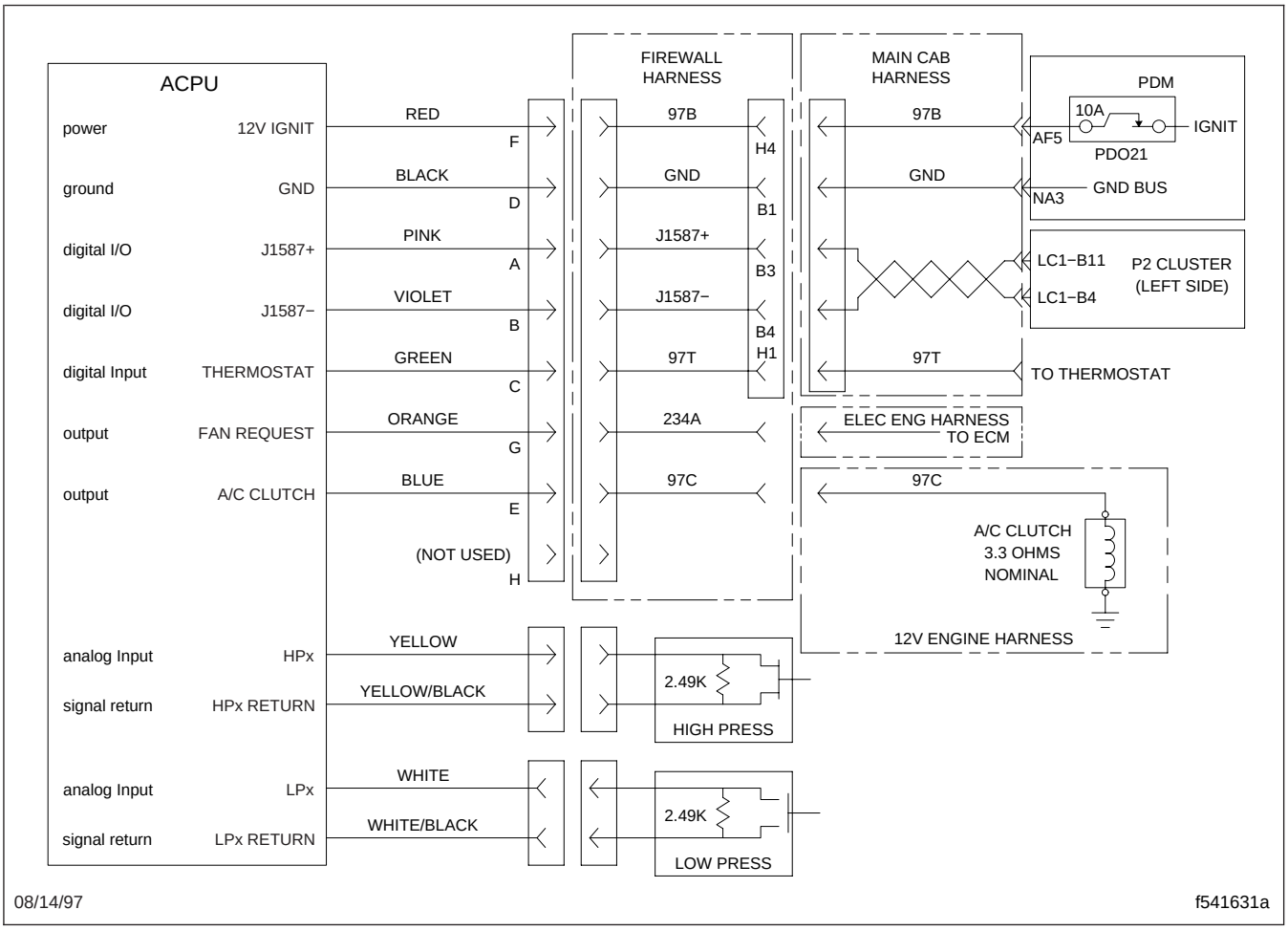


Fig. 6, ACPU System Schematic

either a shorted clutch coil or shorted wiring to the clutch. If this fault is detected, the AC is held off for the remainder of the ignition cycle.

Erratic Thermostatic Switch: The thermostatic switch input has been detected to be switching on and off at a rapid rate. This indicates a bad AC selector, fan switch, thermostatic switch, or intermittent connections in the wiring or connectors.

High Pressure Switch Calibration: Cycle life of the high pressure switch has been exceeded (260,000 cycles). Replace the switch and reset the ACPU by pressing the HPX button in ServiceLink.

NOTE: Use ServiceLink to clear fault codes.

ACPU Troubleshooting Table

ACPU Troubleshooting Table			
Dash Message	**Definition**	**Possible Cause**	**Action**
See **Fig. 7**.	High pressure fault. The system is exhibiting abnormal high pressure activity.	Fan drive failure	Inspect for proper operation of the solenoid valve/relay and/or related components.
		Blocked air flow	Remove the restriction from the condenser.
		Refrigerant overcharge	Recover refrigerant and charge to the manufacturer recommended specification.
		High pressure switch out of tolerance	Perform steps 3.1 through 3.7 in the following section to test fan and compressor operation and replace the high pressure switch if necessary.
		Fan circuit has not been turned on in the Engine Control Module	Disconnect the main harness to the ACPU module. If the engine fan engages, replace the ACPU module. If the engine fan doesn't engage, check the fan circuit in the ECM, and have the ECM programmed to accept ACPU input.
See **Fig. 8**.	Low pressure fault. This is detected by monitoring the ambient temperature and the switching activity of the low pressure switch.	Partial or total loss of refrigerant	Check the system for leaks.
		A damaged low pressure switch	Disconnect the low side pressure switch connector and measure the resistance value of the switch. If the resistance shows 2490 ohms, the switch is operating properly, if resistance shows less than 5 ohms, replace the switch. NOTE: This check must be done with the switch installed, the ignition in the off position, and the system properly charged.
See **Fig. 9**.	Open in wiring to the low pressure switch. Indicates that the wiring to the low pressure switch is damaged.	Unseated connector	Check the connectors at the module and the pressure switch for loose pins.
		Break between wiring harness and pressure switch	Using an ohmmeter, probe the white and white/black pins of the module harness. Resistance should read 2490 ohms with the switch installed and proper charge.
		Moisture intrusion into the connectors or switch	Check seals and inspect wires for hole punctures.
		Incorrect pressure switch installed	Install the correct pressure switch.

Troubleshooting

ACPU Troubleshooting Table			
Dash Message	**Definition**	**Possible Cause**	**Action**
See **Fig. 10**.	Open wire to the A/C clutch. Detected by inadequate current through the compressor clutch. If no current is sensed when the A/C drive is turned on, an open connection to the clutch coil is indicated.	A break in the wiring between the ACPU module and the A/C compressor clutch	Use an ohmmeter to check the wiring for continuity.
		Poor electrical contact between the compressor and the vehicle ground	Using an ohmmeter, test the resistance between the clutch and the compressor, and between the compressor and the engine block. If necessary, loosen the mounting on the compressor and retighten it to repair the contacts.
		No clutch output from the ACPU	Replace the ACPU with a binary switch. For instructions, see Service Bulletin 83-71.
See **Fig. 11**.	Shorted wire or A/C clutch. Detected by excessive current through the compressor clutch.	This means either a shorted clutch coil or shorted wiring to the clutch	With the use of an ohmmeter, check the resistance of the clutch coil. If the reading is less than 2.8 ohms, replace the clutch.
		No clutch output from the ACPU	Replace the ACPU with a binary switch. For instructions, see Service Bulletin 83-71.
See **Fig. 12**.	Erratic evaporator thermostatic switch. The thermostat input has been detected to be switching on and off at a rapid rate.	An erratic power signal between the A/C cab controls and the ACPU module	Check for a bad A/C-On switch, thermostat, or an intermittent connection in the wiring or connection between the cab controls and the ACPU module (pin c).
See **Fig. 13**.	Low system voltage. Indicates voltage has dropped below 11.0 volts.	Possibly caused by a defective alternator, discharged batteries or excessive electrical loads	Check voltage at the control module harness by probing pins D (ground) and F (power). If voltage is less than 11.0 volts, start checking for voltage drops.
See **Fig. 14**.	Open in wiring to the high pressure switch. Indicates that the wiring to the high pressure switch is damaged.	Unseated connector	Check connectors at the module and the pressure switch for loose pins.
		Break between wiring harness and pressure switch	With the use of an ohmmeter, probe the yellow and yellow/black pins of the switch harness. Replace the switch if resistance is greater than 5 ohms.
		Moisture intrusion into the connectors or the switch	Check seals and inspect wires for continuity.
		Incorrect pressure switch installed	Install the correct pressure switch.
See **Fig. 15**.	Cycle life of the high pressure switch has been exceeded.	High pressure switch has exceeded more than 260,000 cycles	Replace the pressure switch with F/L part number 8040151. Using ServiceLink, reset the high pressure cycle counter to zero.

ACPU Troubleshooting Table			
Dash Message	**Definition**	**Possible Cause**	**Action**
No Dash Message.	Clutch is engaged, A/C is not cooling.	Inoperative blower motor, or loose or broken compressor belts	Check for proper operation of the blower motors. Tighten or replace the compressor belts.
No Dash Message.	A/C compressor is not engaging.	System air pressure is less than 60 psi (414 kPa)	Check for low air pressure.
No Dash Message.	A/C system is not cooling properly.	Cable to the heater control valve is disconnected or the valve is not completely closing	Check the cable at the heater control valve and behind the dash. Be sure the valve opens and closes completely.
No Dash Message.	A/C compressor is not engaging.	Engine rpm is less than 300	Check the cause of the low rpm.

Table 9, ACPU Troubleshooting Table

NOTE: Use ServiceLink to clear fault codes.

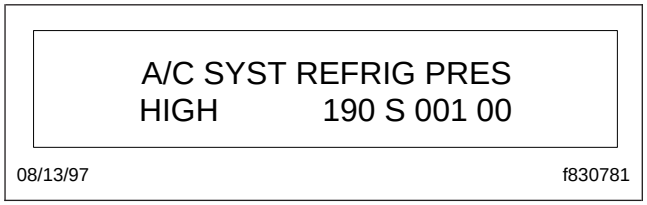


Fig. 7, High Pressure Fault Code

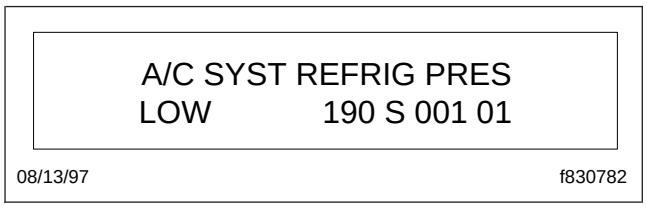


Fig. 8, Low Pressure Fault Code

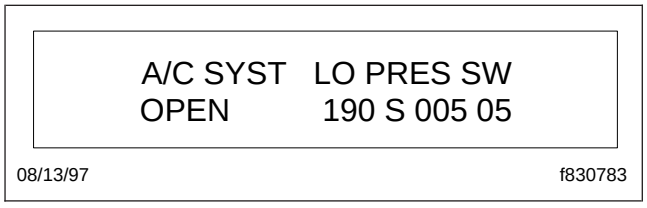


Fig. 9, Low Pressure Switch Open Fault Code

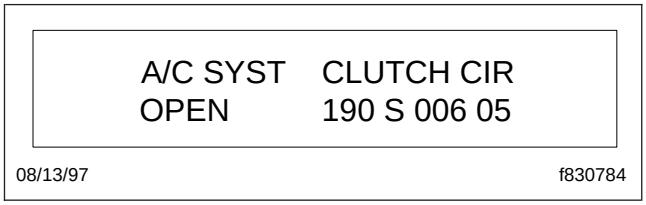


Fig. 10, Open Wire to Clutch Fault Code

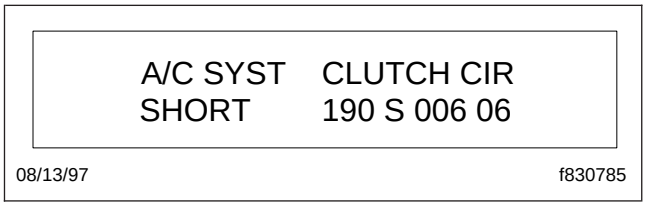


Fig. 11, Shorted Clutch Fault Code

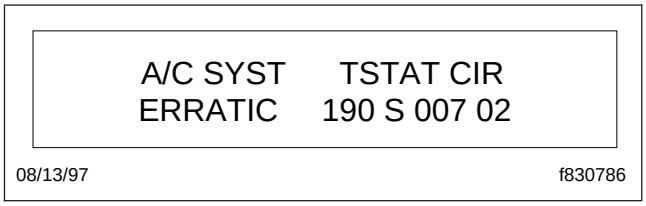


Fig. 12, Erratic Thermostatic Switch Fault Code

Troubleshooting the ACPU

Use the following procedure for troubleshooting ACPU faults not accompanied by fault codes.

Troubleshooting

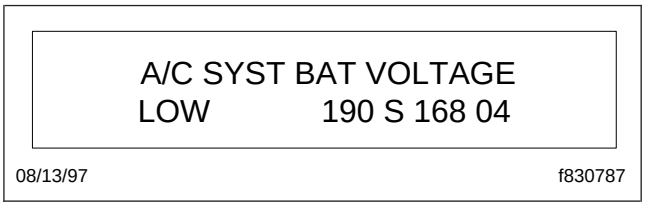


Fig. 13, Low Battery Voltage Fault Code

Fig. 14, High Pressure Switch Open Fault Code

1. Connect ServiceLink to the truck and download the fault codes.

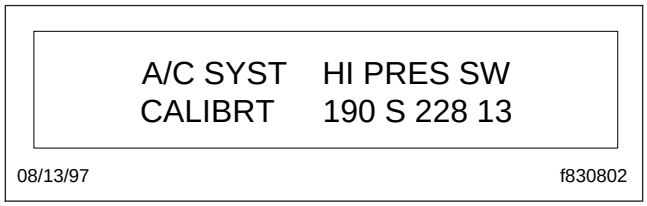


Fig. 15, High Pressure Switch Life Has Exceeded 260,000 Cycles Fault Code

1.1 Make repairs to correct existing fault codes.

1.2 Clear the fault codes using ServiceLink.

1.3 If the ACPU does not report on ServiceLink, see **Table 10**.

Problem—ACPU Not Reported on ServiceLink	
Possible Cause	**Remedy**
No power supply to the ACPU.	Check the voltage between pins D (ground) and F (power) at the frontwall harness connector to the ACPU. If the voltage is less than 11.0 volts, start checking for voltage drops.
Open J1587 circuit.	Check for voltage between pins A (J1587+) and B (1587-) at the frontwall harness connector to the ACPU using a voltmeter in AC mode. The reading on the J1587 bus should be a constantly varying voltage between 0.5 and 5 volts. If there is no voltage signal on the J1587 bus with the ignition on, check for an open circuit in the J1587 bus.
ACPU not responding.	Replace the ACPU with a binary switch. For instructions, see Service Bulletin 83-71.

Table 10, Problem-ACPU Not Reported on ServiceLink

2. Check for initial (lube) cycle.

2.1 With the main AC selector in the AC **off** position, start the truck. The compressor clutch should remain disengaged for about 15 seconds after starting the truck, then the compressor should engage for 15 seconds and shut off. This is the initial (lube) cycle.

2.2 If the compressor does not complete the initial (lube) cycle, see **Table 11**.

Problem—Compressor Doesn't Engage for Initial (Lube) Cycle	
Possible Cause	**Remedy**
Normal operation	If the AC is on, the compressor will operate longer than 15 seconds after the initial engagement.
Active fault codes.	Use ServiceLink to download fault codes and perform necessary repairs.
Low air pressure.	Check the air pressure. It must be above 60 psi (414 kPa) for the compressor to engage.

Problem—Compressor Doesn't Engage for Initial (Lube) Cycle	
Possible Cause	**Remedy**
The high pressure switch is reporting a high pressure situation to the ACPU	Check the resistance between the leads to the high pressure switch. If it is greater than one ohm, check the air conditioning system pressures. If the high side pressure is below 250 to 270 psi (1724 to 1862 kPa), replace the high pressure switch and use ServiceLink to reset the HPX switch counter.
The low pressure switch is reporting a low pressure situation to the ACPU.	Check the resistance between the leads to the low pressure switch. If it shows less than one ohm, check the air conditioning system pressures. If the low side pressure is above 34 psi (234 kPa), replace the low pressure switch.
Low or no battery power to the ACPU.	Check the voltage between pins D (ground) and F (power) at the frontwall harness connector to the ACPU. If the voltage is less than 11.0 volts, start checking for voltage drops.
ACPU is not operating correctly.	Replace the ACPU with a binary switch. For instructions, see Service Bulletin 83-71.

Table 11, Problem-Compressor Doesn't Engage for Initial (Lube) Cycle

3. Test fan and compressor operation.
   - 3.1 Apply the parking brakes and chock the tires.
   - 3.2 Connect a refrigerant service cart to the truck air conditioning system.
   - 3.3 Place cardboard in front of the air conditioning condenser so that it blocks all air from being drawn into the condenser.
   - 3.4 Start the truck with the transmission in neutral, the main cab air conditioning selector switch in the **on** position, and the fan switch on high (position 4).
   - 3.5 Check that the air conditioning compressor engages after about 15 seconds.
   - 3.6 Check the reading of the high pressure gauge on the service cart when the fan comes on the first time. The fan should come on between 290 and 310 psi (1999 and 2137 kPa) on vehicles built before December 11, 1998 or between 340 and 375 psi (2344 and 2586 kPa) on vehicles built from December 11, 1998. This is the high pressure switch **set** point. The pressure may not reach the set point of the high pressure switch if the ambient air temperature is below 60°F (16°C).
   - 3.7 If the compressor disengages after 15 seconds, see **Table 12**.

Problem—The Compressor Doesn't Engage or Stays Engaged After the Initial (Lube) Cycle	
Possible Cause	**Remedy**
Active fault codes.	Use ServiceLink to download fault codes and perform necessary repairs.
High pressure switch reporting a high pressure situation to the ACPU.	Check resistance between the leads to the high pressure switch after the initial (lube) cycle. If the resistance is greater than one ohm and the pressure on the high side of the system is less than 250 to 270 psi (1724 to 1862 kPa), replace the high pressure switch and use ServiceLink to reset the high pressure switch counter.
No power from the thermostat to the ACPU.	With the AC on, check for voltage between pins D (ground) and C (thermostat) at the frontwall harness connector to the ACPU. If the voltage is less than 11.0 volts check the circuit from the main cab HVAC selector switch, through the thermostatic switch, to the ACPU.
The thermostatic sensor detects an evaporator freeze condition.	Determine if the freeze condition should exist. Refer to the steps for the thermostatic switch in this subject.
The ACPU is not operating correctly.	Replace the ACPU with a binary switch. For instructions, see Service Bulletin 83-71.

Table 12, Problem-The Compressor Doesn't Engage or Stays Engaged After the Initial (Lube) Cycle

Troubleshooting

3.8 If the fan does not come on between 290 and 310 psi (1999 and 2137 kPa) on vehicles built before December 11, 1998 or between 340 and 375 psi (2344 and 2586 kPa) on vehicles built from December 11, 1998, see **Table 13** and refer to step 3 in the ACPU Control Rules section of Service Bulletin 83-58.

Problem—The Fan Doesn't Engage at the Set Point	
Possible Cause	**Remedy**
Fault code.	Check ServiceLink for fault codes, make necessary repairs, and clear fault codes with ServiceLink.
Temperature too cold.	If the ambient temperature is too cold (60°F [16°C] or below) the high side pressure may not reach the high pressure set point.
Low refrigerant charge.	If the system does not reach the high pressure set point, there may not be a proper charge in the air conditioning system.
Fan does not engage. Fan request lead is grounded.	Disconnect the main connector to the ACPU and start the engine. If the fan does not come on immediately check to see if the fan request lead from the ACPU to the engine control module is grounded.
The set point of the high pressure switch is incorrect.	Replace the high pressure switch and use ServiceLink to reset the HPX switch counter.
The ACPU is not operating correctly.	On increasing pressure, if the fan does not come on before the compressor shuts off, the ACPU is not operating correctly. Replace the ACPU with a binary switch. For instructions, see Service Bulletin 83-71.

Table 13, Problem-The Fan Doesn't Engage at the Set Point

3.9 Continue to observe the reading of the high pressure gauge on the service cart as the pressure falls. The compressor should re-engage at between 250 and 270 psi (1724 and 1862 kPa). This is the high pressure switch **reset** point. If the compressor does not re-engage at between 250 and 270 psi (1724 and 1862 kPa), see **Table 14**.

Problem—The Compressor Doesn't Re-Engage at the Reset Point	
Possible Cause	**Remedy**
Fault code.	Check ServiceLink for fault codes, make necessary repairs, and clear fault codes with ServiceLink.
The reset point of the high pressure switch is incorrect.	Replace the high pressure switch and use ServiceLink to reset the high pressure switch counter in the ACPU.
The thermostatic sensor detects an evaporator freeze condition.	Determine if a freeze condition should exist. Refer to the information on the thermostatic switch in this subject.
The ACPU is not operating correctly.	Replace the ACPU with a binary switch. For instructions, see Service Bulletin 83-71.

Table 14, Problem-The Compressor Doesn't Re-Engage at the Reset Point

Specifications

See **Fig. 1** for heater-A/C system components.

See **Fig. 2** for the wiring schematic of the BEHR heater and A/C unit.

See **Fig. 3** for the heater-A/C plumbing diagram

See **Fig. 4** for the heater-A/C with CDTC wiring schematic used on the Century Class S/T.

A/C O-Ring Fitting Torque Values*	
Hose Size	**Torque lbf·ft (N·m)**
#6	20–25 (27–34)
#8	30–35 (41–47)
#10 and #12	35–40 (47–54)

* One-inch fittings on the A/C compressor need to be torqued 21 to 27 lbf·ft (28 to 37 N·m) regardless of hose size.

Table 1, A/C O-Ring Fitting Torque Values

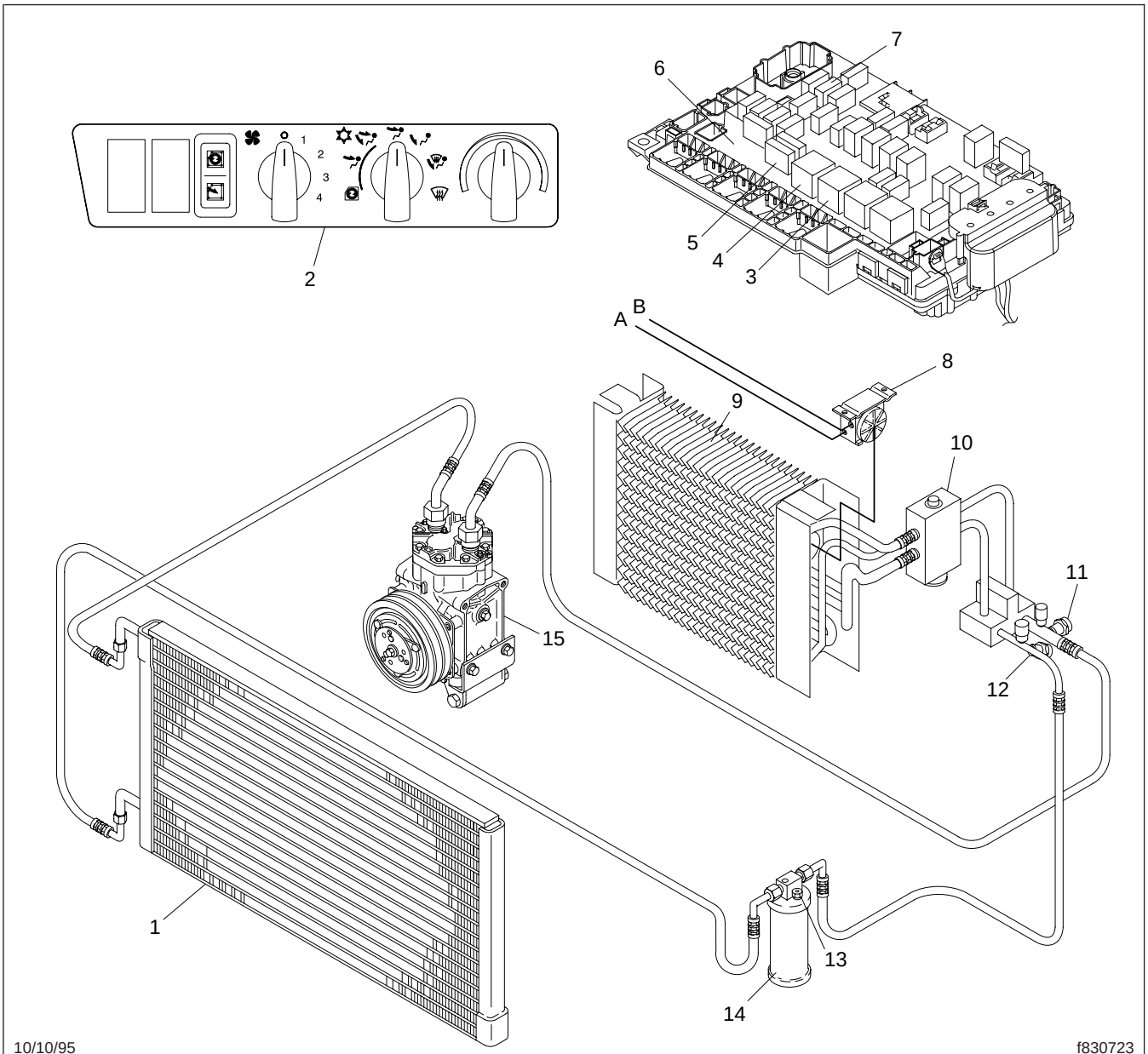
3/4- and 5/8-Inch Heater Hose Clamp Torque Values	
Description	**Torque**
Standard Hose Clamp	40 lbf·in (452 N·cm)
Worm-Gear Hose Clamp	
Breeze Constant-Torque Hose Clamp	
Oetiker Constant-Torque Hose Clamp	18 lbf·in (203 N·cm)

Table 2, 3/4- and 5/8-Inch Heater Hose Clamp Torque Values

System Full-Charge Refrigerant Capacity Specifications			
Build Date	**Air Conditioner Installation**	**With Sleeper A/C**	**Refrigerant Capacity**
Built before April 3, 1998	Conventional	No	2 lb 7 oz (1.10 kg)
		Yes	2 lb 14 oz (1.30 kg)
Built from April 3, 1998	Conventional	No	2 lb 14 oz (1.30 kg)
		Yes	3 lb 7 oz (1.56 kg)

Table 3, System Full-Charge Refrigerant Capacity Specifications

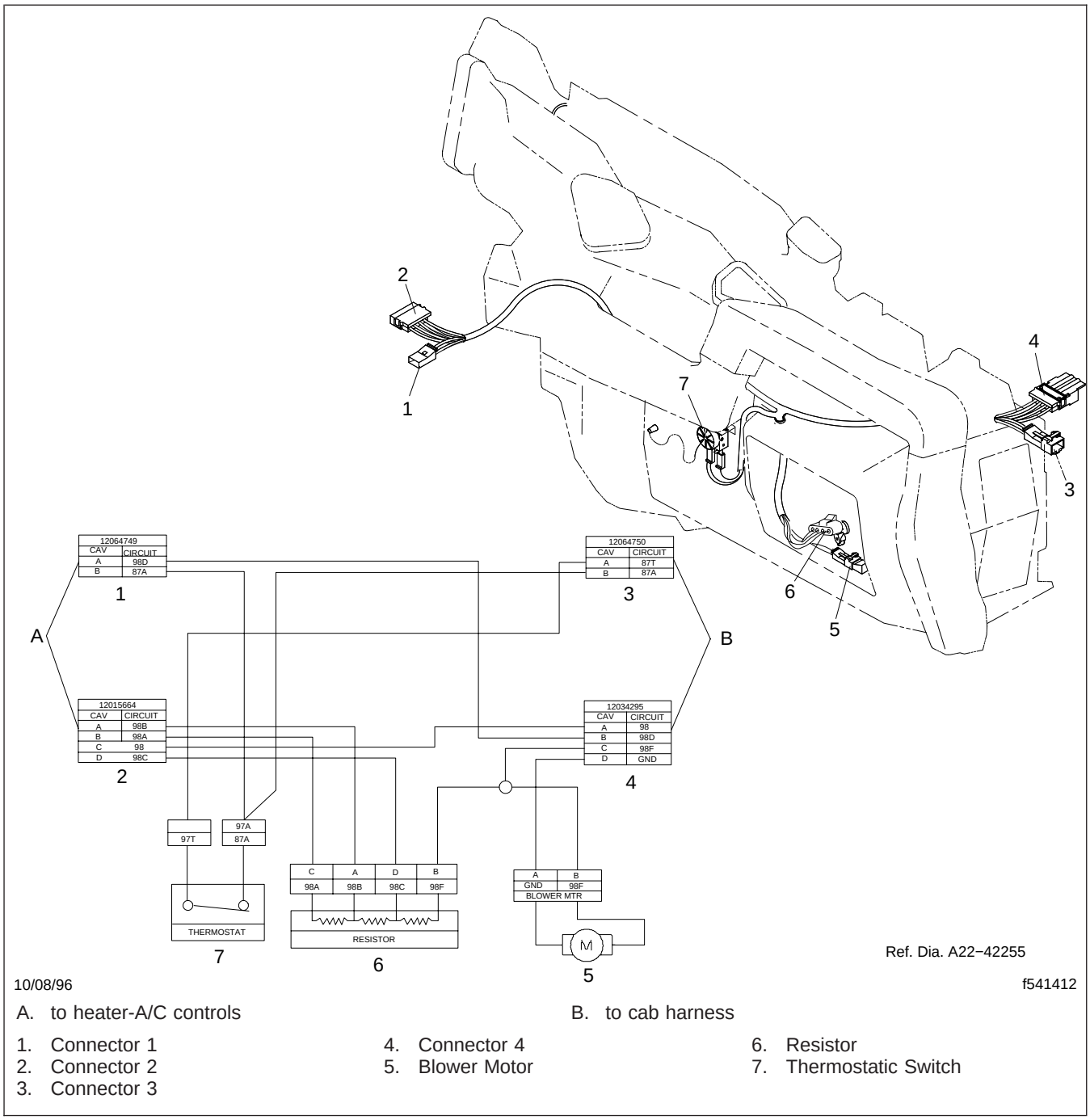
Specifications



A. to A/C clutch relay
B. to blower switch

1. Condenser
2. Climate Control Panel
3. A/C Power Relay
4. A/C High-Speed Relay
5. Circuit Breaker (30A)
6. Power Distribution Module
7. A/C Clutch Circuit Breaker (10A)
8. Thermostatic Switch
9. Evaporator Coil
10. Expansion Valve
11. ACPU Low Pressure Switch (on suction service line)
12. ACPU High Pressure Switch (on discharge service line)
13. Moisture Indicator
14. Receiver-Drier
15. Compressor

Fig. 1, Air Conditioning System Components



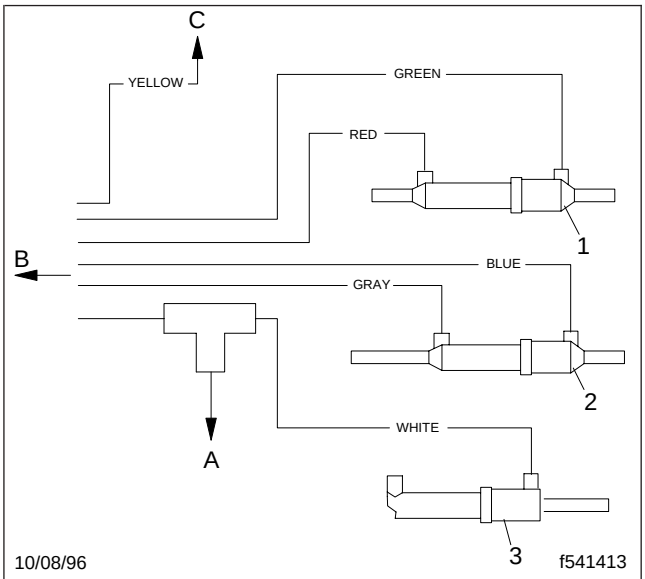
A. to heater-A/C controls

B. to cab harness

1. Connector 1
2. Connector 2
3. Connector 3
4. Connector 4
5. Blower Motor
6. Resistor
7. Thermostatic Switch

Fig. 2, Heater and Air Conditioning Wiring Schematic (BEHR heater and A/C unit only)

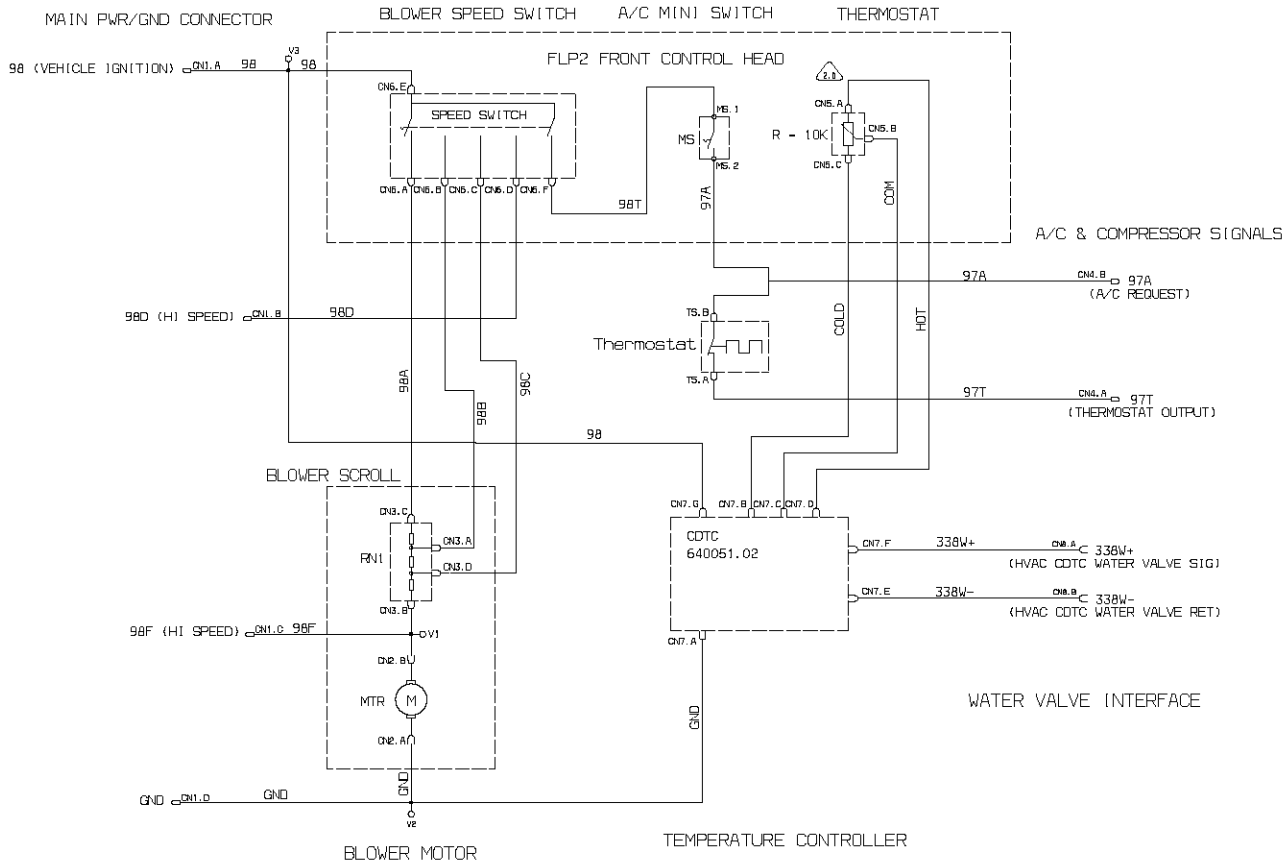
Specifications



A. to recirc air pressure switch
B. to heater-A/C control
C. to air junction block

1. Heater/Defrost Air Cylinder
2. Face Duct Air Cylinder
3. Recirculation Air Cylinder

Fig. 3, Heater and Air Conditioning Plumbing Diagram



RUNNING LIST

PL ITEM #	PART	POS.	LINE	DESCRIPTION
1	CN1			MAIN POWER / GROUND CONNECTOR
1.1	CN1	A	98	IGNITION VOLTAGE
1.1	CN1	B	98D	HI BLOWER SPEED
1.1	CN1	C	98F	HI BLOWER SPEED VIA RELAY
1.1	CN1	D	GND	GROUND
2	CN2			BLOWER MOTOR MATING CONNECTOR
2.1	CN2	A	GND	GROUND
2.1	CN2	B	98F	BLOWER MOTOR + TERMINAL
3	CN3			RESISTOR MATING CONNECTOR
3.1	CN3	A	98B	M1 BLOWER SPEED
3.1	CN3	B	98F	HI BLOWER SPEED
3.1	CN3	C	98A	LOW BLOWER SPEED
3.1	CN3	D	98C	M2 BLOWER SPEED
4	CN4			AC / THERMOSTAT MATING CONNECTOR
4.1	CN4	A	97T	THERMOSTAT OUTPUT
4.1	CN4	B	97A	AC REQUEST
5	CN5			POTENTIOMETER MATING CONNECTOR
5.1	CN5	A	HOT	TEMPERATURE SETPOINT, MAX HOT
5.1	CN5	B	COM	TEMPERATURE SETPOINT, COMMON
5.1	CN5	C	COLD	TEMPERATURE SETPOINT, MAX COLD
6	CN6			BLOWER (NTFC. CONN. @ CONT. HEAD
6.1	CN6	A	98A	LOW BLOWER SPEED
6.1	CN6	B	98B	M1 BLOWER SPEED
6.1	CN6	C	98C	M2 BLOWER SPEED

RUNNING LIST

PL ITEM #	PART	POS.	LINE	DESCRIPTION
6.1	CN6	D	98D	HI BLOWER SPEED
6.1	CN6	E	98	IGNITION VOLTAGE
6.2	CN6	F	98T	BLOWER ON SIGNAL
7	CN7			CDTC MATING CONNECTOR
7.1	CN7	A	GND	GROUND
7.1	CN7	B	COLD	TEMPERATURE SETPOINT, MAX COLD
7.1	CN7	C	COM	TEMPERATURE SETPOINT, COMMON
7.1	CN7	D	HOT	TEMPERATURE SETPOINT, MAX HOT
7.1	CN7	E	338W-	HVAC CDTC WATER VALVE RET
7.1	CN7	F	338W+	HVAC CDTC WATER VALVE SIG
7.1	CN7	G	98	IGNITION VOLTAGE
8	CN8			WATERVALVE MATING CONNECTOR
8.1	CN8	A	338W+	HVAC CDTC WATER VALVE SIG
8.1	CN8	B	338W-	HVAC CDTC WATER VALVE RET
9	MS	1	98T	BLOWER ON SIGNAL
9	MS	2	97A	AC REQUEST
10	TS			T-STAT OUTPUT & AC REQUEST CONNECTOR
10.1	TS	A	97T	THERMOSTAT OUTPUT
10.2	TS	B	97A	AC REQUEST
11	V1		98F	SPLICE
11	V2		GND	SPLICE
11	V3		98	SPLICE

Ref. Dia. A22-42255 Chg. Ltr. J

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Fig. 4, Heater and Air Conditioning With CDTC Wiring Schematic

Specifications

Temperature/Pressure Specifications for Vehicles Without Sleepers				
			With Compressor Running	
Relative Humidity	Outside Air Temperature °F (°C)	Maximum Center Dash Outlet Temperature °F (°C)	Low Pressure psi (kPa)	High Pressure psi (kPa)
Low to Medium (30% to 60%)	70 (21)	48 (9)*	10–18 (69–124)	135 (931)
	80 (27)	52 (11)*	10–20 (69–138)	165 (1138)
	90 (32)	52 (11)	10–27 (69–186)	200 (1379)
	100 (38)	60 (16)	10–32 (69–221)	230 (1586)
	110 (43)	65 (18)	10–35 (69–241)	245 (1689)
High (90%)	70 (21)	50 (10)*	10–18 (69–124)	135 (931)
	80 (27)	52 (11)	10–20 (69–138)	165 (1138)
	90 (32)	60 (16)	10–27 (69–186)	200 (1379)
	100 (38)	68 (20)	10–32 (69–221)	230 (1586)
	110 (43)	74 (23)	10–35 (69–241)	245 (1689)

* The thermostatic switch may cause the compressor to cycle. In these situations, the high-side pressure will vary when the reading is taken and the dash outlet temperature will be higher than normal. If this occurs, use the lowest high-side pressure readings (after the compressor has been running for a time).

Table 4, Temperature/Pressure Specifications for Vehicles Without Sleepers

Temperature/Pressure Specifications for Vehicles With Sleepers					
				With Compressor Running	
Relative Humidity	Outside Air Temperature °F (°C)	Maximum Center Dash Outlet Temperature °F (°C)	Maximum Sleeper Outlet Temperature °F (°C)	Low Pressure psi (kPa)	High Pressure psi (kPa)
Low to Medium (30% to 60%)	70 (21)	48 (9)	49 (9)	10–25 (69–172)	140 (965)
	80 (27)	51 (11)	55 (13)	10–32 (69–221)	185 (1276)
	90 (32)	59 (15)	63 (17)	10–40 (69–276)	220 (1517)
	100 (38)	65 (18)	68 (20)	10–45 (69–310)	255 (1758)
	110 (43)	72 (22)	72 (22)	10–45 (69–310)	270 (1862)
High (90%)	70 (21)	50 (10)	52 (11)	10–25 (69–172)	140 (965)
	80 (27)	56 (13)	59 (15)	10–32 (69–221)	185 (1276)
	90 (32)	65 (18)	67 (19)	10–40 (69–276)	220 (1517)
	100 (38)	78 (26)	75 (24)	10–45 (69–310)	255 (1758)
	110 (43)	87 (31)	87 (31)	10–45 (69–310)	270 (1862)

Table 5, Temperature/Pressure Specifications for Vehicles With Sleepers

Specifications

Electronic Leak Detectors		
Designation	**Manufacturer**	**Comments**
D-TEK, D-Tek Select, and Tek Mate	Leybold Inficon 2 Technology Place East Syracuse, NY 13057 (315) 434–1144	• Rechargeable battery • Hand-held design • Simple to operate
H–10 Professional	Yokogawa Corp. of America 2 Dart Road Newnan, GA 30265 (800) 258–2552	• Rechargeable battery • Carrying case with strap • Calibration leak bottle • Manual sensitivity control • Most sensitive available
J 39400	SPX Kent-Moore 28635 Mound Road Warren, MI 48092 (800) 328–6657	• 12V DC or 120V AC • Carrying case with strap • Calibration leak bottle • Manual sensitivity control • Manual balance control

Table 6, Electronic Leak Detectors

Torque Values	
Part	**Torque**
Junction Block Retainer Plate Bolt (non-SlimLine)	15–19 lbf·ft (20–26 N·m)
ACPU Pressure Switches	96–120 lbf·in (1085–1356 N·cm)

Table 7, Torque Values

SlimLine Seal Assembly Bolt Torque Values	
HVAC Component	**Torque**
A/C Compressor	11 to 15 lbf·ft (15 to 20 N·m)
Condenser	11 to 15 lbf·ft (15 to 20 N·m)
Receiver-Drier	11 to 15 lbf·ft (15 to 20 N·m)
Thermal Expansion Valve	11 to 15 lbf·ft (15 to 20 N·m)
Evaporator	11 to 15 lbf·ft (15 to 20 N·m)
Junction Block	11 to 15 lbf·ft (15 to 20 N·m)

Table 8, SlimLine Seal Assembly Bolt Torque Values

General Description and Principles of Operation

The sleeper heater and air conditioner housings are self-contained, and include the heater core/evaporator coil, blower motor, and control valves. See **Fig. 1** and **Fig. 2**. They are mounted either in the baggage compartment or under the lower bunk, depending on the cab model.

The sleeper heater is plumbed directly to the engine, independent of the cab heater. The sleeper air conditioner is dependent on the cab's air conditioning system, sharing the same refrigerant and compressor.

The Automatic Temperature Control (A.T.C.) system automatically maintains the selected outlet temperature. For general information and principles of operation on the air conditioner, see Section 83.02, **Subject 050**.

The climate control panel for the sleeper heater and air conditioner is installed in various locations in the sleeper, depending on the sleeper size. See **Fig. 3**. Refer to the vehicle driver's manual for operating instructions.

Opening of the A.T.C. water supply solenoid valve allows engine-heated coolant to flow through the heater core. Heat is absorbed by air passing over the heater core fins.

The blower forces the heated air through the ducts and into the sleeper.

The water supply solenoid valve opens when the rotary temperature control knob is turned clockwise to HEAT.

The A.T.C. system has three major components:

- A.T.C Module

  —Supplies power to the water supply solenoid.

  —Monitors air output temperature.

  —Used with the temperature control knob to select the desired air output temperature.

- Water Supply Solenoid Valve

  —Receives power from the A.T.C. module.

  —Controls the supply of water to the heater core.

- Air Temperature Sensor

  —Monitors air output temperature.

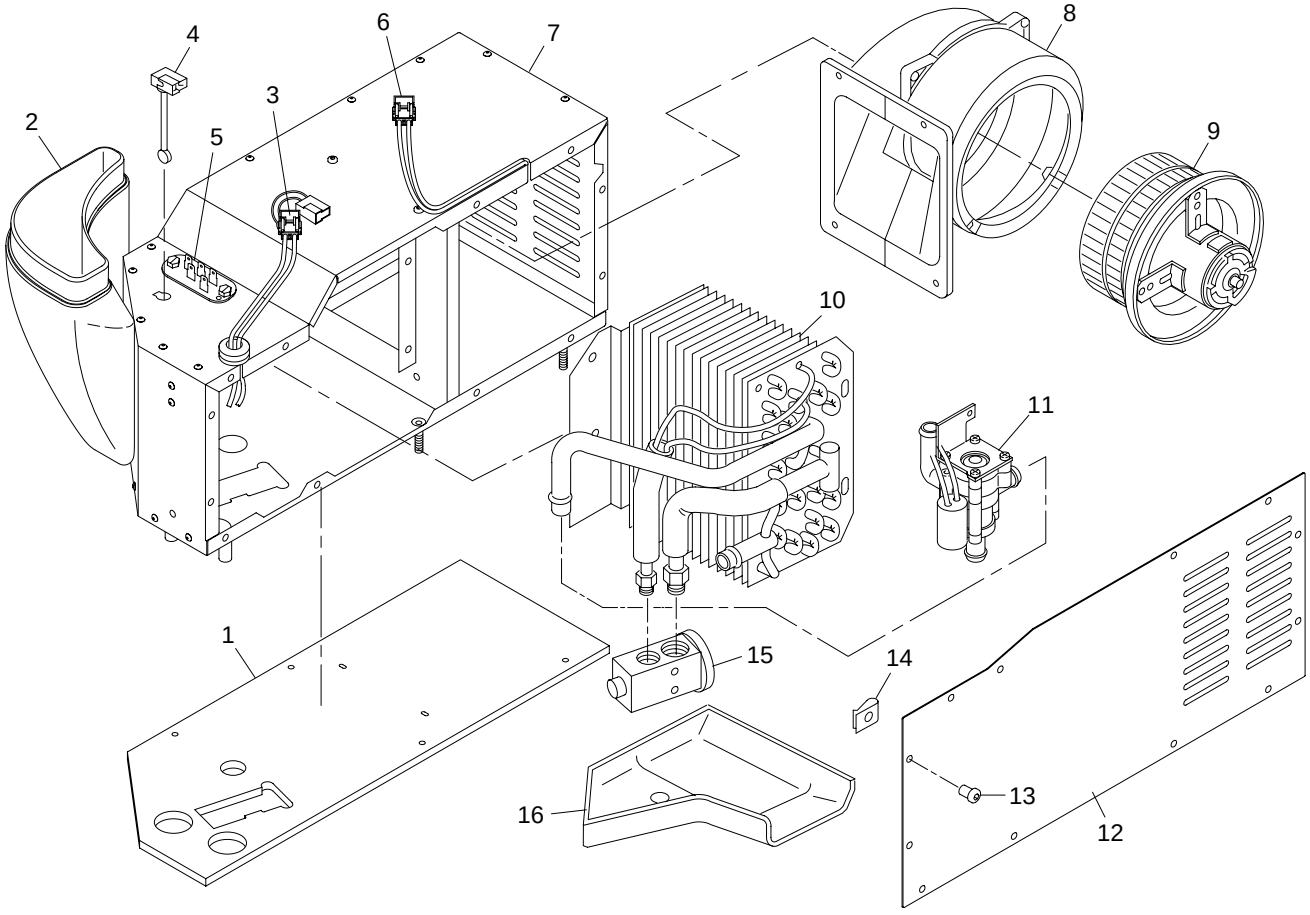
With an A.T.C. system, a preselected temperature is maintained by directing the flow of hot water through the heater core.

Once the operator adjusts the temperature control knob, the air output temperature is monitored by an air temperature sensor at the sleeper heater and air conditioner unit. Any change in output temperature activates the A.T.C. module, energizing or de-energizing the water supply solenoid valve.

If the air is colder than the selected temperature, hot water is allowed to flow into the heater core. As the output temperature reaches the desired setting, the water supply solenoid valve closes, preventing hot water from entering the heater core, until air output temperature becomes too cool again. Then the process starts over.

A fan control knob controls a three-speed blower motor and allows the operator to choose the amount of air flow in the sleeper.

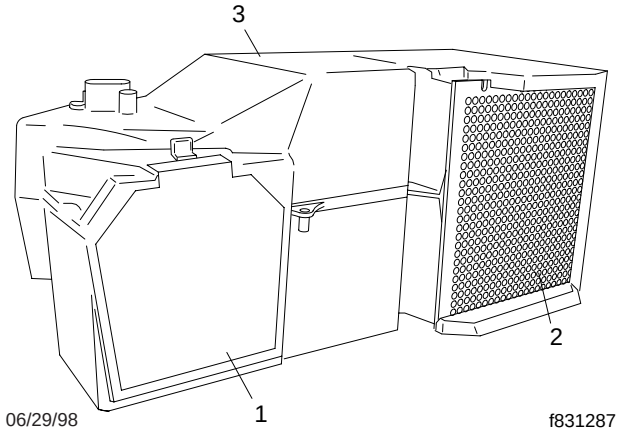
General Description and Principles of Operation



11/10/95 f830740

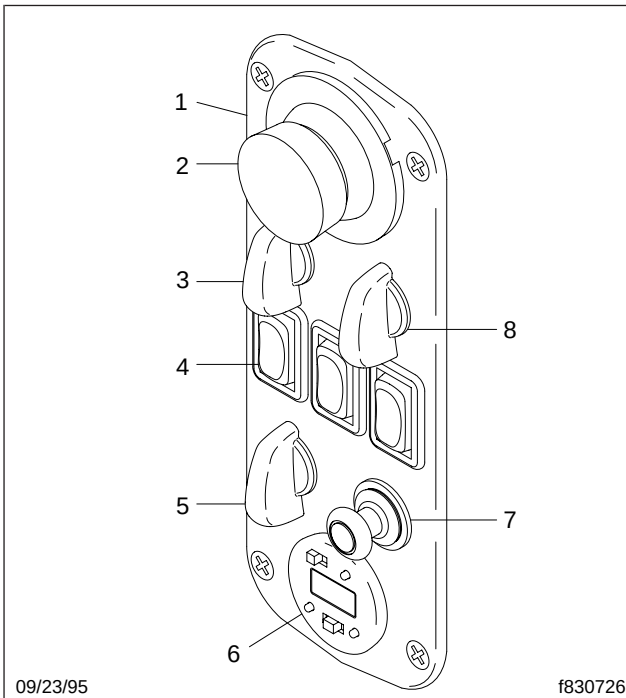
1. Housing Gasket
2. Discharge Air Duct
3. Water Supply Solenoid Valve Electrical Connector
4. Sensor
5. Resistor Block Assembly
6. Blower Motor Electrical Connector
7. Housing Assembly
8. Blower Motor Housing
9. Blower Motor Assembly
10. Evaporator/Heater Core Assembly
11. Water Supply Solenoid Valve
12. Front Cover
13. Screw, 11–16 x 3/4 inch
14. U-Clip
15. Expansion Valve
16. Drain Baffle

Fig. 1, Sleeper Heater and Air Conditioner Assembly, Century Class Conventional



1. Access Panel
2. Filter Screen
3. Sleeper Heater and Air Conditioner Housing

Fig. 2, Sleeper Heater and Air Conditioner Housing With Recirculation Filter



1. Control Panel
2. Reading Lamp
3. Fan Control Knob
4. Dome and Reading Light Switches
5. Volume Control Knob
6. Clock
7. Cigarette Lighter
8. A.T.C. Control Knob

Fig. 3, Control Panel for A.T.C. System

Safety Precautions

Whenever repairs are made to any air conditioner parts that hold R–134a refrigerant, you must recover, purge or flush (if contaminated), evacuate, charge, and leak test the system. In a good system, refrigerant lines are always under pressure and you should disconnect them only after the refrigerant charge has been recovered (discharged) at the service valves.

Refrigerant R–134a is safe when used under the right conditions. Always wear safety goggles and non-leather gloves while recovering, evacuating, charging, and leak testing the system. Do not wear leather gloves; when refrigerant gas or liquid contacts leather, the leather will stick to your skin.

⚠ WARNING

Use care to prevent refrigerant from touching your skin or eyes, because liquid refrigerant, when exposed to the air, quickly evaporates and will freeze skin or eye tissue. Serious injury or blindness could result if you come into contact with liquid refrigerant.

Refrigerant splashed in the eyes should be rinsed with lukewarm water, not hot or cold. Do not rub the eyes. Apply a light bandage and contact a physician right away.

Refrigerant splashed on the skin should be rinsed with lukewarm water, not hot or cold. Do not rub the skin. Apply a light coat of a nonmedicated ointment, such as petroleum jelly. Contact a physician right away.

R–134a refrigerant does not burn at ambient temperatures and atmospheric pressure. However, it can be combustible at pressures as low as 5.5 psig (139 kPa absolute) at 350°F (177°C) when mixed with air concentrations that are greater than 60 percent.

⚠ WARNING

Do not pressure test or leak test R–134a air conditioning systems with compressed air. Combustible mixtures of air and R–134a may form, resulting in a fire or explosion, which could cause personal injury or property damage. R–134a may be safely pressured with dry nitrogen.

You must work in an area where there is a constant flow of fresh air when the system is recovered, evacuated, charged, and leak tested. R–134a vapors have a slightly sweet odor that is difficult to detect. Frequent leak checks and air monitoring equipment are recommended to ensure a safe working environment.

IMPORTANT: When servicing an R–134a air conditioning system, use only service equipment certified to meet the requirements of SAE J2210 (R–134a recycling equipment). The equipment should be operated only by qualified personnel who are familiar with the recycling station manufacturer's instructions.

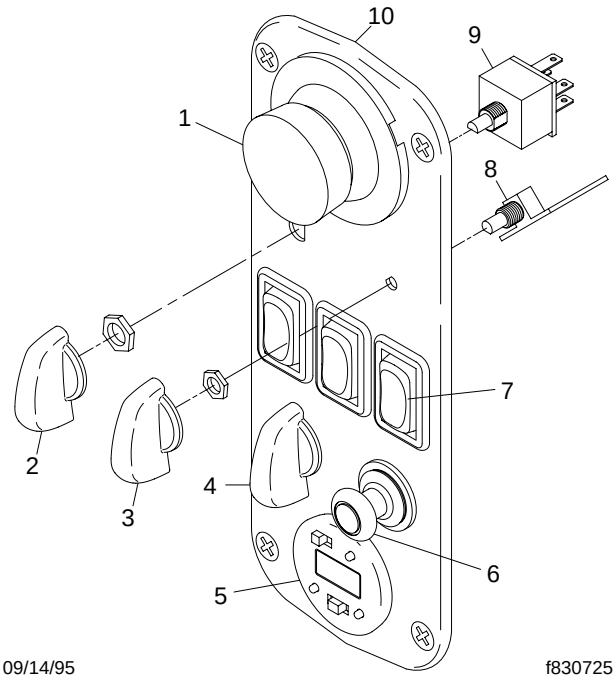
Because of its very low boiling point, refrigerant must be stored under pressure. To prevent the refrigerant containers from exploding, never expose them to temperatures higher than 125°F (52°C).

On R–134a refrigerant systems, polyalkylene glycol (PAG), or polyol ester (POE) oil is used in the compressor. When handling these oils, observe the following:

- Keep the oil free of contaminants;
- Do not expose the a/c system or the oil container to air for long periods of time; PAG and POE oils have a high moisture absorption capacity;
- Use care when handling: painted surfaces, plastic parts, and other components (drive belts) could be damaged if the oil is spilled on them;
- Never mix the oils with other types of refrigerant oil.

Automatic Temperature Control (A.T.C.) Module Replacement

1. Turn off the engine, apply the brakes, and chock the tires.
2. Remove the four screws that attach the control panel to the sleeper compartment wall, and pull the panel away from the wall. See **Fig. 1**.



1. Reading Lamp
2. Fan Control Knob
3. A.T.C. Control Knob
4. Volume Control Knob
5. Clock
6. Cigarette Lighter
7. Dome and Reading Light Switches
8. A.T.C. Control Module
9. Fan Control Switch
10. Control Panel

Fig. 1, Control Panel for A.T.C. System

3. Unplug the wiring connector at the A.T.C. control module.
4. Pull the temperature control knob off of the control switch stem. Remove the nut, and pull the module out of the back of the panel.
5. Install the new module and replace the nut. Replace the temperature control knob.
6. Connect the wiring connector at the A.T.C. module.
7. Install the control panel on the wall. Tighten the four screws firmly.
8. Remove the chocks from the tires.

Fan Control Switch Replacement

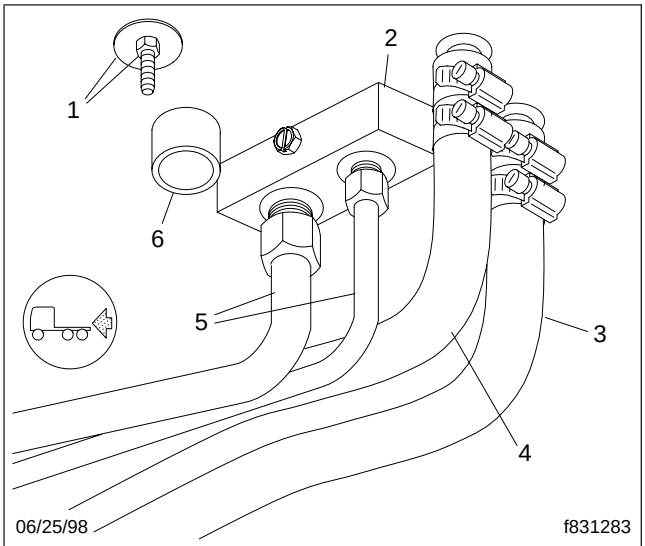
1. Turn off the engine, apply the brakes, and chock the tires.
2. Remove the four screws attaching the control panel to the sleeper compartment wall, and pull the panel away from the wall. See **Fig. 1**.
3. On fan control switches that have four wires, mark the four wires before unplugging them from the connectors. On all other fan control switches, unplug the connector from the switch.
4. Pull the fan control knob off of the control switch stem. Remove the nut, and pull the switch out of the back of the panel.
5. Install the new fan control switch and replace the nut. Position the knob so that the indicating dot aligns with OFF.

IMPORTANT: The tab on the positioning washer between the control panel and the switch should be in the upright position, and as level as possible in order to obtain the full range of the fan control knob.

6. Connect the wires to the switch, making sure the wires are connected to the correct tabs, or plug the connector to the switch.
7. Install the control panel on the wall. Tighten the four screws firmly.
8. Remove the chocks from the tires.

Removal

1. Turn off the engine, apply the parking brakes, and chock the tires.
2. Remove the refrigerant from the air conditioning system. For instructions, see **Section 83.02**, Subject 250.
3. Remove enough coolant from the radiator so that the level of coolant is below the inlet and outlet lines at the expansion valve, or clamp off the radiator hoses to prevent coolant loss.
4. From under the sleeper on the right-hand side of the vehicle, remove the standoff bracket (if equipped) that separates the water supply inlet and outlet lines. See **Fig. 1**. Mark the inlet and outlet lines for later reference and drain the heater core by disconnecting the inlet and outlet lines.
5. From under the sleeper, disconnect the refrigerant lines from the expansion valve. Quickly cap the expansion valve inlet and outlet ports and plug the fittings.



1. Mounting Fasteners
2. Expansion Valve
3. Inlet Line
4. Outlet Line
5. Refrigerant Lines
6. Drain Tube

Fig. 1, Expansion Valve

IMPORTANT: Under no circumstances should the expansion valve ports remain uncapped or the fittings remain unplugged for longer than five minutes total. Water and dirt can damage the refrigerant system. Do not blow shop air through refrigerant lines since shop air is wet (humid).

6. From under the sleeper, remove the nuts and washers that attach the heater and air conditioner housing to the cab floor.
7. Access the sleeper heater and air conditioner housing.

   On vehicles with a baggage compartment on the right-hand side of the cab, open the door to the baggage compartment.

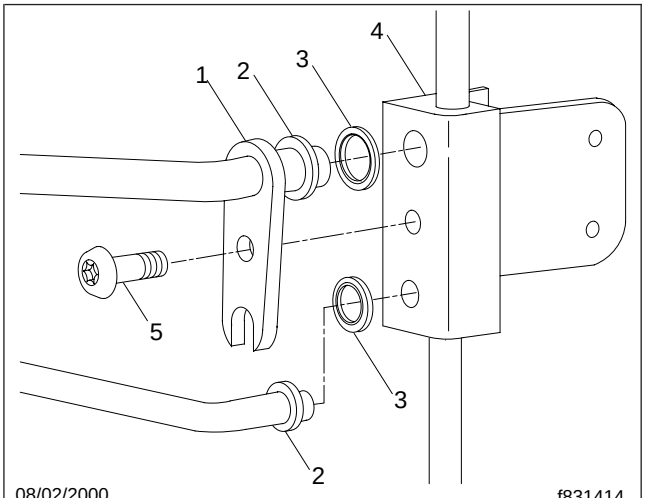
   On vehicles without a baggage compartment on the right-hand side of the cab, raise the mattress and bunk panel to the locked position.
8. Disconnect the wiring harnesses from the sleeper heater and air conditioner housing.
9. Remove the sleeper heater and air conditioner housing from the cab. Be sure not to damage the water drain tube or heater core/evaporator coil while removing the housing.

Installation

1. Place the sleeper heater and air conditioner housing on the cab floor. Make sure the heater core elbows, expansion valve, water drain tube, and mounting studs protrude through the floor.
2. From under the cab, install the washers and nuts on the mounting studs. Tighten the nuts 13 lbf·ft (18 N·m).
3. Connect the wiring harnesses to the sleeper heater and air conditioner housing.
4. Uncap the inlet and outlet ports on the expansion valve. Unplug the fittings. Check the fittings and the inlet and outlet ports. They must be clean and free of nicks, gasket residue, and other foreign material.
5. On hose connections that have threaded fittings, replace the O-rings in the fittings. Lubricate the O-rings with mineral oil before installing.

   On hose connections that have a SlimLine seal assembly (**Fig. 2**), replace the seals. **Do not** lubricate SlimLine seals prior to installation. Use **only** a SlimLine seal on a SlimLine seal assembly.

Heater and Air Conditioner Removal and Installation



1. Plate
2. Fitting
3. Seal
4. Block
5. Bolt

Fig. 2, A Typical SlimLine Seal Assembly

6. Attach the refrigerant lines to the expansion valve.

   On hose connections that have threaded fittings, tighten the #6 fitting 20 to 25 lbf·ft (27 to 34 N·m). Tighten the #10 and #12 fittings 35 to 40 lbf·ft (47 to 54 N·m).

   On hose connections that have a SlimLine seal assembly, torque the bolt on the SlimLine seal assembly 11 to 15 lbf·ft (15 to 20 N·m).

7. Install the standoff bracket (if equipped) that separates the water supply inlet and outlet lines. Attach the inlet and outlet lines to the heater core elbows as marked. Tighten the clamps 40 lbf·in (452 N·cm).

8. Evacuate and charge the air conditioning system. For instructions, see **Section 83.02**, Subject 250.

9. Fill the cooling system with coolant. For coolant specifications, see Group 20 of the *Century Class Trucks Maintenance Manual*.

⚠ CAUTION

Coolant must be filled to the proper level in the surge tank. Low coolant could cause engine overheating, which could damage the engine.

10. Start the engine, let it run for 20 to 30 seconds, and then shut it off. Install a pressure tester, test the cooling system at 10 psi (69 kPa), and then inspect for leaks. If leaks are found, tighten the hose clamps 40 lbf·in (452 N·cm) or replace the hoses as needed. Check the coolant level, and add coolant if needed.

11. Turn the temperature control knob clockwise for warm air.

12. Start the engine. When the radiator thermostat opens, air will be forced from the heater core as the coolant circulates. Check the coolant level again and add coolant if needed.

13. Lower the sleeper mattress and bunk panel or close the baggage compartment door.

14. Remove the chocks from the tires.

Replacement

1. Turn off the engine, apply the brakes, and chock the tires.
2. Access the sleeper heater and air conditioner housing.

   On vehicles with a baggage compartment on the right-hand side of the cab, open the door to the baggage compartment.

   On vehicles without a baggage compartment on the right-hand side of the cab, raise the mattress and bunk panel to their locked position.
3. Remove the blower motor.

   3.1 Disconnect the blower motor cable assembly.

   3.2 On sleeper heater and air conditioner housings that have a one-piece front cover, remove the fasteners that attach the front cover to the housing. Remove the cover.

   On sleeper heater and air conditioner housings that have a recirculation filter, remove the filter screen and filter from the housing. See **Fig. 1**.

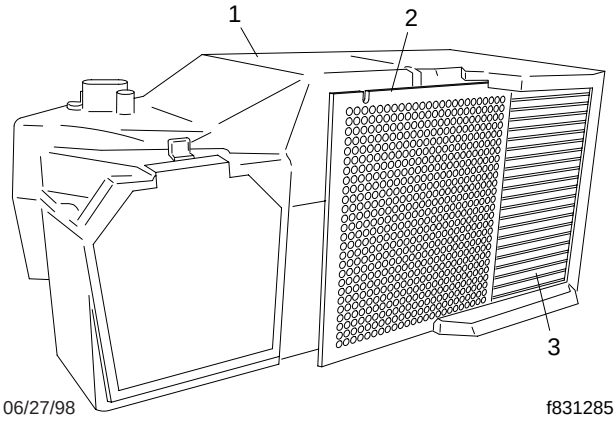
   3.3 Remove the mounting fasteners that attach the motor to the housing. See **Fig. 2**. Remove the blower motor from the housing.
4. Install a new blower motor.

   4.1 Install the fasteners that attach the blower motor to the housing. Tighten the fasteners firmly.

   4.2 Connect the blower motor cable assembly.

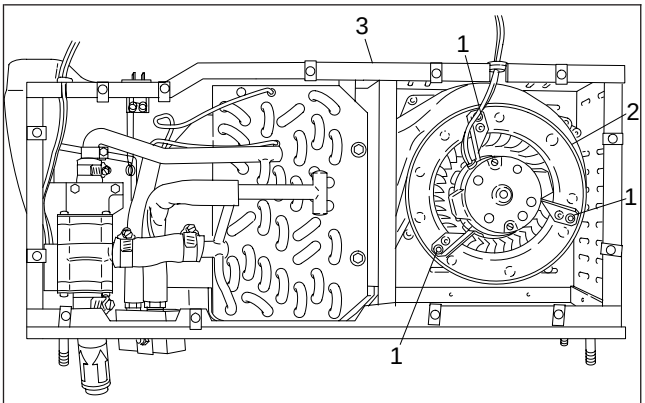
   4.3 On sleeper heater and air conditioner housings that have a one-piece front cover, use the fasteners to attach the front cover to the housing.

   On sleeper heater and air conditioner housings that have a recirculation filter, install the filter and filter screen on the housing.
5. Lower the mattress and bunk panel, or close the baggage compartment door.
6. Remove the chocks from the tires.



1. Sleeper Heater and Air Conditioner Housing
2. Filter Screen
3. Filter

Fig. 1, Sleeper Heater and Air Conditioner Housing With Recirculation Filter



1. Mounting Fastener
2. Blower Motor
3. Sleeper Heater and Air Conditioner Housing

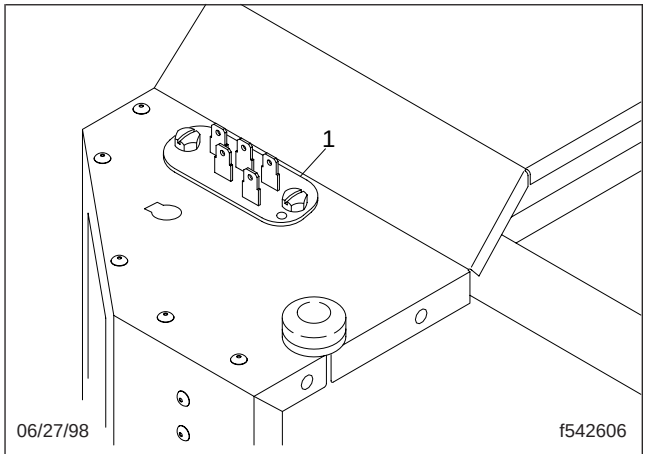
Fig. 2, Blower Motor

Replacement

1. Turn off the engine, apply the parking brakes, and chock the tires.
2. Access the sleeper heater and air conditioner housing.

   On vehicles with a baggage compartment on the right-hand side of the cab, open the door to the baggage compartment.

   On vehicles without a baggage compartment on the right-hand side of the cab, raise the mattress and bunk panel to their locked position.
3. Disconnect the harness from the resistor block assembly. See **Fig. 1** and **Fig. 2**.



1. Resistor Block Assembly

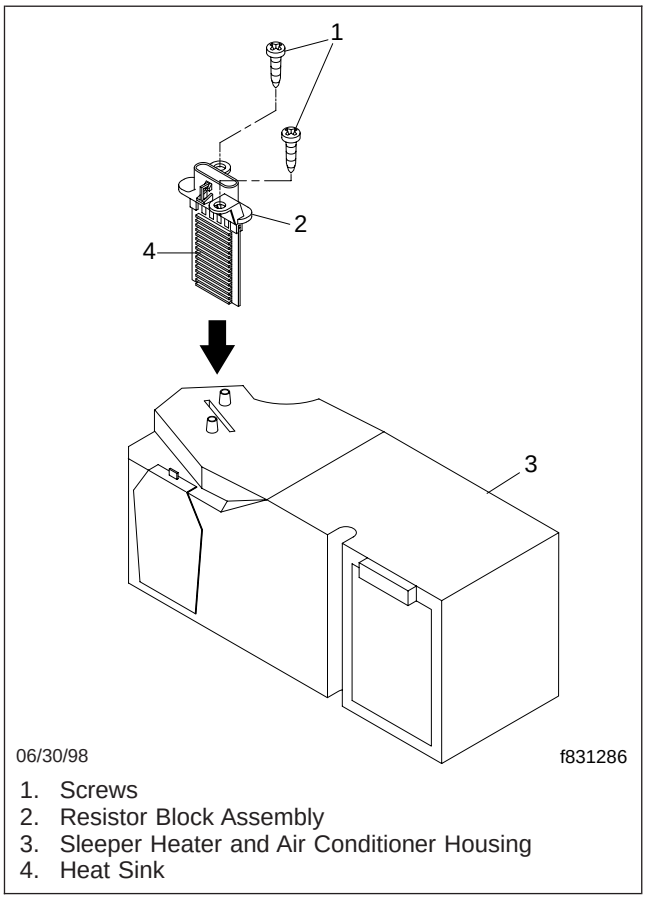
Fig. 1, HVAC Resistor Block, Older Style

4. Remove the screws that attach the resistor block assembly to the sleeper HVAC housing.
5. Remove the resistor block assembly.

CAUTION

Handle the resistor block assembly carefully. If the resistor block assembly is not handled carefully, the heat sink may be damaged or break off the board.

6. Install a new resistor block assembly.
7. Install the screws that fasten the resistor block assembly to the sleeper heater and air conditioner housing.



1. Screws
2. Resistor Block Assembly
3. Sleeper Heater and Air Conditioner Housing
4. Heat Sink

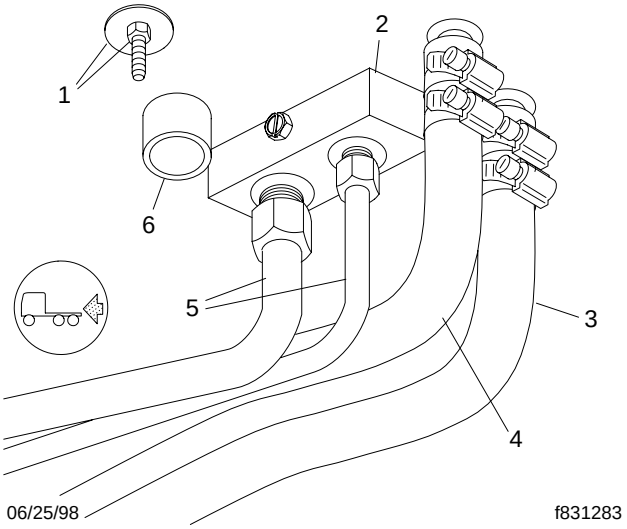
Fig. 2, HVAC Resistor Block, Newer Style

8. Connect the harness to the resistor block assembly.
9. Lower the mattress and bunk panel, or close the baggage compartment door.
10. Remove the chocks from the tires.

A.T.C. Water Supply Solenoid Valve Replacement

Replacement

1. Turn off the engine, apply the parking brakes, and chock the tires.
2. Remove enough coolant from the radiator so that the level of coolant is below the inlet and outlet lines at the expansion valve, or clamp off the radiator hoses to prevent coolant loss.
3. From under the sleeper on the right-hand side of the vehicle, remove the standoff bracket (if equipped) that separates the water supply inlet and outlet lines. Drain the heater core by disconnecting the inlet line. See **Fig. 1**.



1. Mounting Fasteners
2. Expansion Valve
3. Inlet Line
4. Outlet Line
5. Refrigerant Lines
6. Drain Tube

Fig. 1, Expansion Valve

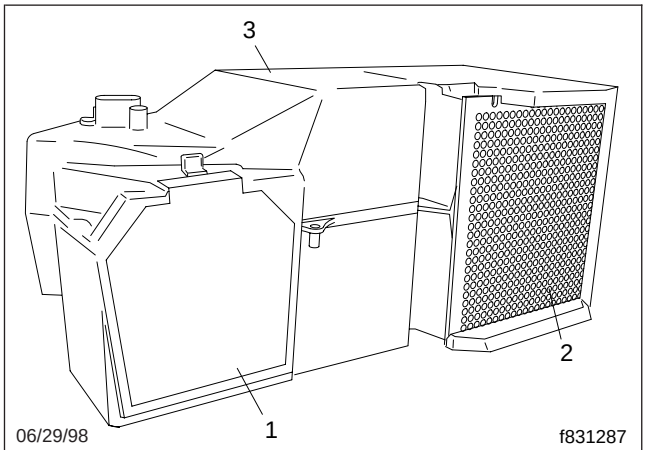
4. Access the sleeper heater and air conditioner housing.

   On vehicles with a baggage compartment on the right-hand side of the cab, open the door to the baggage compartment.

   On vehicles without a baggage compartment on the right-hand side of the cab, raise the mattress and bunk panel to their locked position.
5. Access the water supply solenoid valve.

   On sleeper heater and air conditioner housings that have a one-piece front cover, remove the fasteners that attach the front cover to the housing. Remove the cover.

   On sleeper heater and air conditioner housings that have a recirculation filter, remove the access panel on the front of the housing. See **Fig. 2**.

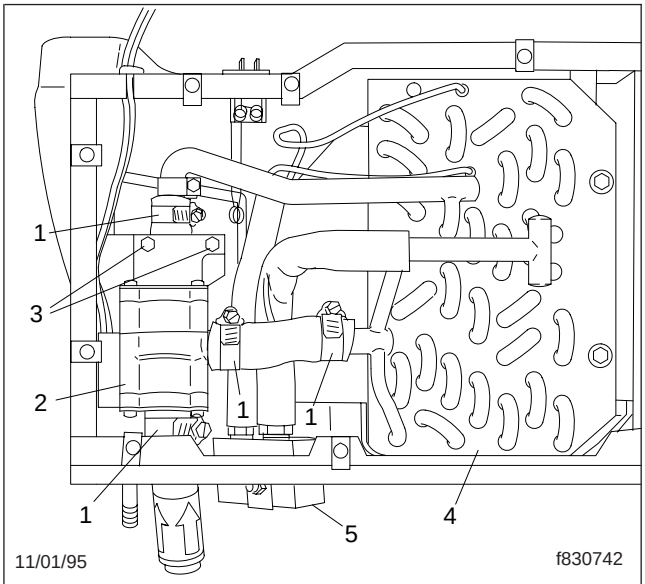


1. Access Panel
2. Filter Screen
3. Sleeper Heater and Air Conditioner Housing

Fig. 2, Sleeper Heater and Air Conditioner Housing With Recirculation Filter

6. Disconnect the water supply solenoid valve wiring harness.
7. Loosen the hose clamps on the hoses that are attached to the water supply solenoid valve, and remove the hoses. See **Fig. 3**.
8. Remove the fasteners that attach the water supply solenoid valve to the housing, and remove the valve.
9. Install a new water supply solenoid valve, and install the fasteners that attach the valve to the housing.
10. Connect the hoses to the water supply solenoid valve, and tighten the hose clamps.
11. Connect the wiring harness to the water supply solenoid valve.
12. Install the standoff bracket (if equipped) that separates the two heater hoses. Reconnect the inlet line under the sleeper. Tighten the clamps 40 lbf·in (452 N·cm).

A.T.C. Water Supply Solenoid Valve Replacement



1. Hose Clamp
2. Water Supply Solenoid Valve
3. Mounting Fasteners
4. Heater Core and Evaporator Coil Assembly
5. Expansion Valve

Fig. 3, A.T.C. Water Supply Solenoid Valve

13. Attach the front cover to the sleeper heater and air conditioner housing, or install the access panel on the housing.
14. Lower the bunk panel and the sleeper mattress, or close the baggage compartment door.
15. Fill the cooling system with coolant. For coolant specifications, see Group 20 of the *Century Class Trucks Maintenance Manual*.

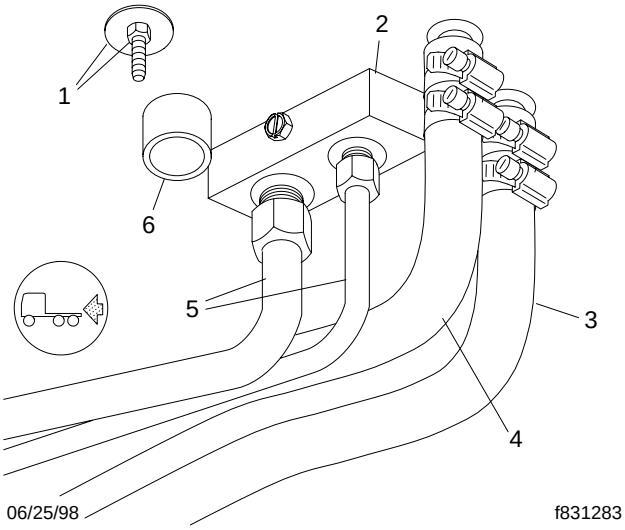
⚠ CAUTION

Coolant must be filled to the proper level in the surge tank. Low coolant could cause engine overheating, which could damage the engine.

16. Remove the chocks from the tires.

Replacement

1. Turn off the engine, apply the parking brakes, and chock the tires.
2. Remove the refrigerant from the air conditioning system. For instructions, see **Section 83.02**, Subject 250.
3. From under the sleeper on the right-hand side of the vehicle, disconnect the refrigerant lines from the expansion valve. See **Fig. 1**. Quickly cap the inlet and outlet ports, and plug the fittings.



1. Mounting Fasteners
2. Expansion Valve
3. Inlet Line
4. Outlet Line
5. Refrigerant Lines
6. Drain Tube

Fig. 1, Expansion Valve

IMPORTANT: Under no circumstances should the ports on the expansion valve remain uncapped or the fittings remain unplugged for longer than five minutes total. Water and dirt can damage the refrigerant system. Do not blow shop air through refrigerant lines since shop air is wet (humid).

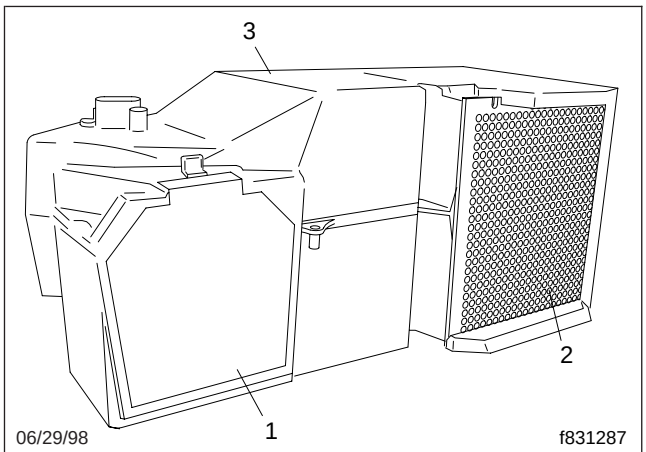
4. Remove enough coolant from the radiator so that the level of coolant is below the inlet and outlet lines at the expansion valve, or clamp off the radiator hoses to prevent coolant loss.
5. Access the sleeper heater and air conditioner housing.

   On vehicles with a baggage compartment on the right-hand side of the cab, open the door to the baggage compartment.

   On vehicles without a baggage compartment on the right-hand side of the cab, raise the mattress and bunk panel to their locked position.
6. Access the expansion valve.

   On sleeper heater and air conditioner housings that have a one-piece front cover, remove the fasteners that attach the front cover to the housing. Remove the cover.

   On sleeper heater and air conditioner housings that have a recirculation filter, remove the access panel on the front of the housing. See **Fig. 2**.



1. Access Panel
2. Filter Screen
3. Sleeper Heater and Air Conditioner Housing

Fig. 2, Sleeper Heater and Air Conditioner Housing With Recirculation Filter

7. Remove the A.T.C. water supply solenoid valve. For instructions, see **Subject 150**.
8. From inside the sleeper heater and air conditioner housing, disconnect the refrigerant lines from the expansion valve. Quickly cap the inlet and outlet ports and plug the fittings.
9. Remove the bolt and nut that attach the expansion valve to the mounting bracket, and remove the expansion valve.
10. Install a new expansion valve. Attach the expansion valve to the mounting bracket with the bolt and nut and tighten 96 lbf·in (1085 N·cm).

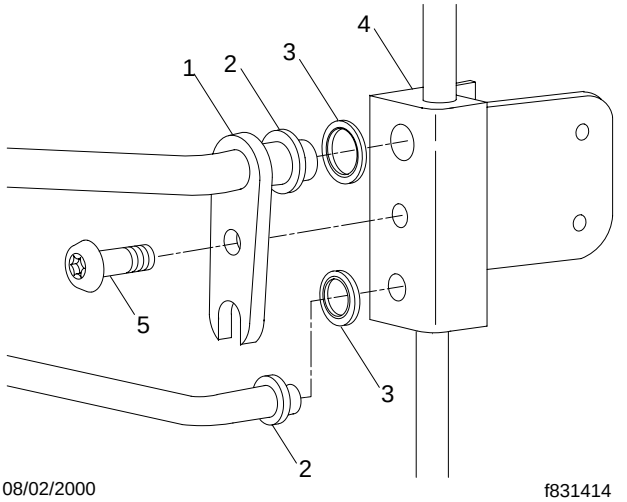
Expansion Valve Replacement

11. Uncap the inlet and outlet ports on the expansion valve. Unplug the fittings. Check the fittings, and the inlet and outlet ports. They must be clean and free of nicks, gasket residue, and other foreign material.
12. On hose connections that have threaded fittings, replace the O-rings in the fittings. Lubricate the O-rings with mineral oil before installing.

    On hose connections that have a SlimLine seal assembly (**Fig. 3**), replace the seals. **Do not** lubricate SlimLine seals prior to installation. Use **only** a SlimLine seal on a SlimLine seal assembly.
13. Install the refrigerant lines on the expansion valve.

    On hose connections that have threaded fittings, torque the #6 fitting 20 to 25 lbf·ft (27 to 34 N·m), and the #10/12 fittings 35 to 40 lbf·ft (47 to 54 N·m).

    On hose connections that have a SlimLine seal assembly, torque the bolt on the SlimLine seal block and plate assembly 11 to 15 lbf·ft (15 to 20 N·m).



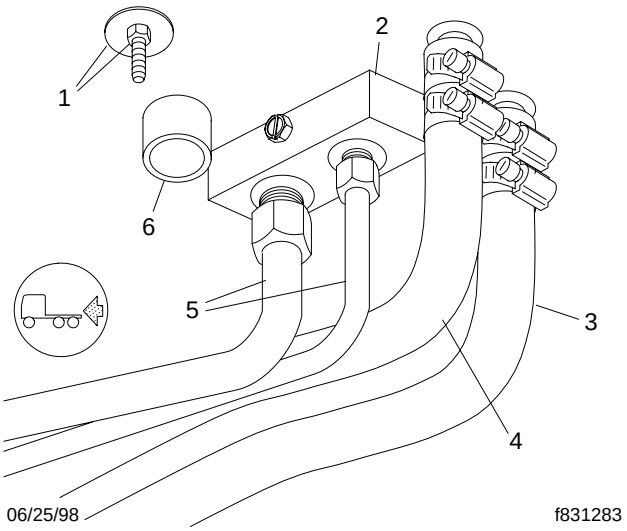
1. Plate
2. Fitting
3. Seal
4. Block
5. Bolt

Fig. 3, A Typical SlimLine Seal Assembly

14. Install the A.T.C. water supply solenoid valve. For instructions, see **Subject 150**.
15. Attach the front cover to the sleeper heater and air conditioner housing, or install the access panel on the housing.
16. Lower the bunk panel and the sleeper mattress, or close the baggage compartment door.
17. Evacuate and charge the air conditioning system. For instructions, see **Section 83.02**, Subject 250.
18. Remove the chocks from the tires.

Replacement

1. Turn off the engine, apply the parking brakes, and chock the tires.
2. Remove the refrigerant from the air conditioning system. For instructions, see **Section 83.02**, Subject 250.
3. Remove enough coolant from the radiator so that the level of coolant is below the inlet and outlet lines at the expansion valve, or clamp off the radiator hoses to prevent coolant loss.
4. From under the sleeper, remove the standoff bracket (if equipped) that separates the water supply inlet and outlet lines. Mark the water supply inlet and outlet lines for later reference and drain the heater core by disconnecting the inlet and outlet lines. See **Fig. 1**.



1. Mounting Fasteners
2. Expansion Valve
3. Inlet Line
4. Outlet Line
5. Refrigerant Lines
6. Drain Tube

Fig. 1, Expansion Valve

5. Access the sleeper heater and air conditioner housing.

   On vehicles with a baggage compartment on the right-hand side of the cab, open the door to the baggage compartment.

   On vehicles without a baggage compartment on the right-hand side of the cab, raise the mattress and bunk panel to the locked position.
6. Access the heater core and evaporator coil.

   On sleeper heater and air conditioner housings that have a one-piece front cover, remove the fasteners that attach the front cover to the housing. Remove the front cover.

   On sleeper heater and air conditioner housings that have a recirculation filter, remove the fasteners that attach the top cover to the housing. Remove the top cover.
7. Disconnect the wiring harnesses from the blower motor, the thermistor, the resistor block assembly, and the A.T.C. water supply solenoid valve.
8. Remove the A.T.C. water supply solenoid valve. For instructions, see **Subject 150**.
9. Disconnect the two refrigerant lines from the top of the expansion valve. Quickly cap the expansion valve inlet and outlet ports and plug the fittings.

IMPORTANT: Under no circumstances should the expansion valve ports remain uncapped or the fittings remain unplugged for longer than five minutes total. Water and dirt can damage the refrigerant system. Do not blow shop air through refrigerant lines since shop air is wet (humid).

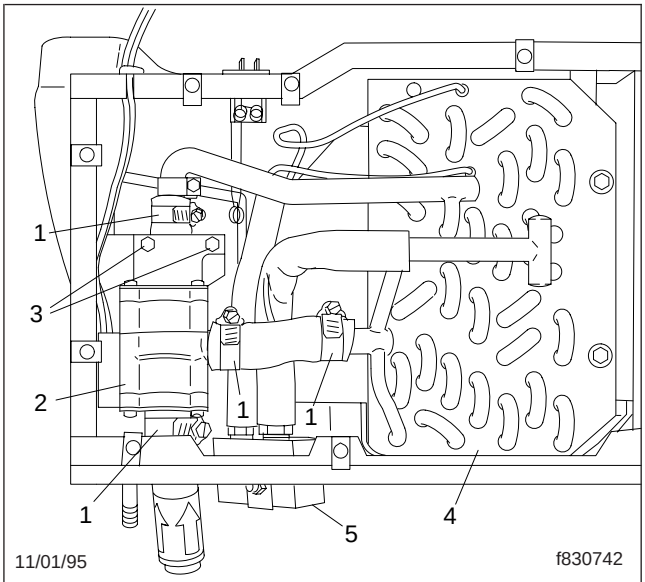
10. Remove the heater core and evaporator coil. See **Fig. 2**.

    10.1 On sleeper heater and air conditioner housings that have a one-piece front cover, remove the four fasteners that attach the heater core and evaporator coil to the housing, and lift the heater core and evaporator coil out of the housing.

    10.2 On sleeper heater and air conditioner housings that have a recirculation filter, lift the heater core and evaporator coil out of the housing.
11. Install a new heater core and evaporator coil.

    11.1 On sleeper heater and air conditioner housings that have a one-piece front cover, install a new heater core and evaporator coil and attach the assembly to the housing using four fasteners. Tighten the fasteners firmly.

Heater Core and Evaporator Coil Replacement



1. Hose Clamp
2. Water Supply Solenoid Valve
3. Mounting Fasteners
4. Heater Core and Evaporator Coil Assembly
5. Expansion Valve

Fig. 2, Heater Core and Evaporator Coil Assembly

11.2 On sleeper heater and air conditioner housings that have a recirculation filter, install a new heater core and evaporator coil.

12. Attach the water outlet line to the heater core.

13. On hose connections that have threaded fittings, replace the O-rings in the fittings. Lubricate the O-rings with mineral oil before installing.

    On hose connections that have a SlimLine seal assembly (**Fig. 3**), replace the seals. **Do not** lubricate SlimLine seals prior to installation. Use **only** a SlimLine seal on a SlimLine seal assembly.

14. Install the refrigerant lines on the expansion valve.

    On hose connections that have threaded fittings, torque the #8 fitting 30 to 35 lbf·ft (41 to 47 N·m), and the #10/12 fittings 35 to 40 lbf·ft (47 to 54 N·m).

    On hose connections that have a SlimLine seal assembly, torque the bolt on the SlimLine seal block and plate assembly 11 to 15 lbf·ft (15 to 20 N·m).

15. Install the A.T.C. water supply solenoid valve. For instructions, see **Subject 150**.

16. On sleeper heater and air conditioner housings that have a one-piece front cover, install the front cover on the housing and attach the fasteners to the cover.

17. On sleeper heater and air conditioner housings that have a recirculation filter, install the top cover on the housing and attach the fasteners to the cover.

18. Evacuate and charge the air conditioning system. For instructions, see **Section 83.02**, Subject 250 in this group.

19. Fill the cooling system with coolant. For coolant specifications, see Group 20 of the *Century Class Trucks Maintenance Manual*.

⚠ CAUTION

Coolant must be filled to the proper level in the surge tank. Low coolant could cause engine overheating, which could damage the engine.

20. Remove the chocks from the tires.

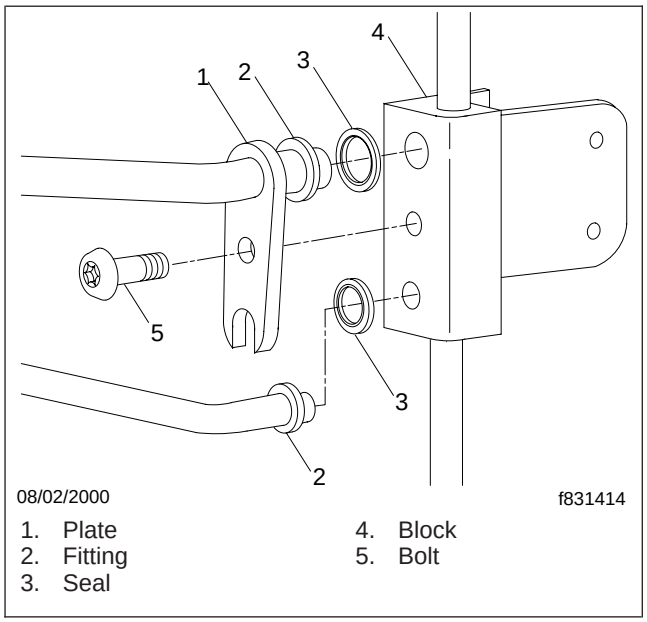


Fig. 3, A Typical SlimLine Seal Assembly

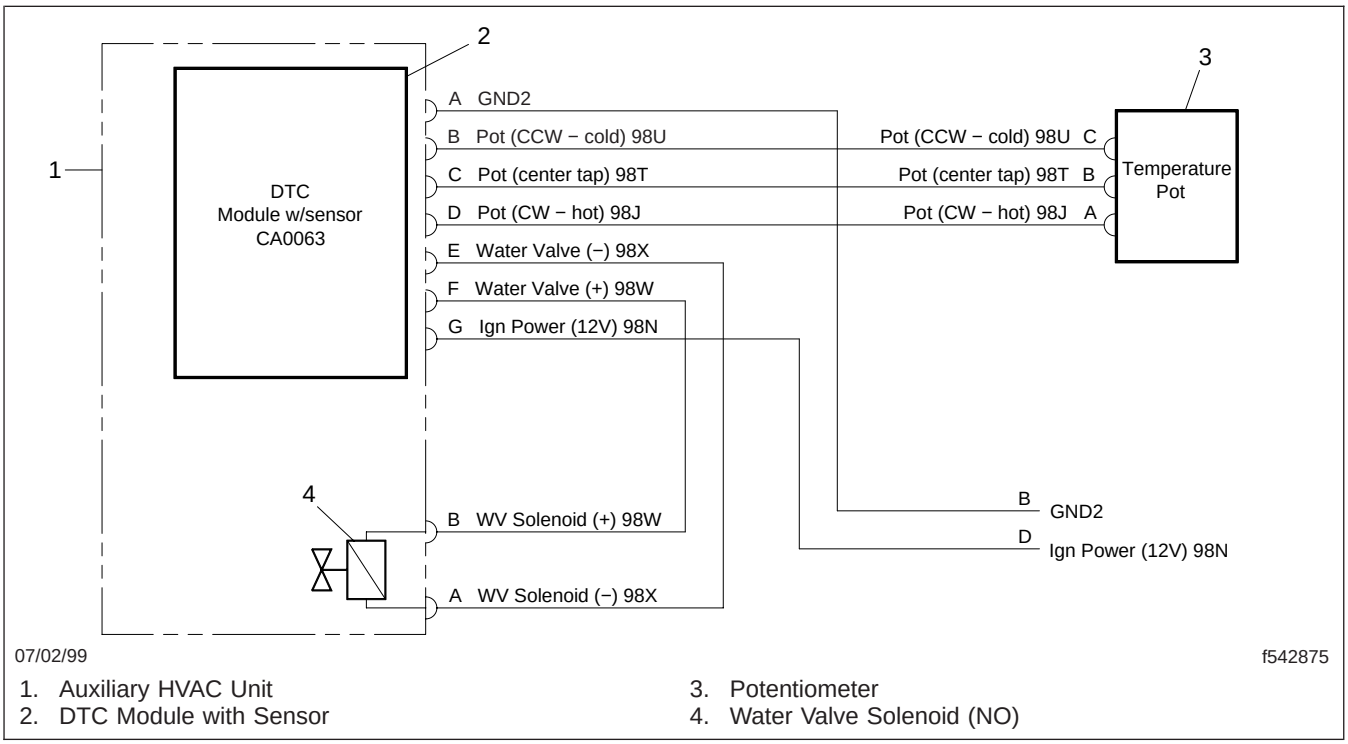
Troubleshooting

Auxiliary HVAC With Constant Discharge Temperature Control

The Constant Discharge Temperature Control (CDTC) module with sensor is mounted on the auxiliary HVAC unit under the bunk. The Discharge Temperature Control (DTC) module with sensor is shown in the diagram in **Fig. 1**. The DTC module receives input from the temperature control pot (potentiometer), which is mounted in the sleeper control panel.

Troubleshooting the CDTC System

Use the troubleshooting procedures in **Table 1** first.



1. Auxiliary HVAC Unit
2. DTC Module with Sensor
3. Potentiometer
4. Water Valve Solenoid (NO)

Fig. 1, Constant Discharge Temperature Control Diagram

CDTC System Initial Electrical Diagnosis				
Test No.	**Test Procedure**	**Test Criteria**	**Test Result**	**Action**
1	Measure voltage at the water valve by backprobing the connector. Voltage should be approximately 12V.	• Engine running • Engine at normal operating temperature • Temperature setting at **full cold**	OK	**Go to test no. 2.**
			Not OK	**Go to test no. 3.**

Troubleshooting

CDTC System Initial Electrical Diagnosis				
Test No.	**Test Procedure**	**Test Criteria**	**Test Result**	**Action**
2	Measure voltage at the water valve by backprobing the connector. Voltage should be approximately 0V.	• Engine running • Engine at normal operating temperature • Temperature setting at **full hot**	OK	There are no apparent electrical problems with the system. With the engine at normal operating temperature, hot air should come from the vents when the temperature setting is **full hot**. When switched to **full cold**, cooler air should come from the vents within approximately 10 minutes. If the system does not operate as stated above, refer to one of the following: • For little or no heat symptom, see **Table 4**. • For blowing warm/hot air symptom, see **Table 5**.
			Not OK	Perform tests in **Table 2**, CDTC System Temperature Potentiometer Test.
3	Repeat test no. 1 using a known good ground instead of water valve ground wire. Voltage should be approximately 12V.	• Engine running • Engine at normal operating temperature • Temperature setting at **full cold**	OK	**Go to test no. 4.**
			Not OK	Perform tests in **Table 2**, CDTC System Temperature Potentiometer Test.
4	Check the ground wire to the controller (terminal A).	—	OK	Perform tests in **Table 2**, CDTC System Temperature Potentiometer Test.
			Not OK	Repair controller ground circuit.

Table 1, CDTC System Initial Electrical Diagnosis

Use the troubleshooting procedures in **Table 1** before using the procedures in **Table 2**.

CDTC System Temperature Potentiometer Test			
Test No.	**Test Procedure**	**Test Result**	**Action**
1	Disconnect the temperature potentiometer from the harness. Using an ohmmeter, measure the potentiometer resistance as follows: • A to B (knob full CCW) 8000 to 12,000 ohms • A to B (knob full CW) 40 to 60 ohms • B to C (knob full CCW) 40 to 60 ohms • B to C (knob full CW) 8000 to 12,000 ohms NOTE: Resistance ranges are approximate.	OK	**Go to test no. 2.**
		Not OK	Replace temperature potentiometer.
2	Connect the potentiometer. Disconnect the harness from the controller. Using an ohmmeter, measure the potentiometer resistance through the harness pins at the controller as follows: • C to D (knob full CCW) 8000 to 12,000 ohms • C to D (knob full CW) 40 to 60 ohms • B to C (knob full CCW) 40 to 60 ohms • B to C (knob full CW) 8000 to 12,000 ohms NOTE: Resistance ranges are approximate.	OK	Temperature potentiometer and wires are okay. Perform tests in the table titled CDTC System Controller Test.
		Not OK	Repair wiring between temperature potentiometer and CDTC controller.

Table 2, CDTC System Temperature Potentiometer Test

Use the troubleshooting procedures in **Table 1** and **Table 2** before using the procedures in **Table 3**.

CDTC System Controller Test				
Test No.	**Test Procedure**	**Test Criteria**	**Test Result**	**Action**
1	Disconnect the harness from the CDTC controller. Measure voltage across pins A and G. Voltage should be approximately 12V.	• Ignition on • CDTC controller disconnected	OK	**Go to test no. 2.**
			Not OK	Check power supply wire and fuse to CDTC controller. Check CDTC controller ground circuit. Repair as necessary.

Troubleshooting

CDTC System Controller Test				
Test No.	**Test Procedure**	**Test Criteria**	**Test Result**	**Action**
2	Connect the harness to the CDTC controller. Measure voltage by backprobing one meter lead to pin F and placing the other lead to a known good ground. Voltage should be approximately 12V.	• Ignition on • CDTC controller connected	OK	**Go to test no. 3.**
			Not OK	Replace the CDTC controller.
3	Measure voltage by backprobing pins F and E of the CDTC controller connector. Voltage readings should be: • Slightly less than 12V when the control knob is **full cold** (CCW) • 0V when the control knob is **full hot** (CW).	• Ignition on • CDTC controller connected	OK	No problem found. Repeat tests **Table 1**.
			Not OK	Replace the CDTC controller.

Table 3, CDTC System Controller Test

Use the troubleshooting procedures in **Table 1** before using the procedures in **Table 4**.

CDTC System Special Test-Symptom: Little or No Heat and Passes All Electrical Tests			
Test No.	**Test Procedure**	**Test Result**	**Action**
1	Check to make sure that the coolant source from the engine is connected to the inlet pipe on the water valve.	OK	**Go to test no. 2.**
		Not OK	Route hose to correct connections.
2	Check to make sure that the water inlet hose at the water valve is hot.	OK	Check for blocked heater core and repair as necessary.
		Not OK	Check for closed heater hose shutoff valve. If okay or not present, repair engine cooling system as necessary.

Table 4, CDTC System Special Test-Symptom: Little or No Heat and Passes All Electrical Tests

Use the troubleshooting procedures in **Table 1** before using the procedures in **Table 5**.

CDTC System Special Test-Symptom: Blows Warm/Hot Air and Passes All Electrical Tests			
Test No.	**Test Procedure**	**Test Result**	**Action**
1	Remove the water valve and visually inspect the inside of the outlet tube to see if the plunger is broken or if debris is preventing the plunger from seating properly.	OK	Problem not found.
		Not OK	If plunger is broken, replace the water valve. If debris is present, clean the cooling system.

Table 5, CDTC System Special Test-Symptom: Blows Warm/Hot Air and Passes All Electrical Tests

See **Table 6** for the electrical pinout descriptions of the DTC module.

DTC Module Pinout	
Pin	**Electrical Function**
A	Ground 2
B	Potentiometer (CCW–cold) 98U
C	Potentiometer (center tap) 98T
D	Potentiometer (CW–hot) 98J
E	Water Valve (–) 98X
F	Water Valve (+) 98W
G	Ignition Power (12V) 98N

Table 6, DTC Module Pinout

Specifications

See **Fig. 1** for the sleeper heater and air conditioner wiring diagram.

Torque Specifications		
Description	**Torque**	
	lbf·in (N·cm)	**lbf·ft (N·m)**
Heater and Air Conditioner Mounting Locknuts	—	13 (18)
Heater Hose Clamps	40 (452)	—
Refrigerant Line (Inlet Side) #6 O-Ring Fitting *	—	20–25 (27– 34)
Refrigerant Line (Outlet Side) #10 O-Ring Fitting *	—	35–40 (47–54)
Blower Motor Mounting Capscrews	28–32 (320–360)	—
Expansion Valve Mounting Bolt	96 (1085)	—

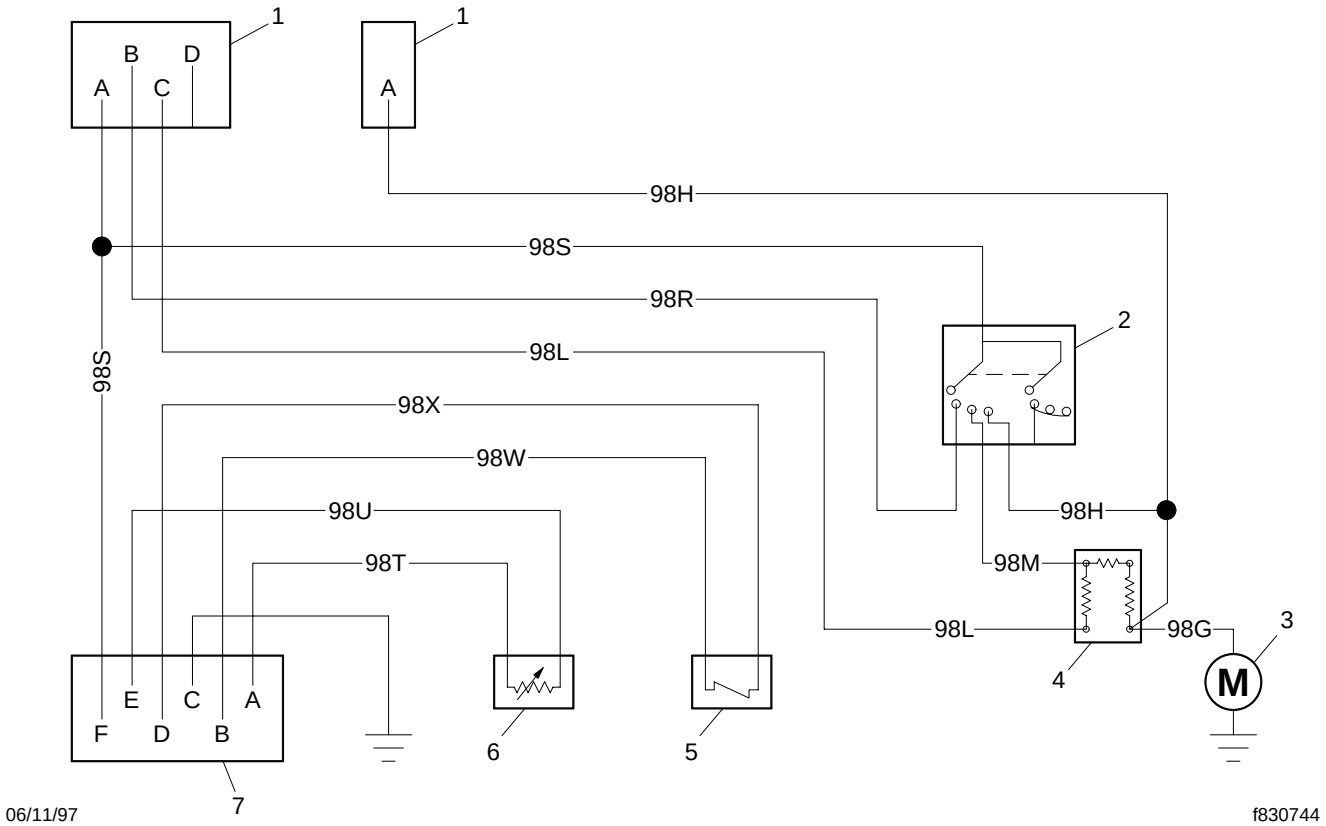
* Replace the O-ring and lubricate it with mineral oil. Apply mineral oil to the male portion of the fitting threads. If equipped with aluminum fittings, apply Molykote M Gear Guard to the male portion of the fitting threads.

Table 1, Torque Specifications

SlimLine Seal Assembly Bolt Torques	
HVAC Component	**Torque**
A/C Compressor	11 to 15 lbf·ft (15 to 20 N·m)
Condenser	11 to 15 lbf·ft (15 to 20 N·m)
Receiver-Drier	11 to 15 lbf·ft (15 to 20 N·m)
Thermal Expansion Valve	11 to 15 lbf·ft (15 to 20 N·m)
Evaporator	11 to 15 lbf·ft (15 to 20 N·m)
Junction Block	11 to 15 lbf·ft (15 to 20 N·m)

Table 2, SlimLine Seal Assembly Bolt Torques

Specifications



1. Sleeper Heater and Air Conditioner Wiring Connector
2. Fan Switch
3. Blower Motor
4. Blower Motor Resistor Block
5. Water Supply Solenoid Valve
6. Temperature Sensor
7. Automatic Temperature Control Module

Fig. 1, Sleeper Heater and Air Conditioner Wiring Diagram

General Information

The heater and air conditioner assembly is mounted behind the passenger dash panels and contains the following major components:

- brushless blower motor
- evaporator core
- heater core
- a recirculation filter
- an optional outside air filter
- three electric actuators
- temperature control, air selection mode, and recirculation doors
- expansion valve
- evaporator temperature sensor

The heating, air conditioning, and ventilating functions of the cab heater and air conditioner system are controlled by the cab climate control panel mounted on the dashboard. Refer to the *Century Class S/T and Coronado Driver's Manual* for operating instructions.

Thermodynamic Principles

Air conditioning is the cooling or refrigeration of the air in the passenger compartment. Refrigeration is accomplished by making practical use of three thermodynamic principles. These principles and their practical application are described below.

Heat Transfer

If two objects of different temperatures are placed near each other, the heat in the warmer object will always travel to the cooler object until both are of equal temperature.

For example, a block of ice in a refrigerator does not transfer its coldness to a nearby carton of milk. Rather, the heat in the warm milk automatically flows to the ice.

The British Thermal Unit (BTU) is used to determine the amount of heat transferred from one object to another. One BTU is the amount of heat required to raise the temperature of 1 pound (0.45 kg) of water 1°F (0.55°C).

For example, to raise the temperature of 1 pound (0.45 kg) of water from 32°F to 212°F (0°C to 100°C), one BTU of heat must be added for 1°F (0.55°C) rise in temperature or a total of 180 BTUs of heat. Conversely, in order to lower the temperature of 1 pound (0.45 kg) of water from 212°F to 32°F (100°C to 0°C), 180 BTUs of heat must be removed from the water.

Latent Heat of Vaporization

When a liquid boils, it absorbs heat without raising the temperature of the resulting gas. When the gas condenses (changes back to a liquid), it gives off heat without lowering the temperature of the resulting liquid.

For example, when 1 pound (0.45 kg) of water at 32°F (0°C) is placed in a container over a flame, the temperature of the water rises 1°F (0.55°C) with each BTU of heat that the water absorbs from the flame. Thus, after it has absorbed 180 BTUs of heat, the water reaches a temperature of 212°F (100°C).

Even though the flame continues to give its heat to the water, the temperature of the water remains at 212°F (100°C). The water however starts to boil or change from a liquid to a gaseous state. It continues to boil until the water has passed off into the atmosphere as vapor. If this vapor were checked with a thermometer, it also would show a temperature of 212°F (100°C).

In other words, there was a rise of only 180°F (from 32°F to 212°F or 0°C to 100°C) in the water and vapor temperature even though the flame applied many more than 180 BTUs of heat. In this case, the heat is absorbed by the liquid in the process of boiling and disappears in the vapor. If the vapor were brought in contact with cool air, the hidden heat would flow into the cooler air and the vapor would condense back to water. Scientists refer to this principle as the latent (hidden) heat of vaporization.

Water has a latent heat of vaporization of 970 BTUs and a boiling point of 212°F (100°C). This means that 1 pound (0.45 kg) of water at 212°F (100°C) will absorb 970 BTUs of heat when changing to vapor at 212°F (100°C). Conversely, the vapor will give off 970 BTUs of heat when condensing back to water at 212°F (100°C).

This heat transfer, occurring when a liquid boils or a vapor condenses, forms the basic principle of all conventional refrigerant systems.

General Information

For a liquid to be a refrigerant, it must also have a low boiling point. That is, the temperature at which it boils must be lower than the substance to be cooled.

R–134a is a non-CFC refrigerant. Its temperature/pressure relationship makes it suitable for mobile air conditioning systems.

Effect of Pressure on Boiling or Condensation

As refrigerant passes through an air conditioning system, it flows under high-pressure conditions, first as a high-pressure vapor between the refrigerant compressor and the condenser, then as a high-pressure liquid between the condenser and the evaporator orifice. It expands to a low-pressure vapor between the evaporator orifice and the refrigerant return port in the refrigerant compressor. As pressures in the closed refrigerant circuit vary, temperatures will also vary. As pressure increases, temperatures also increase; as the pressure decreases, temperatures also decrease. See **Fig. 1** for a diagram of the refrigerant flow.

Description of Components

Binary Switch

Located on the liquid line from the receiver-drier, the binary switch disengages the refrigerant compressor to protect it from harmful operating conditions. It performs two functions:

- If the refrigerant system pressure is too low, the binary switch will keep the compressor from operating. The switch disengages the compressor when the pressure on the high pressure side of the system falls between 27 and 35 psig (186 and 241 kPa). Normal compressor operation resumes when the rising pressure reaches 28 to 36 psig (193 to 248 kPa) above the shutoff pressure. This occurs when the ambient temperature falls to around 31 to 40°F (–0.56 to 4°C) or when refrigerant has leaked out of the system.
- If the refrigerant system pressure on the high pressure side increases to between 427 and 484 psig (2944 and 3337 kPa), the binary switch shuts off the compressor clutch. Too much pressure may be caused by excess refrigerant in the system or anything that causes poor condenser performance such as poor air flow through the condenser. When the system pressure has decreased to 313 to 426 psig (2158 to 2937 kPa), the compressor resumes operation.

NOTE: Since the binary switch is on the high pressure side, the compressor may continue to operate (trying to cool the cab) if most, but not all, of the refrigerant leaks out of the system until the air conditioner is turned off or the vehicle is shut down for a short time. Continuing to run the compressor with a low charge can lead to a lack of lubrication and high temperatures in the compressor.

Blower Motor

The brushless blower motor forces air through the HVAC assembly and through the duct work.

Condenser

A condenser turns hot refrigerant gas coming from the compressor into liquid. The condenser is mounted either in front of or below the radiator. Because of its location, the condenser transfers heat to air that is drawn in by the engine fan and by air that is forced into the engine compartment as the vehicle moves forward.

Electric Actuator

The electric actuator is a combined motor and gearbox and is used to drive the levers and doors within the HVAC assembly. Movement of the levers and doors is controlled by the settings on the climate control panel. There are three actuators on the HVAC assembly: a temperature actuator, a recirculation actuator, and a mode actuator.

Evaporator

Because the evaporator is an area of low pressure in the system, the boiling point of refrigerant lowers, which causes it to absorb heat from the tubing walls and fins. As it absorbs heat, liquid refrigerant quickly boils and turns into a gas.

As heat is absorbed from the outside surfaces of the evaporator, air passing over the unit loses its heat to these cooler surfaces. Moisture in the air condenses

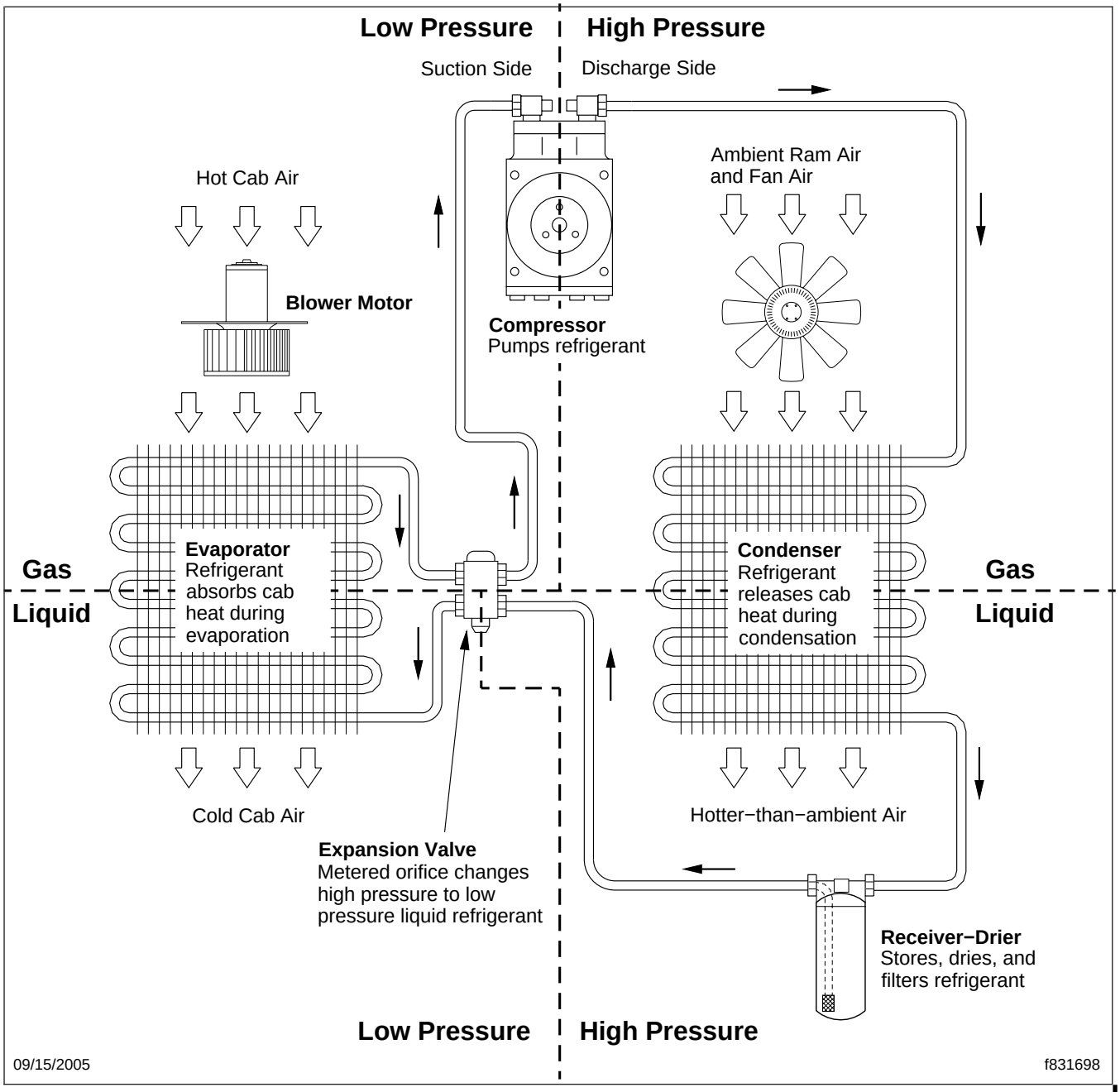


Fig. 1, Refrigerant Flow Diagram

on the outside of the evaporator and drains off as water; the air becomes dehumidified.

Evaporator Temperature Sensor

The temperature of the evaporator is monitored by the evaporator temperature sensor.

The evaporator temperature sensor is in front of the evaporator. The temperature sensor disengages the compressor to prevent the evaporator from freezing up due to, for example, an expansion valve that is stuck open.

Expansion Valve

The expansion valve is a dividing point between the high- and low-pressure parts of the refrigerant system. High-pressure liquid refrigerant from the condenser passes through the expansion valve and moves into the low-pressure area of the evaporator.

An expansion valve controls the flow rate of refrigerant in proportion to the rate of evaporation in the evaporator. If the amount of liquid in the evaporator drops off, the temperature of the gas going to the compressor rises. This causes a diaphragm in the expansion valve to react, which causes an orifice in the valve to open or close. Through the orifice, liquid refrigerant is metered into the evaporator as needed.

Fan Cycling Switch

Located on the junction block liquid line, the fan cycling switch sends a ground signal to the ECM (engine control module) to keep the fan off and take away the ground to engage the fan. The fan will come on if refrigerant pressure is greater than 300 ± 10 psi (2070 ± 69 kPa). The fan turns off when pressure drops below 250 ± 10 psi (1725 ± 69 kPa) and the engine ECU timer (0 to 180 seconds) has expired.

Heater Core

When the engine is on, coolant flows through the heater core tubes heating the tubes and fins. The heat is absorbed by air that is forced through the heater core by the blower motor.

Receiver-Drier

Used as a reservoir and filter for liquid refrigerant from the condenser, a receiver-drier also removes water and acids from the refrigerant. The water-absorbing material, or desiccant, in the unit helps stop blockages from forming in the expansion valve and in other parts of the system.

Refrigerant

Refrigerant absorbs heat from the air in the cab and releases it to the air outside the cab.

In an open container, refrigerants boil at temperatures below the freezing point of water. Sealing and pressurizing refrigerant in the air conditioning system raises its boiling-point temperature.

During refrigerant compressor operation, refrigerant constantly changes from a liquid to a gas. It absorbs heat (boiling) in the low-pressure evaporator and it changes from a gas to a liquid as it releases absorbed heat in the high-pressure condenser.

Refrigerant Compressor

Heat in the low-pressure gas of the evaporator is not heat that can be noticed by touch because liquid refrigerant boils at a temperature much lower than the temperature at which water turns to ice. By touch, the heated gas in the evaporator is very cold. As a result, there is the problem of how to remove heat from cool gas using outside air that may be higher than 100°F (38°C).

With a refrigerant compressor, low-pressure gas from the evaporator can be squeezed into a much smaller space. When the gas is compressed, the heat it contains becomes concentrated. In this way, the gas is made hotter than the outside air without adding heat.

Another function of the compressor is to move refrigerant through the system.

Definition of Terms

Refer to the following terms for a better understanding of the heater and air-conditioning system.

Air Conditioner A system used to control the temperature, humidity, and movement of air in the cab.

Ambient Air Temperature The temperature of air around an object or the outside temperature.

Binary Switch Disengages the refrigerant compressor to protect it from harmful operating conditions.

Blower Motor A brushless blower motor forces air through the HVAC assembly and through the duct work.

Boiling Point The temperature at which a liquid changes to a gas. The boiling point varies with pressure.

Bulk Charging Use of large containers of refrigerant for charging a refrigerant system. Normally used for charging empty systems.

Charge A specific amount of refrigerant or oil by volume or weight. Also, the act of placing an amount of refrigerant or oil in the air conditioning system.

Condensate Water taken from the air, which forms on the outer surface of the evaporator.

Condenser A heat exchanger that is used to remove heat from the refrigerant, changing it from a high-pressure hot gas to a high-pressure warm liquid. Typically the condenser is mounted in front of the radiator.

Condensing Pressure Pressure as read from the gauge at the discharge service valve. Pressure from the discharge side of the compressor into the condenser.

Contaminants Anything other than refrigerant or refrigerant oil in the system. Usually means water, dirt, or air in the system.

Cycling Clutch System A system which controls compressor clutch operation in order to raise or lower the temperature in the cab.

Dehumidify To remove water from the air at the evaporator.

Dehydrate To remove all traces of moisture from the refrigerant system. This process occurs during evacuation.

Desiccant A drying agent used in the receiver-drier to remove water and create an extremely dry condition.

Discharge Line Connects the refrigerant compressor outlet to the condenser inlet.

Discharge Pressure High-side pressure or condensing pressure being discharged from the compressor.

Drive Pulley A pulley attached to the front of the engine crankshaft. It drives the compressor clutch pulley with a belt.

Duct A passageway for the transfer of air from one area to another.

Electric Actuator The actuator is a combined motor and gearbox used to drive the temperature control doors and the air selection mode door within the HVAC assembly.

Evacuate To place a high vacuum in the refrigerant system and dehydrate or remove all traces of moisture.

Evaporate To change state from a liquid to a gas.

Evaporator A component in which liquid refrigerant changes to a gas after it absorbs heat from the air. It also removes some moisture from the air.

Expansion Valve A device that causes a pressure-drop of the refrigerant and also regulates its flow.

Flooding A condition caused by too much liquid refrigerant going into the evaporator, usually caused by an expansion valve that is stuck open.

Flushing A process of passing liquid refrigerant through an air-conditioner component to remove dirt and water from the part. Liquid refrigerant removes heavy contamination, such as gritty dirt and large dirt buildup.

Freeze-Up Failure of a unit to operate properly because of ice forming at the expansion valve orifice or on the evaporator.

Heater Core A part of the heating system in which hot engine coolant flows to provide heat to the cab or to adjust the temperature produced by the air conditioner.

High-Pressure Switch Located on the discharge side of the refrigerant compressor, the high-pressure switch signals the fan on and the refrigerant compressor off in the event of a high pressure condition.

High-Side Service Valve A device located on the liquid line. It allows high-side pressure to be checked and other service operations to be performed.

Humidity The amount of water vapor in the air.

Hydraulic Lock The return of liquid refrigerant to the compressor, which could destroy the unit.

Leak Detector Any device used to detect refrigerant leaks in a refrigerant system.

Liquid Pressure Pressure of refrigerant in the liquid line from the receiver-drier to the thermostatic expansion valve.

Low Head Pressure High-side pressure that is lower than normal due to a system problem.

Low-Pressure Switch Located on the suction side of the refrigerant compressor, the low pressure switch signals the clutch to cycle or shut down in extremely cold temperatures, or if there is a loss of charge.

General Information

Low Suction Pressure Low-side pressure that is lower than normal due to a system problem.

Magnetic Clutch An electrical coupling device used to engage or disengage the compressor.

Manifold A device to control refrigerant flow for system test purposes. It is used with manifold gauges.

Manifold Gauge A calibrated instrument used for measuring system pressures.

Manifold Gauge Set A manifold that is complete with gauges and charging hoses and is used to measure or test pressure.

Micron A metric unit of length equal to one-millionth of a meter. The unit of measure used to measure vacuum drawn from a refrigerant system by a vacuum pump.

Nitrogen A colorless, odorless, dry, inert gas that can be used to purge light contaminants, such as dust, from air conditioner parts.

Opacity A condition that is used to describe contamination of refrigerant oil in the compressor. Fresh refrigerant oil is clear; when contaminated, it appears cloudy or may have fine particles held in suspension.

Overcharge Too much refrigerant or oil in the system.

Polyalkylene Glycol (PAG) A highly refined, synthetic oil that is used in R–134a air conditioning systems.

Polyol Ester (POE) A highly refined, synthetic oil that is used in R–134a air conditioning systems.

psia Pounds per square inch, absolute pressure. Pressure exerted by the air at sea level. Atmospheric pressure is usually measured with a mercury barometer.

psig Pounds per square inch, gauge pressure. Any pressure above normal atmospheric pressure (14.7 psi) is referred to as gauge pressure.

Purge To remove damp air, traces of refrigerant, and loose dirt from a system or part by flushing with a dry, inert gas, such as nitrogen.

Receiver-Drier A combination desiccant, filter, and storage container for liquid refrigerant.

Recovery Removal of the refrigerant from air conditioning systems.

Recycling Removal of contaminants and moisture from R–134a using a recovery and recycling station.

Refrigerant–134a (R–134a) The cooling agent used in automotive air conditioning systems. The chemical name for R–134a is tetrafluoroethane.

Refrigerant Compressor A device used to draw low-pressure refrigerant gas from the evaporator and squeeze it into a high-temperature, high-pressure gas. A second purpose of the compressor is to move refrigerant through the system.

Refrigeration Cycle The complete circulation of refrigerant through an air conditioning system accompanied by changes in temperature and pressure.

Relative Humidity The actual water content of the air in relation to the total water vapor the air can hold at a given temperature.

Suction Line The line connecting the evaporator outlet to the compressor inlet.

Suction Pressure Compressor inlet pressure or the system's low-side pressure.

Suction Service Valve A device that allows low-side pressure to be checked and other service operations to be performed.

Suction Side The low-pressure area of the system extending from the expansion valve to the compressor inlet.

Thermistor A vacuum pressure sensor that is used to measure, in microns of mercury, internal system vacuum levels after evacuation.

Thermostatic Vacuum Gauge A high-vacuum gauge sensitive to pressures ranging from atmospheric pressure to less than 1 micron of mercury with scales reading from 25,000 microns to 1 micron of mercury.

Undercharge A system low on refrigerant resulting in lack of cooling and possible compressor damage.

Vacuum Refers to pressure that is less than atmospheric pressure.

Vacuum Pump A mechanical device used to evacuate and place a high vacuum in the refrigerant system.

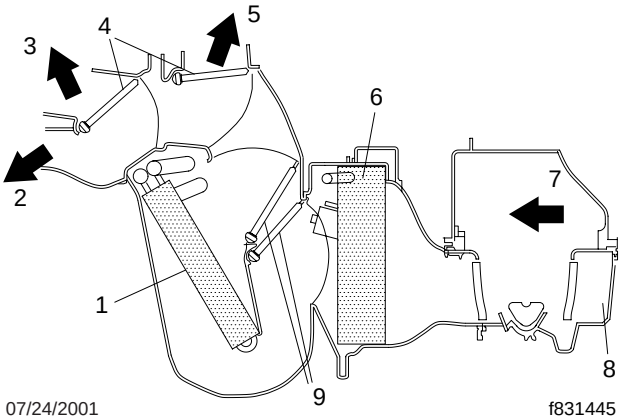
Vacuum Pump Oil Water soluble oil used in some vacuum pumps to absorb moisture from the refrigerant system.

Vapor The gaseous state of a material.

Principles of Operation

In a blend air HVAC system, the heater core is always filled with warm or hot coolant. Air enters the HVAC assembly through the blower and is always directed through the evaporator. If the refrigerant compressor is engaged, the air is cooled. The temperature control doors then direct the air through or around the heater core depending on the climate control settings. The temperature control doors are used to blend the correct amount of cold and hot air to achieve the selected temperature. The temperature control door, the air selection mode door, and the recirculation door are controlled by electric actuators. See **Fig. 2**.

The brushless blower motor does not have a resistor. Its speed is controlled by a built-in power module.



1. Heater Core
2. Floor Outlet
3. Defrost Outlet
4. Air Selection Mode Door
5. Face Outlet
6. Evaporator Core
7. Recirculation Air Inlet
8. Blower
9. Temperature Control Doors

Fig. 2, Cab Heater and Air Conditioner Unit

Safety Precautions

Whenever repairs are made to any air conditioner parts that hold R–134a refrigerant, you must recover, purge or flush (if contaminated), evacuate, charge, and leak test the system. In a good system, refrigerant lines are always under pressure and you should disconnect them only after the refrigerant charge has been recovered (discharged) at the service valves.

Refrigerant R–134a is safe when used under the right conditions. Always wear safety goggles and non-leather gloves while recovering, evacuating, charging, and leak testing the system. Do not wear leather gloves. When refrigerant gas or liquid contacts leather, the leather will stick to your skin.

⚠ WARNING

Use care to prevent refrigerant from touching your skin or eyes because liquid refrigerant, when exposed to the air, quickly evaporates and will freeze skin or eye tissue. Serious injury or blindness could result if you come in contact with liquid refrigerant.

Refrigerant splashed in the eyes should be rinsed with lukewarm water, not hot or cold. Do not rub the eyes. Apply a light bandage and contact a physician right away.

Refrigerant splashed on the skin should be rinsed with lukewarm water, not hot or cold. Do not rub the skin. Apply a light coat of a nonmedicated ointment, such as petroleum jelly. Contact a physician right away.

R–134a refrigerant does not burn at ambient temperatures and atmospheric pressure. However, it can be combustible at pressures as low as 5.5 psig (139 kPa absolute) at 350°F (177°C) when mixed with air concentrations that are greater than 60 percent.

⚠ WARNING

R–134a air conditioning systems should not be pressure tested or leak tested with compressed air. Combustible mixtures of air and R–134a may form, resulting in a fire or explosion that could cause personal injury or property damage. The air conditioning system may be safely pressurized with dry nitrogen.

Always work in an area where there is a constant flow of fresh air when the system is recovered, evacuated, charged, and leak tested. R–134a vapors have a slightly sweet odor that is difficult to detect. Frequent leak checks and air monitoring equipment are recommended to ensure a safe working environment.

IMPORTANT: When servicing an R–134a air conditioning system, use only service equipment certified to meet the requirements of SAE J2210 (R–134a recycling equipment). The equipment should be operated only by qualified personnel who are familiar with the recycling station manufacturer's instructions.

Because of its very low boiling point, refrigerant must be stored under pressure. To prevent the refrigerant containers from exploding, never expose them to temperatures higher than 125°F (52°C).

On R–134a refrigerant systems, polyalkylene glycol (PAG) oil is used in the compressor. When handling PAG oil, observe the following guidelines:

- Keep the oil free of contaminants.
- Do not expose the air conditioning system or the PAG oil container to air for more than five minutes. PAG oil has a high moisture absorption capacity and the oil container should be immediately sealed after each use.
- Use care when handling. Spilled oil could damage painted surfaces, plastic parts, and other components such as drive belts.
- Never mix PAG oil with other types of refrigerant oil.

Heater Core Replacement

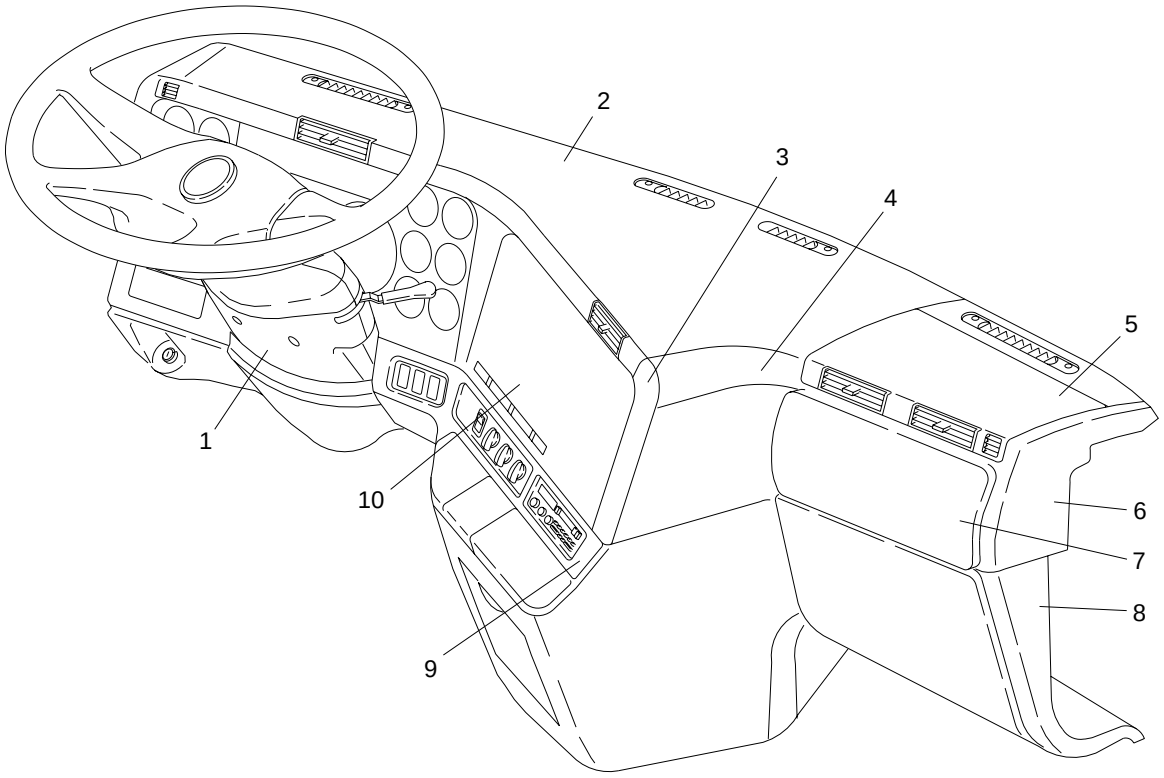
Replacement

1. Turn off the engine, apply the parking brakes, and chock the tires.
2. Disconnect the batteries.
3. Drain the coolant from the cooling system. For instructions, see **Section 20.01**, Subject 100.
4. Remove the dash panels listed below. See **Fig. 1**. For instructions, see **Section 60.08**.
    - electrical cover
    - upper dash cover
    - heater and air conditioner cover
    - waste bin
    - console cover
    - dash trim cap
    - upper dash assembly, center panel
5. Remove the tie straps on the wiring harness as needed to access the heater core.
6. Remove the capscrew that attaches the right side of the shield to the HVAC assembly. Move the shield to access the heater core. See **Fig. 2**.
7. Remove the capscrews that attach the lower duct to the HVAC assembly and remove the lower duct.
8. Remove the capscrews that attach the heater core service cover to the HVAC assembly and remove the service cover. See **Fig. 3**.
9. Remove the air cleaner. For instructions, see **Section 09.01**.
10. Remove the hose clamps that attach the heater hoses to the heater core tubes. Remove the heater hoses.
11. Remove the heater core retaining plate. See **Fig. 4**.
    - 11.1 Remove the capscrew that attaches the heater core retaining plate to the frontwall.
    - 11.2 Remove and set aside the no-drip tape from around the heater core tubes.
    - 11.3 Pull on the tab to remove the retaining plate.
12. From inside the cab, remove the heater core.
13. Install a new heater core in the HVAC assembly. Push the heater core into the HVAC assembly until the heater core makes contact with the far side of the HVAC assembly.
14. Using a capscrew, attach the heater core retaining plate to the frontwall.
15. Install the no-drip tape around the heater core tubes at the retaining plate.
16. Using hose clamps, attach the heater hoses to the heater core tubes.

NOTE: Make sure that the string seal is in the groove on the lower portion of the heater core service cover before installing the service cover.

17. Using capscrews, install the heater core service cover on the HVAC assembly.
18. Using capscrews, attach the lower duct to the HVAC assembly.
19. Using a capscrew, attach the shield to the HVAC assembly.
20. If needed, use tie straps to bundle the wiring harnesses.
21. Install the dash panels listed below. For instructions, see **Section 60.08**.
    - upper dash assembly, center panel
    - dash trim cap
    - console cover
    - waste bin
    - heater and air conditioner cover
    - upper dash cover
    - electrical cover
22. Install the air cleaner. For instructions, see **Section 09.01**.
23. Fill the cooling system with coolant. For instructions, see **Section 20.01**, Subject 100.
24. Connect the batteries.
25. Remove the chocks from the tires.

Heater Core Replacement



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1. Steering Column Cover
2. Left-Side Upper Dash Assembly
3. Dash Trim Cap
4. Upper Dash Assembly, Center Panel
5. Electrical Cover
6. Right-Side Upper Dash Assembly
7. Upper Dash Cover
8. Heater and Air Conditioner Cover
9. Waste Bin Outer Wall
10. Console Cover
11. HVAC/Radio Trim Plate
12. Auxiliary Gauge Panel

Fig. 1, Century Class Conventional Dash Panels

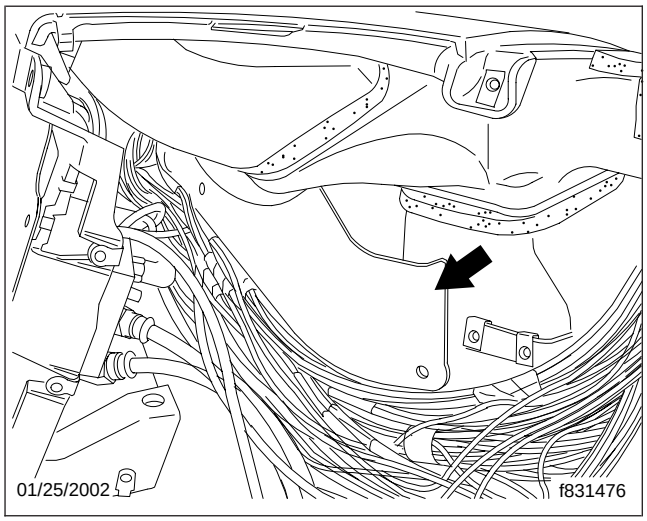
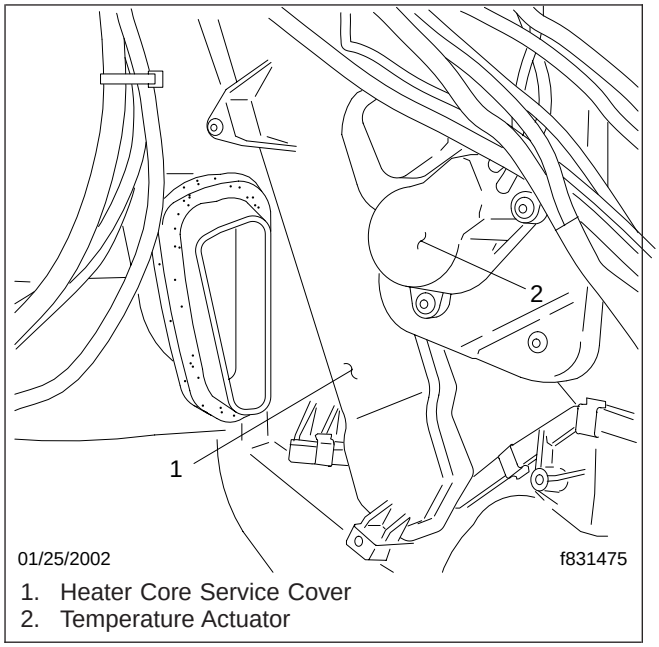
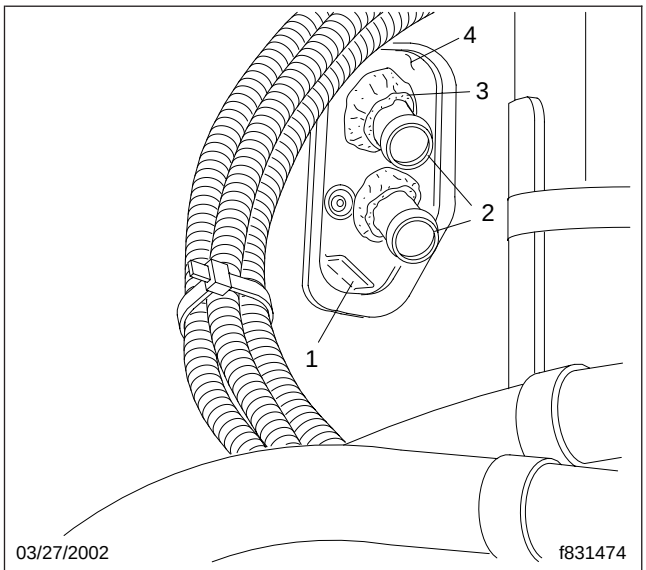


Fig. 2, Shield



1. Heater Core Service Cover
2. Temperature Actuator

Fig. 3, Heater Core Service Cover



1. Tab
2. Heater Core Tubes
3. No-Drip Tape
4. Heater Core Retaining Plate

Fig. 4, Heater Core Retaining Plate

Replacement

1. Turn off the engine, apply the parking brakes, and chock the tires.
2. Disconnect the batteries.
3. Recover the refrigerant from the air conditioning system. For instructions, see **Subject 220**.
4. Remove the dash panels listed below. See **Fig. 1**. For instructions, see **Section 60.08**.
   - electrical cover
   - upper dash cover
   - heater and air conditioner cover
   - waste bin
   - console cover
   - dash trim cap
   - upper dash assembly, center panel
5. Remove the tie straps on the wiring harness as needed to access the evaporator.
6. Disconnect the electrical connector from the evaporator temperature sensor. See **Fig. 2**.
7. Remove the capscrews that attach the evaporator service cover to the HVAC assembly.
8. Remove the air cleaner. For instructions, see **Section 09.01**.
9. Remove the expansion valve and refrigerant lines. See **Fig. 3**.

   9.1 Remove the capscrew that attaches the lower retaining plate and the refrigerant lines to the expansion valve. Remove the refrigerant lines and the retaining plate. Remove and discard the Mini Stat-O-Seals and quickly cap the lines.

   IMPORTANT: Under no circumstances should the refrigerant lines remain uncapped for longer than five minutes. Water and dirt can damage the refrigerant system. Do not blow shop air through refrigerant lines since shop air is wet (humid).

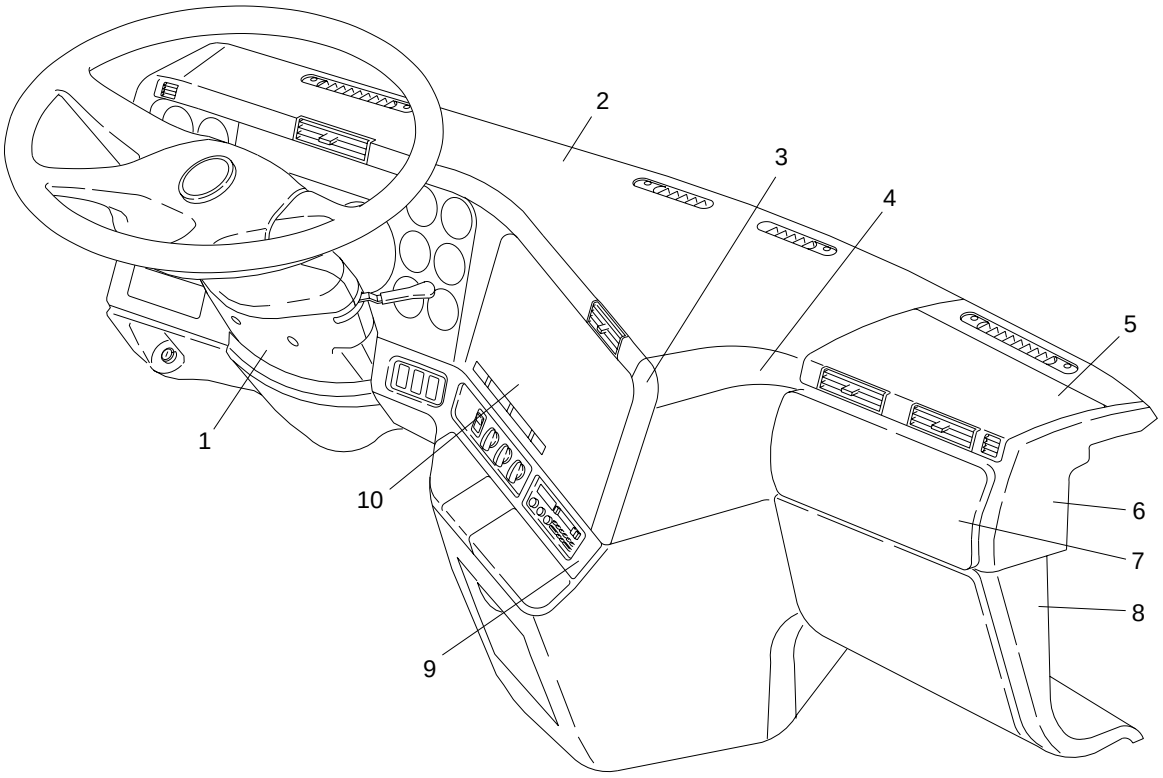
   9.2 Remove the capscrews that attach the upper retaining plate and the expansion valve to the evaporator refrigerant lines. Remove the retaining plate and the expansion valve. Remove and discard the Mini Stat-O-Seals.
10. Remove and set aside the no-drip tape from around the evaporator refrigerant lines at the plate. See **Fig. 4**.
11. Remove the capscrews that attach the plate that fits around the evaporator refrigerant lines to the frontwall. Remove the plate.
12. From inside the cab, remove the evaporator.
13. Install a new evaporator in the HVAC assembly. Press firmly on the evaporator until it makes contact with the far wall of the HVAC assembly.

NOTE: Make sure that the string seal is in the groove on the lower portion of the evaporator service cover before installing the service cover.

14. Using capscrews, install the evaporator service cover on the HVAC assembly. Make sure that the evaporator service cover is correctly seated to the HVAC assembly.
15. Connect the electrical connector to the evaporator temperature sensor.
16. If needed, use tie straps to bundle the wiring harnesses.
17. Install the dash panels listed below. For instructions, see **Section 60.08**.
    - upper dash assembly, center panel
    - dash trim cap
    - console cover
    - waste bin
    - heater and air conditioner cover
    - upper dash cover
    - electrical cover
18. Using capscrews, attach the plate that fits around the evaporator refrigerant lines to the frontwall.
19. Install the no-drip tape around the evaporator refrigerant lines at the plate.
20. Install the expansion valve and refrigerant lines.

    IMPORTANT: Do not lubricate the Mini Stat-O-Seals prior to installation.

Evaporator Replacement



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1. Steering Column Cover
2. Left-Side Upper Dash Assembly
3. Dash Trim Cap
4. Upper Dash Assembly, Center Panel
5. Electrical Cover
6. Right-Side Upper Dash Assembly
7. Upper Dash Cover
8. Heater and Air Conditioner Cover
9. Waste Bin Outer Wall
10. Console Cover
11. HVAC/Radio Trim Plate
12. Auxiliary Gauge Panel

Fig. 1, Century Class Conventional Dash Panels

20.1 Install new Mini Stat-O-Seals on the evaporator refrigerant lines.

20.2 Using capscrews and the upper retaining plate, attach the expansion valve to the evaporator refrigerant lines. Torque the capscrews 35 lbf·in (395 N·cm).

20.3 Install new Mini Stat-O-Seals on the lower refrigerant lines.

20.4 Using a capscrew and the lower retaining plate, attach the refrigerant lines to the expansion valve. Torque the capscrew 11 to 15 lbf·ft (15 to 20 N·m).

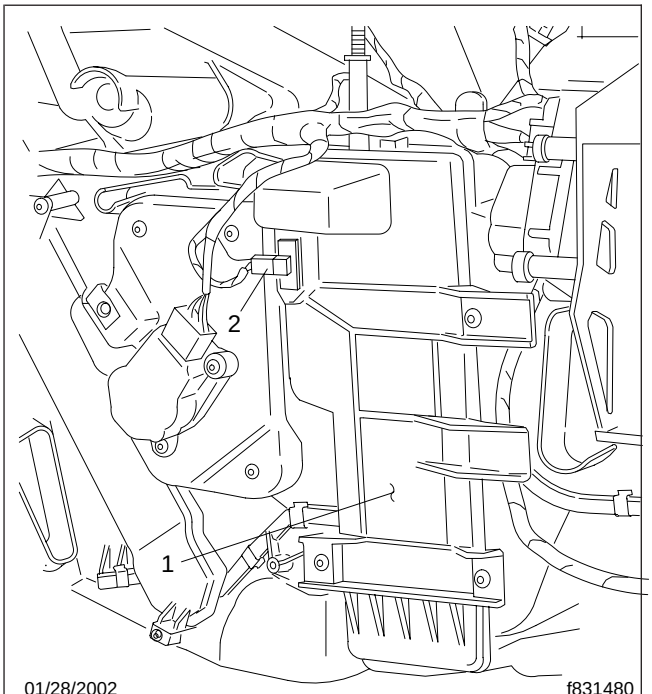
21. Install the air cleaner. For instructions, see **Section 09.01**.

22. Be sure to add refrigerant oil to the compressor to replace that which is lost when the system is recovered. For instructions, see the applicable refrigerant compressor section in **Group 83**.

23. Evacuate and charge the air conditioning system with refrigerant. For instructions, see **Subject 220**.

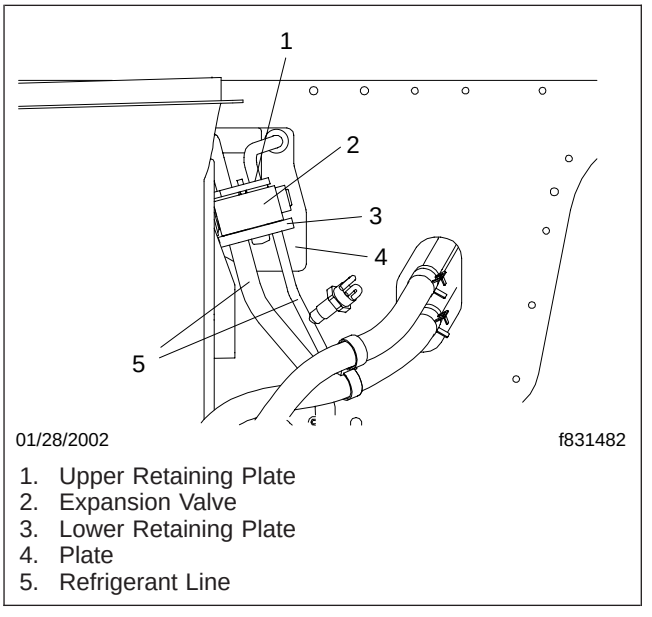
24. Connect the batteries.

25. Remove the chocks from the tires.



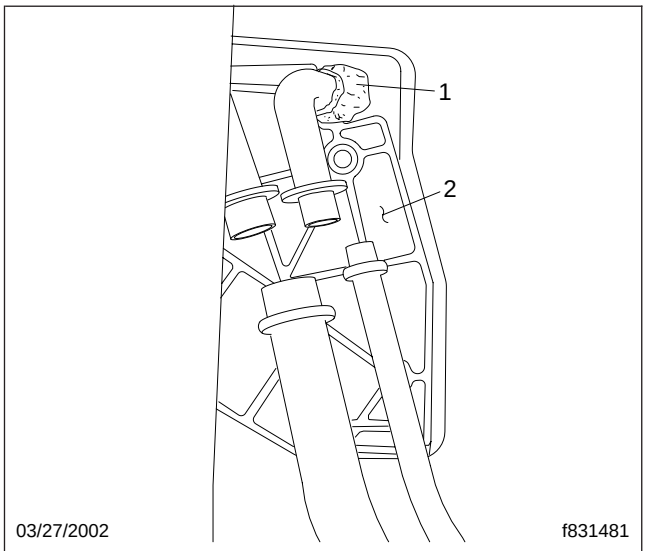
1. Evaporator Service Cover
2. Evaporator Temperature Sensor

Fig. 2, Evaporator Service Cover



1. Upper Retaining Plate
2. Expansion Valve
3. Lower Retaining Plate
4. Plate
5. Refrigerant Line

Fig. 3, Expansion Valve



1. No-Drip Tape
2. Plate

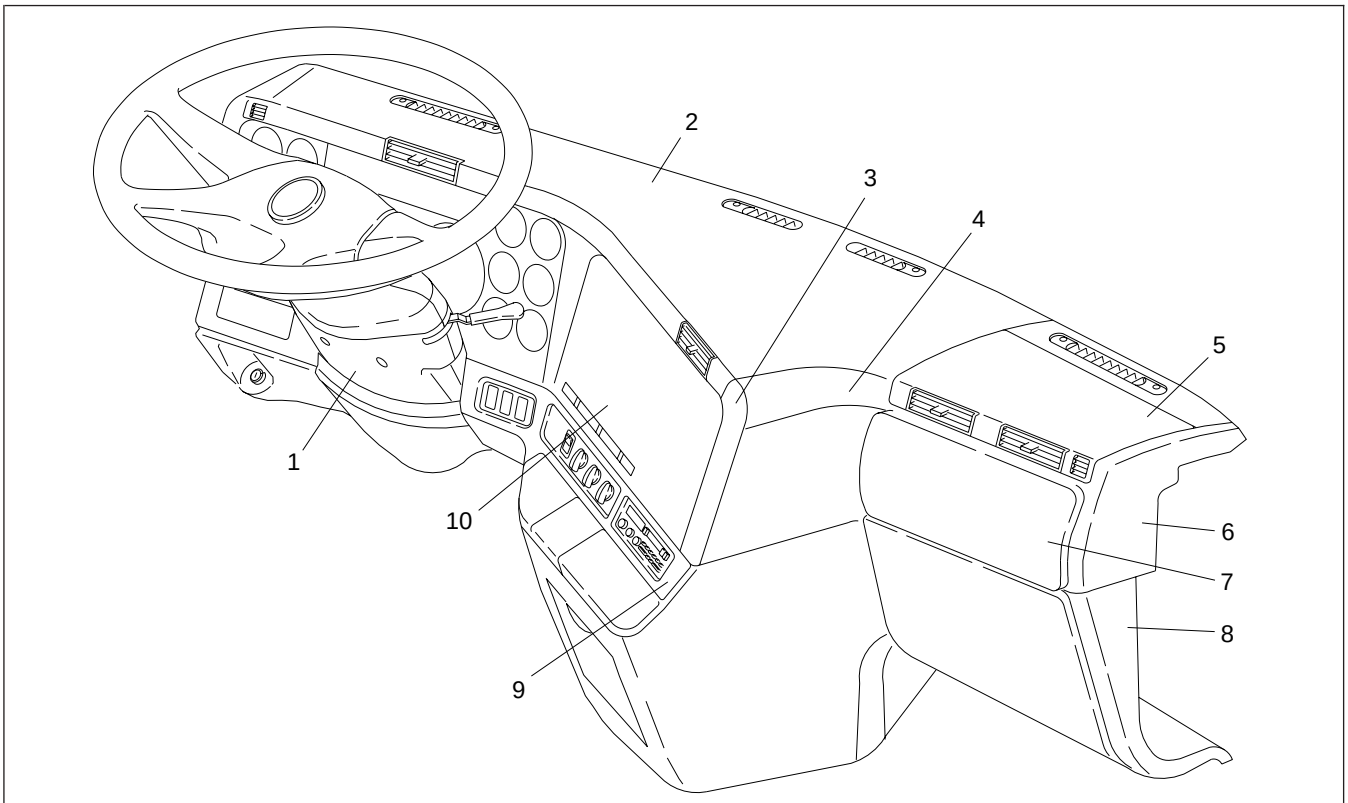
Fig. 4, Plate

Evaporator Temperature Sensor Replacement

Replacement

1. Turn off the engine, apply the parking brakes, and chock the tires.
2. Remove the upper dash cover and the heater and air conditioner cover. See **Fig. 1**. For instructions, see **Section 60.08**.
3. Pull the evaporator temperature sensor out of the evaporator. See **Fig. 2**.
4. Disconnect the electrical connector from the temperature sensor.
5. Connect the electrical connector to the new temperature sensor.
6. Install the evaporator temperature sensor in the evaporator.
7. Install the upper dash cover and the heater and air conditioner cover. For instructions, see **Section 60.08**.
8. Remove the chocks from the tires.

Evaporator Temperature Sensor Replacement



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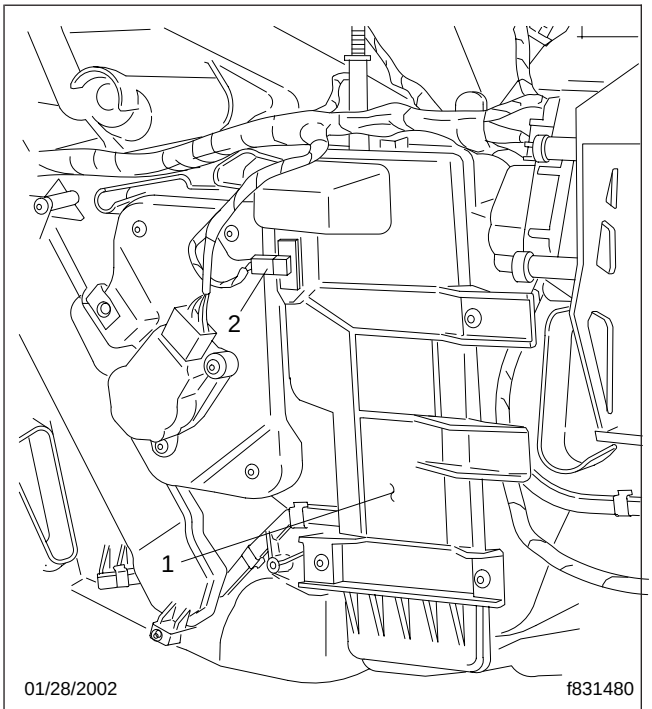
1. Steering Column Cover
2. Left-Side Upper Dash Assembly
3. Dash Trim Cap
4. Upper Dash Assembly, Center Panel
5. Electrical Cover
6. Right-Side Upper Dash Assembly
7. Upper Dash Cover
8. Heater and Air Conditioner Cover
9. Waste Bin Outer Wall
10. Console Cover
11. HVAC/Radio Trim Plate
12. Auxiliary Gauge Panel

Fig. 1, Century Class Conventional Dash Panels

Evaporator Temperature Sensor Replacement

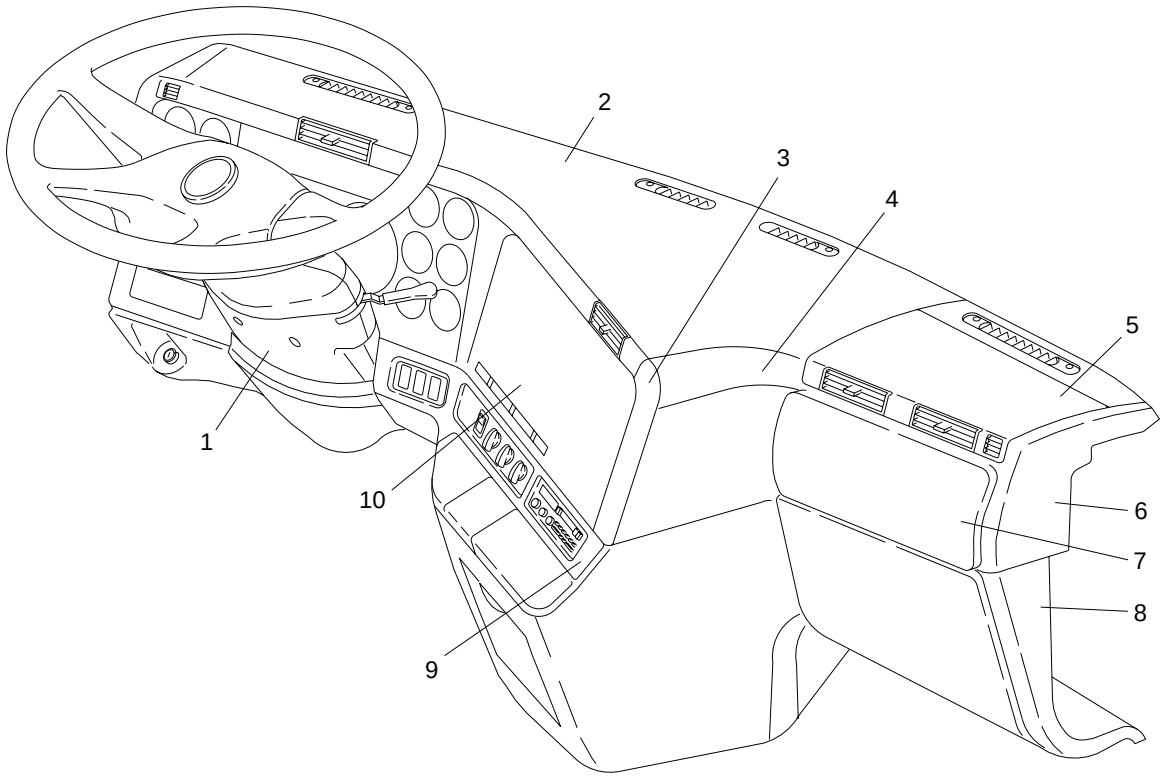


1. Evaporator Service Cover
2. Evaporator Temperature Sensor

Fig. 2, Evaporator Temperature Sensor

Replacement

1. Turn off the engine, apply the parking brakes, and chock the tires.
2. Disconnect the batteries.
3. Remove the upper dash cover and the heater and air conditioner cover. See **Fig. 1**. For instructions, see **Section 60.08**.
6. Disconnect the electrical connector from the blower motor and remove the blower motor.
7. Connect the electrical connector to the new blower motor.
8. Using capscrews, install the blower motor on the HVAC assembly.
9. Using capscrews, attach the lower duct to the HVAC assembly.
10. Install the heater and air conditioner cover and the upper dash cover. For instructions, see **Section 60.08**.



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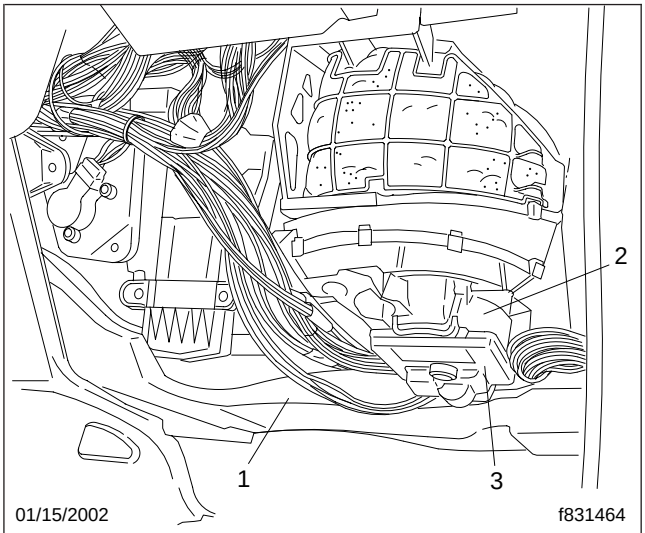
1. Steering Column Cover
2. Left-Side Upper Dash Assembly
3. Dash Trim Cap
4. Upper Dash Assembly, Center Panel
5. Electrical Cover
6. Right-Side Upper Dash Assembly
7. Upper Dash Cover
8. Heater and Air Conditioner Cover
9. Waste Bin Outer Wall
10. Console Cover
11. HVAC/Radio Trim Plate
12. Auxiliary Gauge Panel

Fig. 1, Century Class Conventional Dash Panels

4. Remove the capscrews that attach the lower duct to the HVAC assembly and remove the lower duct. See **Fig. 2**.
5. Remove the capscrews that attach the blower motor to the HVAC assembly.

Blower Motor Replacement



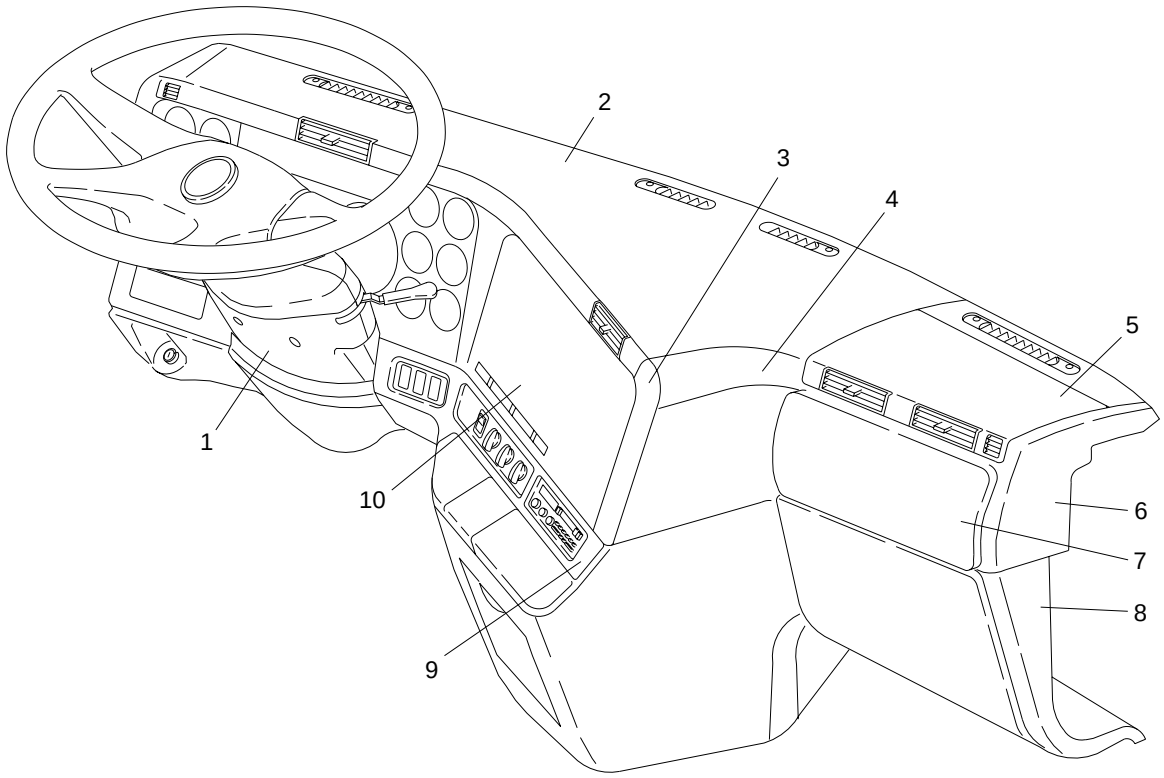
1. Lower Duct
2. Blower Motor
3. Blower Motor Wiring Harness

Fig. 2, Blower Motor

11. Connect the batteries.
12. Remove the chocks from the tires.

Temperature Actuator Replacement

1. Turn off the engine, apply the parking brakes, and chock the tires.
2. Remove the upper dash cover and the heater and air conditioner cover. See **Fig. 1**. For instructions, see **Section 60.08**.
3. Remove the capscrews that attach the temperature actuator to the HVAC assembly. See **Fig. 2**.
4. Disconnect the electrical connector from the actuator and remove the actuator.
5. Connect the electrical connector to the new actuator.
6. Align the actuator to the keyed shaft on the door.
7. Using capscrews, attach the actuator to the HVAC assembly.
8. Install the heater and air conditioner cover and the upper dash cover. For instructions, see **Section 60.08**.
9. Manually calibrate the HVAC system after the actuator has been replaced.



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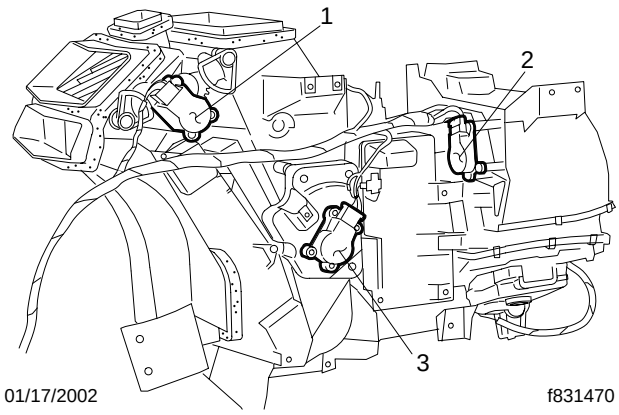
1. Steering Column Cover
2. Left-Side Upper Dash Assembly
3. Dash Trim Cap
4. Upper Dash Assembly, Center Panel
5. Electrical Cover
6. Right-Side Upper Dash Assembly
7. Upper Dash Cover
8. Heater and Air Conditioner Cover
9. Waste Bin Outer Wall
10. Console Cover
11. HVAC/Radio Trim Plate
12. Auxiliary Gauge Panel

Fig. 1, Century Class Conventional Dash Panels

Actuator Replacement



1. Mode Actuator
2. Recirculation Actuator
3. Temperature Actuator

Fig. 2, Actuators

9.1 Turn the ignition key to the on position, but keep the engine off.

9.2 Turn the fan switch to the off position.

9.3 Turn the air selection switch to the full defrost mode.

9.4 Turn the temperature control switch to the full hot position.

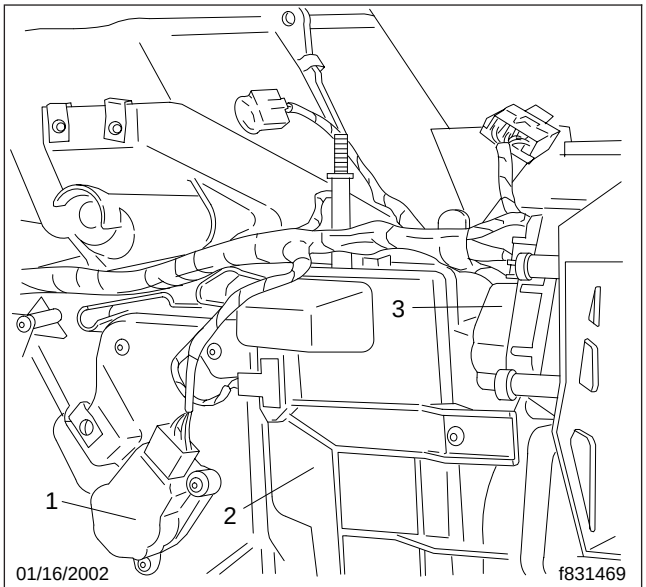
9.5 Press and hold the recirculation and air conditioning buttons for five seconds.

9.6 The recirculation and air conditioning indicators will blink, the fan will turn on the highest fan speed, the air selection switch will cycle through the modes, and the recirculation door will open and close. The entire cycle takes about 20 to 30 seconds.

10. Remove the chocks from the tires.

Recirculation Actuator Replacement

1. Turn off the engine, apply the parking brakes, and chock the tires.
2. Remove the dash panels listed below. See **Fig. 1**. For instructions, see **Section 60.08**.
   - electrical cover
   - upper dash cover
   - heater and air conditioner cover
   - waste bin
   - console cover
   - dash trim cap
   - upper dash assembly, center panel
3. Remove the tie straps on the wiring harnesses as needed to access the capscrews on the recirculation actuator. It may also be necessary to remove the evaporator service cover to access the actuator mounting hardware. See **Fig. 3**.



1. Temperature Actuator
2. Evaporator Service Cover
3. Recirculation Actuator

Fig. 3, Recirculation Actuator

NOTE: If the evaporator service cover is removed, make sure that the string seal is in the groove on the lower portion of the evaporator service cover before installing the service cover.

4. Remove the capscrews that attach the recirculation actuator to the HVAC assembly.
5. Remove the arm from the back of the actuator. Disconnect the electrical connector from the actuator and remove the actuator.
6. Connect the electrical connector to the new actuator.

7. Attach the arm to the back of the actuator and align the actuator to the keyed shaft on the door.
8. Using capscrews, attach the actuator to the HVAC assembly.
9. If needed, use tie straps to bundle the wiring harnesses.
10. Install the dash panels listed below. For instructions, see **Section 60.08**.
    - upper dash assembly, center panel
    - dash trim cap
    - console cover
    - waste bin
    - heater and air conditioner cover
    - upper dash cover
    - electrical cover
11. Manually calibrate the HVAC system after the actuator has been replaced.
    - 11.1 Turn the ignition key to the on position, but keep the engine off.
    - 11.2 Turn the fan switch to the off position.
    - 11.3 Turn the air selection switch to the full defrost mode.
    - 11.4 Turn the temperature control switch to the full hot position.
    - 11.5 Press and hold the recirculation and air conditioning buttons for five seconds.
    - 11.6 The recirculation and air conditioning indicators will blink, the fan will turn on the highest fan speed, the air selection switch will cycle through the modes, and the recirculation door will open and close. The entire cycle takes about 20 to 30 seconds.
12. Remove the chocks from the tires.

Mode Actuator Replacement

1. Turn off the engine, apply the parking brakes, and chock the tires.
2. Remove the dash panels listed below. See **Fig. 1**. For instructions, see **Section 60.08**.
    - electrical cover
    - upper dash cover
    - heater and air conditioner cover
    - waste bin
    - console cover
    - dash trim cap
    - upper dash assembly, center panel
3. If needed, remove the capscrew that attaches the shield to the HVAC assembly and move the shield to access the mode actuator. See **Fig. 4**.

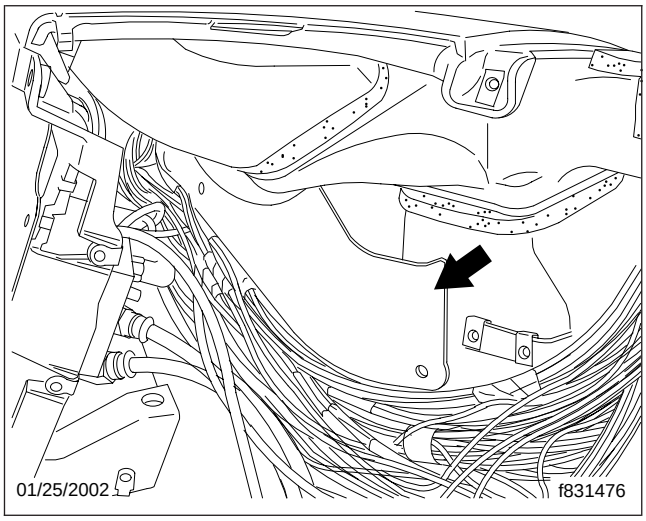


Fig. 4, Shield

4. Remove the capscrews that attach the mode actuator to the HVAC assembly. See **Fig. 2**.
5. Disconnect the electrical connector from the actuator and remove the actuator.
6. Connect the electrical connector to the new mode actuator.
7. Align the actuator to the keyed shaft on the door.
8. Using capscrews, attach the mode actuator to the HVAC assembly.
9. If the shield was moved, move the shield back in place and use a capscrew to attach the shield to the HVAC assembly.
10. Install the dash panels listed below. For instructions, see **Section 60.08**.
    - upper dash assembly, center panel
    - dash trim cap

Actuator Replacement

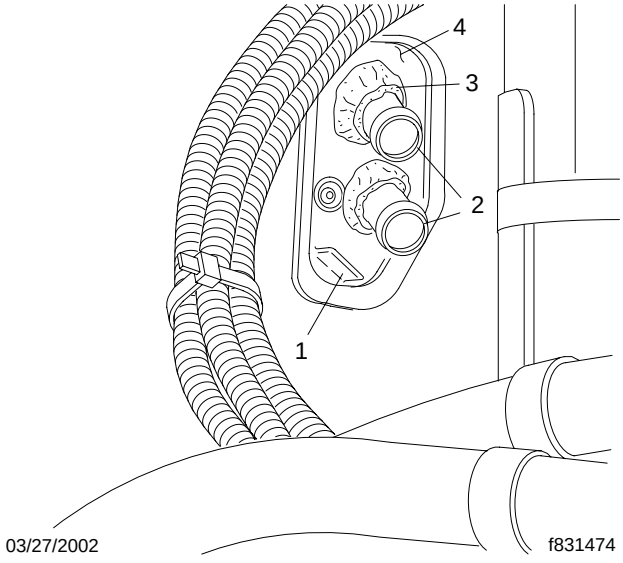
- console cover
- waste bin
- heater and air conditioner cover
- upper dash cover
- electrical cover

11. Manually calibrate the HVAC system after the actuator has been replaced.
    - 11.1 Turn the ignition key to the on position, but keep the engine off.
    - 11.2 Turn the fan switch to the off position.
    - 11.3 Turn the air selection switch to the full defrost mode.
    - 11.4 Turn the temperature control switch to the full hot position.
    - 11.5 Press and hold the recirculation and air conditioning buttons for five seconds.
    - 11.6 The recirculation and air conditioning indicators will blink, the fan will turn on the highest fan speed, the air selection switch will cycle through the modes, and the recirculation door will open and close. The entire cycle takes about 20 to 30 seconds.
12. Remove the chocks from the tires.

Heater and Air Conditioner Assembly Replacement

Replacement

1. Turn off the engine, apply the parking brakes, and chock the tires.
2. Disconnect the batteries.
3. Remove the air cleaner. For instructions, see **Section 09.01**.
4. Drain the coolant from the cooling system. For instructions, see **Section 20.01**, Subject 100.
5. Recover the refrigerant from the air conditioning system. For instructions, see **Subject 220**.
6. Remove the hose clamps that attach the heater hoses to the heater core tubes. Disconnect the heater hoses. See **Fig. 1**.
7. Remove the capscrew that attaches the heater core retaining plate to the frontwall. Pull on the tab to remove the retaining plate. See **Fig. 1**.



1. Tab
2. Heater Core Tubes
3. No-Drip Tape
4. Heater Core Retaining Plate

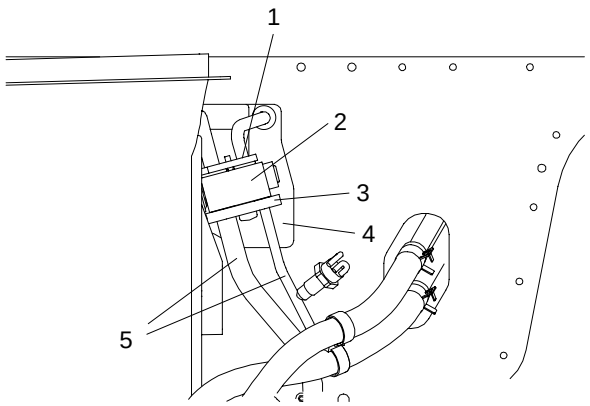
Fig. 1, Heater Core Tubes

8. Remove the expansion valve and refrigerant lines.

   8.1 Remove the capscrew that attaches the lower retaining plate and the refrigerant lines to the expansion valve. Remove the refrigerant lines and retaining plate. Remove and discard the Mini Stat-O-Seals and quickly cap the lines. See **Fig. 2**.

   IMPORTANT: Under no circumstances should the refrigerant lines remain uncapped for longer than five minutes. Water and dirt can damage the refrigerant system. Do not blow shop air through refrigerant lines since shop air is wet (humid).

   8.2 Remove the capscrews that attach the upper retaining plate and the expansion valve to the evaporator refrigerant lines. Remove the retaining plate and the expansion valve. Remove and discard the Mini Stat-O-Seals.



1. Upper Retaining Plate
2. Expansion Valve
3. Lower Retaining Plate
4. Plate
5. Refrigerant Line

Fig. 2, Expansion Valve

9. Remove the capscrews that attach the plate that fits around the evaporator refrigerant lines to the frontwall. Remove the plate. See **Fig. 3**.
10. Remove the dash panels listed below. See **Fig. 4**. For instructions, see **Section 60.08**.
    - electrical cover
    - upper dash cover
    - heater and air conditioner cover
    - waste bin

Heater and Air Conditioner Assembly Replacement

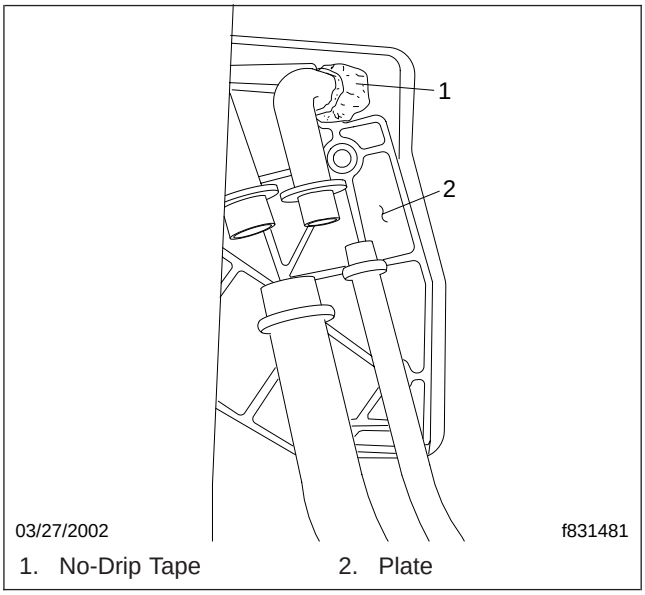


Fig. 3, Plate

- console cover
- dash trim cap
- upper dash assembly, center panel
- left-side upper dash assembly

11. Remove the capscrew on the wiring harness channel that attaches the channel to the temperature control cover. Remove the plastic fastener that attaches the channel to the HVAC assembly.
12. Remove the capscrews that attach the ducts to the HVAC assembly and remove the ducts.
13. Remove the nuts that attach the power distribution module (PDM) to the HVAC assembly.
14. Disconnect the wiring harnesses from the PDM as necessary.
15. Disconnect the power and communication wiring harnesses from the HVAC wiring harness.
16. From the engine side of the frontwall, remove the nut that attaches the HVAC assembly to the frontwall.
17. Remove the hose clamp that attaches the drain hose to the drain tube and remove the drain hose.
18. From inside the cab, remove the capscrews, nuts, and washers that attach the HVAC assembly to the frontwall and remove the assembly.
19. Using a nut, attach a new HVAC assembly to the engine side of the frontwall. Torque the nut 9 to 11 lbf·ft (12 to 15 N·m).
20. From inside the cab, use capscrews, nuts, and washers to attach the HVAC assembly to the frontwall. Torque the nuts and capscrews 9 to 11 lbf·ft (12 to 15 N·m).
21. Using capscrews, attach the plate that fits around the evaporator refrigerant lines to the frontwall.
22. Install the expansion valve and the refrigerant lines.

    IMPORTANT: Do not lubricate the Mini Stat-O-Seals prior to installation.

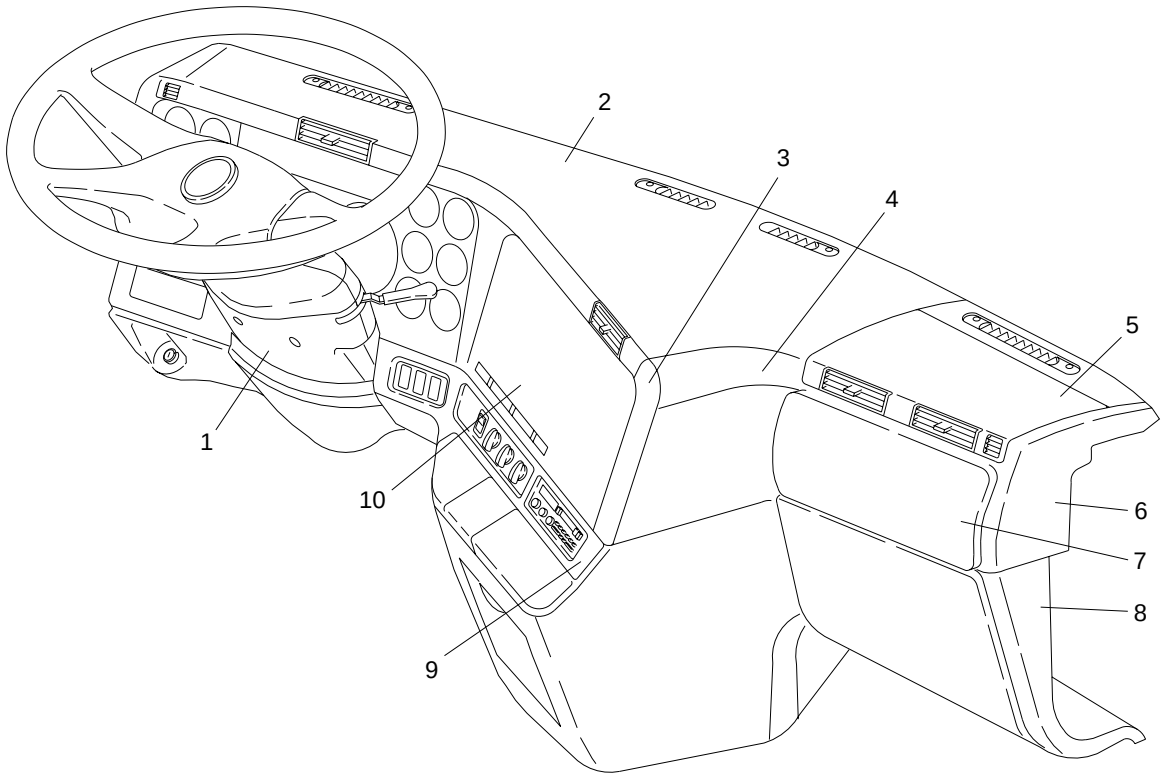
    22.1 Install new Mini Stat-O-Seals on the evaporator refrigerant lines.

    22.2 Using capscrews and the upper retaining plate, attach the expansion valve to the evaporator refrigerant lines. Torque the capscrews 35 lbf·in (395 N·cm).

    22.3 Install new Mini Stat-O-Seals on the lower refrigerant lines.

    22.4 Using a capscrew and the lower retaining plate, attach the refrigerant lines to the expansion valve. Torque the capscrew 11 to 15 lbf·ft (15 to 20 N·m).
23. Using a capscrew, attach the heater core retaining plate to the frontwall.
24. Using hose clamps, attach the heater hoses to the heater core tubes.
25. Using a hose clamp, attach the drain hose to the drain tube.
26. Install the air cleaner. For instructions, see **Section 09.01**, Subject 110.
27. Connect the wiring harnesses to the PDM as necessary.
28. Using nuts, attach the PDM to the HVAC assembly.
29. Using capscrews, attach the ducts to the HVAC assembly.

Heater and Air Conditioner Assembly Replacement



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1. Steering Column Cover
2. Left-Side Upper Dash Assembly
3. Dash Trim Cap
4. Upper Dash Assembly, Center Panel
5. Electrical Cover
6. Right-Side Upper Dash Assembly
7. Upper Dash Cover
8. Heater and Air Conditioner Cover
9. Waste Bin Outer Wall
10. Console Cover
11. HVAC/Radio Trim Plate
12. Auxiliary Gauge Panel

Fig. 4, Century Class Conventional Dash Panels

30. Move the wiring harness channel back in place, and use a capscrew to attach the channel to the temperature control cover. Using a plastic fastener, attach the channel to the HVAC assembly.
31. Connect the HVAC wiring harness to the power and communication wiring harnesses. If needed, use tie straps to bundle the wiring harnesses.
32. Install the dash panels listed below. For instructions, see **Section 60.08**.
    - left-side upper dash assembly
    - upper dash assembly, center panel
    - dash trim cap
    - console cover
    - waste bin
    - heater and air conditioner cover
    - upper dash cover
    - electrical cover
33. Fill the cooling system with coolant. For instructions, see **Section 20.01**, Subject 100.
34. Be sure to add refrigerant oil to the compressor to replace the oil that is lost when the system is recovered. For instructions, see the applicable refrigerant compressor section in **Group 83**.
35. Evacuate and charge the air conditioning system with refrigerant. For instructions, see **Subject 220**.

Heater and Air Conditioner Assembly Replacement

36. Connect the batteries.
37. Calibrate the HVAC system after the HVAC assembly has been removed or replaced.
    - 37.1 Turn the ignition key to the on position, but keep the engine off.
    - 37.2 Turn the fan switch to the off position.
    - 37.3 Turn the air selection switch to the face mode.
    - 37.4 Turn the temperature control switch to the full hot position.
    - 37.5 Press and hold the recirculation button and the air conditioning button for five seconds.
    - 37.6 The recirculation and air conditioning indicators will blink, the fan will turn on the highest fan speed, the air selection switch will cycle through the modes, and the recirculation door will open and close. The entire cycle takes about 20 to 30 seconds.
38. Remove the chocks from the tires.

Expansion Valve Replacement

Replacement

1. Turn off the engine, apply the parking brakes, and chock the tires.
2. Disconnect the batteries.
3. Recover the refrigerant from the air conditioning system. For instructions, see **Subject 220**.
4. Remove the air cleaner. For instructions, see **Section 09.01**.
5. Remove the expansion valve and refrigerant lines.

   5.1 Remove the capscrew that attaches the lower retaining plate and the refrigerant lines to the expansion valve. Remove the refrigerant lines and the retaining plate. Remove and discard the Mini Stat-O-Seals and quickly cap the lines. See **Fig. 1**.

   IMPORTANT: Under no circumstances should the refrigerant lines remain uncapped for longer than five minutes. Water and dirt can damage the refrigerant system. Do not blow shop air through refrigerant lines since shop air is wet (humid).

   5.2 Remove the capscrews that attach the upper retaining plate and the expansion valve to the evaporator refrigerant lines. Remove the retaining plate and the expansion valve. Remove and discard the Mini Stat-O-Seals.

6. Install the expansion valve and refrigerant lines.

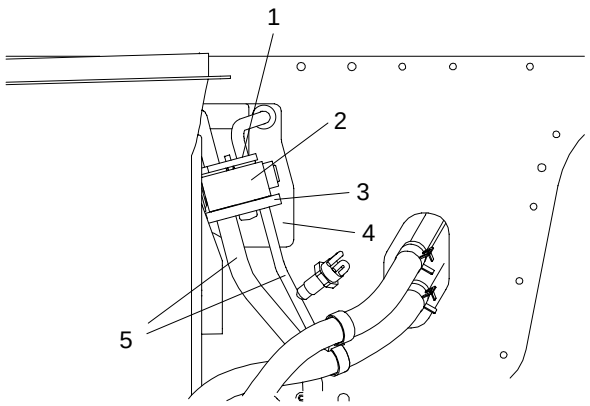
   IMPORTANT: Do not lubricate the Mini Stat-O-Seals prior to installation.

   6.1 Install new Mini Stat-O-Seals on the evaporator refrigerant lines.

   6.2 Using capscrews and the upper retaining plate, attach the new expansion valve to the evaporator refrigerant lines. Torque the capscrews 35 lbf·in (395 N·cm).

   6.3 Install new Mini Stat-O-Seals on the lower refrigerant lines.

   6.4 Using a capscrew and the lower retaining plate, attach the refrigerant lines to the expansion valve. Torque the capscrew 11 to 15 lbf·ft (15 to 20 N·m).



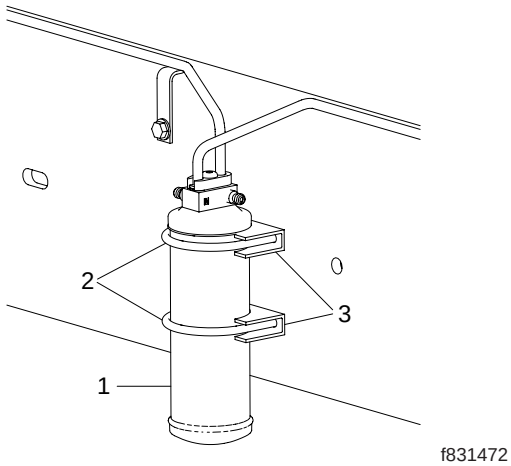
1. Upper Retaining Plate
2. Expansion Valve
3. Lower Retaining Plate
4. Plate
5. Refrigerant Line

Fig. 1, Expansion Valve

7. Install the air cleaner. For instructions, see **Section 09.01**.
8. Be sure to add refrigerant oil to the compressor to replace that which is lost when the system is recovered. For instructions, see the applicable refrigerant compressor section in **Group 83**.
9. Evacuate and charge the air conditioning system with refrigerant. For instructions, see **Subject 220**.
10. Connect the batteries.
11. Remove the chocks from the tires.

Replacement

1. Turn off the engine, apply the parking brakes, and chock the tires.
2. Open the hood.
3. Recover the refrigerant from the air conditioning system. For instructions, see **Subject 220**.
4. Remove the capscrew that attaches the retaining plate and refrigerant lines to the receiver-drier. Disconnect the refrigerant lines from the receiver-drier and remove and discard the Mini Stat-O-Seals. Quickly cap the refrigerant lines. See **Fig. 1**.



1. Receiver-Drier
2. U-Bolt
3. Mounting Bracket

Fig. 1, Receiver-Drier

IMPORTANT: Under no circumstances should the refrigerant lines remain uncapped for longer than five minutes. Water and dirt can damage the refrigerant system. Do not blow shop air through refrigerant lines since shop air is wet (humid).

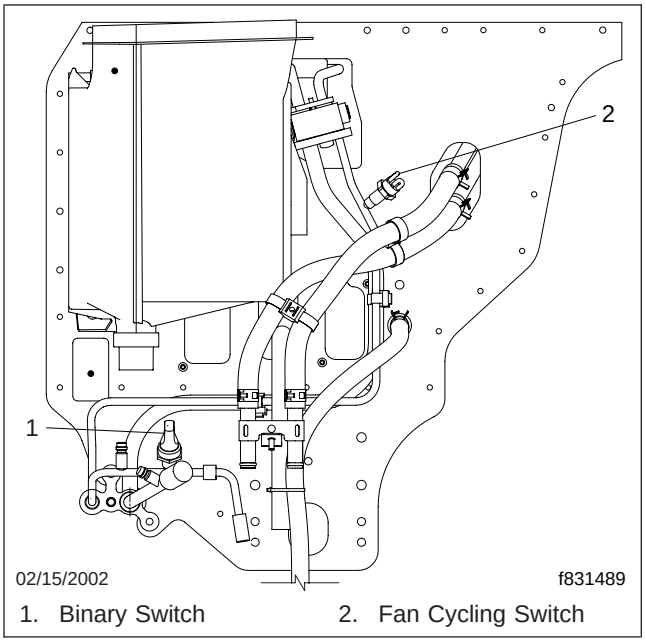
5. Remove the nuts and washers that attach the U-bolts and mounting brackets to the frame rail. Remove the receiver-drier. See **Fig. 1**.

IMPORTANT: If the desiccant cartridge inside the receiver-drier has fallen apart, flush the system and replace the expansion valve and the refrigerant compressor (desiccant matter can't be removed from these parts). A cartridge may fall apart from too much moisture in the system, because of poor evacuation of the system, or lack of maintenance.

6. Using U-bolts, mounting brackets, nuts, and washers, install a new receiver-drier on the frame rail.
7. Uncap the refrigerant lines.
8. Install new Mini Stat-O-Seals on the refrigerant lines. Do not lubricate Mini Stat-O-Seals prior to installation.
9. Using a capscrew, attach the refrigerant lines and retaining plate to the receiver-drier. Torque the capscrew 11 to 15 lbf·ft (15 to 20 N·m).
10. Be sure to add refrigerant oil to the compressor to replace that which is lost when the system is recovered. For instructions, see the applicable refrigerant compressor section in **Group 83**.
11. Evacuate and charge the air conditioning system with refrigerant. For instructions, see **Subject 220**.
12. Return the hood to the operating position.
13. Remove the chocks from the tires.

Replacement

1. Turn off the engine, apply the parking brakes, and chock the tires.
2. Open the hood.
3. Disconnect the electrical connector from the binary switch near the junction block. See **Fig. 1**.



1. Binary Switch 2. Fan Cycling Switch

Fig. 1, Engine Side of Frontwall

4. Remove the binary switch and the O-ring.
5. Lubricate a new O-ring with mineral oil before installing it on the new binary switch.
6. Install the binary switch and tighten 60 to 72 lbf·in (678 to 813 N·cm).
7. Connect the electrical connector to the binary switch.
8. Return the hood to the operating position.
9. Remove the chocks from the tires.

Condenser Removal and Installation

Removal

1. Turn off the engine, apply the parking brakes, and chock the tires.
2. Open the hood.
3. Recover the refrigerant from the air conditioning system. For instructions, see **Subject 220**.
4. Disconnect the refrigerant lines from the condenser and remove and discard the Mini Stat-O-Seals. Quickly cap the condenser inlet and outlet ports if the condenser will be reinstalled and plug the fittings.

IMPORTANT: Under no circumstances should the ports remain uncapped or the fittings remain unplugged for longer than five minutes total. Water and dirt can damage the refrigerant system. Do not blow shop air through refrigerant lines since shop air is wet (humid).

5. Remove the fasteners that attach the condenser to the radiator and remove the condenser.

Installation

1. Place the condenser on the radiator. Install and tighten the fasteners 108 lbf·in (1220 N·cm).
2. Uncap the inlet and outlet ports on the condenser. Unplug the fittings
3. Using only Mini Stat-O-Seals, replace the Mini Stat-O-Seals on the refrigerant lines. Do not lubricate Mini Stat-O-Seals prior to installation.
4. Connect the refrigerant lines to the condenser. Torque the capscrew on the retaining plate 11 to 15 lbf·ft (15 to 20 N·m).
5. Add refrigerant oil to the compressor to replace that which is lost in the old condenser. For instructions, see the applicable refrigerant compressor section in **Group 83**.
6. Evacuate and charge the air conditioning system with refrigerant. For instructions, refer to **Subject 220**.
7. Return the hood to the operating position.
8. Remove the chocks from the tires.

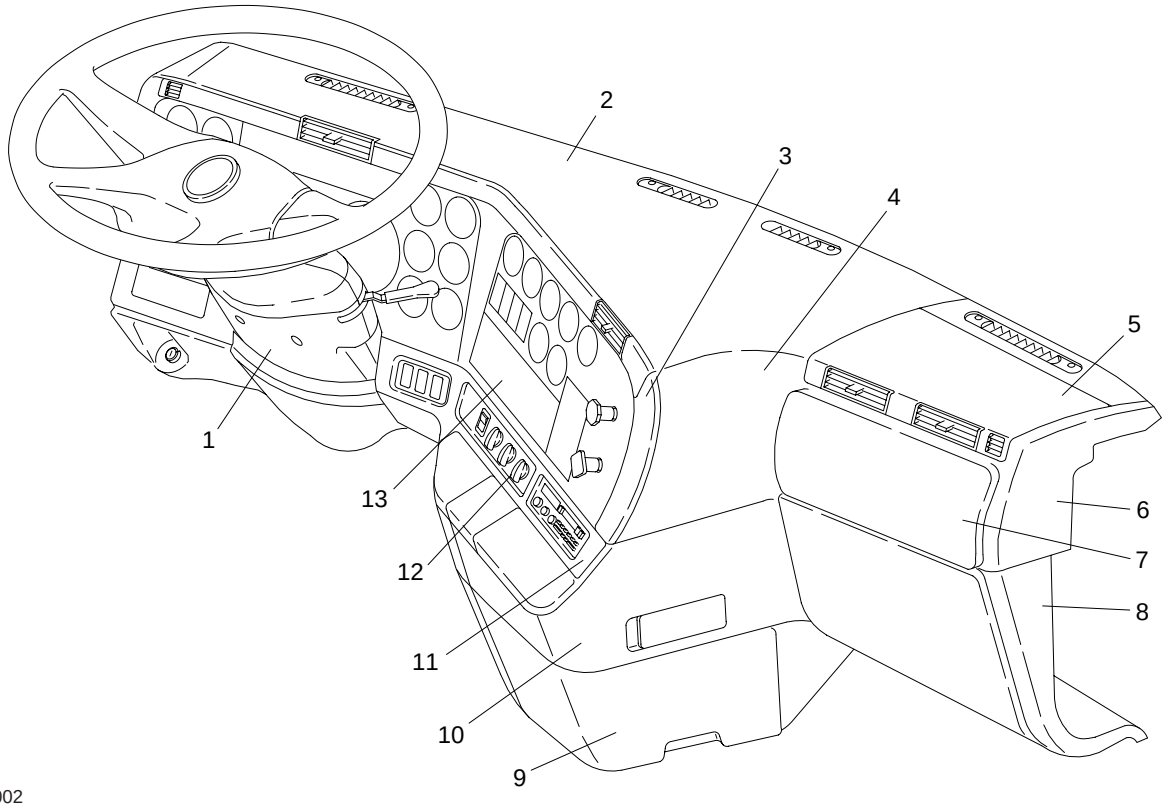
Climate Control Panel (Front Control Unit) Replacement

Replacement

1. Turn off the engine, apply the parking brakes, and chock the tires.
2. Remove the dash trim cap and the HVAC/radio trim plate. See **Fig. 1**. For instructions, see **Section 60.08**.
3. Remove the trailer air supply and the parking brake knobs from the auxiliary gauge panel. See **Fig. 1**.
4. Remove the capscrews that attach the auxiliary gauge panel to the console and move the gauge panel to access the capscrews that attach the climate control panel to the console. See **Fig. 1**.

NOTE: The climate control panel is also referred to as the front control unit (FCU).

5. Remove the capscrews that attach the control panel to the console.
6. Disconnect the electrical connectors from the control panel and remove the control panel.
7. Connect the electrical connectors to the new control panel.



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1. Steering Column Cover
2. Left-Side Upper Dash Assembly
3. Dash Trim Cap
4. Upper Dash Assembly, Center Panel
5. Electrical Cover
6. Right-Side Upper Dash Assembly
7. Upper Dash Cover
8. Heater and Air Conditioner Cover
9. Waste Bin Outer Wall
10. Console Cover
11. HVAC/Radio Trim Plate
12. Climate Control Panel
13. Auxiliary Gauge Panel

Fig. 1, Century Class Conventional Dash Panels

Climate Control Panel (Front Control Unit) Replacement

8. Using capscrews, attach the control panel to the console.
9. Using capscrews, attach the auxiliary gauge panel to the console.
10. Install the trailer air supply and parking brake knobs to the auxiliary gauge panel.
11. Install the HVAC/radio trim plate and the dash trim cap. For instructions, see **Section 60.08**.
12. Manually calibrate the HVAC system after the climate control panel has been removed or replaced.
    - 12.1 Turn the ignition key to the on position, but keep the engine off.
    - 12.2 Turn the fan switch to the off position.
    - 12.3 Turn the air selection switch to the full defrost mode.
    - 12.4 Turn the temperature control switch to the full hot position.
    - 12.5 Press and hold the recirculation and air conditioning buttons for five seconds.
    - 12.6 The recirculation and air conditioning indicators will blink, the fan will turn on the highest fan speed, the air selection switch will cycle through the modes, and the recirculation door will open and close. The entire cycle takes about 20 to 30 seconds.
13. Remove the chocks from the tires.

Identification, Recovery, Evacuating, Purging and Flushing, Charging, and Leak Testing

Required Equipment

You will need a machine, or machines, to identify the refrigerant and to recover, evacuate, flush, and charge the refrigerant system. Ideally, one machine can perform all the following functions:

- Identification–The machine must be able to verify the purity of the refrigerant in the refrigerant system and the presence of hydrocarbon-based refrigerants or other unapproved refrigerants.
- Recovery–The machine must be able to fully recover the refrigerant from the refrigerant system.
- Evacuation–Ideally, the machine should have a vacuum pump rated at 6 cfm and be maintenance free. A machine that requires maintenance is acceptable as long as it is properly maintained.
- Charging–The scale used in charging should be accurate to within ±1 ounce (30 mL).
- Flushing–Adaptors for the compressor(s), expansion device(s), and receiver-drier should be purchased or fabricated to flush the system with refrigerant.

Refrigerant Identification

WARNING

Before doing any of the work below, read the information in Safety Precautions 100. Failure to read and understand the safety precautions, and to take necessary precautions against the dangers involved when working with refrigerant could lead to serious personal injury.

IMPORTANT: Identify the refrigerant in the refrigerant system if you suspect one of the following conditions:

- an excess noncondensable gas, such as nitrogen or air, is in the system
- an unapproved refrigerant is in the system
- the history of refrigerant system repairs is unknown

1. Using a high-quality refrigerant identifier and the manufacturer's instructions, attach the identifier to the vehicle and perform the test.
2. If the vehicle passed the test, it is safe to recover the refrigerant.
3. If the vehicle failed the test due to an excessive amount of noncondensable gas, recover the refrigerant system, then purge the recovery tank of the noncondensable gas.
4. If the vehicle failed the test due to the presence of a hydrocarbon-based refrigerant or a refrigerant other than R-134a, **do not recover the refrigerant into the general-use machine.** To recover the refrigerant system, recover the refrigerant into a separate container that contains refrigerant that must be recycled by a qualified recycling center. It is best to refer the customer to the place where the vehicle was last serviced.

Recovery

WARNING

Before doing any of the work below, read the information in Safety Precautions 100. Failure to read and understand the safety precautions, and to take necessary precautions against the dangers involved when working with refrigerant could lead to serious personal injury.

The recovery process removes most of the refrigerant charge in the system.

1. Turn off the engine, apply the parking brakes, chock the tires, and open the hood.
2. Remove the caps from the suction and discharge service valves.
3. If the history of refrigerant system repairs is unknown, or if you suspect that the system is charged with an unapproved refrigerant, identify the refrigerant using the "Refrigerant Identification" procedures.
4. Wearing protective goggles and nonleather gloves, attach the refrigerant recovery and charging machine hoses to the valves.

IMPORTANT: Push down firmly on the hose connectors until a clicking sound is heard. This will ensure that the coupler is locked.

Identification, Recovery, Evacuating, Purging and Flushing, Charging, and Leak Testing

5. Follow the refrigerant recovery and charging machine manufacturer's instructions and recover all of the refrigerant from the refrigerant system.

IMPORTANT: Always comply with all federal and local regulations regarding refrigerant recovery and disposal. You may be subject to substantial penalties for improper procedures.

6. Measure the oil recovered during the recovery process. The refrigerant system will have to be filled with the same quantity of new refrigerant oil. If the system is contaminated with moisture, all of the compressor oil must be replaced with clean oil. If the system is heavily contaminated with desiccant or grit, replace the compressor, expansion valve, and receiver-drier, and flush the condenser and evaporator(s). After the system is charged, perform a performance check to ensure that the heat exchangers are not plugged.

Evacuating

The main purpose in evacuating the refrigerant system is to remove noncondensable gases (NCG), such as nitrogen and air. The secondary purpose is to boil off free water molecules.

In rare cases, water forms ice crystals at the expansion valve. Ice crystals retard or stop the flow of refrigerant, causing a reduction or complete loss of cooling. As the expansion valve warms due to the lack of refrigerant, the ice melts and passes through the expansion valve. Then refrigerant will flow again until the ice crystals re-form. The result is intermittent cooling.

Refrigerant oil has an extremely high moisture absorption capacity. Typically, the moisture picked up by the oil is passed on to the receiver-drier. If excessive moisture exists in the system, the lubricating ability of the oil is reduced, which could damage the compressor and other components.

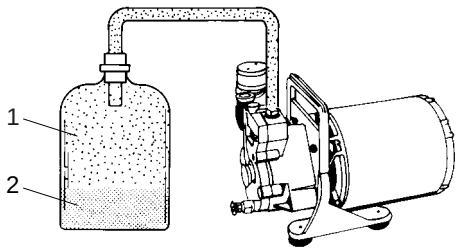
Effects of Pressure on the Boiling Point of Water

⚠ WARNING

Before doing any of the work below, read the information in Safety Precautions 100. Failure to read and understand the safety precautions, and to take necessary precautions against the dangers involved when working with refrigerant could lead to serious personal injury.

Water boils at 212°F (100°C) at an atmospheric pressure of 14.7 psi (101 kPa) at sea level. At higher elevations the atmospheric pressure is lower, which allows water to boil at lower temperatures. See **Table 1** for boiling temperatures of water at converted pressures.

Similarly you can boil and remove water from the air conditioning system by lowering the system pressure to a vacuum to cause the moisture to vaporize at normal ambient temperatures. A vacuum pump can reduce the pressure in the system. Since the pressure is lowest at the pump, NCG and water vapor are pulled out of the system. This process is called evacuation or dehydration. See **Fig. 1**.



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1. Vapor 2. Water

Fig. 1, Water to Vapor

Measuring Vacuum

Vacuum should be measured with an electronic thermistor vacuum gauge, which is designed for use with high vacuum pumps and can accurately read as low as 100 microns. This gauge can have an analog scale or a digital (LED or LCD) display.

The location of the vacuum gauge will affect the reading. The closer to the vacuum source, the lower the reading will be. Follow the manufacturer's instructions for proper use of the vacuum gauge.

If the pressure will not stabilize, it is an indication of a leak. If it does stabilize at a vacuum that is too high, for example 1500 microns Hg, it is an indication of moisture and more evacuation is required.

Boiling Temperatures of Water at Converted Pressures		
Boiling Temperature of Water: °F (°C)	**Absolute Pressure: psi (microns Hg)**	**Vacuum: inHg (mmHg)**
212 (100)	14.696 (759993.4)	0 (0)
205 (96)	12.770 (660400.0)	3.92 (99.6)
194 (90)	10.169 (523881.6)	9.22 (234.2)
176 (80)	6.8699 (355269.8)	15.93 (404.6)
158 (70)	4.5207 (233786.7)	20.72 (526.3)
140 (60)	2.8900 (149580.7)	24.04 (610.6)
122 (50)	1.7987 (92555.1)	26.28 (667.5)
104 (40)	1.0700 (55336.4)	27.74 (704.6)
89 (30)	0.61540 (31826.2)	28.67 (728.2)
86 (27)	0.57010 (26220.4)	28.89 (733.8)
76 (24)	0.44435 (22979.9)	29.02 (737.1)
72 (22)	0.38856 (20094.7)	29.13 (739.9)
69 (21)	0.35084 (18143.7)	29.21 (741.9)
64 (18)	0.29505 (15258.5)	29.32 (744.7)
59 (15)	0.24720 (12783.8)	29.42 (747.3)
53 (12)	0.19888 (10285.0)	29.52 (749.8)
45 (7)	0.14746 (7625.8)	29.62 (752.3)
32 (0)	0.08858 (4579.6)	29.74 (755.4)
21 (–6)	0.05293 (2738.1)	29.81 (757.2)
6 (–14)	0.02521 (1304.0)	29.87 (758.7)
–24 (–31)	0.004905 (253.7)	29.911 (759.74)
–35 (–37)	0.002544 (131.6)	29.915 (759.84)
–60 (–51)	0.0004972 (25.7)	29.9200 (759.968)
–70 (–57)	0.0002443 (12.69)	29.92050 (759.9807)
–90 (–68)	0.0000526 (2.72)	29.92089 (759.9906)

Table 1, Boiling Temperatures of Water at Converted Pressures

Holding a vacuum is only an indication that there are not any leaks that are present under a vacuum. Other leaks may exist when the system is pressurized, so a proper leak test must be performed in conjunction with holding a vacuum.

Maintaining an Oil-Lubricated Vacuum Pump

Maintenance is important for a high-vacuum pump. The oil must be changed at regular intervals to prevent moisture buildup, which will cause decreased pump performance and eventual pump failure.

Pumping down for extremely wet air conditioning systems can completely saturate the pump oil, which will require the replacement of the vacuum pump oil.

⚠ CAUTION

Flush the vacuum pump every fourth time it is used, and before storing for long periods of time.

Identification, Recovery, Evacuating, Purging and Flushing, Charging, and Leak Testing

Acid will form and corrode the pump, if water-laden oil remains in the pump for an extended period.

Vacuum pump oil is water soluble. This aids the pump in reaching a high vacuum by absorbing water and sealing the pump.

Use only vacuum pump oil as a lubricant. Do not use any solvent or any other oil. Clean oil should be run through the pump until it runs out clear. Oil should be added to the fill level indicated on the pump. Check the oil level before each use.

Evacuation Procedure

1. The system must have been recovered and the refrigerant compressor filled with the correct amount of refrigerant oil. Replace the receiver-drier if the system conditions require it.
2. Make sure the vacuum pump has been properly maintained.
3. Wearing protective goggles and nonleather gloves, attach the refrigerant recovery and charging machine hoses, or a vacuum pump, to the valves.

IMPORTANT: Push down firmly on the hose connectors until a clicking sound is heard. This will ensure that the coupler is locked.

4. Follow the refrigerant recovery and charging machine manufacturer's instructions and evacuate the refrigerant system.
5. A minimum of 10 minutes with a 6-cfm pump should be used to evacuate the system. Evacuate the system for a longer period of time if using a smaller pump. Make sure that the vacuum level reaches a point where water would boil and does not go back to zero, then proceed with charging and leak testing the system.

Purging and Flushing

⚠ WARNING

Before doing any of the work below, read the information in Safety Precautions 100. Failure to read and understand the safety precautions, and to take necessary precautions against the dangers involved when working with refrigerant could lead to serious personal injury.

Purging removes damp air, traces of refrigerant, and loose particles from refrigerant parts by passing a stream of inert, dry nitrogen gas through the parts. If left in the system, these contaminants would have an adverse effect on the life and operation of the air conditioning system.

Flushing removes moisture-laden oil and some contamination, such as dirty oil and some particles, that can not be removed by purging with gas. When a part is flushed, liquid refrigerant is forced through it. The liquid picks up the contaminants and flushes them out.

Whether to purge, flush, or replace a part depends on how much contamination there is as previously described.

Normally the system always has pressure in it. Some loss of refrigerant from one season to the next is normal and does not mean that the system is dirty. If refrigerant has leaked until the system is nearly empty and/or refrigerant parts show signs of internal corrosion and grit, the system is contaminated.

If the system is contaminated with moisture, purge all sections of the system. Then change the oil in the compressor and replace the receiver-drier prior to evacuating and charging the system.

If the system is heavily contaminated or if desiccant has circulated through the system, replace the receiver-drier, expansion valve(s), and inspect the compressor.

Do not purge the receiver-drier or the compressor.

Flush the system in segments to lessen the chance of blowing deposits against a port.

Purge or flush the system in the opposite direction of refrigerant flow. In other words, backflush the sections.

Flushing parts with refrigerant requires a refrigerant recovery and charging machine.

Purging Procedure

NOTE: Dry nitrogen gas is required for purging. A pressure regulator is required to regulate between 0 and 200 psi (0 and 1379 kPa). Commercial cylinders of nitrogen contain pressures in excess of 2000 psi (13 790 kPa). This pressure must be reduced to 200 psi (1379 kPa).

1. Recover the refrigerant from the air conditioning system.
2. Disconnect both ends of the line or part being purged. Tightly cap the rest of the system.
3. Make sure the nitrogen bottle control valve, the purging control valve, and the supply line valve are closed.
4. Connect the supply line valve to the outlet end of the part or line.
5. Connect the drain line to the inlet end of the part or line.
6. Place the outlet of the drain line into a container to collect the oil and debris that may come out of the part that is being flushed.
7. Adjust the nitrogen bottle regulator to 200 psi (1379 kPa). Open the nitrogen bottle control valve and the purging control valve. Then slowly open the supply line valve. Check the drain line for gas flow.
8. Let the nitrogen flow at 200 psi (1379 kPa) for 25 to 30 seconds.
9. Lower the pressure to 4 psi (28 kPa) and let it flow for one to two minutes. If the line or part was very wet, allow it to flow until there is no trace of refrigerant oil or solid bits of dirt or grit flowing from the drain tube.
10. Close the nitrogen bottle control valve and the purging control valve first, then close the supply line valve.
11. Disconnect the supply line valve and the drain line. Tightly cap both ends of the part or line.

Flushing Procedure

Method 1

NOTE: Use this method when the recovery and charging machine is equipped with a flush cycle.

1. Recover the refrigerant from the air conditioning system.
2. Disconnect both ends of the line or part(s) being flushed. Tightly cap the lines to the rest of the system.

NOTE: You must remove the expansion device(s), receiver-drier, and compressor(s) when flushing. These components must be removed and bypassed when performing a system flush.

3. Install the flushing adaptors and an inline filter and follow the instructions from the manufacturer of the recovery and charging machine to perform the flush. When flushing the entire system, use an adaptor that fits where the compressor was located and backflush.
4. Remove the adaptors and bypass devices and install the expansion device(s), the compressor, and a new receiver-drier.
5. If installing the existing compressor, remove the oil in it and replace the oil with new oil. New compressors may or may not have a full charge of oil.
6. Charge the system with refrigerant and check the system performance.

Method 2

NOTE: Use this method when two recovery and charging machines are available.

1. Recover the refrigerant from the air conditioning system.
2. Disconnect both ends of the line or part(s) being flushed. Tightly cap the lines to the rest of the system.

NOTE: You must remove the expansion device(s), receiver-drier, and compressor(s) when flushing. These components must be removed and bypassed when performing a system flush.

3. Install the flushing adaptors and an inline filter. When flushing the entire system, use an adaptor that fits where the compressor was located and backflush.
4. Charge the part with 2 pounds (0.9 kg) of refrigerant or the system with 5 pounds (2.3 kg) of refrigerant, then recover the refrigerant with a second machine. It is desirable to start the recovery slightly before the charge cycle is done since this helps to push fluid through the system. Repeat the process several times until you think that all the oil has been removed.
5. Remove the adaptors and bypass devices and install the expansion device(s), the compressor(s), and a new receiver-drier.

Identification, Recovery, Evacuating, Purging and Flushing, Charging, and Leak Testing

6. If installing the existing compressor, remove the oil in it and replace the oil with new oil. New compressors may or may not have a full charge of oil.
7. Charge the system with refrigerant and check the system performance.

Charging

WARNING

Before doing any of the work below, read the information in Safety Precautions 100. Failure to read and understand the safety precautions, and to take necessary precautions against the dangers involved when working with refrigerant could lead to serious personal injury.

NOTE: Before charging, the system must be recovered and evacuated with the recovery and charging machine connected to the service and discharge port connections.

1. Obtain enough refrigerant to fully charge the system. To determine the amount of refrigerant needed to fully charge the system, read the Air Conditioner label on the vehicle or see **Subject 400**.
2. Charge the system on the high side following the refrigerant recovery and charging machine manufacturer's instructions.
3. While the compressor is engaged, check the duct temperature and operating pressures at the suction and discharge ports. Compare the temperature and pressures to those in **Section 83.06, Subject 300**. If the operating pressures are not acceptable, see **Section 83.06, Subject 300** for troubleshooting procedures.
4. Disconnect the hoses.
5. Shut down the engine.
6. Recover the refrigerant that is in the hoses.

Leak Testing Methods

General Information

WARNING

Before doing any of the work below, read the information under Safety Precautions 100. Failure to read the safety precautions, and to take precautions against the dangers involved when working with refrigerant, could lead to serious personal injury.

Refrigerant is nearly odorless. As a result, all of it may leak away and not be noticed until the system stops cooling. All vehicle refrigerant systems lose some refrigerant. Higher loss rates signal a need to locate and repair the leaks.

Leaks are most often found at the compressor hose connections and at the various fittings and joints in the system. If unapproved replacement hoses are installed, refrigerant can be lost through hose permeation.

There are two leak testing methods that can be used to detect leaks in the refrigerant system: UV (ultraviolet) dye leak detection and electronic leak detection. Freightliner recommends using the UV dye leak detection method whenever possible, even though there are some limitations to using this method. A leak on the front seal of the compressor **must** be verified using a heated diode leak detector and the instructions elsewhere in this subject. Visible dye on the front of the compressor clutch **does not** verify that there is a repairable leak at the front seal. Evaporator leaks may not show up with dye, and must be checked using a heated diode leak detector if dye is not present at the condensate drain.

UV Dye Leak Detection

IMPORTANT: When using the UV dye leak detection method, always wear protective eyewear that blocks UV rays and enhances the appearance of the dye. Always wear nonleather gloves and protective eyewear when servicing the air conditioning system.

1. Inspect the refrigerant system for leaks using a UV lamp.
   1.1 Inspect the entire refrigerant system under low lighting using a UV lamp. Low lighting

will increase the apparent brightness of the UV dye at leak sights.

1.2 Move the UV lamp along the entire refrigerant system, looking for signs of damage or corrosion on the fittings, hose-to-line crimps, switch ports, service ports with caps installed (dye inside the port is not an indication of a leak), brazed or welded areas, and around all connections. Check for evaporator leaks by illuminating the condensate drain tube or hole using the UV lamp.

1.3 Move the UV lamp along the refrigerant system following a continuous path so that no potential leak sites are missed. If a leak is found, continue to check the remainder of the system since other leaks may be present.

2. After repairing a leak, remove all UV dye residue remaining on the outside of the refrigerant system using the cleaner provided by the dye manufacturer, or a comparable cleaner. Use a spray bottle of cleaner, a toothbrush, and a spray bottle of clean water for hard-to-reach areas.

NOTE: Minor UV dye residue, or residue that is impossible to reach, will lose its fluorescence over time.

3. See **Table 2** for a list of products that have been tested and approved for use by Freightliner dealers.

Approved Products for UV Dye Leak Detection				
Type of Refrigerant Oil	**Product Description**	**Vendor Part Number**	**Freightliner Part Number**	**Website Address**
PAG	Tracerline BigEZ Kit—Can be injected without discharging the system. • Each kit includes one 4-oz (118-mL) cartridge and an injection tool.	TP-9741CS	ABP N83 327911	www.tracerline.com
	• A 4-oz (118-mL) replacement cartridge services 16 vehicles.	TP-9760-0004CS	ABP N83 327961	
	• An 8-oz (237-mL) replacement cartridge services 32 vehicles.	TP-9760-0108	ABP N83 327951	
POE/ universal	Tracerline BigEZ Kit—Can be injected without discharging the system. • Each kit includes one 4-oz (118-mL) cartridge and an injection tool.	TP-9742CS	ABP N83 327910	www.tracerline.com
	• A 4-oz (118-mL) replacement cartridge services 16 vehicles.	TP-9770-0004CS	ABP N83 327950	
	• An 8-oz (237-mL) replacement cartridge services 32 vehicles.	TP-9770-108	ABP N83 327960	
—	Tracerline Optimax UV Lamp	TP-8680	ABP N83 327985	www.tracerline.com
—	Bright Solutions UV Lamp	BSL760	ABP N83 327967	www.brightsol.com
—	Service Valve Cap	—	PH 660412	—

Table 2, Approved Products for UV Dye Leak Detection

Identification, Recovery, Evacuating, Purging and Flushing, Charging, and Leak Testing

Electronic Leak Detection

NOTE: Do not try to use a leak tester right after connecting or disconnecting service hoses. Traces of refrigerant at the fittings can falsely signal a leak. Always verify a leak by blowing shop air in to the area of the suspected leak and checking the area again.

When checking for leaks, move the probe all the way around the fitting or suspected leak.

Freightliner recommends using only certain makes of the heated diode and infrared (IR) types of electronic leak detectors.

Recommended electronic heated diode type leak detectors are available from their manufacturers. See **Table 3**.

Another type of detector, the corona discharge type, is specifically **not recommended**.

Use the following procedures to locate refrigerant system refrigerant gas leaks using an electronic leak detector.

1. Operate the electronic leak detector in accordance with the manufacturer's instructions.
2. Leak test with the engine turned off.
3. Charge the air conditioning system with sufficient refrigerant to indicate a gauge pressure of at least 50 psi (345 kPa) with the system not operating. Typically, one-half pound (0.22 kg) of refrigerant is sufficient to create 50 psi (345 kPa) of pressure. It may not be possible to produce this amount of pressure and measure leakage if the ambient temperature is less than 59°F (15°C).
4. Be careful not to contaminate the detector probe tip if the part being tested is not clean. Wipe the part off with a dry shop towel or blow it off with shop air. Do not use cleaners or solvents as many detectors are sensitive to their chemical ingredients.
5. Visually inspect the entire refrigerant system. Look for air conditioning lubricant leakage and corrosion or damage to lines, hoses, and all other components. Inspect each questionable location carefully with the detector probe. Check all fittings, couplings, refrigerant controls, service ports (with caps installed), brazed or welded areas, and areas around attachment points and hold-downs.

Electronic Leak Detectors		
Designation	**Manufacturer**	**Comments**
D-TEK, D-Tek Select, and TekMate	Leybold Inficon 2 Technology Place East Syracuse NY 13057 (315) 434–1144	• Rechargeable battery • Hand-held design • Simple to operate
H–10 Professional	Bacharach Inc. c/o Yokogawa Corp. of America 2 Dart Road Newnan GA 30265 (800) 850–0044	• Rechargeable battery • Carrying case with strap • Calibration leak bottle • Manual sensitivity control • Most sensitive available
J 39400	SPX Kent-Moore 28635 Mound Road Warren MI 48092–3499 (800) 328–6657	• 12V DC or 120V AC • Carrying case with strap • Calibration leak bottle • Manual sensitivity control • Manual balance control

Table 3, Electronic Leak Detectors

6. Follow the path of the refrigerant system methodically so that no leaks are missed. If a leak is found, continue to test the rest of the system.
7. Inspect an area of possible leakage slowly and close to the part, moving completely around the part. Move the probe no faster than one to two inches (25 to 50 mm) per second and no farther away than 1/4 inch (6.4 mm) from the part.
8. If a large leak is present in either the system being serviced or the service equipment, the surrounding air will be saturated with refrigerant gas. In this situation the leak detector operates erratically and will indicate leakage without being near a possible leak source. Place a large fan so that a light breeze blows through the work area. Verify a leak by blowing shop air into the area and repeating the inspection. Pinpoint a large leak by blowing out the area often.
9. You may test the evaporator core while it is in its housing. Turn on the blower motor for a minimum of 15 seconds. Shut off the blower and wait for refrigerant gas to accumulate in the housing. Follow the detector instructions for the specific length of time to wait for the gas to accumulate. Insert the detector probe into the blower resistor block, or condensate drain tube if no water is present. If this is not possible insert the probe into the closest opening to the evaporator, such as a heater or vent duct.

NOTE: The presence of water in the condensate drain tube can be determined by inserting the eraser end of a pencil in the drain tube. Inserting the pencil will break the surface tension of any water near the opening of the drain tube and allow the water to drain out before inserting the probe tip. It is only necessary to break the plane of the drain tube with the probe tip. It does not need to be inserted far into the tube.

10. Leak test the front seal area of the compressor. Blow shop air into the cavities in and around the clutch for at least 15 seconds. Let the compressor stand for one minute and then test for leakage. Inspect axial-type compressors (Sanden or Sel-Tec) by placing the probe near the holes at the front of the clutch. See **Fig. 2**. Inspect two-cylinder reciprocating type compressors (Climate Control) by placing the probe between the clutch coil and the compressor. See **Fig. 3**.

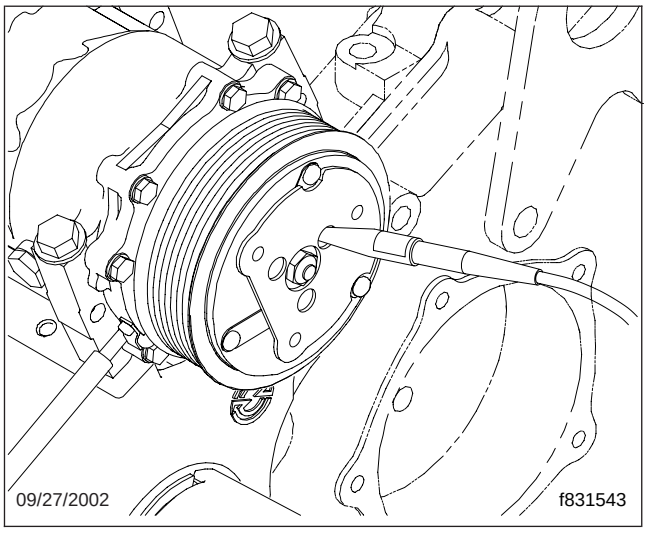


Fig. 2, Axial Type Compressor

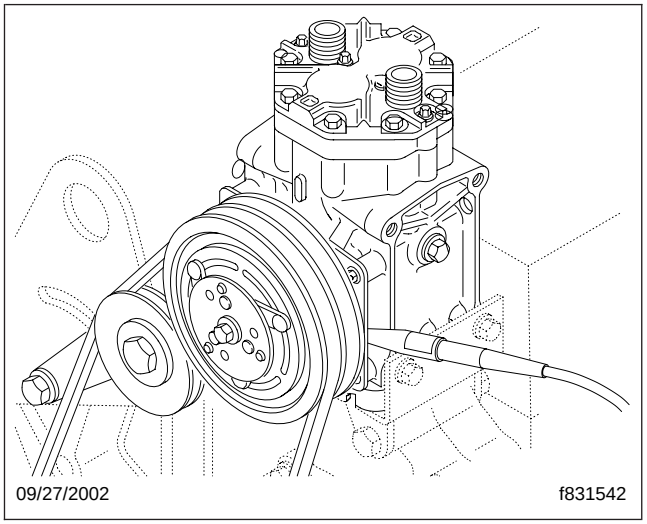


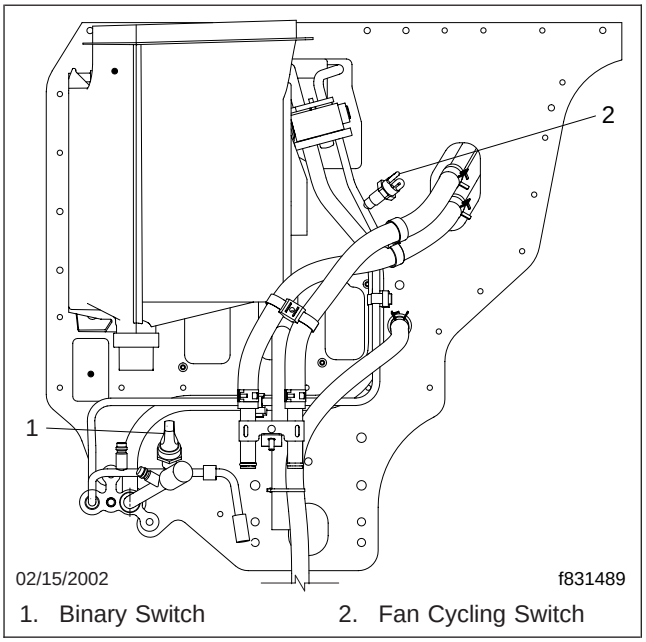
Fig. 3, Two-Cylinder Reciprocating Compressor

IMPORTANT: Be careful not to damage the clutch bearing seal with high pressure shop air.

11. Leak test repaired areas of the system after repairs have been performed. Leak test the service ports (with caps installed) after any service which disturbs the refrigerant system.

Replacement

1. Turn off the engine, apply the parking brakes, and chock the tires.
2. Open the hood.
3. Disconnect the electrical connector from the fan cycling switch near the expansion valve. See **Fig. 1**.



1. Binary Switch 2. Fan Cycling Switch

Fig. 1, Engine Side of Frontwall

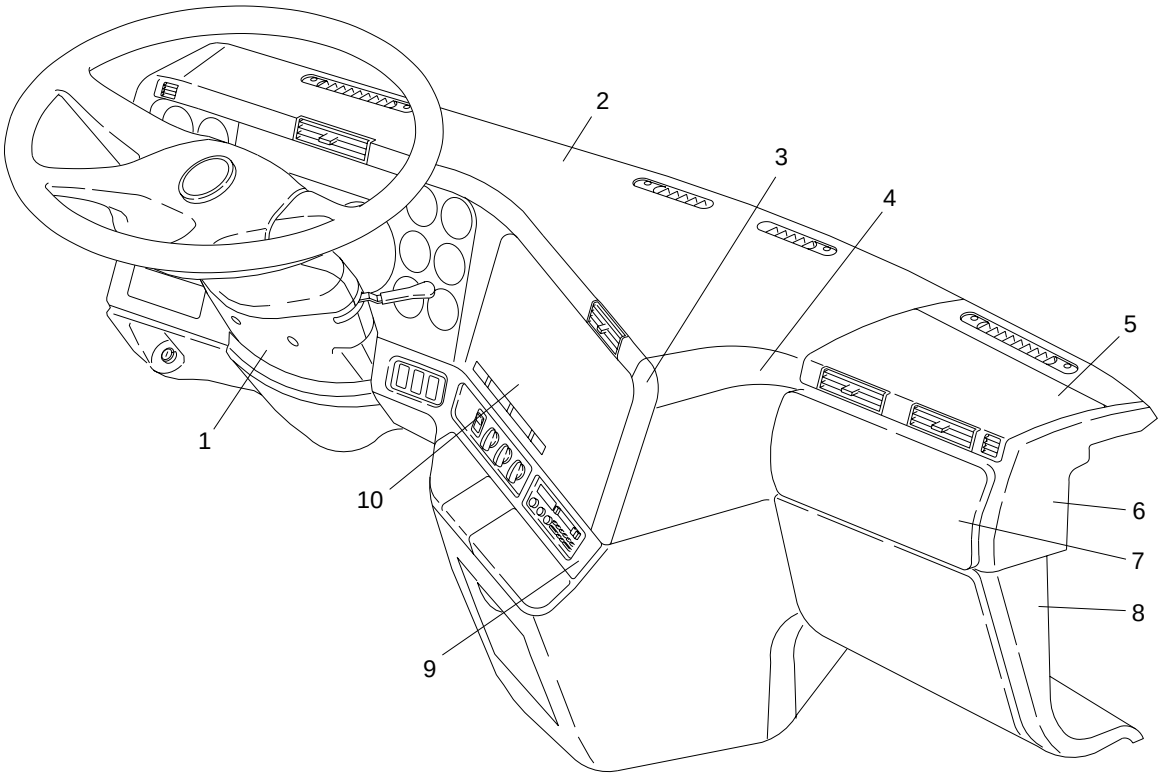
4. Remove the fan cycling switch and the O-ring.
5. Lubricate a new O-ring with mineral oil before installing it on the new fan cycling switch.
6. Install the fan cycling switch on the receiver-drier and tighten 60 to 72 lbf·in (678 to 813 N·cm).
7. Connect the electrical connector to the fan cycling switch.
8. Return the hood to the operating position.
9. Remove the chocks from the tires.

CDTC Sensor Replacement

Replacement

1. Turn off the engine, apply the parking brakes, and chock the tires.
2. Remove the dash panels listed below. See **Fig. 1**. For instructions, see **Section 60.08**.
    - electrical cover
    - upper dash cover
    - heater and air conditioner cover
    - waste bin
    - console cover
    - dash trim cap
    - upper dash assembly, center panel
3. Remove the tie straps on the wiring harness as needed to access the CDTC sensor. See **Fig. 2**.
4. Remove the capscrew that attaches the right side of the shield to the HVAC assembly. Move the shield to access the CDTC sensor. See **Fig. 3**.
5. Disconnect the electrical connector from the CDTC sensor.
6. Turn the CDTC sensor one-quarter turn and remove the CDTC sensor.
7. Install a new CDTC sensor in the HVAC assembly and turn the sensor one-quarter turn.
8. Connect the electrical connector to the CDTC sensor.
9. Using a capscrew, attach the shield to the HVAC assembly.
10. If needed, use tie straps to bundle the wiring harnesses.
11. Install the dash panels listed below. For instructions, see **Section 60.08**.
    - upper dash assembly, center panel
    - dash trim cap
    - console cover
    - waste bin
    - heater and air conditioner cover
    - upper dash cover
    - electrical cover
12. Remove the chocks from the tires.

CDTC Sensor Replacement



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1. Steering Column Cover
2. Left-Side Upper Dash Assembly
3. Dash Trim Cap
4. Upper Dash Assembly, Center Panel
5. Electrical Cover
6. Right-Side Upper Dash Assembly
7. Upper Dash Cover
8. Heater and Air Conditioner Cover
9. Waste Bin Outer Wall
10. Console Cover
11. HVAC/Radio Trim Plate
12. Auxiliary Gauge Panel

Fig. 1, Century Class Conventional Dash Panels

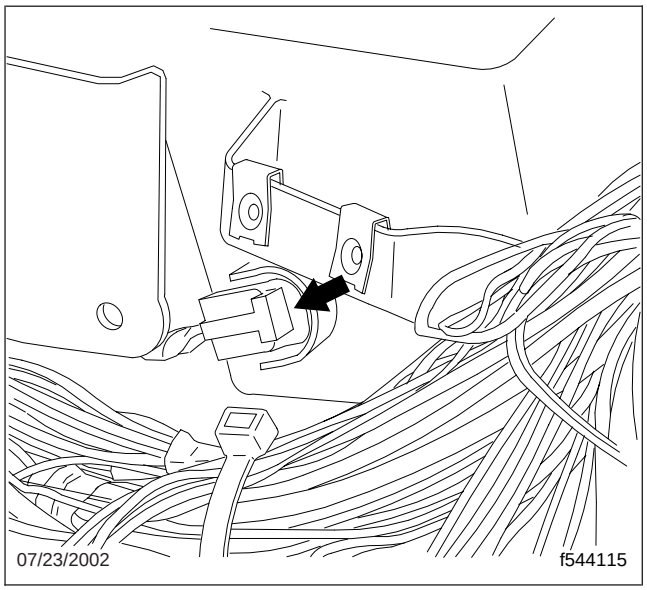


Fig. 2, CDTC Sensor

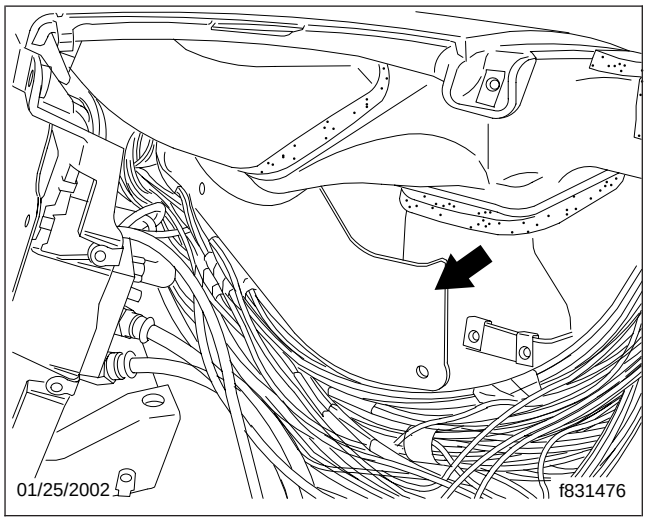
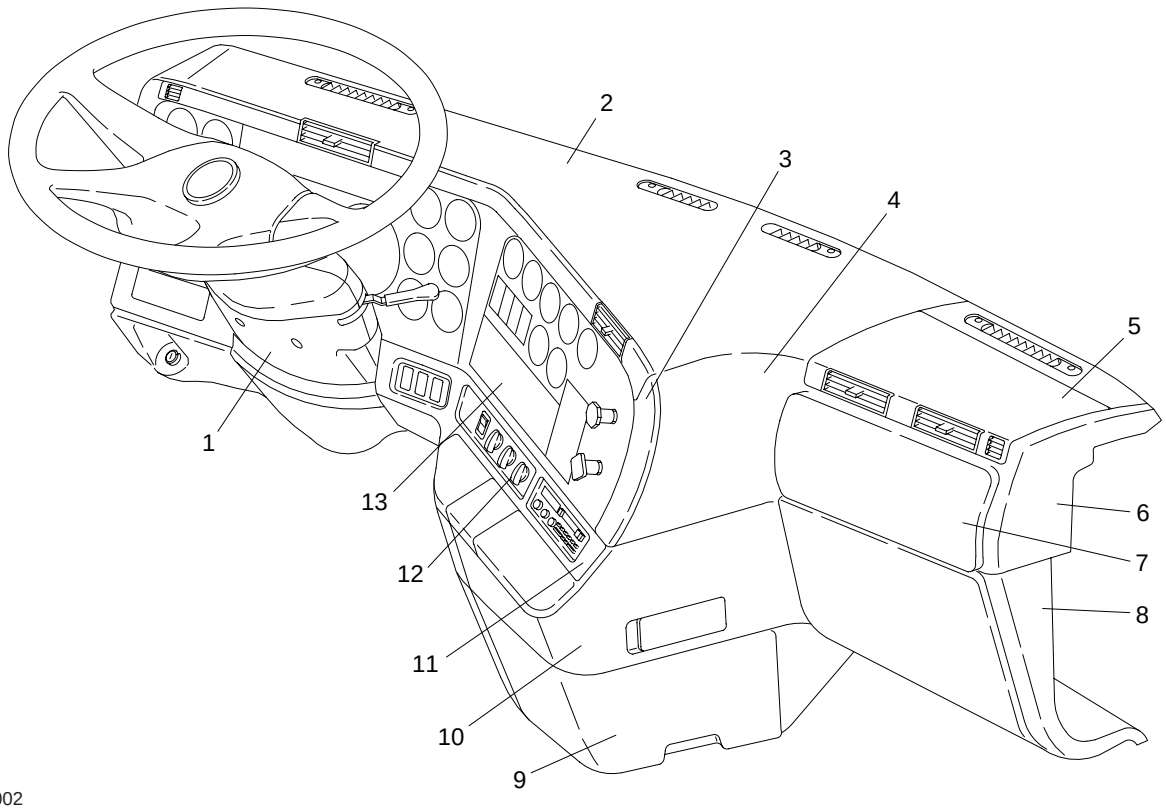


Fig. 3, Shield

Mode Control Kinematics Replacement

Replacement

1. Turn off the engine, apply the parking brakes, and chock the rear tires.
2. Remove the dash panels listed below. See **Fig. 1**. For instructions, see **Section 60.08**.
   - electrical cover
   - upper dash cover
   - heater and air conditioner cover
   - waste bin
   - console cover
   - dash trim cap
   - upper dash assembly, center panel
3. Remove the tie straps on the wiring harnesses as needed to access the wiring harness channel on the HVAC assembly.
4. Pull the plastic fastener that attaches the wiring harness channel to the HVAC assembly out of the HVAC assembly, and move the wiring harness channel to access the mode actuator.
5. Remove the mode actuator from the HVAC assembly. See **Fig. 2**.



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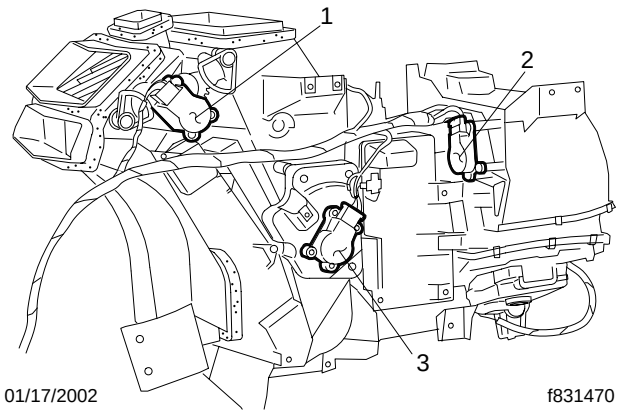
1. Steering Column Cover
2. Left-Side Upper Dash Assembly
3. Dash Trim Cap
4. Upper Dash Assembly, Center Panel
5. Electrical Cover
6. Right-Side Upper Dash Assembly
7. Upper Dash Cover
8. Heater and Air Conditioner Cover
9. Waste Bin Outer Wall
10. Console Cover
11. HVAC/Radio Trim Plate
12. Front Control Unit
13. Auxiliary Gauge Panel

Fig. 1, Dash Panels

Mode Control Kinematics Replacement



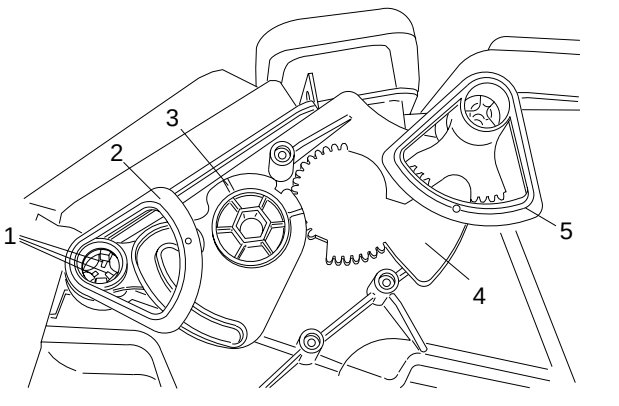
1. Mode Actuator
2. Recirculation Actuator
3. Temperature Actuator

Fig. 2, Actuators

5.1 Remove the capscrews that attach the mode actuator to the HVAC assembly.

5.2 Disconnect the electrical connector from the actuator, and remove the actuator.

6. Remove the defrost door lever, drive gear, face door lever, and idler. See **Fig. 3**.



1. Wing Clips
2. Defrost Door Lever
3. Drive Gear
4. Idler
5. Face Door Lever

Fig. 3, Defrost Door Lever

6.1 Pull the defrost door lever over the wing clips.

6.2 Pull the drive gear and defrost door lever off the pivot and door shaft.

6.3 Pull the face door lever over the wing clips.

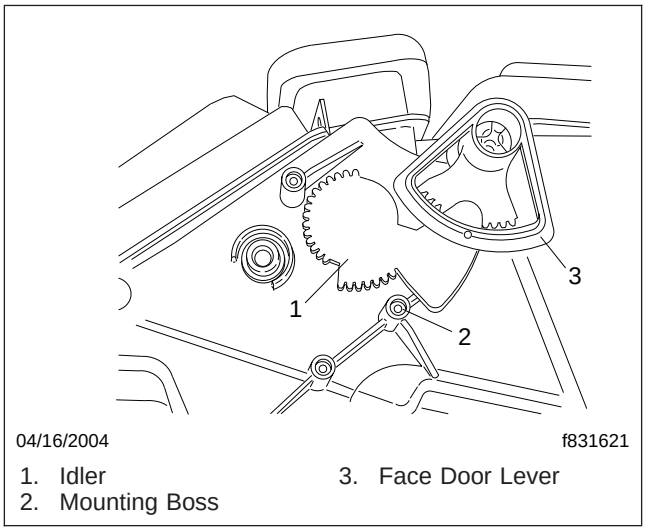
6.4 Pull the idler off the pivot.

6.5 Make sure the wing clips are in good condition. If any of the wings are broken or missing, remove all of the clips.

7. Install a new idler and face door lever.

7.1 Move the face door shaft counterclockwise as far as it will move.

7.2 Install the idler so that it is against the actuator mounting boss. See **Fig. 4**.



1. Idler
2. Mounting Boss
3. Face Door Lever

Fig. 4, Idler and Face Door Lever

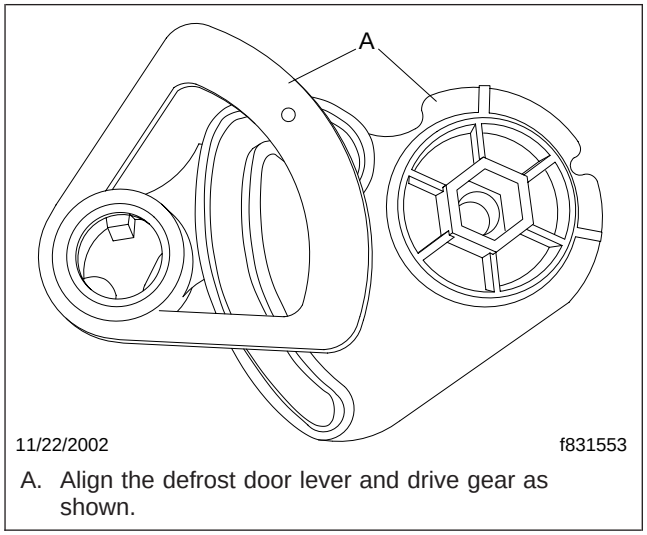
7.3 Press the face door lever on the door shaft until the door lever is secured by the three wing clips. If necessary, use a screwdriver to spread the wing clips for engagement.

7.4 If the wing clips were removed, use a screw similar in size to the actuator mounting screw to install the face door lever on the shaft.

8. Install a new defrost door lever.

8.1 Move the defrost door shaft counterclockwise as far as it will move.

8.2 Align the defrost door lever with the drive gear as shown in **Fig. 5** before installing the parts on the HVAC assembly.



A. Align the defrost door lever and drive gear as shown.

Fig. 5, Defrost Door Lever and Drive Gear

IMPORTANT: Make sure the teeth on the defrost door lever align with the wide tooth on the mating gear. See **Fig. 6**.

8.3 Install the defrost door lever and drive gear as a unit on the HVAC assembly. Make sure the wing clips are visible.

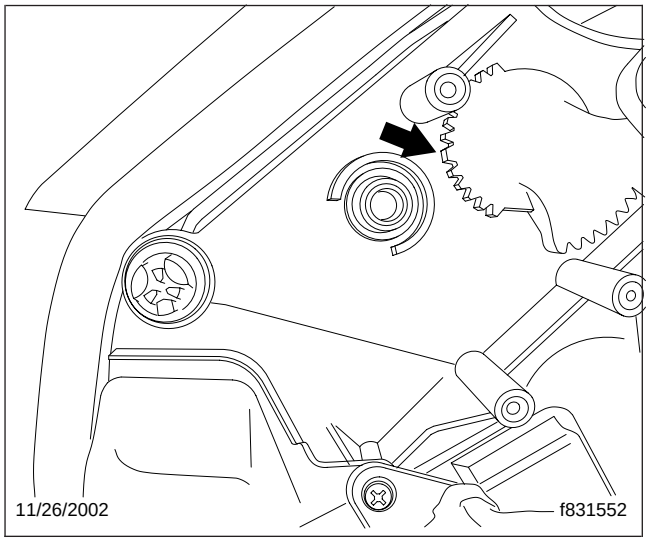


Fig. 6, Wide Tooth on Mating Gear

8.4 Press the defrost door lever on the door shaft until the door lever is secured by the three wing clips. If necessary, use a screwdriver to spread the wing clips for engagement.

8.5 If the wing clips were removed, use a screw similar in size to the actuator mounting screw to install the defrost door lever on the shaft.

9. Install the mode actuator.

   9.1 Connect the electrical connector to the mode actuator.

   9.2 Align the actuator to the keyed shaft on the door.

   9.3 Using capscrews, attach the mode actuator to the HVAC assembly.

10. Move the wiring harness channel back in place and use the plastic fastener to attach the wiring harness channel to the HVAC assembly.

11. If needed, use tie straps to bundle the wiring harnesses.

12. Install the dash panels listed below. For instructions, see **Section 60.08**.

    - upper dash assembly, center panel
    - dash trim cap
    - console cover
    - waste bin
    - heater and air conditioner cover
    - upper dash cover
    - electrical cover

13. Calibrate the HVAC system after the actuator has been replaced.

    13.1 Turn the ignition key to the on position, but keep the engine off.

    13.2 Turn the fan switch to the off position.

    13.3 Turn the air selection switch to the full defrost mode.

    13.4 Turn the temperature control switch to the full hot position.

Mode Control Kinematics Replacement

13.5 Press and hold the recirculation and air conditioning buttons until they begin to blink.

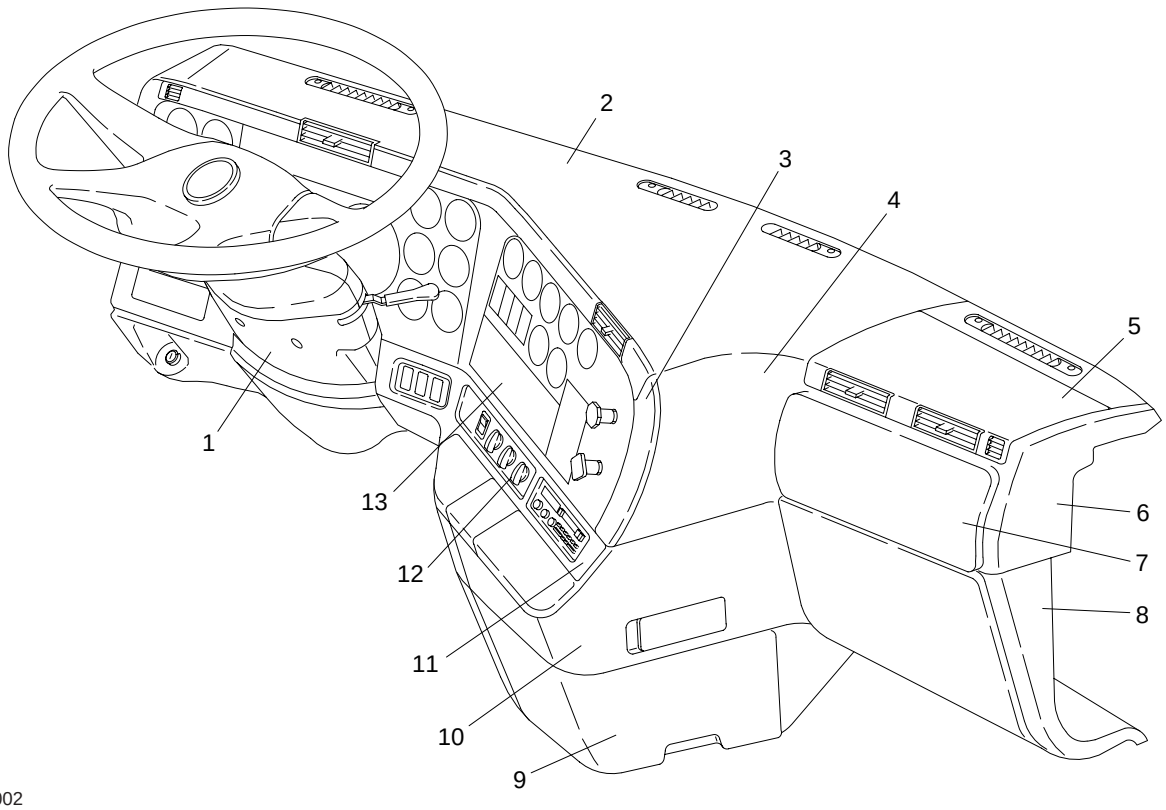
13.6 The recirculation and air conditioning indicators will blink, the fan will turn on the highest fan speed, the air selection switch will cycle through the modes, and the recirculation door will open and close. The entire cycle takes about 20 to 30 seconds.

14. Remove the chocks from the tires.

Temperature Control Kinematics Replacement

Replacement

1. Turn off the engine, apply the parking brakes, and chock the rear tires.
2. Remove the dash panels listed below. See **Fig. 1**. For instructions, see **Section 60.08**.
   - electrical cover
   - upper dash cover
   - heater and air conditioner cover
   - console cover
   - dash trim cap
   - upper dash assembly, center panel
3. Remove the capscrew on the wiring harness channel that attaches the channel to the temperature control cover.
4. Remove the temperature actuator from the temperature control cover. See **Fig. 2**.
   - 4.1 Remove the capscrews that attach the temperature actuator to the temperature control cover.
   - 4.2 Disconnect the electrical connector from the actuator, and remove the actuator.



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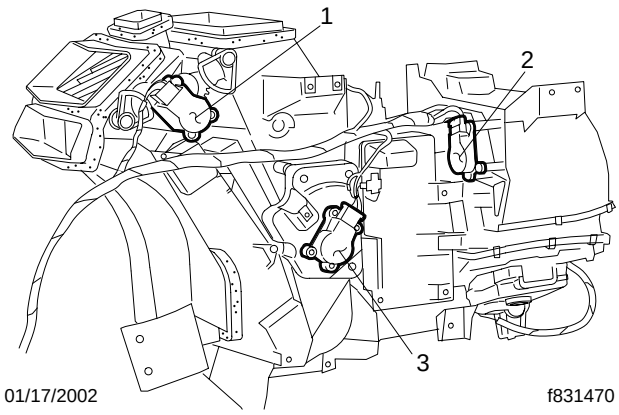
1. Steering Column Cover
2. Left-Side Upper Dash Assembly
3. Dash Trim Cap
4. Upper Dash Assembly, Center Panel
5. Electrical Cover
6. Right-Side Upper Dash Assembly
7. Upper Dash Cover
8. Heater and Air Conditioner Cover
9. Waste Bin Outer Wall
10. Console Cover
11. HVAC/Radio Trim Plate
12. Front Control Unit
13. Auxiliary Gauge Panel

Fig. 1, Dash Panels

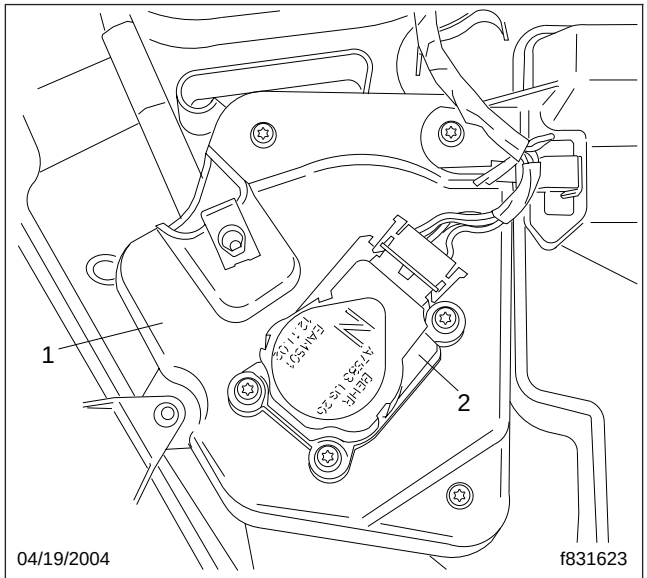
Temperature Control Kinematics Replacement



1. Mode Actuator
2. Recirculation Actuator
3. Temperature Actuator

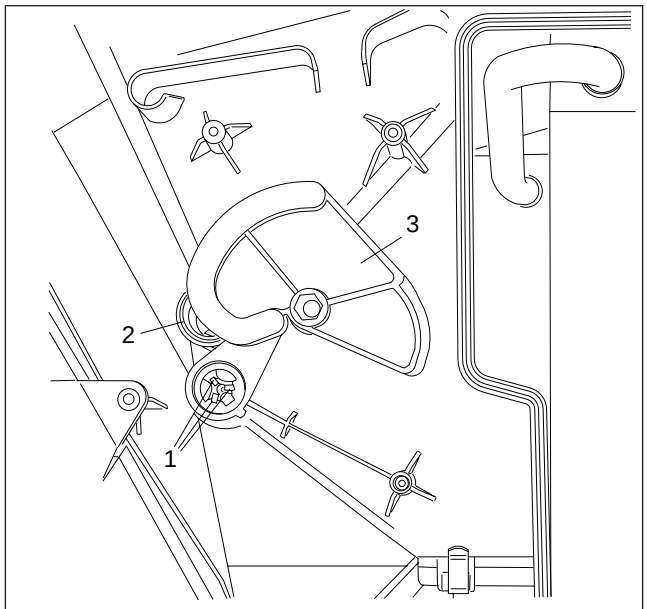
Fig. 2, Actuators

5. Remove the evaporator temperature sensor by turning the sensor counterclockwise one-quarter turn.
6. Remove the capscrews that attach the evaporator service cover to the HVAC assembly. Remove the service cover.
7. Remove the screws that attach the temperature control cover to the HVAC assembly. Remove the cover. See **Fig. 3**.
8. Pull the temperature control cam off the pivot. See **Fig. 4**.
9. Pull the temperature control levers off the wing clips. Make sure the wing clips are in good condition. See **Fig. 4**.
10. Install new temperature control levers.
    - 10.1 If the wing clips are broken, use a screw similar in size to the actuator mounting screw, and a washer to attach the levers to the shafts.
    - 10.2 Install the levers on the shafts. Move the lower lever counterclockwise and the top lever clockwise, then install the cam on the levers. The levers and cam should be in the positions shown in **Fig. 4**.
11. Using capscrews, attach the temperature control cover to the HVAC assembly.
12. Install the temperature actuator.



1. Temperature Control Cover
2. Temperature Actuator

Fig. 3, Temperature Actuator



1. Wing Clips
2. Temperature Control Lever
3. Temperature Control Cam

Fig. 4, Temperature Control Kinematics

12.1 Connect the electrical connector to the temperature actuator.

12.2 Align the actuator to the keyed shaft on the door.

12.3 Using capscrews, attach the temperature actuator to the temperature control cover.

13. Move the wiring harness channel back in place and use a capscrew to attach the channel to the temperature control cover.

14. Install the dash panels listed below. For instructions, see **Section 60.08**.
    - upper dash assembly, center panel
    - dash trim cap
    - console cover
    - heater and air conditioner cover
    - upper dash cover
    - electrical cover

15. Calibrate the HVAC system after the actuator has been installed.

    15.1 Turn the ignition key to the on position, but keep the engine off.

    15.2 Turn the fan switch to the off position.

    15.3 Turn the air selection switch to the full defrost mode.

    15.4 Turn the temperature control switch to the full hot position.

    15.5 Press and hold the recirculation and air conditioning buttons until they begin to blink.

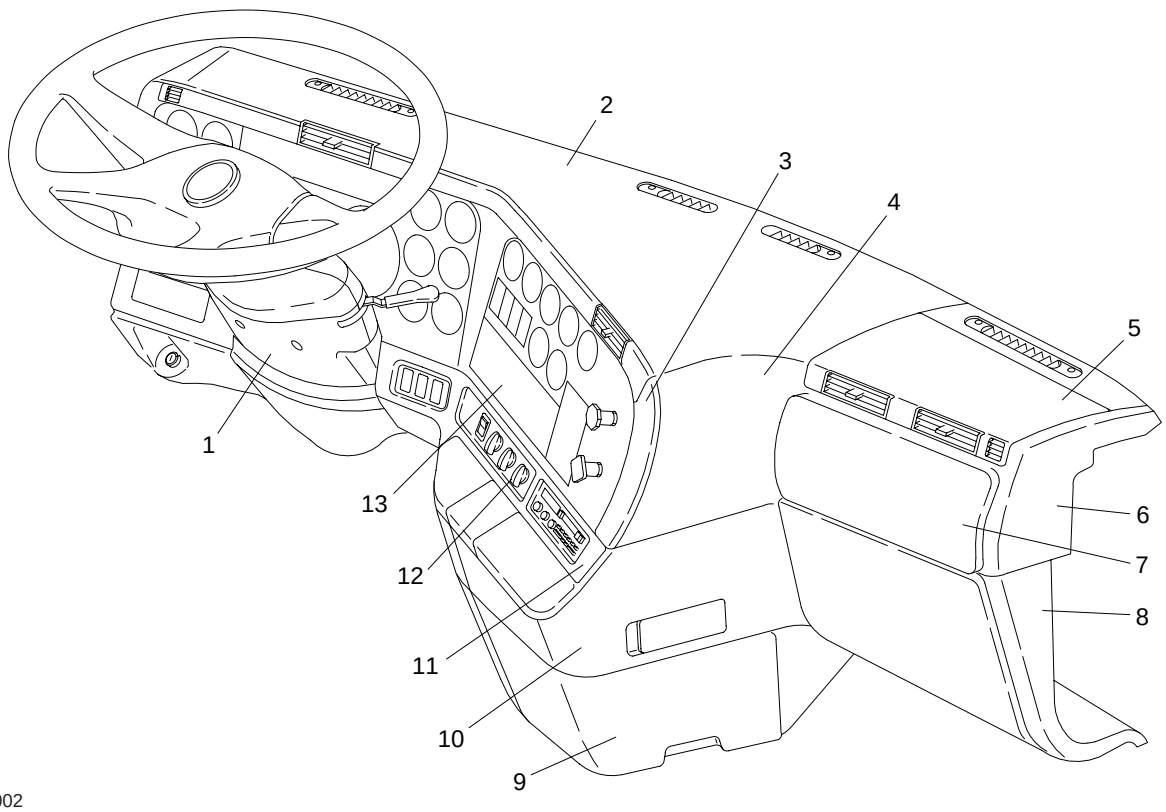
    15.6 The recirculation and air conditioning indicators will blink, the fan will turn on at the highest fan speed, the air selection switch will cycle through the modes, and the recirculation door will open and close. The entire cycle takes about 20 to 30 seconds.

16. Remove the chocks from the tires.

Recirculation and Fresh Air Kinematics Replacement

Replacement

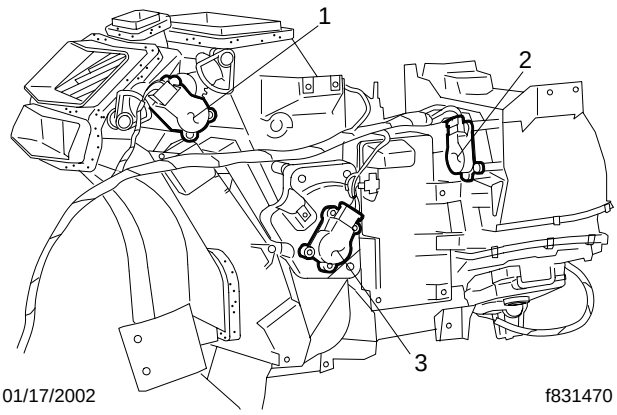
1. Turn off the engine, apply the parking brakes, and chock the rear tires.
2. Remove the dash panels listed below. See **Fig. 1**. For instructions, see **Section 60.08**.
   - electrical cover
   - right-side upper dash assembly
   - upper dash cover
   - heater and air conditioner cover
   - console cover
   - dash trim cap
   - upper dash assembly, center panel
3. Remove the evaporator temperature sensor by turning the sensor counterclockwise one-quarter turn.
4. Remove the capscrews that attach the evaporator service cover to the HVAC assembly. Remove the service cover.
5. Remove the recirculation actuator. See **Fig. 2**.



1. Steering Column Cover
2. Left-Side Upper Dash Assembly
3. Dash Trim Cap
4. Upper Dash Assembly, Center Panel
5. Electrical Cover
6. Right-Side Upper Dash Assembly
7. Upper Dash Cover
8. Heater and Air Conditioner Cover
9. Waste Bin Outer Wall
10. Console Cover
11. HVAC/Radio Trim Plate
12. Front Control Unit
13. Auxiliary Gauge Panel

Fig. 1, Dash Panels

Recirculation and Fresh Air Kinematics Replacement



1. Mode Actuator
2. Recirculation Actuator
3. Temperature Actuator

Fig. 2, Actuators

5.1 Remove the capscrews that attach the recirculation actuator to the HVAC assembly.

5.2 Remove the linkage from the back of the actuator. Disconnect the electrical connector from the actuator, and remove the actuator.

6. Remove the nuts that attach the power distribution module (PDM) to the HVAC assembly. Lift the PDM to access the linkage or arm.
7. Remove the linkage from the lever.
8. Install a new linkage on the lever.
9. Lower the PDM. Using nuts, attach the PDM to the HVAC assembly.
10. Install the recirculation actuator.

    10.1 Connect the electrical connector to the actuator.

    10.2 Attach the linkage to the back of the actuator and align the actuator to the keyed shaft on the door.

    10.3 Using capscrews, attach the actuator to the HVAC assembly.

11. Using capscrews, install the evaporator service cover on the HVAC assembly. Make sure that the evaporator service cover is correctly seated to the HVAC assembly.
12. Install the temperature sensor in the evaporator and turn the sensor clockwise one-quarter turn.
13. Install the dash panels listed below. For instructions, see **Section 60.08**.
    - upper dash assembly, center panel
    - dash trim cap
    - console cover
    - heater and air conditioner cover
    - upper dash cover
    - right-side upper dash assembly
    - electrical cover
14. Calibrate the HVAC system after the actuator has been installed.

    14.1 Turn the ignition key to the on position, but keep the engine off.

    14.2 Turn the fan switch to the off position.

    14.3 Turn the air selection switch to the full defrost mode.

    14.4 Turn the temperature control switch to the full hot position.

    14.5 Press and hold the recirculation and air conditioning buttons until they begin to blink.

    14.6 The recirculation and air conditioning indicators will blink, the fan will turn on at the highest fan speed, the air selection switch will cycle through the modes, and the recirculation door will open and close. The entire cycle takes about 20 to 30 seconds.

15. Remove the chocks from the tires.

Specifications

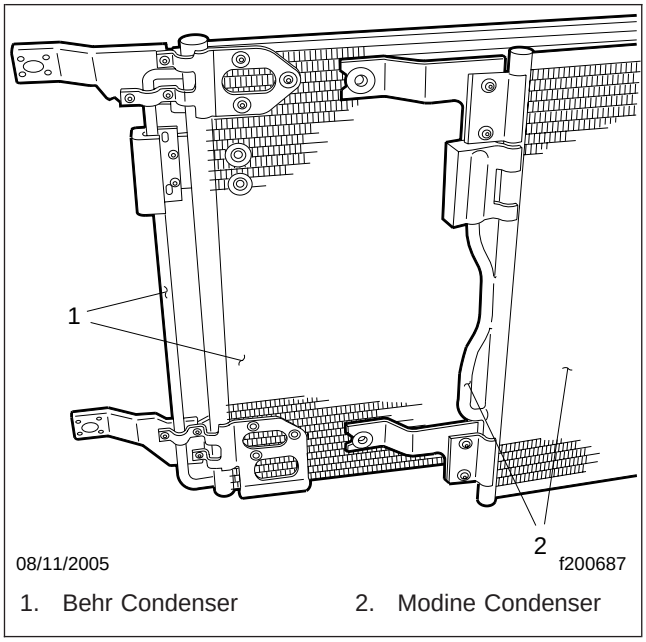
WARNING

R–134a is the only refrigerant that is approved for use on Freightliner vehicles. Several companies offer less expensive, hydrocarbon-based refrigerant, such as propane and methane. Use of these refrigerants will void the warranty on the air conditioning system, cause damage to the air conditioning system, and possibly result in personal injury or property damage. Leaking air conditioning systems charged with hydrocarbon-based refrigerants pose a serious risk of fire or explosion under the hood, or inside the passenger compartment. No vehicle built by Freightliner Trucks can be safely charged with hydrocarbon-based refrigerants, regardless of what the refrigerant supplier states.

When servicing an air conditioning system, be sure to use a refrigerant identifier to ensure that the system has not been charged with something other than R–134a. This should be standard practice since there is no way to tell what services have been previously performed. Identification by service technicians will help to avoid the risk of explosion and guard against contamination of equipment when refrigerant is recovered and recycled.

See **Fig. 1** for an illustration that shows the difference between the Behr and Modine condensers.

Temperature/pressure specifications and wiring diagrams for the blend air HVAC system can be found in **Section 83.06**, Subject 300.



1. Behr Condenser
2. Modine Condenser

Fig. 1, Behr and Modine Condensers

Refrigerant Oil Specifications		
Refrigerant Compressor Make	**Oil Type**	**Refrigerant Oil Capacity**
Sanden	PAG	10.1 oz (286 grams)
Climate Control	PAG	14 oz (397 grams)

Table 1, Refrigerant Oil Specifications

Refrigerant Charge Specifications		
Condenser Make	**Type of Cab**	**Refrigerant Amount**
Behr	Day Cab	2.875 lb or 2 lb 14 oz (1.30 kg)
	SleeperCab	3.438 lb or 3 lb 7 oz (1.56 kg)
Modine	Day Cab	3.25 lb or 3 lb 4 oz (1.47 kg)
	SleeperCab	3.75 lb or 3 lb 12 oz (1.70 kg)

Table 2, Refrigerant Charge Specifications

General Description

The sleeper heater and air conditioner assembly is mounted in either the baggage compartment or under the lower bunk, depending on the cab model, and contains the following major components. See **Fig. 1**.

- brushless blower motor
- evaporator
- heater core
- air filter
- actuator
- temperature control doors
- expansion valve
- CDTC temperature sensor

The heating and air conditioning functions of the sleeper heater and air conditioner system are controlled by the sleeper climate control panel. See **Fig. 2**.

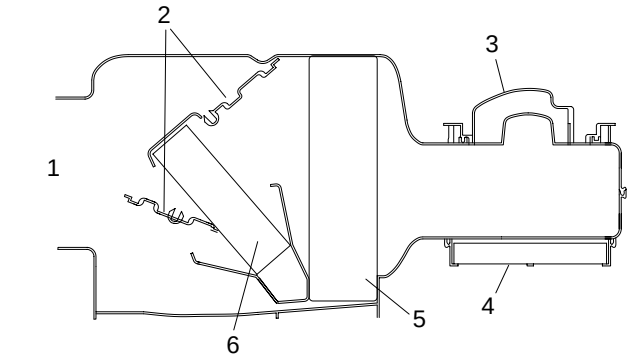
The cab climate control panel may have a bunk override (BUNK OVRD) switch that allows the driver to remotely control the fan speed and temperature settings in the sleeper. The bunk override mode can be canceled by adjusting the fan speed or temperature setting on the sleeper climate control panel when the bunk override mode is on. Refer to the *Century Class S/T and Coronado Driver's Manual* for operating instructions.

Principles of Operation

The sleeper heater and air conditioner system is a constant discharge temperature control (CDTC) system. The CDTC maintains a constant temperature of airflow in the sleeper regardless of outside air temperature, selected fan speed, or engine coolant temperature. Once the temperature control switch is turned to the desired temperature, no other adjustments are necessary.

The sleeper heater is plumbed directly to the engine, independent of the cab heater. The sleeper air conditioner is dependent on the cab air conditioning system, sharing the refrigerant and compressor.

When the air conditioner is operating, the amber indicator on the air conditioning button will be on whether the request for air conditioning comes from the cab climate control panel or the sleeper climate control panel. When the instrument panel lights are on, the blue snowflake indicator on the air conditioning button will be on.



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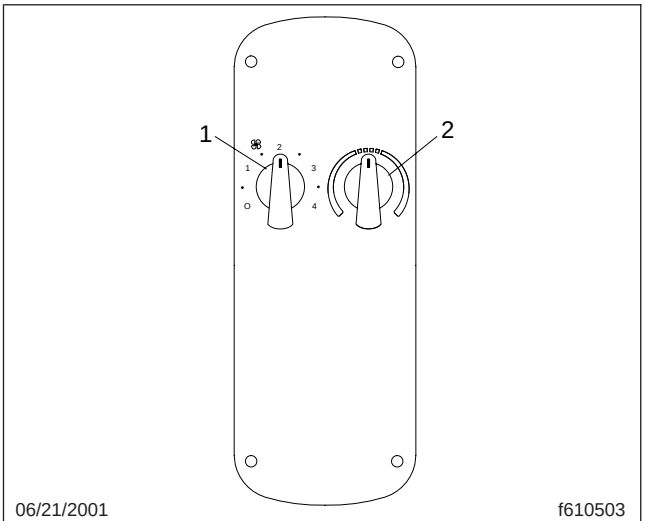
1. Air Outlet
2. Temperature Control Door
3. Blower
4. Air Inlet
5. Evaporator
6. Heater Core

Fig. 1, Sleeper Heater and Air Conditioner Unit



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1. Fan Switch
2. Temperature Control Switch

Fig. 2, Sleeper Climate Control Panel

Safety Precautions

Whenever repairs are made to any air conditioner parts that hold R–134a refrigerant, you must recover, purge or flush (if contaminated), evacuate, charge, and leak test the system. In a good system, refrigerant lines are always under pressure and you should disconnect them only after the refrigerant charge has been recovered (discharged) at the service valves.

Refrigerant R–134a is safe when used under the right conditions. Always wear safety goggles and non-leather gloves while recovering, evacuating, charging, and leak testing the system. Do not wear leather gloves. When refrigerant gas or liquid contacts leather, the leather will stick to your skin.

⚠ WARNING

Use care to prevent refrigerant from touching your skin or eyes because liquid refrigerant, when exposed to the air, quickly evaporates and will freeze skin or eye tissue. Serious injury or blindness could result if you come in contact with liquid refrigerant.

Refrigerant splashed in the eyes should be rinsed with lukewarm water, not hot or cold. Do not rub the eyes. Apply a light bandage and contact a physician right away.

Refrigerant splashed on the skin should be rinsed with lukewarm water, not hot or cold. Do not rub the skin. Apply a light coat of a nonmedicated ointment, such as petroleum jelly. Contact a physician right away.

R–134a refrigerant does not burn at ambient temperatures and atmospheric pressure. However, it can be combustible at pressures as low as 5.5 psig (139 kPa absolute) at 350°F (177°C) when mixed with air concentrations that are greater than 60 percent.

⚠ WARNING

R–134a air conditioning systems should not be pressure tested or leak tested with compressed air. Combustible mixtures of air and R–134a may form, resulting in a fire or explosion that could cause personal injury or property damage. The air conditioning system may be safely pressurized with dry nitrogen.

Always work in an area where there is a constant flow of fresh air when the system is recovered, evacuated, charged, and leak tested. R–134a vapors have a slightly sweet odor that is difficult to detect. Frequent leak checks and air monitoring equipment are recommended to ensure a safe working environment.

IMPORTANT: When servicing an R–134a air conditioning system, use only service equipment certified to meet the requirements of SAE J2210 (R–134a recycling equipment). The equipment should be operated only by qualified personnel who are familiar with the recycling station manufacturer's instructions.

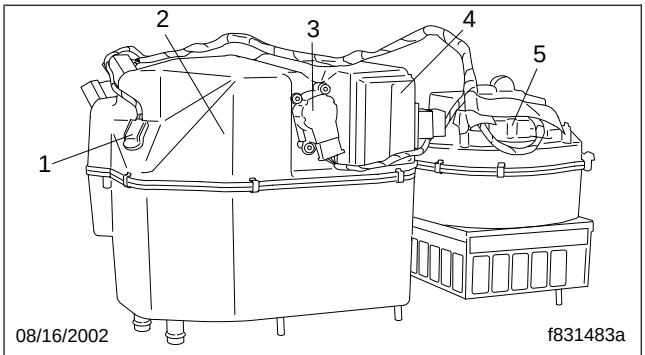
Because of its very low boiling point, refrigerant must be stored under pressure. To prevent the refrigerant containers from exploding, never expose them to temperatures higher than 125°F (52°C).

On R–134a refrigerant systems, polyalkylene glycol (PAG) oil is used in the compressor. When handling PAG oil, observe the following guidelines:

- Keep the oil free of contaminants.
- Do not expose the air conditioning system or the PAG oil container to air for more than five minutes. PAG oil has a high moisture absorption capacity and the oil container should be immediately sealed after each use.
- Use care when handling. Spilled oil could damage painted surfaces, plastic parts, and other components such as drive belts.
- Never mix PAG oil with other types of refrigerant oil.

Replacement

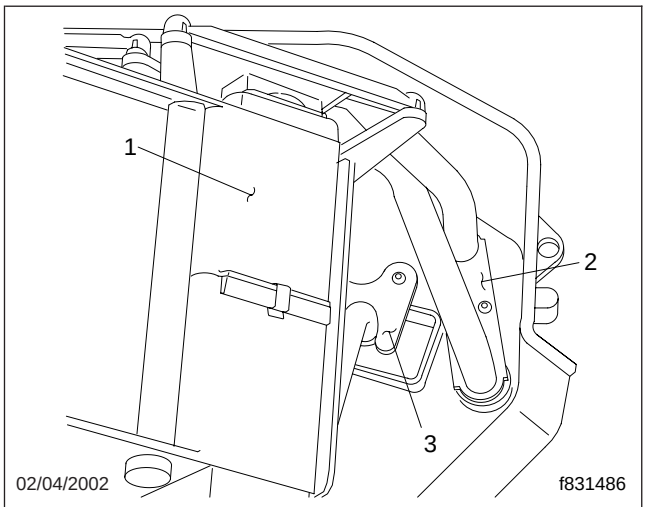
1. Turn off the engine, apply the parking brakes, and chock the tires.
2. Disconnect the batteries.
3. Recover the refrigerant from the air conditioning system. For instructions, see **Section 83.04**, Subject 220.
4. Drain the coolant from the cooling system. For instructions, see **Section 20.01**, Subject 100.
5. Remove the sleeper heater and air conditioner (HVAC) assembly from the vehicle. For instructions, see **Subject 150**.
6. Remove the capscrews that attach the temperature actuator to the HVAC assembly and remove the actuator. See **Fig. 1**.



1. CDTC Sensor
2. Sleeper HVAC Assembly
3. Temperature Actuator
4. Auxiliary Control Unit (ACU)
5. Blower Motor

Fig. 1, Sleeper HVAC Assembly

7. Remove the clips that attach the upper housing of the HVAC assembly to the lower housing. Remove the upper housing.
8. Remove the heater core subassembly from the HVAC assembly.
   - 8.1 Remove the capscrew that attaches the heater tube retention bracket to the lower housing and remove the bracket. See **Fig. 2**.
   - 8.2 Remove the heater core subassembly from the lower housing.

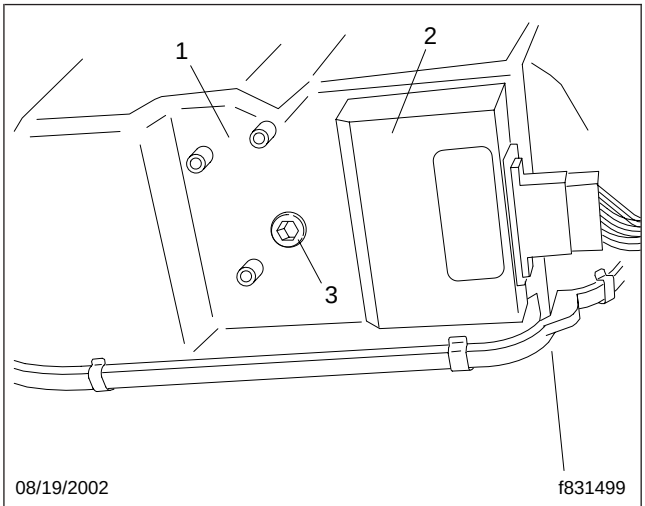


1. Heater Core Subassembly
2. Heater Tube Retention Bracket
3. Evaporator Tube Retaining Bracket

Fig. 2, Heater Core Subassembly

9. Spread the tabs to remove the heater core from the heater core housing. Remove the heater core.
10. Remove the heater core tubes from the heater core.
11. Attach the heater core tubes to the new heater core. Position the heater core tubes as shown in **Fig. 2**.
12. Install the heater core in the heater core housing. Press firmly on the heater core until the tabs are in the locked position.
13. Install the heater core subassembly in the lower housing. Make sure the heater core tubes protrude through the bottom of the housing.
14. Using a capscrew, attach the heater core tubes and the heater tube retention bracket to the lower housing.
15. Install the upper housing on the lower housing. Make sure the entire seam between the two housings is flush.
16. Check that the kinematic drive socket is aligned with the hole in the upper housing. See **Fig. 3**.
17. Using clips, secure the upper housing to the lower housing.

Heater Core Replacement



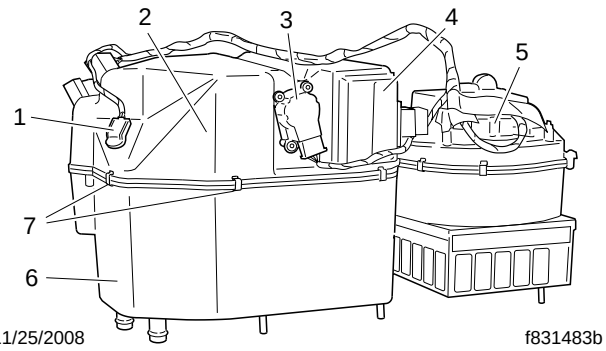
1. Upper Housing
2. Auxiliary Control Unit
3. Kinematic Drive Socket

Fig. 3, Upper Housing

18. Check that the temperature kinematic is working. Turn the kinematic drive lever and verify the temperature mix doors move when the drive lever is turned.
19. Install the temperature actuator.
    - 19.1 Align the actuator to the keyed shaft on the door.
    - 19.2 Using capscrews, attach the actuator to the HVAC assembly.
20. Install the HVAC assembly in the vehicle. For instructions, see **Subject 150**.
21. Fill the cooling system with coolant. For instructions, see **Section 20.01**, Subject 100.
22. Evacuate and charge the air conditioning system. For instructions, see **Section 83.04**, Subject 220.
23. Connect the batteries.
24. Remove the chocks from the tires.

Replacement

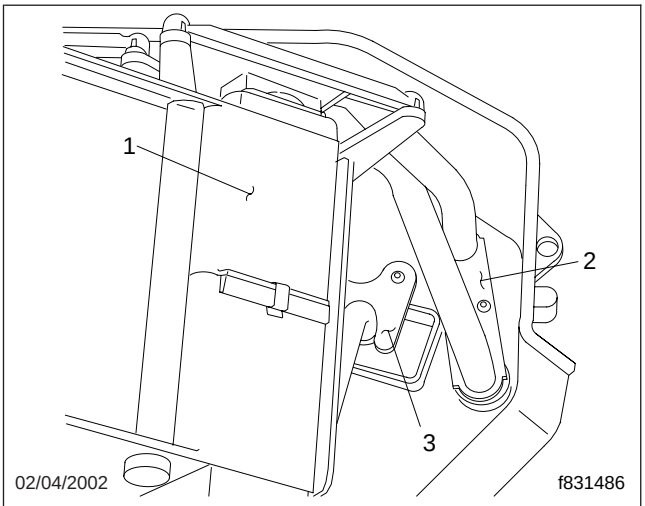
1. Turn off the engine, apply the parking brakes, and chock the tires.
2. Disconnect the batteries.
3. Recover the refrigerant from the air conditioning system. See **Section 83.04, Subject 220** for instructions.
4. Drain the coolant from the cooling system. See **Section 20.01, Subject 100** for instructions.
5. Remove the sleeper heater and air conditioner (HVAC) assembly from the vehicle. See **Subject 150** for instructions.
6. Remove the capscrews that attach the blend door actuator to the HVAC assembly, and remove the actuator. See **Fig. 1**.



1. CDTC Sensor
2. Upper Housing
3. Blend Door Actuator
4. Auxiliary Control Unit (ACU)
5. Blower Motor
6. Lower Housing
7. Clips

Fig. 1, Sleeper HVAC Assembly

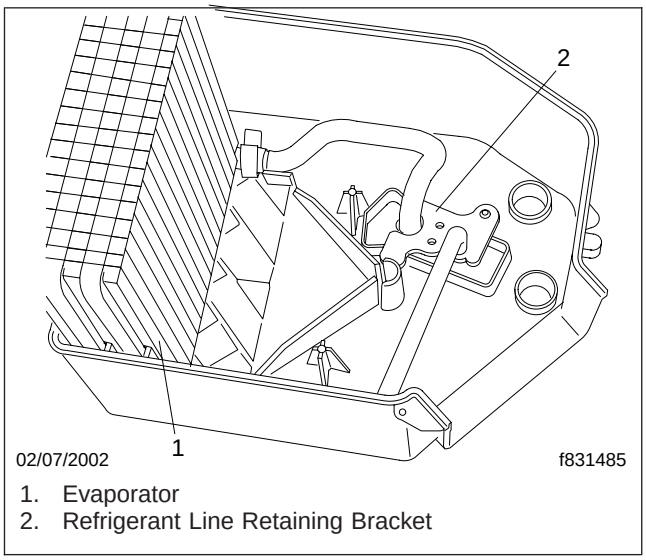
7. Remove the clips that attach the upper housing of the HVAC assembly to the lower housing. Remove the upper housing.
8. Remove the capscrew that attaches the heater tube retention bracket to the lower housing. See **Fig. 2**.
9. Remove the heater core subassembly from the lower housing.



1. Heater Core Subassembly
2. Heater Tube Retention Bracket
3. Refrigerant Line Retaining Bracket

Fig. 2, Heater Core Subassembly

10. Remove the capscrews that attach the refrigerant line retaining bracket to the lower housing. See **Fig. 3**.



1. Evaporator
2. Refrigerant Line Retaining Bracket

Fig. 3, Evaporator

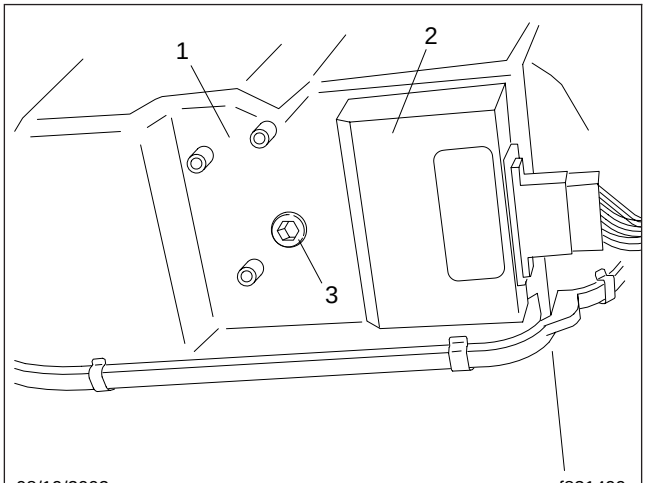
11. Remove the evaporator.
12. Remove the capscrews that attach the upper retaining plate and the expansion valve to the refrigerant lines. Remove the expansion valve.

Evaporator Replacement

13. Remove and discard the Mini Stat-O-Seals from the evaporator refrigerant lines.

IMPORTANT: Do not lubricate the Mini Stat-O-Seals prior to installation.

14. Install new Mini Stat-O-Seals on the evaporator refrigerant lines.
15. Using capscrews, attach the expansion valve and the upper retaining plate to the evaporator refrigerant lines. Tighten the capscrews 35 lbf·in (400 N·cm).
16. Install the evaporator in the lower housing, as follows.
    - 16.1 The base of the evaporator should rest on the condensate channels and the expansion valve should protrude through the bottom of the lower housing.
    - 16.2 Attach the refrigerant line retaining bracket to the housing. See **Fig. 3**.
17. Install the heater core subassembly in the lower housing. Make sure the heater core tubes protrude through the bottom of the housing.
18. Using a capscrew, attach the heater tube retention bracket to the lower housing. See **Fig. 2**.
19. Install the upper housing on the lower housing. Make sure the entire seam between the two housings is flush, and that the kinematic drive socket is aligned with the hole in the upper housing. See **Fig. 4**.
20. Using clips, secure the upper housing to the lower housing.
21. Check that the blend door kinematic is working. Turn the kinematic drive socket and verify the blend doors function correctly.
22. Align the blend door actuator to the drive socket. Then, using capscrews, attach the actuator to the HVAC assembly.
23. Install the HVAC assembly in the vehicle. For instructions, see **Subject 150**.
24. Fill the cooling system with coolant. For instructions, see **Section 20.01, Subject 100**.
25. Connect the batteries.
26. Evacuate and charge the air conditioning system. For instructions, see **Section 83.04, Subject 220**.



1. Upper Housing
2. Auxiliary Control Unit
3. Kinematic Drive Socket

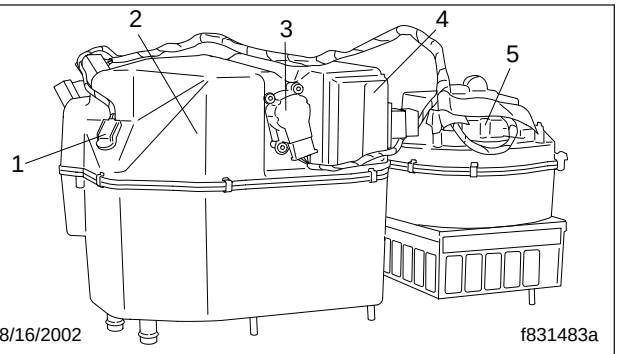
Fig. 4, Upper Housing

Replacement

1. Turn off the engine, apply the parking brakes, and chock the tires.
2. Disconnect the batteries.
3. Access the sleeper heater and air conditioner (HVAC) assembly.

   On vehicles with a baggage compartment on the right side of the cab, open the door to the baggage compartment.

   On vehicles without a baggage compartment on the right side of the cab, raise the mattress and bunk panel to the locked position.
4. Disconnect the electrical connector from the blower motor. See **Fig. 1**.



1. CDTC Sensor
2. Sleeper HVAC Assembly
3. Temperature Actuator
4. Auxiliary Control Unit (ACU)
5. Blower Motor

Fig. 1, Sleeper HVAC Assembly

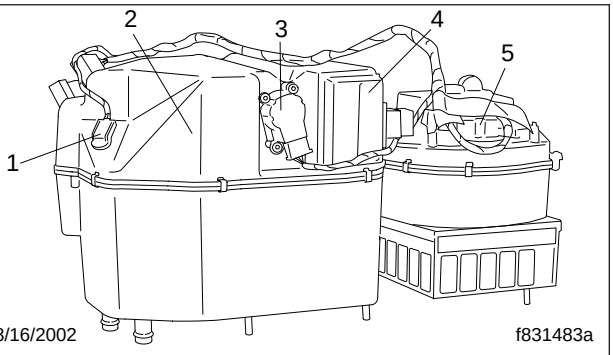
5. Remove the capscrews that attach the blower motor to the HVAC assembly and remove the blower motor.
6. Using capscrews, install a new blower motor on the HVAC assembly.
7. Connect the electrical connector to the blower motor.
8. Lower the sleeper mattress and bunk panel or close the baggage compartment door.
9. Connect the batteries.
10. Remove the chocks from the tires.

Replacement

1. Turn off the engine, apply the parking brakes, and chock the tires.
2. Access the sleeper heater and air conditioner (HVAC) assembly.

   On vehicles with a baggage compartment on the right side of the cab, open the door to the baggage compartment.

   On vehicles without a baggage compartment on the right side of the cab, raise the mattress and bunk panel to the locked position.
3. Remove the capscrews that attach the temperature actuator to the HVAC assembly. See **Fig. 1**.



1. CDTC Sensor
2. Sleeper HVAC Assembly
3. Temperature Actuator
4. Auxiliary Control Unit (ACU)
5. Blower Motor

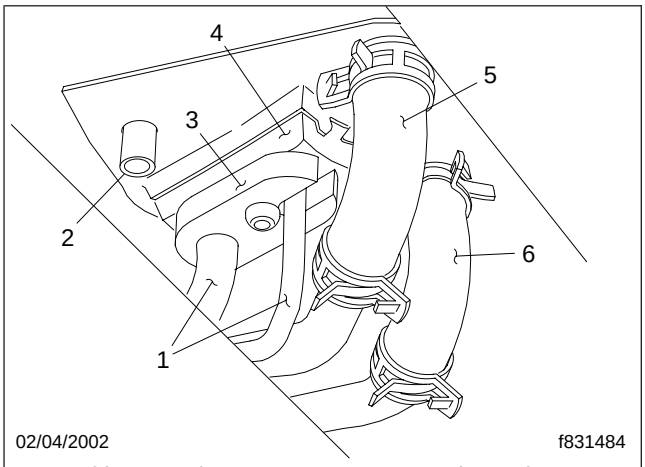
Fig. 1, Sleeper HVAC Assembly

4. Disconnect the electrical connector from the actuator and discard the actuator.
5. Connect the electrical connector to the new actuator.
6. Align the actuator to the keyed shaft on the door.
7. Using capscrews, attach the actuator to the HVAC assembly.
8. Lower the sleeper mattress and bunk panel or close the baggage compartment door.
9. Remove the chocks from the tires.

Heater and Air Conditioner Assembly Removal and Installation

Removal

1. Turn off the engine, apply the parking brakes, and chock the tires.
2. Recover the refrigerant from the air conditioning system. For instructions, see **Section 83.04**, Subject 220.
3. Drain the coolant from the cooling system. For instructions, see **Section 20.01**, Subject 100.
4. Place a drain pan under the sleeper on the right side of the vehicle to catch any coolant that may spill from the coolant lines. Remove the clamps that attach the coolant hoses to the coolant lines and remove the coolant hoses. See **Fig. 1**.



1. Refrigerant Line
2. Drain Tube
3. Retaining Plate
4. Expansion Valve
5. Coolant Return Line
6. Coolant Supply Line

Fig. 1, Expansion Valve

IMPORTANT: Under no circumstances should the expansion valve ports remain uncapped or the fittings remain unplugged for longer than five minutes total. Water and dirt can damage the refrigerant system. Do not blow shop air through refrigerant lines since shop air is wet (humid).

5. From under the sleeper on the right side of the vehicle, remove the capscrew that attaches the lower retaining plate and refrigerant lines to the expansion valve. Remove and discard the Mini Stat-O-Seals. Quickly cap the refrigerant lines. See **Fig. 1**.
6. From under the sleeper, remove the nuts and washers that attach the sleeper heater and air conditioner (HVAC) assembly to the floor of the sleeper.
7. Access the HVAC assembly.

   On vehicles with a baggage compartment on the right side of the cab, open the door to the baggage compartment.

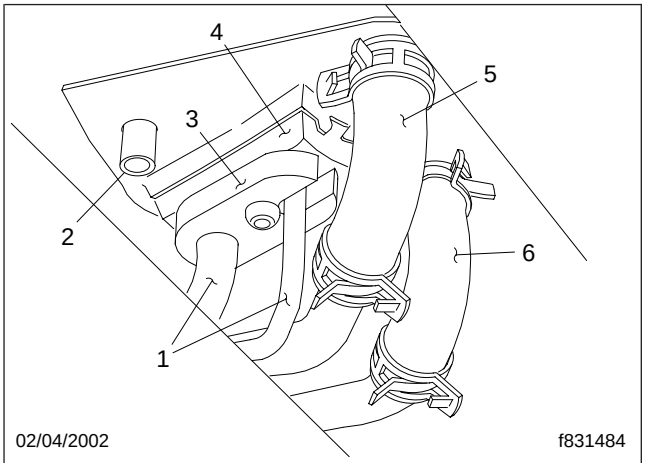
   On vehicles without a baggage compartment on the right side of the cab, raise the mattress and bunk panel to the locked position.
8. From inside the sleeper, disconnect the wiring harnesses from the HVAC assembly.
9. Remove the HVAC assembly from the vehicle.

Installation

1. Place the HVAC assembly on the floor of the sleeper. Make sure the heater core tubes, water drain tube, and mounting studs protrude through the floor.
2. Connect the wiring harnesses to the HVAC assembly.
3. From under the sleeper, install the washers and nuts on the mounting studs. Tighten the nuts 48 lbf·in (542 N·cm) maximum.
4. Uncap the refrigerant lines and install new Mini Stat-O-Seals on the refrigerant lines.
5. Using a capscrew, attach the lower retaining plate and the refrigerant lines to the expansion valve. Torque the capscrew 11 to 15 lbf·ft (15 to 20 N·m).
6. Fill the cooling system with coolant. For instructions, see **Section 20.01**, Subject 100.
7. Evacuate and charge the air conditioning system. For instructions, see **Section 83.04**, Subject 220.
8. Lower the mattress and the bunk panel or close the baggage compartment door.
9. Remove the chocks from the tires.

Replacement

1. Turn off the engine, apply the parking brakes, and chock the tires.
2. Recover the refrigerant from the air conditioning system. For instructions, see **Section 83.04**, Subject 220.
3. From under the sleeper on the right side of the vehicle, remove the capscrew that attaches the lower retaining plate and refrigerant lines to the expansion valve. Remove and discard the Mini Stat-O-Seals. Quickly cap the refrigerant lines. See **Fig. 1**.



1. Refrigerant Lines
2. Drain Tube
3. Retaining Plate
4. Expansion Valve
5. Coolant Return Line
6. Coolant Supply Line

Fig. 1, Expansion Valve

IMPORTANT: Under no circumstances should the refrigerant lines remain uncapped for longer than five minutes. Water and dirt can damage the refrigerant system. Do not blow shop air through refrigerant lines since shop air is wet (humid).

4. Remove the capscrews that attach the expansion valve to the upper retaining plate and remove the expansion valve.
5. Remove and discard the Mini Stat-O-Seals from the refrigerant lines.

IMPORTANT: Do not lubricate the Mini Stat-O-Seals prior to installation.

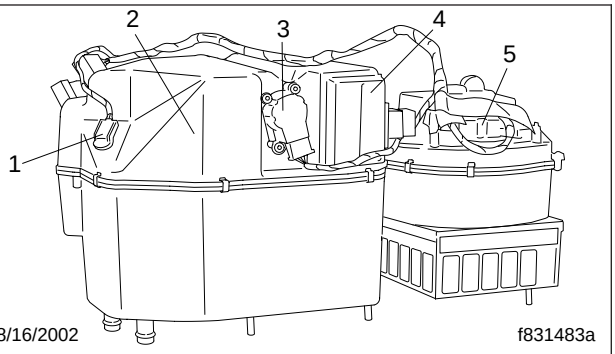
6. Install new Mini Stat-O-Seals on the evaporator refrigerant lines.
7. Using capscrews, attach the new expansion valve to the upper retaining plate. Using a torque wrench set to inch-pounds, tighten the capscrews 35 lbf·in (395 N·cm).
8. Uncap the lower refrigerant lines and install new Mini Stat-O-Seals on the refrigerant lines.
9. Using a capscrew, attach the lower retaining plate and the refrigerant lines to the expansion valve. Torque the capscrew 11 to 15 lbf·ft (15 to 20 N·m).
10. Evacuate and charge the air conditioning system. For instructions, see **Section 83.04**, Subject 220.
11. Remove the chocks from the tires.

Replacement

1. Turn off the engine, apply the parking brakes, and chock the tires.
2. Disconnect the batteries.
3. Access the sleeper heater and air conditioner (HVAC) assembly.

   On vehicles with a baggage compartment on the right side of the cab, open the door to the baggage compartment.

   On vehicles without a baggage compartment on the right side of the cab, raise the mattress and bunk panel to the locked position.
4. Disconnect the electrical connector from the auxiliary control unit (ACU). See **Fig. 1**.



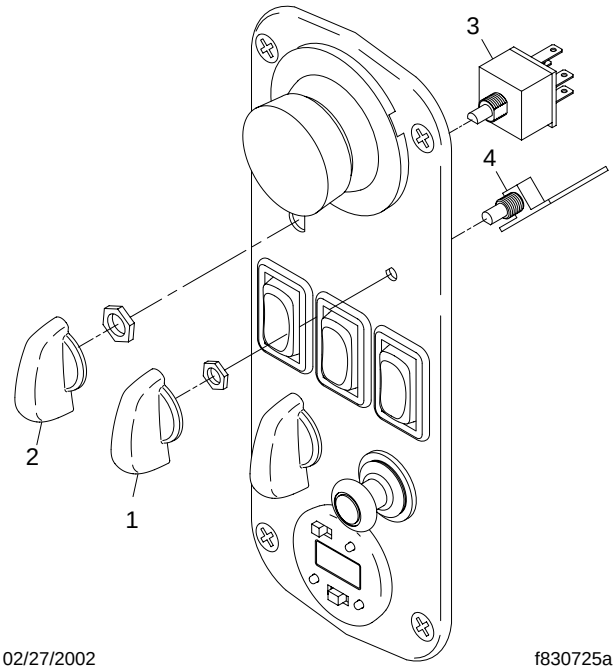
1. CDTC Sensor
2. Sleeper HVAC Assembly
3. Temperature Actuator
4. Auxiliary Control Unit
5. Blower Motor

Fig. 1, Sleeper HVAC Assembly

5. Release the clips at the bottom of the auxiliary control unit to remove the ACU from the HVAC assembly.
6. Connect the electrical connector to the new auxiliary control unit.
7. Install the new auxiliary control unit on the HVAC assembly.
8. Lower the sleeper mattress and bunk panel or close the baggage compartment door.
9. Connect the batteries.
10. Remove the chocks from the tires.

Fan Switch Replacement

1. Turn off the engine, apply the parking brakes, and chock the tires.
2. Disconnect the batteries.
3. Remove the Torx® fasteners that attach the climate control panel to the cab wall and pull the panel away from the wall. See **Fig. 1**.



1. Temperature Control Switch Knob
2. Fan Switch Knob
3. Fan Switch
4. Temperature Control Switch

Fig. 1, Climate Control Panel

4. Pull the fan switch knob off the fan switch.
5. Disconnect the electrical connector from the fan switch.
6. Remove the nut and pull the fan switch out of the control panel.
7. Using a new nut, install a new fan switch on the climate control panel.
8. Attach the fan switch knob to the fan switch.
9. Connect the electrical connector to the fan switch.
10. Using Torx fasteners, attach the climate control panel to the cab wall.
11. Connect the batteries.
12. Remove the chocks from the tires.

Temperature Control Switch Replacement

1. Turn off the engine, apply the parking brakes, and chock the tires.
2. Disconnect the batteries.
3. Remove the Torx fasteners that attach the climate control panel to the cab wall and pull the panel away from the wall. See **Fig. 1**.
4. Pull the temperature control switch knob off the temperature control switch.
5. Disconnect the electrical connector from the temperature control switch.
6. Remove the nut and pull the temperature control switch out of the control panel.
7. Using a new nut, install a new temperature control switch on the climate control panel.
8. Attach the temperature control switch knob to the temperature control switch.
9. Connect the electrical connector to the temperature control switch.
10. Using Torx fasteners, attach the climate control panel to the cab wall.
11. Connect the batteries.
12. Remove the chocks from the tires.

Specifications

WARNING

R–134a is the only refrigerant that is approved for use on Freightliner vehicles. Several companies offer less expensive, hydrocarbon-based refrigerant, such as propane and methane. Use of these refrigerants will void the warranty on the air conditioning system, cause damage to the air conditioning system, and possibly result in personal injury or property damage. Leaking air conditioning systems charged with hydrocarbon-based refrigerants pose a serious risk of fire or explosion under the hood, or inside the passenger compartment. No vehicle built by Freightliner Trucks can be safely charged with hydrocarbon-based refrigerants, regardless of what the refrigerant supplier states.

When servicing an air conditioning system, be sure to use a refrigerant identifier to ensure that the system has not been charged with something other than R–134a. This should be standard practice since there is no way to tell what services have been previously performed. Identification by service technicians will help to avoid the risk of explosion and guard against contamination of equipment when refrigerant is recovered and recycled.

Temperature/pressure specifications and wiring diagrams for the blend air HVAC system can be found in **Section 83.06**, Subject 300.

Refrigerant Oil Specifications		
Refrigerant Compressor Make	**Oil Type**	**Refrigerant Oil Capacity**
Sanden	PAG	10.1 oz (286 grams)
Climate Control	PAG	14 oz (397 grams)

Table 1, Refrigerant Oil Specifications

Refrigerant Charge Specifications		
Condenser Make	**Type of Cab**	**Refrigerant Amount**
Behr	Day Cab	2.875 lb or 2 lb 14 oz (1.30 kg)
	SleeperCab	3.438 lb or 3 lb 7 oz (1.56 kg)
Modine	Day Cab	3.25 lb or 3 lb 4 oz (1.47 kg)
	SleeperCab	3.75 lb or 3 lb 12 oz (1.70 kg)

Table 2, Refrigerant Charge Specifications

Diagnostic Overview

A/C cooling problems fit into two basic failure categories, refrigerant or electrical. The goal of this troubleshooting guide is to provide the information necessary to determine what part is causing the problem. We expect the tech to use approved tools and shop practices, symptom driven diagnostics, and warranty component evaluation guides to properly asses component failures. Refer to www.accessfreightliner.com for available tool information, service training, and warranty documentation.

For system performance testing, ambient temperature must be above 70°F (21°C) to produce reliable results. In order to quickly determine if your symptoms are refrigerant or electrical, two main tools should be utilized by the technician; ServiceLink and a refrigerant gauge set.

General Diagnostic Procedure

1. Perform the preliminary checks.
2. Perform an initial system inspection.
3. Make a determination about which system is suspected (refrigerant or electrical), and follow the symptoms through to a suspected part.
4. Repair the problem.
5. Verify that all of the refrigerant connections removed during the service are properly sealed using an approved refrigerant leak detector.
6. Verify that the problem has been resolved.

System Overview

The blend air system uses Constant Discharge Temperature Control (CDTC) to regulate the temperature in the vehicle. The CDTC is a closed-loop system that uses the climate control panel settings, the temperature sensors, and various J1587 databus inputs to control and maintain the outlet temperature of the system. The blend air system has an electronically controlled, brushless, direct current (BLDC) blower motor that does not require a resistor block to control the blower speed.

In the blend air system, all air is directed through the evaporator. The amount of air needing to be reheated is controlled by the temperature control door, which directs that amount of air through the heater core.

The cab HVAC assembly consists of a blower motor, evaporator, heater core, CDTC sensor, evaporator temperature sensor, and three electric actuators that drive the air direction control doors. The doors perform the following functions:

- temperature control door—controls how much air is directed through or around the heater core
- air selection mode door—directs airflow to the face, floor, or defrost outlets
- recirculation door—controls the amount of outside air that enters the HVAC unit

The cab climate control panel (front control unit) contains the microprocessor that controls the system.

The sleeper or auxiliary HVAC assembly consists of a brushless blower motor, evaporator, heater core, auxiliary control unit, air filter, CDTC temperature sensor, and an electric actuator that drives the temperature control door.

The refrigerant system consists of a compressor, condenser, receiver-drier, thermal expansion valve(s), and pressure sensors.

Preliminary Checks

NOTE: Pay attention to the refrigerant system components for evidence of oil seepage and other potential leaks that will be checked during subsequent diagnostic steps.

Before testing the operation of the air conditioning system, check the following items:

1. Inspect the drive belt and mounting fasteners for signs of wear or looseness.
2. Visually inspect the clutch for signs of over heating, damage, or wear. If necessary, check the clutch gap. For instructions, see **Section 83.01**, Subject 140.
3. Check for road debris buildup on the condenser coil fins. Using air pressure and a whisk broom or a soapy spray of water, carefully clean off the condenser. Be careful not to bend the fins.
4. Inspect the fresh and recirculation air filter elements, and inspect the intake-air ducting for debris.
5. With the engine off, and Optimized Idle (if applicable) disabled, turn the compressor drive plate by hand to feel for grinding or harshness inside the compressor.

Initial Inspection

1. Connect refrigerant pressure gauges and ServiceLink to the vehicle.
2. Start the vehicle and select A/C mode and a cold temp setting to request compressor engagement. If the following conditions are met, the clutch should engage.
    - The engine is running at, or above 450 RPM for at least 5 seconds.
    - Refrigerant system high side pressure is above 20 psi (140 kPa). Pressure reading is taken at the binary switch.
    - Refrigerant system high side pressure is below 450 psi (3100 kPa). Pressure reading is taken at the binary switch.
    - Vehicle compressed air system is above 60 psi (414 kPa). Pressure is taken at the dash ECU, and transmitted on the J1587 databus.
    - Evaporator core temperature sensor above 44°F (6.5°C). Temperature is taken in the main heater box, as a direct input to the FCU.
    - The blower feedback from the main HVAC unit is connected, and the signal is meeting the minimum RPM requirements for each knob position.

At this point you should be seeing some indication of a problem, either electrical or refrigerant.

Electrical—If there are any faults that affect the front control unit (FCU) or any of the parallel systems that provide input information to the FCU, or if the system requirements are being met, but the clutch is still not engaging, there may be an electrical problem related to the FCU, or the voltage signal to the compressor.

Refrigerant—If the low side pressure is drawing down far below 20 psi (140 kPa), or if the high side pressure is rising above 450 psi (3100 kPa), there is a refrigerant related problem.

Post-Repair Procedures

After repair work is completed, verify that the repair resolved the problem.

1. Verify that all of the refrigerant connections removed during the service are properly sealed using an approved refrigerant leak detector.
2. Check for fault codes. There should be no active fault codes that indicate the problem still exists.
3. If there is still a problem, repeat the appropriate tests, and make repairs as needed.
4. Verify again.

Refrigerant System Tests

Use the following procedure to evaluate the performance of the air conditioning system. If the system does not operate within the following guidelines, further diagnosis and repair may be necessary. The dash outlet temperature will fluctuate during each clutch cycle, and the temperature reading should be taken at the lowest value.

1. Park the vehicle out of direct sunlight, shut down the engine, and chock the tires.
2. Open the hood and leave the hood open for the entire test.
3. Open the driver and passenger doors and leave the doors open for the entire test.
4. Note the current ambient air temperature.

NOTE: High relative humidity reduces cooling and could increase the dash outlet temperatures, and high-side system pressures.

5. Using the ambient air temperature readings noted in the previous step, find the temperature/pressure specifications in **Table 1** that best match your ambient conditions.
6. Connect the test gauges to the high and low side service ports.
7. Place a thermometer in the center dash outlet. If the vehicle is a SleeperCab, place another thermometer in the lower sleeper outlet.

NOTE: EPA07 and owner-set idle limits may prevent the warm-up run from continuing without occasional throttle inputs.

8. Start the engine and run the A/C for 15 minutes.
9. Set the engine speed to 1500 rpm and engage the engine fan.
10. Set the cab climate control panel to the following settings:
    - air selection switch to face mode
    - air conditioning on
    - blower speed switch to high
    - temperature control switch to full cold
    - recirculation switch off
11. On SleeperCabs, set the sleeper climate control panel to the following settings (or initiate "bunk override" mode):
    - blower speed switch to high
    - temperature control switch to full cold
12. Allow the system to stabilize at least five minutes or until the dash and sleeper outlet temperatures have reached a minimum, then compare the system values to the information in **Table 1**. The results should be close to those listed, but minor discrepancies are not a guarantee that the system has a refrigerant system problem.

    Possible causes of refrigerant system complaints:
    - Too much oil - High high-side pressure, poor heat rejection at the condenser
    - Too much refrigerant - High high-side pressure, good cooling
    - No enough refrigerant - Low high-side pressure, low low-side pressure, poor cooling
    - Debris in the system - TXV plugged or uncontrollable, compressor turns hard, receiver/dryer is icing
    - Contaminated or incorrect refrigerant - Very inconsistent system pressures and duct temps

Refrigerant System Tests

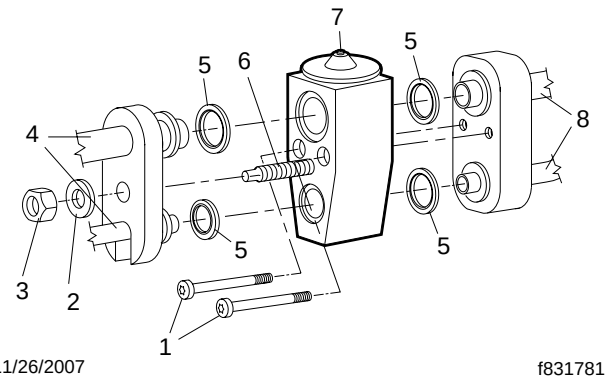
Approximate Temperature/Pressure Specifications at Moderate Humidity (less than 50%)					
Ambient Air Temp.	Center Dash Outlet Temp.	Service Port Pressures		A/C Compressor Status	A/C Compressor Status Comments
		High Side psi (kPa)	Low Side psi (kPa)		
65–75°F (18–24°C)	44–50°F (7–10°C)	94–124 (648–855)	18–25 (124–172)	approximately 50% duty cycle	Cycling on evaporator freeze protection
75–85°F (24–29°C)	45–60°F (7–16°C)	114–125 (786–862)	20–26 (138–179)	approximately 75% duty cycle	
85–95°F (29–35°C)	55–70°F (13–21°C)	135–170 (931–1172)	23–28 (158–193)	On	On steady
95–105°F (35–41°C)	65–80°F (18–27°C)	160–200 (1003–1379)	25–30 (172–207)	On	On steady

Table 1, Approximate Temperature/Pressure Specifications at Moderate Humidity (less than 50%)

Thermal Expansion Valve Testing

General

The thermostatic expansion valve (TXV) (see **Fig. 1**) is a controlling device that regulates the flow of refrigerant into the evaporator. It is actuated by changes in evaporator pressure and the superheat of the refrigerant gas leaving the evaporator. Superheat is defined as any temperature of a gas above the boiling point for that liquid. For example, when a refrigerant liquid boils at a low temperature of 40°F (4.5°C) in the evaporator and then the refrigerant gas increases in temperature, superheat has been added. If this refrigerant changed from a liquid to a gas or vapor at 40°F (4.5°C) and then the refrigerant vapor increased in temperature to 50°F (10°C), then it has been superheated by 10°F (6.5°C). The refrigerant entering the evaporator is metered at a rate that matches the amount of refrigerant being boiled off in the evaporator. In addition to metering refrigerant, the TXV also provides a pressure drop in the system, separating the high-pressure side of the system from the low-pressure side. To operate properly, the TXV must have a steady flow of liquid refrigerant supplied to it by the high side of the system. Issues such as an excessively low refrigerant charge, or contaminates in the system can interrupt this flow of liquid to the valve. In these cases, symptoms may surface making it seem as if the valve is inoperative or plugged. These symptoms can include poor performance, low low-side pressures (even a vacuum) ,etc. Before replacing a TXV, it is important to verify that there are no contaminates in the system and that the refrigerant charge is correct, by performing a refrigerant identification and thorough leak check of the entire system. The TXV is often incorrectly replaced as the primary failed part, but is rarely the cause of a performance issue. In rare instances the power element of the TXV can loose its charge, reducing the range of the TXV, but there is no other situation that can be considered a failure of the TXV. Due to the similarity of symptoms that these root causes have on A/C performance, proper diagnosis is essential to making the correct repairs to the A/C system.



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1. Screw (2)
2. Washer
3. Nut
4. Refrigerant Lines to J-Block
5. Seal
6. Stud
7. Thermal Expansion Valve
8. Refrigerant Lines to Evaporator

Fig. 1, Thermal Expansion Valve Installation

Diagnostics

To determine if the TXV is functioning, watch the low-side pressure while the compressor is engaged. The influence from the TXV modulating can be seen as the low-side gage needle "wags." As the load on the system changes from ambient conditions, the TXV may not wag as much, and care must be taken to prevent false diagnosis. The function of the individual TXVs in a dual evaporator system will be combined to produce the total pressure needle waging that is observed. If a TXV failure is suspected, connect the gage set to the properly charged refrigerant loop, and run the compressor. Watch for the low-side gage needle to wag, indicating that the TXV is working. Depending on the load, the low-side pressure may progress from moderate to high, but the needle will simultaneously wag as the average pressure changes.

Leak Detection

General

The information in this section is intended to convey a general method of leak detecting that should be used to enhance the usefulness of a leak detector being used in accordance with operator's instructions provided by the manufacturer. No technician should attempt to perform leak detection without reading and understanding the owners manuals for the tools being used, and should expect to review those instructions from time to time, to ensure the proper method continues to be used. The process described here was developed using the published list of recommended tools and warranty evaluation guides as a basis for the expectations for repair competence. The only way to confirm that a refrigerant leak exists is by finding a failed or damaged component. A UV flashlight and goggles can be used to provide an indication of a leak, but a approved electronic leak detector must be used to confirm the existence of a leak, and approximate the leak rate. The connections used for A/C refrigerant are intended to seal properly, but given the high level of sensitivity provided by current leak detecting equipment, the detector may indicate a leak even though the connection meets the design specifications. To balance this, the "Acceptable Leak Rates by Component" table in **Specifications** contains the qualifying leak rates for the components used on P2 vehicles. The leak rates, in oz/yr, correspond to the sensitivity values required for all detectors that meet the SAE J2791 functional specifications. By switching between the sensitivity levels, it is possible to discern between leaks of varying sizes and qualify each potential leak. It is expected that a leak rate relates to each component, as it arrives at the factory, but the Mini-Statoseals that connect the components together are specified separately. Additionally, due to the possible difficulty of distinguishing between two minor leaks at a multi-port connection, the leak rate for two Mini-Statoseals should be considered a condemning value if it is not completely clear which seal is leaking.

Method

IMPORTANT: The refrigerant system should be warmed up from completion of the initial inspection, but the engine is off.

1. Shut down the engine.
2. Before testing for compressor leaks, blow shop air near the compressor shaft seal to clear any refrigerant that may have collected.
3. Install caps before testing the service ports.
4. Minimize the amount of wind blowing through the test area, as this will make small leaks harder to find.
5. Set the detector on the most sensitive setting.
6. Start at a point along the refrigerant loop, and methodically follow the refrigerant path, test all around O-ring connections and crimped ends until you reach the starting point.
7. When the detector indicates a suspected leak, move it away from the suspect area, then recheck to the location after the detector has cleared.
    - If the detector continues to indicate a leak, adjust the sensitivity of the detector to match the designed leak specifications shown in "Acceptable Leak Rates by Component" Table, in **Specifications**, and retest the suspected area to confirm the leak.
    - Mark any confirmed leaks, then change the sensitivity back to high and continue checking the system.
8. After the entire system has been checked, recover the refrigerant, investigate each leak point to determine what component failed, and how, then repair leak.

9. Recharge the refrigerant system, then use the electronic leak detector to confirm that each connection opened during the repair is sealed within the design specifications provided in the "Acceptable Leak Rates by Component" table in **Specifications**.

Sanden Compressor Testing, Pressure or Pumping Test

NOTE: This test is meant to be performed after a failure has been repaired, which may have caused damage to the compressor due to low refrigerant or oil levels.

Compressors cause refrigerant to flow through the system by creating a pressure differential, high and low pressures. If the compressor can be forced to produce a high pressure in excess of 350 psi (2415 kPa) it is a good compressor.

IMPORTANT: The compressor pumping test must be performed with the refrigerant system charged to the factory specifications, and functioning properly. This test should only be run for a short time period. Shut the system down immediately once 350 psi (2415 kPa) is achieved.

1. Confirm the system is charged per the OEM requirement before proceeding.
2. Disable the engine cooling fan. The condenser can also be blocked with sheet of cardboard. The purpose is to limit heat removal from the system and build compressor discharge pressure.
3. Start engine and engage the compressor clutch.

   Compressors operating within specification should be capable of reaching 350 psi (2415 kPa).
4. Shut the system down immediately, once 350 psi (2415 kPa) is achieved.

Electrical Component Checking

Blower Motor

General Information

The blower used in the blend air HVAC system is a brushless DC motor (BLDC). The FCU or ACU provides a DC voltage signal to the motor to control speed. This eliminates the need for a resistor block as used on the water-valve controlled HVAC system. The blower motor provides a feedback signal to the FCU or ACU to indicate blower speed and error conditions.

Delayed Speed Change

When the blower speed is changed on the control panel, a delay in actual speed change is normal. The speed will ramp up or down at 1000 rpm per second. Therefore, if the fan is off and then turned on high speed, it will take approximately six seconds for the fan to actually reach full speed.

Starting Sequence Protection Mode

In case the blower motor does not start (the feedback line indicates zero speed), the FCU or ACU will apply five consecutive starting sequences. If all five starting sequences are unsuccessful, the blower motor electronic module enters a starting sequence protection mode. The module will no longer attempt to start the blower motor until the control signal from the FCU or ACU is reset to zero. See "Blower Rotor Stall Protection Mode." This means one of the following must occur:

- Turn the blower speed switch to the off position, then back on.
- Cycle the ignition switch.
- Disconnect/reconnect the blower motor connector.

Possible reasons the blower motor may enter the starting sequence protection mode include:

- locked blower motor rotor
- open circuit in blower motor feedback signal line
- faulty blower motor

Temperature Protection Mode

The blower motor has an internal temperature sensor connected to the blower motor electronic module. The electronic module monitors the blower temperature and enters a protection mode when normal temperature is exceeded. When the blower motor enters protection mode, the blower speed is reduced to 1000 rpm to reduce the load on the motor. When the motor temperature has lowered to the normal range, the blower speed resumes operation according to the control panel settings.

If the temperature continues to rise or remains too high after the blower speed is initially reduced, then the speed is further reduced to minimum speed (about 400 rpm) and then the blower motor stops. Once the blower motor temperature returns to normal, the blower speed resumes operation according to the control panel settings. No reset is required.

Blower Motor Voltage Protection Mode

The blower motor electronic module monitors the voltage supply to the motor and enters a protection mode when the voltage is too high or too low. The protection mode works as described in **Table 1**.

Blower Motor Voltage Protection Mode Conditions

Voltage at the Motor	Results
under 8.5 VDC	Blower motor will shut off and will not restart until the voltage reaches 10.5 VDC and will operate at reduced speed if voltage is under 12VDC.
8.5 to 12.0 VDC	Blower motor will operate at reduced speed. The reduced speed varies with voltage. The lower the voltage, the slower the blower speed.
12.0 to 17.0 VDC	Blower motor operates normally at user selected speed.

Electrical System Tests

Blower Motor Voltage Protection Mode Conditions	
Voltage at the Motor	**Results**
over 17.0 VDC	Blower motor will shut off. Will not restart until voltage reaches 16 VDC.

Table 1, Blower Motor Voltage Protection Mode Conditions

Blower Motor Stall Protection Mode

The blower motor electronic module monitors the blower for a locked rotor condition. If the rotor is locked starting from an off condition, the electronic module will attempt a starting sequence before entering this protection mode. See "Starting Sequence Protection Mode." If the blower rotor locks up and stalls from a running condition, the blower will immediately enter this protection mode. The blower motor will not restart until the blower speed control signal has decreased to minimum by cycling the ignition, or turning the blower speed control from on to off, then back on, and the stall condition has disappeared.

Speed/Diagnostics Feedback Line

The blower motor supplies diagnostic and speed information to the FCU/ACU. See **Table 2** and **Table 3**.

Blower Motor Feedback Signal From Blower to FCU or ACU*		
Speed/Error Conditions	**Signal**	**Duty Cycle**
Blower Speed	Three one-millisecond pulses per revolution. Blower speed is determined by the time between each set of three pulses. Time can be viewed using an oscilloscope. rpm=1/(time between sets of three pulses) x 60	NA
Error—temperature protection mode	10Hz	25%
Error—voltage protection mode	10Hz	50%
Error—blocked rotor	10Hz	75%

* Blower speed and diagnostic information are both provided by the BLDC blower motor on the feedback signal wire; however, the FCU and ACU only use the blower speed information.

Table 2, Blower Motor Feedback Signal from Blower to FCU or ACU

Blower Speed Control Signal From FCU or ACU to Blower*†			
Knob Position	**FCU Signal (DC volts)‡**	**Blower Speed (rpm)**	**Blower Speed Comments**
0	0.0 to 0.74	0	Constant speed in this range
1	0.75 to 1.0	400	Constant speed in this range

Blower Speed Control Signal From FCU or ACU to Blower*†			
Knob Position	**FCU Signal (DC volts)‡**	**Blower Speed (rpm)**	**Blower Speed Comments**
2	1.5	800	Speed varies linearly with voltage in this range.
3	2.0	1200	
4	2.5	1600	
5	3.0	2000	
6	3.5	2400	
7	4.0	2800	
8	4.5	3200	
9	5.0+	3600	
10	5.5+	4000	Constant speed above this range

* Error conditions can be monitored on the feedback signal line using a digital multimeter equipped with a duty cycle function.

† Blower speed and diagnostic information are both provided by the BLDC blower motor on the feedback signal wire; however, the FCU and ACU only use the blower speed information.

‡ These values are based on a system operating voltage of 13.5 VDC.

Table 3, Blower Speed Control Signal from FCU or ACU to Blower

A/C Clutch Circuit

General Operation

The air conditioner compressor clutch is controlled by the FCU. When certain inputs to the FCU are met, the FCU sends the A/C request signal to the A/C clutch relay located in the PDM. This signal is +12 VDC. The request signal causes the A/C clutch relay to make contact between the common and normally open contacts of the relay. This allows current to flow through the relay, then through the binary pressure switch and to theA/C compressor clutch, thus engaging the compressor.

In steady state operation, compressor cycling is controlled by two things: evaporator temperature sensor and an internal FCU timer that prevents the compressor from cycling more than four times per minute. The A/C request signal does not become active until the evaporator temperature sensor is at least 44°F (7°C). See **Table 4**. Once the signal is active and as long as the other conditions are met, the signal remains active until the evaporator temperature sensor reaches 37°F (3°C), then becomes inactive. The A/C request signal does not activate again until the temperature is above 44°F (7°C). With the A/C on in warm or humid weather, the evaporator temperature will most likely remain between 37 to 44°F (3 to 7°C), thus keeping the compressor on continuously.

When the blower speed control is set to any speed other than off, and the air selection switch is set to any setting other than one of the defrost modes, then the user may request A/C by pressing the A/C button. The light on the button turns on and the FCU is placed in A/C mode, thus allowing the compressor to engage when other conditions are met. If the air selection switch is in any of the defrost settings, then the A/C mode is turned on automatically and cannot be turned off by pressing the A/C button.

FCU A/C Request Rules*		
Input	**Input Type**	**State All Inputs Must Be for the FCU to Send A/C Request Signal**
Ignition power	+12V	On
Engine speed	J1587	Above 450 rpm for at least 5 seconds

Electrical System Tests

FCU A/C Request Rules*		
Input	**Input Type**	**State All Inputs Must Be for the FCU to Send A/C Request Signal**
Low air	J1587	Not low
Evaporator temperature sensor	Sensor	Above 44°F (7°C)
A/C switch/light	Control panel	On
Air selection switch	Control panel	Any A/C or defrost setting except when rear override is active
Temperature control switch	Control panel	Any
Fan switch	Control panel	Any setting other than off except when rear override is active; fan will be at least minimum speed.
Compressor cycling timer	Internal FCU logic	15 seconds elapsed since A/C request last active
Main Blower Feedback Signal	Rotational Signal (Hz)	No active faults from the blower feedback signal

* If any input state does not meet the conditions listed in this table, A/C request will not be sent. The only exception is when the sleeper unit requests A/C support by going into rear override mode. See "Cab Override."

Table 4, A/C Request Rules

A/C Mode

The auxiliary HVAC system has the ability to request A/C causing the FCU to engage the compressor. For more information, see "Cab Override."

Once the HVAC system is in A/C mode, the system is able to send the A/C request when all the conditions are met. See **Table 4**. When the system is in A/C mode, the light on the A/C button comes on. Just because the system is in A/C mode does not necessarily mean that the A/C compressor should be engaged. See **Table 4** for A/C request rules.

NOTE: If the air selection switch is changed to defrost when in A/C mode, the A/C mode will remain active and the light on the A/C button will remain on. When in defrost, the user will not be able to cancel A/C mode by pressing the A/C button. If the mode is changed back to A/C, the A/C mode will remain on, but the user will be able to turn it off by pressing the A/C button. See **Fig. 1**.

NOTE: The A/C mode is remembered after an ignition cycle. If the A/C mode indicator was on because the A/C button was pressed before an ignition cycle or battery kill switch cycle, the FCU will remember this mode and activate it again after the cycle.

Defrost Mode

When the HVAC system is in defrost mode, A/C mode is automatically activated and the system is able to send the A/C request when all the conditions are met. When the system is in defrost mode, the light on the A/C button is on. Just because the system is in defrost mode does not necessarily mean that the A/C compressor should be engaged. See **Table 4** forA/C request rules.

NOTE: If the mode is taken out of defrost, A/C mode and the light will be deactivated unless the system was in A/C mode prior to being in defrost mode. When the system is in defrost mode, A/C mode cannot be disabled by pressing the A/C button. See **Fig. 2**.

A/C Request

Once A/C mode is activated, the A/C compressor clutch can be engaged when all the engagement rules are met. The A/C request rules are described in **Table 4**.

Recirculation

Recirculation Mode

Recirculation mode allows the driver to choose between fresh air or recirculated air moving through the HVAC system. When recirc mode is selected, all of the air through the front HVAC unit is recirculated

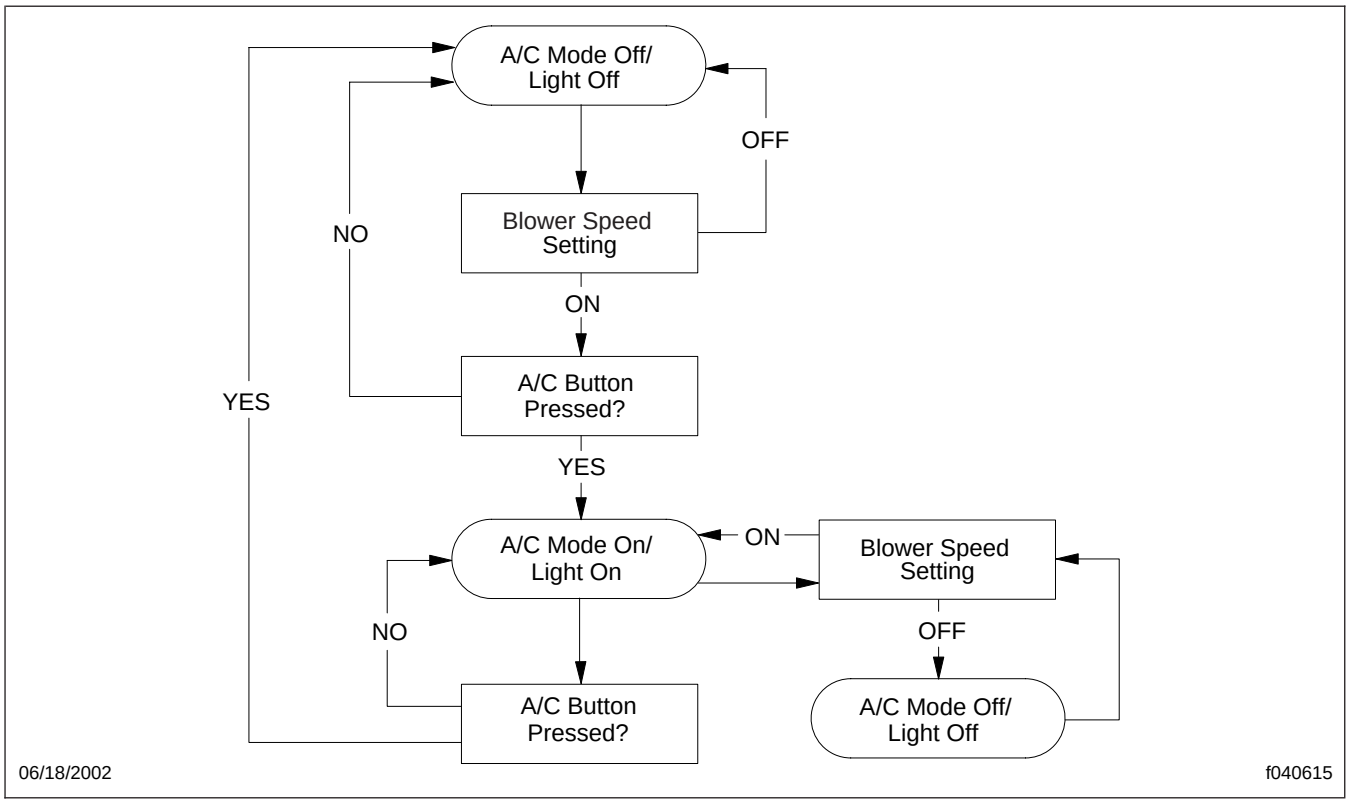


Fig. 1, A/C Mode Function When Not in Defrost Mode

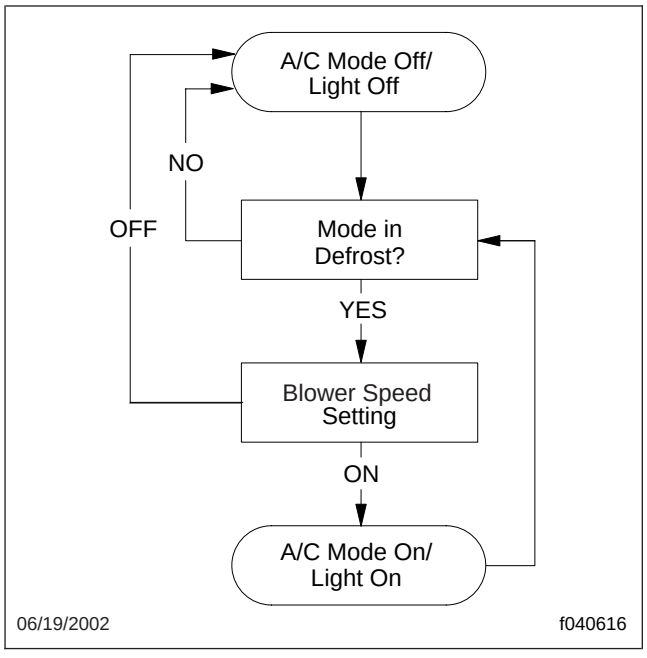


Fig. 2, A/C Mode Function When in Defrost Mode

within the cab, except when the unit is in partial recirc mode, which is explained in "Partial Recirc Mode."

Using the recirculation mode prevents dusty or smoky air from entering the cab and provides better air conditioning performance since the cab air is already cooled and less humid than outside air. Humidity holds a lot of heat.

Partial Recirc Mode

After recirc mode has been on for 20 minutes, the system enters partial recirc mode to introduce a controlled amount of fresh air to the cab. This prevents the air from becoming stagnant if left in recirc mode. The recirc door partially opens to one of two partially open positions depending on vehicle speed. When the vehicle is stopped or moving very slowly, the recirc door opens to its widest partially open position. When the vehicle is moving at slow to moderate speeds, the recirc door opens to its most narrow partially open position. Pressing the recirc button again

resets the 20-minute timer and the system goes into full recirc again. See **Table 5** for information on partial recirc.

Partial Recirc Operation			
Condition	**Vehicle Speed**	**Partial Recirc Door Opening**	**Partial Recirc Door Opening Approximate Height: inch (mm)**
Initial partial recirc position after 20 minutes of full recirculation	Under 5 mph (8 km/h)	Wide	1-1/4 (32)
	Over 5 mph (8km/h)	Narrow	1/8 to 1/4 (3 to 6)
Partial recirc position once initial position is reached	Under 2 mph (3 km/h)	Wide	1-1/4 (32)
	2–8 mph(3–13 km/h)	No change	Either 1-1/4 (32) or 1/8 to 1/4 (3 to 6) depending on vehicle speed prior to entering the 2 to 8 mph (3 to 13 km/h) range.
	Over 8 mph (13km/h)	Narrow	1/8 to 1/4 (3 to 6)

Table 5, Partial Recirc Operation

Recirc Diagnosis

To see the recirc door, remove the heater and air conditioner cover and the recirculation air filter. See **Fig. 3**. When the system is not in recirc mode, the recirc door is fully open. When the system is in recirc mode, the recirc door is closed tight. See **Fig. 3**.

To check partial recirc, turn the engine on and activate the full recirc mode for 20 minutes. After 20 minutes, with the vehicle idling in the shop, the recirc door should open to its widest partially open position. To check if the recirc door adjusts to the narrow, partially open position, have someone drive the vehicle over 8 mph (13 km/h) while observing the recirc door. See **Fig. 3**. Compare the width of the recirc door opening to the values in **Table 5**. If the recirc door does not function as described, check the recirc actuator motor and wiring. If okay, the FCU is probably faulty.

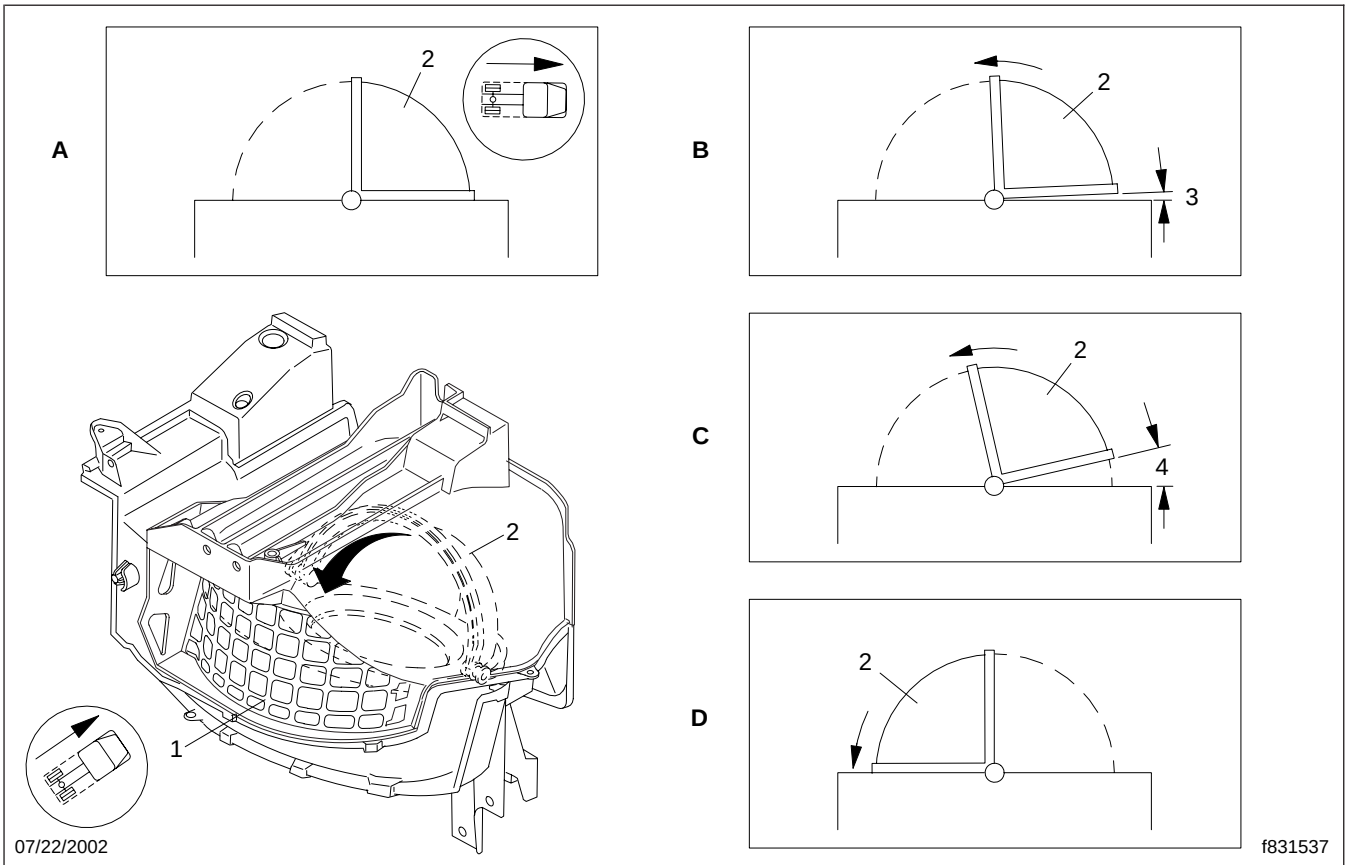
Override

Bunk Override

The auxiliary unit can be controlled from the front control panel by using the bunk override switch. When the upper half of the bunk override switch is pressed to the momentary on position, the front unit broadcasts a snapshot of the front temperature and blower speed settings to the auxiliary unit. The auxiliary unit matches these settings. The temperature and blower speed settings on the front unit can be changed without affecting the auxiliary unit, until the bunk override switch is pressed in the momentary on position again.

When the lower half of the bunk override switch is pressed, bunk override mode turns off and the auxiliary unit reverts to the auxiliary control settings. If the auxiliary control panel settings are changed when the system is in bunk override mode, bunk override will be canceled and the auxiliary unit will operate using the auxiliary control panel settings. See **Table 6** for information on bunk override functionality.

NOTE: If bunk override is activated and then the front blower or temperature settings are changed and the ignition key is cycled, then the bunk override will be active again, but the auxiliary unit will track the new front settings.



A. In recirc mode the recirc door is in the fully closed position.
B. Recirc door in the narrow, partially open position.
C. Recirc door in the widest, partially open position.
D. In non recirc mode the recirc door is in the fully open position.

1. Recirculation Air Filter Retainer
2. Recirc Door
3. Narrow Partially Open Position of approximately1/8 to 1/4 in (3 to 6 mm)
4. Widest Partially Open Position of approximately1-1/4 in (32 mm)

Fig. 3, Recirc Door Operation

Electrical System Tests

Bunk Override Functionality		
Action	**J1587 Messaging/Control**	**Bunk Override Indicator**
Press the upper half of the bunk override switch to turn it on; initially off	When the bunk override switch is pressed to the momentary on position (bunk override mode previously off), the FCU sends a J1587 message to the auxiliary unit requesting that the auxiliary unit go into bunk override mode. The auxiliary unit then goes into bunk override mode and sends a J1587 message to the front unit indicating that bunk override mode in the auxiliary unit is on. Upon receiving this message, the front unit responds by broadcasting a J1587 message that bunk override mode in the front unit is on as well. The front unit then sends a different J1587 message to the auxiliary unit containing the control set points as follows: • blower speed setting • temperature control setting • temperature door position	On NOTE: The indicator on the bunk override switch turns on when the upper half of the switch is pressed.
	The auxiliary unit receives this message and disregards its own temperature and blower speed settings and adjusts its settings to match the front unit settings. The auxiliary unit uses the temperature door position setting as a starting point, then it goes into CDTC operation to maintain the new desired temperature. Blower speed is adjusted to match the front control setting. At this point, the front control panel blower and temperature settings can be changed without affecting the auxiliary unit blower speed and temperature. NOTE: With DataLink Monitor connected to *some early blend air systems*, the auxiliary unit will continuously update its control settings to match the front unit when the system is in bunk override mode. This is not how the system operates without DataLink Monitor connected to the vehicle. The auxiliary unit will maintain the new temperature and blower settings until one of the following occurs: • temperature or blower speed settings changed on the auxiliary control panel • the bunk override switch is pressed to the momentary on or off position • ignition is cycled NOTE: If bunk override was active before an ignition cycle, it will also be active after the ignition cycle, but the auxiliary unit will track the current front setting at the time the ignition is switched on again.	

Bunk Override Functionality		
Action	**J1587 Messaging/Control**	**Bunk Override Indicator**
Press the upper half of the bunk override switch again to the momentary on position; bunk override was already on	When the system is already in bunk override mode and the upper half of the bunk override switch is pressed to the momentary on position, the front control unit sends a new J1587 to the auxiliary unit containing the following new set points: • blower speed setting • temperature control setting • temperature door position The auxiliary unit receives this message and disregards the previous temperature and blower control settings and adjusts its settings to match the new front unit settings (this assumes the front blower setting or temperature setting was changed after the initial bunk override). The auxiliary unit uses the temperature control door position setting as a starting point. Then it goes into CDTC operation to maintain the new desired temperature. Blower speed is adjusted to match the front control setting. NOTE: With DataLink Monitor connected to *some early blend air systems*, the auxiliary unit will continuously update its control settings to match the front unit when the system is in bunk override mode. This is not how the system operates without DataLink Monitor connected to the vehicle. On these early systems you will not be able to change the front settings and update the auxiliary unit with a press of the bunk override switch. The auxiliary unit will maintain the new temperature and blower settings until one of the following occurs: • temperature or blower speed settings changed on the auxiliary control panel • the bunk override switch is pressed to the momentary on or off position • ignition is cycled	On
Press the lower half of bunk override switch to the momentary off position; bunk override mode was on	When the bunk override switch is pressed to the momentary off position (bunk override mode previously on), the FCU sends a J1587 message to the auxiliary unit requesting that the auxiliary unit go out of bunk override mode. The auxiliary unit then goes out of bunk override mode and sends a J1587 message to the front unit indicating that bunk override mode in the auxiliary unit is off. Upon receiving this message, the front unit responds by broadcasting a J1587 message that it too is out of bunk override mode. The auxiliary unit now adjusts its temperature and blower speed to its own settings on the auxiliary control panel and resumes CDTC operation.	Off

Bunk Override Functionality		
Action	**J1587 Messaging/Control**	**Bunk Override Indicator**
Blower or temperature settings on auxiliary control panel changed; bunk override mode was on	When the system is in bunk override mode and the auxiliary blower speed or temperature settings are then changed on the auxiliary control panel, the auxiliary unit goes out of bunk override mode and sends a J1587 message to the front unit indicating that it is no longer in bunk override mode. The front unit receives this message and broadcasts a J1587 message that it too is out of bunk override mode. The indicator light on the bunk override switch turns off. Once out of bunk override mode, the auxiliary unit now adjusts its temperature and blower speed to its own settings on the auxiliary control panel and resumes CDTC operation.	Off
Ignition turned off then back on; bunk override mode was on before the ignition was turned off	When the system is in bunk override mode and the ignition is turned off, then back on, bunk override mode is off. The auxiliary unit will operate to its auxiliary control panel blower and temperature settings.	On

Table 6, Bunk Override Functionality

Cab Override

Rear override is used when the auxiliary unit requires minimum A/C support from the front unit. The front control unit controls the A/C compressor; therefore, if the auxiliary unit requires A/C when the front unit is not in A/C mode or if the front unit is off, then the auxiliary unit can request A/C by initiating rear override.

When the auxiliary unit requires minimum A/C support, it sends a J1587 message requesting that the front control unit go into rear override mode and also sends a message indicating that rear override mode is on in the auxiliary unit. The front unit receives this request and, if not already in A/C mode, goes into rear override mode and sends a J1587 message to the auxiliary unit indicating that rear override mode is on in the front unit. The front unit then sets the blower speed to minimum speed to prevent evaporator core freezing and to allow air to flow across the evaporator temperature sensor to allow compressor cycling. If the blower was previously set to a speed above minimum, that speed will be maintained. The front control unit also turns on the A/C mode indicator on the A/C switch. The front unit will now operate the A/C compressor per A/C request rules. See **Table 4**.

When the auxiliary unit no longer requires minimum A/C support, it sends a J1587 message requesting that the front unit go out of rear override mode and also sends a message indicating that rear override mode is off in the auxiliary unit. The front unit receives this request, goes out of rear override mode, and sends a J1587 message indicating that rear override mode is off in the auxiliary unit. If the front blower speed setting was in the off position, the blower will now shut off. The A/C mode indicator light will turnoff.

Actuator Stepper Motors–Temperature, Recirc, and Mode

General Information

The actuator stepper motors are used to precisely position the temperature control, recirc, and air selection mode doors within the front HVAC unit, and the temperature control door in the auxiliary (bunk) HVAC unit. The motors can operate in both forward and reverse direction. Each motor has four motor windings with diodes wired in series with each winding. The motor direction and position is controlled by the FCU/ACU by applying power and sequencing ground through the four motor windings.

Actuator Stepper Motor Test Procedures

Test the Battery in the Stepper Motor Tester

NOTE: It is very important to check the battery in the stepper motor tester before testing the stepper motor. A weak battery will lead to incorrect test results. See **Fig. 4**.

1. Press the toggle switch on the stepper motor tester to NORMAL and set the rotary switch to position 4.

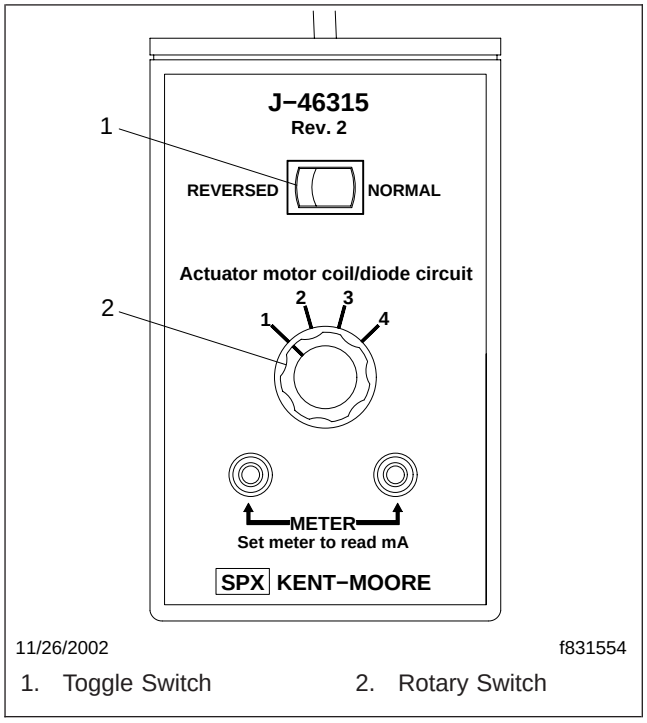


Fig. 4, Actuator Stepper Motor Tester

2. Connect a digital multimeter, set to read DC voltage, as follows:
   - positive lead to the red jack on the stepper motor tester
   - negative lead to pin 6 of the stepper motor tester lead (green wire). See **Fig. 5**.
3. The reading on the digital multimeter should be at least 1.5 VDC. If the reading is less than 1.5 VDC, replace the battery by removing the 4 cap-

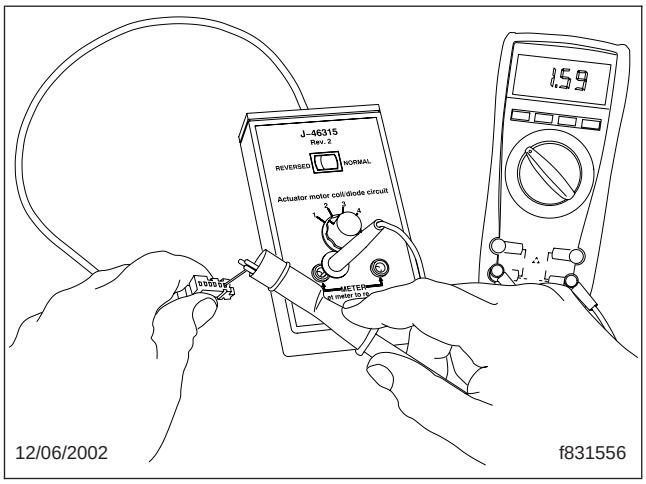


Fig. 5, Place the Negative Lead to Pin 6 of the Stepper Motor Tester Lead

screws that attach the back cover to the stepper motor tester.

The tester uses a single AA 1.5 VDC battery. It is recommended that you use an alkaline battery.

Test the Actuator Stepper Motor

NOTE: The stepper motor has four windings, each with an in-series diode. The stepper motor can be tested on or off the vehicle.

1. Connect the stepper motor tester to the stepper motor. If the stepper motor is being tested while on the vehicle, disconnect the electrical connector from the stepper motor.

   For locations of the actuators and actuator replacement instructions, see **Section 83.04**, Subject 150.
2. Set the digital multimeter to read **milliamps (mA) DC**. Make sure that the test leads on the multimeter are in the appropriate jacks for measuring amperage.
3. Connect the positive lead from the multimeter to the red jack on the stepper motor tester.
4. Connect the negative lead from the multimeter to the black jack. See **Fig. 6**.
5. Press the toggle switch to NORMAL.
6. Set the rotary switch to position 1 and note the reading on the multimeter.

Electrical System Tests

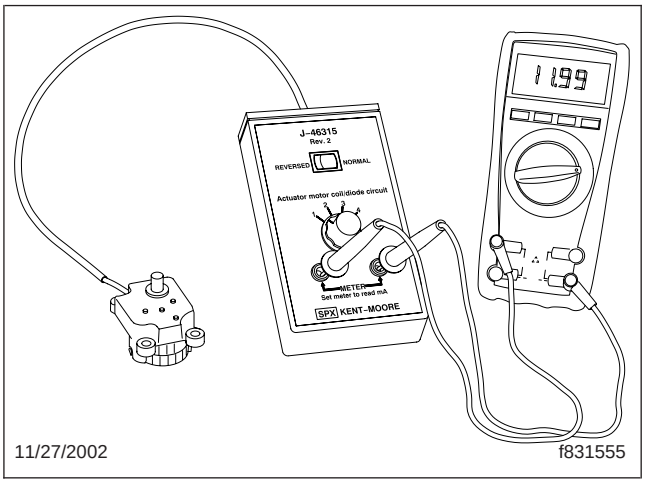


Fig. 6, Testing a Stepper Motor

7. Move the toggle switch to REVERSED and note the reading on the multimeter.
8. Repeat the previous three steps for the 2, 3, and 4 rotary switch positions on the tester. Compare your readings to the readings in **Table 7**.
9. If your readings do not match the readings in **Table 7**, replace the actuator. For instructions, see **Section 83.04**, Subject 150.
10. If the stepper motor was tested on the vehicle, connect the electrical connector to the stepper motor.

Acceptable Readings for the Actuator Stepper Motor Test				
Condition	**Toggle Switch Position**		**Conclusion**	**Action**
	Normal	**Reversed**		
If the readings in all four rotary switch positions are...	10–14 mA	less than 0.2 mA	Normal	None; actuator is okay electrically.
If the readings in any one or more of the rotary switch positions are...	15–350 mA	less than 0.2 mA	Shorted or partially shorted motor coil	Replace actuator.
	less than 0.2 mA	less than 0.2 mA	Open diode or motor coil*	
	0.3–9.9 mA	less than 0.2 mA	Check tester battery and retest. If battery okay, motor winding has high resistance.	
	19–24 mA	19–24 mA	Shorted diode	

* If the reading for each rotary switch and toggle switch position is less than 0.2 mA, check the fuse in the digital multimeter.

Table 7, Acceptable Readings for the Actuator Stepper Motor Test

Actuator Circuit Diagnosis

See **Table 8** for the actuator circuit test procedures.

<table>
<tr><th colspan="5">Actuator Circuit Test</th></tr>
<tr><th>Test No.</th><th>Test</th><th>Test Procedure</th><th>Test Result</th><th>Action</th></tr>
<tr><td rowspan="4">1</td><td rowspan="4">Check for fault codes.</td><td rowspan="4">Check if any one of the following fault codes is active:
<table><tr><th>Group A</th><th>Group B</th></tr><tr><td>146 s005 05</td><td>146 s005 06</td></tr><tr><td>146 s006 05</td><td>146 s006 06</td></tr><tr><td>146 s009 05</td><td>146 s009 06</td></tr><tr><td>200 s009 05</td><td>200 s009 06</td></tr></table>07/02/2002 f040619</td><td>Single fault in Group A is active.</td><td>Go to test no. 2.</td></tr>
<tr><td>All three MID 146 faults are active in Group A.</td><td>Go to test no. 6.</td></tr>
<tr><td>Single fault in Group B is active.</td><td>Go to test no. 8.</td></tr>
<tr><td>No faults listed in Group A or B are active.</td><td>No problem found.</td></tr>
<tr><td rowspan="2">2</td><td rowspan="2">Check voltage to the actuator.
NOTE: In order to measure a valid voltage, it may be necessary to move the respective control :for recirc, press the recirc button; for mix door actuator, move the temperature control switch; for the mode actuator, move the air selection switch.</td><td rowspan="2">For code 146s005 05 (front unit) disconnect the recirc actuator connector, turn the ignition on, measure voltage between connector pin 1 and ground.
For code 146 s006 05 (front unit) disconnect the mode actuator connector, turn the ignition on, measure voltage between connector pin 1 and ground.
For code 146 s009 05 (front unit) disconnect the temperature actuator connector, turn the ignition on, measure voltage between connector pin 1 and ground.
For code 200 s006 05 (auxiliary unit) disconnect the temperature actuator connector, turn the ignition on, measure voltage between connector pin 1 and ground.
NOTE: See Fig. 7, Fig. 8, and Fig. 9.</td><td>Approximately 12V</td><td>Go to test no. 3.</td></tr>
<tr><td>Much less than12V.</td><td>Check wire between pin 1 of the actuator and the FCU/ACU for open circuit. If okay, replace FCU/ACU. Go to test no. 9.</td></tr>
</table>

Electrical System Tests

Actuator Circuit Test				
Test No.	**Test**	**Test Procedure**	**Test Result**	**Action**
3	Check for short to ground on return side of actuator.	For code **146s005 05** (front unit) disconnect all three actuator connectors and the FCU connector. At the recirc actuator connector, check continuity between connector pin 3 and ground. Repeat for pins 4, 5, and 6. For code **146 s006 05** (front unit) disconnect all three actuator connectors and the FCU connector. At the mode actuator connector, check continuity between connector pin 3 and ground. Repeat for pins 4, 5, and 6. For code **146 s009 05** (front unit) disconnect all three actuator connectors and the FCU connector. At the temperature actuator connector, check continuity between connector pin 3 and ground. Repeat for pins 4, 5, and 6. For code **200 s009 05** (auxiliary unit) disconnect the temperature actuator connector and the ACU connector. At the temperature actuator connector, check continuity between connector pin 3 and ground. Repeat for pins 4, 5, and 6. NOTE: See **Fig. 7**, **Fig. 8**, and **Fig. 9**.	Continuity to ground on any pin.	Locate short to ground, repair as necessary, then **go to test no. 9**.
			No continuity to ground on any pin.	**Go to test no. 4**.

<table>
<tr><th colspan="5">Actuator Circuit Test</th></tr>
<tr><th>Test No.</th><th>Test</th><th>Test Procedure</th><th>Test Result</th><th>Action</th></tr>
<tr><td rowspan="2">4</td><td rowspan="2">Check continuity of actuator return side.</td><td rowspan="2">For code 146s005 05 disconnect the recirc actuator connector.

For code 146 s006 05 disconnect the mode actuator connector.

For code 146 s009 05 disconnect the temperature actuator connector.

Check continuity between the following connector pins:

<table><tr><th>FCU</th><th>Actuator</th></tr><tr><td>A2</td><td>3</td></tr><tr><td>B1</td><td>4</td></tr><tr><td>B2</td><td>5</td></tr><tr><td>B3</td><td>6</td></tr></table>07/02/2002 f040620

For code 200 s009 05 (auxiliary unit) disconnect the auxiliary unit temperature actuator connector and the ACU connector.

Check continuity between the following connector pins:

<table><tr><th>ACU</th><th>Actuator</th></tr><tr><td>B8</td><td>3</td></tr><tr><td>B7</td><td>4</td></tr><tr><td>B6</td><td>5</td></tr><tr><td>B5</td><td>6</td></tr></table>07/02/2002 f040621

NOTE: See Fig. 7, Fig. 8, and Fig. 9.</td><td>Continuity on all pin combinations.</td><td>Go to test no. 5.</td></tr>
<tr><td>No continuity on one or more pin combinations.</td><td>Locate open circuit, repair as necessary, then go to test no. 9.</td></tr>
</table>

Electrical System Tests

<table>
<tr><th colspan="5">Actuator Circuit Test</th></tr>
<tr><th>Test No.</th><th>Test</th><th>Test Procedure</th><th>Test Result</th><th>Action</th></tr>
<tr><td rowspan="2">5</td><td rowspan="2">Check actuator.</td><td rowspan="2">For code 146s005 05 (front unit) perform "Actuator Stepper Motor Electrical Test" on the recirc actuator.

For code 146 s006 05 (front unit) perform "Actuator Stepper Motor Electrical Test" on the mode actuator.

For code 146 s009 05 (front unit) perform "Actuator Stepper Motor Electrical Test" on the temperature actuator.

For code 200 s009 05 (auxiliary unit) perform "Actuator Stepper Motor Electrical Test" on the temperature actuator (auxiliary unit).</td><td>Actuator okay.</td><td>Replace FCU/ACU, then go to test no. 9.</td></tr>
<tr><td>Actuator not okay.</td><td>Replace actuator, then go to test no. 9.</td></tr>
<tr><td rowspan="2">6</td><td rowspan="2">Check actuator return circuits for open.</td><td rowspan="2">For all three active codes at the same time, 146 s005 05, 146 s006 05, 146 s009 05, disconnect all three actuator connectors and the FCU connector. At each actuator connector, check continuity between the following connector pins:

<table><tr><th>FCU</th><th>Actuator</th></tr><tr><td>A2</td><td>3</td></tr><tr><td>B1</td><td>4</td></tr><tr><td>B2</td><td>5</td></tr><tr><td>B3</td><td>6</td></tr></table>07/02/2002 f040620

NOTE: See Fig. 7, Fig. 8, and Fig. 9.</td><td>Continuity on all pin combinations.</td><td>Go to test no. 7.</td></tr>
<tr><td>No continuity on one or more pin combinations.</td><td>Locate open circuit, repair as necessary, then go to test no. 9.</td></tr>
<tr><td rowspan="2">7</td><td rowspan="2">Check actuator return circuits for short to ground.</td><td rowspan="2">Disconnect all three actuator connectors and the FCU connector. At the FCU connector, check continuity between pin A2 and ground. Repeat for pins B1, B2, and B3.

NOTE: See Fig. 7, Fig. 8, and Fig. 9.</td><td>Continuity to ground on any pin.</td><td>Repair short to ground, then go to test no. 9.</td></tr>
<tr><td>No continuity to ground on any pin.</td><td>Replace FCU, then go to test no. 9.</td></tr>
</table>

Actuator Circuit Test				
Test No.	**Test**	**Test Procedure**	**Test Result**	**Action**
8	Check for shorted actuator coil.	For code **146s005 06** disconnect the recirc actuator connector, check if fault no longer active (different fault maybe active). For code **146 s006 06** disconnect the mode actuator connector, check if fault no longer active (different fault may be active). For code **146 s009 06** disconnect the temperature actuator connector, check if fault no longer active (different fault may be active). For code **200 s009 06** disconnect the temperature actuator connector (auxiliary unit), check if fault no longer active (different fault may be active). See **Fig. 7**.	Fault no longer active (FMI06), different fault may be active (FMI 05).	Shorted actuator motor is likely. Perform "Actuator Stepper Motor Electrical Test" to confirm, then **go to test no. 9**.
			Fault still active (FMI06).	Check for short to ground in power wire between actuator and FCU/ACU. If no short is found, replace FCU/ACU, then **go to test no. 9**.
9	Verify repair. NOTE: In order to check if a fault status has changed from active to inactive, the recirc button, temperature control switch, or air selection switch needs to be moved while the ignition is on.	Verify that repair resolved the problem.	Problem resolved.	Done.
			Problem unresolved.	**Repeat test no. 1**.

Table 8, Actuator Circuit Test

Evaporator Temperature Sensor

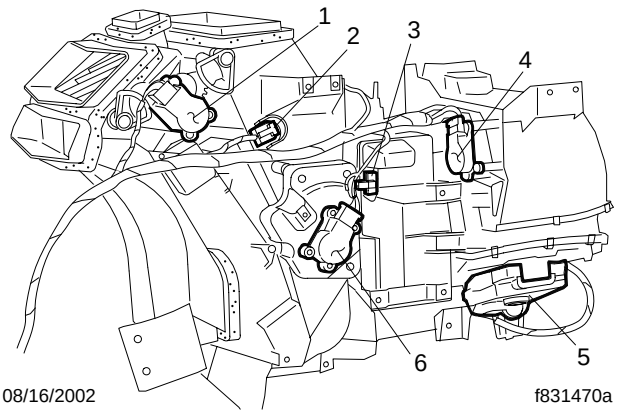
General Information

The evaporator temperature sensor is located on the evaporator. The sensor input to the FCU is used to control the A/C compressor in order to prevent evaporator freezing. The sensor has a negative temperature coefficient (NTC), which means that its resistance decreases as temperature increases.

Evaporator Temperature Sensor Circuit Test

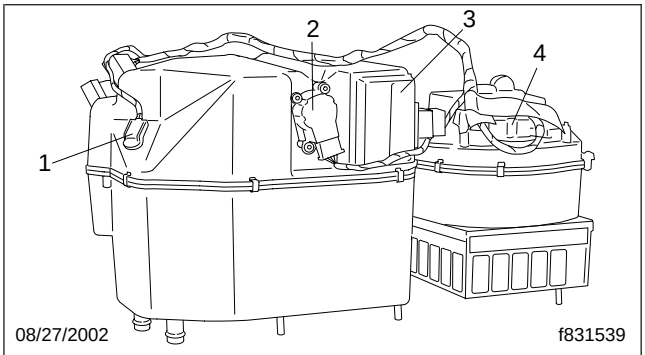
See **Table 9** for the evaporator temperature sensor circuit test procedures.

Electrical System Tests



1. Mode Actuator
2. CDTC Temperature Sensor
3. Evaporator Temperature Sensor
4. Recirculation Actuator
5. Blower Motor
6. Temperature Actuator

Fig. 7, Cab HVAC Assembly



1. CDTC Sensor
2. Temperature Actuator
3. Auxiliary Control Unit (ACU)
4. Blower Motor

Fig. 8, Auxiliary HVAC Assembly

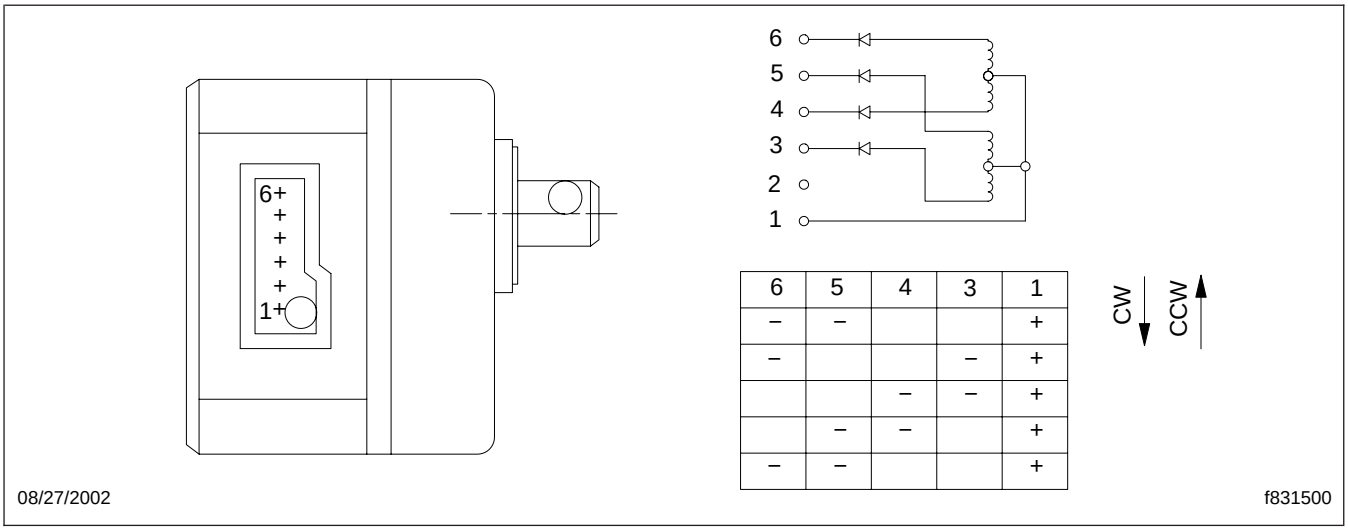


Fig. 9, Actuator Motor Pinouts

Evaporator Temperature Sensor Circuit Test				
Test No.	**Test**	**Test Procedure**	**Test Result**	**Action**
1	Are evaporator temperature sensor fault codes active?	Check if fault code**146 s002 03** or **146 s002 04** is active.	Neither fault isactive.	**Go to test no. 2**.
			146s002 03 is active	Check for sensor signal wire shorted to power. If okay, **go to test no. 2**.
			146s002 04 is active.	Check for sensor signal wire shorted to ground. If okay, replace FCU. **Go to test no. 3**.
2	Check sensor reference voltage.	Disconnect the evaporator sensor. Turn the ignition on and measure the voltage across the sensor connector pins (harness side). The voltage should be 5V if the circuit and FCU are operating correctly.	5V	Perform "Evaporator Temperature Sensor Test."
			Less than 5V.	Check for open circuit in sensor signal and ground wires. If okay, replace FCU. **Go to test no. 3**.
3	Verify repair.	Verify that repair resolved the problem.	Problem solved.	Done.
			Problem unresolved.	**Repeat test no. 1**.

Table 9, Evaporator Temperature Sensor Circuit Test

Evaporator Temperature Sensor Test

When testing the evaporator temperature sensor (**Fig. 10**), the resistance will decrease as the temperature increases, as shown in **Fig. 11**.

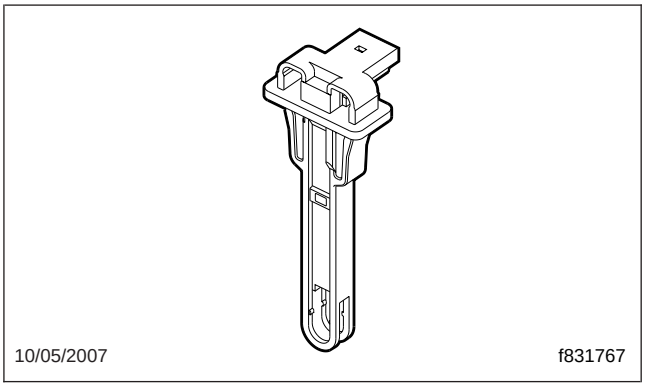


Fig. 10, Evaporator Temperature Sensor

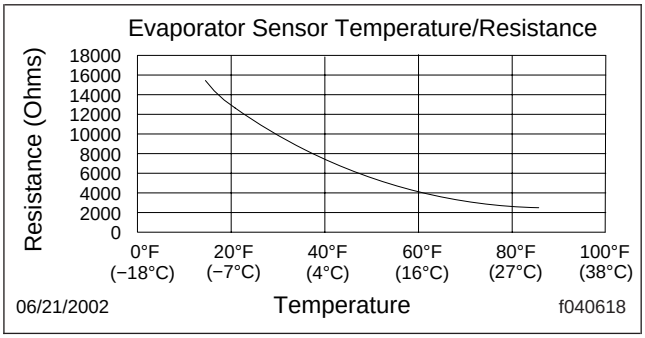


Fig. 11, Evaporator Sensor Temperature/Resistance

1. Remove the sensor and place it in a cup of ice water.
2. After the sensor has been in the ice water for five minutes, measure the sensor resistance.

   The resistance should be 9000 ohms at 32°F (0°C). See **Table 10**.
3. If the resistance differs significantly, replace the sensor.

Evaporator Temperature Sensor Temperature versus Resistance	
Temperature °F (°C)	**Resistance (ohms)**
32 (0)	**9000**
40 (4.4)	7183
50 (10)	5468
60 (15.6)	4209
70 (21.1)	3271
80 (26.7)	2566

Table 10, Evaporator Temperature Sensor Temperature versus Temperature Resistance

Constant Discharge Temperature Control

General Information

CDTC systems maintain a set outlet temperature based on the temperature control switch setting. This is a closed-loop system. The same CDTC sensor is used on both the front and auxiliary HVAC units.

CDTC Temperature Sensor Test

When testing the CDTC temperature sensor (**Fig. 12**), the resistance will decrease as the temperature increases, as shown in **Fig. 13**.

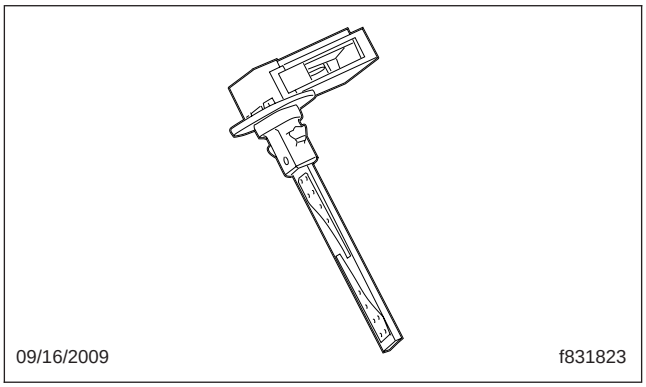


Fig. 12, CDTC Temperature Sensor

1. Allow the system to stabilize to ambient temperatures, and compare the bunk and main evaporator temperature sensor values using the templates in ServicePro. If the two values are significantly different, continue with step #2 to confirm the suspected sensor is not reading properly.

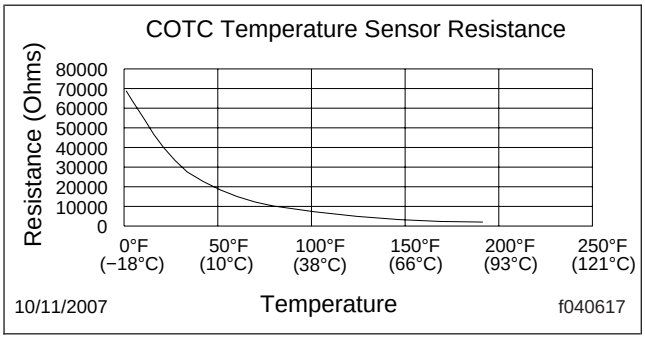


Fig. 13, CDTC Temperature Sensor Temperature vs. Resistance

NOTICE

Do not allow the CDTC temperature sensor to get wet. The circuitry will be damaged.

2. Remove the sensor and place it in a plastic bag, them put the bag and sensor in a cup of ice water.
3. After the sensor has been in the ice water for ten minutes, measure the sensor resistance.

   The resistance should be approximately 29,190 ohms at 32°F (0°C).See **Table 11**.
4. If the resistance differs significantly, replace the sensor.

CDTC Temperature Sensor Temperature versus Resistance	
Temp °F (°C)	**Resistance (ohms)**
32 (0)	**29190**
42 (6)	22180
53 (12)	17050
64 (18)	13250
75 (24)	10400
86 (30)	8240
96 (36)	6590
107 (42)	5320
113 (45)	4790

Table 11, CDTC Temperature Sensor Temperature versus Resistance

Calibration Procedure

When the front control head (FCU) or any actuator motor is replaced, the system must be recalibrated. The calibration procedure allows the FCU to learn the extreme positions of the actuator motors for the recirc door, temperature control door, and the air selection mode door.

Use the following procedure to recalibrate the system.

1. Turn the ignition on, engine off.
2. Set the blower speed to the off position (all the way counterclockwise).
3. Set the air selection switch to full defrost (all the way clockwise).
4. Set the temperature control switch to full hot (all the way clockwise).
5. Press the A/C and recirc buttons at the same time until the indicators on the buttons are both flashing.

   When the indicators on the recirc and A/C buttons start flashing, the FCU has entered calibration mode. Calibration takes place automatically at this point and the blower can be heard operating. When the unit is finished calibrating, the indicators and blower turn off and the system can be operated normally.

DataLink Monitor Templates

General Information

There are two DataLink Monitor templates available in ServiceLink 3.2 or higher, one for day cabs and one for SleeperCabs. The templates allow the technician to monitor temperature and blower speed settings, bunk and rear override mode, A/C mode and A/C request, as well as other information related to the HVAC system. See **Fig. 1** and **Fig. 2**.

DataLink Monitor Template Object Definitions

Front Temperature Control Setting Bar Graph

The front temperature control setting bar graph indicates the position of the temperature control switch in percentage of full hot. Zero percent equals full cold and 100 percent equals full hot. Viewing the bar graph can indicate whether or not the FCU is processing the temperature control switch setting.

When bunk override is initiated, the front temperature setting message is sent to the auxiliary unit. The auxiliary unit then attempts to match this temperature setting.

Front Temperature Mix Door Position Bar Graph

The front temperature mix door position bar graph indicates what the FCU thinks is the position of the temperature mix door in step counts. Step counts range from 0 (when the temperature mix door is in the full cold position) to 3800 (when the temperature mix door is in the full hot position). It is important to know that the actual door position may not be what is indicated by the temperature mix door position bar graph.

When bunk override is initiated, the front temperature mix door step count message is sent to the auxiliary unit. The auxiliary unit uses this as its initial temperature mix door setting to match the front temperature.

Front CDTC Discharge Temperature Bar Graph

The front CDTC discharge temperature bar graph indicates the temperature of the CDTC sensor downstream of the temperature mix door in the front unit. The system uses this temperature sensor to control the mix door to maintain the desired temperature setting of the temperature control switch.

Front Blower Speed Setting Bar Graph

The front blower speed setting bar graph indicates the position of the front blower speed switch in percentage of full speed. Zero percent equals off and 100 percent equals high. Viewing this bar graph can indicate whether or not the FCU is processing the blower speed control switch setting.

When bunk override is initiated, the front blower speed set point message is sent to the auxiliary unit. The auxiliary unit then attempts to match this blower speed setting.

Front Blower Speed Bar Graph

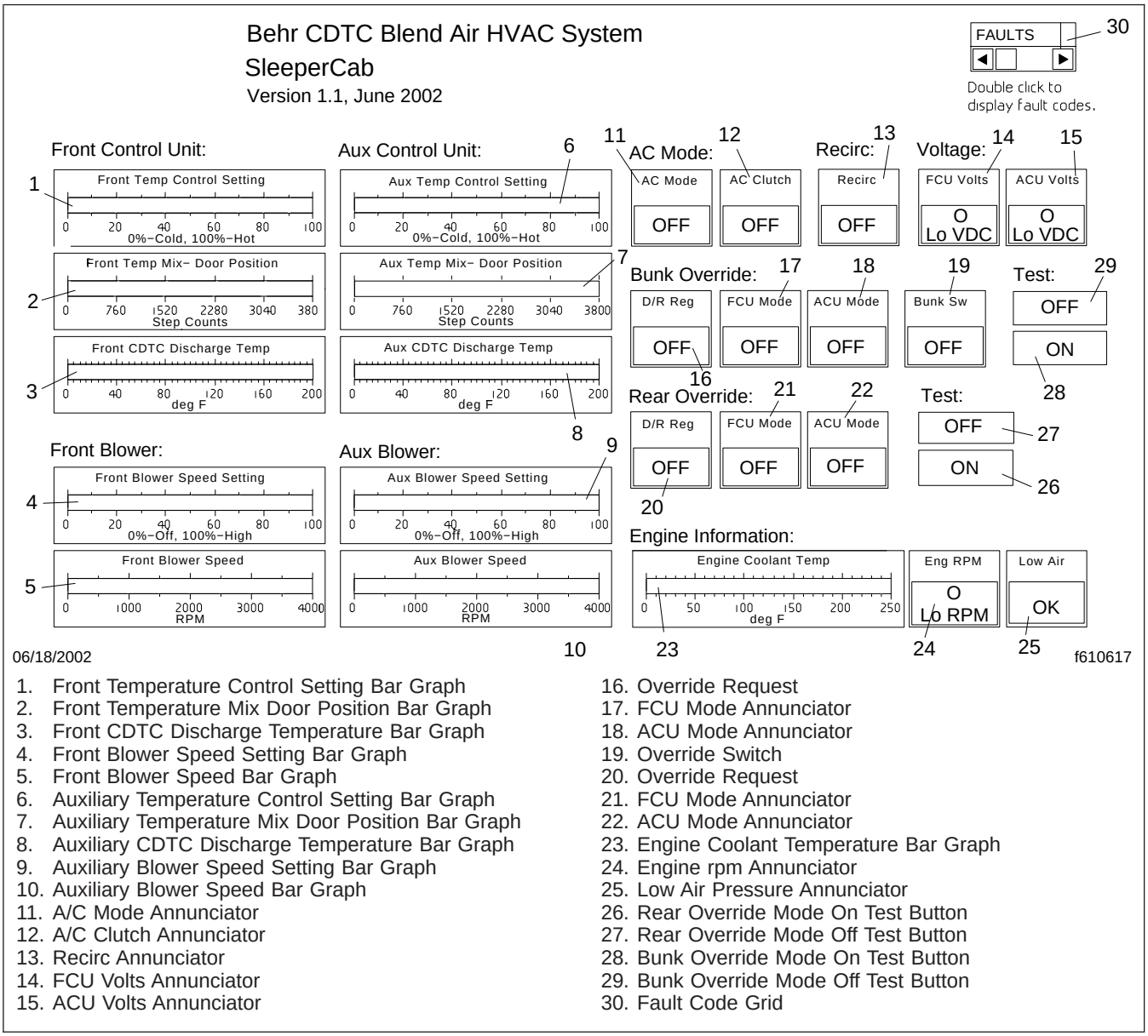
The front blower speed bar graph indicates the front unit blower speed feedback to the FCU.

Auxiliary Temperature Control Setting Bar Graph (SleeperCabs only)

The auxiliary temperature control setting bar graph indicates the position of the auxiliary temperature control switch in percentage of full hot. Zero percent equals full cold and 100 percent equals full hot. Viewing this bar graph can indicate whether or not the ACU is processing the auxiliary temperature control switch setting.

When bunk override is initiated, the front temperature setting message is sent to the auxiliary unit. The auxiliary unit then matches this temperature set point.

Fault Code Driven Diagnosis



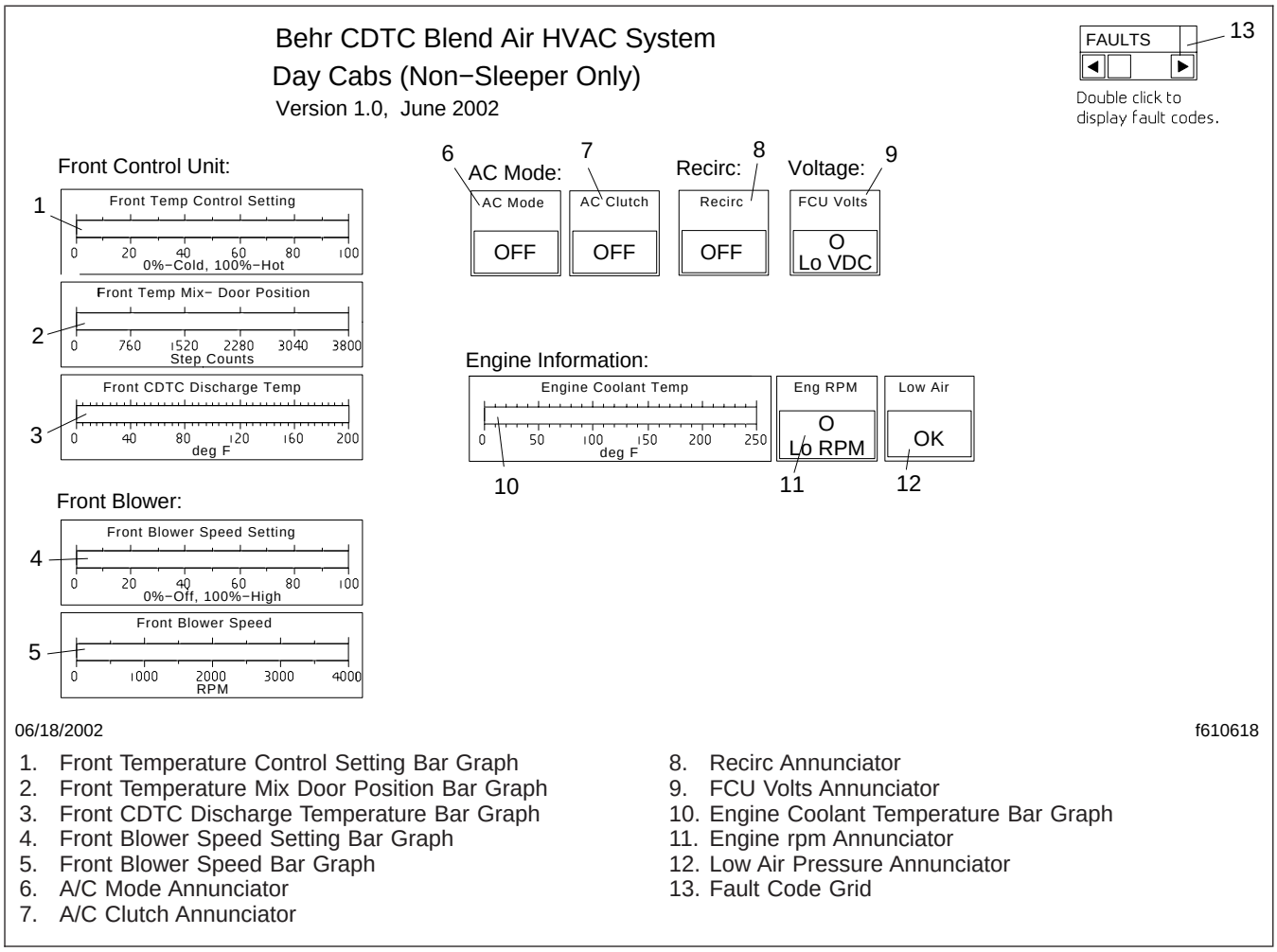
1. Front Temperature Control Setting Bar Graph
2. Front Temperature Mix Door Position Bar Graph
3. Front CDTC Discharge Temperature Bar Graph
4. Front Blower Speed Setting Bar Graph
5. Front Blower Speed Bar Graph
6. Auxiliary Temperature Control Setting Bar Graph
7. Auxiliary Temperature Mix Door Position Bar Graph
8. Auxiliary CDTC Discharge Temperature Bar Graph
9. Auxiliary Blower Speed Setting Bar Graph
10. Auxiliary Blower Speed Bar Graph
11. A/C Mode Annunciator
12. A/C Clutch Annunciator
13. Recirc Annunciator
14. FCU Volts Annunciator
15. ACU Volts Annunciator
16. Override Request
17. FCU Mode Annunciator
18. ACU Mode Annunciator
19. Override Switch
20. Override Request
21. FCU Mode Annunciator
22. ACU Mode Annunciator
23. Engine Coolant Temperature Bar Graph
24. Engine rpm Annunciator
25. Low Air Pressure Annunciator
26. Rear Override Mode On Test Button
27. Rear Override Mode Off Test Button
28. Bunk Override Mode On Test Button
29. Bunk Override Mode Off Test Button
30. Fault Code Grid

Fig. 1, Behr CDTC Blend Air HVAC System SleeperCab

Auxiliary Temperature Mix Door Position Bar Graph (SleeperCabs only)

The auxiliary temperature mix door position bar graph indicates what the ACU thinks is the position of the temperature mix door in step counts. Step counts range from 0 (when the temperature mix door is in the full cold position) to 3800 (when the temperature mix door is in the full hot position). It is important to know that the actual door position may not be what is indicated by the temperature mix door position bar graph.

When bunk override is initiated, the front temperature mix door step count message is sent to the auxiliary



1. Front Temperature Control Setting Bar Graph
2. Front Temperature Mix Door Position Bar Graph
3. Front CDTC Discharge Temperature Bar Graph
4. Front Blower Speed Setting Bar Graph
5. Front Blower Speed Bar Graph
6. A/C Mode Annunciator
7. A/C Clutch Annunciator
8. Recirc Annunciator
9. FCU Volts Annunciator
10. Engine Coolant Temperature Bar Graph
11. Engine rpm Annunciator
12. Low Air Pressure Annunciator
13. Fault Code Grid

Fig. 2, Behr CDTC Blend Air HVAC System Day Cabs

unit. The auxiliary unit uses this as its initial temperature mix door setting to match the front temperature.

Auxiliary CDTC Discharge Temperature Bar Graph (SleeperCabs only)

The auxiliary CDTC discharge temperature bar graph indicates the temperature of the CDTC sensor downstream of the temperature mix door in the auxiliary unit. The system uses this temperature sensor to control the mix door to maintain the desired temperature setting of the temperature control switch.

Auxiliary Blower Speed Setting Bar Graph (SleeperCabs only)

The auxiliary blower speed setting bar graph indicates the position of the auxiliary blower speed control switch in percentage of full speed. Zero percent equals off and 100 percent equals high. Viewing this bar graph can indicate whether or not the ACU is processing the blower speed control switch setting.

When bunk override is initiated, the front blower speed set point message is sent to the auxiliary unit. The auxiliary unit then attempts to match this blower speed setting.

Fault Code Driven Diagnosis

Auxiliary Blower Speed Bar Graph (SleeperCabs only)

The auxiliary blower speed bar graph indicates the auxiliary unit blower speed feedback to the ACU.

A/C Mode Annunciator

The A/C mode annunciator indicates whether or not the FCU is in A/C mode. The front unit is in A/C mode whenever the A/C button on the climate control panel is pressed, when the front control panel is set to any of the defrost modes, or when the front unit is off and the auxiliary unit is initiated for minimum A/C support. When A/C mode is on, the compressor can operate when the compressor control rules are met.

The A/C mode annunciator has three possible conditions: ON, OFF, or NA/ERR (not available or error).

A/C Clutch Annunciator

The A/C clutch annunciator indicates whether or not the signal to the A/C clutch relay is active or not. The A/C relay controls the A/C compressor.

The A/C clutch annunciator has three possible conditions: ON, OFF, or NA/ERR (not available or error).

Recirc Annunciator

The recirc annunciator indicates whether or not the front unit is in recirculation mode. When the unit is in recirculation mode, the front unit will recirculate air within the cab. If recirc is on longer than 20 minutes, the front unit goes into partial recirc mode letting in a small amount of fresh air. When recirc mode is inactive, all of the air circulating through the unit is outside air.

The recirc annunciator has three possible conditions: ON, OFF, or NA/ERR (not available or error).

FCU Volts Annunciator

The FCU volts annunciator indicates the input voltage the front control unit senses. The annunciator will indicate low voltage below 9 volts and high voltage above 16 volts. The normal operating range for the front unit is 9 to 16 volts.

ACU Volts Annunciator (SleeperCabs only)

The ACU volts annunciator indicates the input voltage the auxiliary control unit senses. The annunciator will indicate low voltage below 9 volts and high voltage above 16 volts. The normal operating voltage range for the auxiliary unit is 9 to 16 volts.

Override Request (SleeperCabs only)

The override request annunciator indicates when the FCU sends a message to the ACU requesting that it go into or out of bunk override mode. The request is initiated when the FCU senses that the bunk override switch is in the on or off position.

The override request annunciator has three possible conditions: ON, OFF, or NA/ERR (not available or error). The annunciator normally shows NA/ERR except when requesting bunk override mode on or off. On or off is usually displayed briefly.

FCU Mode Annunciator (SleeperCabs only)

The FCU mode annunciator indicates the status of bunk override mode in the auxiliary unit (ACU). After the auxiliary unit receives the bunk override on request message from the front unit, it goes into bunk override mode and sends a message indicating that it is in bunk override mode indicated by the ACU mode annunciator. The front unit acknowledges the message sent by the auxiliary unit and indicates that it too is in bunk override mode indicated by the FCU mode annunciator. The FCU mode annunciator works similarly if bunk override is turned off.

The FCU mode annunciator has three possible conditions: ON, OFF, or NA/ERR (not available or error).

ACU Mode Annunciator (SleeperCabs only)

The ACU mode annunciator indicates the status of bunk override mode in the auxiliary unit (ACU). After the auxiliary unit receives the bunk override on request message from the front unit, it goes into bunk override mode and sends a message indicating that it is in bunk override mode indicated by the ACU

mode annunciator. The ACU mode annunciator works similarly if bunk override mode is turned off.

The ACU mode annunciator has three possible conditions: ON, OFF, or NA/ERR (not available or error).

Bunk Override Switch (SleeperCabs only)

The bunk override switch annunciator indicates the status of the bunk override switch. The bunk override switch controls the bunk override mode function. The annunciator has three possible conditions: ON, OFF, or NA/ERR (not available or error)

The annunciator normally shows NA/ERR except when in the on or off momentary positions.

Override Request (SleeperCabs only)

The override request annunciator indicates when the ACU sends a message to the FCU requesting rear override mode to be on or off. The request is initiated when the auxiliary unit requires minimum A/C support; that is, when it requires the A/C compressor to operate if the front unit is not already controlling the A/C compressor.

The override request annunciator has three possible conditions: ON, OFF, or NA/ERR (not available or error). The annunciator normally shows NA/ERR except when requesting rear override mode on or off. On or off is usually displayed briefly.

FCU Mode Annunciator (SleeperCabs only)

The FCU mode annunciator indicates the status of rear override mode in the front unit (FCU). After the front unit receives the rear override on request message from the auxiliary unit, it goes into bunk override mode and sends a message indicating that it is in rear override mode indicated by the FCU mode annunciator. The FCU mode annunciator works similarly if bunk override mode is turned off.

The FCU mode annunciator has three possible conditions: ON, OFF, or NA/ERR (not available or error).

ACU Mode Annunciator (SleeperCabs only)

The ACU mode annunciator indicates the status of rear override mode in the auxiliary unit (ACU). After the front unit receives the rear override on request message from the auxiliary unit, it goes into rear override mode and sends a message indicating that it is in rear override mode indicated by the ACU mode annunciator. The ACU mode annunciator works similarly if rear override mode is turned off.

The ACU mode annunciator has three possible conditions: ON, OFF, or NA/ERR (not available or error).

Engine Coolant Temperature Bar Graph

Engine coolant temperature is one of the inputs used by the front and auxiliary control units to control unit outlet temperature. It is provided on the template so the technician can be sure that all tests are performed when the engine is at normal operating temperature. Poor A/C performance and poor heater performance can be indicated by improper operating temperature.

Engine RPM Annunciator

The engine rpm annunciator is used to indicate engine rpm. Engine rpm is one of the inputs for controlling the A/C compressor clutch. The A/C compressor clutch does not engage when the engine speed is below 450 rpm.

Low Air Pressure Annunciator

The low air pressure annunciator is used to indicate low air pressure in the primary or secondary air system. The message that controls the low air pressure annunciator comes from the ICU. The message is one of the inputs used by the front control unit to control A/C compressor operation. The A/C compressor clutch does not engage when the system air pressure is low. The message is sent by the ICU, but at intervals long enough that may cause the annunciator to flash periodically. A flashing DLM template object indicates that a message is not being received.

Rear Override Mode ON Test Button (SleeperCabs only)

The rear override mode ON test button is used to manually send a rear override request to the FCU. This is the same message that the ACU sends to the FCU when it requests A/C support from the front unit. To use this test, turn off the front blower then press the rear override mode ON test button. After doing this, the FCU mode annunciator (item 21 in **Fig. 1**) should be in the on state. The A/C mode annunciator (item 11 in **Fig. 1**) should also be in the on state and the front blower should be at minimum speed. The A/C clutch annunciator (item 12 in **Fig. 1**) may or may not be in the on state depending on whether the A/C clutch rules have been met (engine running, adequate system air pressure, evaporator sensor in correct range). This test simulates the ACU. If the test is successful and rear override is not functioning, then the problem most likely is either that the ACU is not communicating on the J1587 databus, or there is a problem with the ACU itself or its control inputs.

Rear Override Mode OFF Test Button (SleeperCabs only)

The rear override mode OFF test button is used to manually send a rear override off request to the FCU. This is the same message the ACU sends to the FCU when it no longer requests A/C support from the front unit. The button should be used after initiating rear override mode with the ON test button.

Bunk Override Mode ON Test Button (SleeperCabs only)

The bunk override mode ON test button is used to manually send a bunk override request to the ACU. This is the same message that the FCU sends to the ACU when the driver presses the bunk override switch on the climate control panel. When the bunk override ON test button is pressed, ACU mode annunciator (item 18 in **Fig. 1**)should be in the ON state. The auxiliary unit should then begin matching the front temperature and blower speed settings.

Bunk Override Mode OFF Test Button (SleeperCabs only)

The bunk override mode OFF test button is used to manually send a bunk override OFF request to the ACU. This is the same message the FCU sends to the ACU when the bunk override switch on the climate control panel is pressed to the off position. The button should be used after initiating bunk override mode with the ON test button.

Fault Code Grid

Double click on the fault code grid to display J1587 fault codes.

Fault Code Diagnostics

Front Control Unit (FCU) (MID 146) J1587 Fault Codes by SID			
SID	**FMI**	**Fault Description**	**Action**
001	03	CDTC sensor: voltage above normal, shorted high, or open circuit	See CDTC Temperature Sensor Circuit Test table, in **Subject 350**, for diagnosis.
	04	CDTC sensor: voltage below normal, shorted low	See CDTC Temperature Sensor Circuit Test table, in **Subject 350**, for diagnosis.
002	03	Evap temp sensor: voltage above normal, shorted high, or open circuit	See Evaporator Temperature Sensor Circuit Test table, in **Subject 350**, for diagnosis.
	04	Evap temp sensor: voltage below normal, shorted low	See Evaporator Temperature Sensor Circuit Test table, in **Subject 350**, for diagnosis.

Front Control Unit (FCU) (MID 146) J1587 Fault Codes by SID			
SID	**FMI**	**Fault Description**	**Action**
005	05	Recirc/OSA door actuator: current below normal or open circuit	See Actuator Circuit Test table, in **Subject 350**, for diagnosis.
	06	Recirc/OSA door actuator: current above normal or circuit shorted to ground	See Actuator Circuit Test table, in **Subject 350**, for diagnosis.
006	05	Mode door actuator: current below normal or open circuit	See Actuator Circuit Test table, in **Subject 350**, for diagnosis.
	06	Mode door actuator: current above normal or circuit shorted to ground	See Actuator Circuit Test table, in **Subject 350**, for diagnosis.
009	05	Temperature control door: current below normal or open circuit	See Actuator Circuit Test table, in **Subject 350**, for diagnosis.
	06	Temperature control door: current above normal or circuit shorted to ground	See Actuator Circuit Test talbe, in **Subject 350**, for diagnosis.
010	02	Blower motor: output data erratic or intermittent	The FCU compares the analog output signal (speed signal) with what it thinks it should be. If determined to be in error, this fault will become active. To diagnose: 1. Disconnect blower motor. If fault is no longer active, replace the blower motor. If still active, go to step 2. 2. Disconnect the blower speed signal output wire (pin A11) from the FCU connector. Make sure connector is plugged into FCU after removing wire. If fault is no longer active, check for short to power or short to ground on output wire. If fault is still active, replace FCU.
	12	Blower motor: bad component, speed is invalid or incorrect	This fault can occur if the blower speed feedback differs from the speed control signal being sent by the FCU. See Diagnosis for Blower Speed is Not Available table, in **Subject 350**.
011	05	A/C clutch relay: current below normal or open circuit	This fault indicates an open circuit in one of the following: circuit 97T between the FCU and the A/C clutch relay, open relay coil, or open relay coil ground circuit. See A/C Request Circuit Test table, in **Subject 350**, for diagnosis.
	06	A/C clutch relay: current above normal or circuit shorted to ground	This fault indicates that there is a short to ground in circuit 97T between the FCU and the A/C clutch relay, or a shorted relay. See A/C Request Circuit Test table, in **Subject 350**, for diagnosis.
250	02	J1587 databus: data erratic, intermittent, or incorrect	Check J1587 databus, repair as necessary. See **Group 54** for more information on troubleshooting the J1587 databus.
	12	Bad ECU/EEPROM error	Replace FCU.

Table 1, Front Control Unit (FCU) (MID 146) J1587 Fault Codes by SID

Fault Code Driven Diagnosis

Front Control Unit (FCU) (MID 146) J1587 Fault Codes by PID			
PID	**FMI**	**Fault Description**	**Action**
168	03	Supply voltage too high (above 16.0 VDC)	Check vehicle charging system, repair as necessary. See **Group 15** for more information.
	04	Supply voltage too low (below 9.0 VDC)	Check vehicle batteries and charging system. If okay, check power and ground circuits to HVAC system. Use voltage drop tests to isolate problem.

Table 2, Front Control Unit (FCU) (MID 146) J1587 Fault Codes by PID

Auxiliary Control Unit (ACU) (MID 200) J1587 Fault Codes by SID			
SID	**FMI**	**Fault Description**	**Action**
001	03	CDTC sensor: voltage above normal, shorted high, or open circuit	See CDTC Temperature Sensor Circuit Test table, in **Subject 350**, for diagnosis.
	04	CDTC sensor: voltage below normal, shorted low	See CDTC Temperature Sensor Circuit Test table, in **Subject 350**, for diagnosis.
009	05	Temperature actuator: current below normal or open circuit	See Actuator Circuit Test in **Subject 350**, for diagnosis.
	06	Temperature actuator: current above normal or circuit shorted to ground	See Actuator Circuit Test table, in **Subject 350**, for diagnosis.
010	02	Blower motor: output data erratic or intermittent	The ACU compares the analog output signal (speed signal) with what it thinks it should be. If determined to be in error, this fault will become active. To diagnose: 1. Disconnect blower motor. If fault is no longer active, replace the blower motor. If still active, go to step 2. 2. Remove the blower speed signal output wire (pin B4) from the ACU connector. Make sure connector is plugged into ACU after removing wire. If fault is no longer active, check for short to power or short to ground on output wire. If fault is still active, replace ACU.
	12	Blower motor: bad component, speed is invalid or incorrect	This fault can occur if the blower speed feedback differs from the speed control signal being sent by the ACU. See Diagnosis for Blower Speed is Not Available table, in **Subject 350**.
250	02	J1587 databus: data erratic, intermittent, or incorrect	Check J1587 databus, repair as necessary.
	12	Bad ECU/EEPROM error	Replace ACU.

Table 3, Auxiliary Control Unit (ACU) (MID 200) J1587 Fault Codes by SID

Auxiliary Control Unit (ACU) (MID 200) J1587 Fault Codes by PID			
PID	**FMI**	**Fault Description**	**Action**
168	03	Supply voltage too high (above 16.0 VDC)	Check vehicle charging system, repair as necessary. See **Group 15** for more information.
	04	Supply voltage too low (below 9.0 VDC)	Check vehicle batteries and charging system. See **Group 15** for more information. If okay, check power and ground circuits to HVAC system. Use voltage drop tests to isolate problem.

Table 4, Auxiliary Control Unit (ACU) (MID 200) J1587 Fault Codes by PID

A/C Performance Diagnosis

IMPORTANT: Before using the symptom driven diagnostics tables, perform the appropriate procedures in "Preliminary Checks" and "Refrigerant System Tests" for each complaint.

Problem—Warm Airflow When the Air Conditioner is On, A/C Not Working, or Poor A/C Performance (dash outlet temperature is too high)

Problem—Warm Airflow When the Air Conditioner is On, A/C Not Working, or Poor A/C Performance (dash outlet temperature is too high)	
Possible Cause	**Remedy**
Refrigerant charge too low.	Perform leak test. Repair any leaks, evacuate the system, replace the receiver-drier (only if color indicates it is saturated with moisture), add a full charge of refrigerant.
Contaminated refrigerant.	Check refrigerant for moisture and/or mixed refrigerant contamination, repair as necessary.
Refrigerant charge too high.	Evacuate the system, charge system with proper amount of refrigerant.
Moisture in the system.	Moisture in the system may cause ice crystals to form and possibly block the flow of refrigerant at the expansion valve or other places in the system. Recover the refrigerant, replace the receiver-drier, evacuate the system, and add a full charge of refrigerant.
A/C compressor not working.	The refrigerant charge is too high or too low (will cause the binary pressure switch to open and prevent the compressor from operating).
	Worn or loose A/C compressor drive belt, tighten or replace as necessary.
	Faulty A/C compressor or clutch, repair as necessary.
	A/C compressor clutch not engaging. See "A/C Clutch Circuit" for diagnosis.
Ice formed on evaporator core.	Ice buildup on the evaporator core can block airflow through the evaporator, thus producing little or no cooling. This may occur if the compressor is not cycling off at the correct temperature. For evaporator sensor testing, see "Evaporator Temperature Sensor."
Temperature door not operating correctly, front and auxiliary units.	Electrical problem with temperature actuator. Check for fault codes. See fault code tables, in **Subject 340**, for diagnosis.
	Mechanical problem with temperature door. Check for obstructions or broken components, repair as necessary. NOTE: The actuator has no feedback to the FCU/ACU to verify position. If there are no fault codes and the actuator signal appears to be working in the DataLink Monitor template, then suspect a mechanical problem.
Wiring problem between climate control panel and ACU, auxiliary unit only.	See **Table 11**, Sleeper Climate Control Panel Circuit Diagnosis.
Faulty temperature control potentiometer.	See **Table 11**, Sleeper Climate Control Panel Circuit Diagnosis.
Blockage or restriction in refrigerant system.	A blockage or restriction can usually be found by locating an abrupt temperature change at a location in the system; for example, in a line or the condenser. Repair as necessary.
Blower motor in protection mode (reduced airflow).	See "Blower Motor."
System out of calibration, front unit only.	See "Calibration Procedure."

Symptom Driven Diagnosis

Problem—No Fresh Air, Front Unit Only (nonrecirculation mode)

Problem—No Fresh Air, Front Unit Only (nonrecirculation mode)	
Possible Cause	**Remedy**
Recirc door not operating correctly.	Electrical problem with recirc door actuator. Check for fault codes. See fault code tables, in **Subject 340**, for diagnosis. Also see "Recirculation" and "Actuator Stepper Motors—Temperature, Recirc, and Mode."
	Mechanical problem with recirc door. Check for obstructions or broken components, repair as necessary. NOTE: The actuator has no feedback to the FCU/ACU to verify position. If there are no fault codes and the actuator signal appears to be working in the DataLink Monitor template, then suspect a mechanical problem.
Restricted filter or intake.	Clean as necessary.
System out of calibration.	See "Calibration Procedure."

Problem—Low Side Pressure Too Low

Problem—Low Side Pressure Too Low	
Possible Cause	**Remedy**
Refrigerant system restriction or blockage.	Check the expansion valve and other components for blockage (blockage may be due to moisture causing ice buildup).
Refrigerant charge too low.	Perform leak test. Repair any leaks, evacuate the system, replace the receiver-drier (only if color indicates it is saturated with moisture), add a full charge of refrigerant.

Problem—High Side Pressure Too High

Problem—High Side Pressure Too High	
Possible Cause	**Remedy**
Restricted airflow through condenser.	Check for dirt and debris buildup in front of condenser, clean as necessary.
	Check engine fan operation.
Restriction or blockage in condenser or line from condenser to receiver-drier.	Restriction or blockage will usually be indicated by a cool spot or ice buildup near the restriction or blockage. Repair as necessary. NOTE: If the compressor has recently failed, the restriction may be due to leftover debris from the failed compressor.
Air in refrigerant.	Check refrigerant purity, evacuate, and charge as necessary.
Engine overheating.	Check engine cooling system.
Engine fan not working correctly.	See **Group 20**, check fan cycling switch.

Problem—Compressor Runs Continuously

Problem—Compressor Runs Continuously*	
Possible Cause	**Remedy**
Refrigerant charge too high.	Evacuate the system, replace the receiver-drier (only if color indicates it is saturated with moisture), add a full charge of refrigerant.
Faulty evaporator temperature sensor.	See "Evaporator Temperature Sensor."

* This is normal when the ambient temperature and/or relative humidity is high.

Problem—Little or No Heat, Front and Auxiliary Units

Problem—Little or No Heat, Front and Auxiliary Units	
Possible Cause	**Remedy**
Low engine coolant.	Check coolant level.
Plugged heater core.	Flush coolant system or replace heater core as necessary. NOTE: This can be checked by feeling the inlet and outlet heater hoses. There should be a slight temperature difference when the temperature is set to hot and the fan is on high (engine at operating temperature). A large temperature difference indicates a blockage.
Faulty engine thermostat.	Check if thermostat is stuck open, this may cause the engine to not reach operating temperature under light load or when ambient temperatures are low.
Temperature door not operating correctly.	Electrical problem with temperature actuator. Check for fault codes. See fault code tables, in **Subject 340**, for diagnosis. Also see "Override."
	Mechanical problem with temperature door. Check for obstructions or broken components, repair as necessary. NOTE: The actuator has no feedback to the FCU/ACU to verify position. If there are no fault codes and the actuator signal appears to be working in the DataLink Monitor template, then suspect a mechanical problem.
System out of calibration, front unit only.	See "Calibration Procedure."

Problem—Water or Engine Coolant Leaking from HVAC Unit Inside the Cab, Front and Auxiliary Units

Problem—Water or Engine Coolant Leaking from HVAC Unit Inside the Cab, Front and Auxiliary Units*	
Possible Cause	**Remedy**
Plugged drain tubes.	Clean as necessary.
Leaking heater core.	Replace heater core.

* Clear water dripping from the HVAC unit under the hood is normal when the A/C is on. This is from moisture condensing out of the air as it cools going through the evaporator.

Symptom Driven Diagnosis

Problem—Recirculation Mode Not Working, Front Unit Only

Problem—Recirculation Mode Not Working, Front Unit Only	
Possible Cause	**Remedy**
Recirc door not operating correctly.	Electrical problem with recirc actuator. Check for fault codes. See fault code tables, in **Subject 340**, for diagnosis. Also see "Recirculation" and "Actuator Stepper Motors—Temperature, Recirc and Mode." Mechanical problem with recirculation door. Check for obstructions or broken components, repair as necessary. NOTE: The actuator has no feedback to the FCU/ACU to verify position. If there are no fault codes and the actuator signal appears to be working in the DataLink Monitor template, then suspect a mechanical problem.
System out of calibration.	See "Calibration Procedure."

Problem—Air Does Not Come Out of Correct Outlets, Front Unit Only

Problem—Air Does Not Come Out of Correct Outlets, Front Unit Only*	
Possible Cause	**Remedy**
Mode door not operating correctly.	Electrical problem with mode actuator. Check for fault codes. See fault code tables, in **Subject 340**, for diagnosis. Also see "Recirculation" and "Actuator Stepper Motors—Temperature, Recirc and Mode."
	Mechanical problem with mode door. Check for obstructions or broken components, repair as necessary. NOTE: The actuator has no feedback to the FCU/ACU to verify position. If there are no fault codes and the actuator signal appears to be working in the DataLink Monitor template, then suspect a mechanical problem.
Broken or disconnected duct.	Repair as necessary.
System out of calibration.	See "Calibration Procedure."

* For example, air directed to windshield outlets when air selection switch is set to floor outlets.

Problem—Warm Air from Outlets When Temperature is Set to Cold (A/C not on)

Problem—Warm Air from Outlets When Temperature is Set to Cold (A/C not on)	
Possible Cause	**Remedy**
Temperature door not operating correctly.	Electrical problem with temperature actuator. Check for fault codes. See fault code tables, in **Subject 340**, for diagnosis. Also see "Actuator Stepper Motors—Temperature, Recirc, and Mode."
	Mechanical problem with temperature door. Check for obstructions or broken components, repair as necessary. NOTE: The actuator has no feedback to the FCU/ACU to verify position. If there are no fault codes and the actuator signal appears to be working in the DataLink Monitor template, then suspect a mechanical problem.

Problem—Warm Air from Outlets When Temperature is Set to Cold (A/C not on)	
Possible Cause	**Remedy**
System out of calibration, front unit only.	See "Calibration Procedure."
Wiring/temperature control problem, auxiliary unit only.	See **Table 11**, Sleeper Climate Control Panel Circuit Diagnosis.

Problem—No Backlighting, Front Unit Only

Problem—No Backlighting, Front Unit Only	
Possible Cause	**Remedy**
Dim signal not reaching the FCU or faulty FCU.	See "Backlighting Diagnosis."

Problem—Blower Not Working, Operates at Reduced Speed, or Runs Then Shuts Off, Front and Auxiliary Units

Problem—Blower Not Working, Operates at Reduced Speed, or Runs Then Shuts Off, Front and Auxiliary Units	
Possible Cause	**Remedy**
Blower in protection mode.	Check for fault codes.
Wiring problem.	See fault code tables, in **Subject 340**, for diagnosis.
Faulty blower motor.	If there are no active fault codes, refer to "Blower Motor" for more information.
Wiring problem between sleeper climate control panel and ACU, auxiliary unit only.	See **Table 11**, Sleeper Climate Control Panel Circuit Diagnosis.
Faulty blower control potentiometer, auxiliary unit only.	See **Table 11**, Sleeper Climate Control Panel Circuit Diagnosis.

Problem—Bunk Override Does Not Work, SleeperCab Only (cannot override auxiliary blower and temperature settings from the front)

Problem—Bunk Override Does Not Work, SleeperCab Only (cannot override auxiliary blower and temperature settings from the front)	
Possible Cause	**Remedy**
Faulty bunk override switch.	Check switch. See "Override" for diagnosis. Verify switch operation using DataLink Monitor template.
Wiring problem.	Check wiring between override switch and FCU.
No J1587 databus communication between FCU and ACU.	Using ServiceLink, make sure both the FCU (MID 146) and ACU (MID 200) appear in the ECU list. If one ECU does not appear in the list, troubleshoot the J1587 databus. See **Group 54** for more information. Also see "Override" for diagnosis. NOTE: Vehicles without a sleeper do not have an ACU.
Faulty FCU.	See "Override" for diagnosis.
Faulty ACU.	See "Override" for diagnosis.

Symptom Driven Diagnosis

Problem—Rear Override Does Not Work, SleeperCab Only (minimum A/C support)

Problem—Rear Override Does Not Work, SleeperCab Only (minimum A/C support)*	
Possible Cause	**Remedy**
Front not providing A/C support for auxiliary (rear override not working).	Check rear override function. See "Override" for diagnosis. Problem may be no J1587 databus communication between the ACU and FCU.

* Rear cannot override to request A/C compressor when front unit is off. This should also cause front unit to operate at minimum blower speed if off.

A/C Clutch Circuit Diagnosis

Before performing tests on the A/C clutch circuit, perform the diagnostic tests in **Table 1**.

NOTE: Do not perform the test procedures in **Table 3** before performing the test procedures in **Table 1**.

A/C Clutch Does Not Engage				
Test No.	**Test**	**Test Procedure**	**Test Result**	**Action**
1	Check control settings.	In order for the A/C compressor to operate, the controls must be set as follows: • blower speed at any setting other than off • air selection in one of A/C or defrost settings • A/C button is pressed; light on • engine running above 450 rpm • ambient temperature at the evaporator sensor must be above 44°F (7°C) forA/C compressor to engage If these conditions are met, the A/C compressor should engage. It may cycle on/off.	Conditions met, A/C compressor engages.	No problem found.
			Conditions met, A/C compressor does not engage.	**Go to test no. 2**.
2	Check for fault codes.	Connect ServiceLink and check for fault codes. Check if one of the following fault codes is active: • 146 s011 05 • 146 s011 06 NOTE: See Front Control Unit (FCU) (MID 146) J1587 Fault Codes by SID table, in **Subject 340**, for fault code descriptions.	One of these faults is active.	See **Table 3**.
			Faults other than these are active.	Repair fault before proceeding.
			No active faults.	**Go to test no. 3**.

A/C Clutch Does Not Engage				
Test No.	**Test**	**Test Procedure**	**Test Result**	**Action**
3	Check if A/C request is being sent.	Connect PC to vehicle and open the Behr CDTC Blend Air HVAC System DataLink Monitor template. Do the following: • Start the engine. • Set the blower to any speed except off. • Set the air selection switch to face mode. • Press the A/C button; the light should be on. Observe the A/C request annunciator in the template. The A/C request signal should be active and the A/C compressor should engage when the previous conditions are met and the following conditions are met: • Evaporator sensor is above 44°F (7°C). • Engine speed above 450 rpm. See template. • Low air pressure signal is not being broadcast by the instrument cluster. See template.	A/C request signal is active.	See **Table 4**.
			A/C request signal is not active.	**Go to test no. 4**.
4	Check evaporator sensor.	Note the ambient air temperature. Measure the resistance of the evaporator temperature sensor and compare the reading with the value in **Table 2** or **Fig.1**. The reading should correspond to a temperature approximately equal to the ambient temperature. NOTE: The evaporator sensor temperature must be above 44°F (7°C) before the FCU will send the A/C request signal to the A/C clutch relay. Therefore the sensor resistance must be below approximately 6500 ohms. See **Table 2** or **Fig. 1**. Also see **Fig. 2**.	Less than 6500 ohms	Check wiring between FCU and evaporator temperature sensor. If okay and all other inputs are met, such that the A/C request signal should be sent, then replace the FCU.**Go to test no. 5**.
			More than 6500ohms	The FCU is not sending an A/C request signal because the sensor is indicating the temperature is below 44°F (7°C). If temperature is known to be well above this temperature, then replace the sensor. **Go to test no. 5**.

Symptom Driven Diagnosis

A/C Clutch Does Not Engage				
Test No.	**Test**	**Test Procedure**	**Test Result**	**Action**
5	Verify repair.	Verify that repair resolved the problem.	Problem resolved	Done
			Problem unresolved	**Repeat test no. 1**.

Table 1, A/C Clutch Does Not Engage

Evaporator Temperature Sensor Temperature versus Resistance			
Temperature °F (°C)	**Resistance (ohms)**	**Temperature °F (°C)**	**Resistance (ohms)**
20 (–6.7)	12,814	55 (12.8)	4792
25 (–3.9)	11,036	60 (15.6)	4209
30 (–1.1)	9535	65 (18.3)	3706
32 (0)	**9000**	70 (21.1)	3271
35 (1.7)	8265	75 (23.9)	2894
40 (4.4)	7183	80 (26.7)	2566
45 (7.2)	6259	85 (29.4)	2281
50 (10)	5468		

Table 2, Evaporator Temperature Sensor Temperature versus Temperature Resistance

A/C Request Circuit Test				
Test No.	**Test**	**Test Procedure**	**Test Result**	**Action**
1	Which fault code is active?	NOTE: Circuit problems between the FCU and A/C clutch relay (coil side) will activate fault codes.	146 s011 05 is active	**Go to test no. 2**.
			146 s011 06 is active	**Go to test no. 5**.
2	Check A/C clutch relay.	Remove the A/C clutch relay from the PDM. Measure the resistance across the relay coil (pins 85 and 86). NOTE: If the relay coil is open, the resistance will be approximately 680 ohms.	72–87 ohms	**Go to test no. 3**.
			Not 72–87 ohms	Replace relay.**Go to test no. 7**.
3	Check A/C clutch relay coil ground.	With the A/C clutch relay removed, check resistance between the ground side of the relay coil (PDM side) and the negative battery terminal. Make sure the batteries are disconnected or result may be inconclusive.	Less than 1 ohm	**Go to test no. 4**.
			More than 1 ohm	Repair relay coil ground circuit. **Go to test no. 7**.

A/C Request Circuit Test				
Test No.	**Test**	**Test Procedure**	**Test Result**	**Action**
4	Check circuit 97T.	Remove the A/C clutch relay. Disconnect the B connector from the back of the FCU. Measure resistance between the power side of the relay coil (PDM side) and pin B10 at the FCU B connector.	Less than 1 ohm	No problem found.**Repeat test numbers 1 through 4**.
			More than 1 ohm	Locate and repair high resistance or open in circuit 97T. **Go to test no. 7**.
5	Check A/C clutch relay.	Remove the A/C clutch relay from the PDM. Measure the resistance across the relay coil (pins 85 and 86). NOTE: If the relay coil is open, the resistance will be approximately 680 ohms.	72–87 ohms	**Go to test no. 6**.
			Not 72–87 ohms	Replace relay.**Go to test no. 7**.
6	Check circuit 97T for short to ground.	Disconnect the B connector from the back of the FCU. Measure resistance between pin B10 of the FCU B connector and the negative battery terminal. Make sure batteries are disconnected or result may be inconclusive.	72–87 ohms	No problem found. Repeat tests and look for possible intermittent short to ground in circuit 97T. **Go to test no. 7**.
			Less than 72 ohms	Locate short to ground in circuit 97T. Repair as necessary. **Go to test no. 7**.
7	Verify repair.	Verify that repair corrected the fault code and the problem is resolved.	Problem resolved	Done.
			Problem unresolved	**Repeat test no. 1**.

Table 3, A/C Request Circuit Test

NOTE: Do not perform the test procedures in **Table 4** before performing the test procedures in **Table 1**.

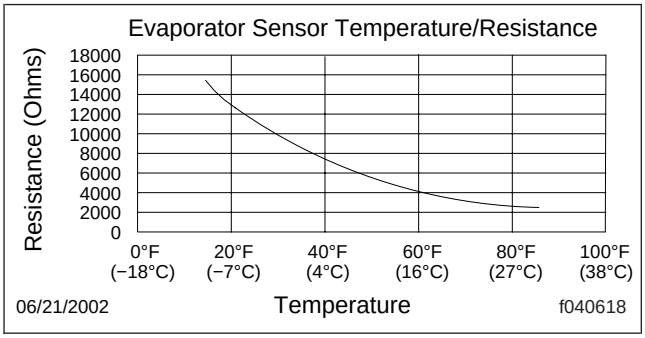


Fig. 1, Evaporator Sensor Temperature/Resistance

Symptom Driven Diagnosis

A/C Clutch Circuit Test				
Test No.	**Test**	**Test Procedure**	**Test Result**	**Action**
1	Check power to A/C clutch relay.	Remove the A/C clutch relay from the PDM. Turn the ignition on and check for voltage on the PDM socket that corresponds to pin 87 A/C clutch relay.	No voltage	**Go to test no. 2**.
			12V	**Go to test no. 3**.
2	Check A/C clutch fuse.	Check the 20A A/C clutch fuse in the PDM (fuse 55).	Fuse okay	Check to make sure power is getting to fuse. If okay, check circuit between fuse and A/C clutch relay. Repair as necessary, then **go to test no. 6**.
			Fuse blown	Locate source of high current between the PDM and the A/C compressor clutch. The circuit may be shorted to ground. Repair as necessary, then **go to test no. 6**.
3	Check A/C clutch circuit resistance.	Remove the A/C clutch relay from the PDM. Measure the resistance between the PDM socket that corresponds to circuit 97T and the negative battery terminal. NOTE: Make sure batteries are disconnected. Failure to do so may give inconclusive results.	2.85 to 4 ohms	Check the A/C clutch relay. Make sure pin 87 is making contact with pin 30 when the relay is energized. Replace as necessary, then **go to test no. 6**.
			More than 4 ohms	**Go to test no. 4**.
4	Check binary switch.	Disconnect the binary switch and check continuity across the switch terminals.	Continuity	**Go to test no. 5**.
			No continuity	Check refrigerant pressures. If pressure is below the binary switch cutout pressure, the system is severely undercharged. Locate source of leak and recharge. If pressures are within the binary switch range, replace the binary switch then **go to test no. 6**.

A/C Clutch Circuit Test				
Test No.	**Test**	**Test Procedure**	**Test Result**	**Action**
5	Measure resistance of the A/C clutch.	Disconnect the connector at the A/C compressor. Measure resistance on the compressor side of the connector.	2.85–3.33 ohms	Problem is most likely high resistance or open circuit in wiring between the A/C clutch relay in the PDM and the A/C compressor. Be sure to check A/C compressor clutch ground circuit. The most definitive way to isolate the problem is to manually energize the circuit at the relay and use voltage drop measurements to isolate the problem, then **go to test no. 6**.
			Not 2.85–3.33 ohms	Replace A/C compressor clutch, then **go to test no. 6**.
6	Verify repair.	Verify that repair corrected the fault code and the problem is resolved.	Problem resolved	Done.
			Problem unresolved	**Repeat test no. 1**.

Table 4, A/C Clutch Circuit Test

Bunk Override Diagnosis

The front control unit will remember bunk override setting after an ignition cycle and initiate bunk override again. Both the front and auxiliary units will be in bunk override mode.

See **Table 5** for bunk override diagnosis procedures.

Bunk Override Diagnosis				
Test No.	**Test**	**Test Procedure**	**Test Result**	**Action**
1	Check bunk override function with DataLink Monitor Test.	Open the DataLink Monitor template for this system. Turn the ignition on. Set the front blower to high and the temperature to hot. Set the auxiliary blower to off and the temperature to cold. In the template, press the bunk override ON test button. The ACU bunk override mode annunciator state should be ON and the auxiliary blower and temperature settings should match the front settings (can be observed on the template. Note that it takes about a minute for the settings to completely change.)	The ACU bunk override mode state is ON and auxiliary blower and temperature settings closely match front settings.	**Go to test no. 3**.
			The ACU bunk override mode state is ON and auxiliary blower and/or temperature settings do not match the front unit.	Replace ACU, then **go to test no. 5**.
			The ACU bunk override mode state is OFF or NA/ERR.	**Go to test no. 2**.

Symptom Driven Diagnosis

Bunk Override Diagnosis				
Test No.	**Test**	**Test Procedure**	**Test Result**	**Action**
2	Verify J1587 communication.	Connect ServiceLink to the vehicle. Check if both the FCU (MID 146) and ACU (MID 200) appear in the ECU list.	Both ECUs appear in the ECU list.	**Go to test no. 3**.
			One or both ECUs do not appear in the ECU list or ServiceLink is unable to connect to vehicle.	Troubleshoot and repair J1587 databus. Refer to **Group 54** for more information. **Go to test no. 5**.
3	Check override switch operation.	Open the DataLink Monitor template for this system. While observing the bunk override switch annunciator in DLM, press the switch to the momentary on position, then to the momentary off position. The annunciator should indicate switch position. When the switch is in the normal position, the annunciator should indicate NA/ERR.	Switch functions as described.	**Go to test no. 4**
			Switch does not function as described.	Check override switch and wiring. Repair as necessary. If okay, replace the FCU. **Go to test no. 5**.
4	Check if FCU is sending bunk override request.	Open the DataLink Monitor template for this system. While observing the Bunk O/R Request annunciator, press the bunk override switch to the momentary on position then release it. The O/R request annunciator should be in the ON state then read NA/ERR.	Bunk O/R request annunciator briefly indicates ON then goes to NA/ERR and FCU and ACU bunk override mode state is ON.	Problem not found. Verify complaint, check for intermittent problems, repeat tests if necessary.
			Bunk O/R request annunciator remains in the ON state.	Check ACU; it is not responding to the bunk override request. Make sure it has power and ground andJ1587 databus communication. If okay, replace ACU. **Go to test no. 5**.
			Bunk O/R request annunciator does not ever indicate it is in the ON state.	Repeat test 3. If okay, replace FCU, then **go to test no. 5**.
5	Verify repair.	Verify that repair corrected the fault code and the problem is resolved.	Problem resolved.	Done.
			Problem unresolved.	**Repeat test no. 1**.

Table 5, Bunk Override Diagnosis

See **Table 6** for rear override diagnosis procedures.

Rear Override Diagnosis				
Test No.	**Test**	**Test Procedure**	**Test Result**	**Action**
1	Check rear override function with DataLink Monitor Test. NOTE: If the front unit diagnoses a bad blower motor, then it will not go into rear override mode and will not activate the A/C request signal.	Open the DataLink Monitor template for this system. Turn the ignition on. Set the front blower to off. Set the auxiliary blower to high and the temperature to full cold. In the template, press the rear override ON test button. On the template, the FCU rear override mode annunciator state should be ON and the A/C mode annunciator should be ON. The A/C clutch annunciator will not be on unless the A/C request rules are met (engine running, air pressure up, etc.). The front blower should be on low speed and the A/C indicator light on the A/C button should be on.	FCU rear override mode state annunciator in ON and A/C mode annunciator is ON.	**Go to test no. 3**.
			FCU rear override mode state annunciator is ON and A/C mode annunciator is OFF.	Replace FCU, then **go to test no. 4**.
			FCU rear override mode state annunciator is OFF.	**Go to test no. 2**
2	Verify J1587 communication.	Connect ServiceLink to the vehicle. Check if both the FCU (MID 146) and ACU (MID 200) appear in the ECU list.	Both ECUs appear in the ECU list.	Replace FCU, then **go to test no. 4**.
			One or both ECUs do not appear in the ECU list or ServiceLink is unable to connect to vehicle.	Troubleshoot and repair J1587 databus. Refer to **Group 54** for more information. **Go to test no. 4**.

Symptom Driven Diagnosis

Rear Override Diagnosis				
Test No.	**Test**	**Test Procedure**	**Test Result**	**Action**
3	Check if ACU is sending rear override request.	Open the DataLink Monitor template for this system. Start the engine. Turn the front blower off. While observing the Rear Override O/R Request annunciator in DataLink monitor, set the auxiliary temperature control switch to full cold and the auxiliary blower speed to high. The O/R Request annunciator should momentarily be in the ON state, then read NA/ERR. It may take a moment for this to happen.	O/R Request annunciator briefly indicates ON , then goes to NA/ERR, and FCU and ACU rear override mode state annunciators are ON, and A/C mode state annunciator is ON.	Problem not found. Rear override is functioning normally.
			O/R Request annunciator stays in the ON state.	Check FCU. It is not responding to the rear override request. Make sure it has power and ground andJ1587 databus communication. If okay, replace FCU. **Go to test no. 4**.
			O/R Request annunciator does not ever indicate it is in the ON state.	Repeat test no. 3. If ambient temperature is low, the auxiliary unit may not request rear override. Replace ACU if repeated test fails. **Go to test no. 4**
4	Verify repair.	Verify that repair resolved the problem.	Problem resolved.	Done.
			Problem unresolved.	**Repeat test no. 1**.

Table 6, Rear Override Diagnosis

Actuator Diagnosis

See **Table 7** for the actuator circuit test procedures.

Actuator Circuit Test				
Test No.	**Test**	**Test Procedure**	**Test Result**	**Action**
1	Check for fault codes.	Check if any one of the following fault codes is active: **Group A**: 146 s005 05; 146 s006 05; 146 s009 05; 200 s009 05 **Group B**: 146 s005 06; 146 s006 06; 146 s009 06; 200 s009 06 07/02/2002 f040619	Single fault in Group A isactive.	**Go to test no. 2**.
			All three MID 146 faults are active in Group A.	**Go to test no. 6**.
			Single fault in Group B is active.	**Go to test no. 8**.
			No faults listed in Group A or B are active.	No problem found.

Actuator Circuit Test				
Test No.	**Test**	**Test Procedure**	**Test Result**	**Action**
2	Check voltage to the actuator. NOTE: In order to measure a valid voltage, it may be necessary to move the respective control :for recirc, press the recirc button; for mix door actuator, move the temperature control switch; for the mode actuator, move the air selection switch.	For code **146s005 05** (front unit) disconnect the recirc actuator connector, turn the ignition on, measure voltage between connector pin 1 and ground. For code **146 s006 05** (front unit) disconnect the mode actuator connector, turn the ignition on, measure voltage between connector pin 1 and ground. For code **146 s009 05** (front unit) disconnect the temperature actuator connector, turn the ignition on, measure voltage between connector pin 1 and ground. For code **200 s006 05** (auxiliary unit) disconnect the temperature actuator connector, turn the ignition on, measure voltage between connector pin 1 and ground. NOTE: See **Fig. 2**, **Fig. 3**, and **Fig. 4**.	Approximately 12V	**Go to test no. 3**.
			Much less than 12V.	Check wire between pin 1 of the actuator and the FCU/ACU for open circuit. If okay, replace FCU/ACU. **Go to test no. 9**.

Symptom Driven Diagnosis

Actuator Circuit Test				
Test No.	**Test**	**Test Procedure**	**Test Result**	**Action**
3	Check for short to ground on return side of actuator.	For code **146s005 05** (front unit) disconnect all three actuator connectors and the FCU connector. At the recirc actuator connector, check continuity between connector pin 3 and ground. Repeat for pins 4, 5, and 6. For code **146 s006 05** (front unit) disconnect all three actuator connectors and the FCU connector. At the mode actuator connector, check continuity between connector pin 3 and ground. Repeat for pins 4, 5, and 6. For code **146 s009 05** (front unit) disconnect all three actuator connectors and the FCU connector. At the temperature actuator connector, check continuity between connector pin 3 and ground. Repeat for pins 4, 5, and 6. For code **200 s009 05** (auxiliary unit) disconnect the temperature actuator connector and the ACU connector. At the temperature actuator connector, check continuity between connector pin 3 and ground. Repeat for pins 4, 5, and 6. NOTE: See **Fig. 2**, **Fig. 3**, and **Fig. 4**.	Continuity to ground on any pin.	Locate short to ground, repair as necessary, then **go to test no. 9**.
			No continuity to ground on any pin.	**Go to test no. 4**.

<table>
<tr><th colspan="5">Actuator Circuit Test</th></tr>
<tr><th>Test No.</th><th>Test</th><th>Test Procedure</th><th>Test Result</th><th>Action</th></tr>
<tr><td rowspan="2">4</td><td rowspan="2">Check continuity of actuator return side.</td><td rowspan="2">For code 146s005 05 disconnect the recirc actuator connector.

For code 146 s006 05 disconnect the mode actuator connector.

For code 146 s009 05 disconnect the temperature actuator connector.

Check continuity between the following connector pins:

<table><tr><th>FCU</th><th>Actuator</th></tr><tr><td>A2</td><td>3</td></tr><tr><td>B1</td><td>4</td></tr><tr><td>B2</td><td>5</td></tr><tr><td>B3</td><td>6</td></tr></table>07/02/2002 f040620

For code 200 s009 05 (auxiliary unit) disconnect the auxiliary unit temperature actuator connector and the ACU connector.

Check continuity between the following connector pins:

<table><tr><th>ACU</th><th>Actuator</th></tr><tr><td>B8</td><td>3</td></tr><tr><td>B7</td><td>4</td></tr><tr><td>B6</td><td>5</td></tr><tr><td>B5</td><td>6</td></tr></table>07/02/2002 f040621

NOTE: See Fig. 2, Fig. 3, and Fig. 4.</td><td>Continuity on all pin combinations.</td><td>Go to test no. 5.</td></tr>
<tr><td>No continuity on one or more pin combinations.</td><td>Locate open circuit, repair as necessary, then go to test no. 9.</td></tr>
</table>

Symptom Driven Diagnosis

<table>
<tr><th colspan="5">Actuator Circuit Test</th></tr>
<tr><th>Test No.</th><th>Test</th><th>Test Procedure</th><th>Test Result</th><th>Action</th></tr>
<tr><td rowspan="2">5</td><td rowspan="2">Check actuator.</td><td rowspan="2">For code 146s005 05 (front unit) perform "Actuator Stepper Motor Electrical Test" on the recirc actuator.

For code 146 s006 05 (front unit) perform "Actuator Stepper Motor Electrical Test" on the mode actuator.

For code 146 s009 05 (front unit) perform "Actuator Stepper Motor Electrical Test" on the temperature actuator.

For code 200 s009 05 (auxiliary unit) perform "Actuator Stepper Motor Electrical Test" on the temperature actuator (auxiliary unit).</td><td>Actuator okay.</td><td>Replace FCU/ACU, thengo to test no. 9.</td></tr>
<tr><td>Actuator not okay.</td><td>Replace actuator, thengo to test no. 9.</td></tr>
<tr><td rowspan="2">6</td><td rowspan="2">Check actuator return circuits for open.</td><td rowspan="2">For all three active codes at the same time, 146 s005 05, 146 s006 05, 146 s009 05, disconnect all three actuator connectors and the FCU connector. At each actuator connector, check continuity between the following connector pins:

<table><tr><th>FCU</th><th>Actuator</th></tr><tr><td>A2</td><td>3</td></tr><tr><td>B1</td><td>4</td></tr><tr><td>B2</td><td>5</td></tr><tr><td>B3</td><td>6</td></tr></table>07/02/2002 f040620

NOTE: See Fig. 2, Fig. 3, and Fig. 4.</td><td>Continuity on all pin combinations.</td><td>Go to test no. 7.</td></tr>
<tr><td>No continuity on one or more pin combinations.</td><td>Locate open circuit, repair as necessary, then go to test no. 9.</td></tr>
<tr><td rowspan="2">7</td><td rowspan="2">Check actuator return circuits for short to ground.</td><td rowspan="2">Disconnect all three actuator connectors and the FCU connector. At the FCU connector, check continuity between pin A2 and ground. Repeat for pins B1, B2, and B3.

NOTE: See Fig. 2, Fig. 3, and Fig. 4.</td><td>Continuity to ground on any pin.</td><td>Repair short to ground, thengo to test no. 9.</td></tr>
<tr><td>No continuity to ground on any pin.</td><td>Replace FCU, thengo to test no. 9.</td></tr>
</table>

Actuator Circuit Test				
Test No.	**Test**	**Test Procedure**	**Test Result**	**Action**
8	Check for shorted actuator coil.	For code **146s005 06** disconnect the recirc actuator connector, check if fault no longer active (different fault maybe active). For code **146 s006 06** disconnect the mode actuator connector, check if fault no longer active (different fault may be active). For code **146 s009 06** disconnect the temperature actuator connector, check if fault no longer active (different fault may be active). For code **200 s009 06** disconnect the temperature actuator connector (auxiliary unit), check if fault no longer active (different fault may be active). See **Fig. 2**.	Fault no longer active (FMI06), different fault may be active (FMI 05).	Shorted actuator motor is likely. Perform "Actuator Stepper Motor Electrical Test" to confirm, then **go to test no. 9**.
			Fault still active (FMI06).	Check for short to ground in power wire between actuator and FCU/ACU. If no short is found, replace FCU/ACU, then **go to test no. 9**.
9	Verify repair. NOTE: In order to check if a fault status has changed from active to inactive, the recirc button, temperature control switch, or air selection switch needs to be moved while the ignition is on.	Verify that repair resolved the problem.	Problem resolved.	Done.
			Problem unresolved.	**Repeat test no. 1**.

Table 7, Actuator Circuit Test

Temperature Sensor Diagnosis

See **Table 8** for the evaporator temperature sensor circuit test procedures.

Symptom Driven Diagnosis

Evaporator Temperature Sensor Circuit Test				
Test No.	**Test**	**Test Procedure**	**Test Result**	**Action**
1	Are evaporator temperature sensor fault codes active?	Check if fault code**146 s002 03** or **146 s002 04** is active.	Neither fault isactive.	**Go to test no. 2**.
			146s002 03 is active	Check for sensor signal wire shorted to power. If okay, **go to test no. 2**.
			146s002 04 is active.	Check for sensor signal wire shorted to ground. If okay, replace FCU. **Go to test no. 3**.
2	Check sensor reference voltage.	Disconnect the evaporator sensor. Turn the ignition on and measure the voltage across the sensor connector pins (harness side). The voltage should be 5V if the circuit and FCU are operating correctly.	5V	Perform "Evaporator Temperature Sensor Test."
			Less than 5V.	Check for open circuit in sensor signal and ground wires. If okay, replace FCU. **Go to test no. 3**.
3	Verify repair.	Verify that repair resolved the problem.	Problem solved.	Done.
			Problem unresolved.	**Repeat test no. 1**.

Table 8, Evaporator Temperature Sensor Circuit Test

See **Table 9** for the CDTC temperature sensor circuit test procedures.

CDTC Temperature Sensor Circuit Test				
Test No.	**Test**	**Test Procedure**	**Test Result**	**Action**
1	Are CDTC temperature sensor fault codes active?	Check if one of the following fault codes is active: **146 s001 03**, **146 s001 04**, or**200 s001 03**, **200 s001 04**.	None of these faults isactive.	**Go to test no. 2**.
			146s001 03 or **200 s001 03** is active.	Check for sensor signal wire shorted to power. If okay, **go to test no. 2**.
			146s001 04 or **200 s001 04** is active.	Check for sensor signal wire shorted to ground. If okay, replace FCU/ACU. **Go to test no. 3**.
2	Check sensor reference voltage.	Disconnect the CDTC sensor. Turn the ignition on and measure the voltage across the sensor connector pins (harness side). The voltage should be 5V if the circuit and FCU/ACU are operating correctly.	5V	Perform "CDTC Temperature Sensor Test."
			Less than 5V.	Check for open circuit in sensor signal and ground wires. If okay, replace FCU/ACU. **Go to test no. 3**.

CDTC Temperature Sensor Circuit Test				
Test No.	**Test**	**Test Procedure**	**Test Result**	**Action**
3	Verify repair.	Verify that repair resolved the problem.	Problem resolved.	Done.
			Problem unresolved.	**Repeat test no. 1**.

Table 9, CDTC Temperature Sensor Circuit Test

Backlighting Diagnosis

See **Table 10** for backlighting diagnosis.

Backlighting Diagnosis				
Test No.	**Test**	**Test Procedure**	**Test Result**	**Action**
1	Check backlighting operation.	Turn on the headlights and check for the following conditions: • Condition 1—all backlighting (instrument cluster, panel switches, and HVAC FCU) not working • Condition 2—HVAC FCU and bunk override switch backlighting not working • Condition 3—only HVAC FCU backlighting not working • Condition 4—only bunk override switch backlighting not working	Condition 1	See Group 54 for backlighting diagnosis.
			Condition 2	**Go to test no. 2**.
			Condition 3	**Go to test no. 3**.
			Condition 4	**Go to test no. 4**.
2	Check circuits 29A and GND1.	Disconnect AS2 connector. Turn headlights on. Measure voltage at pins A(+) and F(–) of the AS2 connector on the main cab harness side.	9–16V	Check AS2 connector for damaged pins. If damaged pins are found, repair as necessary then **go to test no. 5**. If no damage is found, **repeat test no. 1**.
			Less than 9V (0V)	Check for open in circuits 29A and GND1 in the main cab harness. Repair as necessary, then **go to test no. 5**.
3	Check circuits DIM+ and GND1 to FCU.	Disconnect the FCU connector. Turn headlights on. Measure voltage at pins A6(+) and A7(–) of the FCU connector.	9–16V	Replace FCU, then **go to test no. 5**.
			Less than 9V (0V)	Check circuits DIM+ and GND1 between the FCU connector and the AS2 connector for circuit fault (open or short). Repair as necessary, then **go to test no. 5**.

Symptom Driven Diagnosis

Backlighting Diagnosis				
Test No.	**Test**	**Test Procedure**	**Test Result**	**Action**
4	Check circuits DIM+ and GND1 to override switch.	Disconnect the override switch connector. Turn headlights on. Measure voltage at pins 10(+) and 8(–) of the override switch connector.	9–16V	Replace the override switch, then **go to test no. 5**.
			Less than 9V (0V)	Check circuits DIM+ and GND1 between the override switch and AS2 connectors for circuit faults (open or short). Repair as necessary, then **go to test no. 5**.
5	Verify repair.	Verify that repair solved the backlighting problem.	Problem resolved.	Done.
			Problem unresolved.	**Repeat test no. 1**.

Table 10, Backlighting Diagnosis

Sleeper Climate Control Panel Circuit Diagnosis

See **Table 11** for sleeper climate control panel circuit diagnosis.

Sleeper Climate Control Panel Circuit Diagnosis				
Test No.	**Test**	**Test Procedure**	**Test Result**	**Action**
1	Does the symptom involve both the blower and temperature control?	—	No, affects only one of these	**Go to test no. 4**.
			Yes, affects both	**Go to test no. 2**.
2	Check the 12VDC ignition supply to the control panel.	Gain access to the back of the sleeper control panel. Disconnect the blower and temperature potentiometer connectors. Turn the ignition on. At the blower speed potentiometer connector, check for voltage at pin A (circuit 98N). Repeat test for temperature potentiometer connector pin A (circuit 98N).	Voltage at both pins	**Go to test no. 3**.
			Voltage at only one pin	Check circuit 98N between connector with no voltage and splice in harness. Repair as necessary.
			No voltage at either pin	Check 10A fuse in B-pillar PDM. If blown, check for short in circuit 98N. If okay, check circuit 98N for open and check ignition supply to fuse panel. Repair as necessary.

Sleeper Climate Control Panel Circuit Diagnosis				
Test No.	**Test**	**Test Procedure**	**Test Result**	**Action**
3	Check control panel ground circuit.	Make sure the ignition is off and the batteries are disconnected. Failure to do this may give inconclusive test results. Disconnect the blower and temperature potentiometer connectors. At the blower speed potentiometer connector, check resistance between pin C (circuit GND) and the battery negative terminal. Repeat test for temperature potentiometer connector pin C (circuit GND).	Both less than one ohm	Check ACU power and ground wiring. ACU may be malfunctioning.
			One more than 1 ohm	Check GND circuit between affected potentiometer circuit and the splice in the harness. Repair as necessary.
			Both more than 1 ohm	Check GND wiring to potentiometers. Check ACU ground circuit.
4	Which potentiometer circuit is affected?		Blower control	**Go to test no. 5**.
			Temperature control	**Go to test no. 6**.
5	Check for blower potentiometer voltage signal at the ACU.	Remove the ACU from the HVAC unit; leave the connector plugged in. Turn the ignition on. Backprobe ACU connector pin A2 and check for voltage while rotating the blower speed control knob from low to high.	Voltage ranges from 0.5 to 12.5VDC	Sleeper climate control panel circuit is not the problem. Check for fault codes and see "Blower Motor Diagnostics–Front and Auxiliary Units."
			Voltage does not vary; remains steady regardless of value	Check circuit 98M between blower speed potentiometer and ACU. Repair as necessary. If okay, replace potentiometer.
6	Check for temperature potentiometer voltage signal at the ACU.	Remove the ACU from the HVAC unit; leave the connector plugged in. Turn the ignition on. Backprobe ACU connector pin A5 and check for voltage while rotating the temperature control knob from cold to hot.	Voltage ranges from 0.5 to 12.5 VDC	Sleeper climate control panel circuit is not the problem. Check for fault codes and see "Actuator Stepper Motors—Temperature, Recirc, and Mode" for temperature actuator diagnostics.
			Voltage does not vary; remains steady regardless of value	Check circuit 98T between temperature potentiometer and ACU. Repair as necessary. If okay, replace potentiometer.

Table 11, Sleeper Climate Control Panel Circuit Diagnosis

Blower Motor Diagnostics—Front and Auxiliary Units

See **Table 12** and **Table 13** for blower motor diagnostics.

Symptom Driven Diagnosis

Blower Will Not Operate or Operates at Reduced Speed				
Test No.	**Test**	**Test Procedure**	**Test Result**	**Action**
1	Is fault 146 s010 02 or 200 s010 02 active?	—	Yes	See fault code tables, in **Subject 340**, for diagnosis.
			No	**Go to test no. 2**.
2	Check power and ground.	Disconnect the blower motor connector. Turn ignition on. Check for voltage across pins 3 and 4 of the connector. NOTE: If system voltage is too high or too low, this may cause the blower motor to enter voltage protection mode. This will cause the blower to operate at reduced speed or stop working altogether.	12–17V (should be approx. battery voltage)	**Go to test no. 3**.
			0V	Check 30A blower motor fuse in PDM. Check blower motor power and ground circuits for open (circuits 98 and GND). Repair as necessary, then **go to test no. 7**.
			Less than 12V (not 0) or more than 17V	Blower has most likely entered voltage protection mode. Correct voltage problem as necessary, then **go to test no. 7**.
3	Check speed control signal at blower motor.	Disconnect the blower motor connector. Turn ignition on. Check voltage between connector pin 6 and ground while rotating the blower control switch from off to full speed. The voltage should be approximately 0V (off) to 5V+ (high).	Voltage full range (0–5V+)	**Go to test no. 4**.
			Voltage stays at 0V	Check speed control wire for open circuit between blower motor and FCU or ACU. If okay, check FCU/ACU. Repair/replace as necessary, then **go to test no. 7**.
4	Check for mechanical obstruction/locked rotor.	Remove the blower motor from the HVAC housing. Check for obstruction preventing blower from turning. Check if rotor spins freely by hand.	Obstruction	Remove obstruction as necessary, then **go to test no. 7**.
			Rotor locked	Replace blower motor, then **go to test no. 7**.
			Neither	**Go to test no. 5**.

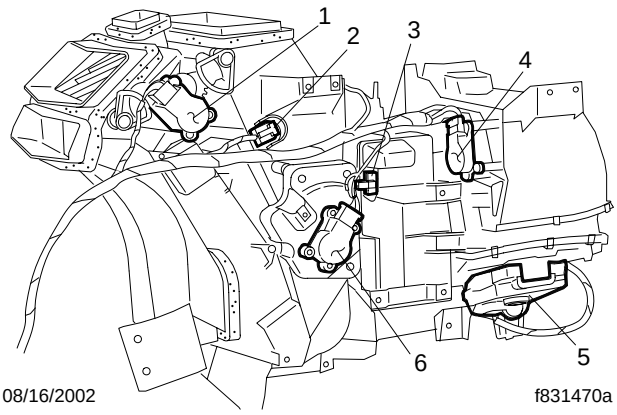
Blower Will Not Operate or Operates at Reduced Speed				
Test No.	**Test**	**Test Procedure**	**Test Result**	**Action**
5	Check voltage drop.	Remove the blower motor from the HVAC housing. Turn ignition on, set blower speed to high. Check voltage on the power and ground circuits by back-probing the blower motor connector. Check between the positive and negative battery posts. NOTE: High voltage drop may cause the blower motor to enter voltage protection mode. This will cause the blower to operate at reduced speed and, if severe enough, may stop the blower altogether.	Less than 0.2V	**Go to test no. 6**.
			More than 0.2V	Locate source of high resistance causing voltage drop. Repair as necessary then **go to test no. 7**.
6	Does the blower motor operate at all?	—	Yes	Check if blower motor feels hot and make sure there are no obstructions to airflow. If no obstructed airflow or blower feels hot, replace blower motor then**go to test no. 7**.
			No	Replace blower motor, then **go to test no. 7**.
7	Verify repair.	Verify that repair resolved the problem.	Problem resolved	Done
			Problem unresolved	**Repeat test no. 1**.

Table 12, Blower Will Not Operate or Operates at Reduced Speed

Diagnosis for Blower Speed is Not Available				
Test No.	**Test**	**Test Procedure**	**Test Result**	**Action**
1	Does blower operate at all?	—	Yes	**Go to test no. 2**.
			No	Perform the tests in **Table 12**.
2	Check feedback speed/diagnostic circuit.	Check for open or short circuit in blower motor feedback speed/ diagnostic circuit between the blower motor and the FCU/ACU.	Circuit is open or shorted	Repair blower motor feedback speed/diagnostic circuit then, **go to test no. 3**.
			Circuit okay	Perform the tests in **Table 12**.
3	Verify repair.	Verify that repair resolved the problem.	Problem resolved	Done
			Problem unresolved	**Repeat test no. 1**.

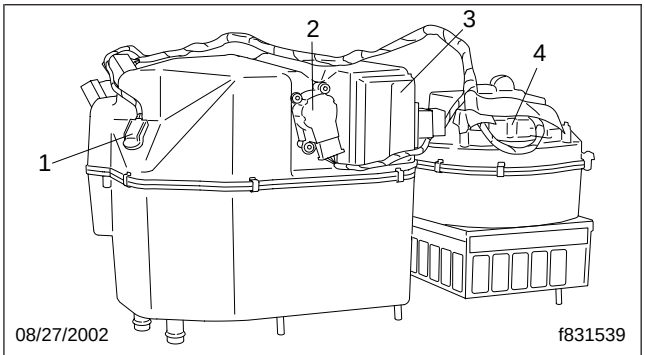
Table 13, Diagnosis for Blower Speed is Not Available

Symptom Driven Diagnosis



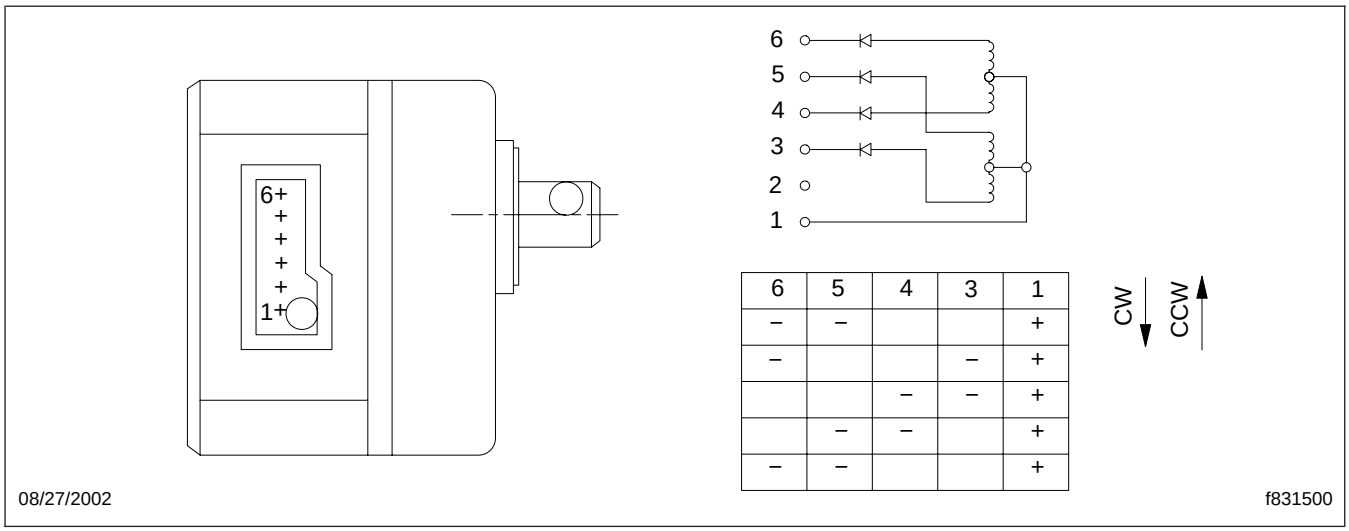
1. Mode Actuator
2. CDTC Temperature Sensor
3. Evaporator Temperature Sensor
4. Recirculation Actuator
5. Blower Motor
6. Temperature Actuator

Fig. 2, Cab HVAC Assembly



1. CDTC Sensor
2. Temperature Actuator
3. Auxiliary Control Unit (ACU)
4. Blower Motor

Fig. 3, Auxiliary HVAC Assembly



6	5	4	3	1
–	–			+
–			–	+
		–	–	+
	–	–		+
–	–			+

Fig. 4, Actuator Motor Pinouts

Specifications

Acceptable Leak Rates by Component	
Component	**Acceptable Leak Rates**
J-Block Body	0.25 oz/yr and greater condemns these components
Evaporators (main and auxiliary)	
Condenser	
Receiver Dryer (Body)	
Lines/Hoses	
Capped Charge Ports	
Mini-Stato seal (1 - when the leak can be tied to a single seal)	
Mini-Stato seals (2 - when the leak cannot be tied to a single seal)	0.50 oz/yr and greater condemns these components
Compressor (shaft seal, housing, etc.)	
TXV (Power Valve and Super Heat Cap)	
Sensor/Switches (O-ring and crimped body connections)	

Table 1, Acceptable Leak Rates by Component

Overview

The Bergstrom NITE (No Idle Thermal Environment) parked, or no-idle, air conditioning system is a compact, electrically powered, 3000-BTU system. It is designed to provide a means of air conditioning to the sleeper area without having the engine running. It is completely self-contained, and runs on 12-volt deep-cycle batteries. The system is designed to maintain cool air in the sleeper interior. For optimal operation, the curtain between the cab and the sleeper must be closed when using the A/C system. The parked A/C unit will not cool down a hot sleeper that has been sitting in the sun without the vehicle A/C running. If the interior temperature is higher than desired, start the engine and run the vehicle A/C system until the desired sleeper temperature is achieved. This will help cool the sleeper to a temperature the parked A/C system can maintain. Once the sleeper temperature is lowered, the system will maintain a comfortable setting.

The unit is located under the lower bunk in the sleeper compartment. The unit gets its intake air from the under-bunk area through a grate in the top panel. An air intake grille is located on the front panel of the lower bunk. The outlet ducting runs from the left side of the unit to an outlet near the bunk occupant's face on the back wall of the sleeper. It is important to keep the air intake grille, and the area under the bunk, free of objects that might block air flow or put objectionable odors into the cooling air. Air for the condenser is taken in from under the cab and exhausted through another opening in the cab floor.

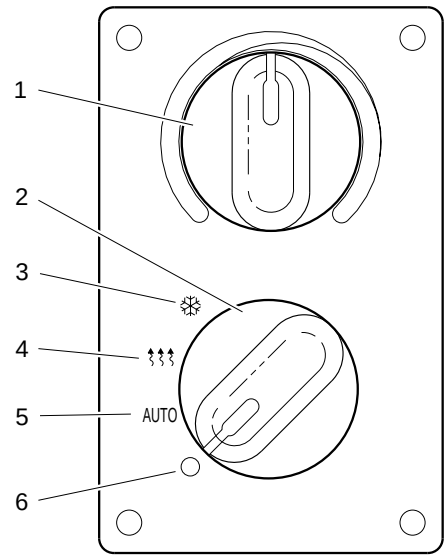
The system receives power from four deep-cycle batteries located between the frame rails. These batteries are completely isolated from the starting batteries to keep the starting batteries from being drawn down during operation.

IMPORTANT: The refrigerant system in the parked A/C unit is a sealed system, it is not serviceable. If problems occur; contact the NITE line at 1-866-204-8570, or visit www.nitesystem-.com.

Operation

The control panel for the parked A/C and heater is located on the back wall of the sleeper near the left side. It has a temperature control dial, and a four-position mode selector switch. Turn the temperature control dial to the left for cooling, and to the right for heat. See **Fig. 1**. See **Table 1** for a description of the function of the mode switch.

The system must be turned off whenever it is not in use, or the batteries may not charge properly. After using the system, turn the mode switch to the OFF position, even if the unit is not running.



1. Temperature Control Dial
2. Mode Switch
3. A/C Only
4. Heat Only
5. AUTO
6. Off

Fig. 1, Parked A/C and Heater Control Panel

Parked A/C and Heater Mode Switch Operation	
Mode	**Function**
Off	Turns the unit off.
AUTO	Allows the unit to automatically heat or cool the sleeper, depending on the temperature setting and the sleeper temperature. Adjusts the compressor, heater, and fans to keep temperature constant.
Heat Only	Allows only the heat portion of the system to run. Adjusts the heater only to keep the temperature constant.

General Information

Parked A/C and Heater Mode Switch Operation	
Mode	**Function**
A/C Only	Allows only the A/C portion of the system to run. Adjusts compressor and fans only to keep the temperature constant.

Table 1, Parked A/C and Heater Mode Switch Operation

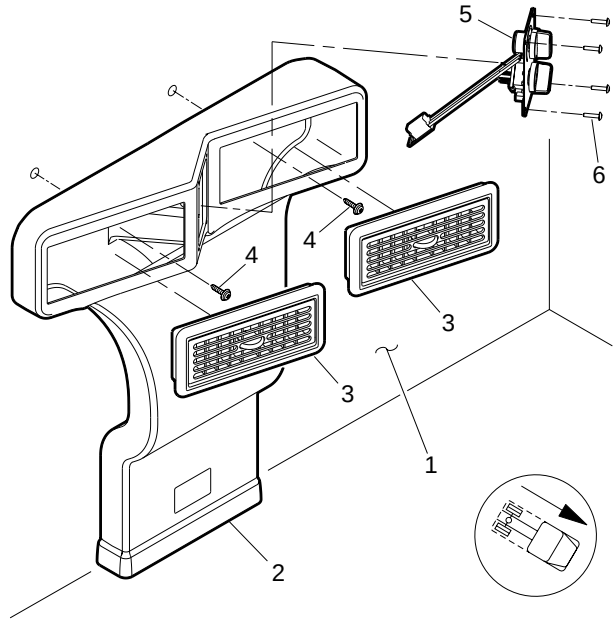
Safety Precautions

IMPORTANT: The refrigerant system on this unit is **not** servicable. Do not attempt to open the refrigerant system. The only reason you should come in contact with the refrigerant is if there is a leak in the system.

Control Panel Removal and Installation

Removal

1. Park the vehicle on a level surface, shut down the engine, set the parking brakes, and chock the tires. Disconnect the vehicle batteries.
2. Remove the outlet grilles. See **Fig. 1**.



1. Sleeper Back Wall
2. Plenum
3. Grille
4. Plenum Screws
5. Control Panel
6. Control Panel Screws

Fig. 1, Plenum and Control Panel Installation

3. Remove the screws that hold the plenum to the back wall of the sleeper.
4. Tilt the plenum out from the wall, and disconnect the wires.
5. Remove the fasteners, and remove the control panel.

Installation

1. Position the control panel in the opening in the housing, and install the fasteners.
2. Connect the wires to the control panel.
3. Position the plenum, and install the fasteners.
4. Install the outlet grilles.
5. Connect the batteries.

Replacement

1. Park the vehicle on a level surface, shut down the engine, set the parking brakes, and chock the tires. Disconnect the vehicle batteries.

NOTE: Mark all wires for reference before disconnecting them.

2. Disconnect the harness and the battery cables at the terminals under the sleeper floor. See **Fig. 1**.

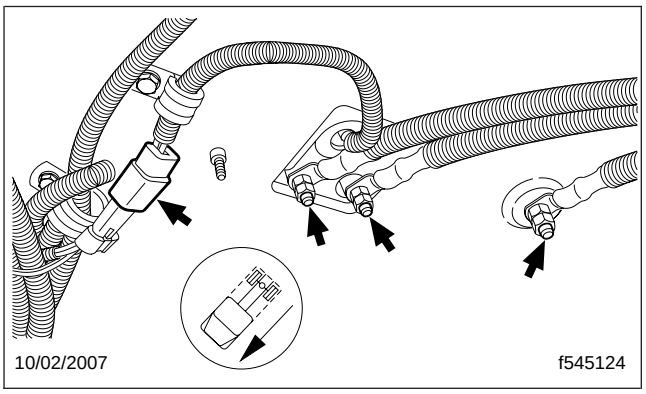


Fig. 1, Harness and Battery Cables

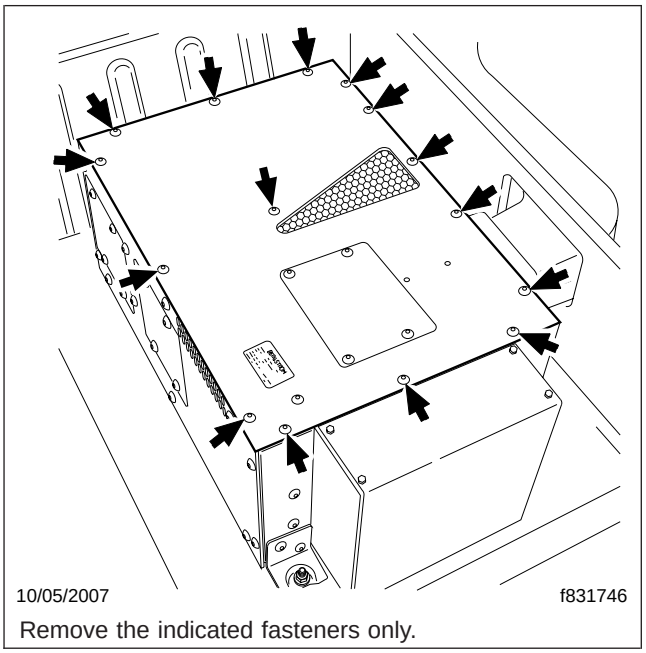
3. Raise and secure the lower bunk.
4. Disconnect the air duct from the outlet opening on the left side of the unit.
5. Disconnect the wires that go to the control panel.
6. Remove the nuts at the corners of the unit.

NOTE: The unit weighs approximately 70 lb (32 kg), and it is awkward to handle in the tight confines of the sleeper. Be careful when lifting it, to avoid personal injury or damaging the cab interior parts.

7. Lift the unit out of the under-bunk area.
8. Position the unit on the mounting studs in the under bunk area, and install the mounting nuts.
9. Connect the wires to the control panel.
10. Attach the air duct to the outlet opening in the left side of the unit.
11. Connect the harness and the battery cables to the terminals under the sleeper floor.
12. Connect the batteries.
13. Lower the bunk.

Replacement

1. Park the vehicle on a level surface, shut down the engine, set the parking brakes, and chock the tires. Disconnect the vehicle batteries.
2. Raise and secure the lower bunk.
3. Remove the top panel. See **Fig. 1**.



Remove the indicated fasteners only.

Fig. 1, Top Access Panel

4. Remove the two fasteners on the inside panel of the unit. See **Fig. 2**.
5. Remove the two fasteners on the outside of the unit, below the outlet duct.
6. Disconnect the wire connector at the blower.
7. Lift the blower assembly out of the unit housing.
8. Position the blower assembly in the unit housing.
9. Connect the wire connector at the blower.
10. Install the blower mounting fasteners; two inside, and two outside.
11. Connect the batteries.
12. Install the top panel.
13. Lower the bunk.

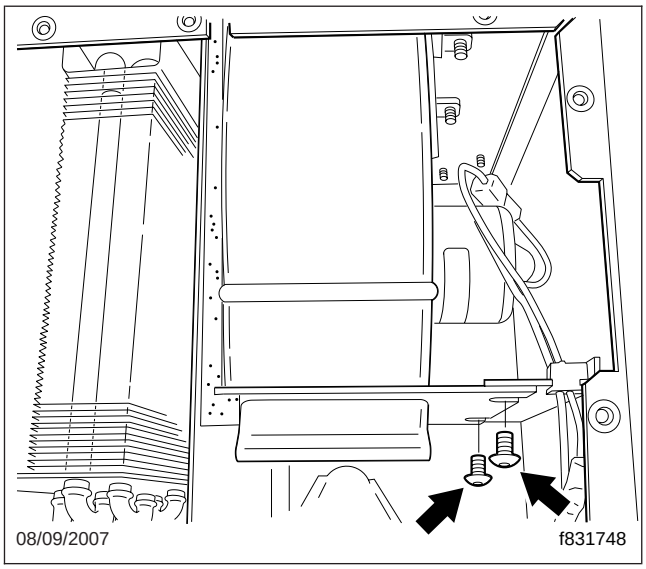


Fig. 2, Inside Blower Fasteners

Replacement

1. Park the vehicle on a level surface, shut down the engine, set the parking brakes, and chock the tires. Disconnect the vehicle batteries.
2. Raise and secure the lower bunk.
3. Remove the top panel. See **Fig. 1**.

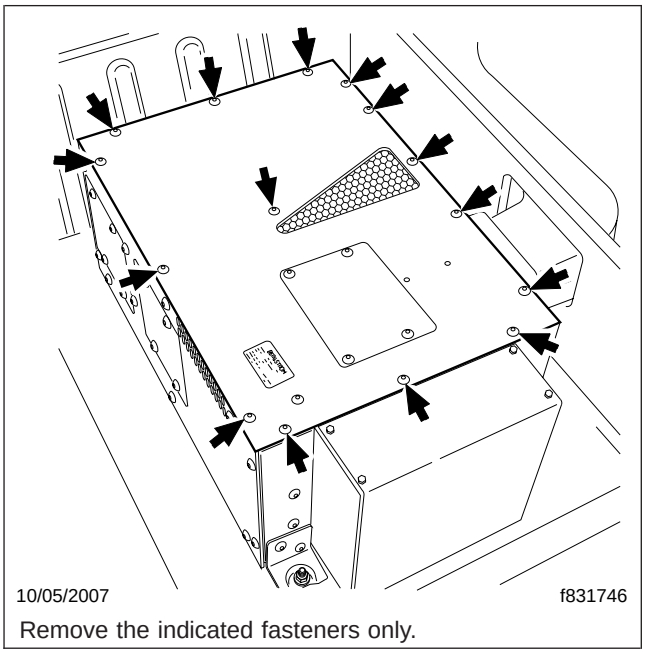


Fig. 1, Top Access Panels

4. Remove the fasteners from the condenser fan assembly. See **Fig. 2**.
5. Cut any wire ties as needed, and disconnect the wire connector from the condenser fan.
6. Remove the condenser fan assembly from the unit housing.
7. Position the condenser fan assembly in the unit housing, and install the fasteners.
8. Connect the wire connector and install wire ties as needed.
9. Connect the batteries.
10. Install the top panel.
11. Lower the bunk.

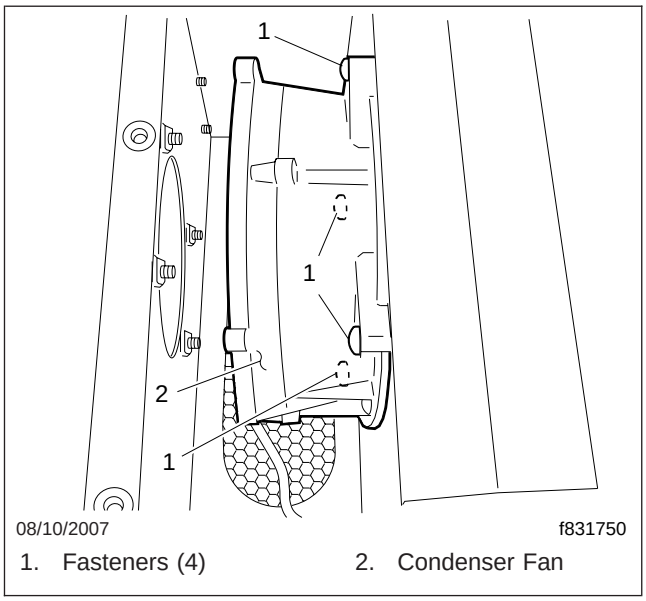


Fig. 2, Condenser Fan Installation

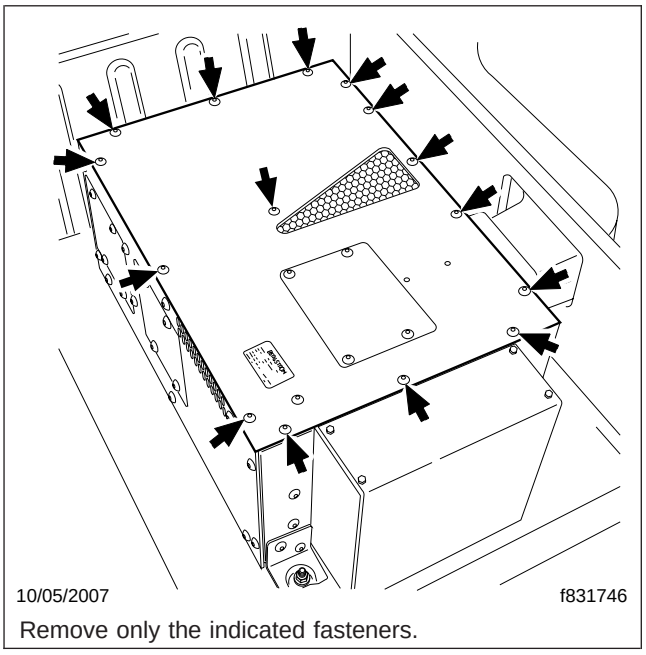
Compressor Control Module Replacement

Replacement

NOTICE

When removing or installing the control module housing, be very careful not to damage the exposed control board. Even a small chip or crack in the control board can ruin it.

1. Park the vehicle on a level surface, shut down the engine, set the parking brakes, and chock the tires. Disconnect both sets of vehicle batteries.
2. Raise and secure the lower bunk.
3. Remove the top panel. See **Fig. 1**.



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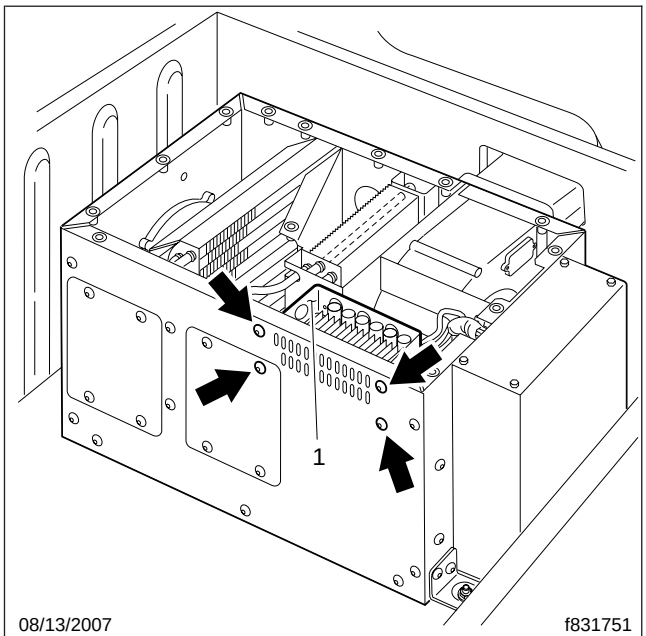
Remove only the indicated fasteners.

Fig. 1, Top Access Panels

4. Remove the four control module housing fasteners on the side panel. See **Fig. 2**.

IMPORTANT: Make sure to note the positions of the wires to the compressor motor. Connecting them incorrectly will cause the compressor to malfunction. The wires to the temperature sensor can go either way. See **Fig. 3** for wire positions.



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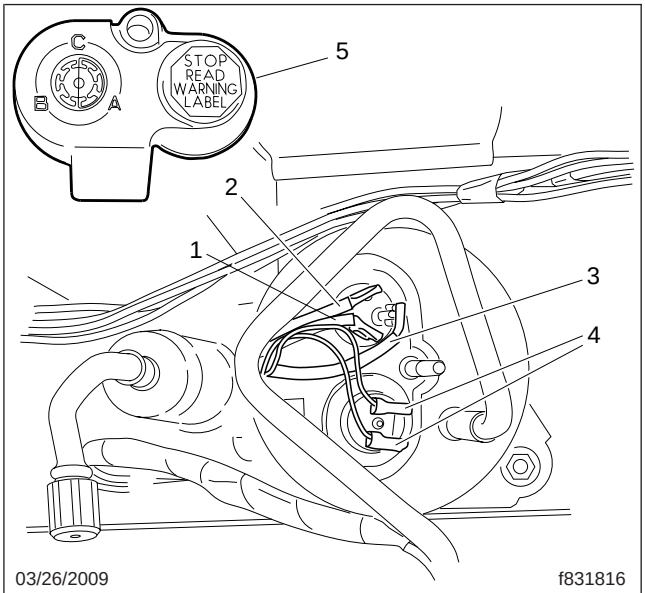
1. Compressor Control Module

Fig. 2, Control-Module-Housing Fasteners

5. Remove the connector cap from the compressor, and disconnect the wires to the motor and temperature sensor.
6. Disconnect the power supply wires from the compressor.
7. Disconnect the connector from the harness to the control board.
8. Carefully remove the compressor control module.
9. Connect the power supply wires to the compressor. See **Fig. 3** for wire positions.
10. Install the compressor cap and nut.
11. Position the compressor control module in the unit housing.
12. Connect the wire connectors to the power supply and the control board.
13. Install the compressor control module fasteners.
14. Connect the batteries.
15. Install the top panel.
16. Lower the bunk.

Compressor Control Module Replacement



1. Blue Wire (position A)
2. Orange Wire (position B)
3. Yellow Wire (position C)
4. Black Wires, Temperature Sensor
5. Connector Cap

Fig. 3, Compressor Wire Connections

Replacement

1. Park the vehicle on a level surface, shut down the engine, set the parking brakes, and chock the tires. Disconnect the vehicle batteries.
2. Raise and secure the lower bunk.
3. Remove the top panel. See **Fig. 1**.

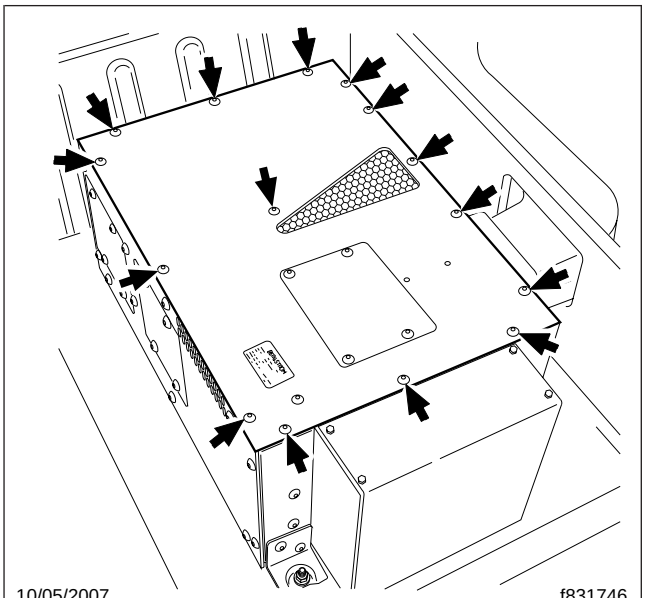


Fig. 1, Top Access Panels

4. Unplug the freeze switch.
5. Remove the fastener. See **Fig. 2**.
6. Remove the freeze switch probe from the evaporator coil, and pull the probe, wire, and rubber grommet out the hole on the panel. See **Fig. 3**.
7. Remove the freeze switch.
8. Insert the probe into the evaporator core in the same location as the original. Install the grommet in the hole in the panel.
9. Position the new freeze switch and install the fastener.
10. Connect the wire into the switch.
11. Connect the batteries.
12. Install the top panel.
13. Lower the bunk.

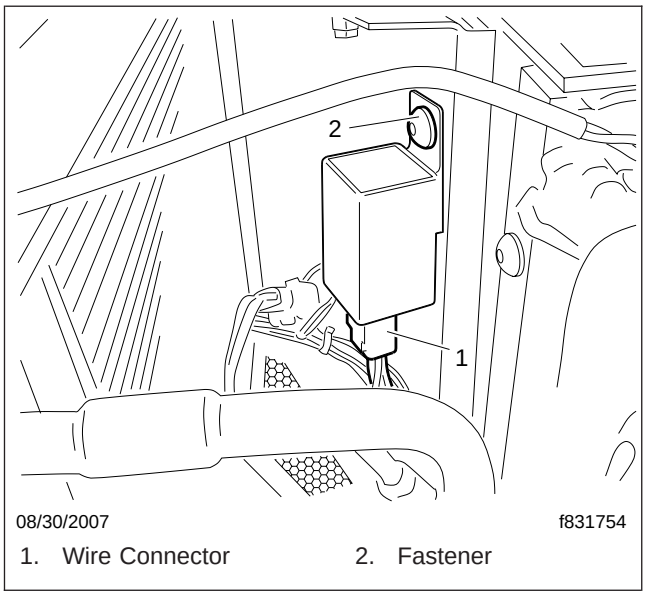


Fig. 2, Freeze Switch

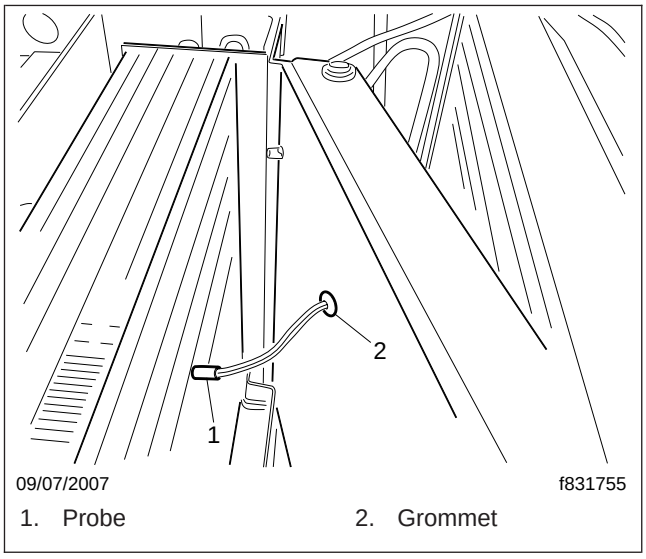


Fig. 3, Freeze Switch Probe

Replacement

1. Park the vehicle on a level surface, shut down the engine, set the parking brakes, and chock the tires. Disconnect both sets of vehicle batteries.
2. Raise and secure the lower bunk.
3. Remove the top panel. See **Fig. 1**.

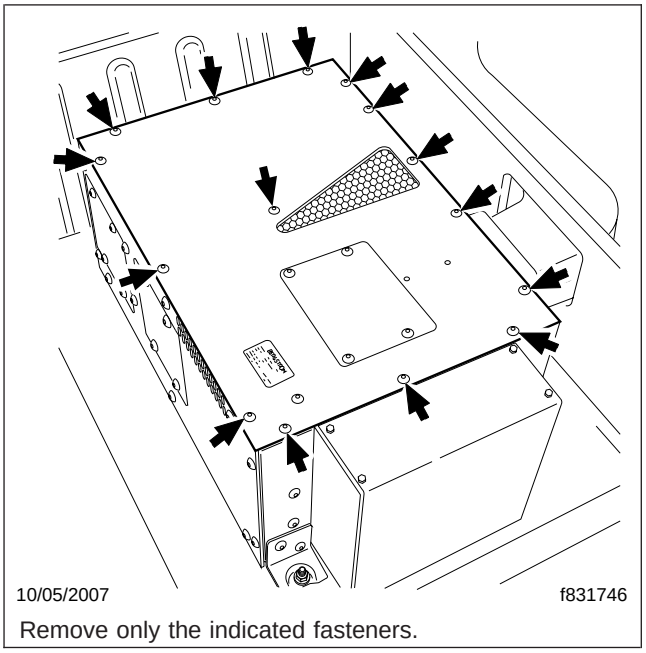


Fig. 1, Top Access Panel

4. Disconnect the three wire connectors from the unit control module. See **Fig. 2**.
5. Remove the electrical box cover. See **Fig. 3**.
6. Disconnect the wires that connect to the bottom of the electrical box, under the sleeper. See **Fig. 4**.

NOTE: There may be a vapor barrier affixed to the bottom of the unit, including electrical box. If so, carefully cut it loose in order to be able to tilt the electrical box out from the unit without damaging the vapor barrier.

7. Remove the four sheetmetal screws that hold the electrical box to the front of the unit, and tilt the electrical box away from the unit. See **Fig. 5** or **Fig. 6**.

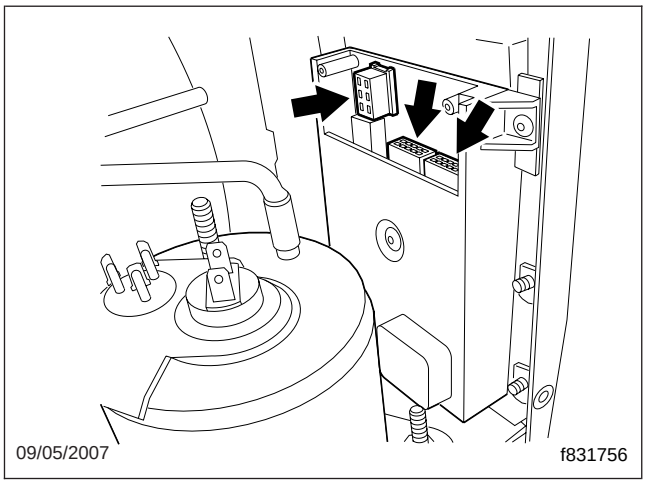


Fig. 2, Control Module Wiring

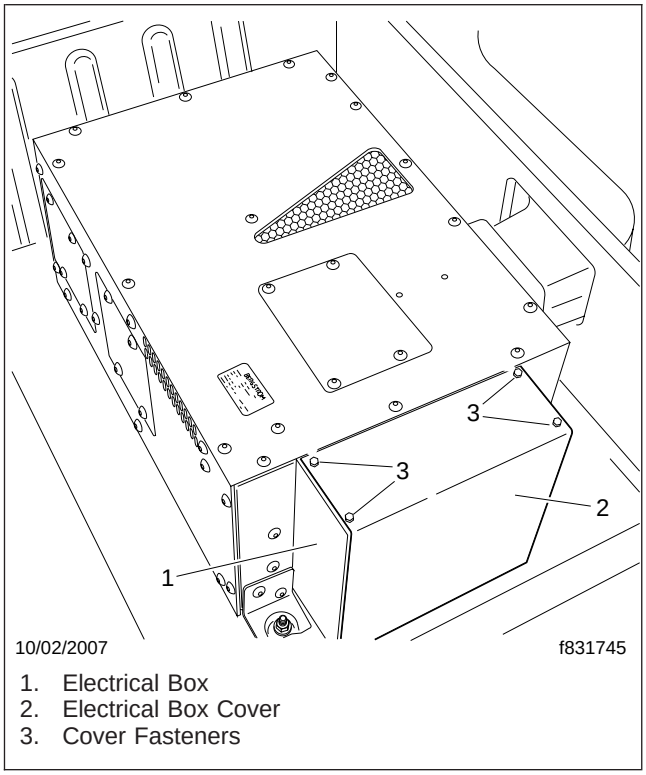


Fig. 3, Electrical Box Installation

8. Remove the fasteners for the control module mounting plate from the outside of the unit. See **Fig. 7**. Slide the mounting plate out of the unit with the control module attached.

Unit Control Module Replacement

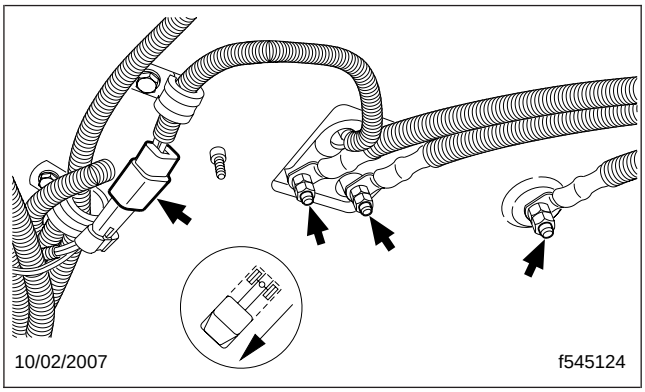
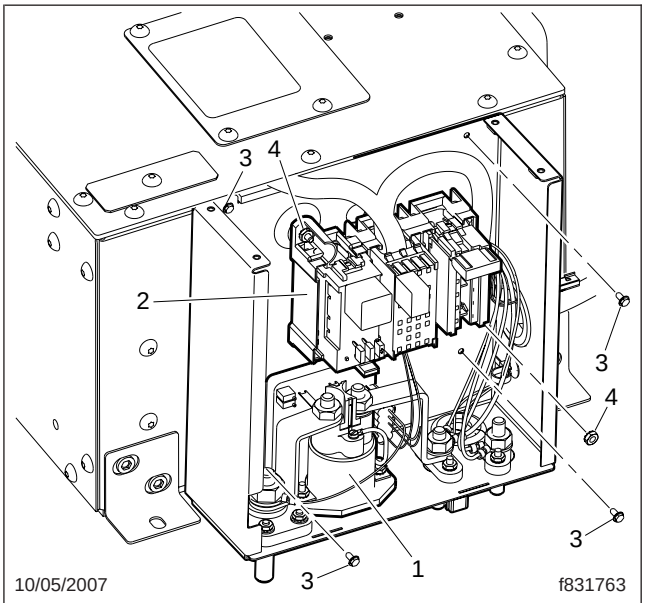


Fig. 4, Under Cab Wires (internal separator wiring shown)



1. Separator
2. Fuse Panel
3. Sheetmetal Screws, Electrical Box (4)
4. Fuse Panel Nuts

Fig. 5, Fuse Panel and Separator

9. Remove the control module fasteners, and remove the control module from the mounting plate. See **Fig. 8**.
10. Position the control module on the mounting panel, and install the fasteners.
11. Position the mounting panel in the unit housing, and install the fasteners from the outside.
12. Position the electrical box, and install the screws.

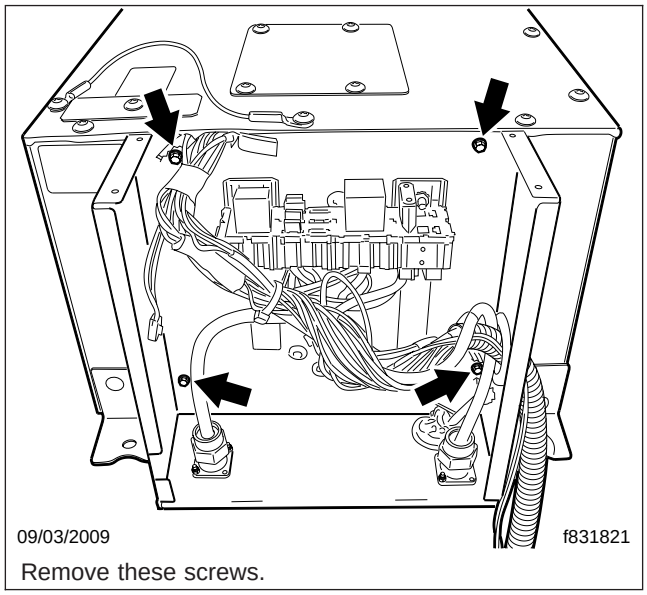


Fig. 6, Electrical Box, Frame-Rail Mounted Separator

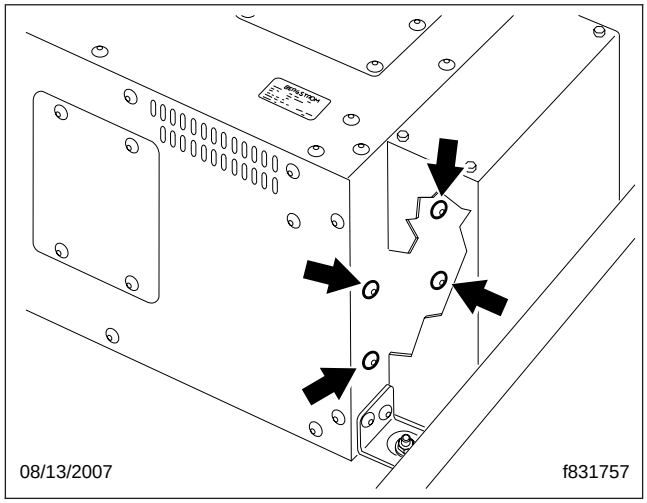


Fig. 7, Control Module Mounting-Plate Fasteners

13. Connect the wires to the bottom of the electrical box, under the sleeper.
14. Connect the three wiring connectors to the control module.
15. Connect the batteries.
16. Install the top panel and electrical box cover.
17. Lower the bunk.

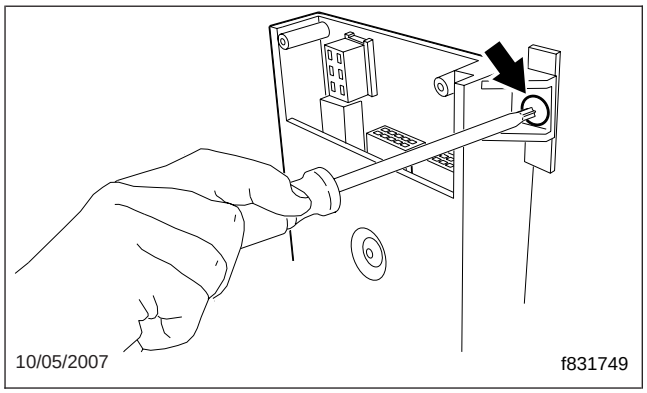


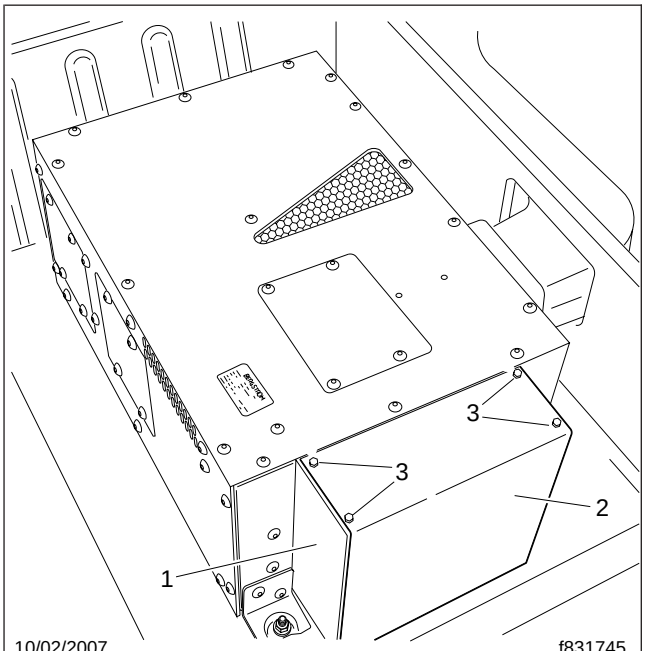
Fig. 8, Control Module Fastener

Interconnect Controller Replacement

On early installations of the NITE system, the interconnect controller, also know as the separator, is installed in the electrical box on the side of the unit under the bunk. On later models, it is installed on the left-hand side of one of the crossmembers under the back of the cab. It is a sealed unit, and is not serviceable. If the controller fails, replace it.

Electrical Box Mounted Interconnect Controller Replacement

1. Park the vehicle on a level surface, shut down the engine, set the parking brakes, and chock the tires. Disconnect both sets of vehicle batteries.
2. Raise and secure the lower bunk.
3. Remove the electrical box cover. See **Fig. 1**.



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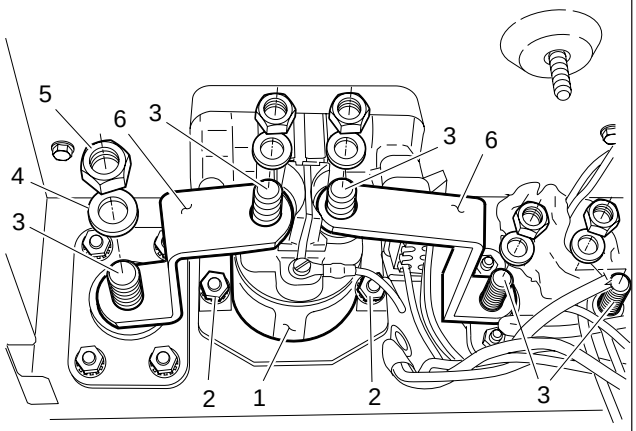
1. Electrical Box
2. Electrical Box Cover
3. Cover Fasteners

Fig. 1, Electrical Box Cover

4. Remove the nuts and washers from the terminals, and remove the two copper buss bars. See **Fig. 2**.



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1. Separator
2. Separator Mounting Nut
3. Terminal
4. Washer
5. Terminal Nut
6. Copper Buss Bars

Fig. 2, Separator Installation

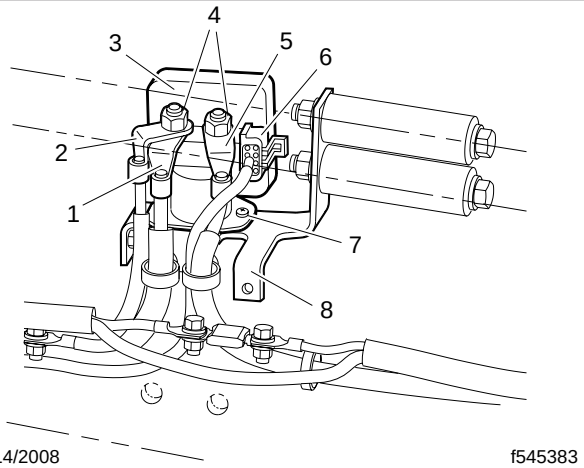
5. Remove the separator mounting nuts, and remove the separator.
6. Position the new separator, and install the mounting nuts.
7. Position the buss bars and install the mounting nuts and washers.
8. Connect the batteries.
9. Install the electrical box cover.
10. Lower the bunk.

Crossmember Mounted Interconnect Controller Replacement

The battery interconnect controller is located on the left-hand side of one of the crossmembers under the back of the cab. See **Fig. 3**.

1. Apply the parking brakes, and chock the tires.
2. Disconnect the vehicle batteries.
3. Disconnect the parked HVAC batteries.
4. Remove the cover from the interconnect controller.
5. Unplug the controller-to-PHVAC unit harness.

Interconnect Controller Replacement



1. Cable, Controller-to-PHVAC Unit
2. Harness, Controller-to-Battery
3. Interconnect Controller
4. Controller Posts and Nuts
5. Cable, Battery-to-Controller
6. Harness, Controller-to-PHVAC Unit
7. Fasteners
8. Bracket

Fig. 3, Interconnect Controller Installation (typical)

6. Remove the nuts and washers, and disconnect the battery cables and controller-to-battery harness from the controller posts.
7. Remove the mounting fasteners and remove the controller.
8. Position the new controller and install the mounting fasteners. Tighten 4 to 5 lbf·in (6 to 7 N·cm).
9. Connect the battery cables and controller-to-battery harness to the controller posts, and install the nuts and washers. Tighten 112 lbf·in (1270 N·cm).
10. Connect the controller-to-PHVAC unit harness.
11. Install the controller cover.
12. Connect both sets of batteries.

Operational Checks

Table 1 explains how to check the main components of the system for proper operation.

Operational Checks		
Component	**Function**	**Operational Check**
Evaporator Blower	Draws cab air through the evaporator coils and blows it through the ducting back to the cab. The system is 100% recirculation. There are two air intakes; one on the unit, and one on the front lower panel of the bunk.	Switch the NITE control to position 1; you must feel air coming out of the duct louvers. Then switch the NITE control to position 2; you must feel an increase of the airflow coming out of the duct louvers. NOTE: Make sure nothing blocks the air intake opening (recirculation) on the NITE unit or the bunk.
Condenser Fan	Takes ambient outside air from under the sleeper floor and blows it through the condenser coil to cool it, then exhausts it through the floor outside the vehicle.	With the unit running, go under the sleeper and check that air is flowing into the unit at the intake, and out of the condenser air outlet.
Compressor	Compresses the refrigerant and moves it through the system.	With the compressor running at LOW speed, listen or feel the compressor speed by its sound and vibration. Wait 1 minute. Then set the control to HIGH speed: you must notice a change in the sound and/or vibration of the unit when the compressor speed changes.

Table 1, Operational Checks

Unit Electrical Power Checking

1. Check the NITE unit voltage.
   - 1.1 Locate the power supply cables (red and black cables) close to the unit.
   - 1.2 Check the voltage.

     When the NITE batteries are fully charged, and when the control position is on HIGH, you must read between 12 and 12.5 volts.
2. Check the NITE unit current.
   - 2.1 Switch the NITE unit control to the HIGH position.
   - 2.2 Using a clamp-on inductive ammeter, measure the current on the NITE unit power supply (red) cable. You must read between 27 and 35 Amps.

Air Temperature at the Louvers

Check the louvers temperature: when the NITE unit control is on HIGH position, when the sleeper temperature is between 75 and 80°F (24 and 27°C), and when the outside temperature is between 90 and 95°F (195 and 205°C), measure the temperature directly at one of the duct louvers. You must read between 55 and 62°F (13 and 17°C).

Condenser Outlet Temperature

As described earlier in this document the NITE unit pulls air from outside, under the sleeper floor, to cool down the condenser coil, then the air is rejected to the outside from the sleeper floor too. When the NITE unit is running in HIGH position, go under the sleeper and locate the condenser air outlet (rectangle opening with a screen). The temperature at the condenser outlet must be 10 to 20°F (6 to 12°C) higher than the outside temperature.

Temperature/Amperage Testing

1. Set mode to A/C only.
2. Set the temperature setting to max cold.
3. Place your hand on the sensor so it detects high temperature.

4. Open the vehicle doors and allow the ambient temperature to stabilize on the condenser and unit.
5. Let the unit run about 10 minutes before measuring the temperature and current.

   Table 2 shows temperature and amperage parameters for testing the system.

Separator Electrical Checking, Engine OFF

1. Check for loose electrical connections.
2. Check that the installation is wired according to the electrical diagram. See **Specifications, 400** for wiring diagrams.
3. Check that the 16 gauge ground wire is connected to the bottom blade terminal of the separator on one end, and to a good ground on the other end.
4. Check that the batteries are properly connected.
5. Make sure the battery ground cable is connected to a good ground.
6. Make sure the NITE unit power cables are connected to the correct terminals of the NITE batteries. The red cable goes to the positive terminal; the black cable goes to the ground.
7. Check that the voltage on the vehicle batteries is the same as the voltage at the separator (main batteries side). When checking the voltage on the separator, use the ground terminal on the separator. Both voltage readings should be the same.
8. Check that the voltage on the NITE batteries is the same as the voltage on the separator ("AUX" batteries side). When you check the voltage at the separator, use the ground terminal on the separator. Both voltage readings should be the same (approximately 12 volts).

Separator Electrical Checking, Engine Running

The separator controls the charging of the batteries as follows.

- When the engine is running, the alternator charges the vehicle batteries only, until the vehicle battery voltage reaches 13.2 volts. During this period, the separator is open and the NITE batteries are not being charged.
- When the vehicle batteries reach 13.2 volts, the separator closes, allowing the NITE batteries to charge.

1. With the engine running, check the voltage of the vehicle batteries. It should be higher than the voltage when the engine is OFF, more than 13 volts.
2. Check that the separator is operating properly. When the vehicle battery voltage reaches 13.2 volts, the separator closes, and the system starts charging the NITE batteries. There is an audible “click” when the separator closes.
3. With the engine running, check the voltage of the NITE batteries. It should be higher than the voltage when the engine is OFF, and approximately the same as the vehicle batteries.
4. Verify that the separator is allowing the NITE batteries to charge. Using a clamp-on-type inductive ammeter, on the cable that connects the separator to the NITE batteries positive terminal, measure the amps going to the NITE batteries. It should read more than 0 amps.

Temperature and Amperage Parameters		
Ambient Temperature: °F (°C)	**Louver Temperature: °F (°C)**	**Amps**
65 (18)	47–53 (8–12)	21–27
66 (19)	48–54 (9–12)	21–27
67 (19)	49–55 (9–13)	22–28
68 (20)	50–56 (10–13)	22–28
69 (21)	51–57 (11–14)	23–29
70 (21)	52–58 (11–14)	23–29

Temperature and Amperage Parameters		
Ambient Temperature: °F (°C)	**Louver Temperature: °F (°C)**	**Amps**
71 (22)	54–60 (12–16)	24–30
72 (22)	55–61 (13–16)	24–30
73 (23)	56–62 (13–17)	25–31
74 (23)	57–63 (14–17)	25–31
75 (24)	58–64 (14–18)	26–32
76 (24)	59–65 (15–18)	26–32
77 (25)	60–66 (16–19)	27–33
78 (26)	60–66 (16–19)	27–33
79 (26)	61–67 (16–19)	27–33
80 (27)	62–68 (17–20)	28–34
81 (27)	63–69 (17–21)	28–34
82 (28)	64–70 (18–21)	29–35
83 (28)	65–71 (18–22)	29–35
84 (29)	66–72 (19–22)	30–36
85 (29)	67–73 (19–23)	30–36
86 (30)	68–74 (20–23)	30–36
87 (31)	69–75 (21–24)	31–37
88 (31)	69–75 (21–24)	31–37
89 (32)	70–76 (21–24)	32–38
90 (32)	71–77 (22–25)	32–38
91 (33)	72–78 (22–26)	32–38
92 (33)	73–79 (23–26)	33–39
93 (34)	73–79 (23–26)	33–39
94 (34)	74–80 (23–27)	33–39
95 (35)	75–81 (24–27)	34–40
96 (36)	76–82 (24–28)	34–40
97 (36)	77–83 (25–28)	35–41
98 (37)	77–83 (25–28)	35–41
99 (37)	78–84 (26–29)	35–41
100 (38)	79–85 (26–29)	36–42
101 (38)	80–86 (27–30)	36–42
102 (39)	80–86 (27–30)	36–42
103 (39)	81–87 (27–31)	37–43
104 (40)	82–88 (28–31)	37–43
105 (41)	82–88 (28–31)	37–43

Table 2, Temperature and Amperage Parameters

Specifications

Table 1 details technical specifications of the NITE system as installed on Century Class Trucks. **Table 2** shows temperature and amperage parameters for testing the system.

Figure 1, **Fig. 2**, and **Fig. 3** show the wiring diagram for the Parked HVAC system.

System Specifications		
A/C	Cooling Capacity	3100 BTU/hour
	Voltage	12 Volts DC
	System Power	400–450 Watts
	Dimensions	22 x 16 x 11 inch (560 x 406 x 280 mm)
Power	Capacity	440 amp hours
	Battery Life	2+ years
	Operation time	10–12 hours
	Recharge Time	4–6 hours
	Battery Count	4

Table 1, System Specifications

Temperature and Amperage Parameters		
Ambient Temperature: °F (°C)	**Louver Temperature: °F (°C)**	**Amps**
65 (18)	47–53 (8–12)	21–27
66 (19)	48–54 (9–12)	21–27
67 (19)	49–55 (9–13)	22–28
68 (20)	50–56 (10–13)	22–28
69 (21)	51–57 (11–14)	23–29
70 (21)	52–58 (11–14)	23–29
71 (22)	54–60 (12–16)	24–30
72 (22)	55–61 (13–16)	24–30
73 (23)	56–62 (13–17)	25–31
74 (23)	57–63 (14–17)	25–31
75 (24)	58–64 (14–18)	26–32
76 (24)	59–65 (15–18)	26–32
77 (25)	60–66 (16–19)	27–33
78 (26)	60–66 (16–19)	27–33
79 (26)	61–67 (16–19)	27–33
80 (27)	62–68 (17–20)	28–34
81 (27)	63–69 (17–21)	28–34
82 (28)	64–70 (18–21)	29–35
83 (28)	65–71 (18–22)	29–35
84 (29)	66–72 (19–22)	30–36

Specifications

Temperature and Amperage Parameters		
Ambient Temperature: °F (°C)	**Louver Temperature: °F (°C)**	**Amps**
85 (29)	67–73 (19–23)	30–36
86 (30)	68–74 (20–23)	30–36
87 (31)	69–75 (21–24)	31–37
88 (31)	69–75 (21–24)	31–37
89 (32)	70–76 (21–24)	32–38
90 (32)	71–77 (22–25)	32–38
91 (33)	72–78 (22–26)	32–38
92 (33)	73–79 (23–26)	33–39
93 (34)	73–79 (23–26)	33–39
94 (34)	74–80 (23–27)	33–39
95 (35)	75–81 (24–27)	34–40
96 (36)	76–82 (24–28)	34–40
97 (36)	77–83 (25–28)	35–41
98 (37)	77–83 (25–28)	35–41
99 (37)	78–84 (26–29)	35–41
100 (38)	79–85 (26–29)	36–42
101 (38)	80–86 (27–30)	36–42
102 (39)	80–86 (27–30)	36–42
103 (39)	81–87 (27–31)	37–43
104 (40)	82–88 (28–31)	37–43
105 (41)	82–88 (28–31)	37–43

Table 2, Temperature and Amperage Parameters

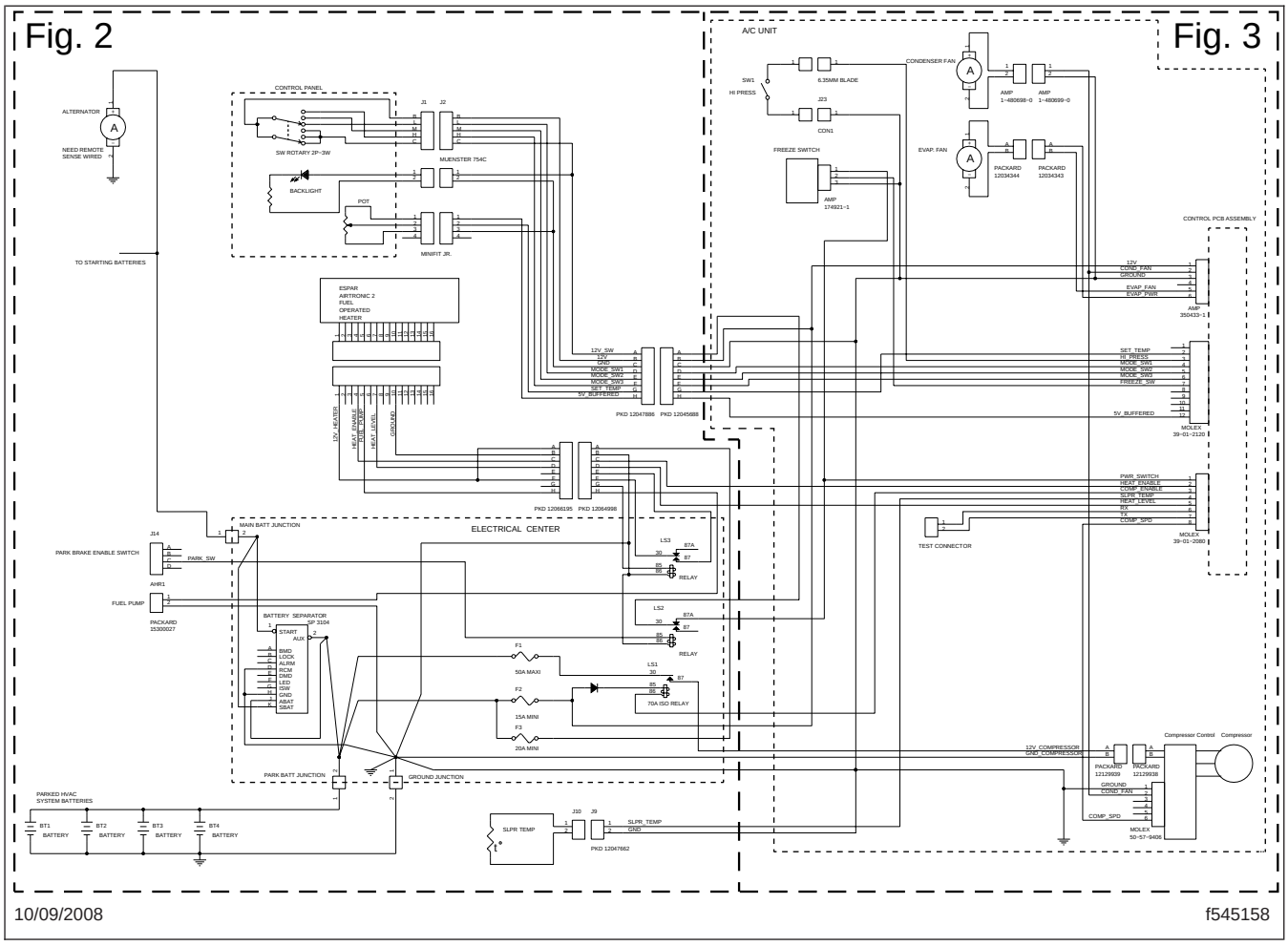


Fig. 1, Parked HVAC Wiring

Specifications

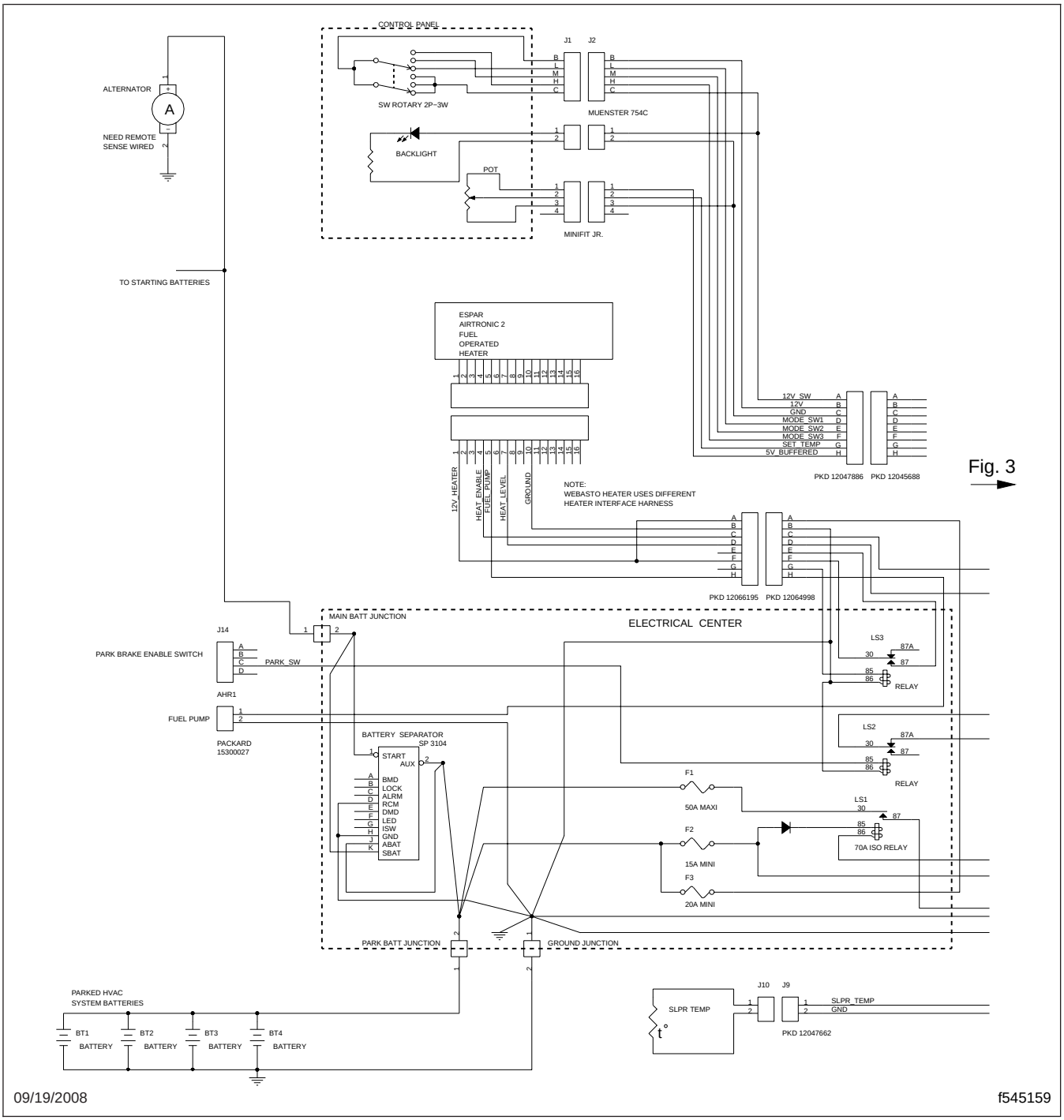


Fig. 3

Fig. 2, Parked HVAC Wiring (expanded, part 1)

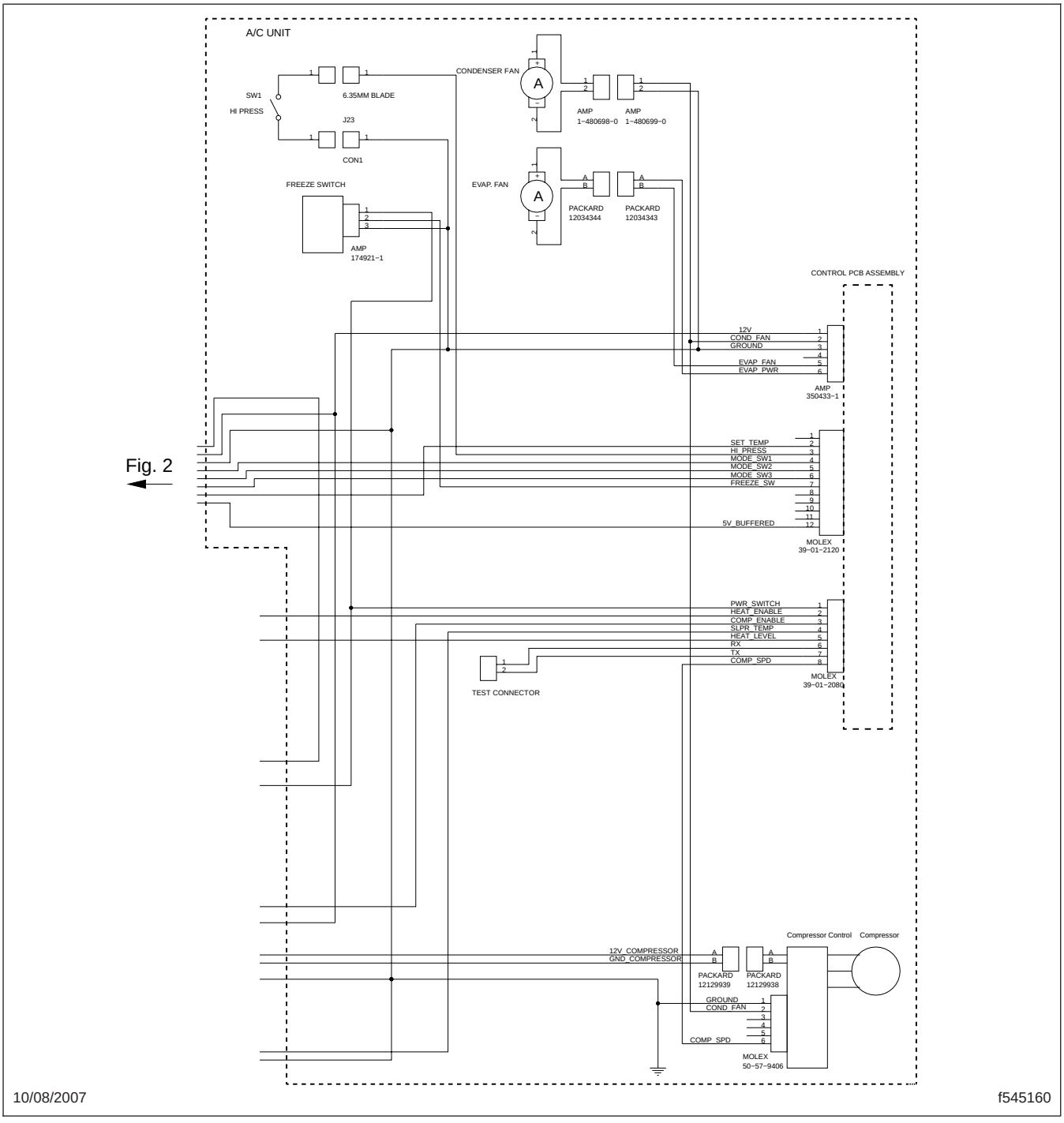


Fig. 2

Fig. 3, Parked HVAC Wiring (expanded, part 2)

General Information

The main purpose of the refrigerant compressor is to draw refrigerant gas from the evaporator and squeeze it into high-pressure gas. High pressure raises the condensation point of refrigerant gas, which allows the condenser to change it to a liquid so that it can be used for cooling again. A second purpose of the compressor is to move refrigerant through the air conditioner system.

The Climate Control compressor is a two-piston design. The pistons are driven by a crankshaft and connecting rods.

The compressor is monitored by the Air Conditioning Protection Unit (ACPU) which consists of an electronic control module, high and low pressure switches, and the thermostatic switch. During operation, the clutch is engaged, transmitting the rotation of the pulley to the compressor. When the cab temperature drops sufficiently, the ACPU system breaks the circuit to the compressor clutch, disengaging the clutch, and allowing the pulley to rotate without turning the compressor.

Refer to the heater and air conditioning section in this group for more information on the ACPU system. Additionally, the control module registers fault codes that warn of existing or impending problems with the compressor and the air conditioning system. For further information on system fault codes, refer to the section in **Group 54** in the vehicle service manual which discusses the Instrumentation Control Unit. Additionally, if ServicePro is available, consult the technician diagnostic routine covering the ACPU system.

Safety Precautions

Whenever repairs are made to any air conditioner parts that hold R–134a refrigerant, you must recover, purge or flush (if contaminated), evacuate, charge, and leak test the system. In a good system, refrigerant lines are always under pressure and you should disconnect them only after the refrigerant charge has been recovered (discharged) at the service valves.

Refrigerant R–134a is safe when used under the right conditions. Always wear safety goggles and non-leather gloves while recovering, evacuating, charging, and leak testing the system. Do not wear leather gloves; when refrigerant gas or liquid contacts leather, the leather will stick to your skin.

⚠ WARNING

WARNING: Use care to prevent refrigerant from touching your skin or eyes, because liquid refrigerant, when exposed to the air, quickly evaporates and will freeze skin or eye tissue. Serious injury or blindness could result if you come into contact with liquid refrigerant.

Refrigerant splashed in the eyes should be rinsed with lukewarm water, not hot or cold. Do not rub the eyes. Apply a light bandage and contact a physician right away.

Refrigerant splashed on the skin should be rinsed with lukewarm water, not hot or cold. Do not rub the skin. Apply a light coat of a nonmedicated ointment, such as petroleum jelly. Contact a physician right away.

R–134a refrigerant does not burn at ambient temperatures and atmospheric pressure. However, it can be combustible at pressures as low as 5.5 psig (139 kPa absolute) at 350°F (177°C) when mixed with air concentrations that are greater than 60 percent.

⚠ WARNING

WARNING: R–134a air conditioning systems should not be pressure tested or leak tested with compressed air. Combustible mixtures of air and R–134a may form, resulting in a fire or explosion, which could cause personal injury or property damage. R–134a may be safely pressured with dry nitrogen.

You must work in an area where there is a constant flow of fresh air when the system is recovered, evacuated, charged, and leak tested. R–134a vapors have a slightly sweet odor that is difficult to detect. Frequent leak checks and air monitoring equipment are recommended to ensure a safe working environment.

IMPORTANT: When servicing an R–134a air conditioning system, use only service equipment certified to meet the requirements of SAE J2210 (R–134a recycling equipment). The equipment should be operated only by qualified personnel who are familiar with the recycling station manufacturer's instructions.

Because of its very low boiling point, refrigerant must be stored under pressure. To prevent the refrigerant containers from exploding, never expose them to temperatures higher than 125°F (52°C).

On R–134a refrigerant systems, polyol ester (POE) refrigerant oil or polyalkylene glycol (PAG) refrigerant oil is used in the compressor. When handling refrigerant oil, observe the following guidelines:

- Keep the oil free of contaminants.
- Do not expose the air conditioning system or the refrigerant oil container to air for long periods of time. Refrigerant oil absorbs moisture quickly.
- Use care when handling. Spilled oil could damage painted surfaces, plastic parts, and other components such as drive belts.
- Never mix refrigerant oil types.

Pre-Service Checks

⚠ WARNING

WARNING: Before doing any work, read the information under Safety Precautions, 100. Failure to read the safety precautions, and to be aware of the dangers involved when working with refrigerant, could lead to serious personal injury.

Some special tools are needed for doing repair work on the compressor. Refer to the special tools table in **Specifications, 400.** Tool kits can be bought from the distributor listed under the special tools table in **Specifications, 400.**

NOTE: Compressor problems usually show in one of four ways: abnormal noise; seizure; leakage; or low suction and discharge pressures. Resonant compressor noises are not causes for alarm; irregular noise or rattles are likely to be caused by broken parts. To check for seizure, de-energize the magnetic clutch and see if the drive plate can be turned. If it won't turn, the compressor has seized.

Do the following checks whenever the air conditioner system is not cooling enough and the causes are unknown.

1. Be sure to check the moisture indicator, to see if moisture is the cause of the problems. The air conditioner should be on when checking the indicator; it is better to check it at the end of a day's run.
2. Check the drive belt and mounting:
   - 2.1 On the drive belt, look for wear, damage, or oil. If worn, oil-soaked, or damaged, remove it and install a new one. Refer to the drive belt section in **Group 01** of this manual for instructions.
   - 2.2 Check the compressor mounting parts for loose fasteners, cracks, or other damage. Tighten loose fasteners to the torque value in the torque specifications table under **Specifications, 400.** Repair or replace cracked or damaged brackets.
   - 2.3 Check the tension of the compressor drive belt. Refer to the drive belt section in **Group 01** of this manual for instructions.
   - 2.4 Check the compressor oil level. Refer to **Subject 130** for instructions.
3. Check the wiring and connections to the compressor clutch. Replace damaged wiring and tighten loose connections.
4. Check for road debris build-up on the condenser coil fins. Using air pressure and a whiskbroom or a solution of soap and water, carefully clean the condenser; be careful not to bend the fins.
5. Check the refrigerant charge in the air conditioner system; for instructions, refer to the heater and air conditioner section in this group.
6. Check the valve plate and cylinder gasket **(Subject 160),** and the shaft seal **(Subject 150)** for damage. Replace as needed.

NOTE: For other possible causes of air conditioner problems, refer to the heater and air conditioner section in this group and to the applicable fan clutch section in **Group 20** of this manual.

Removal

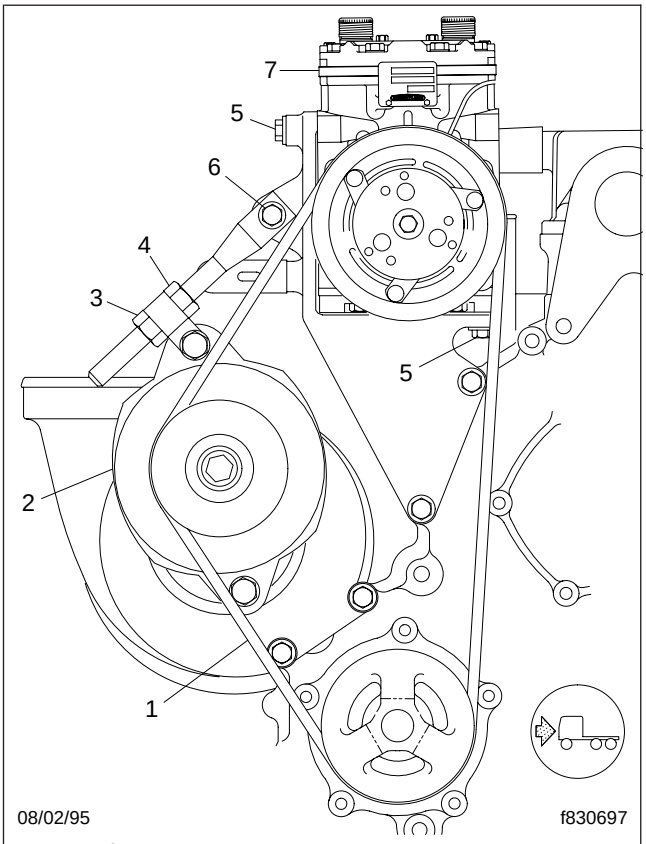
⚠ WARNING

Before doing any of the work below, read the information under Safety Precautions 100. Failure to read the safety precautions and to be aware of the dangers involved when working with refrigerant, could lead to serious personal injury.

1. Turn off the engine, apply the brakes, and chock the tires.
2. Recover the refrigerant from the air conditioning system. For instructions, refer to Section 83.02, **Subject 250**.
3. On Argosy COEs, tilt the cab. For cab tilt instructions, see **Group 60** in this manual.
4. Disconnect the discharge and suction lines from the compressor. Quickly cap the discharge and suction ports and plug the fittings.

IMPORTANT: Under no circumstances should the ports on the compressor remain uncapped or the fittings remain unplugged for longer than five minutes total. Water and dirt can damage the refrigerant system. Do not blow shop air through refrigerant lines since shop air is wet (humid).

5. Disconnect the clutch cable connector.
6. On Century Class Conventionals with a V-belt, remove the V-belt. If equipped with a serpentine belt, see the next step.
   - 6.1 On vehicles with Detroit Diesel Series 50 and 60 engines, loosen the adjusting rod jam nut, back off the adjustment nut, and loosen the compressor mounting bolts. See **Fig. 1**. Move the compressor towards the alternator until the belt can be removed from the compressor.
   - 6.2 On vehicles with Cummins and Caterpillar engines, loosen the compressor pivot bolt. See **Fig. 2** and **Fig. 3**. Loosen the adjusting rod jam nut, then back off the adjustment nut until the belt can be removed.
   - 6.3 Remove the V-belt. Don't pry or roll it off the pulleys.

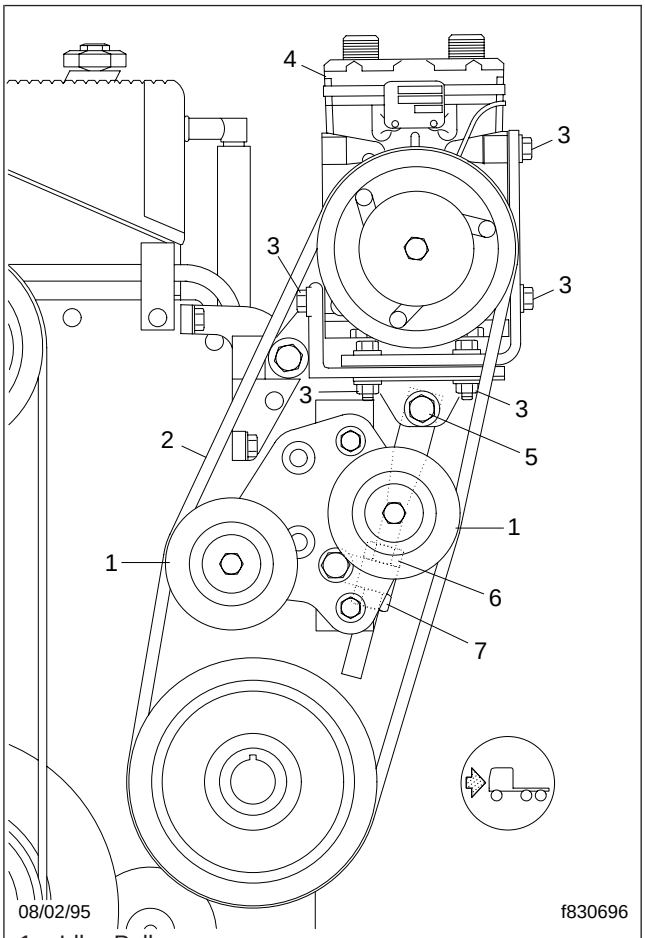


1. V-Belt
2. Alternator
3. Jam Nut
4. Adjustment Nut
5. Compressor Mounting Bolt
6. Adjusting Rod Attachment Bolt
7. Refrigerant Compressor

Fig. 1, Compressor Mounted on a Detroit Diesel Series 60 Engine, Century Class Conventional

7. On Century Class Conventionals with a serpentine belt, remove the belt by using a 1/2-inch breaker bar and rotating the automatic belt tensioner clockwise.
8. On Argosy COEs, remove the serpentine belt by using a 1/2-inch breaker bar and rotating the automatic belt tensioner clockwise. See **Fig. 4**.
9. On Century Class Conventionals, remove the compressor.
   - 9.1 On vehicles with Detroit Diesel Series 50 and 60 engines, remove the adjusting rod

Refrigerant Compressor Removal and Installation



1. Idler Pulley
2. V-Belt
3. Compressor Mounting Bolt and Nut
4. Refrigerant Compressor
5. Pivot Bolt
6. Adjustment Nut
7. Jam Nut

Fig. 2, Compressor Mounted on a Cummins M11 Engine, Century Class Conventional

attachment bolt. Remove the compressor mounting bolts and the compressor.

9.2 On vehicles with Cummins and Caterpillar engines, pivot the compressor mounting bracket as needed to access the compressor mounting bolts. Remove the compressor mounting bolts and the compressor.

10. On Argosy COEs with Detroit Diesel Series 60 engines, remove the compressor.

10.1 Remove the bolt, washer, and nut that attach the bracket on the radiator inlet hose to the bracket on the compressor.

10.2 Remove the capscrew and washer that attach the cushion clamp that holds two lines and an electrical cable to the compressor.

10.3 Remove the compressor mounting capscrews and washers and remove the compressor. See **Fig. 4**.

Installation

IMPORTANT: A new compressor is filled with refrigerant oil and nitrogen gas. The quantity is printed on a label attached to the compressor. When installing a new compressor on the vehicle, do all of the steps below. If installing a used compressor, don't do the first step.

1. Prepare a new compressor.

1.1 Gently release the nitrogen gas from the discharge side of the compressor. Be careful not to let the oil flow out.

1.2 Turn the compressor shaft several times by hand to distribute oil which has settled in the cylinder.

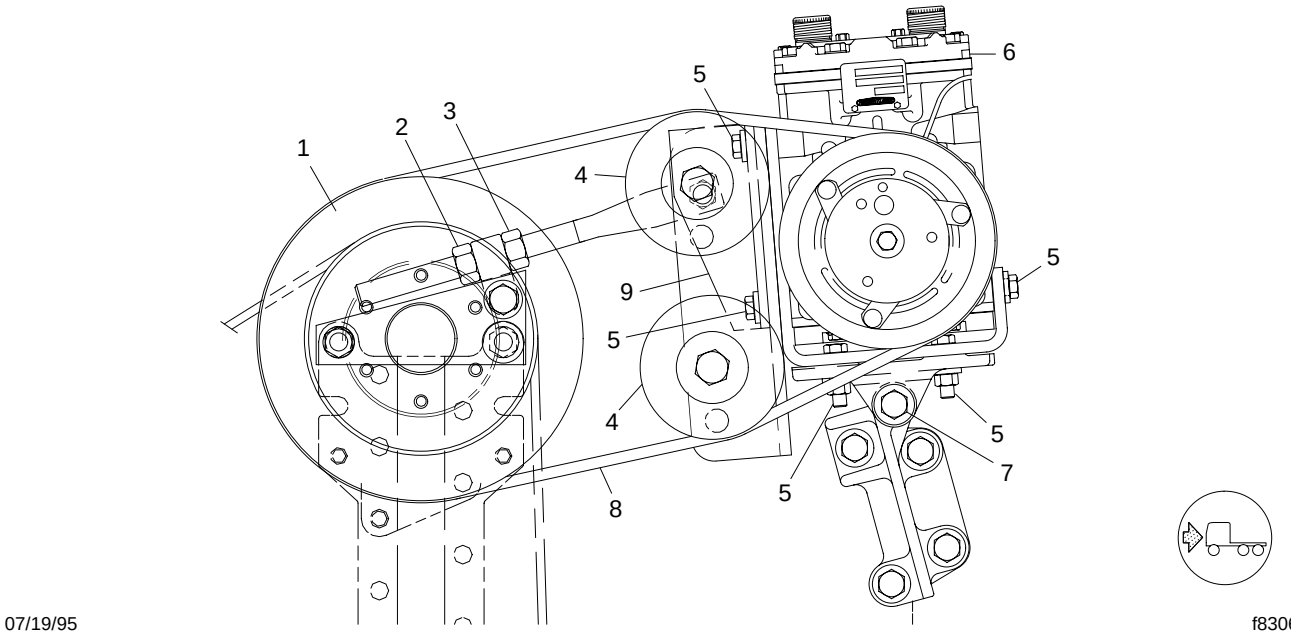
2. On Century Class Conventionals, place the compressor on the mounting bracket. Loosely install the mounting bolts to hold the compressor in place. On Detroit Diesel Series 50 and 60 engines, install the adjusting rod attachment bolt.

3. On Argosy COEs, install the compressor.

3.1 Place the compressor on the mounting bracket. Install the washers and capscrews on the bottom of the bracket and tighten 20 to 25 lbf·ft (27 to 34 N·m). Install the washers and capscrews on the side of the bracket and tighten 20 to 25 lbf·ft (27 to 34 N·m).

3.2 Install the washer and capscrew that attach the cushion clamp to the compressor.

3.3 Install the bolt, washer, and nut that attach the radiator inlet hose bracket to the bracket on the compressor.



1. Fan Drive
2. Jam Nut
3. Adjustment Nut
4. Idler Pulley
5. Compressor Mounting Bolt
6. Refrigerant Compressor
7. Pivot Bolt
8. V-Belt
9. Adjustment Link Bracket

Fig. 3, Compressor Mounted on a Caterpillar 3176 Engine, Century Class Conventional

4. On Century Class Conventionals, install the V-belt or the serpentine belt. Refer to **Group 01** for V-belt installation and adjustment procedures.

   4.1 On vehicles with Detroit Diesel Series 50 and 60 engines, tighten the bottom mounting bolts 20 to 25 lbf·ft (27 to 34 N·m). Then, tighten the side mounting bolts 20 to 25 lbf·ft (27 to 34 N·m). Tighten the adjusting rod attachment bolt 20 to 25 lbf·ft (27 to 34 N·m).

   4.2 On vehicles with Cummins and Caterpillar engines, tighten the mounting bolts 20 to 25 lbf·ft (27 to 34 N·m). Tighten the pivot bolt 68 lbf·ft (92 N·m). Tighten the adjusting rod jam nut 155 lbf·ft (210 N·m).

5. On Argosy COEs, install the belt.

6. Uncap the discharge and suction ports. Unplug the fittings. Check the fittings and the discharge and suction ports. They must be clean and free of nicks, gasket residue, and other foreign material.

7. On hose connections that have threaded fittings, replace the O-rings in the fittings. Lubricate the O-rings with mineral oil before installing.

   On hose connections that have a SlimLine seal assembly (**Fig. 5**), replace the seals. **Do not** lubricate SlimLine seals prior to installation. Use **only** a SlimLine seal on a SlimLine seal assembly.

8. Connect the refrigerant hoses to the compressor.

   On hose connections that have threaded fittings, torque the fittings 21 to 27 lbf·ft (28 to 37 N·m).

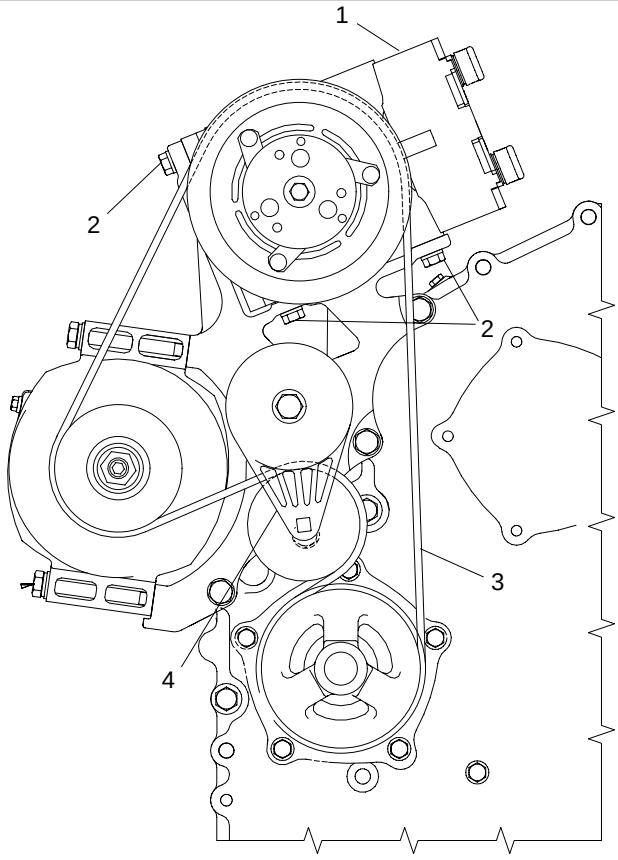
   On hose connections that have a SlimLine seal assembly, torque the bolt on the SlimLine seal assembly 11 to 15 lbf·ft (15 to 20 N·m).

9. Connect the clutch cable connector to the clutch.

10. Replace the receiver-drier. For instructions, refer to Section 83.02, **Subject 200**.

11. Check the oil in the compressor, as specified in **Subject 130**.

Refrigerant Compressor Removal and Installation



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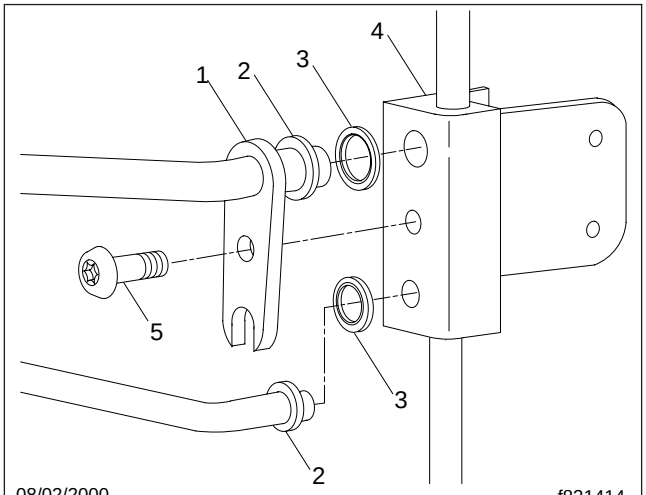
1. Refrigerant Compressor
2. Mounting Capscrews
3. Belt
4. Automatic Belt Tensioner

Fig. 4, Compressor Mounted on a Detroit Diesel Series 60 Engine, Argosy COE

12. Evacuate, charge, and leak test the refrigerant system. For instructions, refer to Section 83.02 **Subject 250**.
13. Return the hood or cab to the operating position. For cab tilt instructions, see **Group 60** in this manual.
14. Remove the chocks from the tires.



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1. Plate
2. Fitting
3. Seal
4. Block
5. Bolt

Fig. 5, A Typical SlimLine Seal Assembly

Oil Check and Adding Oil to the Refrigerant Compressor

General Information

IMPORTANT: On R–134a air conditioning systems, new compressors are factory-charged with about 14 fl oz (414 mL) of refrigerant oil. Some refrigerant oil is circulated through the system with the refrigerant, and cannot leave the system except through a leak, when the system is discharged or recovered, or when a system part is replaced.

Oil must be from a container that has not been opened, or that has been tightly sealed since its last use. Refer to the applicable refrigerant oils table in **Specifications, 400** for recommended oils. Tubing, funnels, or other equipment used to transfer the oil should be very clean and dry.

IMPORTANT: Add the same amount of oil that is removed when the system is discharged or recovered, or when a system part is replaced. The list below provides approximate refill amounts for the R–134a air conditioning system.

A. Oil charge—the entire system should have *about* 14 fl oz (414 mL) of refrigerant oil. There should be 10 fl oz (296 mL) in the compressor. Each major component has *about* 2.0 fl oz (59 mL) of oil (this amount has been rounded off for ease of adding oil to the compressor). Therefore, additional oil must be added to the compressor when a major component is replaced.

NOTE: As an example, if the condenser and the receiver-drier are to be replaced, first check the oil level of the compressor. The compressor should have 10 fl oz (296 mL). Add oil if needed. Then, after replacing the condenser and the receiver-drier, add an additional 4.0 fl oz (118 mL) of oil to the compressor. The entire system should then have about 14 fl oz (414 mL).

When handling refrigerant oil:

- The oil should be free of water, dust, metal powder, and other foreign substances.
- Don't mix refrigerant oil with other types or viscosities of oil.
- Refrigerant oil absorbs moisture when exposed to the air for any period of time. After use, quickly seal the oil container.

IMPORTANT: Replacing only the amount of oil that is removed during evacuation may result in the wrong oil charge because the oil charge may have been incorrect prior to evacuation. The only way to ensure the proper oil charge is to check the oil level of the compressor with a dipstick.

B. Receiver-drier—when the receiver-drier is replaced, *about* 2.0 fl oz (59 mL) must be added to the compressor in addition to the 10 fl oz (296 mL) that the compressor requires.

IMPORTANT: A new receiver-drier does not contain any refrigerant oil.

C. Condenser—when the condenser is replaced, *about* 2.0 fl oz (59 mL) must be added to the compressor in addition to the 10 fl oz (296 mL) that the compressor requires.

D. Evaporator coil—when the evaporator coil is replaced, *about* 2.0 fl oz (59 mL) must be added to the compressor in addition to the 10 fl oz (296 mL) that the compressor requires.

IMPORTANT: Check the compressor oil level whenever the system has been opened.

⚠ WARNING

Don't remove the oil fill plug without first recovering the system. Failure to recover the system could cause uncontrolled release of high-pressure refrigerant, which can freeze skin and eye tissue causing serious injury or blindness.

1. Recover the refrigerant from the air conditioner system. For instructions, refer to the cab heater and air conditioner section in this group.
2. Remove the oil fill plug and O-ring.
3. Check the oil level with the dipstick. When the compressor is mounted vertically, use either plug; when mounted in any other orientation, use the upper plug. **Figure 1** shows the oil level with the refrigerant compressor mounted at 22 degrees. **Figure 2** shows the oil level with the refrigerant compressor mounted at 45 degrees.

   If the dipstick bottoms out before going in more than 3 inches (75 mm), it is hitting the compressor crankshaft. Rotate the drive plate by hand and insert the dipstick again until it contacts the

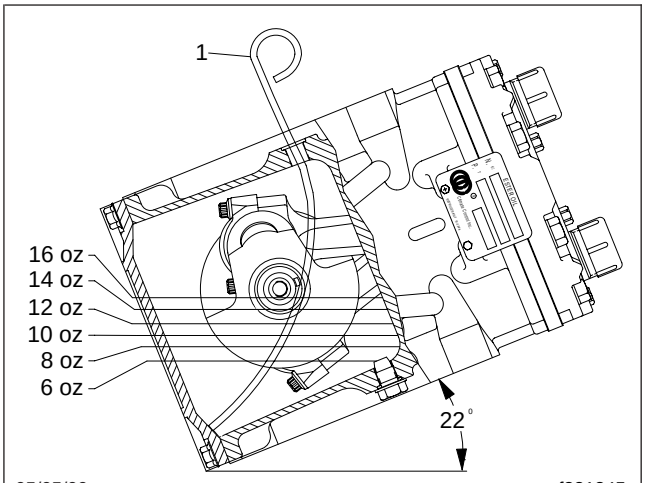
Oil Check and Adding Oil to the Refrigerant Compressor

bottom of the sump. See **Table 1** to determine the oil quantity. Add or remove oil from the compressor so that the oil charge is 10 fl oz (296 mL).

Oil Quantity at Various Dipstick Depths				
Dipstick Depth				Oil Quantity fl oz (mL)
0-Degree Mount (horizontal) inches (mm)	22-Degree Mount inches (mm)	45-Degree Mount inches (mm)	90-Degree Mount (vertical) inches (mm)	
13/16 (20.6)	1-3/4 (44.5)	1-5/8 (41.3)	7/8 (22.2)	6 (177)
1 (25.4)	2-1/16 (52.4)	1-13/16 (46)	1 (25.4)	8 (237)
1-13/16 (30.2)	2-5/16 (58.7)	2 (50.8)	1-1/8 (28.6)	10 (296)
1-5/8 (41.3)	2-9/16 (65.1)	2-1/4 (57.2)	1-7/16 (36.5)	12 (355)
1-13/16 (46)	2-7/8 (73)	2-7/16 (61.9)	1-11/16 (43)	14 (414)
1-15/16 (49.2)	3-1/8 (79.4)	2-5/8 (66.7)	1-7/8 (47.6)	16 (473)

Table 1, Oil Quantity at Various Dipstick Depths

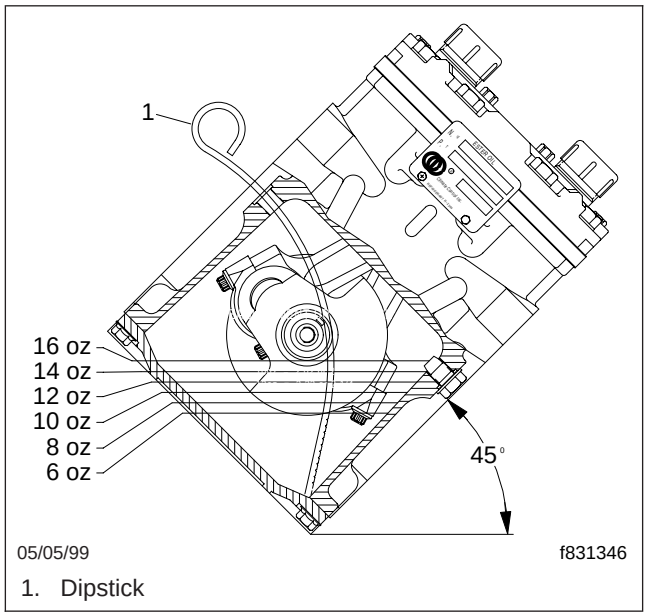
NOTE: A dipstick can be made locally or pur-



1. Dipstick

Fig. 1, Oil Level With Refrigerant Compressor Mounted at 22 Degrees

chased from a special tools supplier. Refer to the special tools table in **Specifications, 400**. If made locally, it can be formed from 1/8-inch diameter by 8-5/16 inch long stock. See **Fig. 3**. Use a nonferrous material that is not subject to corrosion. Notching the end makes it easier to see the oil depth.

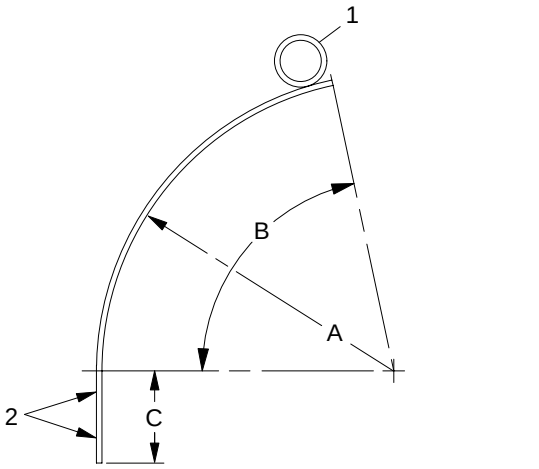


1. Dipstick

Fig. 2, Oil Level With Refrigerant Compressor Mounted at 45 Degrees

4. Being careful not to twist the O-ring, slip it over the oil fill plug threads. Insert the plug in the oil fill opening and tighten it until snug. If the plug leaks, don't attempt to stop the leak by overtightening. Leaks may be caused by dirt under the O-ring, dirt on the seat, a broken O-ring, or a

damaged seat on the oil fill plug or opening. Correct the problem and install a new O-ring.



NOTE: Left-Hand Mounting: Check oil when shaft key is down. Right-Hand Mounting: Check oil when shaft key is up.

A. 4-3/4 Inches (121 mm) Radius
B. 78°
C. 1-1/2 Inches (38 mm)
1. Finger Ring
2. 12 Notches, 1/8 Inch (3.2 mm) Apart

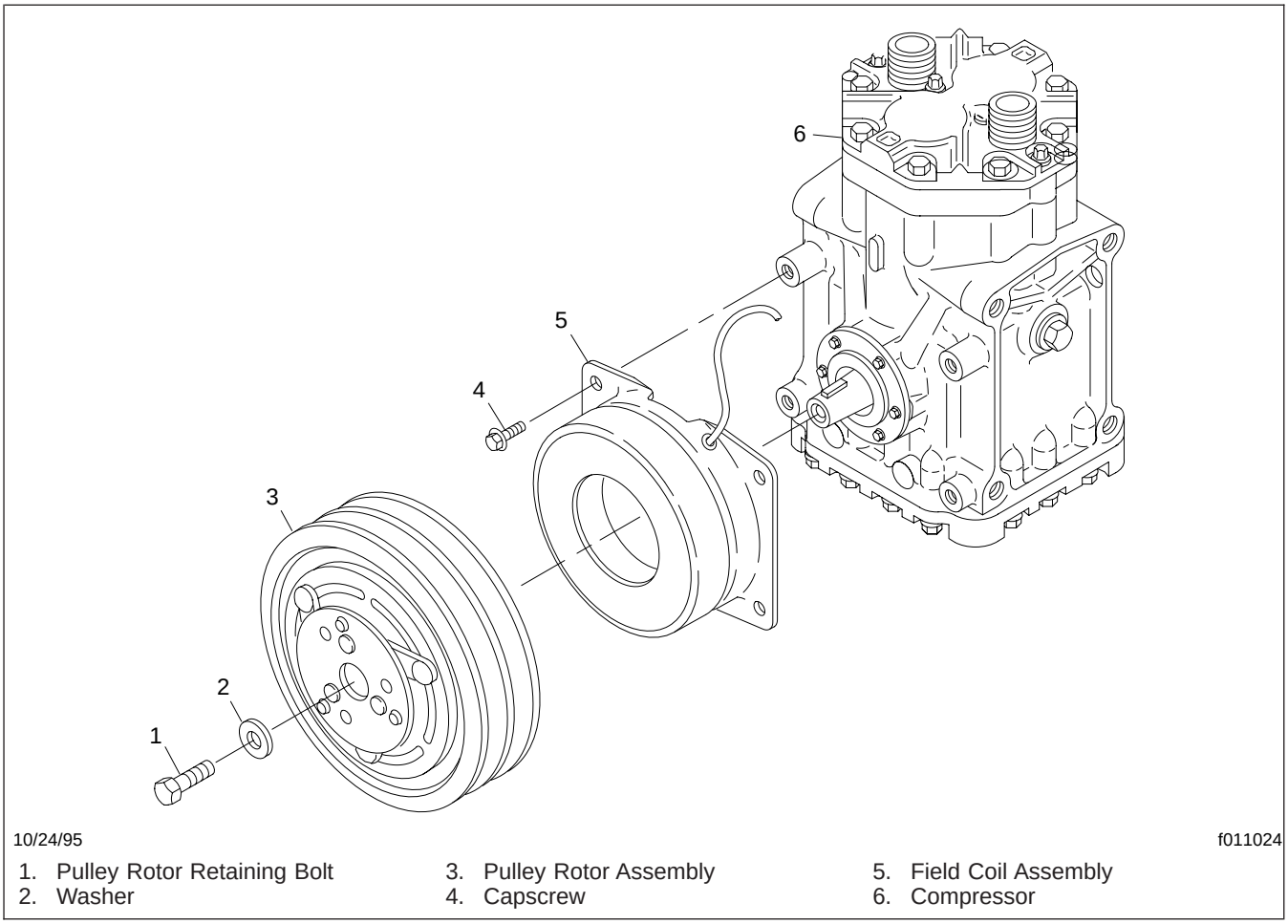
Fig. 3, Dipstick Specifications

5. Evacuate, charge, and leak test the refrigerant system. For instructions, refer to the cab heater and air conditioner section in this group.

Refrigerant Compressor Magnetic Clutch Assembly Removal, Inspection, and Installation

Removal

1. Remove the 5/16-inch pulley rotor retaining bolt from the center of the pulley rotor. See **Fig. 1**.
5. Remove the four 1/4–20 capscrews holding the field coil assembly to the compressor housing.
6. Remove the field coil assembly.



1. Pulley Rotor Retaining Bolt
2. Washer
3. Pulley Rotor Assembly
4. Capscrew
5. Field Coil Assembly
6. Compressor

Fig. 1, Pulley Rotor and Field Coil Assemblies

2. Install a 5/8–11 capscrew in the hub of the pulley rotor assembly.
3. Tighten the screw to pull the pulley rotor assembly off the compressor shaft.

⚠ CAUTION

CAUTION: Do not try to remove the pulley rotor assembly by prying or hammering. This can damage the assembly.

4. Disconnect the field coil electrical lead wire.

Inspection

1. Inspect the drive plate. If the friction surface shows signs of damage due to too much heat, replace the drive plate and pulley assembly.
2. Check the appearance of the pulley assembly. If the frictional surface of the pulley shows signs of too much grooving due to slippage, replace both the pulley and drive plate. Clean the friction surfaces of the pulley assembly before installing it.

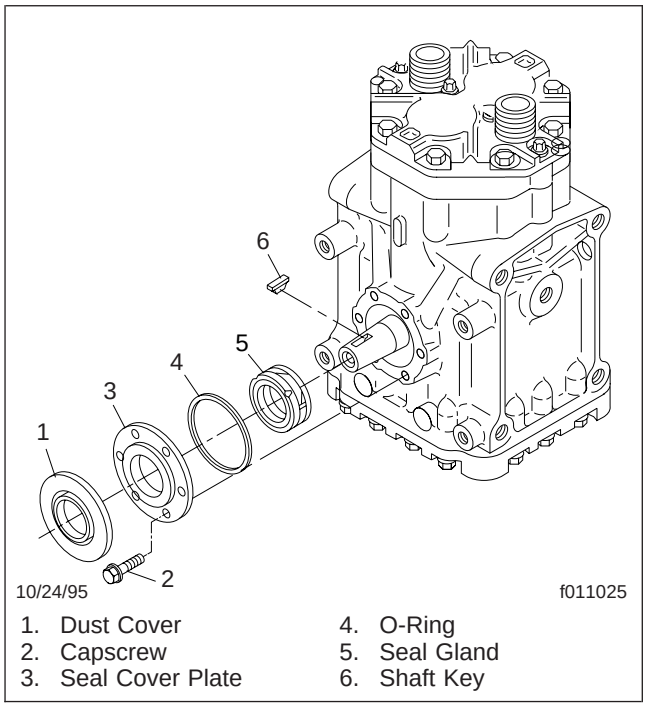
Refrigerant Compressor Magnetic Clutch Assembly Removal, Inspection, and Installation

3. Check the coil for a loose connector and for cracked insulation. Replace it, if necessary.

Installation

1. Position the field coil assembly on the compressor housing with the four screw mounting holes aligned with the bosses on the housing.
2. Apply Loctite® 262 or 680 to the four 1/4–20 capscrews (on those threads that do not already have dry Loctite on them).
3. Install the capscrews and gradually tighten them to align the coil assembly. Final torque should be 15 lbf·ft (20 N·m).
4. Taking care to properly align and seat the shaft and hub keyways, attach the pulley rotor assembly to the compressor shaft.
5. Install the 5/16–24 center bolt and washer. Tighten the bolt about 20 lbf·ft (27 N·m).
6. Turn the pulley rotor assembly by hand to make sure it moves freely without interference with the field coil assembly.
7. Connect the lead wire from the field coil to the vehicle electrical circuit.
8. Engage and disengage the clutch several times to check for correct operation.

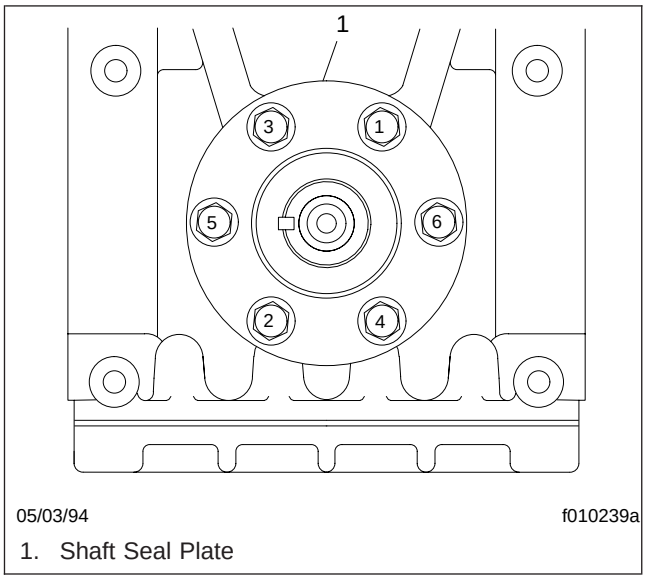
Replacement (See Fig. 1)



1. Dust Cover
2. Capscrew
3. Seal Cover Plate
4. O-Ring
5. Seal Gland
6. Shaft Key

Fig. 1, Shaft Seal Replacement

1. Remove the compressor from the vehicle. For instructions refer to **Subject 120.**
2. Using the clutch center jacking bolt, remove the clutch.
3. Remove the dust cover if present.
4. Remove the seal cover plate. Using the seal puller, pull out and discard the seal gland. Do not use a screwdriver to pry the seal gland from the compressor shaft; this could damage the shaft. Discard all seal parts including the O-ring.
5. Clean the shaft and seal cavity with a clean lint-free cloth.
6. Dip the new seal gland in mineral oil.
7. Push the seal assembly **(Fig. 1),** minus the carbon ring (inside the seal gland), over the end of the shaft with the carbon ring retainer facing out. Use the seal installer tool to move the seal assembly into position on the shaft.
8. Place the carbon ring in the ring retainer so the lapped surface is facing out. The notches in the outside edge of the carbon ring must engage the driving lugs and be firmly seated in the retainer.
9. Coat a new O-ring with mineral oil so it will stick; then, install it in the seal cover plate groove.
10. Install the seal cover plate so there is equal clearance around the shaft. Install the capscrews, and tighten them 60 to 84 lbf·in (680 to 940 N·cm) in sequence. **See Fig. 2.**



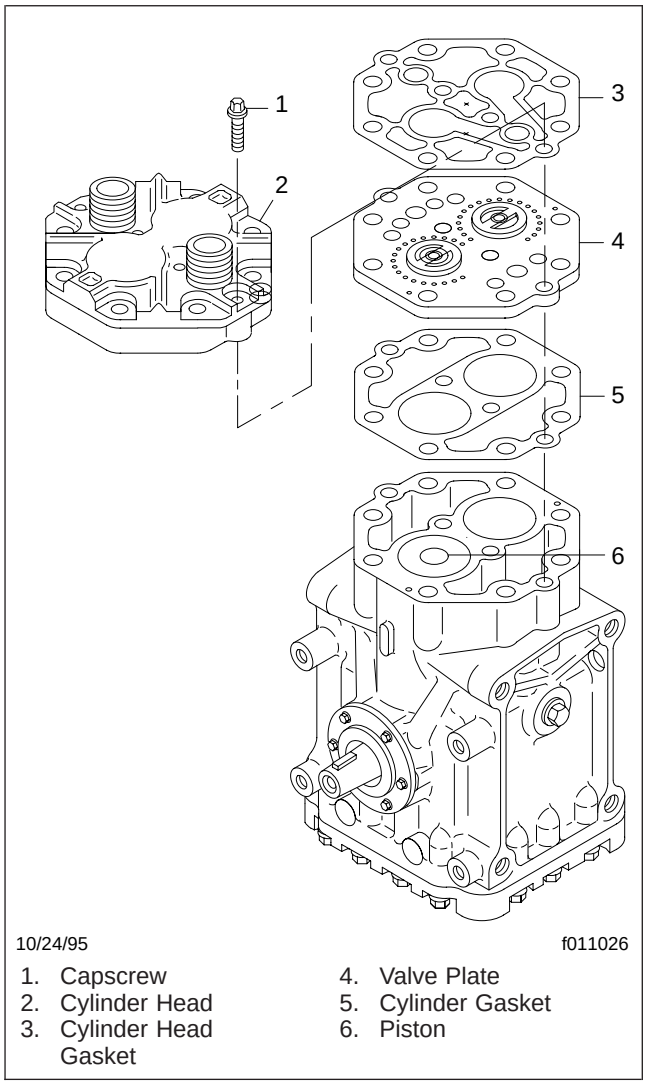
1. Shaft Seal Plate

Fig. 2, Tightening Sequence

11. Place the dust cover on the shaft before inserting the shaft key. As the clutch bolt is tightened, the dust cover will be drawn into the proper position.

Refrigerant Compressor Head and Valve Plate Removal and Installation

Removal (See Fig. 1)



1. Capscrew
2. Cylinder Head
3. Cylinder Head Gasket
4. Valve Plate
5. Cylinder Gasket
6. Piston

Fig. 1, Head and Valve Plate Removal

NOTE: Before doing any work on the head and valve plate, open both service valves to release any gas pressure in the compressor. The cylinder head is made of aluminum; be careful when removing it not to damage the sealing surfaces.

1. Remove the screws from the cylinder head. **See Fig. 2.**
2. Remove the valve plate and head from the cylinder by prying or tapping under the ears extending from the valve plate. If the head and valve plate adhere, hold the head and tap the valve plate ears away from the head with a soft hammer.

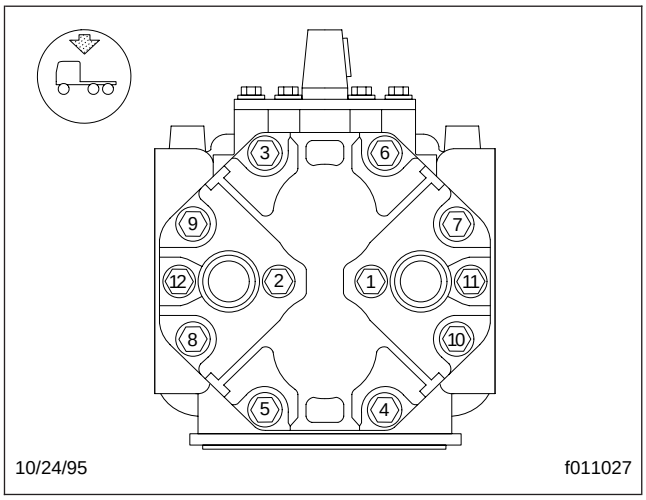


Fig. 2, Head and Service Valve Screws Tightening Sequence

CAUTION

CAUTION: Do not hit or tap the head to separate it from the valve plate. Damage to the head may result.

3. Being careful not to scratch or nick the machined sealing surfaces, remove all gasket material adhering to the head, valve plate, or cylinder.

Installation

NOTE: Valves and valve plates are furnished only as a complete assembly.

1. Apply a thin film of clean mineral oil to the area of the crankcase to be covered by the cylinder gasket. Place the cylinder gasket in position on the cylinder so the dowel pins in the crankcase pass through the dowel pin holes in the cylinder gasket.
2. Apply a thin film of clean mineral oil to the top and bottom valve plate areas to be covered by gaskets. Place the valve plate in position on the cylinder gasket so the discharge valve assemblies are facing up and the locating dowel pins go through the dowel pin holes in the valve plate.

Refrigerant Compressor Head and Valve Plate Removal and Installation

The discharge valve assemblies are the smaller diameter ones with the restrainer over the valve reed.

3. Place the head gasket in position on the valve plate so the dowel pins go through the dowel pin holes in the gasket.
4. Apply a light film of clean mineral oil to the machined surface of the cylinder head which contacts the head gasket. Place the head on the cylinder head gasket so the dowel pins go into the dowel pin holes in the head.
5. Insert the head screws and tighten all the screws until the heads make contact.
6. Tighten the head screws 17 to 25 lbf·ft (23 to 34 N·m) in sequence. **See Fig. 2.**

Refrigerant Compressor Pistons, Connecting Rods, Crankshaft, and Bearing Removal and Installation

Piston and Connecting Rod Removal

The pistons and connecting rods are easily accessible after removing the head, valve plate assembly, and base plate. If the connecting rods will be reused, mark the rod, cap and crankshaft throw so the rod can be installed in exactly the same position on the crank pin.

Crankshaft and Bearing Removal

NOTE: When replacing the crankshaft, both the front (seal end) and rear main bearings should also be replaced since they may be damaged during removal.

1. Remove the four screws from the rear bearing cover plate.
2. Remove the cover plate by gently prying it loose from the crankcase, being careful that the housing is pulled parallel to the bearing surface.
3. Remove all components down to the crankcase, crankshaft, and seal end main bearing assembly.
4. Wash this assembly in a solvent, that meets or exceeds OSHA guidelines, to remove all traces of oil and grease. Allow it to dry.
5. Heat the assembly in an oven set to 300°F (150°C).

CAUTION

CAUTION: Heat the complete assembly evenly in an oven. Localized heating may crack the crankcase.

6. Remove the crankshaft and ball bearing assembly from the crankcase.
7. If the crankshaft is reusable, remove the ball bearing assembly. Hold the crankshaft vertically in a vise with the flywheel end up, gripping the shaft at the unmachined center throw. Using two large screwdrivers as a pry under the bearing race, force the bearing upward and remove it from the shaft.

Crankshaft and Bearing Installation

1. Press the rear ball bearing onto the crankshaft by exerting pressure on the bearing inner race.
2. Make sure that the shaft, bearing, and recess in the crankcase are clean and free of burrs.
3. Heat the crankcase in an oven set to 300°F (150°C).

CAUTION

CAUTION: Heat the complete assembly evenly in an oven. Localized heating may crack the crankcase.

4. Using the opening in the bottom of the crankcase as a point of entry, place the seal end bearing in the recess. If necessary, apply force to the outer race to be sure that it is seated in the bottom of the recess.
5. Allow the crankcase to cool. Install the crankshaft through the rear bearing cover plate opening, and guide the flywheel end through the inner race of the ball bearing.
6. Place the crankcase so that it is completely supported on the ball bearing inner race. Then, press the shaft into place until the shaft boss contacts the inner bearing race.

CAUTION

CAUTION:If the housing is not completely supported by the inner bearing race, the bearing may be destroyed.

7. Install the rear bearing cover plate with the O-ring in the crankcase. A slight force may be required due to the small clearances between the outer race of the ball bearing and the bearing cover plate recess.
8. Install the four capscrews and tighten them 10 to 16 lbf·ft (14 to 22 N·m) in sequence. **See Fig. 1.**

Refrigerant Compressor Pistons, Connecting Rods, Crankshaft, and Bearing Removal and Installation

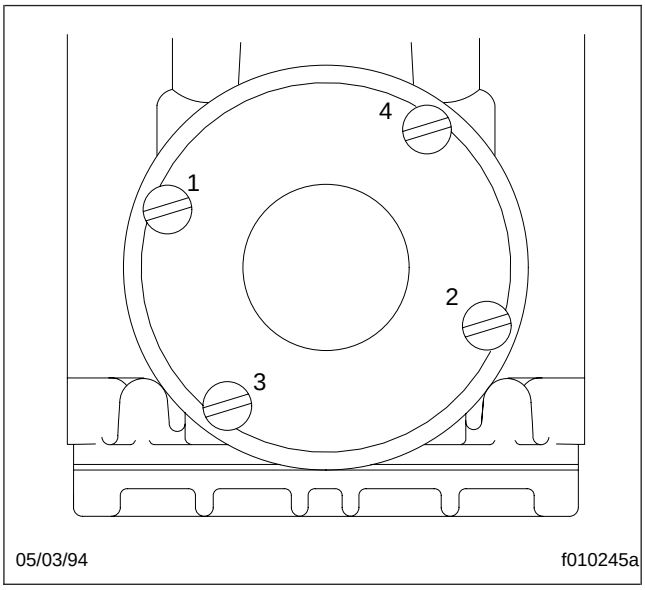


Fig. 1, Rear Bearing Cover Plate Capscrew Tightening Sequence

Piston and Connecting Rod Installation

NOTE: When installing either the original or a new piston and connecting rod assembly, coat all bearing surfaces with clean oil of the same brand used in the crankcase.

When installing the assembly into the cylinder, the wrist pin roll pin must be positioned toward the center of the compressor. If positioned toward the outside, the roll pin may hit the crankshaft when the piston is at bottom dead center.

When installing a used connecting rod, match up the marks made during removal. When installing a new connecting rod, the dowel pins in the bearing cap must be positioned to enter the holes in the rod.

1. Install the piston and connecting rod assemblies.
2. Install the connecting rod capscrews and tighten them 12 to 16 lbf·ft (16 to 22 N·m).
3. Wipe all parts with a lint free cloth to make sure they are clean.
4. Install the base plate. Tighten the capscrews 10 to 16 lbf·ft (14 to 22 N·m) in sequence. **See Fig. 2.**

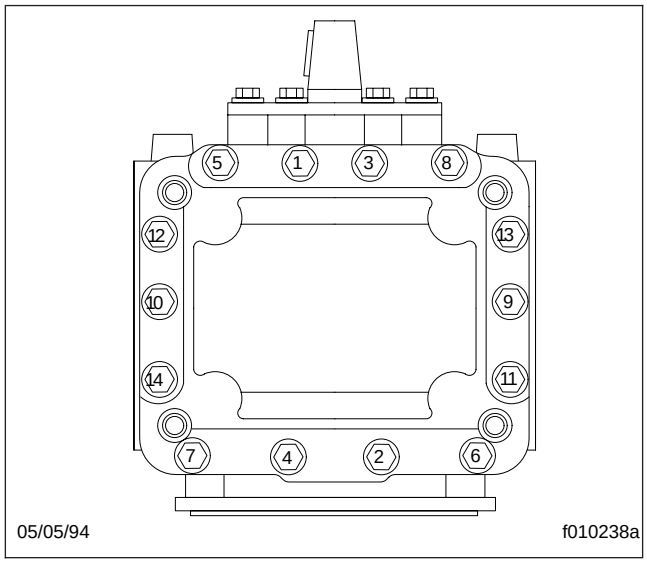


Fig. 2, Baseplate Capscrew Tightening Sequence

5. Install the head and valve plate assembly. For instructions, refer to **Subject 160.**
6. Fill the crankcase with the recommended oil. Refer to the refrigerant oil table in **Specifications 400.**
7. Close all openings to prevent the entrance of foreign material.

Special tools can be ordered from your local tool supplier.

Torque Specifications				
Location	**Thread**	**Head Type**	**Torque**	
			lbf·ft (N·m)	**lbf·in (N·cm)**
Base Plate	1/4-20	Hex	10–16 (14–22)	—
Connecting Rod	1/4–20	12-point	12–16 (16–22)	—
Rear Bearing Cover Plate	1/4–20	Flat	10–16 (14–22)	—
Cylinder Head	5/16–18	Hex	17–25 (23–34)	—
Seal Plate	10–24	Hex	—	60–84 (680–940)
Tube-O Valve	1–14	Hex	35–40 (47–54)	—
Mounting Screw	3/8–16	Hex	35 (47)	—
Oil Fill Plug	3/8–24	Hex	—	60–120 (680–1360)
Clutch Bolt	5/16–24	Hex	20 (27)	—

Table 1, Torque Specifications

SlimLine Seal Assembly Torque Specifications	
HVAC Component	**Torque**
A/C Compressor	11 to 15 lbf·ft (15 to 20 N·m)
Condenser	11 to 15 lbf·ft (15 to 20 N·m)
Receiver-Drier	11 to 15 lbf·ft (15 to 20 N·m)
Thermal Expansion Valve	11 to 15 lbf·ft (15 to 20 N·m)
Evaporator	11 to 15 lbf·ft (15 to 20 N·m)
Junction Block	11 to 15 lbf·ft (15 to 20 N·m)

Table 2, SlimLine Seal Assembly Torque Specifications

O-Ring Fitting Torque Specifications	
Hose Size	**Torque**
#6	20–25 lbf·ft (27–34 N·m)
#8	30–35 lbf·ft (41–47 N·m)
#10/12	35–40 lbf·ft (47–54 N·m)
One-Inch Fittings on Compressor	21–27 lbf·ft (28–37 N·m)

Table 3, O-Ring Fitting Torque Specifications

Specifications

Recommended Refrigerant Oils, R-134a Systems*		
Description	**Part Number**	**Compressor Manufacture Date**
Polyalkylene Glycol (PAG)	ABP N83 326055	Prior to May 5, 1995, and from July 2002
Polyol Ester (POE)	ABP N83 326008	May 5, 1995, through July 2002

* Look at the identification tag on the refrigerant compressor to determine the type of refrigerant oil that should be used in the air conditioning system. If the type of oil is not specified on the identification tag, use the compressor manufacture date to determine the type of oil to use.

Table 4, Recommended Refrigerant Oils, R-134a Systems

General Description

The hoods on these vehicles are made of fiberglass, and are manufactured by the SMC process.

SMC, which stands for "sheet molding compound," is a fiberglass and thermosetting polyester material. SMC hoods are easily recognized by their smooth inner surface. To make each part, SMC sheets first are placed between matching mold halves. Then, heat and pressure are applied to the mold in order to cure (solidify) the SMC resin. At the end of the process, an in-mold coating is injected onto the part to prepare it for priming and topcoating.

Hood Mounting and Components

The hood assembly is mounted on two pivot brackets. The brackets are on the outside of the frame rails on older Century Class Conventionals and inside the frame rails on newer Century Class Conventionals and Coronados. The pivot brackets are attached to the front cross-member gusset. The hood pivots work in conjunction with the tilt-assist and tilt-limiting mechanisms to allow a forward hood tilt adequate for vehicle service.

In the operating position, the rear of the hood is supported by hood mounting brackets, which are attached to the cab. The rear brackets hold the hood in the correct position for operation. The hood is held in place with latches, one on each side.

The hood hinge brackets are adjustable forward and backward. The rear hood mounting brackets are adjustable up and down.

The Century Class hood assembly is equipped with a polished and anodized aluminum grille. The grille is attached to the hood with four fasteners. The hood is also equipped with a headlight bucket assembly, that features a headlight and turn signal/parking light combination on each fender.

The Coronado hood assembly is a higher, more classic design with separate, full fenders that are bolted to the sides of the hood. It is equipped with a polished stainless steel grille that attaches to the hood with two fasteners at the top and an isolator which fits into a hole at the bottom. The hood features chrome air scoops and accent lights on both sides, a chrome grille surround, chrome headlight bezels, headlight recesses integral with the fenders, and a hood ornament.

Hood Removal, Installation, and Adjustment

These procedures apply to the following vehicle models, as specified:

- All Century Class Conventionals
- Coronado

The hood pivot assembly is slightly different for each application.

⚠ WARNING

Do not attempt to lift the hood; it weighs about 150 lb (68 kg). Lifting the hood could result in personal injury or damage to the hood assembly and other components.

Removal

1. Drive the vehicle back and forth to settle the frame and suspension. Park the vehicle on a flat, level surface. Shut down the engine, apply the parking brake, and chock the tires.
2. Remove the grille; see **Subject 110**.
3. For Century Class Conventionals, remove the bumper; see **Section 31.03** (aerodynamic bumper), or **Section 31.12** (non-aerodynamic bumper).
4. Place a support between the floor and the front of the hood. The support should be as wide and as long as the front of the hood, and should be at the same height as the lowest edge of the hood in the fully open position. Place cardboard, carpet, rags, or other padding on top of the support to protect the hood.
5. Release the hood latches, and tilt the hood completely open.
6. Disconnect the headlight wiring from both sides of the hood.
7. For Century Class Conventionals built in or after September 2000, and Coronados, remove the torsion bars; see **Subject 120**.
8. Move the hood to a less than full-tilt position to allow slackness in the tilt-limiting straps. Disconnect the straps by removing the fasteners attached to the inside surface of the hood.
9. Tilt the hood fully open, and rest it on the support.
10. For Century Class Conventionals built before September 2000, remove the washers and nuts from the hood hinge shoulder bolts, then use a punch and hammer to tap the shoulder bolts from the hood hinges; see **Fig. 1**.

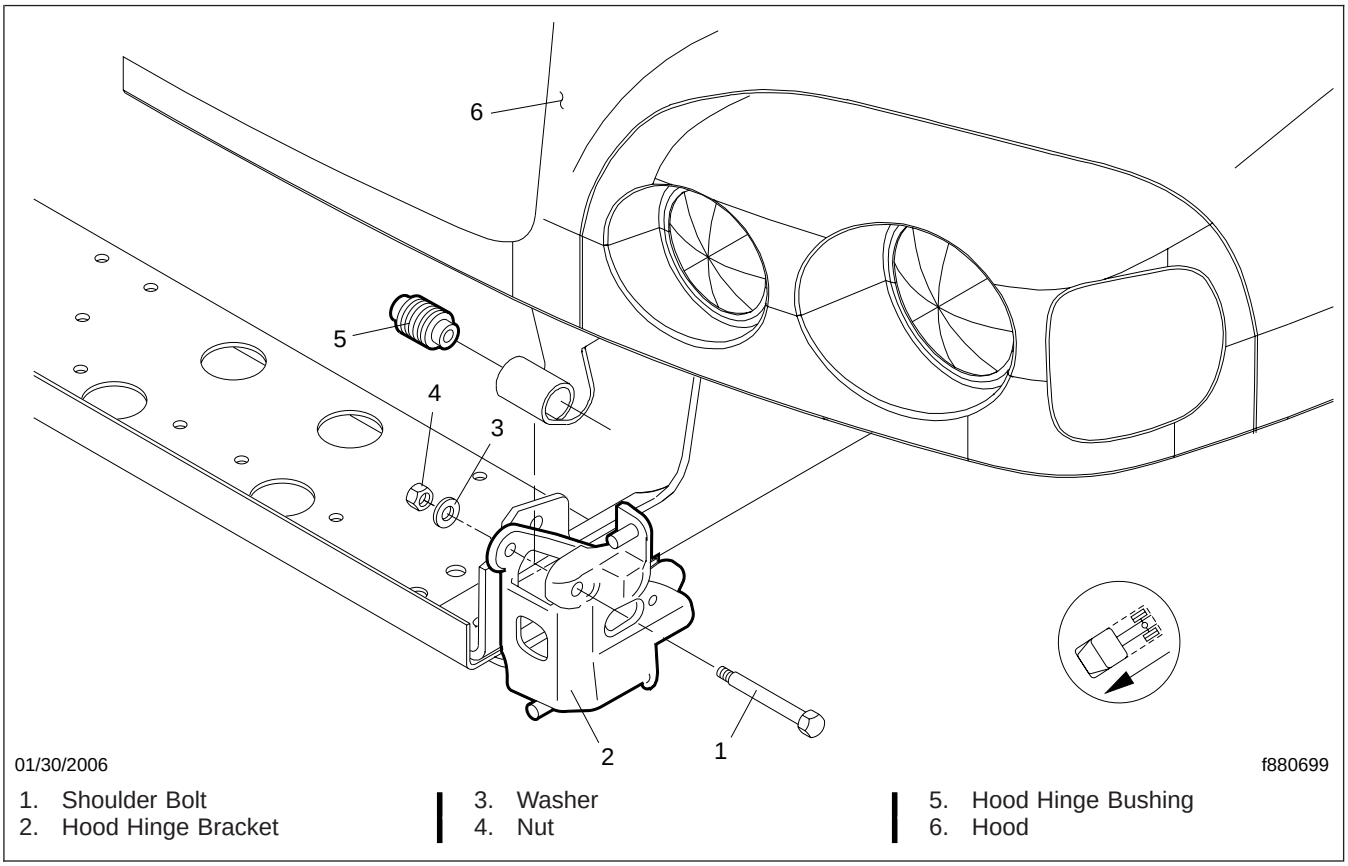
    For Century Class Conventionals built in or after September 2000, and Coronados, remove the cotter pins and washers from the clevis pins, then use a punch and hammer to tap the clevis pins from the hood hinges. See **Fig. 2** and **Fig. 3** for Century Class Conventionals and **Fig. 4** for Coronados.
11. Carefully roll or slide the hood support away from the vehicle; do not try to lift the hood.

Installation

1. With the tires chocked, place the disconnected electrical wiring onto the front crossmember to avoid problems during hood installation.
2. With the hood in the forward-tilt position and resting on the support at about the same height as the top of the bumper, move the support and hood into alignment with the front of the vehicle. Do not try to lift the hood.
3. For Century Class Conventionals built before September 2000, tap the shoulder bolts into place in the hood hinges, using a rubber hammer, then install the washers and nuts; see **Fig. 1**. Tighten the nuts 26 lbf·ft (35 N·m).

    For Century Class Conventionals built in or after September 2000, and Coronados, tap the clevis pins into place in the hood hinges. Install the washers and new cotter pins. See **Fig. 2** and **Fig. 3** for Century Class Conventionals and **Fig. 4** for Coronados.
4. Lower the hood until it is balanced over the pivots, between the full-tilt and closed positions. Have an assistant hold the hood in this position.
5. Attach the two tilt-limiting straps to the inside surface of the hood.
6. Open the hood to the full-tilt position.
7. For Century Class Conventionals built in or after September 2000, and Coronados, install the torsion bars; see **Subject 120**.
8. Connect the headlight wiring.

Hood Removal, Installation, and Adjustment



1. Shoulder Bolt
2. Hood Hinge Bracket
3. Washer
4. Nut
5. Hood Hinge Bushing
6. Hood

Fig. 1, Hood Installation (Century Class Conventional built before September 2000)

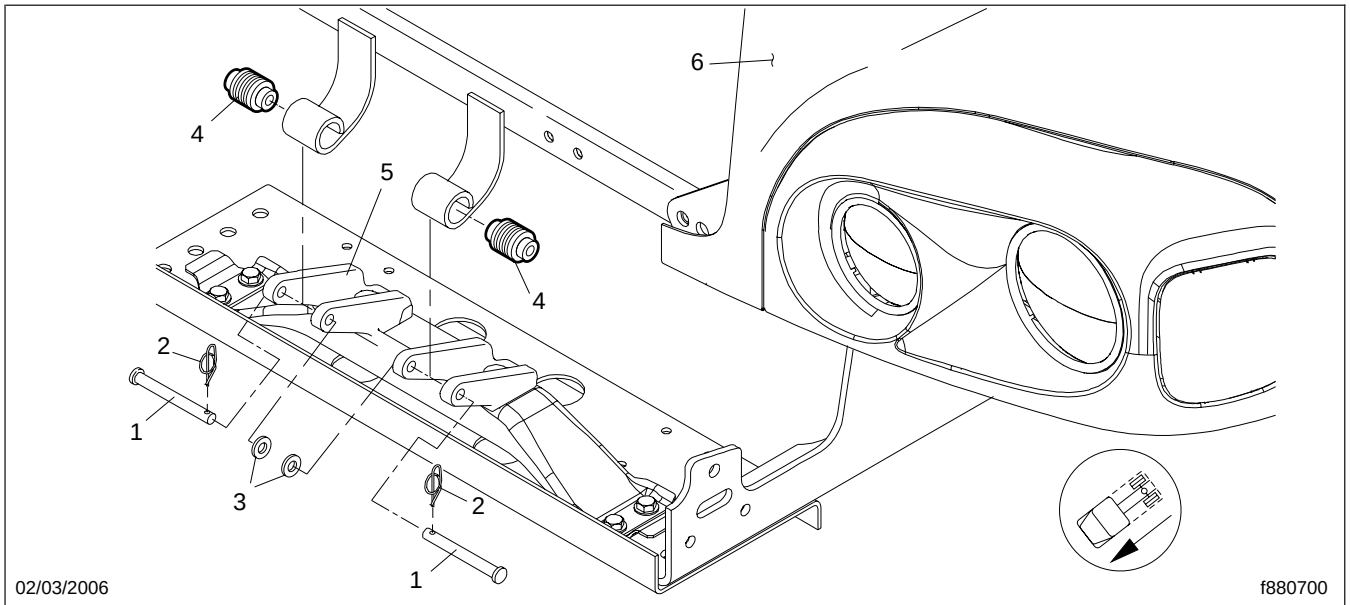
9. For Century Class Conventionals, install the bumper; see **Group 31**.
10. Close and latch the hood.
11. Install the grille; see **Subject 110**.
12. Remove the chocks.

Adjustment

NOTE: If the vehicle has had damage to the chassis, the frame must be straightened before adjusting the hood.

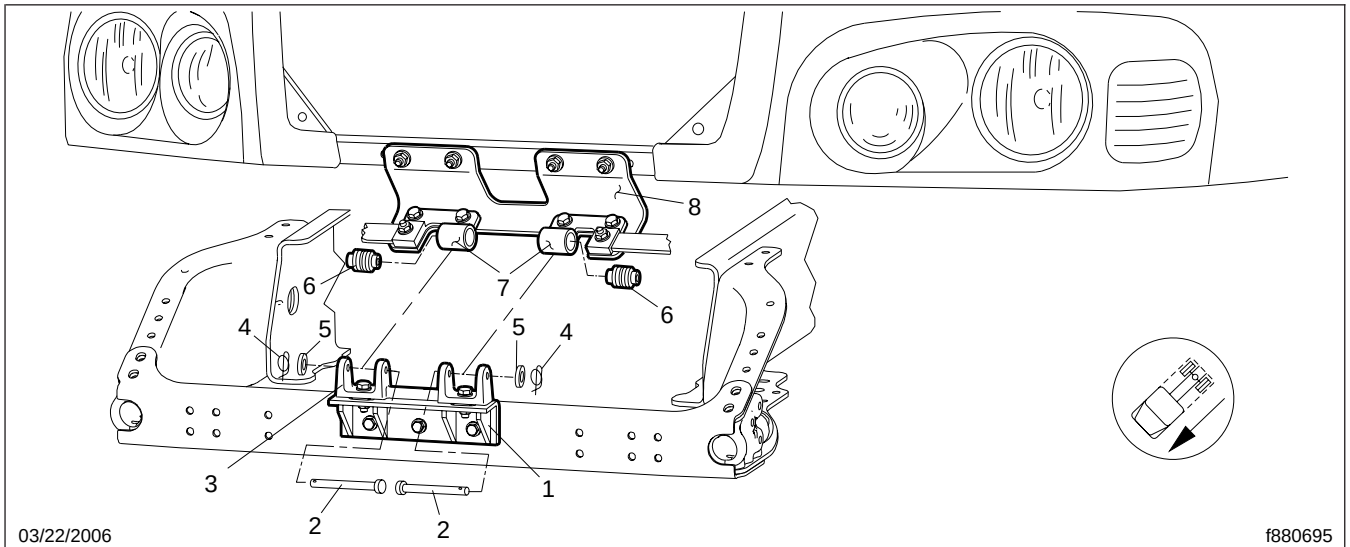
1. Drive the vehicle back and forth to settle the frame and suspension. Park the vehicle on a flat, level surface. Shut down the engine, apply the parking brakes, and chock the tires.
2. Verify that the cab ride height and alignment are correct, as follows.
   - 2.1 Check the cab ride height, and adjust it, if necessary; see **Section 60.01, Subject 100**.
   - 2.2 Inspect the front cab mounts. The outboard edge of the cab mount assembly should be parallel to the grooves inscribed on the top surface of the frame rail bracket, and the same number of grooves should be visible on the bracket on each side of the vehicle; see **Fig. 5**.
3. Check that the hood is straight and aligned with the cab. Check the gap between the hood and the cowl (**Fig. 6**, Ref. A). It should be the same on both sides of the vehicle.
4. If adjustment is necessary, loosen the hood to adjust the alignment, as follows.
   - 4.1 Remove the bumper; see **Section 31.03** (aerodynamic bumper), or **Section 31.12** (non-aerodynamic bumper).

Hood Removal, Installation, and Adjustment



1. Clevis Pin
2. Cotter Pin
3. Washers
4. Hood Hinge Bushing
5. Hood Hinge Bracket
6. Hood

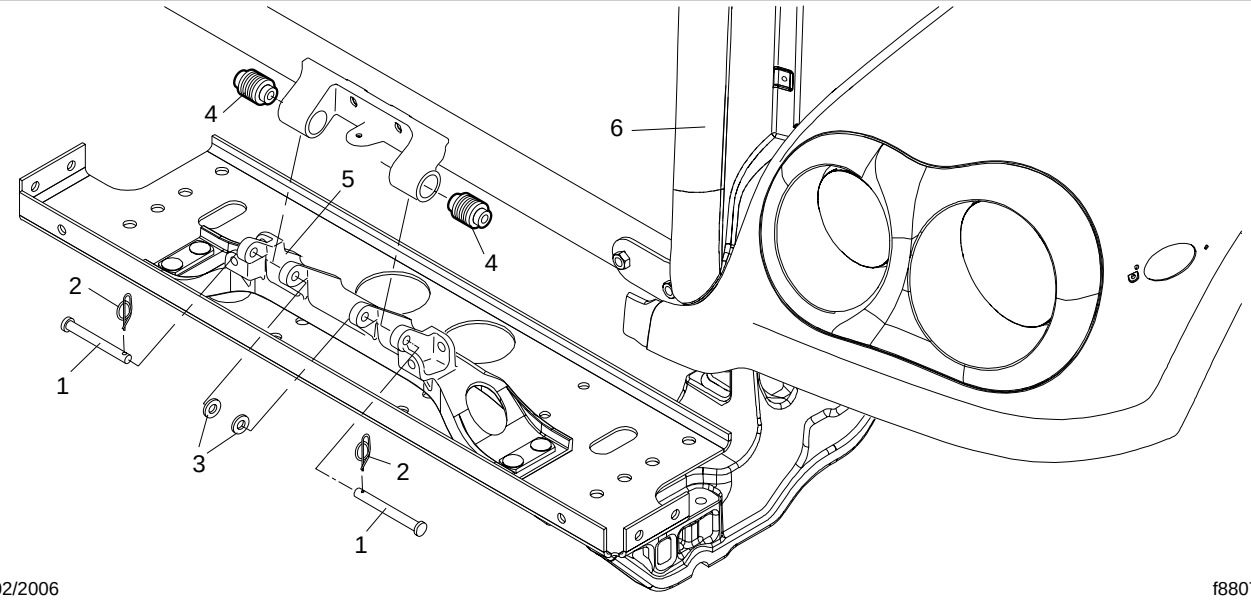
Fig. 2, Hood Installation (Century Class Conventional built from September 2002, with an engine manufactured through December 31, 2006)



1. Support Bracket
2. Clevis Pin
3. Hood Hinge Bracket
4. Cotter Pin
5. Washer
6. Hood Hinge Bushing
7. Hood Hinges
8. Hood Hinge Plate

Fig. 3, Hood Installation (Century Class Conventional with an EPA07 compliant engine)

Hood Removal, Installation, and Adjustment



1. Clevis Pin
2. Cotter Pin
3. Washers
4. Hood Hinge Bushing
5. Hood Hinge Bracket
6. Hood

Fig. 4, Hood Installation (Coronado)

4.2 Open the hood, and remove the torsion bar assemblies; see **Subject 120**.

4.3 With the help of an assistant, close the hood.

4.4 Loosen the bolts that attach the hood hinge brackets to the front crossmember.

4.5 Move the hood until the hood-to-cowl gap spacing is equal on both sides of the vehicle.

4.6 Tighten the bolts that attach the hood hinge brackets to the front crossmember.

4.7 With the help of an assistant, open the hood.

4.8 Install the torsion bar assemblies; see **Subject 120**.

4.9 Install the bumper; see **Section 31.03** (aerodynamic bumper), or **Section 31.12** (non-aerodynamic bumper).

5. Check the position of the cab-mounted hood rear isolator (**Fig. 7**), as follows.

5.1 Clean the grease from the isolator and hood-mounted rear support.

5.2 Apply large dabs of silicone-based grease to the flat top surfaces on the isolator.

5.3 Close and open the hood.

5.4 Check the grease marks on the hood-mounted rear support to see where the isolator and the hood support meet. The flat spots on the hood-mounted rear support should touch the flat spots on the top surface of the isolator. The rib on the support should align with the groove in the isolator.

6. If necessary, adjust the isolator positioning.

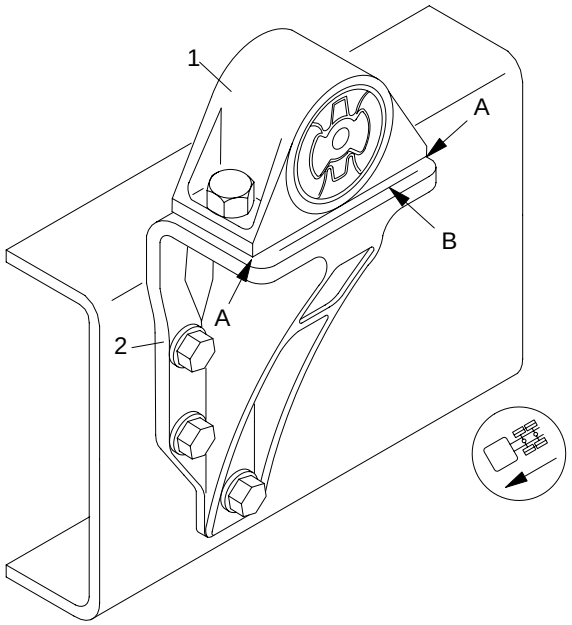
6.1 Loosen the carriage bolts that attach the isolator to the cab.

6.2 Adjust the isolator position.

6.3 Tighten the carriage bolts that attach the isolator to the cab.

7. Spread silicone-based grease on the top surface and notch of the isolator. Wipe off excess grease.

8. Lower the hood and fasten the hood latches.



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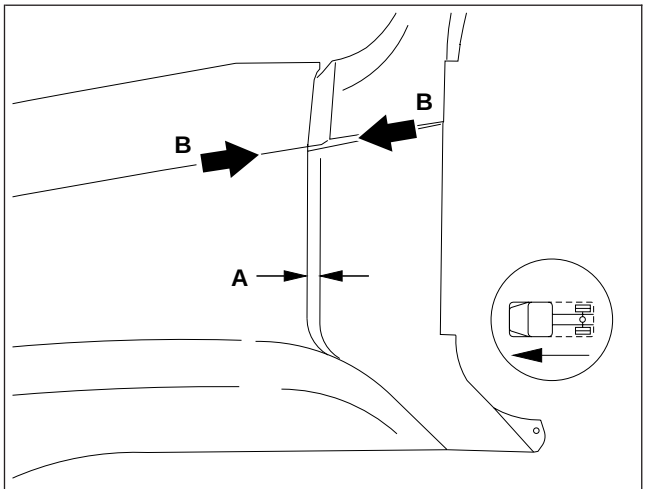
A. The edge of the cab mount assembly should be parallel to the grooves on the bracket.
B. The same number of grooves should be visible on the bracket on each side of the vehicle.

1. Cab Mount Assembly 2. Frame Rail Bracket

Fig. 5, Forward Cab Mount

9. Check the hood vertical alignment. With the hood closed and latched, inspect the connecting seam in the hood. The seam should align with the bottom edge of the A-pillar cover (**Fig. 6**, Ref. B).
10. If necessary, adjust the vertical alignment of the hood, as follows.
    - 10.1 Open the hood.
    - 10.2 Loosen the carriage bolts on both hood rear isolators enough to allow the isolators to move when a slight force is applied; see **Fig. 7**.
    - 10.3 Raise the isolators to the highest position.
    - 10.4 With the help of an assistant, slowly lower the hood until the seam on the hood aligns with the lower A-pillar cover, then return the hood to the full-open position.
    - 10.5 Tighten the carriage bolts on the isolators.



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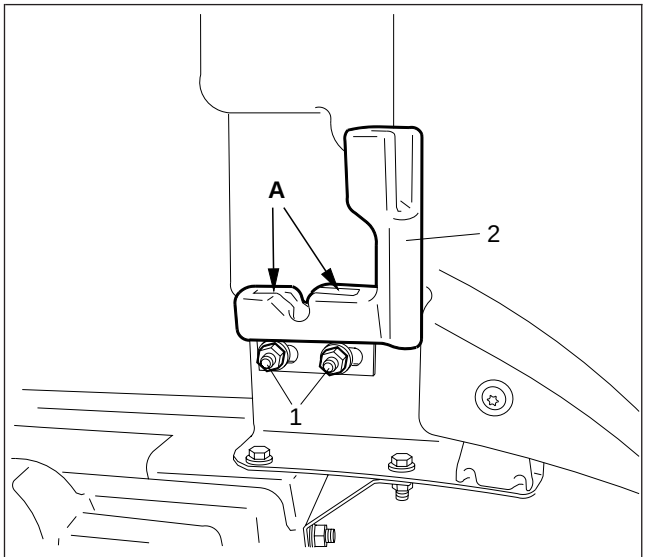
A. The gap between the hood and cowl should be the same on both sides of the vehicle.
B. The seam on the hood and the bottom of the B-pillar cover should line up.

Fig. 6, Checking Hood Alignment (Century Class shown)



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A. Apply grease here.

1. Carriage Bolts 2. Hood Rear Isolator

Fig. 7, Hood Rear Isolator (Century Class shown)

- 10.6 Lower the hood and fasten the hood latches.

Hood Removal, Installation, and Adjustment

11. Remove the chocks.

Procedures under these headings apply to the following vehicle models, as specified:

- Century Class Conventional built before November 2003
- Century Class Conventional built in or after November 2003
- Coronado

Century Class Conventional Built Before November 2003

Removal

1. With the vehicle parked on a level surface, apply the parking brakes and chock the tires.
2. Remove the four fasteners that attach the grille to the hood; see **Fig. 1**. Remove the grille.

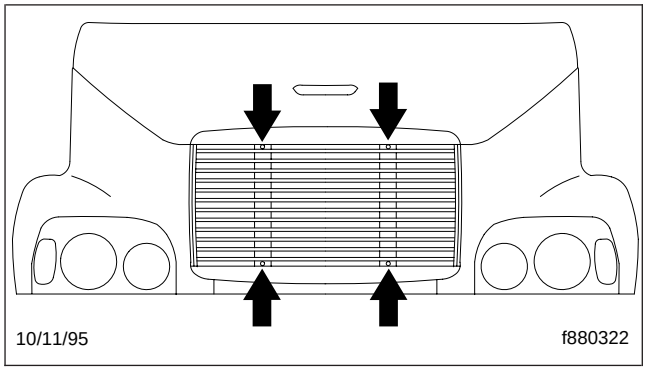


Fig. 1, Location of Grille Fasteners (Century Class Conventional built before November 2003)

Installation

1. With the tires chocked, place the grille on the hood, and line up the fastener holes with the holes on the hood.
2. Install the fasteners into the threaded isolators. Tighten the fasteners 48 lbf·in (540 N·cm).
3. Remove the chocks.

Century Class Conventional Built In or After November 2003

Removal

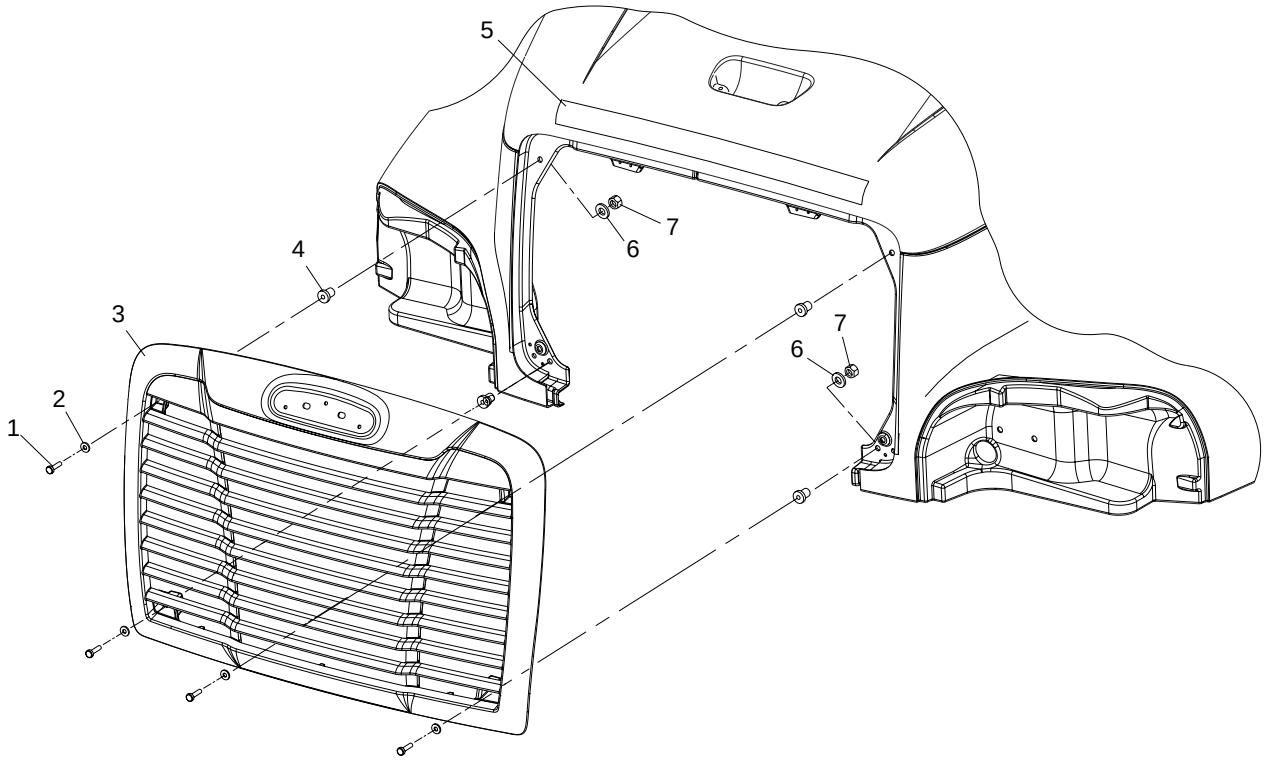
1. With the vehicle parked on a level surface, apply the parking brakes and chock the tires.
2. Open the hood. Check the back of the grille. If there are two nuts and washers that attach the grille to the hood, one on the upper right and one on the lower left, remove them. Close the hood.
3. Remove the four screws and washers that attach the grille to the hood; see **Fig. 2**.
4. Lift up on the top lip of the grille to loosen the double-sided tape on the underside, and remove the grille from the hood.
5. Remove any adhesive tape left on the hood surface or the underside of the grille.

Installation

1. With the tires chocked, using soap and water, clean the hood surface area that is covered by the grille, then wipe the surface with a fifty-percent solution of isopropyl alcohol and water.
2. If a new grille is being installed, remove the backing from the adhesive strip on the underside of the new grille.

   If the original grille is being reinstalled, clean and dry the underside surface of the grille and affix a piece of double-sided tape to it.
3. Place the grille in position on the hood, with the grille fastener holes lined up with the holes on the hood; see **Fig. 2**.
4. Install the fasteners into the threaded isolators and tighten them 12 lbf·in (135 N·cm).
5. Install the two nuts and washers, if such were removed, on the back of the grille.
6. Apply firm pressure to the top of the grille over the adhesive strip to ensure good adhesion.
7. Remove the chocks.

Grille Removal and Installation



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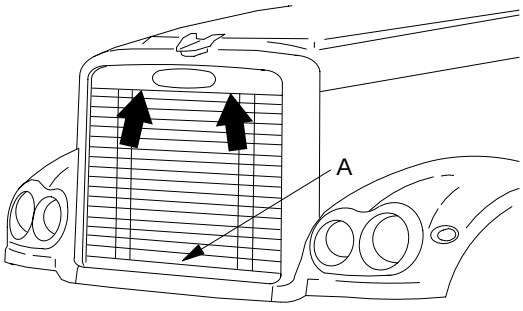
1. Machine Screw
2. Washer
3. Grille
4. Wellnut
5. Adhesive Tape
6. Washer (some installations)
7. Nut (some installations)

Fig. 2, Grille Mounting (Century Class Conventional, built in or after November 2003)

Coronado

Removal

1. With the vehicle parked on a level surface, apply the parking brakes and chock the tires.
2. Remove the two upper fasteners that hold the grille in place; see **Fig. 3**.
3. With the hood open, push the top of the grille up into the hood while pulling the bottom of the grille forward, to remove the isolator stud from its mount.
4. Pull the grille through the hood opening.



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A. An isolator stud fits into the hole on the hood hinge here.

Fig. 3, Location of Grille Fasteners (Coronado)

Installation

1. With the tires chocked and the hood open, fit the isolator stud at the bottom of the grille into the hole on the hood hinge, then align the holes at the top of the grille with those in the hood; see **Fig. 3**.
2. Install the fasteners into the threaded isolators. Tighten the fasteners 48 lbf·in (540 N·cm).
3. Close and latch the hood.
4. Remove the chocks.

Hood Torsion Bar Tilt-Assist Mechanism Removal and Installation

Procedures under these headings apply to the following vehicle models, as specified:

- Century Class Conventional built before September 2000
- Century Class Conventional built from September 2000, with an engine manufactured through December 31, 2006
- Century Class Conventional with an EPA07 compliant engine
- Coronado

Century Class Conventional Built Before September 2000

Removal

1. With the vehicle parked, apply the parking brakes and chock the tires.
2. Remove the grille; see **Subject 110**.
3. Tilt the hood completely open.
4. Remove the four bolts that secure the center bracket; see **Fig. 1**.
5. Rotate the center bracket 180 degrees.
6. Pull the torsion bar free from the center bracket.
7. Rotate the torsion bar, then slide it through and out of the hood-hinge mounting bracket.
8. Repeat the procedure on the opposite side.

Installation

1. With the tires chocked, the hood open, and the center bracket rotated, move the torsion bars into an approximate position.
2. Rotate the center bracket into position, and install the four bolts.
3. Tap each torsion bar on the outer end, until the L-shaped end of the bar is firmly held in position by the center bracket.
4. Close and latch the hood.
5. Install the grille; see **Subject 110**.
6. Remove the chocks.

Century Class Conventional Built From September 2000, with an Engine Manufactured Through December 31, 2006

Removal

1. With the vehicle parked, apply the parking brakes and chock the tires.
2. Remove the grille; see **Subject 110**.
3. Tilt the hood completely open.
4. Remove the four mounting bolts that attach the torsion bar assemblies to the hood crossbar; see **Fig. 2**.
5. Slide each torsion bar assembly out of the slot in the pivot bracket.

NOTE: If the torsion bars are pushing against the pivot brackets, slightly close the hood to loosen them.

Installation

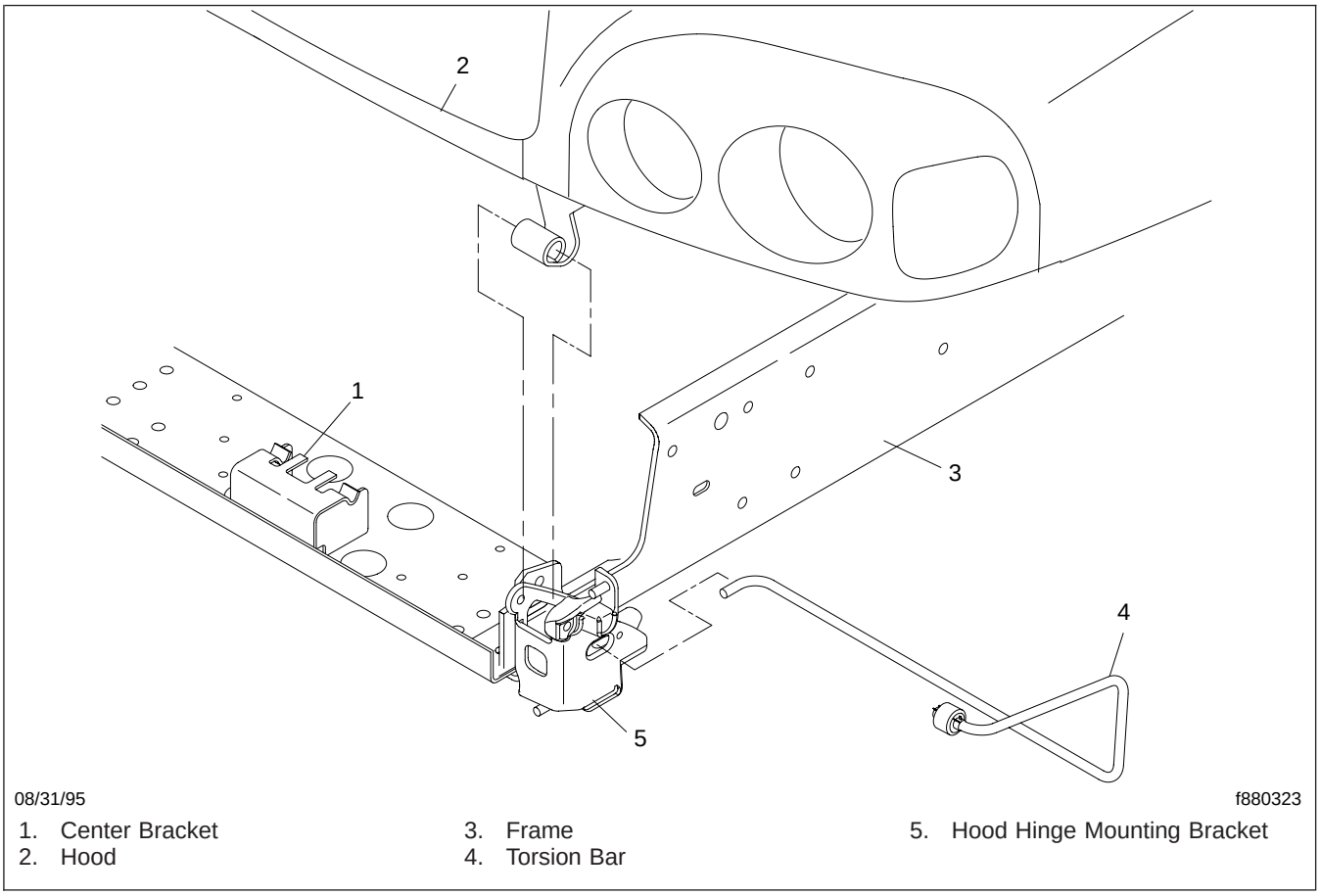
1. With the tires chocked and the hood open, on each side of the vehicle, slide the torsion bar assembly into the slot in the pivot bracket.
2. Install the four bolts that attach the torsion bar assemblies to the hood crossbar; see **Fig. 2**. Tighten the bolts 68 lbf·ft (92 N·m).
3. Close and latch the hood.
4. Install the grille; see **Subject 110**.
5. Remove the chocks.

Century Class Conventional with an EPA07 Compliant Engine

Removal

1. With the vehicle parked, apply the parking brakes and chock the tires.
2. Remove the grille; see **Subject 110** .
3. Tilt the hood completely open.

Hood Torsion Bar Tilt-Assist Mechanism Removal and Installation



1. Center Bracket
2. Hood
3. Frame
4. Torsion Bar
5. Hood Hinge Mounting Bracket

Fig. 1, Torsion Bar Tilt-Assist Mechanism (Century Class Conventional built before September 2000)

4. Remove the fasteners that attach the torsion bars to the pivot-end clamps/hood hinges; see **Fig. 3**.
5. Slide each torsion bar, first out of the pivot-end clamp, then out of the slot in the pivot bracket.

NOTE: If the torsion bars are pushing against the pivot brackets, slightly close the hood to loosen them.

Installation

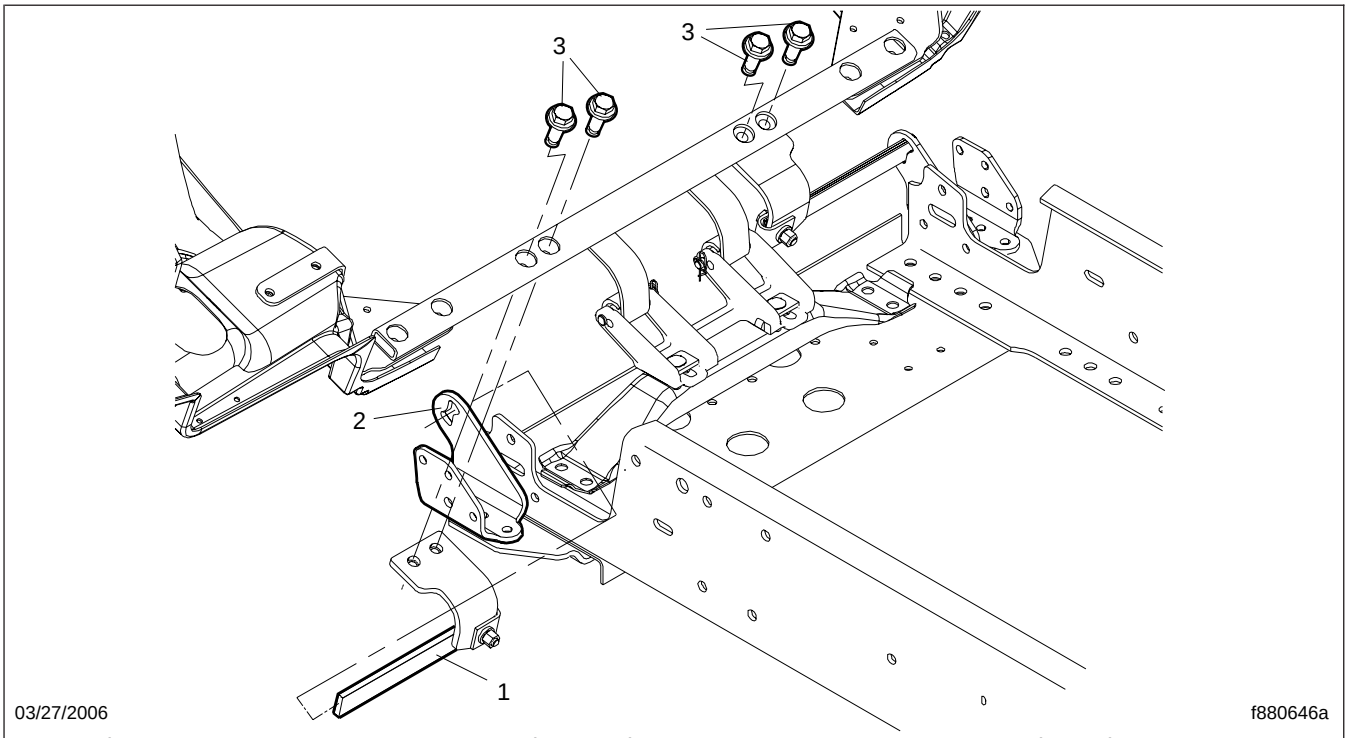
1. With the tires chocked and the hood open, on each side of the vehicle, slide the torsion bars into the slot in the pivot bracket, and then into the pivot-end clamp.
2. Install the fasteners that attach the torsion bars to the pivot-end clamps/hood hinges; see **Fig. 3**.
3. Close and latch the hood.
4. Install the grille; see **Subject 110**.
5. Remove the chocks.

Coronado

Removal

1. With the vehicle parked, apply the parking brakes and chock the tires.
2. Remove the grille; see **Subject 110**.
3. Tilt the hood completely open.
4. On one side of the vehicle, remove the fasteners that hold the inboard end of the torsion bar, the bearing block, and the pivot end to the hood pivot assembly; see **Fig. 4**.

Hood Torsion Bar Tilt-Assist Mechanism Removal and Installation



1. Torsion Bar
2. Pivot Bracket
3. Mounting Bolt

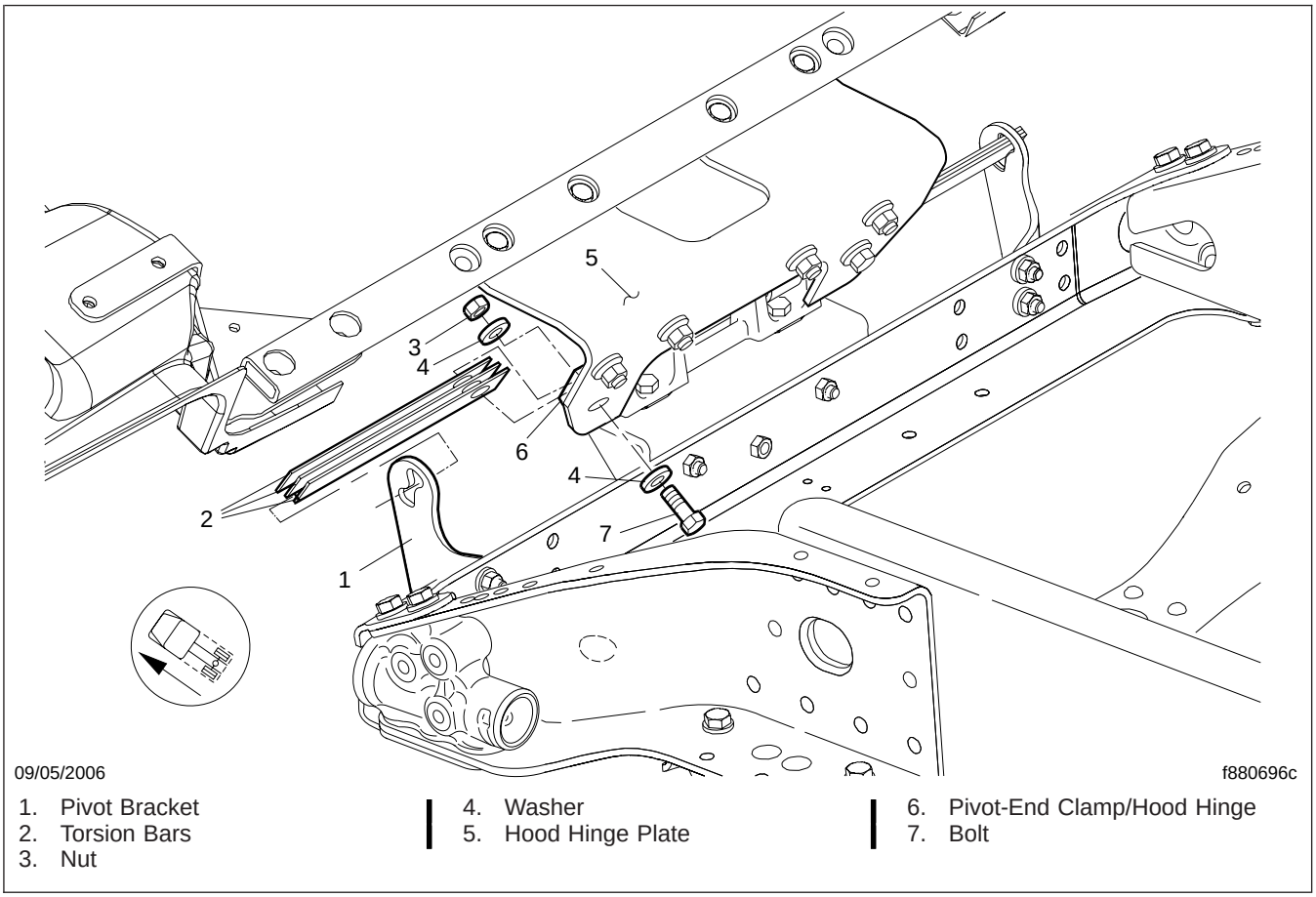
Fig. 2, Hood Tilt-Assist Assembly (Century Class Conventional Built From September 2000, with an Engine Manufactured Through December 31, 2006)

5. Repeat the procedure on the other side of the vehicle.
6. On one side of the vehicle, remove the fasteners that hold the outboard end of the torsion bar to the actuator.
7. Repeat the procedure on the other side of the vehicle.
8. Remove the torsion bars.
9. If replacing the pivot ends, remove the shoulder bolts that hold them in place.

Installation

1. With the tires chocked and the hood open, install the pivot ends (if they were removed). Tighten the 3/8–16 nut on the shoulder bolt 28 lbf·ft (38 N·m).
2. Attach the outboard ends of the torsion bars to the actuators.
3. Open the hood to the full-tilt position.
4. On one side of the vehicle, attach the inboard end of the torsion bar and the bearing block to the hood-pivot assembly. Tighten the fasteners 91 lbf·ft (123 N·m). Repeat on the other side of the vehicle.
5. Close and latch the hood.
6. Install the grille; see **Subject 110**.
7. Remove the chocks.

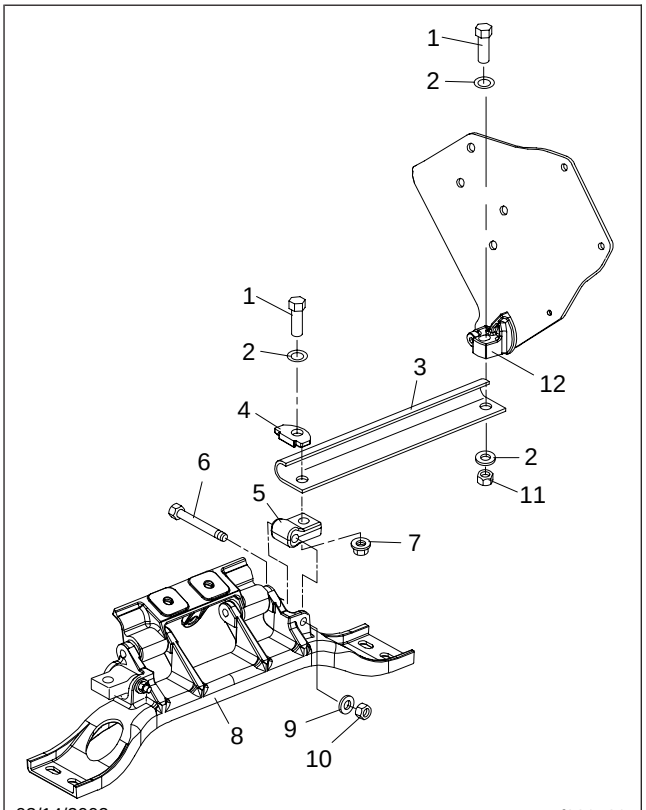
Hood Torsion Bar Tilt-Assist Mechanism Removal and Installation



1. Pivot Bracket
2. Torsion Bars
3. Nut
4. Washer
5. Hood Hinge Plate
6. Pivot-End Clamp/Hood Hinge
7. Bolt

Fig. 3, Hood Tilt-Assist Assembly (Century Class Conventional with an EPA07 Compliant Engine)

Hood Torsion Bar Tilt-Assist Mechanism Removal and Installation



1. Hexbolt, 1/2–13
2. Flatwasher
3. Torsion Bar
4. Bearing Block
5. Torsion-Bar Pivot End
6. Shoulder Bolt
7. Flanged Hexnut, 1/2–13
8. Hood Pivot Assembly
9. Hardened Washer
10. Hexnut, 3/8–16
11. Hexnut, 1/2–13
12. Torsion-Bar Actuator

Fig. 4, Tilt-Assist Torsion Bar Mechanism (Coronado)

Hood Repair Safety Precautions

Precautions

Before performing any fiberglass repairs, read the following precautions. Observe any additional precautions given by the manufacturers of the repair materials used.

1. All of the raw materials used in repairing fiberglass are harmful to the eyes and could cause blindness. Wear goggles or other protective eye shields to reduce the chances of splash contacting your eyes.
2. Wear protective gloves, as some people may have skin sensitivity to resin. Also, don't allow the hardener to contact your skin. The hardener can be a skin irritant.

IMPORTANT: In case the hardener or resin contacts your skin, wash with soap and water. If the hardener or resin should contact your eyes, rinse with plenty of water (15 minutes), and call a doctor.

3. When working with fiberglass materials, wear old clothing, since the resin may damage garment material. Wash the clothing before wearing again.
4. Most of the liquids involved in fiberglass repair and cleanup (especially when using acetone as a solvent) are flammable; some are also toxic. Don't perform repairs in areas where exposed (or stored) flammable liquids may contact an open flame or any burning material, such as a cigarette. Don't perform repairs in areas that are not well-ventilated.

⚠ WARNING

WARNING: Do fiberglass repairs in a safe workshop area to prevent severe personal injury due to explosion of flammable liquids or breathing of toxic fumes.

5. Do not use electric tools when the fumes of flammable solvents are present. The heat or sparks generated by the tools could create a fire hazard.
6. When grinding or sanding fiberglass surfaces, wear goggles or other protective eye shields, and also an air purifying respirator, either a throwaway type or one with a replaceable particulate filter(s). Don't breath grinding dust or particles, otherwise irritation may occur. Also, during grinding and sanding operations, wear a disposable (paper) shop coat to keep dust and fiber slivers off your clothing.
7. Because fiberglass dust can shorten the life of electrical units, air-powered tools are preferred (for frequent use).
8. Unless fiberglass repairs are done on a regular (daily) basis, don't save leftover liquids. If liquids must be saved, store them in cool, dark areas, away from direct sunlight.

General Information

If a joint between two parts has separated and there is no damage at the joint area, the parts can be rebonded. Or, if a part is damaged and the adjoining parts are not damaged, the damaged part can be separated from the hood and new or used parts can be bonded in place. A section of a part can be replaced as long as the section does not include a joint between two parts. Fenders and headlight reinforcements are available as replacement parts or for use in section replacements. If the damage is such that the parts cannot be replaced, or a section replacement cannot be done, replace the entire hood assembly.

For minor surface cracks (cracks that do not go through the laminate) see *Surface Damage Repair*.

For cracks that go through the laminate, or large damaged areas, see *Structural Damage Repair*.

For section replacement or to rebond parts see *Hood Component Rebonding*.

Before performing any fiberglass repairs, read the precautions listed in **Subject 130**. Observe any additional precautions given by the manufacturers of the repair materials used.

Surface Damage Repair

Surface damage refers to scratches, chips, or nicks on the outer surface of the hood. Use the following instructions to repair surface damage:

1. Inspect the damaged area. If the cracks go all the way through the hood see *Structural Damage Repair* for instructions.
2. Clean the area with 3M™ General Purpose Adhesive Cleaner. Inspect the area closely.
3. Using 220-grit or finer sandpaper, remove all of the paint around the damaged area to a distance of about 1-1/2 inches (4 cm).
4. Clean the area with dry compressed shop air.
5. Apply 3M Automix 08275 (400 ml syringe) or 08266 (600 ml syringe) adhesive and spread a thin layer using a squeegee applicator. Cover the entire damaged area, overlapping onto the painted surface. Leave a crowned excess of adhesive, slightly higher than the painted surface.

NOTE: When dispensing 3M Automix two-part adhesives, the first few inches to come from the cartridge will be discolored; discard this adhesive. Continue to dispense the adhesive, producing a continuous bead of uniform size and uniform color.

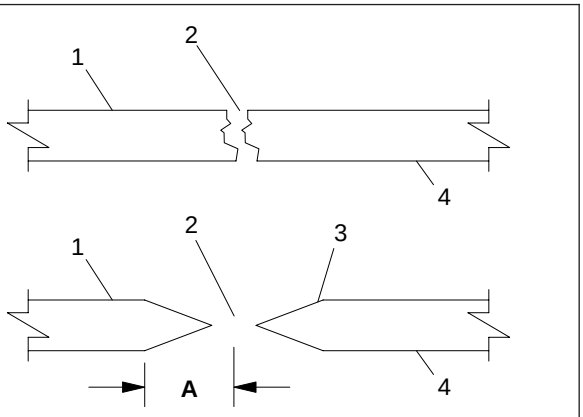
6. After the adhesive dries (about 35 minutes), sand it with a hand-held disc pad. Use 320-grit or finer sandpaper. Feather the edges of the fill so there are no visible sharp edges.
7. Clean the area with dry compressed shop air. Mask the area, then spot prime and paint it. Primer can be applied immediately after sanding.

Structural Damage Repair

Structural damage refers to any type of damage, from hairline cracks to large fractures or punctures that penetrate through the laminate and affect the structural soundness of the damaged part. For large damaged areas it may be easier to replace the panel. In such cases see *Hood Component Rebonding*.

1. If a sound-absorbent liner is present on the underside of the damaged area, remove the panel(s) to provide an adequate working area.
2. Clean both sides of the damaged area with 3M General Purpose Adhesive Cleaner. Inspect the area closely; all dirt, water, grease, and oils must be removed.
3. Inspect the area to determine the extent of the damage by pushing on the surfaces immediately surrounding and underneath the damaged area. All ragged edges, cracks, and unsound fragments will need to be removed. Using a marking pen, mark a circle on both sides of the hood, 3 to 4 inches around the damaged area.
4. Using a grinder on both sides of the hood, grind through the hood at the point of damage, and taper out to the marked circle. In some cases it will be necessary to greatly enlarge the hole in order to grind back to sound material. See **Fig. 1**.
5. Using dry compressed shop air, blow off the area and inspect for any remaining cracks. If cracks still exist, grind the area tapering out towards sound material.

Repair of SMC Hoods



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A. Grind a recess one-half the depth of the laminate and extending 3 to 4 inches outward in all directions from the damaged area.

1. Laminate
2. Crack
3. Taper
4. Engine Side of Hood

Fig. 1, Tapered Hole

6. Sand the surface of the tapered area around the hole, using a DA sander with 80-grit or less sandpaper, to even out the tapers and leave a rough bonding surface.
7. Clean the sanded areas using dry compressed shop air and wipe the area with a clean cloth.
8. Cut a series of patches for the underside of the hood out of fiberglass mat. The first patch should be about 2-inches larger than the hole, but still able to fit in the sanded area. Cut additional sections from the mat, cutting each section progressively smaller.
9. On the outside of the hood, tape over the damaged area using aluminum panel repair tape.
10. Apply 3M Automix 08277 adhesive to the underside of the area to be repaired.

NOTE: When dispensing 3M Automix 08277 adhesive, the first few inches to come from the cartridge will be discolored. Discard this adhesive. Continue to dispense the adhesive until a continuous bead of uniform size and color is produced.

11. Use a plastic squeegee applicator to spread a thin layer of the 3M Automix 08277 adhesive over the damaged area.
12. Lay the largest piece of fiberglass matting on a piece of clean cardboard and work a generous amount of 3M Automix 08277 adhesive into the matting. On the underside of the hood, center the matting over the repair area, and apply the adhesive-embedded matting over the work area, working out any air bubbles.
13. Apply adhesive to the next smaller section of fiberglass matting using the same technique as the larger piece.
14. Apply the next smaller section of fiberglass matting to the larger piece, again working out any air bubbles.
15. Add a final thin layer of adhesive to the embedded sections of matting until the damaged area is even with the surrounding surfaces. The adhesive should be hard enough in 50 minutes to allow sanding.
16. Remove the tape backing from the outside surface.
17. Re-wipe the outside surface of the repair area with 3M General Purpose Adhesive Cleaner.
18. Using a DA sander with 80-grit sandpaper, sand the adhesive on the outside of the hood.
19. Clean the sanded area using dry compressed air, and wipe with a clean cloth.
20. Use a plastic squeegee applicator to spread a thin layer of the adhesive over the scuffed area.
21. Add a generous amount of 3M Automix 08275 adhesive over the entire repair area, building it up slightly above the level of the hood panel surface.
22. Allow the hood to dry for 30 minutes before sanding.
23. After the adhesive dries, sand the repaired area to a smooth flat surface. Prime and paint the surfaces on both sides of the hood.

Hood Component Rebonding

1. If rebonding a joint that has separated, or if replacing a damaged part, completely separate each part, using a heat gun and putty knife. Remove all of the old adhesive. The heat gun will soften the adhesive and allow it to be peeled from the fiberglass.

2. Clean the surfaces to be bonded with 3M General Purpose Adhesive Cleaner. Inspect the area closely to be sure all of the old adhesive, dirt, water, grease, and oils are removed.
3. Scuff the surfaces with 80- to 220-grit sandpaper.
4. Before applying adhesive, test fit the parts by clamping the replacement part in position. Remove the replacement part for application of the adhesive.
5. Select a 3M Automix adhesive based on the desired working time, and apply the adhesive to the areas to be bonded. See **Table 1** for open times.

NOTE: Open time is affected by temperature only. The open time is cut in half for every 20°F over 72°F (6°C over 22°C). The time doubles for every 20°F below 72°F (6°C below 22°C). The adhesive is not recommended for use when the temperature is less than 62°F (16°C).

6. Clamp the parts together and remove any excess adhesive that squeezes out.

NOTE: When clamping parts together there should be a gap between parts for the adhesive to bond properly. The gap should be about the spacing of a paper clip. If necessary, cut a paper clip in half and place the paper clip sections at two places along the bond seam to act as spacers.

7. Let the adhesive dry for 5 times the specified open time. For example, if using 3M Automix 08277 adhesive: open time X 5 = drying time; so 10 minutes open time is 50 minutes drying time.

3M™ Part Number	Syringe Size	Open Time	Use
08270	400 ml	1.5 min.	Minor crack repair and small part replacement
08271	400 ml	3.5 min.	Inner hood structure replacement
08267	600 ml	3.5 min.	Inner hood structure replacement
08277	400 ml	10.0 min.	Inside crack repair (self leveling)
08272	400 ml	10.0 min.	Fender replacement
08268	600 ml	10.0 min.	Fender replacement
08273	400 ml	35.0 min.	Large part replacement
08269	600 ml	35.0 min.	Large part replacement
08275	400 ml	10.0 min.	Permanent adhesive (not for removable sections)

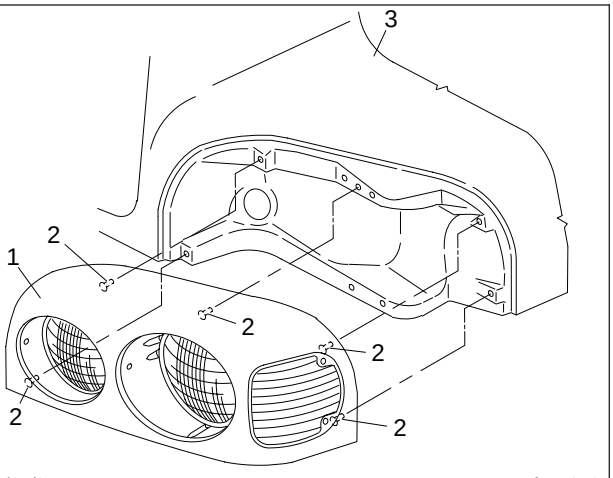
Table 1, Adhesive Open Times

Headlight Bucket Assembly Removal and Installation

NOTE: This procedure applies only to the Century Class Conventionals.

Removal

1. Tilt the hood fully open.
2. Disconnect the headlight wiring connectors from the hood.
3. Remove the five screws and nuts that attach the headlight bucket assembly to the hood. See **Fig. 1**.



1. Headlight Bucket Assembly
2. Screw
3. Hood

Fig. 1, Headlight Bucket Assembly-to-Hood Attachment

4. Remove the headlight bucket assembly from the hood.

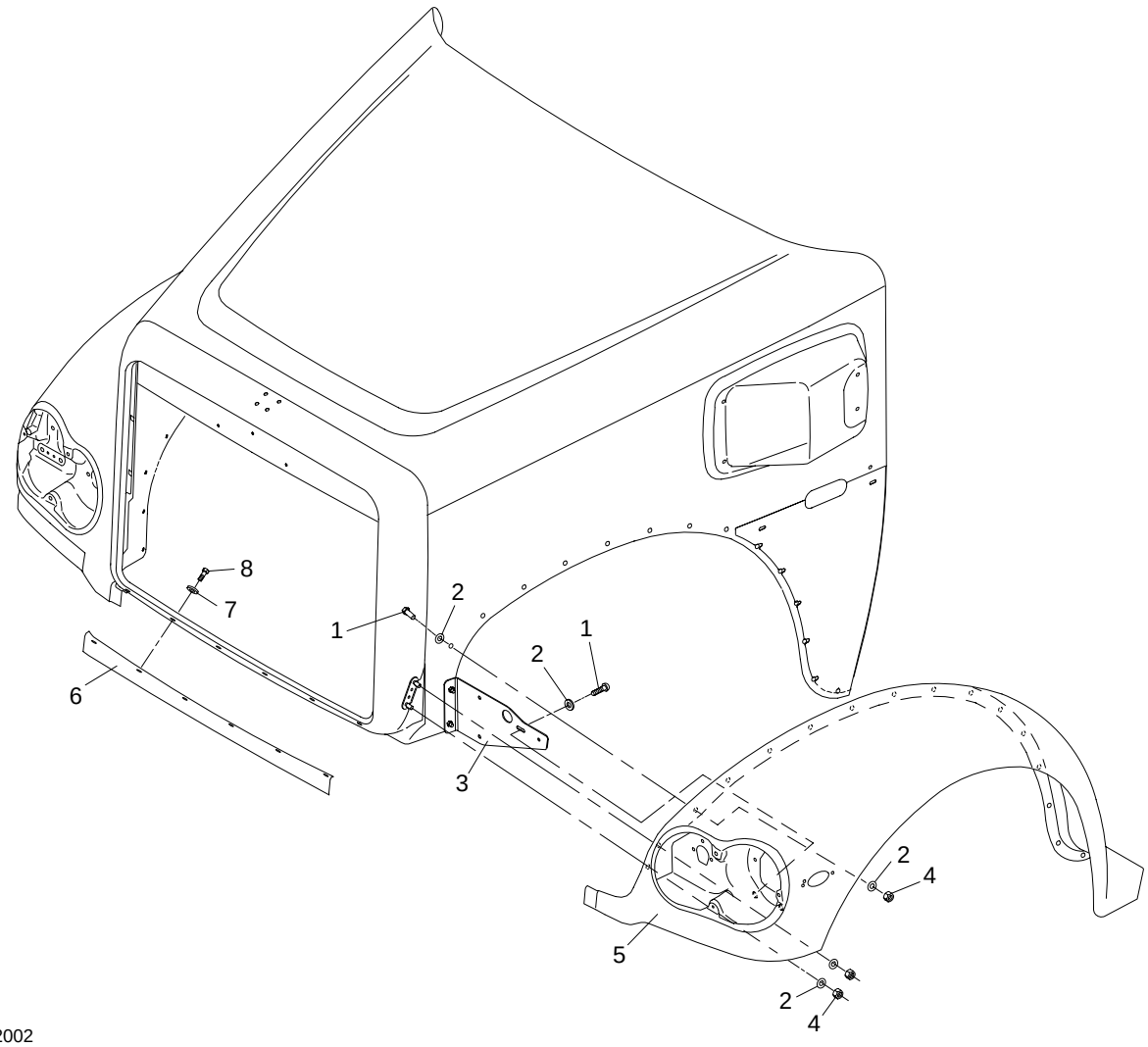
Installation

1. Install the headlight bucket assembly on the hood.
2. Tighten the five screws and nuts until snug.
3. Connect the headlight wiring connectors.
4. Return the hood to the operating position.

Coronado Fender Replacement

Replacement

NOTE: See **Fig. 1** for this procedure.



1. Torx-Head Screw
2. Washer
3. Headlight Support Bracket
4. Hexnut
5. Fender
6. Bottom Panel
7. Flatwasher
8. Hexbolt

Fig. 1, Fender Installation, Coronado

1. Park the vehicle on a level surface, shut down the engine, set the parking brake, and chock the tires.
2. Remove the grille. For instructions, see **Subject 110**.
3. Tilt the hood.
4. Remove the extreme outboard bottom fastener for the grille surround. This also holds the bottom inboard fender tab in place.
5. Remove the headlight bezel.
6. Disconnect the headlight and turn-signal wiring.

Coronado Fender Replacement

7. Remove the rubber splash shield from the back of the headlight assembly.
8. Remove the headlight and turn-signal assemblies from the fender.
9. Remove all the fasteners holding the fender to the hood, except for the nuts on the two studs at the inboard edge of the headlight assembly recess and those holding the fender to the headlight support bracket.

IMPORTANT: The hexbolts are different lengths. Mark the location of the longer hexbolts before removing them. They are used to attach the wiring brackets to the hood.

10. Close the hood.
11. Remove the nuts and washers from the two studs at the inboard edge of the headlight assembly recess.
12. Remove the two outboard fasteners holding the fender to the headlight support bracket.
13. Remove the fender from the vehicle.
14. With the hood lowered, and using an assistant, put the fender in place. Make sure the inboard lower tab on the fender fits under the grille surround.
15. Install the one rear fender fastener, bolt head inboard.
16. Install the two hexnuts on the studs at the inboard side of the headlight recess. Tighten them firmly.
17. Tilt the hood and install the remaining fasteners.

    Install the fasteners, bolt heads outboard, in an alternate pattern, starting at the center and working your way outward on both sides. Make sure the longer fasteners are used for the wiring brackets.

    Tighten the fasteners 26 lbf·ft (35 N·m).
18. Install the headlight and turn signal assemblies, and connect the wiring.
19. Install the rubber splash shield onto the rear side of the headlight recess.
20. Install the two fasteners that attach the fender to the headlight support bracket.
21. Install the headlight bezel.
22. Install the grille. For instructions, see **Subject 110**.
23. Close the hood and secure the hood latches.
24. Remove the chocks from the tires.

Repair Tools, Materials (SMC Hood)

SURFACE DAMAGE

Required tools and materials:

- Xylene, acetone, or equivalent solvent
- 220 or finer grit sandpaper
- 320 or finer grit sandpaper
- Hand-held disc pad
- Self-leveling adhesive [1]
- Applicator squeegee
- Primer [2]

STRUCTURAL DAMAGE

Section Replacement (Punctures and Large Fractures)

Required tools and materials:

- Scrap SMC from a damaged hood
- Xylene, acetone, or equivalent solvent
- Saber saw
- Router bit
- Razor-blade knife
- Woven fiberglass cloth
- Clamps
- 80 to 220 grit sandpaper
- 220 or finer grit sandpaper
- 320 or finer grit sandpaper
- Hand-held disc pad
- Adhesive for bonding strips (if needed) [3]
- Self-leveling adhesive [1]
- Applicator squeegee
- Primer [2]

Crack or Small Hole

Required tools and materials:

- Xylene, acetone, or equivalent solvent
- 1/8-inch diameter drill bit
- Router bit
- Razor-blade knife
- Woven fiberglass cloth
- 80 to 220 grit sandpaper
- 220 or finer grit sandpaper
- 320 or finer grit sandpaper
- Hand-held disc pad
- Self-leveling adhesive [1]
- Applicator squeegee
- Primer [2]

HOOD COMPONENT REBONDING

Required tools and materials:

- Solvent [4]
- 80 to 220 grit sandpaper
- Clamps, clamping bolts with washers
- 0.030" (0.76 mm) diameter glass beads
- Adhesive [3]
- Primer [2]
- Heat gun
- Putty knife, hacksaw blade

[1] Use Ashland Pliogrip 7775L self-leveling urethane adhesive. 7775L has no sag resistance and, therefore, is useful for filling cracks and channels, and for bonding glass-fiber reinforcing fabrics. Ashland products are available through Freightliner dealers. See **Table 2** and **Table 3**.

[2] Use Sherwin Williams BB–11 black conductive primer. Contact your local Sherwin Williams automotive paint distributor to purchase this primer.

[3] Ashland Pliogrip 7773 or 7779 adhesives are recommended for this application, but 7771 and 7770 may be substituted. A heat gun may be used to speed curing times. Ashland products are available through Freightliner dealers. See **Table 2**.

[4] Use Ashland 6036 primer or methylene chloride. Contact Ashland Merchandising Group, telephone (419) 289–9588, to purchase this primer.

Specifications

Torque Values				
Description	**Size**	**Grade**	**Torque lbf·ft (N·m)**	**Torque lbf·in (N·cm)**
Hood Shoulder Bolt Locknuts	3/8–16	C	28 (38)	—
Rear Hood-Mount Locator Bolt Nuts	3/8–16	B	28 (38)	—
Hood Hinge Bracket Locknuts and Bolts	1/2–13	8	68 (92)	—
Rear Hood Bracket Bolts	5/16–18	B	16 (22)	—
Grille Mounting Nuts	1/4–20	—	—	48 (600)
Torsion Bar Center Bracket Mounting Nuts	1/2–13	8	68 (92)	—

Table 1, Torque Values

NOTE: Ashland Pliogrip 7700 and 8000 Series adhesives and accessories are available through Freightliner dealers and PDCs. The 7700 Series adhesives are two-part urethane adhesives, specially formulated and packaged for repair of hoods and other fiber-reinforced plastics. Adhesive 7775L is a self-leveling mixture that is appropriate when a surface filler or glass fabric reinforcement repair is required. The 8000 Series adhesives are also two-part urethane adhesives, available for those who prefer to use these earlier-generation adhesives. Descriptions, working times, and curing times (sanding and repainting) for the various adhesives are shown below in **Table 2** and **Table 4**.

Ashland adhesive accessories are listed in **Table 3** and **Table 5**.

NOTE: All of the adhesives develop the same bonding strength; specific adhesives may be preferred to change working times.

NOTE: All working and curing times correspond to an ambient temperature of 73°F (23°C) in the workplace; humidity level will NOT affect working or curing times.

IMPORTANT: While a heat gun may be used to speed adhesive curing time, do not overheat the adhesive. The maximum allowable temperature is 180°F (82°C).

Working and Curing Times for 7700 Series Adhesives				
Description	**Part Number**	**Working Time in Minutes**	**Curing Time in Minutes**	**Curing Time in Hours**
Adhesive, two 1.7 oz (50 ml) cartridges, 3.4 oz (100 ml)	ACA 7771	1.5	10.0	—
Adhesive, two 1.7 oz (50 ml) cartridges, 3.4 oz (100 ml)	ACA 7773	3.5	30.0	—
Adhesive, two 10 oz (300 ml) cartridges, 20 oz (600 ml)	ACA 7773 300	3.5	30.0	—
Adhesive, two 1.7 oz (50 ml) cartridges, 3.4 oz (100 ml)	ACA 7775L	5.0	50.0	—
Adhesive, two 1.7 oz (50 ml) cartridges, 3.4 oz (100 ml)	ACA 7779	10.0	—	1.0
Adhesive, two 10 oz (300 ml) cartridges, 20 oz (600 ml)	ACA 7779 300	10.0	—	1.0
Adhesive, two 1.7 oz (50 ml) cartridges, 3.4 oz (100 ml)	ACA 7770	35.0	—	2.5 – 3.0
Adhesive, two 10 oz (300 ml) cartridges, 20 oz (600 ml)	ACA 7770 300	35.0	—	2.5 – 3.0

Table 2, Working and Curing Times for 7700 Series Adhesives

Specifications

7700 Series Accessories	
Description	**Part Number**
Manual Applicator Gun for 10 oz (300 ml) Cartridges	ACA TS526C
1/4" Mixing Nozzles for 1.7 oz (50 ml) Cartridges (100/box) *	ACA 583 238
Pneumatic Applicator Gun for 10 oz (300 ml) Cartridges	ACA TS525
3/8" Mixing Nozzles for 10 oz (300 ml) Cartridges (100/box) *	ACA F 771072

* These are additional mixing nozzles. Each adhesive cartridge comes with two mixing nozzles.

Table 3, 7700 Series Accessories

Working and Curing Times for 8000 Series Adhesives				
Description	**Part Number**	**Working Time in Minutes**	**Curing Time in Minutes**	**Curing Time in Hours**
Adhesive, Supermix 4:1, 12 oz (355 ml)	ACA 8104	4	30	—
Adhesive, Supermix 4:1, 12 oz (355 ml)	ACA 8110	10	—	1
Adhesive, Supermix 4:1, 12 oz (355 ml)	ACA 8145	50	—	5 – 8

Table 4, Working and Curing Times for 8000 Series Adhesives

8000 Series Accessories	
Description	**Part Number**
Pneumatic Applicator Gun for 12 oz (355 ml) Cartridges	ACA 582 2241
3/8" Mixing Nozzles for 8000 Series Cartridges (100/box) *	ACA F 771072

* These are additional mixing nozzles. Each adhesive cartridge comes with two mixing nozzles.

Table 5, 8000 Series Accessories

General Description

The Twinflow midship-mounted fire pump is a centrifugal pumping system designed to deliver large volumes of water under pressure. See **Fig. 1**.

Generally, the pump consists of the following major components:

- cast-iron pump body
- bronze impeller(s) and a stainless steel shaft
- pump gear box
- priming system
- pressure control device
- valves

There are numerous other components, such as the AutoLube and the mechanical seal.

Pump type is determined by the number of impellers on a common shaft. The impeller, which is mounted on a shaft rotated by the vehicle's engine via the driveline, provides velocity to the water causing it to build enough pressure and volume to be used for firefighting applications. See **Fig. 2**.

Bearings support and align the impeller shaft and other components. The bearings must be maintained on a scheduled basis.

The pump body is split horizontally in two sections for the ease of removal of the impeller assembly, including the bearings and the clearance rings.

The pump gear box and the impeller assembly are removable from the bottom of the vehicle in order to avoid interference with the pump plumbing and control mechanisms.

The pump has two large suction inlets, one on each side of the vehicle, though other inlets may be present. The inlets and the internal pump outlets are on opposite sides of the pump to balance forces caused by the intake and the discharge of water.

The AutoLube is built into the pump assembly to continuously force oil to the impeller shaft bushing to lubricate and cool the impeller bushing.

Principles of Operation

A centrifugal pump such as the Twinflow fire pump operates on the principle wherein centrifugal force is created by a rapidly spinning disk, or impeller. Water is routed to the center of the impeller, which throws the water outward from the center of the impeller. When water is confined in a closed container, in this instance, the pump body, the water pressure increases. The pressure level depends on how fast the impeller is rotating.

Water enters the spinning impeller at the intake and is confined by shrouds and vanes in the impeller, which, in turn, builds pressure.

The vanes guide the water away from the inlet to the discharge to reduce the water's turbulence and to move the water toward the outer edge of the impeller.

The shrouds serve as the sides of the impeller and confine the water to the centrifugal acceleration.

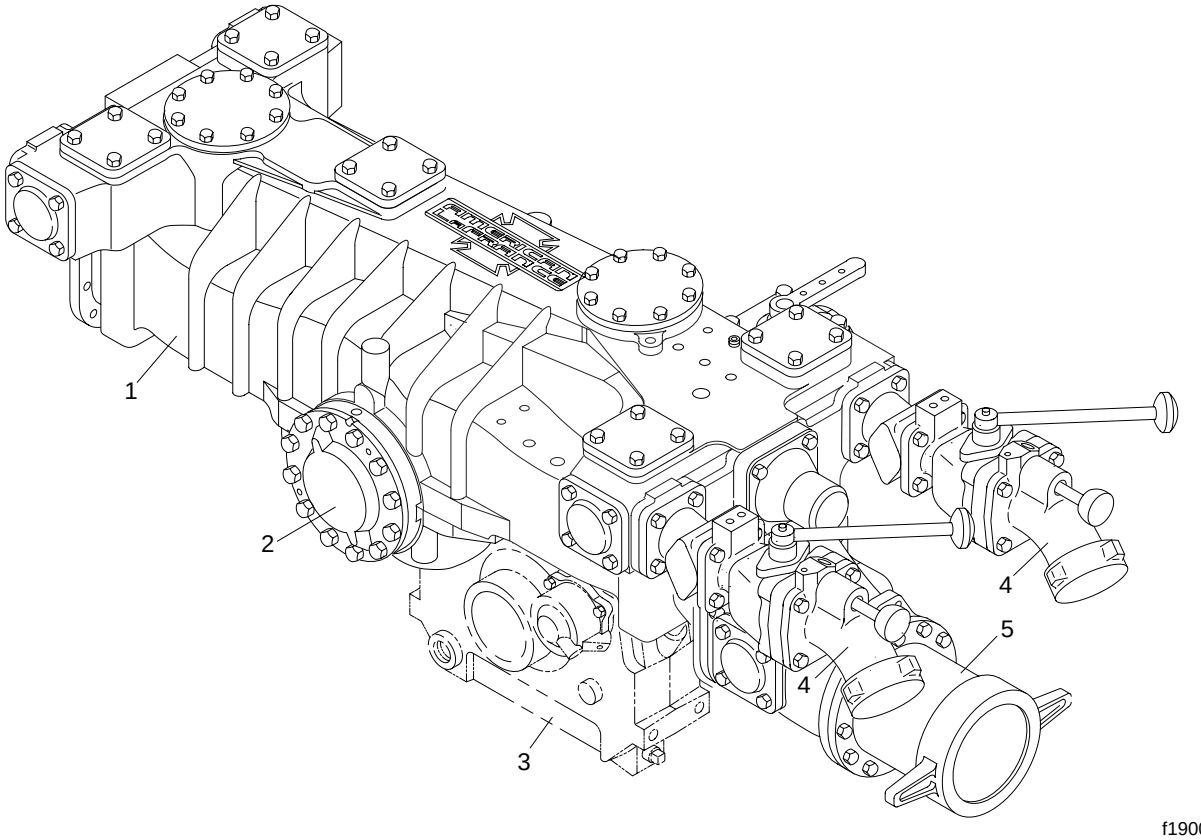
Single-stage pumps provide the same operating and rating-test pressures as a two-stage pump, but the two-stage pump offers additional operating (water) pressure.

The primary difference between a single-stage and a two-stage pump is that the single-stage has only one impeller and no transfer valve to switch between volume and pressure operation. A transfer valve is a two-position valve that permits the impellers in a two-stage pump to operate in parallel (volume) or series (pressure).

In two-stage pumps, the volume operation results in the pressure at the pump intake being added to the equal pressure developed by the impellers, and the amount of water sent to the discharge being the sum of the flows of the two impellers. The pressure operation features the impellers operating in series, or the output of the primary impeller supplied from the pump intake is supplied to the input of the secondary impeller. Thus, the pressure at the pump discharge is the sum of the pressures of the two impellers plus the pressure at the intake. The flow is then half of the volume operation.

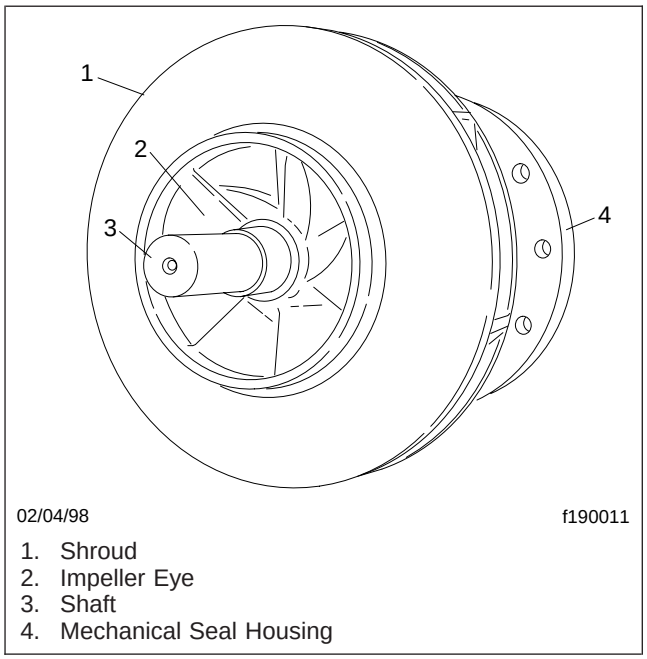
In both types of pumps, the pressurized water is prevented from returning to the intake of the impeller(s) by clearance rings. Centrifugal pumps have clearance rings mounted between the spinning impeller and the pump body. Clearance rings and the hubs of the impeller(s) will, over time, become worn or pitted and may need to be replaced or machined to a smaller diameter.

General Information



1. Pump Body
2. AutoLube
3. Gear Box
4. Discharge
5. Intake

Fig. 1, Twinflow Fire Pump (single-stage shown)



1. Shroud
2. Impeller Eye
3. Shaft
4. Mechanical Seal Housing

Fig. 2, Twinflow Fire Pump Gear Box

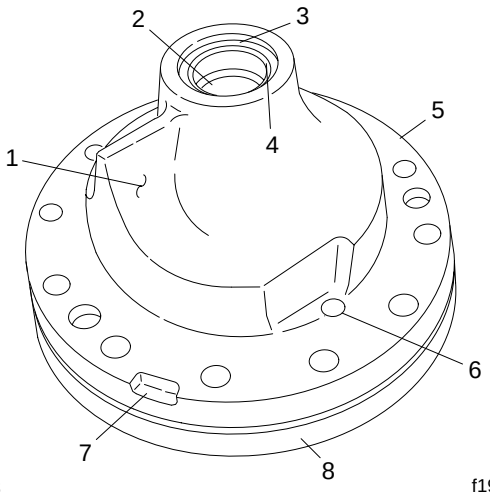
Replacement

1. Park the vehicle on a level surface. Shut down the engine. Set the parking brake and chock the front and rear tires.
2. Drain the water from the pump.
3. Remove the fill and drain plugs from the AutoLube reservoir and drain the oil.
4. Use a center punch to mark the AutoLube cover and the front bearing housing for proper alignment during assembly.

⚠ CAUTION

Do not use a chisel to separate the AutoLube from the pump body because the mating surfaces may be scratched or gouged, which could result in a leak. The AutoLube is manufactured from cast metal and if it becomes necessary to pry the AutoLube apart from the pump body, pry between the AutoLube and the pump body or at the AutoLube notches.

5. Remove the 1/2–13 x 2 capscrews attaching the AutoLube to the pump body and gently pry the AutoLube from the pump body and impeller shaft.
6. Place the AutoLube face down on a work bench and remove the two 3/8–16 x 3/4 allen-head capscrews from the impeller side. Separate the two halves and remove the diaphragm.
7. Remove the seal lock ring.
8. Remove the oil seal from the inner half of the AutoLube.
9. Check the impeller shaft bushing for wear.
10. Clean the inner and outer halves of the AutoLube.
11. Clean the gasket surfaces of the AutoLube and the pump body.
12. Check for restrictions in the water passages to the rear half of the AutoLube.
13. If it is necessary to replace the impeller shaft bushing, press the bushing from the inner side of the inner half of the AutoLube (on the side opposite of the impeller). Install the bushing from the impeller side of the inner half of the AutoLube. See **Fig. 1**.



1. Cut Water
2. Bushing
3. Lock Ring
4. Seal
5. Front Bearing Housing
6. Water Passage
7. Pry Notches
8. AutoLube Cover

Fig. 1, Impeller Shaft Bushing

⚠ CAUTION

The impeller shaft bushing seats against a shoulder in the inner half of the AutoLube and can only be removed and installed as described or the AutoLube may be damaged.

14. Install the new oil seal in the inner half of the AutoLube.
15. Install the seal lock ring.
16. Position the diaphragm on the inner half of the AutoLube.
17. Line up the marks and place the outer half of the AutoLube onto the inner half. Apply Loctite® 242 to the two 3/8–16 x 3/4 allen-head capscrews. Tighten 30 lbf·ft (41 N·m).
18. Install the new gasket on the AutoLube and position the assembly (with the top up) onto the impeller shaft. Attach the AutoLube with 1/2–13 x 2 capscrews and tighten 80 lbf·ft (108 N·m).

AutoLube Seal Replacement

CAUTION

Do not damage the oil seal. A damaged oil seal could result in damage to the AutoLube assembly as well as the pump.

19. To fill the AutoLube with 90w oil, pump the oil in from the bottom plug opening until the oil spills from the top opening. This eliminates air pockets and false readings.

CAUTION

Purge the air from the AutoLube while filling it with oil or a "false-fill" situation will develop, which could cause damage to the AutoLube and other components.

20. Add water to the pump.
21. Operate the fire pump and check the AutoLube for water or oil leaks.
22. Remove the tire chocks.

Fire Pump Gearbox Removal, Disassembly, Assembly, and Installation

Removal

1. Park the vehicle on a level surface. Shut down the engine. Set the parking brake and chock the front and rear tires.
2. Drain the water from the pump.
3. Drain the gearbox lubricant to prevent contamination.
4. Disconnect the pressure lubrication line to the gearbox cover. Keep the line primed with lubricant.
5. Disconnect the drive shafts from the gearbox.
6. Disconnect the electrical switches and the air lines. Mark the switches and air lines for assembly.
7. Disconnect the pump gearbox cooling lines.

⚠ WARNING

The gearbox is heavy. Support the gearbox with a lifting or supporting device while removing it from the pump body. Failure to do so could result in the gearbox falling, which could result in personal injury or property damage.

NOTE: Before removing the gearbox, use a center punch to mark the rear bearing housing, the mechanical seal housing, the oil pump cover, and the pump body to ensure proper alignment during reassembly.

8. Support the gearbox with an appropriate device.
9. Remove the six 1/2–13 x 1-3/4 capscrews that attach the gearbox cover to the top of the gearbox.
10. Remove the 7/16–14 x 1-1/4 capscrews that attach the gearbox to the rear bearing housing.
11. Lower the gearbox. Be sure to balance the gearbox so that it does not tip from the lowering device. See **Fig. 1**.
12. Remove the gearbox cover.

NOTE: The threaded holes may need to be cleaned.

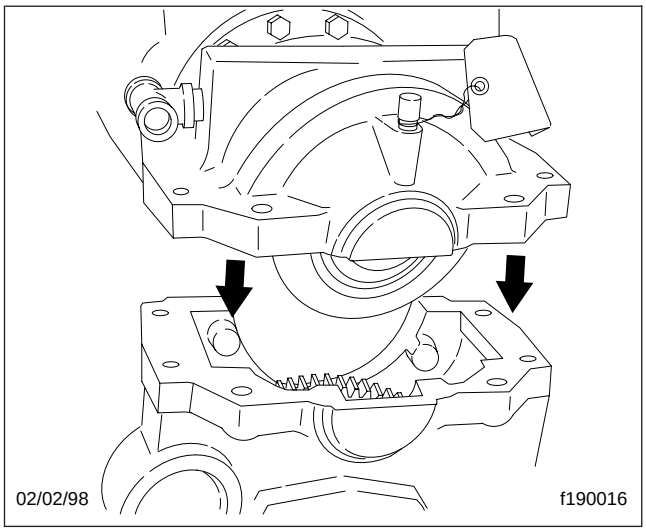


Fig. 1, Lowering the Fire Pump Gearbox

Disassembly

1. Remove and disassemble the intermediate shaft assembly.
   - 1.1 Disconnect the oil suction line from the lubrication pump.
   - 1.2 Remove the capscrews attaching the front bearing housing to the lubrication pump. Then remove the housing and pump assembly.

   NOTE: The rear bearing housing has threaded holes for 1/4–20 jackscrews to assist in removal.

   - 1.3 Remove the capscrews attaching the rear bearing housing to the lubrication pump.
   - 1.4 Reach into the top of the gearbox housing and remove the intermediate gear and shaft assembly. The bearing inner cups are pressed onto the shaft, so care must be taken not to damage the cups during removal.
   - 1.5 Using a bearing splitter, clamp the halves of the splitter onto the back edge of the intermediate shaft bearing cup. Attach a crossbar puller to the bearing splitter halves and remove the cup. Care must be taken when removing the cup not to damage the lubrication pump spline in the cen-

Fire Pump Gearbox Removal, Disassembly, Assembly, and Installation

ter of the intermediate shaft. Repeat the procedure for the opposite side bearing cup.

1.6 Using a gear puller with reversed jaws, remove the intermediate shaft bearing cone from the intermediate shaft rear cover.

⚠ CAUTION

Lubrication pump impeller vanes are fragile and may break or chip. Impeller vanes are installed only one way. If removal of the vanes is necessary, note the installation direction of the vanes (rounded edge). Failure to install the vanes properly will result in pump gearbox failure.

1.7 When disassembling the lubrication pump, be sure to note the number of gaskets and shims that are under the cover. Set these components aside for reassembly.

1.8 Using a centerpunch, mark the lubrication pump position and remove the six 1/4–20 x 5/8 capscrews.

1.9 Remove the lubrication pump cover.

1.10 Remove the lubrication pump impeller and the shaft, being careful not to damage the impeller vanes.

1.11 Using a gear puller with reversed jaws, remove the intermediate shaft bearing cone from the intermediate shaft front cover. Care must be taken when removing the cup so as not to damage the lubrication pump spline in the center of the intermediate shaft cover.

2. Remove and disassemble the output shaft assembly.

2.1 Remove the manual shift eye from the rear of the shift yoke shaft.

2.2 Remove the detent allen-head screw, spring and detent ball from the top of the output shaft housing.

2.3 Remove the shift and interlock switches on the output shaft housing.

2.4 Remove the 7/16–14 x 2-1/4 capscrews retaining the output shaft and the housing to the gearbox housing. Carefully remove the output shaft housing by sliding the housing from the shift yoke shaft.

2.5 Remove the input shaft pilot bearing from the output shaft.

2.6 Remove the 3/4–10 x 1-1/2 capscrew retaining the rear driveline yoke to the output shaft and remove the yoke.

2.7 Remove the output shaft seal.

2.8 Remove the output shaft by sliding it from the output shaft housing from the rear to the front. Use caution when sliding the output shaft through the bearing cones and spacer(s).

⚠ CAUTION

Bearing cups, cones, and spacers are factory preset for end play and are only provided as a matched set. It is important that bearing cups, bearing cones, and spacers, when removed, be kept together in matched sets. Input and output shaft bearing and spacer sets are different. Failure to keep matched sets together or to not use factory preset and matched bearing and spacer sets will void warranty and may result in gearbox failure.

2.9 Remove the inner and outer bearing cones.

2.10 Using a brass drift, carefully drive out the outer bearing cup from the inside out. Remove the internal retaining ring and then the spacer(s).

2.11 Using a brass drift, carefully drive out the inner bearing cup from the outside in.

2.12 Remove the shaft seal from the output shaft housing.

3. Remove and disassemble the input shaft assembly.

3.1 Remove the three 5/16–18 x 1 capscrews from the shift cylinder and carefully slide the shift cylinder from the piston.

3.2 Remove the nut and then remove the piston from the shift shaft. Remove the seal ring from the piston.

Fire Pump Gearbox Removal, Disassembly, Assembly, and Installation

⚠ CAUTION

Do not remove the piston from the shift yoke shaft unless it is damaged and replacement is mandatory. When installing a new piston, replace the locknut and tighten snugly, but do not overtighten as the nut can become distorted, which can cause shift failures.

3.3 Remove the shift shaft, the shift fork, and the shift ring assembly from the gearbox. Make sure the shift ring does not get dropped or damaged.

3.4 Note the location and orientation of the shift fork on the shaft, then remove the 3/8–16 x 1-1/4 screw from the shift fork and remove the fork from the shift shaft.

3.5 Remove the shift shaft support block. Then remove the seal from the support block.

NOTE: One ear of the shift yoke is machined and will fit one way. Make a note of the location of the machined ear when removing the shift yoke.

3.6 Remove the 3/4–10 x 1-1/2 capscrew attaching the front driveline yoke to the input shaft. Remove the yoke.

3.7 Remove the input shaft by sliding the input shaft from the output shaft housing opening at the rear of the gearbox. Use caution when sliding the input shaft through the bearing cones, the thrustwasher, and the drive gear. Place wooden blocks to support the drive gear and to protect the windage tray, and force the shaft loose.

⚠ CAUTION

Bearing cups, cones, and spacers are factory preset for end play and are only provided as a matched set. It is important that bearing cups, bearing cones, and spacers, when removed, be kept together in matched sets. Input and output shaft bearing and spacer sets are different. Failure to keep matched sets together or to not use factory preset and matched bearing and spacer sets will void warranty and may result in gearbox failure.

There are two bearings of different widths supporting the drive gear on the input shaft. It is important that these bearings be installed in the drive gear in the proper location. Note the location of the bearings when removed. Failure to install the bearings properly can result in gearbox failure.

3.8 Reaching through the top of the gearbox housing, carefully remove the drive gear, the inner bearing cone, and thrustwasher. Remove the drive gear bearings.

3.9 Using a magnet, remove the positioning pins from the windage tray. Then remove the windage tray and the positioning springs.

3.10 Remove the input shaft seal.

3.11 Remove the outer bearing cone.

3.12 Using a brass drift, carefully drive out the outer bearing cup from the inside out. Remove the internal retaining ring and the spacer(s).

3.13 Using a brass drift, carefully drive out the inner bearing cup from the outside in.

4. Inspect the cooling tube for damage and leaks.
5. Remove the gearbox lubrication oil filter from the suction inlet on the gearbox housing.
6. Clean and inspect each component of the gearbox assembly. Inspect the bearing cups and the cones for wear, pitting, and damage. Inspect the gear tooth surfaces for wear damage and pitting. Inspect the shift shaft block for wear. Inspect the gasket surfaces for nicks and gouges. Replace all components that are worn, damaged, or pitted.

Assembly

1. Install a new transmission lubrication oil filter.
2. Assemble and install the input shaft assembly.

⚠ CAUTION

Bearing cups, cones, and spacers are factory preset for end play and are only provided as a matched set. It is important that bearing cups, bearing cones, and spacers, when removed, be

Fire Pump Gearbox Removal, Disassembly, Assembly, and Installation

kept together in matched sets. Input and output shaft bearing and spacer sets are different. Failure to keep matched sets together or to not use factory preset and matched bearing and spacer sets will void warranty and may result in transmission failure.

2.1 Using a brass drift or a bearing cup installation tool, install the inner bearing cup from the inside out. Then install the spacer(s) and insert the retaining ring.

2.2 Using a brass drift or a bearing cup installation tool, install the outer bearing cup from the outside in.

2.3 Coat the outer bearing cone with oil. Install the outer bearing cone.

2.4 Install the input shaft seal.

2.5 Install the windage tray positioning springs and windage tray. While holding the windage tray in place against the positioning springs, install the windage tray positioning pins.

⚠ CAUTION

There are two bearings of different widths supporting the drive gear on the input shaft. It is important that these bearings be installed in the drive gear in the proper location. The location of the bearings should have been noted when removed from the assembly. Make sure that the lubrication holes are aligned in the center of the larger bearing. Failure to install the bearings properly may result in transmission failure.

2.6 Coat the new drive bearings with oil and install in the drive gear.

2.7 Coat the inner bearing cone with oil and install. Then install the thrustwasher.

2.8 Reaching through the top of the transmission housing, install the drive gear into position against the thrustwasher, being careful not to dislodge the windage tray.

2.9 Slide the input shaft through the output shaft housing opening at the rear of the transmission through the drive gear, the thrustwasher, and the bearing cones and spacer(s).

2.10 Install the front driveline yoke on the input shaft, being careful to not damage the input shaft seal. Apply Loctite® 242 to the 3/4–10 x 1-1/2 yoke retaining capscrew. Then install the capscrew and washer and tighten 225 lbf·ft (305 N·m).

NOTE: Apply a coat of Loctite® to all screws prior to reassembly.

NOTE: One ear of the shift yoke is machined and it will only fit one way. Make sure the yoke is oriented on the shaft in the position noted during disassembly.

2.11 Make sure the shift fork is properly aligned (the machined side should be toward the threaded end of the shift shaft) and slide the new shift fork on the shift shaft. Align the shift fork with the groove in the shaft and secure the shift fork in place with a 3/8–16 x 1-1/4 screw. Tighten the screw 33 lbf·ft (45 N·m).

2.12 Install a new seal on the shift shaft support block. Install a new gasket on the shift shaft support block. Install the shift shaft support block and gasket in the gearbox using two 1/4–20 x 5/8 capscrews. Tighten the capscrews 96 lbf·in (1085 N·cm).

2.13 Place the shift ring into the shift fork grooves. While holding the shift ring in place, insert the shift shaft into the gearbox through the bushing. Make sure the teeth on the shift shaft ring line up with the teeth on the input shaft and gear.

2.14 Apply a light coating of grease to the new seal ring, then install the seal ring on the shift piston. Install the piston on the shift shaft end.

⚠ CAUTION

When installing the piston, use a new locknut and tighten snugly but do not overtighten. Overtightening the locknut may distort the piston and cause shift failures.

2.15 Secure the piston in place with a new locknut.

2.16 Apply a light coating of grease to the shift cylinder seal and install the seal in the groove on the shift cylinder.

2.17 Install the shift cylinder using three 5/16–18 x 1 screws. Tighten the screws 17 lbf·ft (23 N·m).

3. Assemble and install the output shaft assembly.

3.1 Install a new shift shaft seal in the output shaft housing.

⚠ CAUTION

Bearing cups, cones, and spacers are factory preset for end play and are only provided as a matched set. It is important that bearing cups, bearing cones, and spacers, when removed, be kept together in matched sets. Input and output shaft bearing and spacer sets are different. Failure to keep matched sets together or to not use factory preset and matched bearing and spacer sets will void warranty and may result in transmission failure.

3.2 Using a brass drift or a bearing cup installation tool, install the inner bearing cup from the inside out. Install the spacer(s). Then install the retaining ring.

3.3 Using a brass drift or a bearing cup installation tool, install the outer bearing cup from the outside in.

3.4 Coat the outer bearing cone with oil and then install it.

3.5 Install the output shaft seal.

3.6 Apply a coating of oil to the inner bearing cone and install.

3.7 Apply a coating of oil to the input shaft pilot bearing and then install the bearing into the output shaft.

3.8 Install the output shaft by sliding the shaft in through the output shaft housing from the front to the rear. Be careful when sliding the output shaft through the bearing cones and spacer(s).

3.9 Install the rear driveline yoke on the output shaft, taking care not to damage the output shaft seal. Apply Loctite® 242 to the 3/4–10 x 1-1/2 capscrew. Then install the capscrew and washer and tighten 225 lbf·ft (305 N·m).

3.10 Install a new gasket onto the output shaft housing.

3.11 Apply Loctite® 242 to the two 7/16–14 x 2-1/4 and the four 7/16–14 x 1-3/4 capscrews. Then install the output shaft and housing, sliding the housing onto the shift yoke shaft. Install and tighten the 2-1/4-inch capscrews 50 lbf·ft (68 N·m) and the 1-3/4-inch capscrews 53 lbf·ft (72 N·m).

3.12 Install the shift and interlock switches on the output shaft housing.

3.13 Apply Loctite® 242 to the detent allen-head screw and install the detent ball, spring, and allen-head screw.

3.14 Install the manual shift eye from the rear of the shift yoke shaft.

3.15 Rotate the input shaft to check for proper movement.

4. Assemble and install the intermediate shaft assembly.

4.1 Press a new bearing cone into the intermediate shaft rear cover, coat the cone with oil and install a new cover seal.

4.2 Press a new bearing cone into the intermediate shaft front cover, coat the cone with oil and install a new cover seal.

⚠ CAUTION

Lubrication pump impeller vanes are fragile and may break or chip. Impeller vanes are installed only one way. If removal of the vanes is necessary, note the installation of the vanes. Failure to install the vanes properly will result in transmission failure.

IMPORTANT: To ensure proper operation of the oil pump, use the same number of gaskets and shims that were removed when the oil pump was disassembled.

4.3 Install the lubrication pump impeller assembly, vanes, and shaft into the front cover aligning the matchmarks. Apply Loctite® 242 to the six 1/4–20 x 5/8 capscrews and tighten 8 lbf·ft (11 N·m).

Fire Pump Gearbox Removal, Disassembly, Assembly, and Installation

4.4 Press the new bearing cups onto the intermediate shaft, one on each side of the intermediate gear.

4.5 Reaching through the top of the transmission housing, install the intermediate gear and shaft assembly taking care not to damage the bearing cups.

4.6 Holding the intermediate gear assembly in place, install the rear intermediate shaft cover. Apply Loctite® 242 to the three 7/16–14 x 1-1/4 capscrews and install but do not torque.

4.7 Install the front intermediate shaft cover, aligning the lubrication pump shaft spline with the intermediate shaft spline. Apply Loctite® 242 to the three 7/16–14 x 1-1/4 capscrews and tighten all six capscrews 53 lbf·ft (72 N·m).

4.8 Connect the oil suction line to the lubrication pump.

4.9 Rotate the input shaft and manually shift the transmission to check for proper movement and operation.

Installation

1. Install a new gasket on the seating surface of the rear bearing housing.

⚠ CAUTION

Properly align the rear bearing housing. If the rear bearing housing is not aligned with the matchmarks, the gear tooth mesh could be incorrect and may result in damage to the gearbox.

2. Using a lifting device, lift the gearbox into position (around the rear bearing housing). Apply Loctite® 242 to the six 1/2–13 x 1-3/4 capscrews and attach the gearbox cover to the gearbox. Tighten finger-tight, but do not torque.
3. Apply Loctite® 242 to the twelve 7/16–14 x 1-1/4 capscrews and insert the capscrews through the rear bearing housing cover and gasket into the gearbox. Tighten 53 lbf·ft (72 N·m).
4. Tighten the six 1/2–13 x 1-3/4 capscrews 65 lbf·ft (88 N·m).
5. Connect the pump gearbox cooling lines.
6. Connect the air lines and electrical switches.
7. Connect the drive shafts. Tighten the yoke fasteners 225 lbf·ft (305 N·m) and tighten the bearing retaining strap capscrews 40 to 48 lbf·ft (54 to 65 N·m).
8. Connect the lubrication line to the gearbox cover.
9. Fill the gearbox with the necessary lubricant.
10. Operate the pump and check for leaks. Verify the oil pressure at 25 to 35 psi (172 to 241 kPa) at the oil injection point.
11. Remove the chocks from the front and rear tires.

Replacement

1. Park the vehicle on a level surface. Shut down the engine. Set the parking brake and chock the front and rear tires.
2. Drain the water from the pump.

⚠ WARNING

The gearbox assembly is heavy. Support the lower gearbox assembly with a lifting device. Failure to do so could result in the assembly falling, which could result in personal injury or property damage.

3. Remove the gearbox. See **Subject 110** for information.
4. Remove the 5/8–11 x 1-1/4 capscrew and bearing retaining washer from the end of the impeller shaft.
5. Remove the twelve 1/2–13 x 1-3/4 capscrews that attach the rear bearing housing to the pump body.
6. Install two 1/2–13 x 3 jackscrews into the 1/2–13 threaded holes provided in the rear bearing housing. See **Fig. 1**.
7. Use a centerpunch to mark the rear bearing housing, the mechanical seal housing, and the pump body so that the components are properly aligned during assembly.
8. Turn the two jack screws evenly, clockwise, to push the rear bearing housing from the impeller shaft and pump body.

NOTE: To prevent damage to components as the rear bearing housing is pushed from the impeller shaft, place your hands under the gear opening to catch the gear, key, and bearings.

NOTE: It may be necessary to use pry bars to gently assist in removing the inner bearings and gear.

9. Remove the jack bolts.
10. Remove the slinger from the impeller shaft.
11. Remove the four 7/16–14 x 1-1/4 capscrews from the mechanical seal cover. See **Fig. 2**. Use a center punch to mark the seal cover for proper alignment during installation.
12. Use pry bars if necessary in the provided slots to loosen the mechanical seal cover from the impeller shaft and the pump body.
13. Remove the old mechanical seal, being careful not to damage the impeller shaft. Use two small hook-tools positioned about 180 degrees apart to pull the mechanical seal from the seal cavity if necessary.
14. Clean the seal cavity and the impeller shaft.
15. Inspect the retaining ring on the shaft.
16. Remove the burrs at the gear key slot and the bearing lands, and remove the oil seal in the rear bearing housing. See **Fig. 3**.

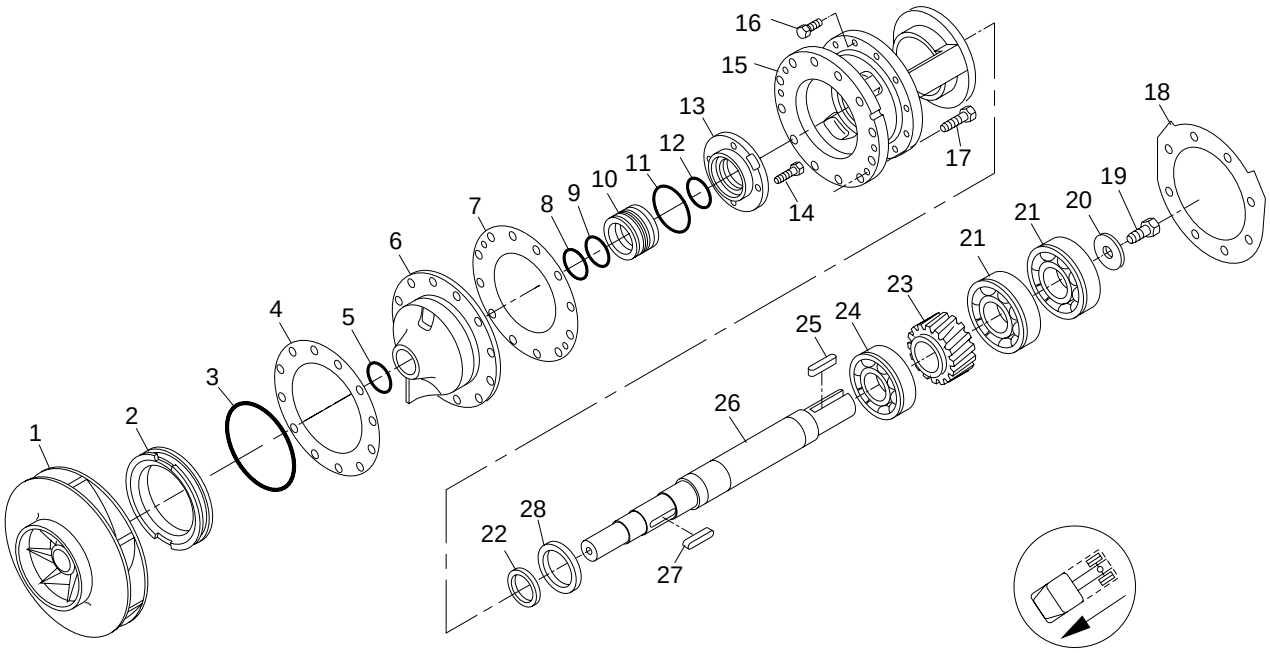
IMPORTANT: Always replace the entire mechanical seal with a new Twinflow mechanical seal assembly.

⚠ CAUTION

When installing a new mechanical seal do not touch the sealing surface of the carbon seal ring or the metal seat while handling or installing. Oil and grease can damage the bellows of the mechanical seal. Use only a soap-and-water solution to lubricate the mechanical seal.

17. Clean the housing and the impeller shaft, and lubricate the impeller shaft and the new mechanical seal with a soap-and-water solution.
18. Install the new mechanical seal bellows over the end of the impeller shaft with the spring oriented toward the impeller. Using a soft pusher tube and keeping your fingers away from the carbon seal, carefully push the mechanical seal assembly into the mechanical seal cavity. If binding occurs, apply more soap-and-water solution to the impeller shaft and the bellows.
19. Install the steel cup and seat it into the mechanical seal cover. Lubricate with a soap-and-water solution.
20. Remove and replace the seal rings in the mechanical seal cover. Apply the soap-and-water solution to the seal rings and then slide over the

Mechanical Seal Replacement



1. Impeller
2. Clearance Ring
3. Rear Bearing Housing Seal
4. Bearing/Seal Housing Gasket (impeller side)
5. Shaft Retaining Ring
6. Mechanical Seal Housing
7. Bearing/Seal Housing Gasket (mechanical seal side)
8. Shaft Seal Ring
9. Shaft Retaining Ring
10. Mechanical Seal And Steel Cup Assembly
11. Mechanical Seal Piston Ring
12. Shaft Seal Ring
13. Mechanical Seal Cover
14. Hexhead Screw, 7/16–14 x 1-1/4
15. Rear Bearing Housing
16. Hexhead Screw, 7/16–14 x 1-1/2
17. Hexhead Screw, 1/2–13 x 1-3/4
18. Rear Bearing Housing Gasket
19. Hexhead Screw, 5/8–11 x 1-1/4
20. Rear Bearing Washer
21. Bearing (aft)
22. Pump Shaft Slinger
23. Pump Shaft Gear
24. Bearing (forward)
25. Pump Shaft Gear Key
26. Pump Shaft
27. Impeller Key
28. Drive Unit Oil Seal

Fig. 1, Impeller Shaft Assembly (exploded view)

end of the impeller shaft. Make sure the mechanical seal remains seated in the bore of the cover.

21. Insert the mechanical seal cover into the mechanical seal cavity aligning it with the bolt holes and the orientation marks.
22. Insert the bolts in the mechanical seal housing to prevent the housing from rotating.
23. Install the four 7/16–14 x 1-1/4 capscrews. Tighten 53 lbf·ft (72 N·m).
24. Install the new slinger onto the impeller shaft. Then remove the retaining bolts.
25. Install the new gasket and oil seal in the rear bearing housing. Slide the housing and front bearing onto the rear impeller shaft. The bearing is a press-fit onto the impeller shaft and slip-fit in the housing.

IMPORTANT: Do not allow the weight of the rear bearing housing to rest on the oil seal.

26. Insert the gear through the opening in the housing and align it with the impeller shaft. Slide the

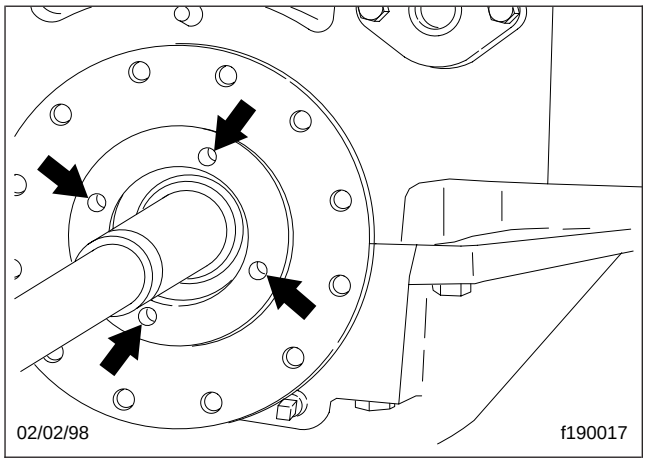
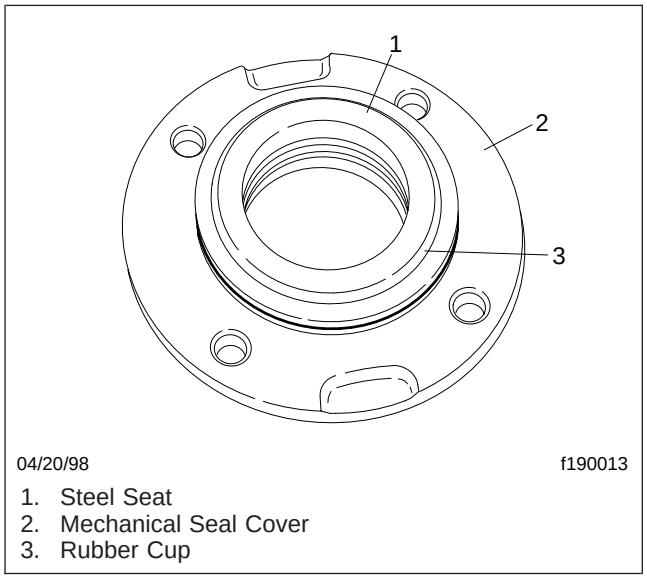


Fig. 2, Remove Four Capscrews



1. Steel Seat
2. Mechanical Seal Cover
3. Rubber Cup

Fig. 3, Mechanical Seal Assembly

housing, front bearing and gear onto the shaft. The front bearing will stop when the inner race contacts the seat on the impeller shaft.

27. Line up the keyway in the gear and install the key into the keyway.
28. Slide one of the two rear bearings onto the impeller shaft and into the housing. The rear bearings are a press-fit onto the shaft and a slip-fit in the housing.
29. Using a series of different length capscrews, install the rear bearing housing to the pump body. When it is possible, install the four capscrews (approximately 90 degrees apart). These bolts, in combination with the rear bearing, will center the housing. Double check to be sure the housing is centered and will clear the mechanical seal assembly.
30. Install the pusher bolt in the rear of the impeller shaft. Tighten the nut on the pusher bolt while holding the pusher bolt, pushing the rear bearing into the housing. Remove the pusher bolt and install the second of the two rear bearings. Then install the pusher bolt and tighten the nut while holding the pusher bolt to install the bearing.
31. Continue to tighten the nut on the pusher bolt while making sure the housing is aligned and centered. Once the pusher bolt is snug, the rear housing assembly, the gear, and the bearings should be in place. Remove the pusher bolt and rotate the impeller assembly by placing a large screwdriver between the housing and the gear. The impeller assembly should rotate.

NOTE: A new impeller will have some resistance when the impeller shaft is rotated.

32. Apply Loctite® 242 to the 5/8–11 x 1-1/4 bearing retainer capscrew. Install and tighten 80 lbf·ft (108 N·m).
33. Apply Loctite® 242 to the twelve 1/2–13 x 1-3/4 capscrews, install and tighten 80 lbf·ft (108 N·m).
34. Install the gearbox. See **Subject 110** for information.
35. Perform the annual service test on the pump. Check for leaks. Verify the oil pressure at 25 to 35 psi (172 to 241 kPa) at the oil injection point.
36. Remove the chocks from the front and rear tires.

Removal

1. Park the vehicle on a level surface. Shut down the engine. Set the parking brake and chock the front and rear tires.
2. Drain the water from the pump.

⚠ WARNING

The gearbox assembly is heavy. Support the lower gearbox assembly with a lifting device. Failure to do so could result in the assembly falling, which could result in personal injury or property damage.

3. Remove the gearbox. See **Subject 110** for information.

⚠ WARNING

The lower pump body is heavy. Support the lower pump body and impeller assembly with a lifting device. Failure to do so could result in the lower pump body and impeller assembly falling, which could result in personal injury or property damage.

4. Remove the drain lines from the lower pump body. See **Fig. 1**.
5. Drain the oil from the AutoLube and remove the 1/2–13 x 2 capscrews from the upper half of the AutoLube and pump body.
6. Remove the 7/16–14 x 1-1/2 capscrews from the upper half of the rear bearing housing and pump body.
7. Remove the 1/2–13 x 1-1/4 capscrews from the lower pump body.

⚠ WARNING

Do not remove the four capscrews, one in each corner of the lower pump body, until the lifting device is in position. Failure to do so could result in the lower pump body and impeller assembly falling, which could result in personal injury or property damage.

8. Position the lifting device into place with the lower pump body lifting adapter between the lifting device and the lower pump body.
9. Remove the 5/8–11 x 5 capscrews in each corner of the lower pump body.
10. Lower the lower pump body and impeller assembly. Be sure to balance the assembly so that it does not tip from the lifting device.
11. Remove the remaining capscrews from the lower half of the AutoLube, the rear bearing housing, and the lower pump body.

⚠ WARNING

The impeller assembly is heavy. Do not attempt to lift the assembly without the aid of another person or persons, or a lifting device. Failure to do so could result in the impeller assembly falling, which could result in personal injury or property damage.

12. Remove the remaining screws from the rear bearing housing and then from the lower pump body.
13. Lift the impeller assembly from the lower pump housing. See **Fig. 2**. Set the assembly aside.
14. Clean all gasket surfaces of the upper and lower pump bodies, as well as those on the AutoLube and the rear bearing housing face.
15. Clean the clearance ring and clearance ring seats in both the upper and lower pump body halves to remove all the buildup material so that the new clearance ring will seat properly.

NOTE: Pitting of the clearance rings may occur from the buildup material and the effects of corrosion. Once the seats are cleaned, any pitting on the clearance rings is considered normal.

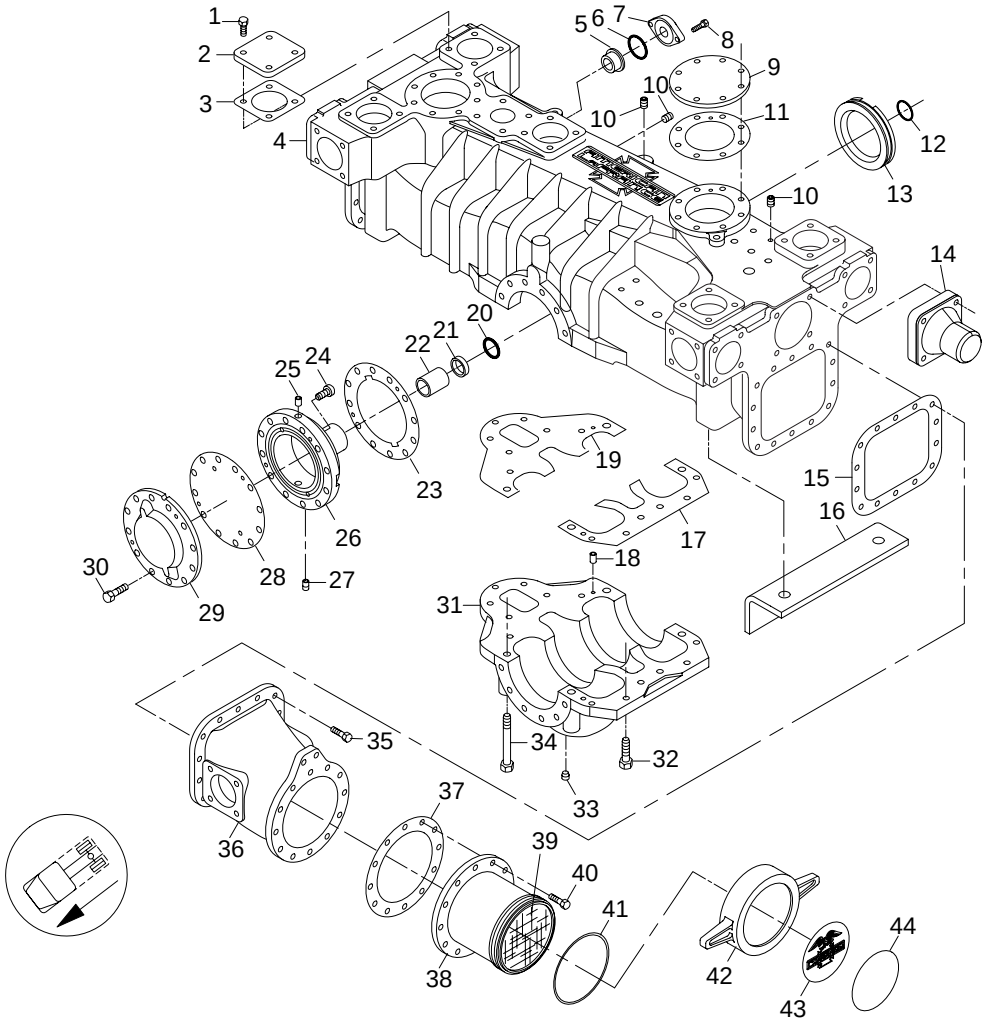
Installation

1. Install the pump body gaskets to the lower pump body, trimming as necessary to fit.

⚠ CAUTION

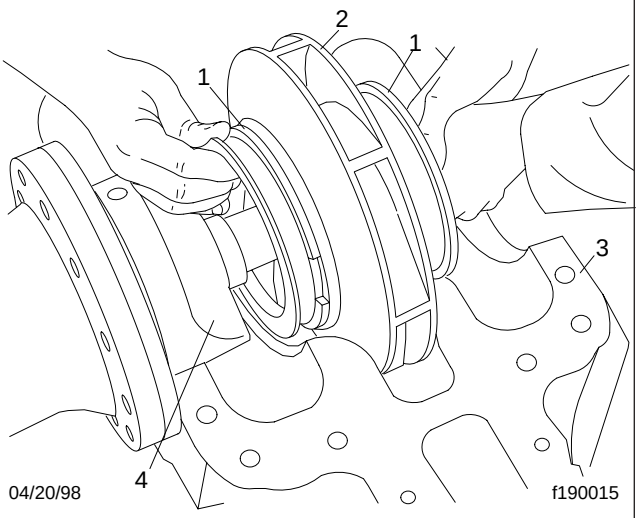
Failure to line up the clearance ring lock notches with the pump body tabs (as described in the next step) may result in pinched clearance rings, which could result in pump damage and pump failure.

Impeller Assembly Removal and Installation



1. Hexhead Screw, 7/16–14 x 1-1/4
2. Blank Flange
3. Flange Gasket
4. Upper Pump Body
5. Priming Valve Strainer
6. Priming Valve Plate Seal Ring
7. Priming Valve Plate
8. Hexhead Screw, 7/16–14 x 1-1/4
9. Tank Connection Flange
10. Plug, 1/4-inch
11. Tank Connection Gasket
12. Impeller Retaining Ring
13. Clearance Ring
14. QD Relief Valve Assembly
15. Suction Tube Extension Gasket
16. Pump Mounting Bracket
17. Pump Body Gasket (left side)
18. Dowel Pin
19. Pump Body Gasket (right side)
20. Oil Seal Retaining Ring
21. Front Bearing Housing Oil Seal
22. Front Bearing
23. Bearing/Seal Housing Gasket
24. Allen-head Screw, 3/8–16 x 3/4
25. Brass Socket Plug, 1/4-inch
26. Front Bearing Housing Assembly
27. Brass Socket Plug, 1/4-inch
28. Front Bearing Diaphragm
29. Front Bearing Cover
30. Hexhead Screw, 1/2–13 x 2
31. Lower Pump Body
32. Hexhead Screw, 1/2–13 x 1-3/4
33. Plug, 1/2-inch
34. Hexhead Screw, 5/8–11 x 5
35. Hexhead Screw, 1/2–13 x 1-1/4
36. Suction Tube Extension
37. Suction Tube Round Gasket
38. Suction Tube, 6-inch
39. Suction Strainer, 6-inch
40. Hexhead Screw, 7/16–14 x 1-1/4
41. Suction Cap Washer
42. Suction Cap
43. Medallion
44. Medallion O-Ring

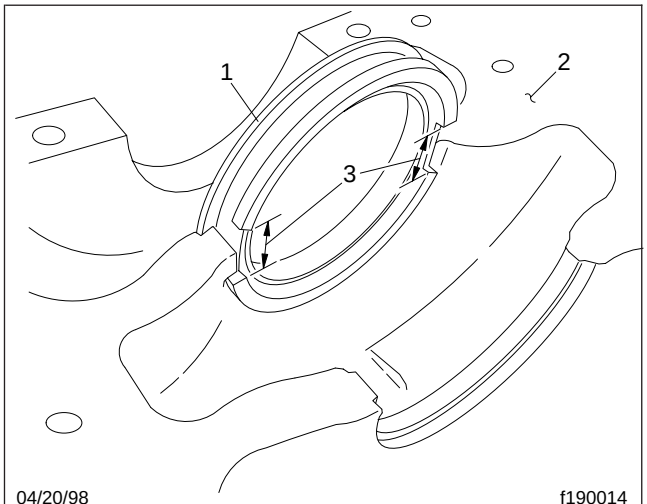
Fig. 1, Fire Pump Body Assembly (exploded view)



1. Clearance Ring
2. Impeller
3. Lower Pump Housing
4. Cut Water

Fig. 2, Lifting the Impeller Assembly from the Lower Pump Housing

2. Install the impeller assembly into the lower pump housing carefully aligning the clearance ring lock-notch with the clearance ring lock tabs in the lower pump body. Then rotate the clearance rings to one side to open up lock notches to line up with the lock tabs in the upper pump body. See **Fig. 3**.
3. Install the 1/2–13 x 1-3/4 capscrews through the rear bearing housing and the mechanical seal housing. Do not tighten.
4. Make sure the dowel pins are in the upper pump body to assist in aligning the lower pump body with the upper pump body.
5. Using a lifting device, slowly raise the lower pump body and the impeller assembly into place, making sure that the lower pump body aligns with the dowel pins and the clearance ring notches align with the clearance ring lock tabs in the upper pump body.
6. Rotate the impeller and check for freedom of movement when the lower pump body and the impeller assembly is in place.



1. Clearance Ring
2. Lower Pump Housing
3. Clearance Ring Notch

Fig. 3, Clearance Ring Mounted in Pump Housing

7. Apply Loctite® 242 and install the four 5/8–11 x 5 capscrews (one at each corner of the lower pump body). Tighten snug but do not fully torque.
8. Install the 1/2–13 x 1-3/4 screws in the rear bearing housing and mechanical seal housing. Tighten 53 lbf·ft (72 N·m).
9. Remove the lifting device.
10. Apply Loctite® 242 to the 1/2–13 x 1-3/4 lower pump body capscrews and install them. Tighten snug but do not torque.
11. Torque the 5/8–11 x 5 capscrews 150 lbf·ft (203 N·m) then, starting from the center and moving outward, tighten the lower pump body capscrews 65 lbf·ft (88 N·m).
12. Install the AutoLube. See **Subject 100** for instructions.
13. Install the gearbox. See **Subject 110** for instructions.
14. Operate the pump and check for leaks. Verify the oil pressure at 25 to 35 psi (172 to 241 kPa) at the oil injection point.
15. Remove the chocks.

Single-Stage Pump

Disassembly

1. Park the vehicle on a level surface. Shut down the engine. Set the parking brake and chock the front and rear tires.
2. Remove the AutoLube. See **Subject 100** for instructions.
3. Remove the fire pump gear box. See **Subject 110** for instructions.
4. Remove the impeller assembly. See **Subject 130** for instructions and see **Fig. 1**for an exploded view of the assembly.
5. Place the impeller shaft on a work bench.
6. Note the orientation of the impeller vanes.
7. Remove the outer retaining ring.

⚠ WARNING

Wear protective, heat-resistant gloves while heating the impeller to remove it from the impeller shaft. Heated metal can cause injury to your hands.

⚠ CAUTION

Do not overheat the impeller. The impeller is constructed of bronze. If the impeller is overheated and turns red or blue during removal from the shaft, it has been weakened and must be replaced.

8. Using an acetylene torch, carefully heat the "eye" of the impeller for approximately two minutes.
9. When heated properly, the impeller will slide free of the shaft. If the impeller moves but does not slide free, do not immediately reheat. Allow the complete assembly to cool to room temperature then reheat and remove the impeller.
10. Allow the components to cool to room temperature.
11. Remove the inner clearance ring.
12. Remove the key.
13. Remove the inner retaining ring and slide the mechanical seal housing from the impeller shaft

Assembly

1. Clean the impeller shaft, the keyway, and the mechanical seal housing and face.
2. Check the waterway in the mechanical seal housing for restrictions.
3. Install the mechanical seal housing onto the impeller shaft.
4. Install the inner retaining ring.
5. Install the new gasket on the mechanical seal housing face.
6. Install the key into the keyway.

⚠ CAUTION

If the impeller or clearance rings are dropped, damaged, or deformed, they will need to be replaced.

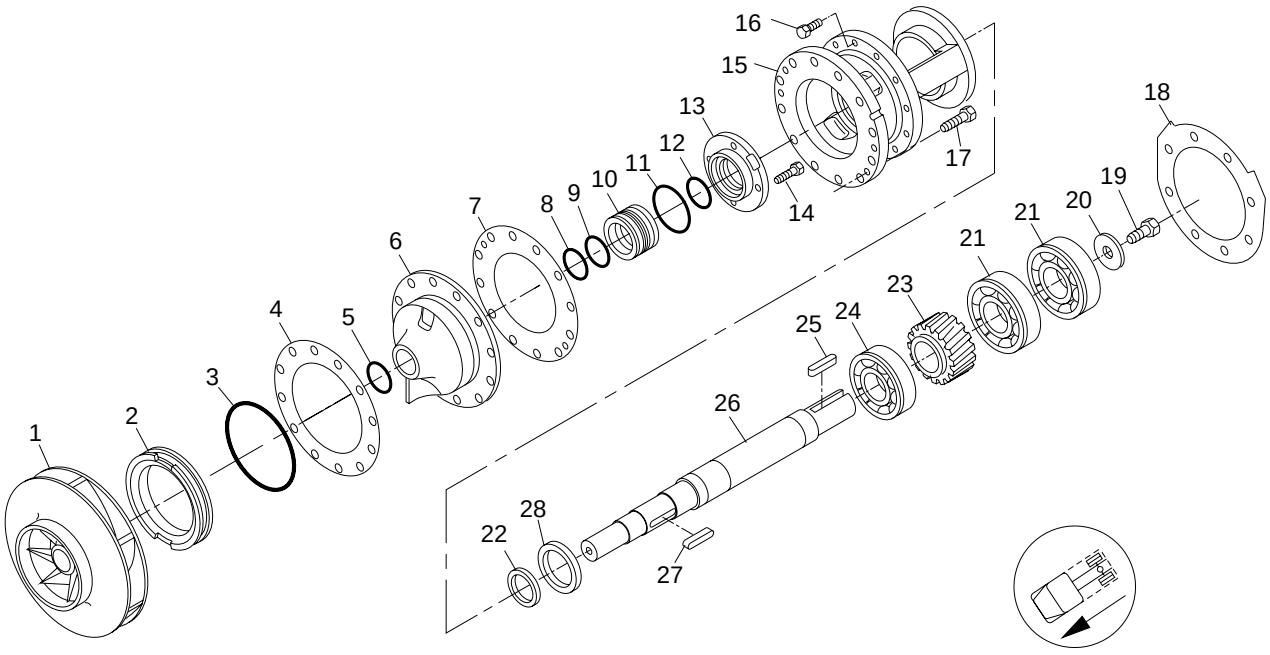
7. Install the inner clearance ring.

⚠ WARNING

Wear protective, heat-resistant gloves while heating the impeller to install it onto the impeller shaft. Heated metal can cause injury to your hands.

8. Using the torch, heat the "eye" of the new impeller for approximately two minutes. Then slide the impeller onto the shaft with vanes in proper orientation. If the impeller does not fully slide onto the shaft allow the assembly to cool to room temperature before reheating.
9. Install the outer retaining ring.
10. Install the impeller assembly. See **Subject 130** for instructions.
11. Install the outer clearance ring.
12. Install the impeller shaft assembly.
13. Install the fire pump gear box. See **Subject 110** for instructions.
14. Install the AutoLube. See **Subject 100** for instructions.
15. Remove the chocks from the front and rear tires.

Impeller Shaft Disassembly and Assembly



1. Impeller
2. Clearance Ring
3. Rear Bearing Housing Seal
4. Bearing/Seal Housing Gasket (impeller side)
5. Shaft Retaining Ring
6. Mechanical Seal Housing
7. Bearing/Seal Housing Gasket (mechanical seal side)
8. Shaft Seal Ring
9. Shaft Retaining Ring
10. Mechanical Seal And Steel Cup Assembly
11. Mechanical Seal Piston Ring
12. Shaft Seal Ring
13. Mechanical Seal Cover
14. Hexhead Screw, 7/16–14 x 1-1/4
15. Rear Bearing Housing
16. Hexhead Screw, 7/16–14 x 1-1/2
17. Hexhead Screw, 1/2–13 x 1-3/4
18. Rear Bearing Housing Gasket
19. Hexhead Screw, 5/8–11 x 1-1/4
20. Rear Bearing Washer
21. Bearing (aft)
22. Pump Shaft Slinger
23. Pump Shaft Gear
24. Bearing (forward)
25. Pump Shaft Gear Key
26. Pump Shaft
27. Impeller Key
28. Drive Unit Oil Seal

Fig. 1, Impeller Shaft Assembly (exploded view)

Two-Stage Pump

Disassembly

1. Park the vehicle on a level surface. Shut down the engine. Set the parking brake and chock the front and rear tires.
2. Remove the AutoLube. See **Subject 100** for instructions.
3. Remove the fire pump gear box. See **Subject 110** for instructions.
4. Remove the impeller assembly. See **Subject 130** for instructions.
5. Place the impeller shaft assembly on a work bench.
6. Note the position of the impeller vanes.
7. Remove the inner and the outer retaining rings and then remove the mechanical seal housing.

⚠ WARNING

Wear protective, heat-resistant gloves while heating an impeller to remove it from the impeller shaft. Heated metal can cause injury to your hands.

⚠ CAUTION

Do not overheat the impeller. An impeller is constructed of bronze. If the impeller is overheated and turns red or blue during removal from the shaft, it has been weakened and must be replaced.

8. With an acetylene torch, carefully heat the "eye" of the impellers for approximately two minutes.

IMPORTANT: Mark the impellers as to whether they are the primary or secondary impeller in relation to the AutoLube. Improper or backward installation of the impellers affects pump performance.

9. When heated properly, an impeller will slide free of the shaft. If the impeller moves but fails to slide free, do not immediately reheat. Allow the complete assembly to cool to room temperature then reheat and remove the impellers. Heat the secondary impeller and remove. Then rotate the impeller shaft assembly end for end and heat and remove the primary impeller.
10. Remove the center support bearing.
11. Remove mechanical seal housing and then the inner clearance ring.
12. Remove the key.
13. Remove the inner retaining ring and slide the mechanical seal housing from the impeller shaft.

Assembly

1. Clean the impeller shaft, the keyway, and the mechanical seal housing and face.
2. Check the waterway in the mechanical seal housing for restrictions.
3. Install the new gasket on the mechanical seal housing face.
4. Install the key into the keyway.

⚠ CAUTION

If the impellers or the clearance rings are dropped, damaged, or deformed, they require replacement.

5. Install the inner clearance ring.

⚠ WARNING

Wear protective, heat-resistant gloves while heating the impeller to install it onto the impeller shaft. Heated metal can cause injury to your hands.

6. Using the torch, heat the "eye" of each impeller for approximately two minutes. Then slide the individual impellers onto the shaft. If an impeller does not fully slide onto the shaft allow the assembly to cool to room temperature before reheating.
7. Install the outer retaining ring.
8. Install the outer clearance ring.
9. Install the impeller assembly. See **Subject 130** for instructions.
10. Install the mechanical seal housing onto the impeller shaft.
11. Install the impeller shaft assembly.
12. Install the fire pump gear box. See **Subject 110** for instructions.
13. Install the AutoLube. See **Subject 100** for instructions.
14. Remove the chocks from the front and rear tires.

Pilot Valve

Park the vehicle on a level surface. Shut down the engine. Set the parking brake and chock the front and rear tires.

1. Drain the fire pump.
2. Rotate the adjustment handwheel counterclockwise to remove the spring tension.
3. Remove the capscrew and nut attaching the adjustment handwheel to the adjustment shaft. Then remove the handwheel.

⚠ CAUTION

Identify and mark the line connections on the control body before removing. Improper connection of lines may result in the failure of the pilot valve, which could cause damage to the fire pump.

4. Remove the pump discharge pressure line and the relief valve line from the control body of the pilot valve.
5. While holding the pilot valve, remove the four 1/4–20 x 5/8 machine screws attaching the valve and cover plate to the Pump Operator's Panel, and separate the valve, plate, and the relief valve setting indicator (if equipped with PMD) from the panel.
6. Disassemble the pilot valve.
   - 6.1 Remove the four 5/16–18 x 1 allen-head capscrews securing the control body to the rear of the spring housing. Then remove the control body.

⚠ CAUTION

Do not use pliers to unscrew the control valve from the diaphragm clamp. Damage to the control valve will render the pilot valve inoperative.

   - 6.2 Unscrew the control valve from the diaphragm clamp. Remove the diaphragm washer and the diaphragm.
   - 6.3 Remove the retaining ring, the seal, and the bearing.

⚠ WARNING

Use a spring compressor to remove the pilot valve spring. The spring is under compression and could become uncompressed, which could result in personal injury.

   - 6.4 Turn the adjustment handwheel clockwise to unscrew the adjustment shaft from the adjustment nut. From the handwheel end, remove the adjustment shaft from the spring housing.
   - 6.5 Remove both springs, the adjustment nut, and diaphragm clamp as an assembly from the spring housing and then separate.
7. Clean all the pilot valve components. Inspect and lubricate with grease the threads on the adjustment shaft.
8. Assemble the pilot valve.

⚠ WARNING

Use a spring compressor to install the pilot valve spring. The spring is under compression and could become uncompressed, which could result in personal injury.

⚠ CAUTION

Always remove the pilot valve discharge pressure inlet screen, which is located in the top of the discharge side of the pump. Clean or replace as necessary. Failure to do so could render the pilot valve inoperative.

   - 8.1 Combine both springs, the adjustment nut and the diaphragm clamp as an assembly and install into the spring housing. Align the guide pin-in adjustment nut with the slot in the spring housing and the indicator plate on the PMD.
   - 8.2 Slide the adjustment shaft into the spring housing from the handwheel end. Turn the adjustment handwheel counterclockwise in order to screw the adjustment shaft into the adjustment nut until it bottoms in the diaphragm clamp. Do not put the springs under tension.

Valve Removal, Disassembly, Assembly and Installation

8.3 Lubricate the new bearing and slide the new bearing and bearing washer over the adjustment shaft into the spring body housing. Install the retaining ring. Then install the new seal washer and rotate the adjustment shaft in both directions to check for freedom of movement.

8.4 Install the new diaphragm washer and diaphragm. Screw the control valve into the diaphragm clamp.

8.5 Install the control body. Apply Loctite® 242 to the four 5/16–18 x 1 allen-head capscrews attaching the control body to the rear of the spring housing.

9. Holding the pilot valve, align the cover plate and install the four 1/4–20 x 5/8 machine screws attaching the pilot valve and cover plate to the Pump Operator's Panel.
10. Install the pump discharge pressure line and relief valve line to the control body of the pilot valve.
11. Slide the adjustment handwheel onto the adjustment shaft and then install the retaining capscrew and nut.
12. Fill the pump and test the valve for proper operation and leaks.

Transfer Valve

See **Fig. 1** for an exploded view of the transfer valve.

1. Drain the fire pump.

IMPORTANT: The transfer valve is a timed device. It is therefore important during disassembly to note the location of the transfer bracket locating pin, the transfer drum stop pin, the transfer drum sleeve locating pin, and the transfer drum stem key. It is not necessary to remove the transfer bracket locating pin, the transfer drum sleeve locating pin, or the transfer drum stop pin during disassembly.

2. Turn the adjustment handwheel clockwise until it stops. The transfer indicator should be at the top of the slotted guide in the cover plate.
3. Remove the two allen-head set screws from the transfer indicator guide. Slide the transfer indicator guide (on an adjustment stem) towards the transfer valve.
4. Remove the stem drive gear lock pin. Slide the adjustment stem from the stem drive, the support, and the transfer indicator guide, being careful not to drop or damage the transfer indicator guide and transfer indicator.
5. Remove the four 7/16–14 x 1-1/4 capscrews retaining the transfer bracket assembly to the pump body. Carefully remove the transfer bracket and the transfer valve drum.
6. Disassemble the valve.

   6.1 Remove the locating pin that secures the countershaft in place.

   6.2 Remove the countershaft from the countershaft gear.

   6.3 Remove the countershaft gear and the countershaft gear spring from the transfer bracket assembly.

   6.4 Remove the allen-head set screw from the transfer drum gear. Slide the transfer drum gear from the drum stem. Remove the woodruff key from the transfer drum stem.

   6.5 Separate the transfer bracket from the transfer drum by sliding it from the transfer drum stem.

   6.6 Slide the transfer drum from the transfer sleeve.

7. Assemble the valve.

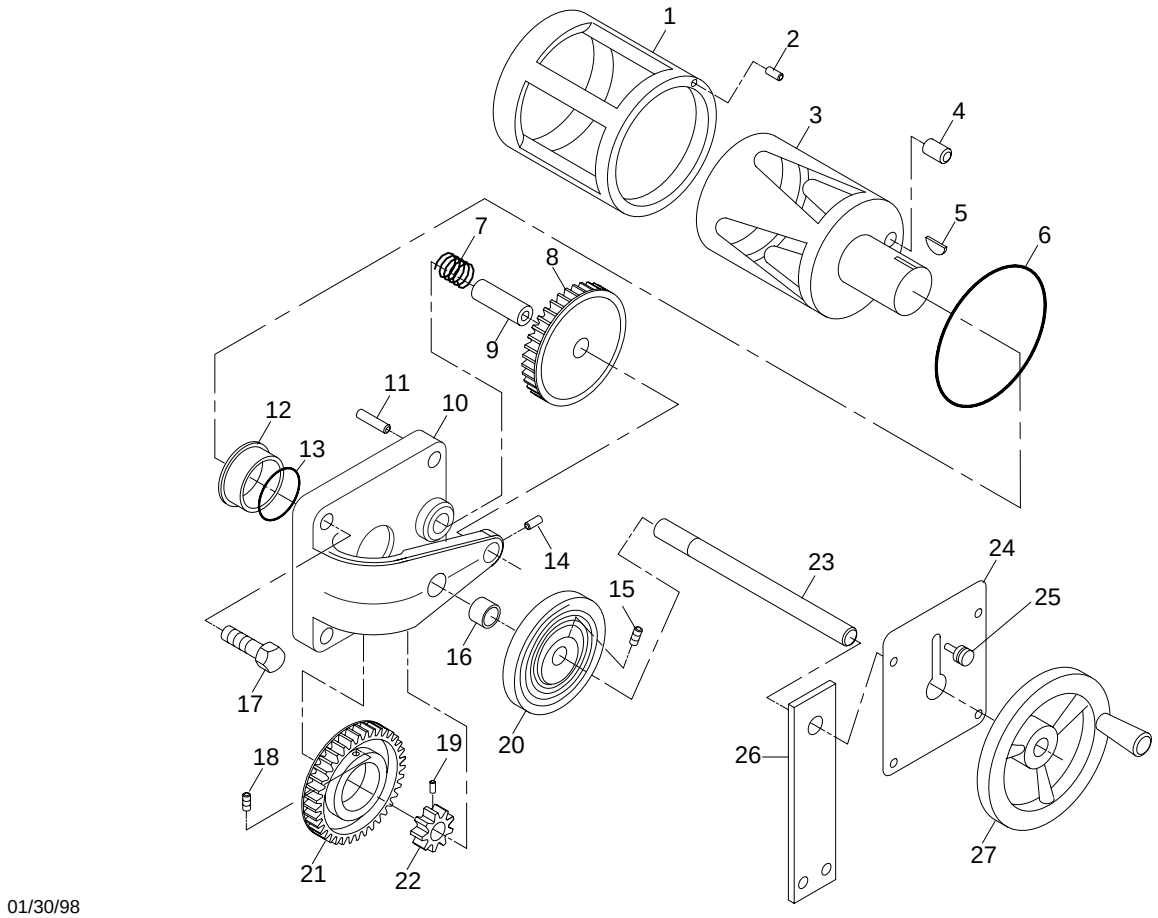
   7.1 Clean and inspect all sealing surfaces, the mating surfaces of the transfer valve drum and sleeve. Clean and inspect the transfer bracket bushings and bushing surface on the transfer valve stem and the transfer valve adjustment stem.

   7.2 Install new O-ring seals on the transfer valve drum stem and the transfer valve bracket.

   7.3 Slide the transfer drum into the transfer bracket, being careful not to damage the bearing surfaces. Then rotate the transfer drum until the drum stop pin is in the correct position.

   7.4 Install the woodruff key into the transfer drum stem. Install the transfer drum gear

Valve Removal, Disassembly, Assembly and Installation



1. Transfer Drum Sleeve
2. Locating Pin
3. Transfer Drum
4. Transfer Drum Stop Pin
5. Gear Key
6. Transfer Bracket Seal Ring
7. Countershaft Gear Spring
8. Transfer Valve Countershaft Gear
9. Transfer Countershaft
10. Transfer Bracket (with bearings) Assembly
11. Bracket Locating Pin
12. Drum Bracket Bearing
13. Transfer Drum Seal Ring
14. Locating Pin
15. Sockethead Setscrew, 1/4–20 x 3/8
16. Transfer Valve Stem Drive Gear
17. Hexhead Screw, 7/16–14 x 1-1/4
18. Sockethead Setscrew, #10–32 x 1/2
19. Gear Lock Pin
20. Transfer Indicator Guide
21. Transfer Valve Transfer Drum Gear
22. Transfer Stem Drive Gear
23. Transfer Stem
24. Instruction Plate
25. Transfer Indicator
26. Support Stem
27. Adjusting Wheel Assembly

Fig. 1, Transfer Valve

onto the transfer drum stem. Apply Loctite® 242 to the allen-head set screw and install the transfer drum gear.

7.5 Assemble the countershaft gear spring in the countershaft gear and position the assembly into place in the transfer bracket. Then install the countershaft and the

Valve Removal, Disassembly, Assembly and Installation

countershaft locating pin to lock the countershaft in place.

8. Install the transfer valve.
   - 8.1 Align the transfer drum stop pin, the transfer bracket locating pin, and the transfer drum sleeve locating pin into proper position.
   - 8.2 Install the transfer valve drum and bracket assembly into the pump body.
   - 8.3 Apply Loctite® 242 to the four 7/16–14 x 1-1/4 transfer bracket capscrews and install and tighten 53 lbf·ft (72 N·m).
   - 8.4 Slide the adjustment stem through the cover plate, the transfer indicator guide, and the support and transfer bracket.
   - 8.5 Insert the stem drive gear into place in the transfer bracket and then slide the adjustment stem through the stem drive gear.
   - 8.6 Insert the stem drive gear lock pin into place, locking the stem drive gear onto the adjustment stem.
   - 8.7 Apply Loctite® 242 to the transfer indicator guide set screws and install. Do not tighten.
   - 8.8 Turn the adjustment handwheel counterclockwise until it stops. Make sure the transfer indicator is at the top of the slotted guide toward the transfer indicator, making certain that the transfer indicator engages the transfer indicator guide in the top groove. Then tighten the inside set screw in the transfer guide indicator.
   - 8.9 Rotate the adjustment handwheel from stop to stop. The transfer indicator should move freely from the top to the bottom of the slotted guide in the cover plate.
   - 8.10 Tighten the outside set screw in the transfer indicator guide, and recheck the movement of the transfer indicator.
9. Fill the pump and test the valve for proper operation and leaks.

Back Flow Valve

1. Drain the water tank and the pump.
2. Disconnect the control linkage at the Tank-to-Pump valve.
3. Disconnect both ends of the flexible hose connecting the water tank to the tank-to-pump valve. Then slide the flexible hose toward the water tank outlet or the tank-to-pump valve plumbing.

NOTE: If the tank-to-pump valve is air-operated, drain the vehicle's air system and disconnect the supply and the return line on the valve actuator, but do not remove the actuator from the valve. Also, the tank-to-pump valve may be connected to the pump body by capscrews or studs with nuts. If studs are used, it may be necessary to remove some or all of the studs to remove the valve. If so, remove only the studs necessary to remove the valve as any studs left will assist in realigning the valve during installation.

4. Remove the eight 7/16–14 x 1-1/2 capscrews retaining the tank-to-pump valve to the pump body.
5. Remove the tank-to-pump valve and associated plumbing.

NOTE: The back flow valve is a flat butterfly plate with two pivots attached at the top. These pivots fit into two open pivot sockets in the pump body. When the gasket is removed, the back flow valve may fall out.

6. Remove the old gasket from the pump body.
7. Remove the back flow valve.
8. To install the back flow valve, first clean all of the gasket surfaces on the pump body and the tank-to-pump flange.
9. Install the back flow valve. Using two fingers, hold the pivots in the pivot sockets and check the valve for freedom of movement.
10. Install a new gasket.
11. Apply Loctite® 242 to the eight 7/16–14 x 1-1/2 capscrews and attach the tank-to-pump valve to the pump body. Tighten 53 lbf·ft (72 N·m).
12. Slide the flexible connection hose so it is evenly spaced and secured on the water tank outlet and the tank-to-pump valve plumbing.

13. Attach the tank-to-pump valve controls and linkage.
14. Fill the pump and test the valve for proper operation and leaks.

Sensing Valve

1. Disconnect the following lines at the sensing valve:
    - pilot valve discharge line
    - QG relief valve line
    - PG relief valve line
    - sensing valve pump suction line
    - drain lines
2. Remove the 7/16–14 x 2 sensing valve mounting capscrew.
3. Remove the four 5/16–18 x 1 capscrews attaching the control body to the rear of the spring housing. Remove the control body, being careful not to lose the sensing valve spring.
4. Remove the control valve from the sensing valve body.
5. Unscrew the sensing valve from the diaphragm, being careful not to damage the control valve. Remove the diaphragm.
6. Before installing the sensing valve, clean all components.

⚠ CAUTION

Always remove the sensing valve suction inlet screen. Clean or replace as necessary. The screen is located in the suction side of the pump. Failure to do so may render components inoperative.

7. Install a new diaphragm on the diaphragm clamp. Apply Loctite® to the threads on the control valve and install the control valve into the sensing valve body.
8. Install the sensing valve spring into the valve body cover.
9. Apply Loctite® 242 to the four 5/16–18 x 1 capscrews and attach the control body to the rear of the spring housing. Make sure that the sensing valve spring properly aligns with the diaphragm clamp.
10. Make sure the up arrow is aligned properly.
11. Apply Loctite® 242 to the 7/16–14 x 2 sensing valve mounting capscrew. Tighten 40 lbf·ft (54 N·m).
12. Connect all lines.
13. Fill the pump and test the valve for proper operation and leaks.

TPM Relief Valve

1. Disconnect the line to the sensing valve and drain the fire pump. Make note of the wire connections.
2. Disconnect the indicator light switch.
3. Remove the four 7/16–14 x 1-1/4 capscrews attaching the relief valve assembly to the pump body.
4. Using a twisting motion, remove the relief valve assembly.
5. To disassemble the valve, remove the indicator light switch and remove the cover retaining ring and slide the cover out of the relief valve body.
6. Apply a small amount of pressure to the relief valve piston and remove the piston retaining ring. Carefully release the pressure held to the piston by the spring.
7. Remove the relief valve from the opposite end, sliding the relief valve stem out of the piston.
8. Reach through the center hole of the piston and pull the piston out of the indicator switch end of the relief valve body. Then remove the piston spring.
9. To assemble and install the valve, first clean and inspect all components.
10. Clean all sealing surfaces and install new O-rings seals.
11. Install the relief valve into the relief valve body.
12. Install the piston spring by sliding the piston into the relief valve body while at the same time sliding the piston onto the relief valve system.

Valve Removal, Disassembly, Assembly and Installation

13. Apply light pressure to the piston to compress the piston spring and install the piston retaining ring.
14. Slide the cover into the relief valve body. Then install the cover retaining ring.
15. Using a powered test light, screw the indicator light switch in until the light goes out. Then turn an additional 3/4 to 1-1/4 turn. Apply Loctite® to the jamnut and tighten.
16. Slide the relief valve assembly into the pump body with the side marked "top" up, being careful not to damage the O-rings.
17. Apply Loctite® 242 to the four 7/16–14 x 1-1/4 capscrews and install the assembly in the pump body. Tighten 53 lbf·ft (72 N·m).
18. Connect the indicator light switch.
19. Fill the pump and test the valve for proper operation and leaks.

QD Relief Valve

See **Fig. 2** for an exploded view of the QD relief valve.

1. Drain the pump.
2. Note the location of the wires and disconnect the indicator light switch.
3. Disconnect the relief valve supply line from the pilot valve and drain the line.
4. Remove the two 7/16–14 x 1-1/4 capscrews attaching the relief valve indicator light switch and the mounting bracket assembly to the relief valve cover. Remove the light switch and the bracket.
5. Compress the relief valve return spring by hand and remove the E-clip and washer. Then remove the return spring.
6. Remove the two remaining 7/16–14 x 1-1/4 capscrews retaining the relief valve cover to the pump body. Using a twisting motion, carefully remove the relief valve cover.

⚠ CAUTION

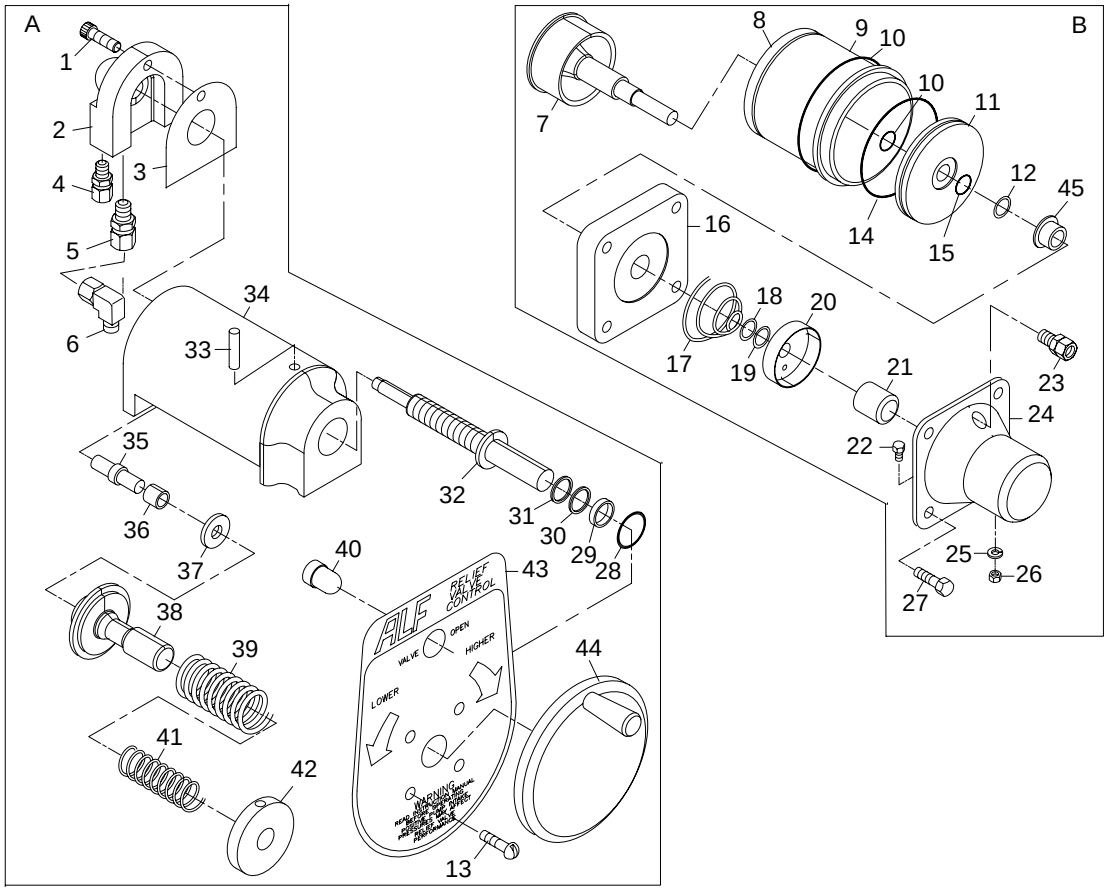
Do not push the relief valve too far into the pump body as it may fall into the pump body and become lodged or damaged. The relief valve is made of brass and is easily damaged by prying or hammering. Damaged valves must be replaced.

7. Remove the retaining ring securing the relief valve piston to the relief valve. Gently push the relief valve into the pump body approximately 1 inch (25 mm) and then pull it back out in a snap-motion. This should pop the relief valve piston out of the relief valve body. Repeat if necessary.

NOTE: It is not necessary to remove the relief valve unless it is damaged. To remove the relief valve, the relief valve body will have to be removed and the complete relief valve assembly will need to be replaced as it will be necessary to pry the relief valve body from the pump body, which will likely damage it.

8. Clean and inspect all of the relief valve assembly components.
9. Clean all sealing surfaces and install new O-rings and Quad-ring seals.
10. Install the relief valve piston in the stem of the relief valve. Do not push the relief valve into the pump body. As it is necessary to start the piston onto the relief valve stem, push the piston until you can grasp the relief valve stem. Then pull the relief valve stem outward while pushing on the relief valve piston. Once the relief valve piston is seated against the shoulder of the relief valve stem, install the retaining ring.
11. Operate the relief valve by hand to check for freedom of movement.
12. Slide the relief valve cover gasket and cover over the top of the relief valve stem to align the relief valve supply line from the pilot valve in the original position. Then apply Loctite® 242 to two 7/16–14 x 1-1/4 capscrews and install opposite of each other. Tighten, but do not torque.
13. Compress and install the return spring and secure it with a washer and E-clip.
14. Align the indicator light switch mounting bracket and switch with the two empty holes in the relief valve cover. Install the two remaining capscrews. Tighten all capscrews 53 lbf·ft (72 N·m).
15. Connect the relief valve supply line from the pilot valve. Also connect the drain line.
16. Connect the indicator light switch.

Valve Removal, Disassembly, Assembly and Installation



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A. PM Relief Valve Control Assembly
B. QD Relief Valve System Assembly

1. Sockethead Screw, 5/16–18 x 1
2. Control Body Assembly
3. PM Control Valve Diaphragm
4. Connector Tube, 1/8–3/4
5. Connector Tube, 1/4–3/8
6. Connector Strainer
7. Relief Valve
8. Valve Body Seal Ring
9. Relief Valve Body
10. Piston Seal Ring
11. Transfer/Relief Valve Piston
12. Piston Retaining Ring
13. Screw, 1/4–20 x 5/8
14. Cover and Piston Seal Ring
15. Cover Seal Ring
16. Relief Valve Cover
17. Valve Spring
18. Washer
19. Spring Retaining Ring
20. Switch Strap
21. Indicator Light Switch
22. Hexhead Screw, #10–32 x 1/2
23. Connector Tube, 1/4" x 3/8"
24. Switch Bracket
25. Lockwasher, #10
26. Hexnut, #10–32
27. Hexhead Screw, 7/16–14 x 2-1/4
28. Sealing Washer
29. Bearing Washer Retaining Ring
30. Bearing Washer
31. Thrust Bearing
32. Adjusting Stem
33. Indicator Pin
34. Spring Housing
35. Control Valve
36. Control Valve Bearing
37. Diaphragm Support Bearing
38. Diaphragm Clamp
39. Outside Spring
40. Light Bulb
41. Inside Spring
42. Adjusting Nut
43. Instruction Plate
44. Adjusting Wheel Assembly

Fig. 2, QD Relief Valve

Valve Removal, Disassembly, Assembly and Installation

17. Fill the pump and test the valve for proper operation and leaks.

TPM Dump Valve

1. Drain the pump.
2. Disconnect the indicator light switch.
3. Disconnect the line to the sensing valve.
4. Remove one 7/16–14 x 2 sensing valve mounting capscrew.
5. Remove the four 7/16–14 x 1-3/4 capscrews retaining the relief valve assembly to the atmosphere dump.
6. Remove the four 7/16–14 x 1-1/2 relief valve mounting capscrews to remove the relief valve from the pump body.
7. Remove the relief valve assembly
8. Remove the four 7/16–14 x 1-3/4 capscrews retaining the relief valve cover to the relief valve body.
9. Remove the indicator light switch assembly.
10. Apply a small amount of pressure to the relief valve spring and remove the spring retaining ring and washer. Carefully release the pressure held on the spring and then remove the spring.
11. Remove the relief valve cover.
12. Remove the piston retaining ring.
13. Remove the relief valve from the opposite end, sliding the relief valve stem out of the piston.
14. Reaching through the center hole of the piston, gently pull the piston from the indicator switch end of the relief valve body.
15. Before assembling and installing the valve, clean and inspect all components of the relief valve assembly.
16. Clean all sealing gasket surfaces and install new O-rings and gaskets.
17. Install the relief valve into the relief valve body.
18. Slide the piston into the relief valve body while at the same time sliding the piston onto the relief valve stem. Then install the piston retaining ring.
19. Install the new gasket and then install the cover onto the relief valve body.
20. Install two 7/16–14 x 1-3/4 capscrews finger-tight to keep the relief valve cover aligned with the valve body.
21. Install the valve spring over the relief valve stem. Then apply pressure to the valve spring to compress the spring.
22. Install the spring washer and the retaining ring.
23. Remove the two 7/16–14 x 1-3/4 capscrews installed to keep the relief valve cover aligned with the valve body. Place the indicator switch assembly into position on the relief valve cover. Apply Loctite® 242 to the four capscrews, install, and tighten 53 lbf·ft (72 N·m).
24. Apply Loctite® 242 to the four 7/16–14 x 1-1/2 capscrews to install the new gasket for the relief valve to the pump surface.
25. Apply Loctite® 242 to the four 7/16–14 x 1-1/2 capscrews and install the new gasket and relief valve assembly to the atmosphere dump. Tighten 53 lbf·ft (72 N·m).
26. Apply Loctite® 242 to the 7/16–14 x 2 capscrew, install the sensing valve and tighten 40 lbf·ft (54 N·m). Make sure the arrow points upward.
27. Connect the indicator light switch.
28. Connect the line to the sensing valve.
29. Fill the pump and test the valve for proper operation and leaks.

Check Valves (two-stage only)

1. Drain the pump.

NOTE: There are two check valves (one on each side) in the suction side on the front of the two-stage pump body. The following procedure is used for both check valves.

2. Remove the four 1/2–13 x 1-1/4 capscrews from the check valve cover on the front side of the pump body.
3. Remove the check valve.
4. Clean the gasket surfaces and inspect the check valve pivots and pivot sockets.

5. Install the check valve.
6. Install the new gasket in the pump body.
7. Apply Loctite® to the four capscrews and secure the check valve cover to the pump body with the capscrews, being careful to align the check valve pivot with the pivot socket in the check valve cover. Tighten 53 lbf·ft (75 N·m).
8. Fill the pump and test the valve for proper operation and leaks.

SPV Priming Valve

1. Drain the pump.
2. Disconnect the 3/4-inch (19 mm) vacuum hose connecting the priming valve to the primer.
3. Remove two 7/16–14 nuts attaching the priming valve to the studs in the pump body. If the studs are damaged, replace them with 7/16–14 x 1-3/4 zinc plated studs.

NOTE: If the valve strainer and O-ring seal remains on the pump body, remove it carefully for cleaning and installation. If the valve strainer is removed as part of the priming valve, remove it from the body and set it aside. Use care as the valve strainer is easily damaged.

4. Note the location of the drain hole on the diaphragm cover and then remove the eight 5/16–18 x 3/4 capscrews securing the diaphragm cover to the valve body. Remove the diaphragm cover and the diaphragm.
5. Hold pressure on the diaphragm washer to compress the valve spring then remove the diaphragm washer retaining screw. Remove the diaphragm washer and valve spring. From the opposite side of the valve body, remove the valve.
6. Clean all the components of the priming valve and mating surfaces. Inspect the valve seat and replace if worn or damaged.
7. Install the valve into the valve body from the pump side of the body.
8. Install the valve spring and diaphragm washer onto the valve. Apply Loctite® 242 to the diaphragm washer retaining screw, compress the valve spring with the diaphragm washer, and install the valve.
9. Align the diaphragm holes with the capscrew holes in the diaphragm cover. Apply Loctite® 242 to the eight 5/16–18 x 3/4 capscrews and install the diaphragm cover and diaphragm valve body. Tighten 17 lbf·ft (23 N·m).
10. Install the valve strainer and O-ring seal onto the pump side of the priming valve.
11. Apply Loctite® 242 on the two 7/16–14 priming valve mounting nuts and install the priming valve into the pump body. Tighten 40 lbf·ft (54 N·m).
12. Connect the vacuum hose to the primer.
13. Fill the pump and test the valve for proper operation and leaks.

Troubleshooting

Lack of use causes many problems for fire pumps and fire pump components.

IMPORTANT: The entire pumping system should be exercised on a regular basis, at least weekly. This routine procedure should include all discharge valves and suction valves.

Abuse of the fire pump is rarely a problem. If the pump and pump components have been abused, indications of problems may be fairly obvious. For example, bent controls are a common indicator.

Simultaneous oil and water leaks are uncommon. Normally, a water leak indicates that a line has come loose or is broken. Gaskets are used between mating surfaces *without* sealant. If a leak is present at a gasket-mating surface, whether oil or water, the components should be disassembled and repaired.

Be certain when a device indicates it is not working that it is not asimple electrical problem, such as a burned-out indicator bulb.

Troubleshooting Tables

Problem—Pump Will Not Engage

Problem—Pump Will Not Engage	
Possible Cause	**Remedy**
Parking brake not set.	Set the parking brake.
Transmission not in neutral.	Shift transmission to neutral.
Insufficient air supply.	Repeat the recommended shift procedure: Check the air pressure gauges. This procedure requires at least 100 psi (689 kPa), and shut the engine down and check for air leaks.
Pump shift or application of parking brake attempted before apparatus was stopped.	Release the braking system momentarily and repeat the recommended shift procedure. *

* This condition is known as "Butt Tooth," which occurs when the transmission shifts and the shift gear-teeth and the teeth on the drive gear do not line up and butt up against each other. The Twinflow fire pump transmission is designed with a sliding shift collar. Therefore, the occurrence of "Butt Tooth" will be rare.

Problem—Pump Will Not Shift

Problem—Pump Will Not Shift	
Possible Cause	**Remedy**
Battery voltage low.	Turn off accessories. Check the charging system of the apparatus. Inspect the batteries. If okay, recharge and try shift again.
Interface/Interlock module not receiving proper inputs.	Check the Officers Information Center output.
Transmission not receiving lock-up input.	Check output to transmission with Prolink.

Problem—Pump Will Not Prime

Problem—Pump Will Not Prime	
Possible Cause	**Remedy**
Low battery voltage.	Increase the engine speed 1000 to 1200 rpm for temporary support for electrical system requirements and primer operation. *
Worn or damaged priming system.	Perform the "Dry Vacuum Test" which follows the troubleshooting tables in this subject. If pump is tight but primer develops less than 22 inches of vacuum, the primer pump, motor, or Priming Valve may be worn or damaged.

Troubleshooting

Problem—Pump Will Not Prime	
Possible Cause	**Remedy**
Primer not operated long enough.	Operate for 30 seconds for pump up to 1250 gpm or for 45 seconds for 1500 and up gpm pump. Add 15 additional seconds if priming from front or rear suction. Do not run primer over 45 seconds. Stop and check for causes.
Suction lifts too high.	Do not attempt lifts exceeding 22 feet, except at low elevations.
Suction strainer blocked.	Check and clean.
Air pocket in suction hose or pump.	Place suction hose lower than suction intake. Slightly open a discharge valve momentarily to release trapped air.
Air leaks.	Perform the "Dry Vacuum Test" which follows the troubleshooting tables in this subject. Then shut engine off and listen for air leaks. Pressurize the discharge side of the pump with approximately 100 psi (689 kPa) from the hydrant and check for water leaks. Check connections and gaskets.

* Electric primer does not require engine speed to be increased for operation. A primer can and will draw in excess of 300 amps and primer operation can last 45 seconds.

Problem—Pump Loses Prime

Problem—Pump Loses Prime	
Possible Cause	**Remedy**
Suction lifts too high.	Do not attempt lifts exceeding 22 feet except at low elevations.
Suction strainer blocked.	Check and clean.
Air leaks.	Check all connections and gaskets. Perform the "Dry Vacuum Test" which follows the troubleshooting tables in this subject.
Pump pressure is too low when discharge appliance is opened.	Prime the pump again. Raise pump pressure higher and open the discharge appliance slowly.

Problem—Pump Primer Does Not Operate Properly

Problem—Pump Primer Does Not Operate Properly	
Possible Cause	**Remedy**
Does not operate electrically.	Check the battery, connections, primer, and primer control. Check the control switch and solenoid on the primer. If the primer has not been used recently, it could be frozen. It should, if contact is still being made internally, show heavy current draw.
Primer is slow or lower than normal.	Check batteries, wiring, and connections. A large quantity of suction hoses or suction pipes can exceed primer capabilities. Too small diameter or too long a length of piping between primer and pump can exceed primer capabilities. Lift not to exceed 20 feet (6 m) and 10 feet (3 m) for testing. The primer pump itself may be worn out.
Pulls some prime.	The primer pump could be in need of repairs or cleaning. Check for air leaks and verify that the Priming Valve is not sticking.
Pulls full prime.	Check for air leaks. Check for clogged inlet strainer and screens. Check that the suction hose is submerged in adequate water supply. Check for air pockets and air accumulation in piping. Check for turbulence in piping. The pump impeller may be damaged or severely worn.

Problem—Insufficient Capacity or Pressure

Problem—Insufficient Capacity or Pressure	
Possible Cause	**Remedy**
Insufficient engine power.	Check engine performance.
Improperly set relief valve.	Readjust the relief valve to a higher pressure setting. If the relief valve is set too low it will open to relieve pressure and reduce capacity.
Transmission in incorrect range.	Check the transmission selector for correct range recommended for pumping procedure. Check that the Fourth range lockup has occurred. If the transmission shifts while increasing engine speed, lock up has not occurred. Check engine speed or drive shaft speed for correct transmission range and inaccurate tachometer.
Air leaks.	Perform the "Dry Vacuum Test" which follows the troubleshooting tables in this subject.
Transfer valve in incorrect position.	Transfer valve must be in the "parallel or volume" setting for capacity in the "series or pressure" setting for pressure. The transfer valve indicator may be out of adjustment. At idle, shift the transfer valve back and forth. You should hear the check valves close and see a change in pressure on the Master Pressure gauge.
Tank fill valve leaking.	Repair the leak.

Problem—Engine Speed Too High for Capacity or Pressure

Problem—Engine Speed Too High for Capacity or Pressure	
Possible Cause	**Remedy**
Impeller blockage.	Check and clean. Backflushing through the discharge side of the pump may clear the obstruction. It may require disassembly of the pump.
Worn impeller or clearance rings.	Overhaul the pump. All other possibilities should be eliminated before overhauling the pump.
Suction strainer blocked.	Clean and check.
Lift too high.	Lifts over 10 feet will cause higher engine speeds and vacuum.
Transmission in incorrect range.	Check the transmission selector for correct range for recommended pumping procedure. Check that Fourth range lockup has occurred. If the transmission shifts while increasing engine speed, lockup has not occurred. Check engine speed or drive shaft speed for correct transmission range and inaccurate tachometer.
Check Valves damaged or missing.	At idle, shift the transfer valve back and forth. You should detect a change in the engine/pump sound, hear the check valves close, and see a change in the pressure on the Master Pressure gauge. If no apparent change occurs, remove the suction inlet cap and visually inspect the check valves. Insert a broom handle in the suction inlet and gently push each check valve open and let it close. Check valves should move freely.
Tank fill valve leaking.	Repair the leak.

Troubleshooting

Problem—Relief Valve Does Not Relieve When Valves are Closed

Problem—Relief Valve Does Not Relieve When Valves are Closed	
Possible Cause	**Remedy**
Incorrect pilot valve setting.	Repeat the proper procedure for setting the relief valve.
Pilot valve inoperative.	Disassemble, clean, and lubricate. Inspect the control valve diaphragm for wear or damage.
Relief valve inoperative.	Disassemble, clean, and lubricate.

Problem—Relief Valve Does Not Recover When Valves are Opened

Problem—Relief Valve Does Not Recover When Valves are Opened	
Possible Cause	**Remedy**
Dirt in system resulting in slow or sticky operation.	Disassemble, clean and lubricate.

Problem—Unable to Attain Proper Setting

Problem—Unable to Attain Proper Setting	
Possible Cause	**Remedy**
Incorrect procedure.	Check procedure and reset.
Blocked strainer.	Disconnect the pilot valve supply line from the discharge side of pump. Remove the 90-degree fitting where the supply line connects to the pump. The strainer is attached to this fitting. Clean or replace the strainer and fitting assembly.
Dirt in pilot valve.	Disassemble, clean, and lubricate.
Hunting condition.	Insufficient water supply to the pilot valve. Check strainer and supply lines. If there is dirt in the pilot valve, disassemble, clean, and lubricate.

Problem—TPM Valve Does Not Relieve

Problem—TPM Valve Does Not Relieve	
Possible Cause	**Remedy**
Sensing valve inoperative.	Disassemble, clean, and lubricate. Inspect the control valve diaphragm for wear or damage.
PG relief valve inoperative.	Disassemble, clean, and lubricate.
PG relief valve sluggish.	Check and clean the discharge and suction strainers in the pump body.

Problem—TPM Valve Does Not Recover

Problem—TPM Valve Does Not Recover	
Possible Cause	**Remedy**
Dirt in system resulting in slow or sticky operation.	Disassemble, clean, and lubricate. Check and clean the discharge and suction strainers in the pump body.

Problem—AutoLube

Problem—AutoLube	
Possible Cause	**Remedy**
External leaks.	External leaks are the result of gasket failures. Disassemble and repair.
Internal leaks.	If water is leaking, replace the diaphragm. If oil is leaking, replace the AutoLube seal and the impeller bushing. Heavy oil usage by the AutoLube or oil present in the water when the pump master drain is opened indicates that the AutoLube seal and possibly the impeller bushing is damaged.

Problem—Mechanical Seal Leaks

Problem—Mechanical Seal Leaks	
Possible Cause	**Remedy**
Leak at mechanical seal.	If the mechanical seal is leaking it will have to be replaced. If properly cared for, the mechanical seal should be almost maintenance free. Water quality will greatly affect seal life. The most common failure of the mechanical seal is from thermal-shock. That is running the pump dry, heating up the seal and then opening to a cool or cold water supply. The seal may shatter. Check the AutoLube. If the bushing is worn or missing, the impeller shaft will wobble and fracture the mechanical seal.

Problem—Pump Gear Box Does Not Function Properly

Problem—Pump Gear Box Does Not Function Properly	
Possible Cause	**Remedy**
Water in gear box.	Locate and repair the leak. Remove and clean the gear box filter. Replace the transmission oil. Water leaking onto the input drive shaft of the pump gear box will actually be screwed into the pump transmission past the oil seals. This is not a seal problem. Be certain the slinger(s) are in place. Check the pump gear box cooling line for internal fractures. Pump gear box will fill with water and overflow through breather.
Whine in gear box.	Check the oil level. If oil is low, helical gears and/or tapered bearings will whine. Check oil pressure. If the filter is clogged, oil pressure will be low. Drain oil and check for metal. Remove filter and check for metal. If metal is detected, pump gear box will have to be disassembled for complete inspection and repairs.
Knock or rattle in gear box.	Check for gears missing teeth. Check for damaged bearings. Disassemble and repair. *

* The cause may include foreign objects, low or contaminated oil, or low oil pressure. Low oil level or pressure will result in the transmission being damaged due to overheating.

Dry Vacuum Test

1. Open all the intake valves.
2. Cap all intakes, and close and uncap all discharge valves.

Troubleshooting

3. Using the pump's priming devices, develop a vacuum of at least 22 inHg (74.5 kPa) for 30 seconds for pumps up to 1250 gpm or 45 seconds for pumps 1500 gpm or greater.
4. Reduce the maximum vacuum attained by 1 inHg (3.4 kPa) for each 1,000 ft. (305 m) of elevation of the test site above 2,000 ft. (610 m).

NOTE: The vacuum should not drop more than 10 inHg (33.9 kPa) in five minutes. Do not operate the pump priming device once the five-minute test has begun.

Specifications

See **Fig. 1** for the fire pump wiring diagram.

See **Fig. 2** for the fire pump controls wiring diagram. See **Fig. 3** for a detailed view of the RH switch panel for the fire pump controls and **Fig. 4** for a detailed view of the electrical center.

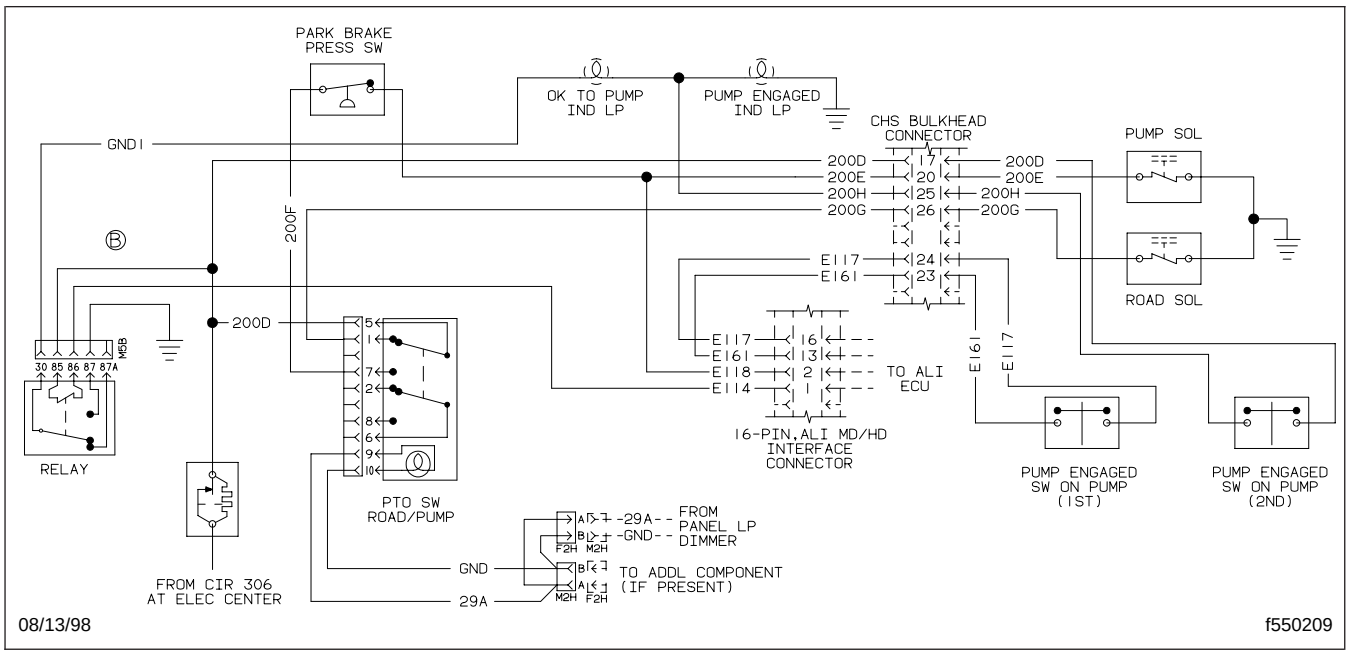


Fig. 1, Fire Pump Wiring Diagram

Specifications

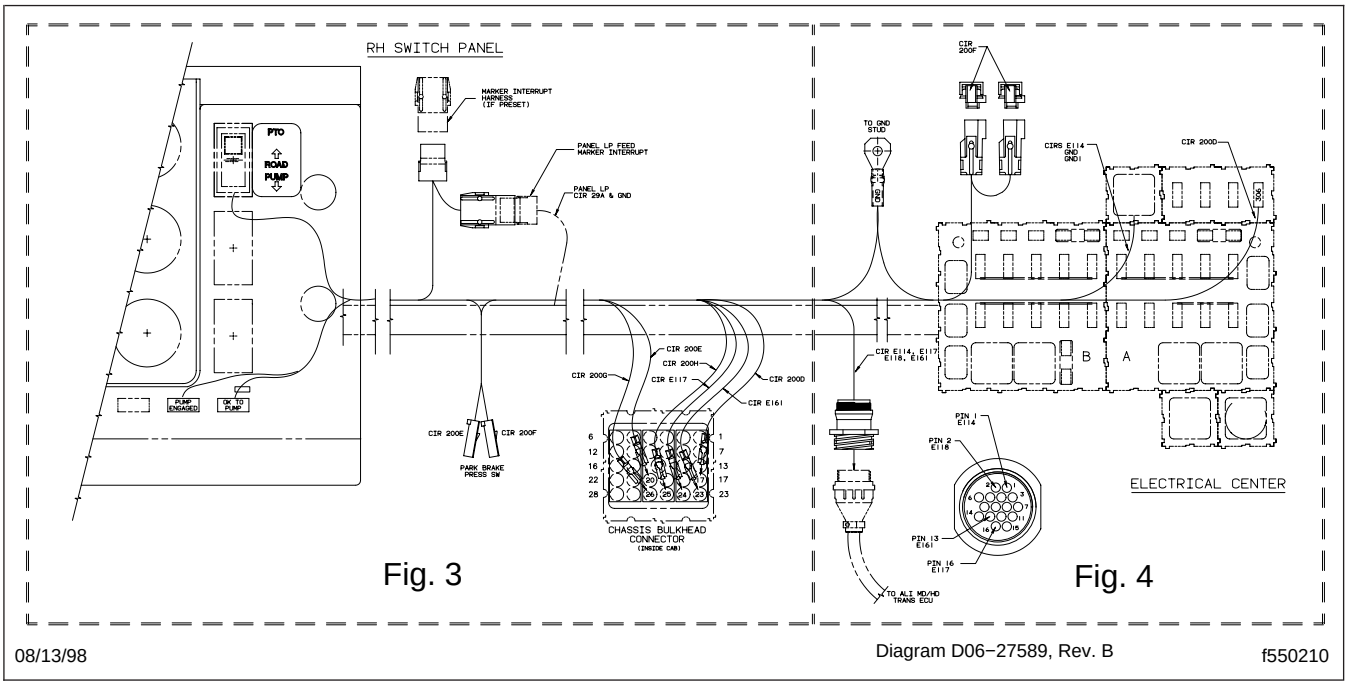


Fig. 2, Fire Pump Controls Wiring Diagram

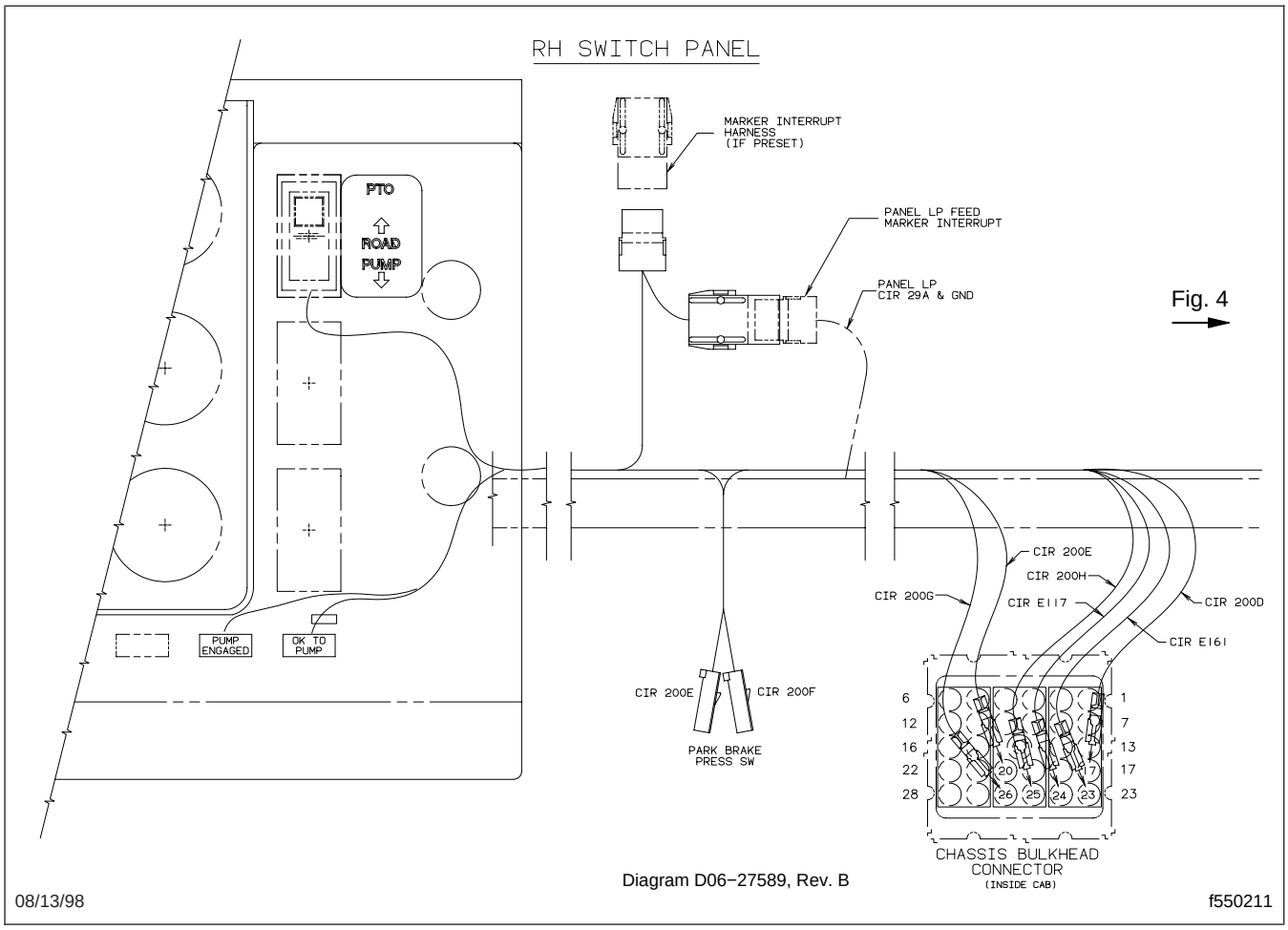


Fig. 3, Fire Pump Controls, RH Switch Panel

Specifications

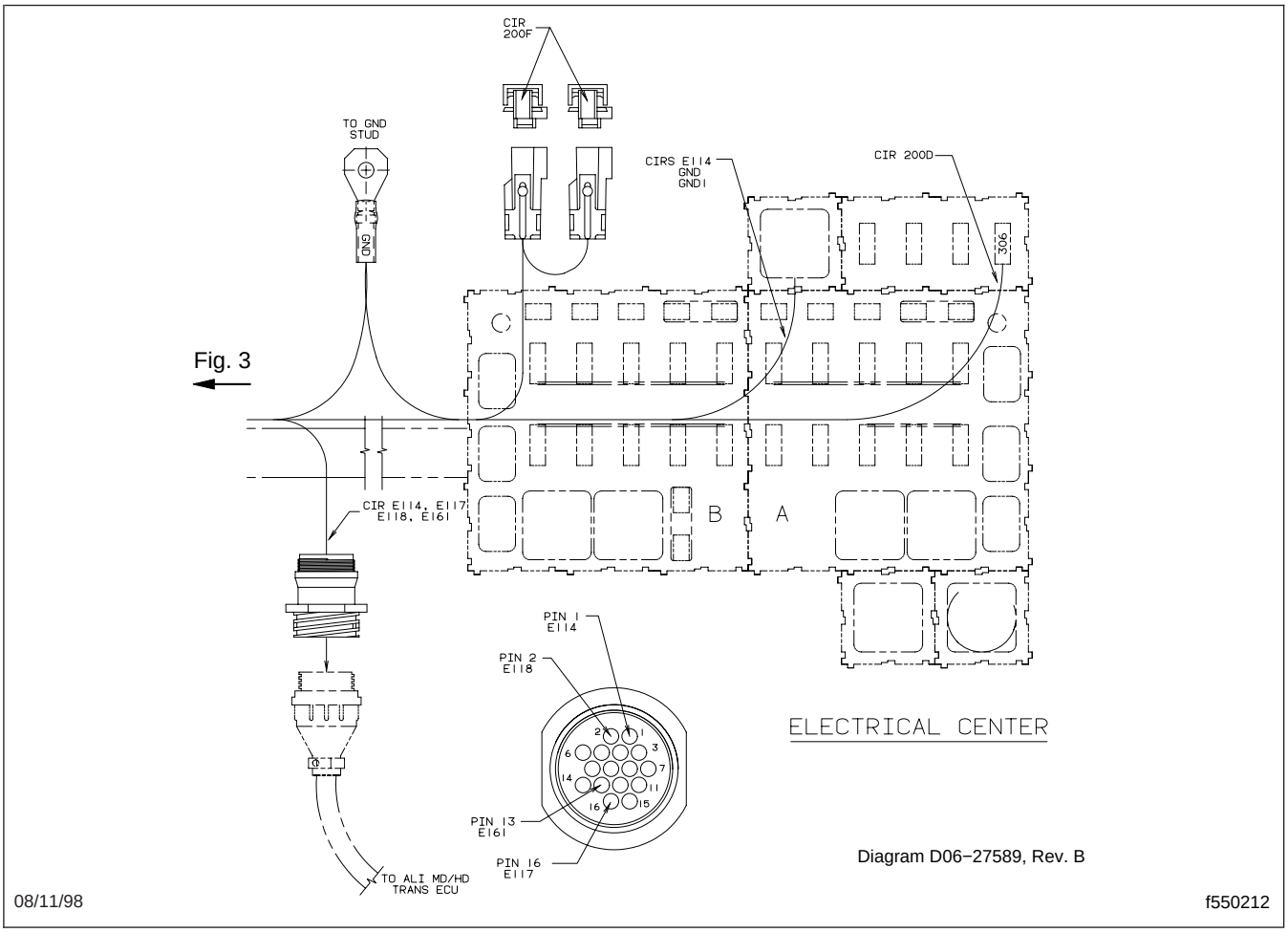


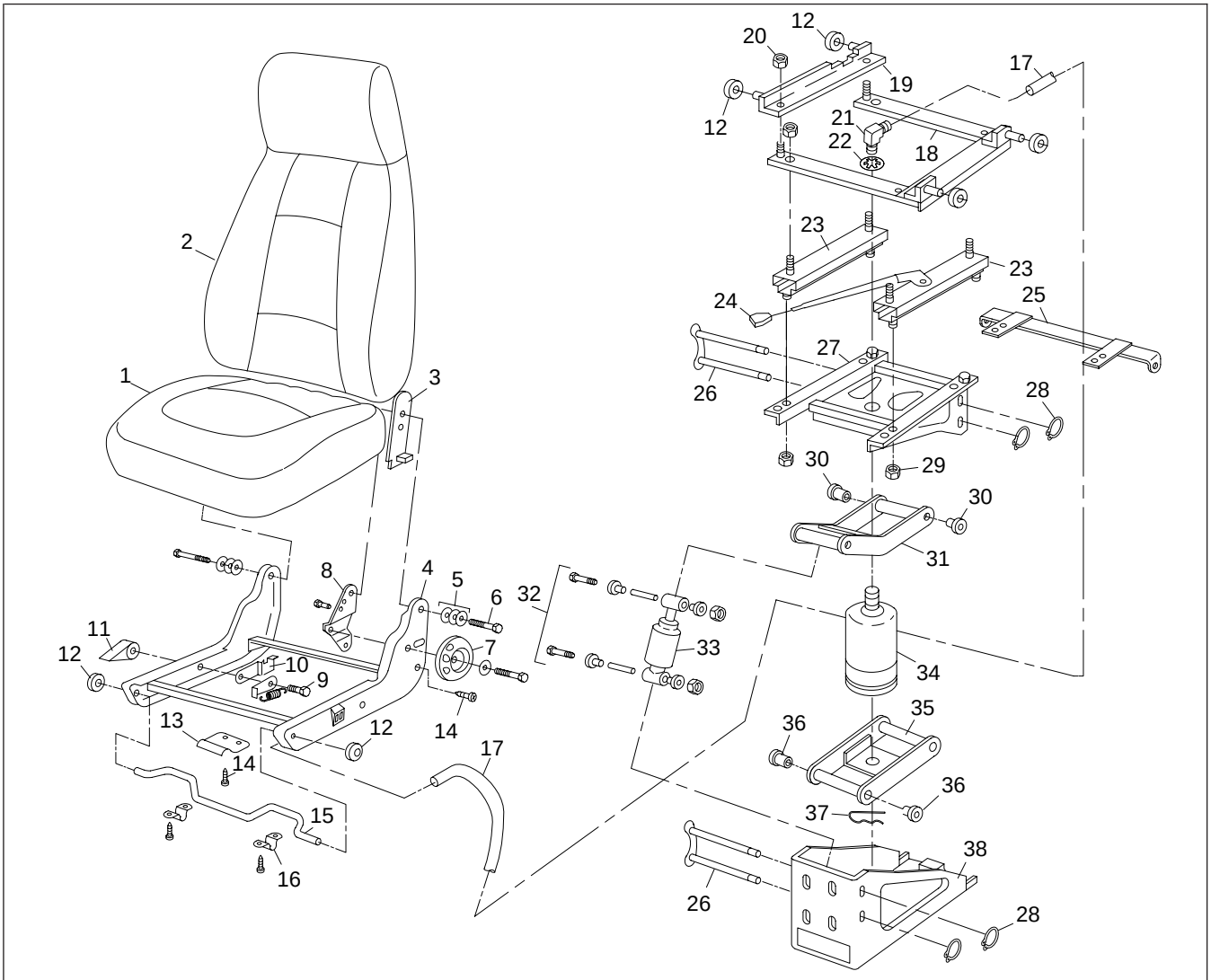
Fig. 4, Fire Pump Controls, Electrical Center

General Information

National Cush-N-Aire II air suspension seats (see **Fig. 1**) offer adjustment features for height, fore and aft positioning, back cushion tilt, lumbar support, and seat cushion tilt. The air suspension and height-adjustment features are provided by an inflatable air spring (air bag) that receives air pressure from the vehicle air system; pressure in the air spring is controlled by a set of switches attached to the seat frame. Each seat is equipped with a shock absorber to dampen unwanted up and down motion of the seat. An isolator (Chugger-Snubber®) allows the seat to move in a simple pendulum motion to isolate its occupant from the cab's fore and aft motion; at the side of the seat's lower frame is an isolator lockout handle that can be used whenever the isolator feature is not desired.

For a complete description of, and operating instructions for, all seat adjustment features, refer to the vehicle driver's manual.

General Information



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1. Seat Cushion
2. Seat Back
3. Back Frame Bracket
4. Upper Seat Frame
5. Flatwashers
6. Back Frame Bolt
7. Back Recline Adjustment Knob
8. Back Limit Bolt Bracket
9. Cushion Adjustment Bolt
10. Cushion Adjustment Bracket
11. Cushion Adjustment Lever
12. Bearing
13. Adjustment Rod Bracket
14. Fastener
15. Adjustment Rod
16. Adjustment Rod Bracket
17. Air Hose
18. Isolator
19. Isolator Bar
20. Locknut
21. Hose Barbed Fitting
22. Retaining Ring
23. Track
24. Fore-and-Aft Adjustment Lever
25. Belt Bar
26. Connected Shaft
27. Seat Support
28. Snap Ring
29. Locknut
30. Bearing
31. Upper Arm
32. Shock Absorber Assembly
33. Shock Absorber
34. Air Spring
35. Lower Arm
36. Bearing
37. Pin Clip
38. Seat Base

Fig. 1, National Cush-N-Aire II Seat

Removal

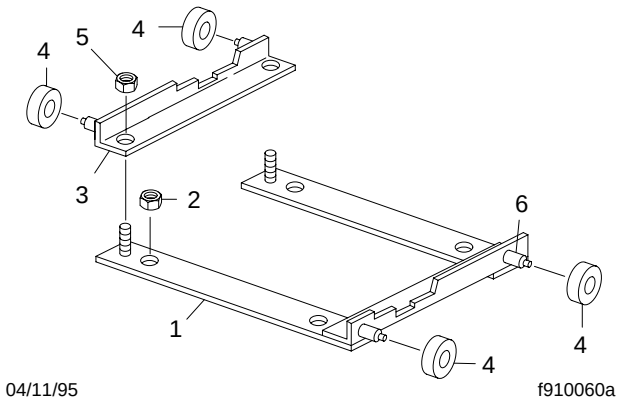
1. Apply the parking brakes, and chock the tires.
2. Push in on the top of the seat ride-height rocker switch until the seat is adjusted to its maximum height.
3. If the seat is equipped with a seat suspension shroud, remove the shroud. It is held in place with Velcro and upholstery-panel fasteners.
4. Cut a wooden block to the length required to support the seat at its maximum height, and place the block between the air suspension seat base and the rear crosstube of the lower arm.
5. Drain the vehicle air reservoirs. Then push in on the bottom of the seat ride-height rocker switch until all air is exhausted from the air spring.
6. Disconnect the air valve air-supply hose at the quick-connect union behind the seat.
7. Using an 11/16-inch wrench or a T50 Torx wrench, unscrew the capscrews that attach the seat-belt straps and tether straps to the intermediate-connecting-point threaded rod.
8. Remove the capscrews and washers that attach the seat to the cab deck. Remove the seat from the cab.

Installation

1. Place the seat on the cab deck. Insert the capscrews through the washers and the seat base. Tighten the capscrews 27 lbf·ft (37 N·m).
2. Attach the brackets of the seat-belt straps and tether straps to the intermediate-connecting-point threaded rod. Tighten the capscrews 40 lbf·ft (54 N·m).
3. Attach the air valve air-supply hose by pressing the pneumatic tubing into the quick-connect union behind the seat.
4. Start the engine and allow the air reservoirs to fill. Push in on the top of the seat ride-height rocker switch until the seat is adjusted to its maximum height, then remove the wooden block that supports the seat suspension.
5. If the seat is equipped with a seat suspension shroud, install the shroud.

Isolator Assembly (Chugger-Snubber®) Replacement

Replacement (see Fig. 1)



1. Welded Bearing Support Frame
2. Locknut
3. Bearing Support Rail
4. Bearing
5. Hexnut
6. Bearing Stud

Fig. 1, Isolator Assembly

1. Remove the air spring supply hose from the seat.
2. Cut off the air spring supply hose close to the barbed fitting; minimize hose length loss. Remove the scrap hose from the barbed fitting. Tape the hose and fitting ends to prevent dirt or other matter from entering.
3. Remove the hexnuts that attach the isolator bearing support rail to the studs on the isolator bearing support frame.
4. Lift up on the side of the seat's lower frame, to slide the bearing support rail up and off the bearing support frame.

NOTE: Two of the isolator bearings will fall off when the bearing support rail is removed.

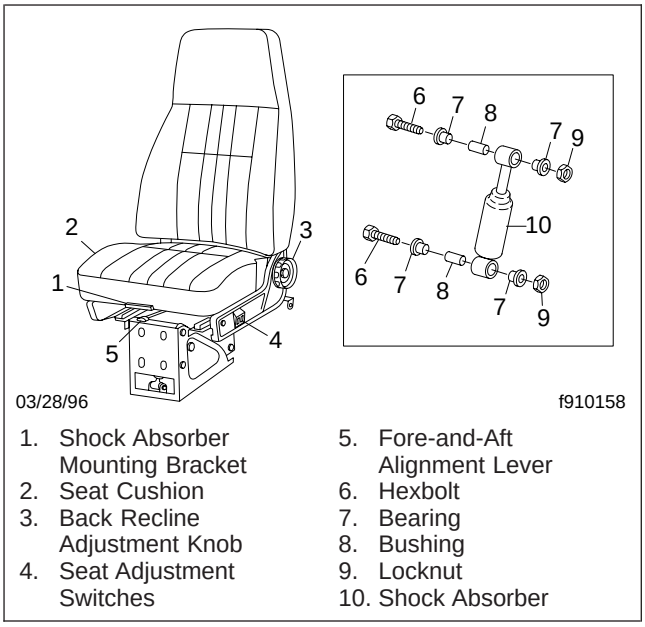
5. Push the seat's upper seat frame toward the opposite side, to remove the other two bearings. Remove the bearings and the unattached upper seat components.
6. Remove the four 5/16–18 locknuts from the bearing support frame. Remove the bearing support frame.
7. Using a multi-purpose chassis grease, lubricate the bearing cups and new isolator bearings.
8. Install the welded bearing support frame on the track assembly. Tighten the four 5/16–18 locknuts 15 lbf·ft (20 N·m).
9. Install two of the isolator bearings on the bearing studs of the bearing support frame, then align the bearing cups on the upper seat frame over the bearings.
10. Assemble the isolator bearing support rail and the two remaining isolator bearings. With the seat cushion tilted forward, install the support rail's bearings in the upper seat frame, and lower the seat frame and support rail assembly onto the isolator bearing support frame. Install the 5/16–18 hexnuts, and tighten them finger-tight.

    Push the isolator assembly fore and aft, and check the position of the isolator bearing support rail before tightening the hexnuts. The isolator should be tight enough to eliminate side play without interfering with the fore-and-aft movement of the seat. Tighten the 5/16–18 hexnuts 15 lbf·ft (20 N·m).
11. Install the air spring supply hose.

Shock Absorber Removal and Installation

Removal (see Fig. 1)

1. Move the fore-and-aft adjustment lever to the right, and slide the upper seat assembly back as far as possible.
2. Raise the upper seat assembly to maximum height. Support the seat in this position by placing a wooden block between the lower arm and the seat base.
3. Remove the shock absorber, bushings, and bearings.



1. Shock Absorber Mounting Bracket
2. Seat Cushion
3. Back Recline Adjustment Knob
4. Seat Adjustment Switches
5. Fore-and-Aft Alignment Lever
6. Hexbolt
7. Bearing
8. Bushing
9. Locknut
10. Shock Absorber

Fig. 1, Shock Absorber Removal/Installation

3.1 Remove the nuts and bolts that attach the shock absorber to the upper arm and the seat base. Remove the shock absorber.

3.2 Remove the bushings and bearings from the shock absorber.

Installation (see Fig. 1)

1. Check the operation of the shock absorber, and replace it if needed.
2. Install the shock absorber and new bearings and bushings.

2.1 Install new bearings and bushings in the shock absorber eyes.

2.2 With the upper arm blocked up, position the shock absorber so its piston-rod end is in the mounting bracket of the upper arm. Install the bolt and locknut to attach the shock absorber to the bracket. Tighten the locknut 25 lbf·ft (34 N·m).

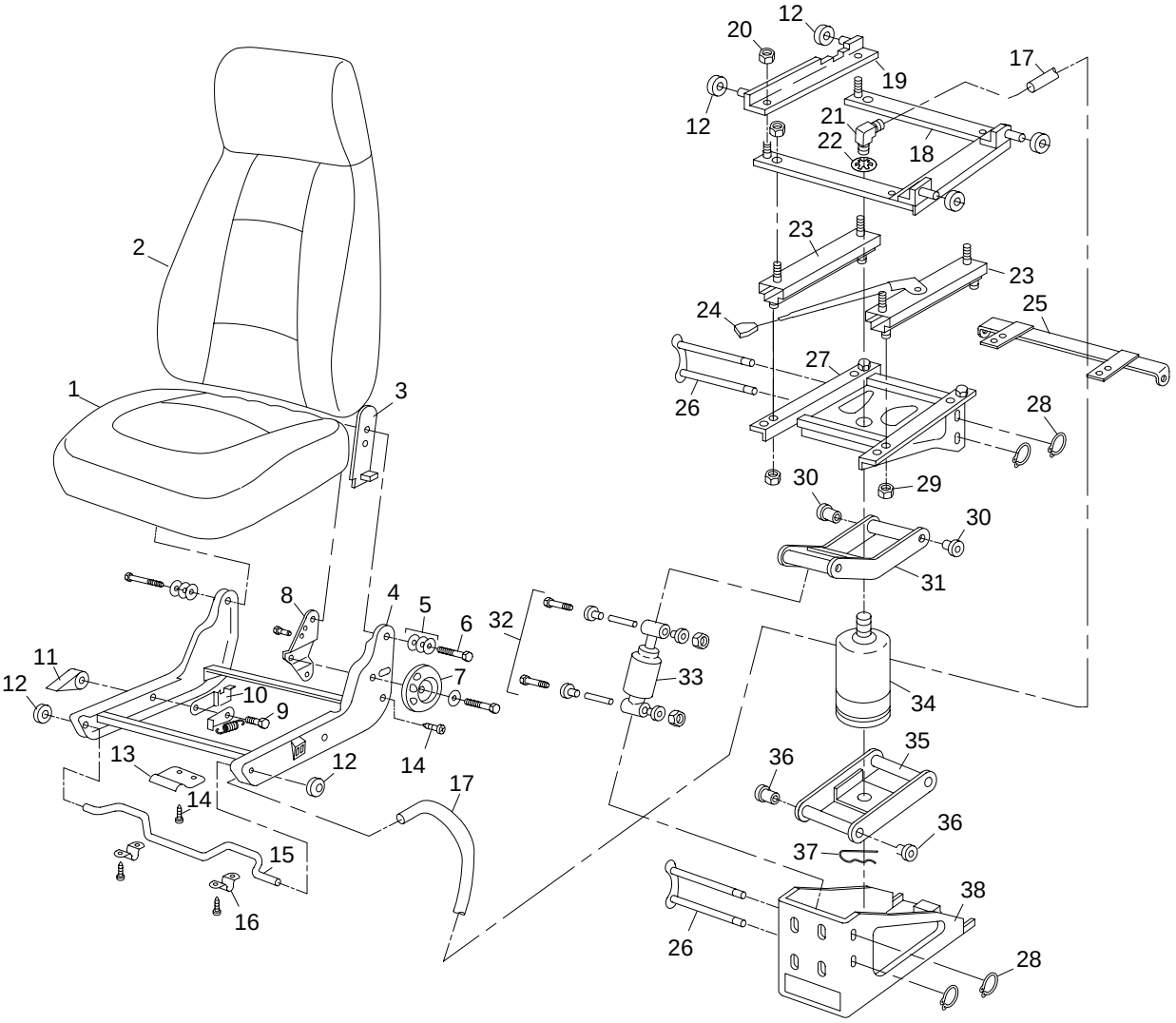
2.3 Position the cylinder end of the shock absorber in the mounting bracket of the seat base. Attach the shock absorber to the seat base. Tighten the locknut 25 lbf·ft (34 N·m).

3. Raise the seat. Remove the wooden block.

Replacement (see Fig. 1)

1. Raise the upper seat assembly to maximum height. Support the seat in this position by placing a wooden block between the lower arm and the seat base.
2. Remove the seat from the vehicle as instructed in **Subject 100**.
3. Lay the seat on its side, with the wooden block still in place.
4. Remove, as an assembly, the fitting and the air hose from the air spring. Tape the end of the fitting to prevent dirt or other matter from entering.
5. Pry the pin clip from the bottom of the air spring.
6. Remove the retaining ring that secures the air spring to the upper arm. Remove the air spring.
7. Position the new air spring in the seat base, and secure it with a new pin clip.
8. Insert the top of the air spring in the opening of the upper arm. Install the retaining ring on the air spring.
9. Install the air spring fitting and air hose in the top of the air spring.
10. Install the seat as instructed in **Subject 100**.
11. Raise the seat. Remove the wooden block.

Air Spring Replacement



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1. Seat Cushion
2. Seat Back
3. Back Frame Bracket
4. Upper Seat Frame
5. Flatwashers
6. Back Frame Bolt
7. Back Recline Adjustment Knob
8. Back Limit Bolt Bracket
9. Cushion Adjuster Bolt
10. Cushion Adjustment Bracket
11. Cushion Adjustment Lever
12. Bearing
13. Adjustment Rod Bracket
14. Fastener
15. Adjustment Rod
16. Adjustment Rod Bracket
17. Air Hose
18. Isolator
19. Isolator Bar
20. Locknut
21. Hose Barbed Fitting
22. Retaining Ring
23. Track
24. Fore-and-Aft Adjustment Lever
25. Belt Bar
26. Connected Shaft
27. Seat Support
28. Snap Ring
29. Locknut
30. Bearing
31. Upper Arm
32. Shock Absorber Assembly
33. Shock Absorber
34. Air Spring
35. Lower Arm
36. Bearing
37. Pin Clip
38. Seat Base

Fig. 1, National Cush-N-Aire II Seat

Base Assembly Bearing/Sleeve Replacement

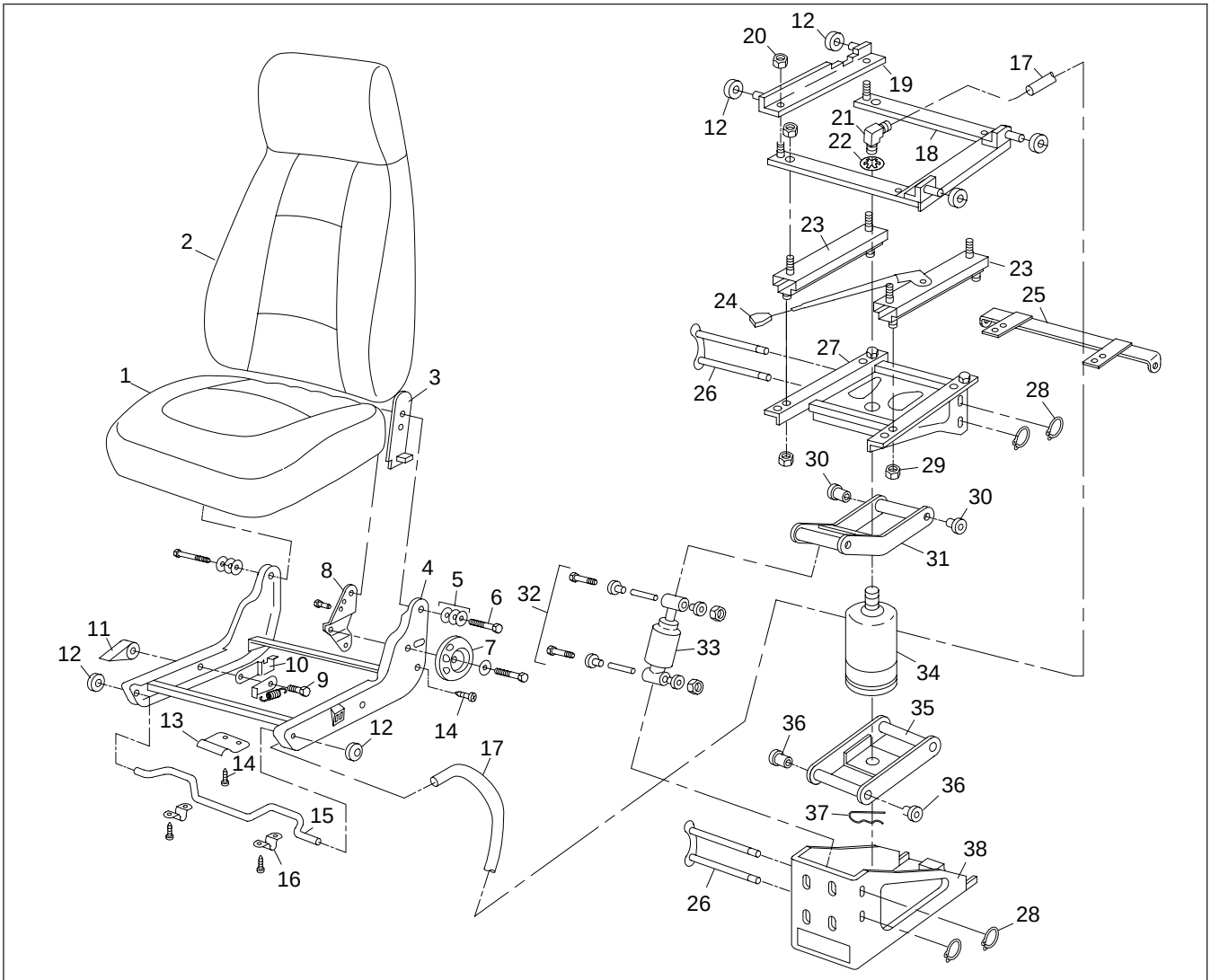
Replacement (see Fig. 1)

1. Remove the shock absorber as instructed in **Subject 120**.
2. Remove the seat as instructed in **Subject 100**.
3. Remove the four locknuts that attach the track assemblies, seat track stop, belt bar and bearings, and upper seat assembly to the seat support. Remove the upper seat assembly, track assemblies, seat track stop, and belt bar and spacers.
4. Remove the retaining ring that secures the air spring to the upper arm.
5. Remove the bearings and/or sleeves from the seat support and the seat base and the upper and lower arms.
   - 5.1 Use snap ring pliers to remove the four snap rings from the connected shaft assemblies. Then, using a drift punch, drive out the shaft assemblies from the seat support and the seat base.

   NOTE: Place the punch against the snap ring end of the shafts. Drive each shaft end a little at a time; the two shafts are connected to each other on the opposite side.

   - 5.2 Remove the seat support, and the upper and lower arms from the air spring and seat base.
   - 5.3 Remove the bearings/sleeves from the upper and lower arms. Discard the bearings/sleeves.
   - 5.4 If so equipped, remove the sleeves/bearings from the seat support and the seat base. Discard the sleeves/bearings.
6. Install new bearings/sleeves, as equipped. See **Fig. 1**.
   - 6.1 Install new bearings/sleeves in the upper and lower arm tubes.
   - 6.2 If so equipped, install new sleeves/bearings in the seat support and the seat base.
   - 6.3 Align the tubes of the lower and upper arms with the holes in the seat base. Be sure the notch in the lower arm is forward and up, and the notch in the upper arm is to the rear and down.
   - 6.4 Install the connected shaft assembly through the seat base and the upper and lower arm forward tubes.
   - 6.5 Align the holes of the seat support with the rear tubes of the lower and upper arms.
   - 6.6 As equipped, install and tighten the pivot bolts, or install the connected shaft assembly through the seat support and the upper and lower arm tubes.
   - 6.7 For connected shaft assemblies, use snap ring pliers to install the snap rings that secure the shafts and the arms to the seat base and the seat support.
7. Insert the top of the air spring through the upper arm. Install the retaining ring.
8. Set the seat base assembly upright.
9. Install the shock absorber as instructed in **Subject 120**.
10. Place the belt bar and bearings, seat track stop, track assemblies, and upper seat assembly on the seat base. Install the locknuts, and tighten 15 lbf·ft (20 N·m).
11. Install the seat as instructed in **Subject 100**.

Base Assembly Bearing/Sleeve Replacement



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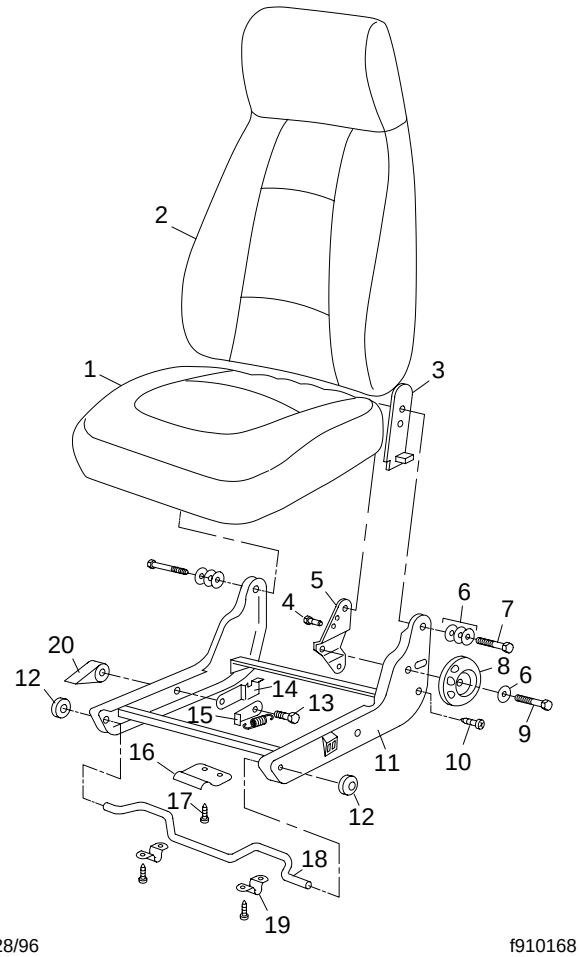
1. Seat Cushion
2. Seat Back
3. Back Frame Bracket
4. Lower Frame
5. Flatwashers
6. Back Frame Bolt
7. Back Recline Adjustment Knob
8. Back Limit Bolt Bracket
9. Cushion Adjustment Bolt
10. Cushion Adjustment Bracket
11. Cushion Adjustment Lever
12. Bearing
13. Adjustment Rod Bracket
14. Fastener
15. Adjustment Rod
16. Adjustment Rod Bracket
17. Air Hose
18. Isolator
19. Isolator Bar
20. Locknut
21. Hose Barbed Fitting
22. Retaining Ring
23. Track
24. Fore-and-Aft Adjustment Lever
25. Belt Bar
26. Connected Shaft
27. Seat Support
28. Snap Ring
29. Locknut
30. Bearing
31. Upper Arm
32. Shock Absorber Assembly
33. Shock Absorber
34. Air Spring
35. Lower Arm
36. Bearing
37. Pin Clip
38. Seat Base

Fig. 1, National Cush-N-Aire II Seat

Removal (see Fig. 1)



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1. Seat Cushion
2. Seat Back
3. Back Frame Bracket
4. Back Limit Bolt
5. Back Limit Bolt Bracket
6. Flatwashers
7. Back Frame Bolt
8. Back Recline Adjustment Knob
9. Hexbolt
10. Screw
11. Lower Frame
12. Bearing
13. Cushion Adjustment Bolt
14. Cushion Adjustment Bracket
15. Cushion Adjustment Spring Bracket
16. Adjustment Rod Bracket
17. Fastener
18. Adjustment Rod
19. Adjustment Rod Bracket
20. Cushion Adjustment Lever

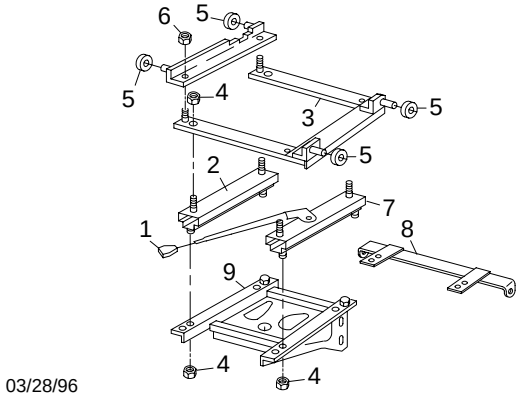
Fig. 1, Upper Seat Frame Assembly (exploded view)

1. Remove the suspension shroud (if equipped) from the seat base.
2. Remove the plastic tie strap that attaches the seat cushion to the upper seat frame assembly.
3. Remove the fasteners that attach the seat cushion to the front cushion adjustment rod. Remove the seat cushion.
4. Disconnect the air spring supply hose from the air spring.
5. Remove the four locknuts from under the top flange of the seat support assembly.
6. Remove the lower frame from the seat base.

Installation

1. Place the lower frame on the seat support assembly. Install the locknuts under the top flange of the seat support assembly. Tighten the locknuts 10 lbf·ft (15 N·m).
2. Attach the air spring supply hose to the air spring. Make sure that the air hose moves without any restrictions when the seat is moved forward or rearward.
3. Position the seat cushion, then install the fasteners that attach the seat cushion to the front cushion adjustment rod.
4. Install a new plastic tie strap to secure the seat cushion to the lower frame assembly.
5. Install the suspension shroud (if equipped) on the seat base.

Replacement (see Fig. 1)



1. Fore-and-Aft Adjustment Lever
2. Right-Side Track
3. Welded Bearing Support Frame
4. Locknut
5. Bearing
6. Hexnut
7. Left-Side Track
8. Belt Bar
9. Seat Support

Fig. 1, Track Assembly (exploded view)

1. Raise the upper seat assembly to maximum height. Support the seat in this position by placing a wooden block between the lower base and lower arm.
2. Pull up and support the rear edge of the seat cushion as needed to gain access to the isolator-assembly-to-track-assembly 5/16–18 locknuts.
3. Remove the air spring supply hose from the seat.
   - 3.1 Cut and remove the tie strap that attaches the air spring supply hose to the track assembly latch mechanism.
   - 3.2 Remove the air spring supply hose (as an assembly), and lay it on the cab deck, behind the seat.
4. Remove the four 5/16–18 locknuts that attach the isolator assembly to the top of the track assemblies. Remove the upper seat assembly.
5. Remove the four 5/16–18 locknuts that attach the track assemblies to the top of the seat support. Remove the track assemblies.
6. With the holes in the belt bar, belt bar spacers, and seat track stop aligned with the holes in the seat support, install the new track assemblies on the seat support. Install and tighten the four 5/16–18 locknuts 15 lbf·ft (20 N·m).
7. Move the upper half of the track assemblies as needed to align their studs with the holes in the isolator assembly. Place the upper seat assembly on the track assemblies. Install and tighten the four 5/16–18 locknuts 15 lbf·ft (20 N·m).
8. Install the air spring supply hose.
   - 8.1 Install a new tie strap to attach the air spring supply hose to the track assembly latch mechanism.
   - 8.2 Install a new tie strap to attach the air valve supply hose to the belt bar.
9. Move the fore-and-aft adjustment lever to the right, and slide the upper seat assembly forward and rearward while making sure that the air hose moves without restriction. Return the seat cushion to its original position.
10. Raise the seat. Remove the wooden block.

Specifications

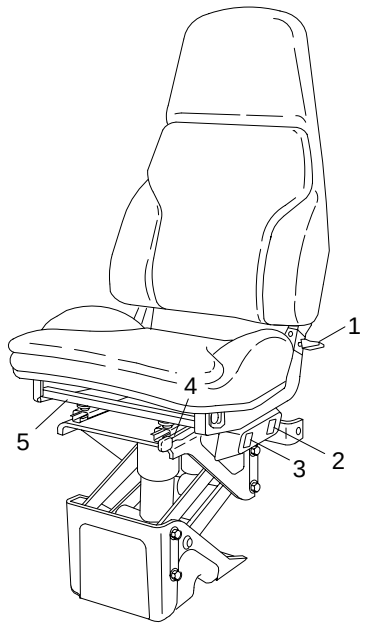
Fastener Torques	
Description	**Torque: lbf·ft (N·m)**
Seat Base to Cab Deck Socket-Head Bolts	13 (18)
Seat Belt/Tether Belt to Belt Bar Capscrews	40 (54)
Shock Absorber to Bracket Locknuts	25 (34)
Track Assembly to Isolator Assembly Locknuts	15 (20)
Track Assembly to Upper Seat Frame Locknuts	15 (20)

Table 1, Fastener Torques

General Information

NOTE: Call Dura-Form Customer Service at 800–553–3013 to answer any questions concerning any Dura-Form seat style not covered by the information provided.

The Dura-Form Fleetcruiser air suspension seats offer lumbar support, back cushion tilt adjustment, height adjustment, a fore and aft isolator system, and seat cushion adjustment. See **Fig. 1**.



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1. Back Cushion Tilt Adjustment
2. Lumbar Support
3. Height Adjustment
4. Isolator and Fore-Aft Adjustment
5. Seat Cushion Adjustment

Fig. 1, Dura-Form Fleetcruiser Seat

For complete operating instructions, see the vehicle driver's manual.

Removal

NOTE: Call Dura-Form Customer Service at 800–553–3013 to answer any questions concerning any Dura-Form seat style not covered by the information provided.

1. Apply the parking brakes, and chock the tires.
2. Press the seat height adjustment rocker switch until the seat is adjusted to its maximum height.
3. If the seat is equipped with a seat suspension shroud, remove the shroud. It is held in place with Velcro and upholstery-panel fasteners.

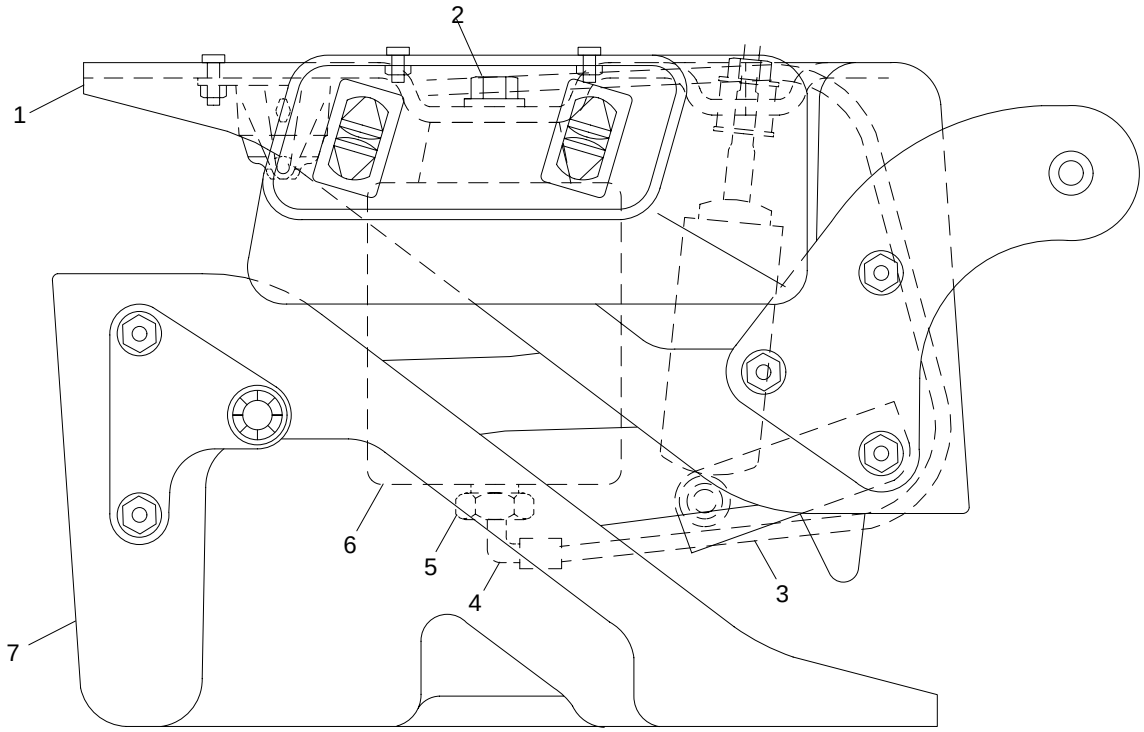
   If the seat is equipped with a rubber bellows seat suspension cover, raise the rubber bellows.
4. Cut a wooden block to the length required to support the seat at its maximum height, and place the block between the air suspension lower base and the rear crosstube of the lower arm.
5. Drain the vehicle air reservoirs. Then, press the seat height adjustment rocker switch until all air is exhausted from the air spring.
6. Disconnect the air valve air-supply hose at the quick-connect union behind the seat.
7. Using an 11/16-inch wrench or a T50 Torx® wrench, unscrew the capscrews that attach the seat-belt straps and tether straps to the intermediate-connecting-point threaded rod.
8. Remove the capscrews and washers that attach the seat to the cab deck. Remove the seat and both mounting support channels from the cab.

Installation

1. Place the seat on the cab deck. Position a mounting support channel at the front edge, and another at the rear edge of the seat base. Insert the capscrews through the washers, the support channels, and the seat base. Tighten the capscrews 27 lbf·ft (37 N·m).
2. Attach the brackets of the seat-belt straps and tether straps to the intermediate-connecting-point threaded rod. Tighten the capscrews 40 lbf·ft (54 N·m).
3. Connect the air valve air-supply hose by pressing the pneumatic tubing into the quick-connect union behind the seat.
4. Start the engine and allow the air reservoirs to fill. Press the seat height adjustment rocker switch until the seat is adjusted to its maximum height. If the seat is equipped with a rubber bellows seat suspension cover, raise the rubber bellows. Remove the wooden block that supports the seat suspension.
5. If the seat is equipped with a seat suspension shroud, install the shroud.
6. Remove the chocks from the tires.

Air Spring Removal and Installation

Removal (See Fig. 1)



03/06/97 f910211

1. Upper Housing
2. Hexhead Bolt
3. Tubing, Valve To Spring
4. Elbow
5. Jam Nut
6. Air Spring
7. Lower Housing

Fig. 1, Air Spring Assembly

NOTE: Call Dura-Form Customer Service at 800–553–3013 to answer any questions concerning any Dura-Form seat style not covered by the information provided.

1. Apply the parking brakes, and chock the tires.
2. Press the seat height adjustment switch until the seat is adjusted to its maximum height.
3. Cut a wooden block to the length required to support the seat at its maximum height, and place the block between the lower housing and the upper housing.
4. Drain the vehicle air reservoirs. Then press the seat height adjustment switch until all the air is exhausted from the air spring.
5. Disconnect the 7/16-inch air fitting at the bottom of the air spring. Remove the 3/4-inch jam nut.
6. Remove the 1/2-inch hexhead bolt and lockwasher at the top of the air spring.
7. Compress the air spring and rotate it forward to lift it out.

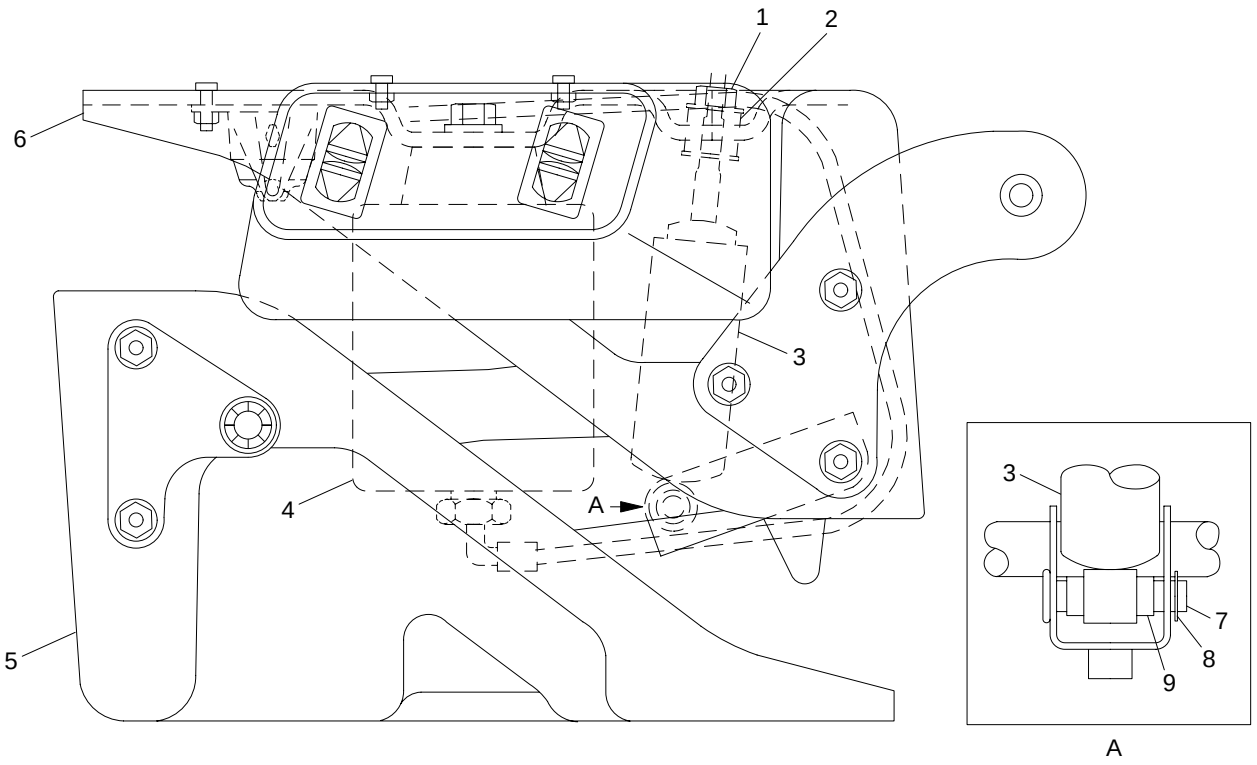
Installation (See Fig. 1)

1. Compress the air spring and install it by rotating it rearward.
2. Install the 1/2-inch hexhead bolt and lockwasher at the top of the air spring. Tighten 15 to 20 lbf·ft (20 to 27 N·m).

Air Spring Removal and Installation

3. Apply pipe sealant to the threads of the elbow. Insert the tube into the fitting until the tube bottoms in the fitting, then tighten one wrench turn past finger tight. Tighten the pipe threads on the fitting 12 to 18 lbf·ft (16 to 24 N·m).
4. Connect the air fitting to the air spring with the 3/4-inch jam nut. Tighten 72 to 96 lbf·in (800 to 1100 N·cm).
5. Start the engine and allow the air reservoirs to fill. Press the seat height adjustment switch until the seat is adjusted to its maxium height, then remove the wooden block.
6. Remove the chocks from the tires.

Removal (See Fig. 1)



A. Shock Mounting
1. Nut
2. Bushing
3. Shock Absorber
4. Air Spring
5. Lower Housing
6. Upper Housing
7. Shock Pin
8. Retaining Ring
9. Shock Bearing

Fig. 1, Shock Absorber Assembly

NOTE: Call Dura-Form Customer Service at 800–553–3013 to answer any questions concerning any Dura-Form seat style not covered by the information provided.

1. Apply the parking brakes, and chock the tires.
2. Press the seat height adjustment switch until the seat is adjusted to its maximum height.
3. Cut a wooden block to the length required to support the seat at its maximum height, and place the block between the lower housing and the upper housing.
4. Remove the 5/16-inch nut at the top of the shock absorber.
5. Remove the retaining ring and the shock pin at the bottom of the shock absorber.
6. Remove the shock absorber.

Installation (See Fig. 1)

1. Install the shock absorber.
2. Install the 5/16-inch nut at the top of the shock absorber. Tighten 10 to 15 lbf·ft (14 to 20 N·m).

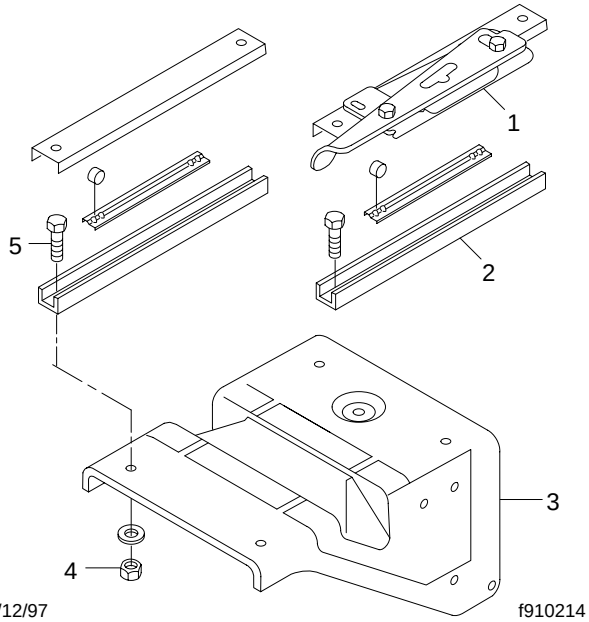
NOTE: The pin hole closest to the air spring is the firmer ride.

3. Install the shock pin and the retaining ring at the bottom of the shock absorber.

Shock Absorber Removal and Installation

4. Remove the wooden block from the seat, and the chocks from the tires.

Removal (See Fig. 1)



1. Isolator Plate and Handle
2. Slide
3. Upper Housing
4. Nut
5. Screw

Fig. 1, Isolator and Slides Assembly

NOTE: Call Dura-Form Customer Service at 800–553–3013 to answer any questions concerning any Dura-Form seat style not covered by the information provided.

1. Apply the parking brakes, and chock the tires.
2. Press the seat height adjustment switch until the seat is adjusted to its maximum height.
3. Cut a wooden block to the length required to support the seat at its maximum height, and place the block between the lower housing and the upper housing.
4. Remove the seat/back assembly using the instructions in **Subject 140**.
5. Remove the isolator assembly using a 1/2-inch socket and a 1/2-inch wrench.

Installation (See Fig. 1)

1. Install the isolator assembly using a 1/2-inch socket or wrench and a screwdriver.
2. Install the seat/back assembly using the instructions in **Subject 140**.
3. Remove the wooden block from the seat, and the chocks from the tires.

Seat/Back Assembly Removal and Installation

Removal

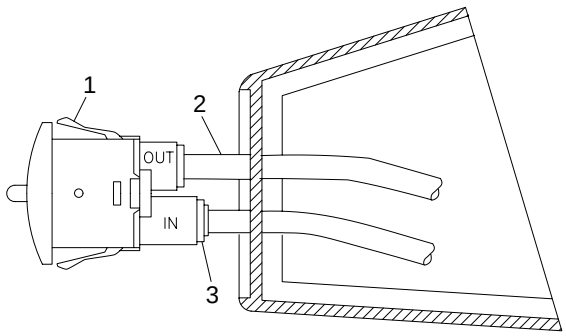
NOTE: Call Dura-Form Customer Service at 800–553-–3013 to answer any questions concerning any Dura-Form seat style not covered by the information provided.

1. Apply the parking brakes, and chock the tires.
2. Remove the four mounting bolts using a 1/2-inch socket and a 1/2-inch wrench.
3. Remove the seat/back assembly.

Installation

1. Place the seat/back assembly onto the isolator assembly.
2. Install the four mounting bolts using a 1/2-inch socket and a 1/2-inch wrench.
3. Remove the chocks from the tires.

Removal (See Fig. 1)



1. Retaining Fingers
2. Air Hose
3. Retaining Ring

Fig. 1, Air Valve Assembly

NOTE: Call Dura-Form Customer Service at 800–553–3013 to answer any questions concerning any Dura-Form seat style not covered by the information provided.

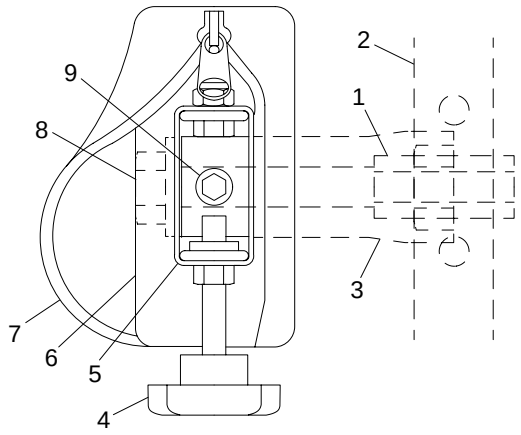
1. Apply the parking brakes, and chock the tires.
2. Drain the vehicle air reservoirs. Then press the seat height adjustment rocker switch until all air is exhausted from the air spring.
3. Reach behind and inside the air control panel and compress the two retaining fingers together on the air valve.
4. Remove the air valve by pushing it outward through the slot in the control panel.
5. Compress the gray retaining ring on the valve body inlet port toward the valve, and pull on the air hose to remove it from the valve.
6. Repeat the previous step for the outlet port.

Installation (See Fig. 1)

IMPORTANT: When installing the air lines, make sure they are connected to the same valve port they were removed from, and are firmly pressed into place. The new air line will insert approximately 1/2-inch when installed properly.

1. Install the air lines in the valve. Pull outward slightly on the new air lines to ensure a solid installation. Do not compress the air line retaining rings when verifying the installation.
2. Make sure the valve is properly oriented, and firmly press the complete valve back into the slot in the air control panel until you hear a "click." The "click" assures the valve retaining fingers are properly secured to the air control panel.
3. Start the engine and allow the air reservoirs to fill.
4. Remove the chocks from the tires.

Removal (See Fig. 1)



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1. Coupling Nut (welded to seat frame assembly)
2. Seat Frame Assembly
3. Pivot Bar
4. Adjustment Knob
5. Armrest Tube
6. Armrest Foam
7. Armrest Cover
8. Armrest Bolt
9. Socket Head Screw

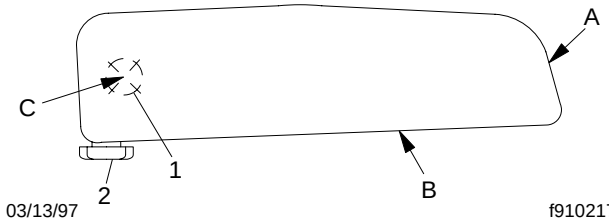
Fig. 1, Armrest, Rear View

NOTE: Call Dura-Form Customer Service at 800–553–3013 to answer any questions concerning any Dura-Form seat style not covered by the information provided.

1. Apply the parking brakes, and chock the tires.
2. Unzip the armrest cover.
3. Remove the socket head screw from the pivot bar in the armrest.
4. Loosen the armrest bolt.
5. Remove the armrest.
6. Remove the pivot arm from the seat back.

Installation

1. Locate the hole in the side of the armrest foam and make an incision. See **Fig. 2**.
2. Locate the coupling nut (welded to the seat frame assembly). Make an incision in the seat back cover. See **Fig. 3**.



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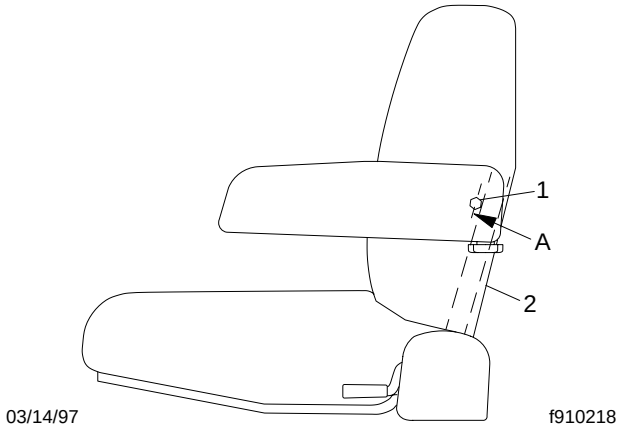
A. Front
B. Bottom
C. Place incision on this side for the left-hand armrest. Place on the opposite side for the right-hand armrest.
1. Hole
2. Adjustment Knob

Fig. 2, Armrest



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A. Place incision on this side for the left-hand armrest. Place on the opposite side for the right-hand armrest.
1. Coupling Nut (welded to seat frame assembly)
2. Seat Back

Fig. 3, Coupling Nut Location

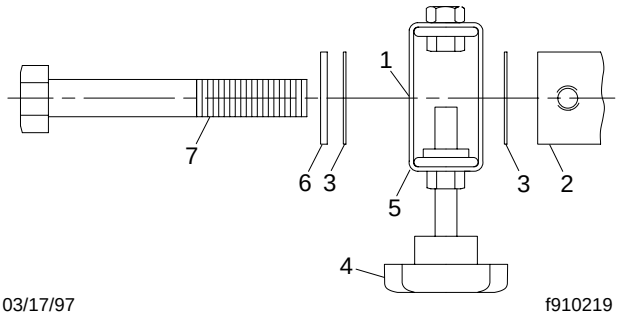
3. Insert the pivot bar through the incision in the seat back cover. Slide the pivot bar over the coupling nut with the hole for the socket head screw facing rearward. See **Fig. 1**.

NOTE: The seat back cover and foam will hold the pivot bar in place while the remainder of the armrest is prepared for assembly.

4. Unzip the armrest cover and assemble the armrest bolt, the metal washer, and the plastic washers through the hole in the side of the armrest tube. See **Fig. 4**. The armrest tube must be

Armrest Removal and Installation

clamped between the two plastic washers when assembly is complete.



1. Small Hole
2. Pivot Bar
3. Plastic Washer
4. Adjustment Knob
5. Armrest Tube
6. Metal Washer
7. Armrest Bolt

Fig. 4, Armrest Assembly

5. Slide the assembled armrest over the pivot bar. Tighten the armrest bolt 22 to 23 lbf·ft (29 to 31 N·m). See **Fig. 1**.

IMPORTANT: The pivot bar must be seated against the seat frame while the armrest bolt is tightened.

6. Install the socket head screw into the pivot bar. See **Fig. 1**. Tighten 10 to 16 lbf·ft (13 to 21 N·m).
7. Zip up the armrest cover.
8. Remove the chocks from the tires.

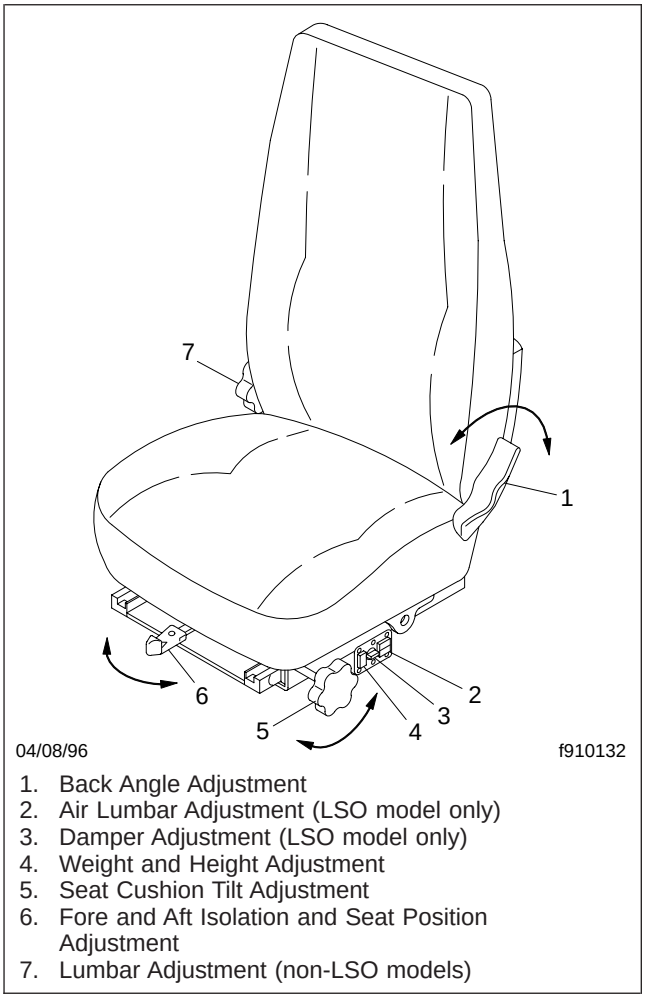
Specifications

Fastener Torques		
Description	**Size**	**Torque**
Seat Base Hexhead Capscrews	3/8–16	27 lbf·ft (37 N·m)
Intermediate-Connecting-Point Rod Capscrews	11/16	40 lbf·ft (54 N·m)
Air Spring Hexhead Bolt	1/2	15–20 lbf·ft (20–27 N·m)
Air Spring Fitting Pipe Threads	—	12–18 lbf·ft (16–24 N·m)
Air Fitting to Air Spring Jam Nut	3/4	72–96 lbf·in (800–1100 N·cm)
Shock Absorber Nut	5/16	10–15 lbf·ft (14–20 N·m)
Armrest Bolt	—	22–23 lbf·ft (29–31 N·m)
Socket Head Screw	—	10–16 lbf·ft (13–21 N·m)

Table 1, Fastener Torques

General Information

The Bostrom Talladega 900 series air suspension seats offer weight-height adjustment, infinite adjustment Parabar II lumbar support and a fore and aft roller track isolator system. See **Fig. 1**.

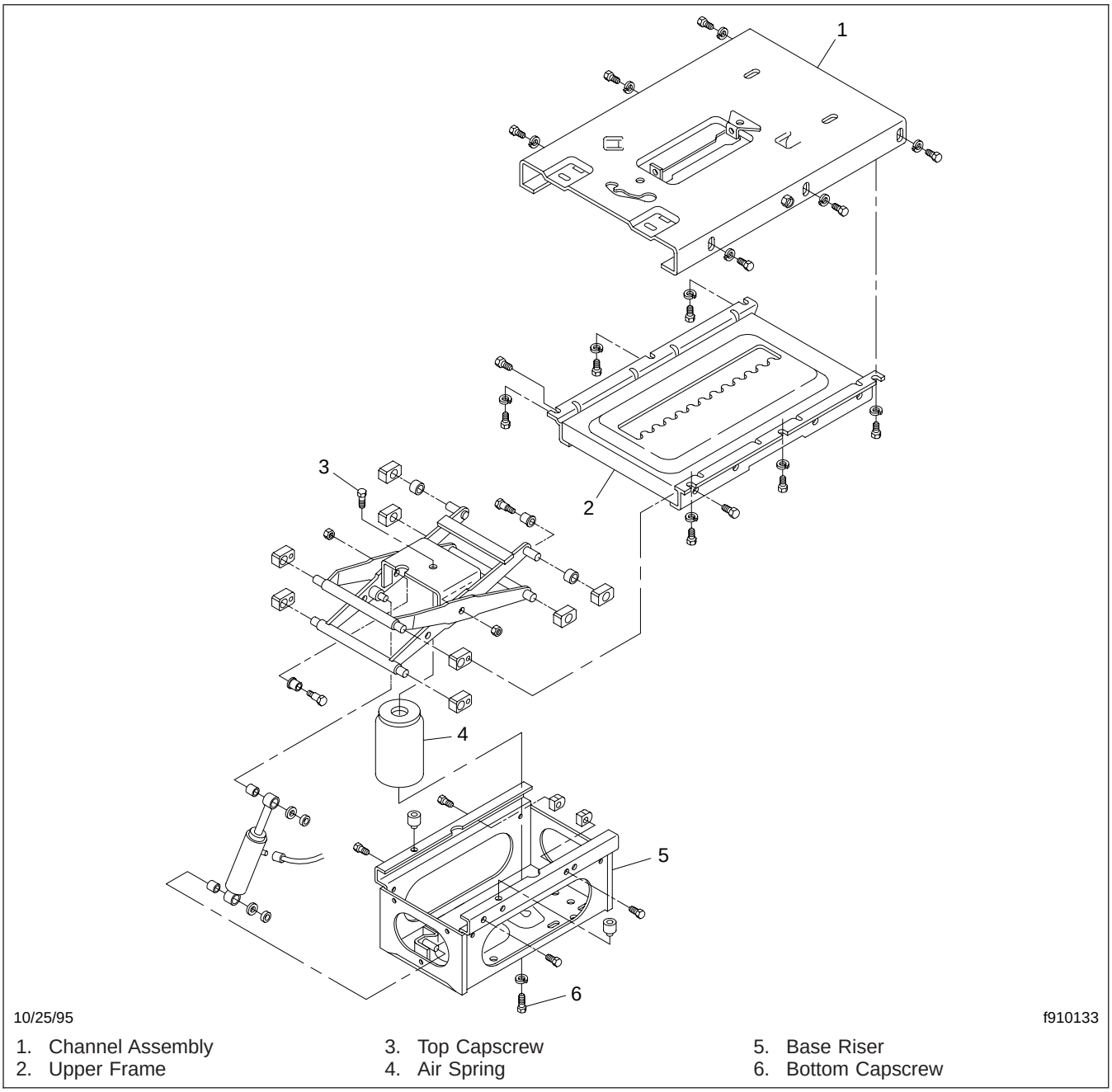


1. Back Angle Adjustment
2. Air Lumbar Adjustment (LSO model only)
3. Damper Adjustment (LSO model only)
4. Weight and Height Adjustment
5. Seat Cushion Tilt Adjustment
6. Fore and Aft Isolation and Seat Position Adjustment
7. Lumbar Adjustment (non-LSO models)

Fig. 1, Bostrom Talladega 900 Series Seat

For complete operating instructions, refer to the vehicle driver's manual.

Removal (See Fig. 1)



1. Channel Assembly
2. Upper Frame
3. Top Capscrew
4. Air Spring
5. Base Riser
6. Bottom Capscrew

Fig. 1, Bostrom Talladega 900 Series Seat Air Spring

NOTE: The seat, the seat/back assembly, and the channel assembly do not need to be re-

Air Spring Removal and Installation

moved. Move the channel assembly to the rearmost position to provide access to the air spring.

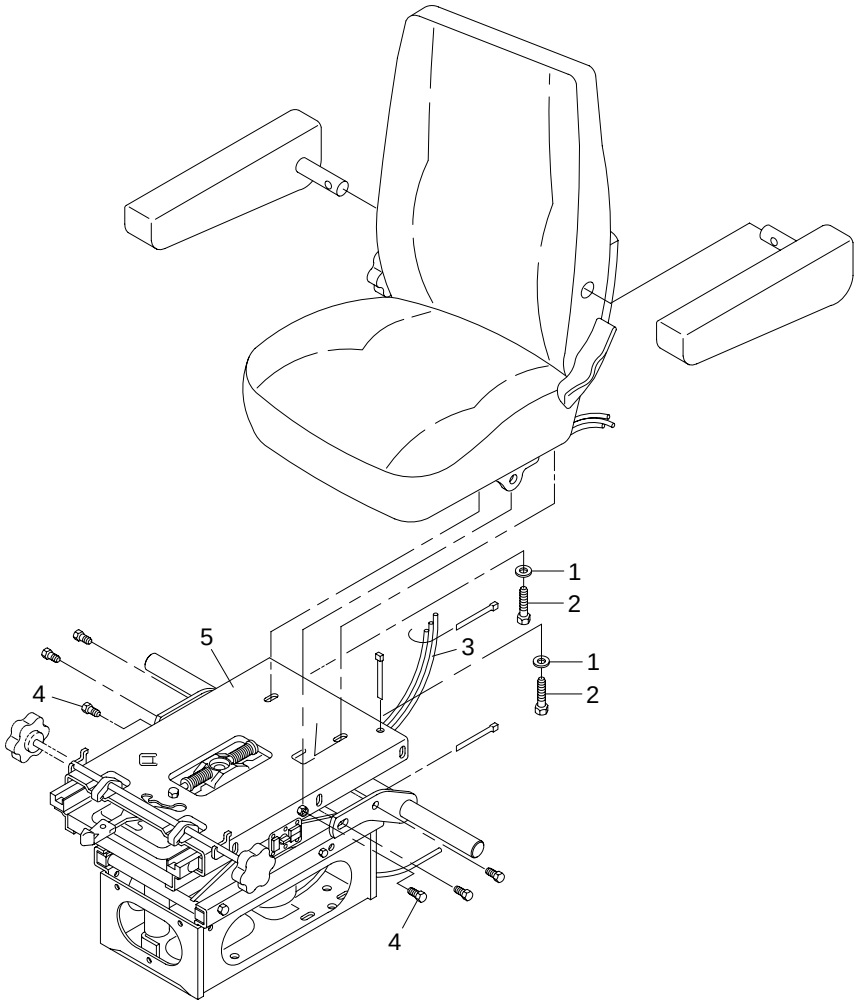
1. Fill the air spring so that the seat is at maximum height.
2. Block the suspension up with a spacer placed between the base riser and the upper frame .
3. Release the air pressure from the air spring so that the seat is supported by the spacer.
4. Disconnect the air line from the air spring by pushing in the collar of the fitting while pullling the air line out of the fitting.
5. Remove the top capscrew, and loosen the bottom capscrew through the rear opening in the base riser. Remove the air spring from the suspension.

Installation (See Fig. 1)

1. Assemble the bottom capscrew to the new air spring. Install the air spring by fitting the bottom capscrew into the key hole opening in the bottom of the base riser. Position the air spring so the fitting at the bottom of the air spring is toward the front of the seat.
2. Tighten the bottom capscrew 9 to 11 lbf·ft (12 to 15 N·m).
3. Install the top capscrew and torque 15 to 19 lbf·ft (20 to 26 N·m).
4. Connect the air line to the fitting in the air spring by pushing the tube into the fitting.
5. Fill the air spring and remove the spacer block.

Seat/Back Assembly Removal and Installation

Removal (See Fig. 1)



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1. Flatwasher
2. Capscrew
3. Air Lines
4. Shoulder Bolt
5. Channel Assembly

Fig. 1, Bostrom Talladega 900 Series Seat

1. Adjust the seat/back assembly to the most rearward position and remove the two capscrews and flatwashers from the underside of the channel assembly.
2. Remove the two shoulder bolts from the channel assembly.
3. Disconnect the air lines.
4. Remove the seat/back assembly.

Installation (See Fig. 1)

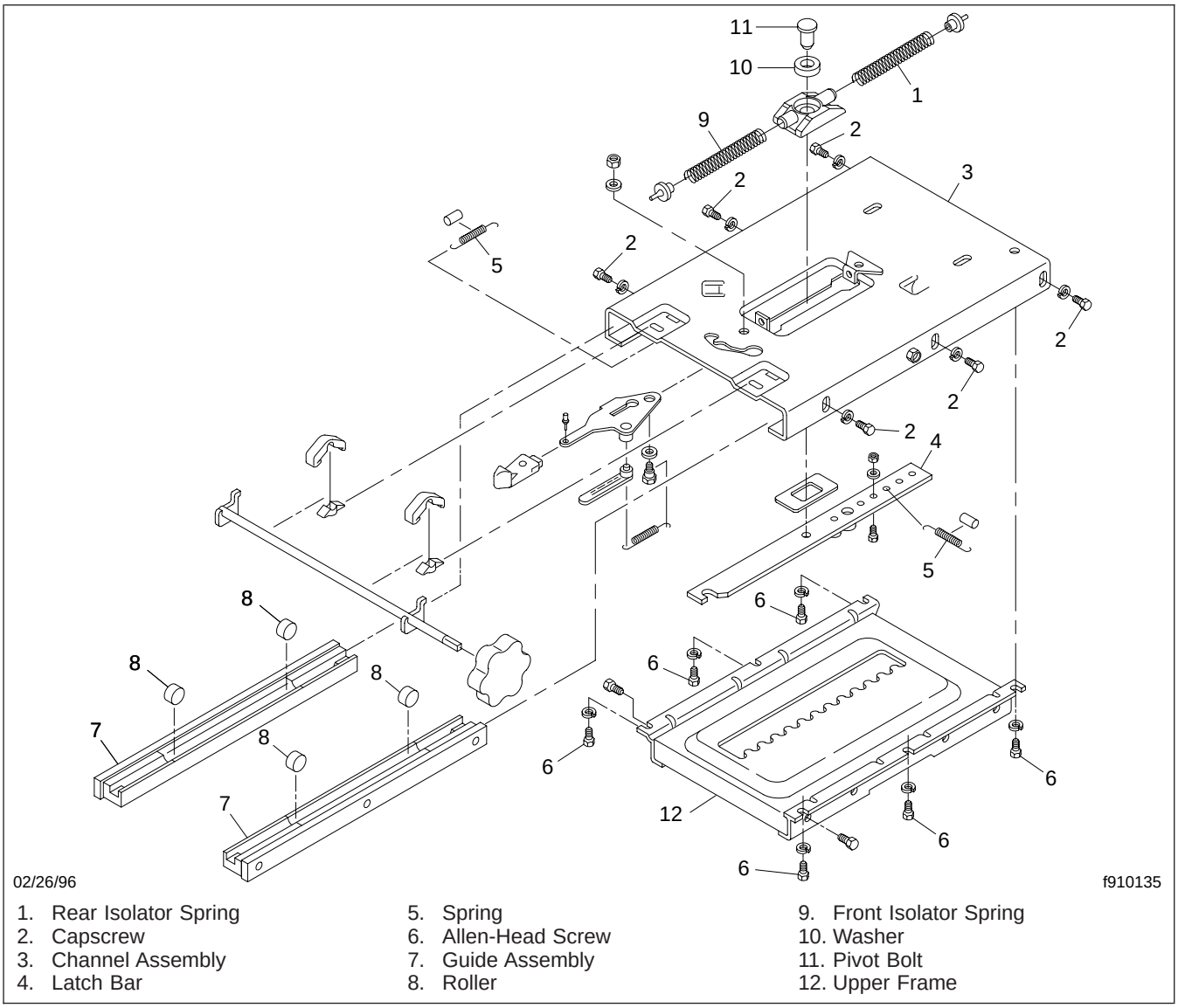
1. Place the seat/back assembly onto the channel assembly.
2. Connect the air lines to the air spring, and the air line to the vehicle air supply.

Seat/Back Assembly Removal and Installation

3. Install the two shoulder bolts in the channel assembly.
4. Install the two capscrews and flatwashers in the underside of the channel assembly.

Fore and Aft Isolation Channel Removal and Installation

Removal (See Fig. 1)



1. Rear Isolator Spring
2. Capscrew
3. Channel Assembly
4. Latch Bar
5. Spring
6. Allen-Head Screw
7. Guide Assembly
8. Roller
9. Front Isolator Spring
10. Washer
11. Pivot Bolt
12. Upper Frame

Fig. 1, Channel Assembly (exploded)

1. Remove the seat/back assembly. See **Subject 110**.
2. With the channel assembly set in its unlocked position, or in the "isolation position," push the channel assembly rearward and remove the rear isolator spring. Pull the channel assembly forward and remove the front isolator spring.
3. Adjust the channel assembly until the cutouts in the underside of the channel line up with the allen-head screws. Remove the allen-head screws.
4. Remove the three capscrews on each side of the channel assembly.

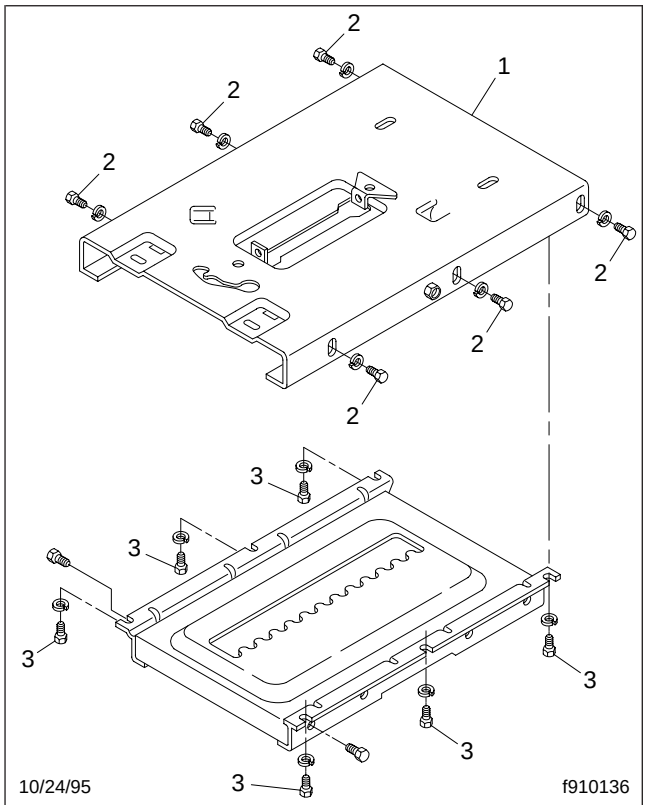
Fore and Aft Isolation Channel Removal and Installation

5. Remove both guide assemblies and the four rollers.
6. Disconnect the spring from the latch bar.
7. Remove the pivot bolt and washer, slide the latch bar out, and remove the channel assembly.

Installation (See Fig. 1)

1. Place the channel assembly onto the upper frame, slide the latch bar in, and install the pivot bolt and washer. Torque the bolt 26 to 34 lbf·ft (36 to 46 N·m).
2. Connect the springs to the latch bar.
3. Install both guide assemblies and the four rollers.
4. Install the three screws on each side of the channel assembly. Torque the screws 15 to 17 lbf·ft (20 to 23 N·m).
5. Install the six allen-head screws on the underside of the channel assembly. Torque the screws 15 to 17 lbf·ft (20 to 23 N·m).
6. With the channel assembly in the isolation position, pull the assembly forward and install the front isolator spring. Push the assembly rearward and install the rear isolator spring.
7. Adjust the channel assembly using the instructions in **Subject 130**.
8. Install the seat/back assembly. See **Subject 110**.

Adjustment (See Fig. 1)

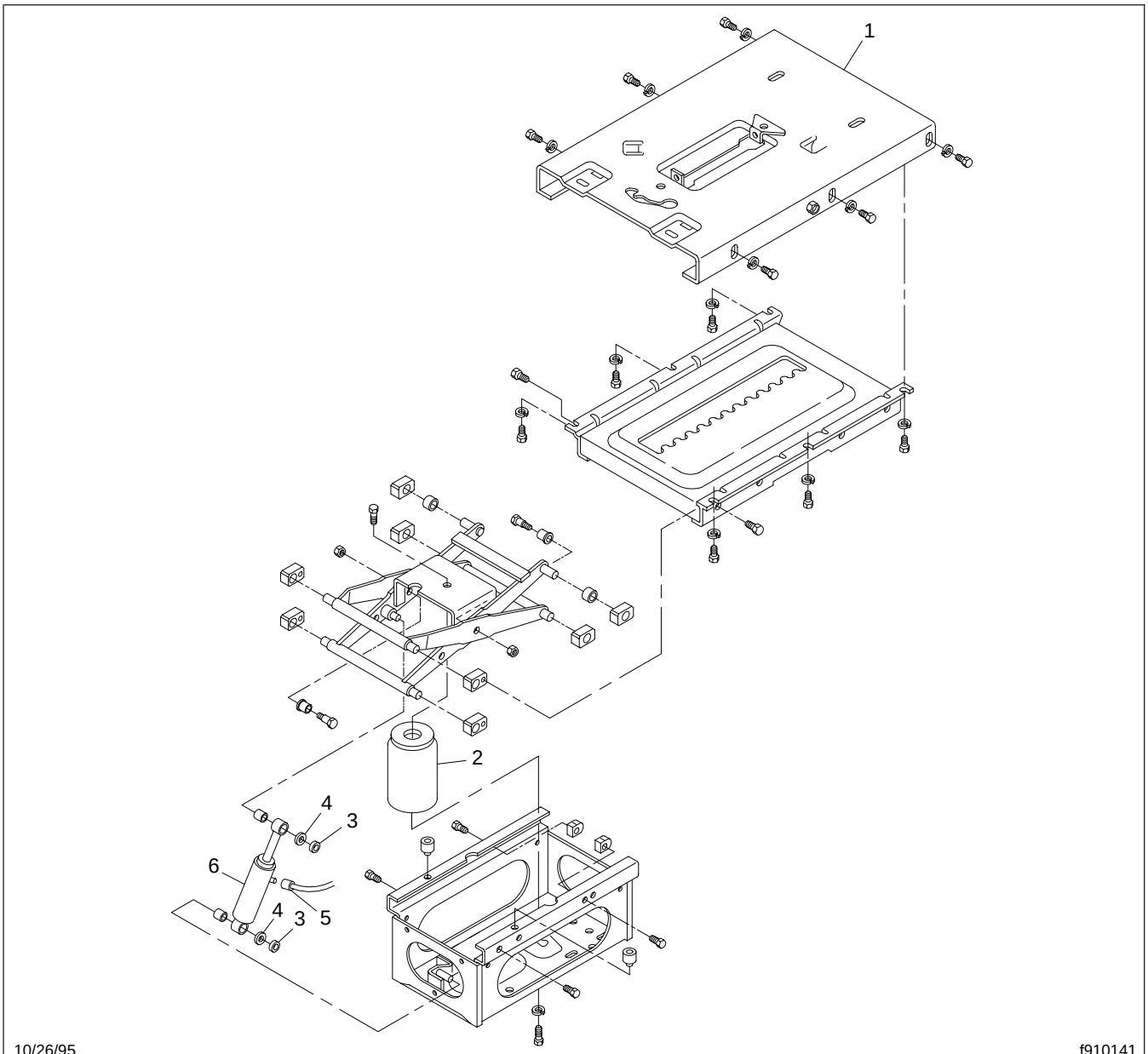


1. Channel Assembly
2. Capscrew
3. Allen-Head Screw

Fig. 1, Channel Assembly

1. Remove the seat/back assembly from the channel assembly using the instructions in **Subject 110**.
2. Adjust the channel assembly so the cutouts in the underside of the channel assembly line up with the Allen-head screws.
3. Use a 5/32-inch Allen wrench to loosen the six screws underneath the channel assembly.
4. Push the slide track outward to take up excessive lateral movement and retighten the six screws. Torque the screws 5 to 7 lbf·ft (7 to 9 N·m).
5. Loosen the six capscrews along the side of the channel assembly.
6. Push down on the channel assembly to adjust vertical play and tighten the six capscrews 5 to 7 lbf·ft (7 to 9 N·m).

Removal (See Fig. 1)



1. Channel Assembly
2. Air Spring
3. Push-On Fastener
4. Thrust Washer
5. Control Cable (LSO model only)
6. Damper

Fig. 1, Channel Assembly (exploded)

NOTE: The seat/back assembly does not need to be removed.

1. Move the channel assembly to the rearmost position to provide access to the damper assembly.

Damper Removal and Installation

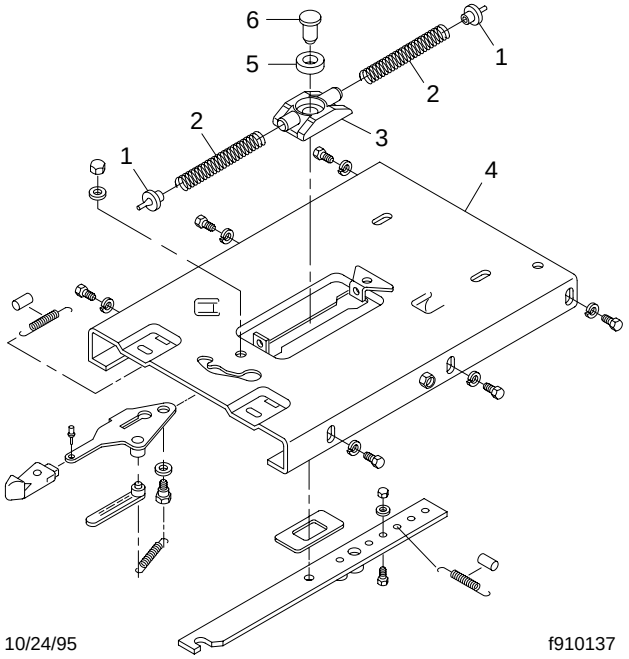
2. Fill the air spring so that the seat is at maximum height.
3. Use pliers or a screwdriver to twist off the push-on fasteners. The push-on fasteners are not reusable.
4. On LSO models only, disconnect the control cable from the damper. Remove the damper.

Installation (See Fig. 1)

1. Install the new damper with the flanges of the bearings to the outside of the suspension. On LSO model only, connect the control cable.
2. Install the thrustwashers and the new push-on fasteners until they seat. A 1/2-inch box-end wrench works well to push the fasteners on.

Isolation Bumper Removal and Installation

Removal (See Fig. 1)



1. Isolation Bumper
2. Isolation Spring
3. Pivot Block
4. Channel Assembly
5. Washer
6. Pivot Bolt

Fig. 1, Channel and Isolation Bumper Assembly

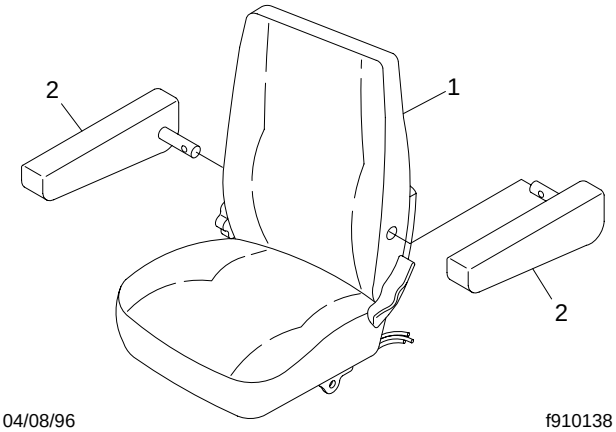
1. Remove the seat/back assembly using the instructions in **Subject 110**.
2. Remove the two isolation springs by pushing the channel assembly rearward to remove the rear spring and pulling the channel assembly forward to remove the front spring.
3. Remove the isolation bumpers.

Installation (See Fig. 1)

1. If the pivot block was removed, install the pivot block with the pivot bolt and washer. Torque the bolt 26 to 34 lbf·ft (36 to 46 N·m).
2. Install the isolation bumpers.
3. Install the two isolation springs by pulling the channel assembly forward to install the front spring and pushing the channel assembly rearward to install the rear spring.
4. Install the seat/back assembly using the instructions in **Subject 110**.

Back Cover/Pad Assembly Removal and Installation

Removal (See Fig. 1)



1. Upper Seat Assembly
2. Armrest

Fig. 1, Upper Seat Assembly (armrests removed)

1. Remove the seat/back assembly from the suspension, using the instructions in **Subject 110**. Remove the armrests if the seat assembly has armrests.
2. Remove the back cover and pad from the seat frame assembly. Note the location of the fasteners on the existing back cover.

Installation (See Fig. 1)

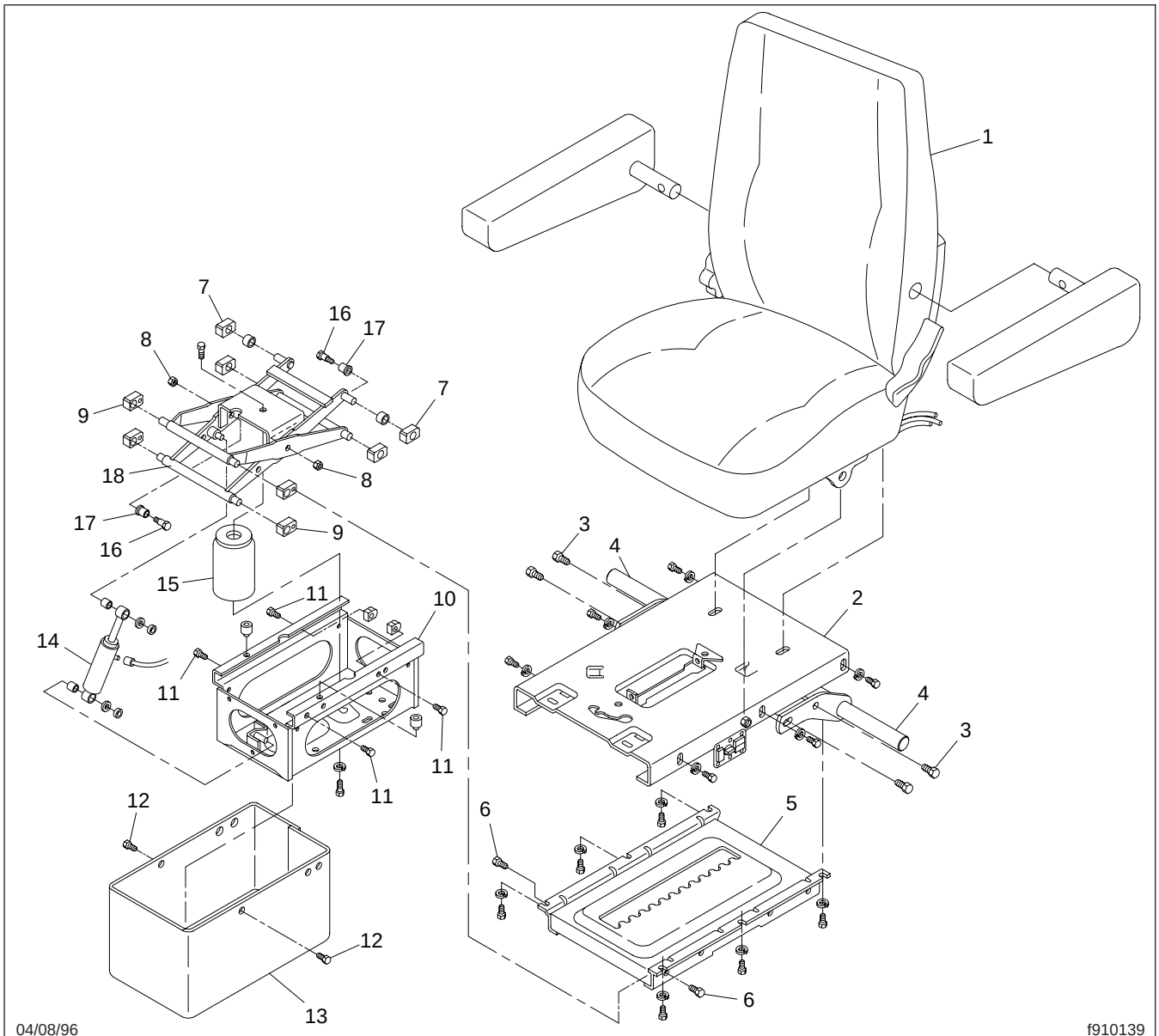
1. Place a new pad over the back frame. If the seat has lumbar adjustment, make a cut in the edge of the pad to fit around the handle.
2. Place the cover (inside out) over the top of the back pad. Pull down the cover until the three tie-down tabs are even with the three slots in the pad. Pull the tie down tabs through the slots in the pad and run a short wire through all three tabs. Continue to pull the cover down completely over the pad. Tuck the front flap of the back cover between the seat cushion and the bottom of the back pad and lock the J welt together.

NOTE: If the seat is a high back, there will be two sets of tie down tabs (six total with two wires) to be pulled through the back pad and wired.

3. Attach the upper seat assembly to the suspension using the instructions in **Subject 110**. Install the armrests if the seat has armrests.

Suspension Rebuild Bearing/Slide Block Removal and Installation

Removal (See Fig. 1)



1. Seat/Back Assembly
2. Channel Assembly
3. Capscrew
4. ICP Bracket
5. Upper Frame
6. Capscrew
7. Slide Block
8. Nut
9. Bearing Block
10. Base Riser
11. Capscrew
12. Fastener
13. Suspension Cover
14. Damper
15. Air Spring
16. Shoulder Bolt
17. Bearing
18. Slide Lever Assembly

Fig. 1, Bostrom Talladega 900 Series Seat (exploded)

Suspension Rebuild Bearing/Slide Block Removal and Installation

1. Bleed all the air from the supply line. Disconnect the air supply line from the seat. Using the air valve, exhaust all air from the air spring. Remove the complete seat assembly from the vehicle.
2. Remove the seat/back assembly using the instructions in **Subject 110**.
3. Remove the channel assembly using the instructions in **Subject 120**.
4. Remove the capscrews and the ICP bracket. If the seat assembly has a suspension cover, remove the fasteners and the suspension cover.
5. Block the suspension up with a spacer block placed between the base riser and the upper frame.
6. Remove the capscrews from the upper bearing blocks.
7. Remove the upper frame assembly by sliding it forward off the bearing blocks and the slide blocks.
8. Remove the air spring using the instructions in **Subject 100**. Mark the air lines for reassembly.
9. Remove the damper using the instructions in **Subject 140**.
10. Remove the capscrews from the lower bearing blocks and slide the lever assemblies forward until the bearing blocks are removed from the channel on the base riser. Slide the lever assemblies rearward to remove the slide blocks from the channel.
11. Remove the shoulder bolts and nuts from the pivots of the lever assemblies and inspect the bolts. If the bolts are worn, replace them.

Installation (See Fig. 1)

1. Replace the bearings at the pivots on the lever assembly by pushing out the old bearings and pressing in the new bearings. The flange of the bearings should be on the outside of the lever assembly.
2. Install the shoulder bolts and nuts into the pivots of the lever assemblies. Torque the bolts 18 to 22 lbf·ft (24 to 30 N·m).
3. Install new bearing blocks, spacers, and slide blocks on the levers with the beveled surfaces outward, then slide the levers with blocks into the channel on the base riser. Torque the capscrews 27 to 33 lbf·ft (37 to 45 N·m).
4. Slide the upper frame assembly over the blocks. Line up the capscrews with the bearing blocks (Ref. 9) and torque the capscrews 27 to 33 lbf·ft (37 to 45 N·m).
5. Manually move the suspension up and down to make sure there are no clearance problems.
6. Block the suspension up with a spacer block placed between the base riser and the upper frame. Install the air spring using the instructions in **Subject 100**.
7. Install the damper using the instructions in **Subject 140**.
8. Install the ICP bracket and capscrews. If the seat assembly has a suspension cover, install the suspension cover and the fasteners.
9. Install the channel assembly using the instructions in **Subject 120**.
10. Install the seat/back assembly using the instructions in **Subject 110**.
11. Adjust lateral (side) play using the instructions in **Subject 130**.
12. Install the seat assembly in the vehicle. Connect the air supply line to the seat.

Basic Wiring Diagram

For the basic wiring diagram for the Bostrom power seat, see **Fig. 1**.

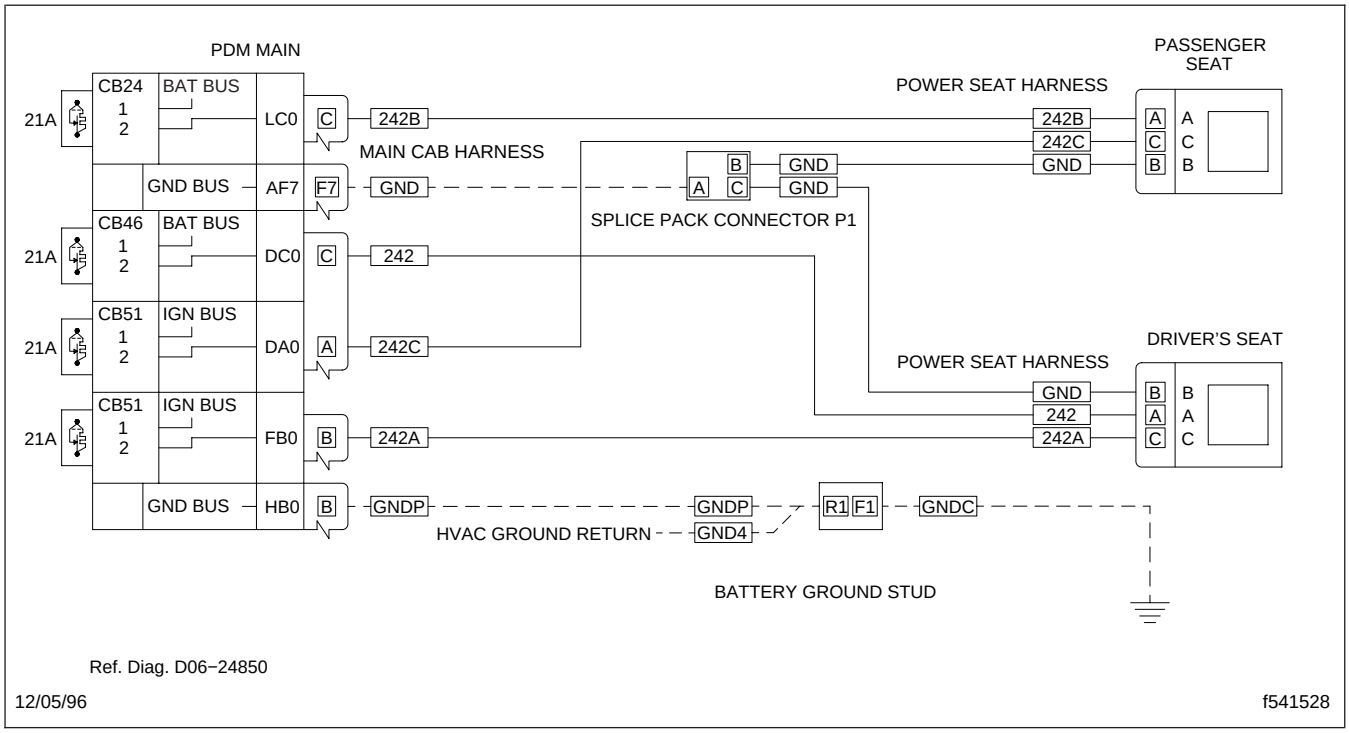


Fig. 1, Basic Wiring, Bostrom Power Seat

Recaro Seat Removal and Installation

Seat Removal

1. Apply the parking brakes, and chock the tires.
2. Press the seat ride-height rocker switch until the seat is adjusted to its maximum height.
3. Cut a wooden block to the length required to support the seat at its maximum height, and place the block in the seat suspension.
4. Drain the vehicle air reservoirs. Then press the seat ride-height rocker switch until all air is exhausted from the air spring.
5. Disconnect the air valve air-supply hose at the quick-connect union behind the seat.
6. Pull apart the connector for the wiring that provides electrical power to the seat. The connector is under the lower B-pillar cover.
7. If the seat is being replaced, use a T50 Torx wrench to unscrew the capscrews that attach the seat-belt straps to the seat belt connection brackets.
8. Remove the capscrews and washers that attach the seat to the cab deck. Remove the seat from the cab.

Seat Installation

1. Place the seat on the cab deck. Insert the capscrews through the washers and the seat base. Tighten the capscrews 27 lbf·ft (37 N·m).
2. If the seat belts were removed, attach the brackets of the seat-belt straps to the seat belt connection brackets on the seat. Tighten the Torx capscrews 40 lbf·ft (54 N·m).
3. Push together the halves of the connector for the wiring that provides electrical power to the seat.
4. Attach the air valve air-supply hose by pressing the pneumatic tubing into the quick-connect union behind the seat.
5. Start the engine and allow the air reservoirs to fill. Press the seat ride-height rocker switch until the seat is adjusted to its maximum height. Remove the wooden block that supports the seat suspension.

Replacement

IMPORTANT: When any part of a seat-belt system needs replacement, the entire seat-belt system must be replaced—both the retractor side and the buckle side, and if equipped, both tether belts. See **Fig. 1** and **Fig. 2**.

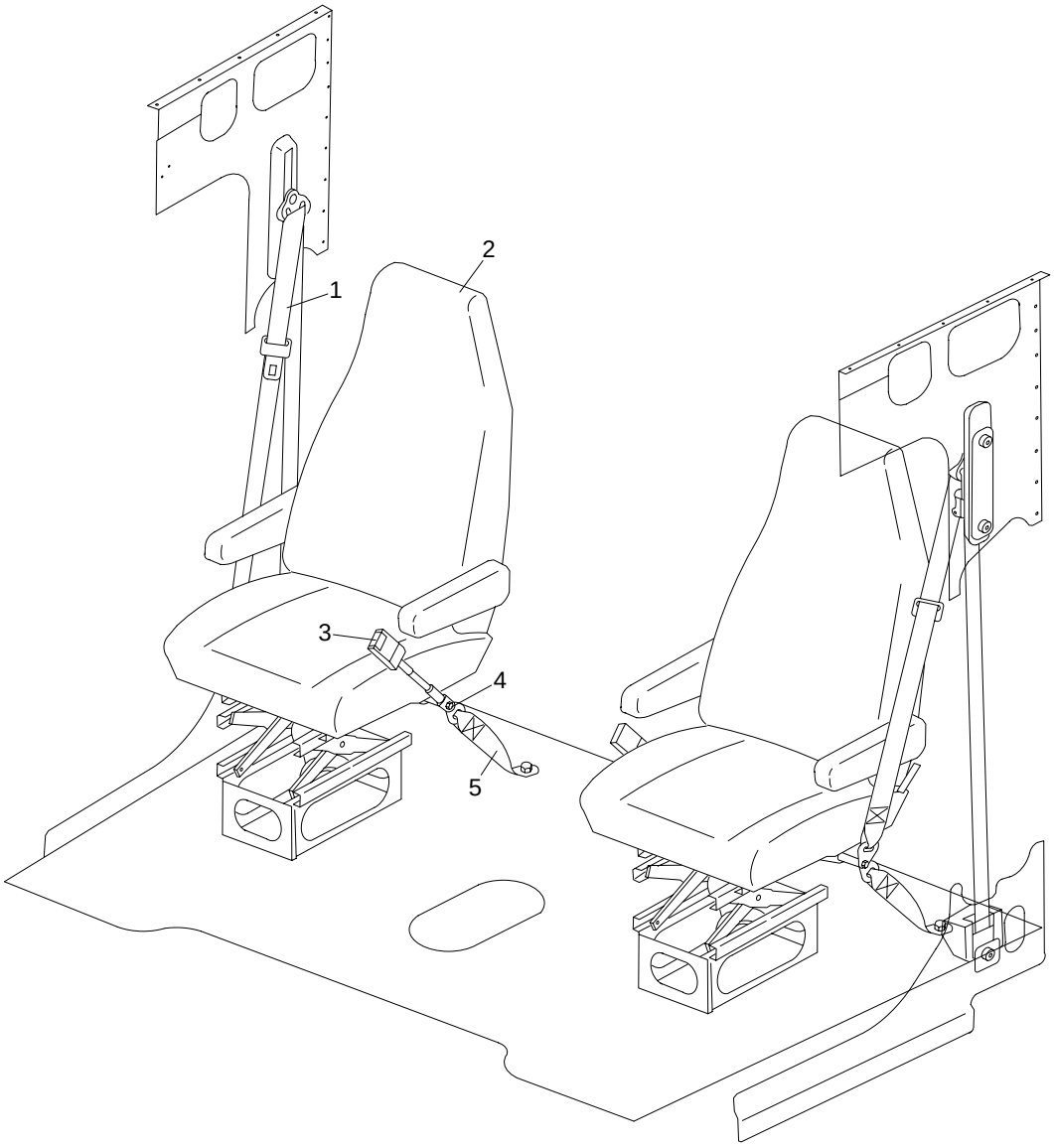
Any time a vehicle is involved in an accident, the entire vehicle's seat-belt system must be replaced before again operating the vehicle.

1. Apply the parking brakes, and chock the tires.
2. If the seat belts are for an air-adjustable seat, use an 11/16-inch socket or a T50 Torx wrench to unscrew the capscrews that attach the brackets of the seat-belt straps, and if equipped, the tether belts, to the intermediate-connecting-point threaded rod. Remove and discard the buckle-side of the seat belt.

   If the seat belts are for a static passenger seat, use an 11/16-inch socket or a T50 Torx wrench to unscrew the capscrews that attach both seat-belt angled brackets to the cab deck. Remove and discard the buckle-side of the seat belt.
3. If an air-adjustable seat has tether belts, use an 11/16-inch socket or a T50 Torx wrench to unscrew the capscrews that attach both tether belt brackets to the cab deck. Remove and discard the tether belts.
4. Use an 11/16-inch socket or a T50 Torx wrench to unscrew the capscrew that attaches the seat belt retractor to the lower cab wall. Then unscrew the T50 Torx capscrews that attach the adjustable D-loop mechanism to the upper cab wall. Remove and discard the retractor-side of the seat belt.
5. Attach the adjustable D-loop mechanism of the new seat belt to the upper cab wall; tighten the Torx capscrews 40 lbf·ft (54 N·m). Attach the seat belt retractor to the lower cab wall; tighten the capscrews 40 lbf·ft (54 N·m).
6. If tether belts are required for an air-adjustable seat, attach the angled brackets of the new tether belts to the cab floor; tighten the capscrews 40 lbf·ft (54 N·m).
7. If the seat belts are for an air-adjustable seat, insert the capscrews of the seat belt brackets through the straight brackets of the tether belts (if so equipped), and attach the brackets to the intermediate-connecting-point threaded rod. Tighten the capscrews 40 lbf·ft (54 N·m).

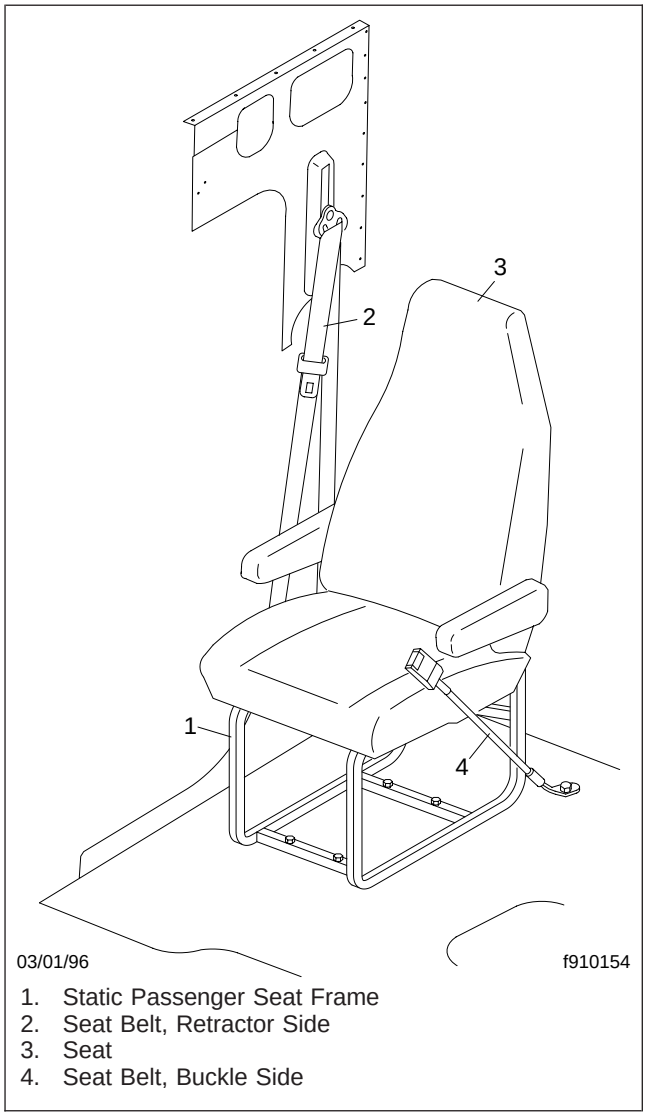
   If the seat belts are for a static passenger seat, attach both seat-belt angled brackets to the cab deck. Tighten the capscrews 40 lbf·ft (54 N·m).
8. Remove the chocks from the tires.

Seat-Belt/Tether Belt Replacement



1. Seat Belt
2. Seat
3. Buckle
4. Intermediate Connection Point
5. Tether Belt

Fig. 1, Seat Belt/Tether Belt Assembly (dual adjustable seats shown)



1. Static Passenger Seat Frame
2. Seat Belt, Retractor Side
3. Seat
4. Seat Belt, Buckle Side

Fig. 2, Seat Belt Assembly (static passenger seat shown)

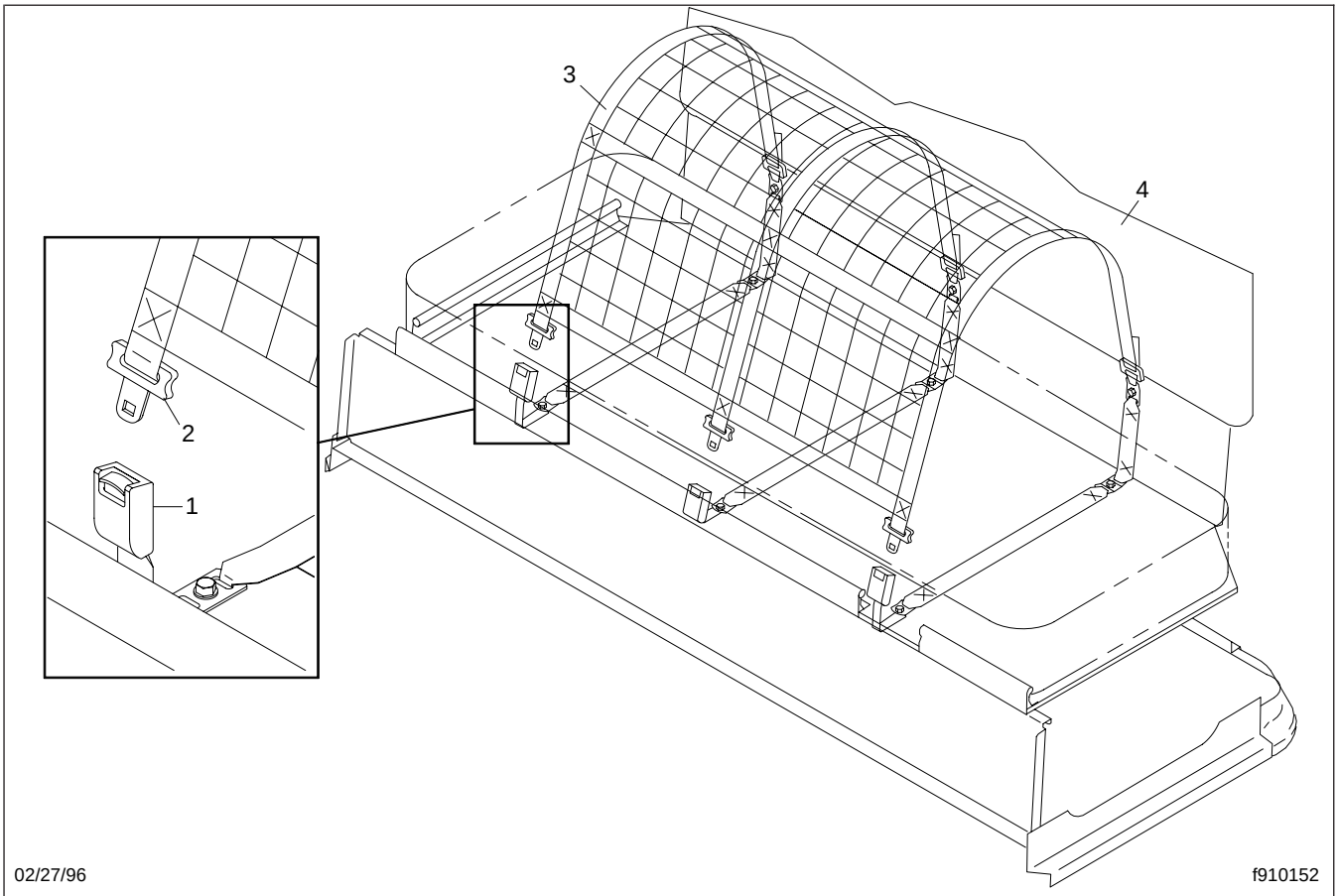
Bunk Restraint Removal and Installation

Removal

IMPORTANT: When any part of a restraint system needs replacement, the entire restraint system must be replaced. See **Fig. 1** .

Any time a vehicle is involved in an accident, the entire restraint system must be replaced before again operating the vehicle.

4. Remove the cover caps from the hexhead bolts on the bunk hatch and from the hexhead bolts that attach the bunk restraint to the rear wall of the cab.
5. Remove the six hexhead bolts on the rear wall.
6. Lift the bunk hatch to access the nuts attached to the hexhead bolts on the bunk hatch.



1. Buckle
2. Grip
3. Restraint
4. Rear Cab Wall

Fig. 1, Bunk Restraint Assembly

1. Shut down the engine and set the parking brake.
2. Chock the front tires.
3. Remove the mattress from the bunk.
7. Remove the three bolts on the bunk hatch.
8. Remove the bunk restraint.

Installation

1. Position the bunk restraint.

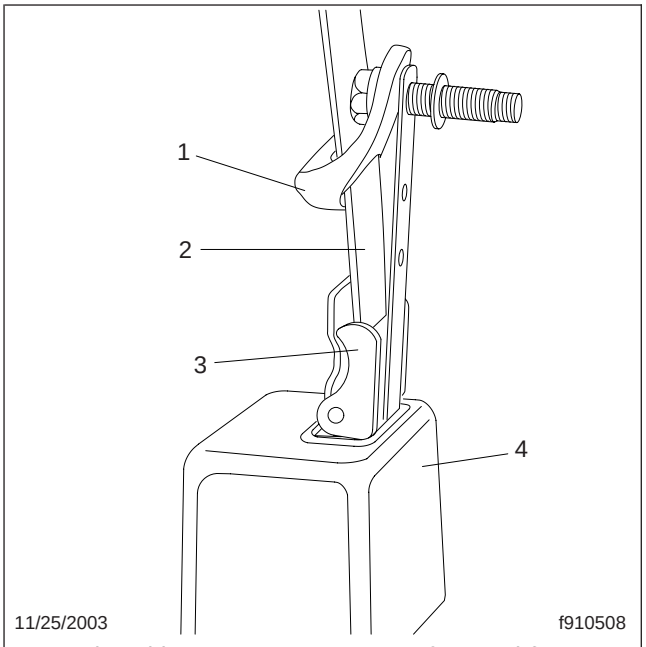
Bunk Restraint Removal and Installation

2. Lift the bunk hatch, install the three hexhead bolts onto the bunk hatch, and secure them with nuts. Tighten to 35 to 45 lbf·ft (47 to 61 N·m).
3. Lower the bunk hatch.
4. Attach the six hexhead bolts to the rear wall of the cab. Tighten to 35 to 45 lbf·ft (47 to 61 N·m).
5. Attach the cover caps to all of the hexhead bolts.
6. Return the mattress to the bunk.
7. Remove the chocks from the tires.

Unlocking an Installed Retractor

Seat belt retractors are locking up and preventing the webbing from being extracted. This condition is known as reverse lock-up and is caused by excessive webbing spooling into the retractor before installation in the vehicle.

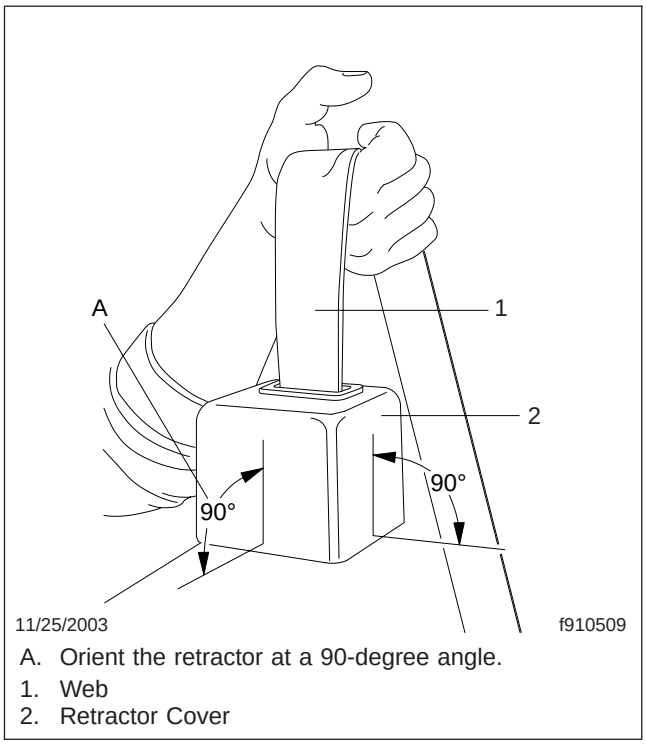
1. Park the vehicle, apply the parking brake, shut down the engine, and chock the front and rear tires.
2. Verify that the retractor is mounted in the 90-degree position. See **Fig. 1**.
3. Firmly grasp the web close to the retractor. See **Fig. 2**.



1. Web Guide Loop
2. Web
3. Komfort Latch®
4. Retractor Cover

Fig. 1, Retractor in the 90-Degree Position

4. Pull on the web with enough force to tighten the web onto the spool until the webbing locks back onto the retractor. The retractor should unlock when tension is released.
5. Remove the chocks from the tires.



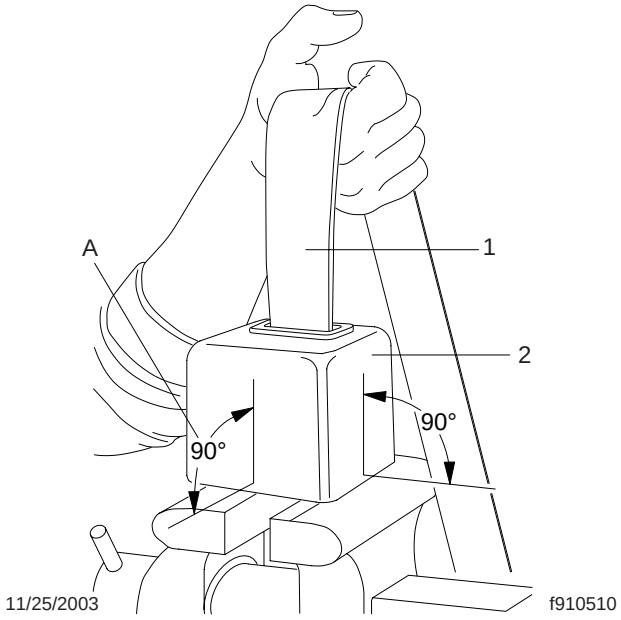
A. Orient the retractor at a 90-degree angle.
1. Web
2. Retractor Cover

Fig. 2, Firmly Grasp the Webbing

Unlocking an Uninstalled Retractor

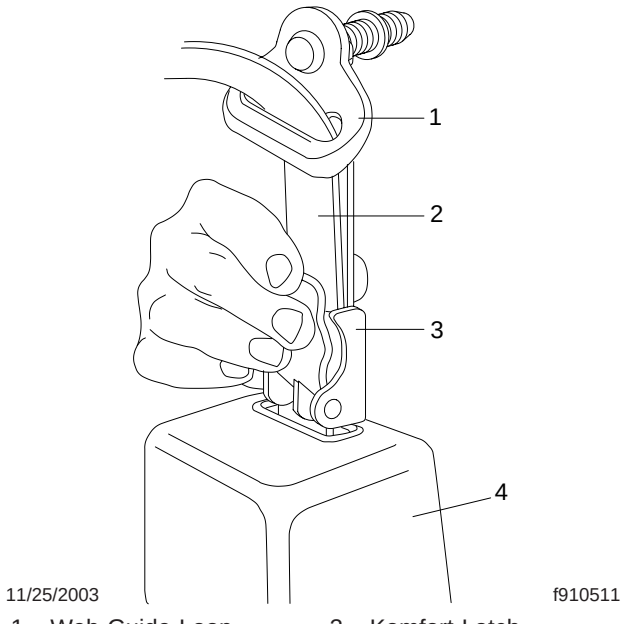
1. Clamp the retractor in a vice at a 90-degree angle. See **Fig. 3**.
2. Pull on the web with enough force to tighten the web onto the spool.
3. Release the web. This allows 1/2-inch (12.7-mm) of the webbing to feed back into the retractor storage housing and unlock the retractor.
4. Pull all the webbing out of the retractor, and allow only 12 to 15 inches (304 to 381 mm) to retract. Lock the Komfort Latch on the web. See **Fig. 4**.

Seat Belt Retractor Unlocking



A. Retractor oriented at a 90-degree angle.
1. Web
2. Retractor Cover

Fig. 3, Place the Retractor in a Vice



1. Web Guide Loop
2. Web
3. Komfort Latch
4. Retractor Cover

Fig. 4, Lock the Komfort Latch

General Information

The air bag only system and the air bag/SPACE system, when used with seat belts, provide additional protection to the driver and/or passenger in severe frontal collisions.

A new air bag only system became available on May 12, 2000. This system is different from the air bag only system installed prior to May 12, 2000. In this section, the air bag only system installed prior to May 12, 2000 and the SPACE system will be covered.

For information on the air bag only system installed from May 12, 2000, see **Section 46.09** in the *Century Class Trucks Workshop Manual*.

The SPACE system provides a significant increase in seat stability during a severe frontal collision. When the SPACE module in the Seat Pretensioner Activation for Crash survival Enhancement (SPACE) system senses a severe, life-threatening frontal impact, the module triggers two gas-cylinders mounted at the base of the seat. See **Fig. 1**. The gas cylinders activate the power cinches that then tighten the lap and shoulder belts against the occupant of the seat and lower the seat suspension, moving the occupant down and away from the steering wheel and ceiling. The air bag is activated simultaneously.

IMPORTANT: The SPACE system will activate during a severe frontal collision even if the seat belts are not fastened, but the SPACE system only provides protection to the occupant when the seat belts are fastened.

⚠ WARNING

Damaged seat belts or seat belts that were worn in an accident must be replaced and their anchoring points must be checked. Do not attempt to modify the SPACE system. Doing so could change the effectiveness of the system. The SPACE system must be replaced after being activated. Failure to do so may result in personal injury or death.

There are two types of systems that provide supplemental protection during a severe frontal collision:

- the air bag/SPACE system and air bag only system installed prior to May 12, 2000
- the air bag only system installed from May 12, 2000

IMPORTANT: There is no difference between an air bag/SPACE system installed from May 12, 2000 and an air bag/SPACE system installed prior to May 12, 2000. There is a difference in the air bag only system installed from May 12, 2000 and the air bag only system installed prior to May 12, 2000.

To determine which type of supplemental protection system is installed in the vehicle, look at the module under the driver's seat. The air bag/SPACE system and the air bag only system installed prior to May 12, 2000 have a SPACE module. If the vehicle has a SPACE system, gas cylinders are also located under the driver's seat. See **Fig. 2**. The air bag only system that became available on May 12, 2000 has an air bag sensor module located under the driver's seat. See **Fig. 3**.

There are troubleshooting procedures and wiring diagrams for the air bag/SPACE system and the air bag only system installed prior to May 12, 2000. There is another set of troubleshooting procedures and a wiring diagram for the air bag only system installed from May 12, 2000.

The air bag/SPACE system and the air bag only system installed prior to May 12, 2000 can have one of the following configurations:

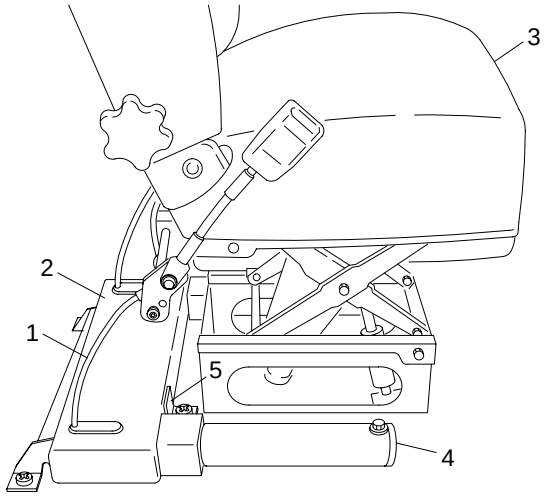
- a driver-side air bag only system
- a driver-side air bag and SPACE system
- a driver-side air bag and driver- and passenger-side SPACE system

The air bag and SPACE system and the SPACE only system use the same SPACE module and electrical connector. The air bag only system, installed prior to May 12, 2000, uses a modified SPACE module and the same electrical connector used in the other two systems.

The air bag only system that became available on May 12, 2000 has an air bag sensor module and a different electrical connector than the connector used on the air bag/SPACE system.

The operational readiness of the air bag only system and the air bag/SPACE system is indicated by the supplemental restraint system (SRS) indicator on the dash. The SRS indicator comes on when the ignition is turned on, and then goes off. The indicator will re-

main on if there is a problem with the air bag/SPACE system. The vehicle should be serviced if the SRS indicator does not come on when the ignition is turned on or if the SRS indicator remains on.



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1. Pretensioning Cable
2. SPACE Module
3. Seat
4. Gas Cylinder
5. Sensor Bracket

Fig. 1, SPACE System Components

⚠ WARNING

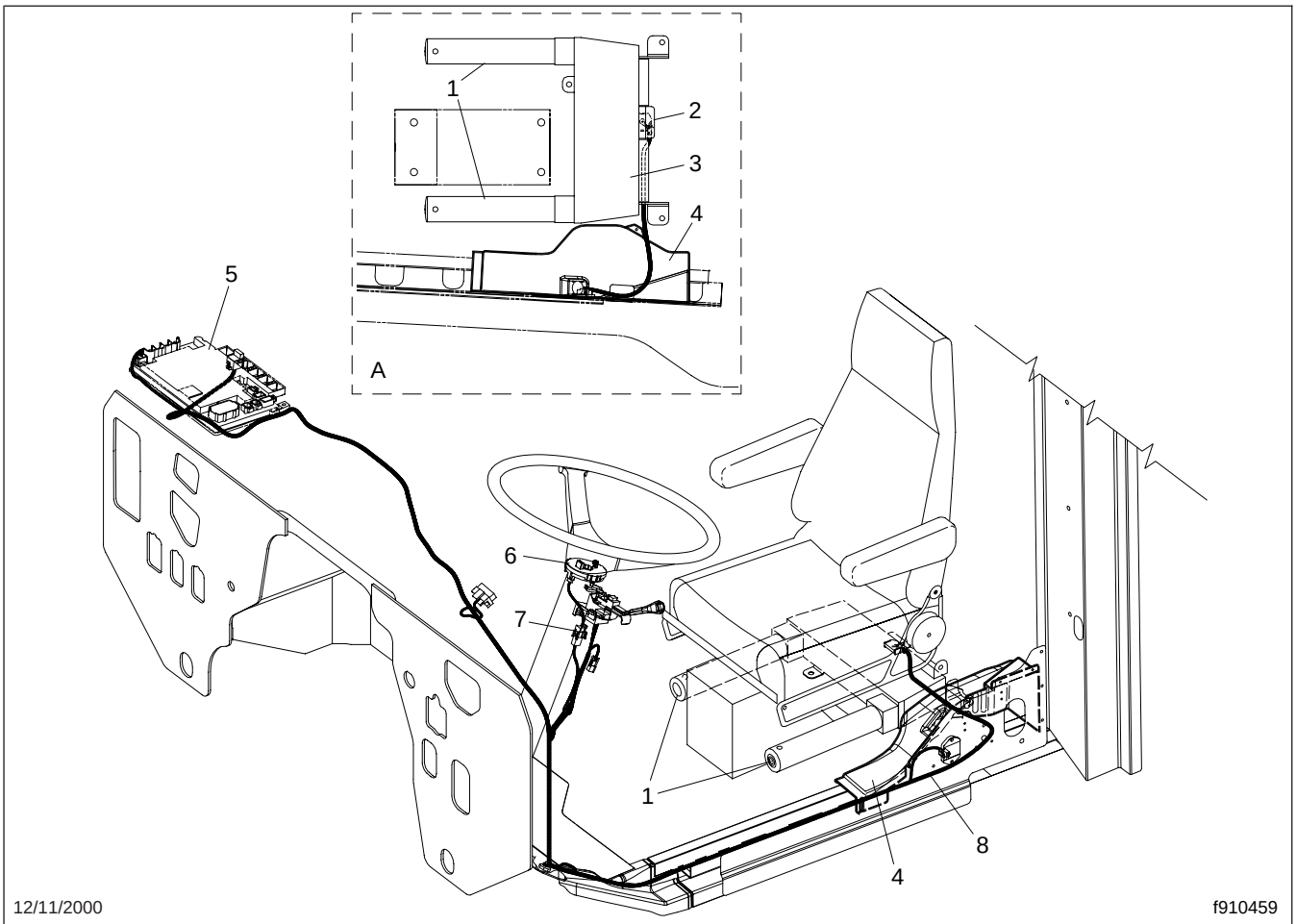
The SPACE and the air bag systems are designed to activate only in severe or life-threatening frontal collisions. Only in these situations will they provide supplemental protection. The driver and the passenger should always wear seat belts. For maximum protection in the event of a collision or rollover, the driver's back must be against the seat back in a normal seated position and the driver's head must be upright. The seat belts must be fastened and properly positioned on the body. Because the air bag inflates with considerable speed and force, it is important that the driver maintain a proper seat position to stay a safe distance from the inflating air bag.

Objects must not be placed on the steering wheel or between you and the steering wheel, or on the SPACE system components. Doing so may cause harm during an accident because the objects could be propelled by the expanding air bag or hinder the operation of the SPACE mechanism.

Failure to follow these instructions may result in personal injury or death.

⚠ CAUTION

Before performing any electric welding on a vehicle, disconnect the battery power and ground cables and the Driver-Side SPACE (DSS) connector. See Fig. 2. At the rear of the seat base, remove the fasteners that attach the connector plate to the SPACE module. Disconnect the connector inside the SPACE module. See Subject 120 in this section for instructions. Electric currents produced during electric welding can damage various electronic components on the vehicle.

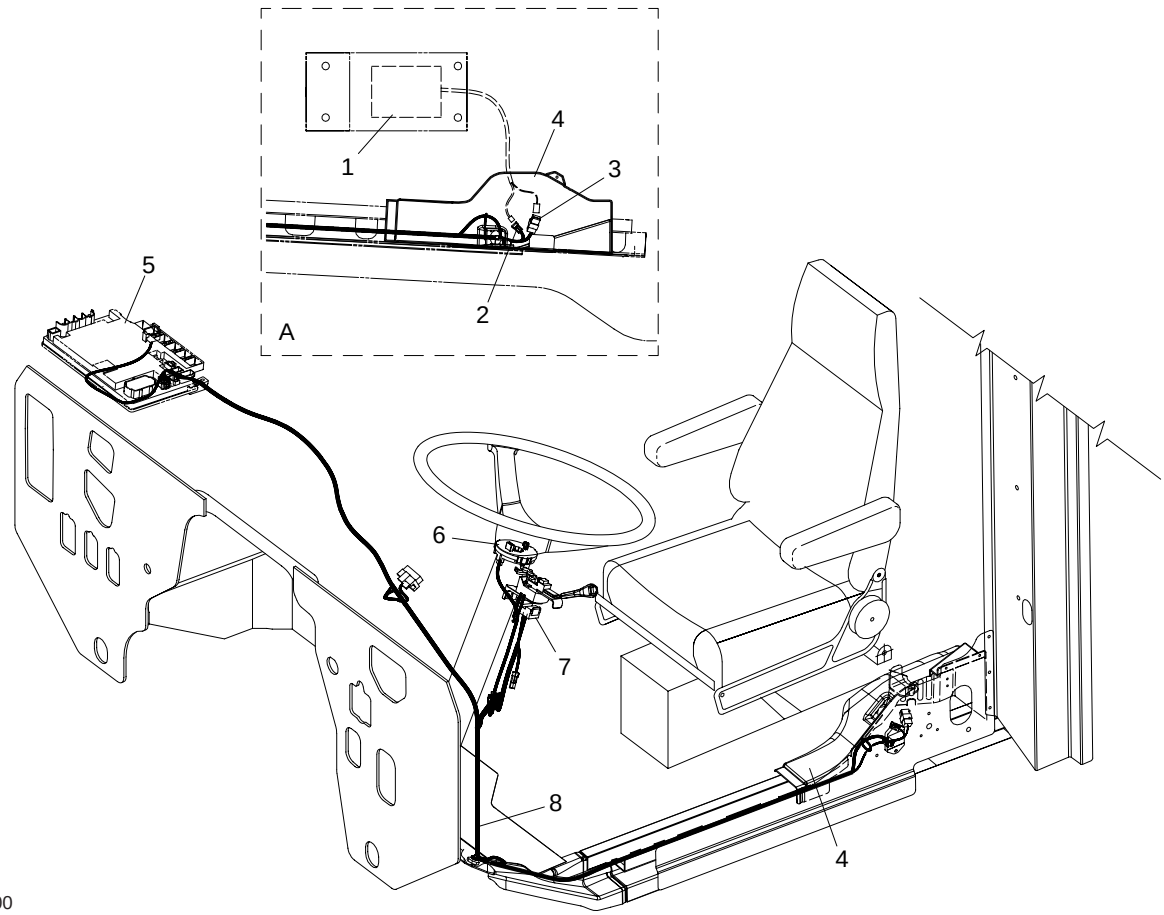


A. Top view of Air Bag/SPACE System

1. Gas Cylinder (SPACE system only)
2. DSS (Driver-Side SPACE) Connector
3. Driver-Side SPACE Module
4. B Pillar Cover
5. Power Distribution Module
6. Clockspring
7. SRS (Supplemental Restraint System) Connector
8. Air Bag Wiring Harness

Fig. 2, Air Bag Harness Routing on Air Bag/SPACE Systems and Air Bag Only Systems Installed Prior to May 12, 2000

General Information



A. Top view of Air Bag Sensor Module
1. Air Bag Sensor Module
2. AS2 Connector
3. AS1 Connector
4. B Pillar Cover
5. Power Distribution Module
6. Clockspring
7. SRS1 (Supplemental Restraint System) Connector
8. Air Bag Wiring Harness

Fig. 3, Air Bag Harness Routing on Air Bag Only Systems Installed From May 12, 2000

Safety Guidelines

The air bag only system and the air bag/SPACE system contain components that use combustible chemicals. Because these chemicals are combustible, care must be taken when replacing or handling system components.

⚠ WARNING

The components and chemicals used in the air bag only and air bag/SPACE systems are hazardous. Failure to observe the following safety guidelines could lead to the unintentional deployment of these systems, which could cause serious bodily injury or death.

Safety Guidelines for the Air Bag/SPACE System

⚠ WARNING

Do not attempt to service the air bag/SPACE system. Damaged or deployed air bag/SPACE systems should be examined before any attempt is made to remove, replace, or handle the air bag/SPACE system components. Unintentional or improper initiation of the air bag/SPACE system could cause severe bodily injury or death.

Do not attempt to service or to disassemble the SPACE module. The SPACE module cannot be serviced. Doing so could result in severe bodily injury or death.

Although the air bag/SPACE system components will not likely explode, self-deploy, or produce shrapnel, care must be taken when it is necessary to replace or perform work around the air bag/SPACE system components. Review the following list of warnings. Failure to do so could result in severe injury or death.

- **Do not cut, drill, braze, solder, weld, probe, or strike any part of the air bag/SPACE system.**
- **Store undeployed and undamaged air bag/SPACE system components in a cool, dry, enclosed area.**
- **Keep all liquids, acids, halogens, heavy metals, and heavy salts away from the air bag/SPACE system.**
- **Do not expose the air bag/SPACE system components to electricity.**
- **Do not attempt to adapt, reuse, or install an air bag/SPACE system in any vehicle other than the specific vehicle for which it is designed.**
- **On vehicles with SPACE, keep hands and tools away from the scissor points under the seats.**
- **Do not cut wires or tamper with the connectors between the vehicle wiring harness and the air bag/SPACE system unless the troubleshooting diagnostics specifically directs you to do so. Cutting or removing the electrical connectors could cause unintentional deployment.**
- **Never probe a circuit on the passenger-side SPACE connector unless the harness is disconnected between the test point and the passenger-side SPACE module. Voltage supplied by a digital multimeter or self-powered test light could cause the passenger-side SPACE unit to deploy.**
- **Store, transport, dispose of, and recycle air bag/SPACE system components in accordance with all applicable federal, state, and local regulations.**
- **Replace damaged seat belts or seat belts that were worn in an accident, and check all anchoring points.**
- **The air bag/SPACE system requires a special seat belt. Care must be taken to be sure the correct seat belt is used.**
- **When reactivating the system for the first time after repairs have been made, stand outside of the cab and away from the front of the air bag while turning on the ignition. Check that the SRS indicator comes on for a few seconds and then goes out. Make sure there are no active fault codes.**

Safety Guidelines for the Air Bag System

⚠ WARNING

Damaged air bag systems should be examined before any attempt is made to remove or to deploy the air bag. Unintentional air bag deployment could cause severe bodily injury or death.

Do not attempt to disassemble the air bag inflator unit or breach the integrity of the sealed metallic inflator case. Doing so could cause severe bodily injury or death.

Do not allow system chemicals to contact other liquids, combustibles, and flammable materials. Doing so could cause chemical burns or personal injury.

The surface of the deployed air bag may contain small amounts of sodium hydroxide (which is a by-product of the gas generant combustion) and metallic sodium. Sodium hydroxide may be irritating to the skin and eyes. Always wear rubber gloves and safety glasses when handling a deployed air bag. Immediately wash your hands and exposed skin areas with a mild soap and water. Flush your eyes immediately if exposed to sodium hydroxide.

⚠ WARNING

Consider undeployed air bags to be dangerous and capable of deploying at any time. When it is necessary to work with air bag only systems, review the following list of correct handling procedures and warnings. Failure to do so could result in severe injury or death.

- **Carry undeployed air bags with the bag and the trim cover pointed away from your body.**
- **Place undeployed air bags face up on a surface in an enclosed area.**
- **Do not place objects near or on top of an undeployed air bag.**
- **Store undeployed and undamaged air bag modules in a cool, dry, enclosed area.**
- **Keep all liquids, acids, halogens, heavy metals, and heavy salts away from the air bag system.**
- **Do not cut, drill, braze, solder, weld, probe, or strike any part of the air bag system.**
- **Do not expose the air bag module to electricity. Never probe a circuit on the air bag side of a connector unless the harness or air bag is disconnected between the test point and the air bag.**
- **Do not attempt to adapt, reuse, or install an air bag system in any vehicle other than the specific vehicle for which it is designed.**
- **Do not cut wires or tamper with the connector between the vehicle wiring harness and the air bag module unless the troubleshooting diagnostics specifically directs you to do so. Cutting or removing the connector from the system will disable the safety shunt and could cause unintentional deployment.**
- **Allow deployed air bag systems to cool after deployment.**
- **Air bag systems should be deployed in an open area or outdoors to prevent accidental fires.**
- **Wear rubber gloves and safety glasses when handling a deployed air bag.**
- **Wash your hands and exposed skin surface areas immediately after handling a deployed system.**
- **Store, transport, dispose of, and recycle air bag system components in accordance with all applicable federal, state, and local regulations.**
- **When reactivating the system for the first time after repairs have been made, stand outside of the cab and away from the front of the air bag while turning on the ignition. Check that the SRS indicator comes on for a few seconds and then goes out. Make sure there are no active fault codes.**

Air Bag Replacement

NOTE: The following air bag replacement procedure is for the air bag only system installed prior to May 12, 2000 and the air bag/SPACE system. For information on the air bag only system installed on or after May 12, 2000, see **Section 46.09**.

IMPORTANT: There is no difference between an air bag/SPACE system installed on or after May 12, 2000 and an air bag/SPACE system installed prior to May 12, 2000. There is a difference in the air bag only system installed on or after May 12, 2000 and the air bag only system installed prior to May 12, 2000.

To determine which type of supplemental protection system is installed in the vehicle, look at the module under the driver's seat. The air bag/SPACE system and the air bag only system installed prior to May 12, 2000 have a SPACE module. If the vehicle has a SPACE system, gas cylinders are also located under the driver's seat. See **Fig. 1**. The air bag only system that became available on May 12, 2000 has an air bag sensor module located under the driver's seat. See **Fig. 2**.

⚠ WARNING

Damaged air bag systems should be examined before any attempt is made to remove or to deploy the air bag. Unintentional or improper initiation of an air bag deployment could cause severe bodily injury or death.

1. Turn off the engine, apply the parking brakes, and chock the rear tires.
2. Disconnect the batteries and wait two minutes before proceeding.

⚠ WARNING

Wait two minutes after disconnecting the batteries to allow the internal components to discharge. Failure to allow the components to discharge could cause the air bag to deploy, resulting in severe bodily injury or death.

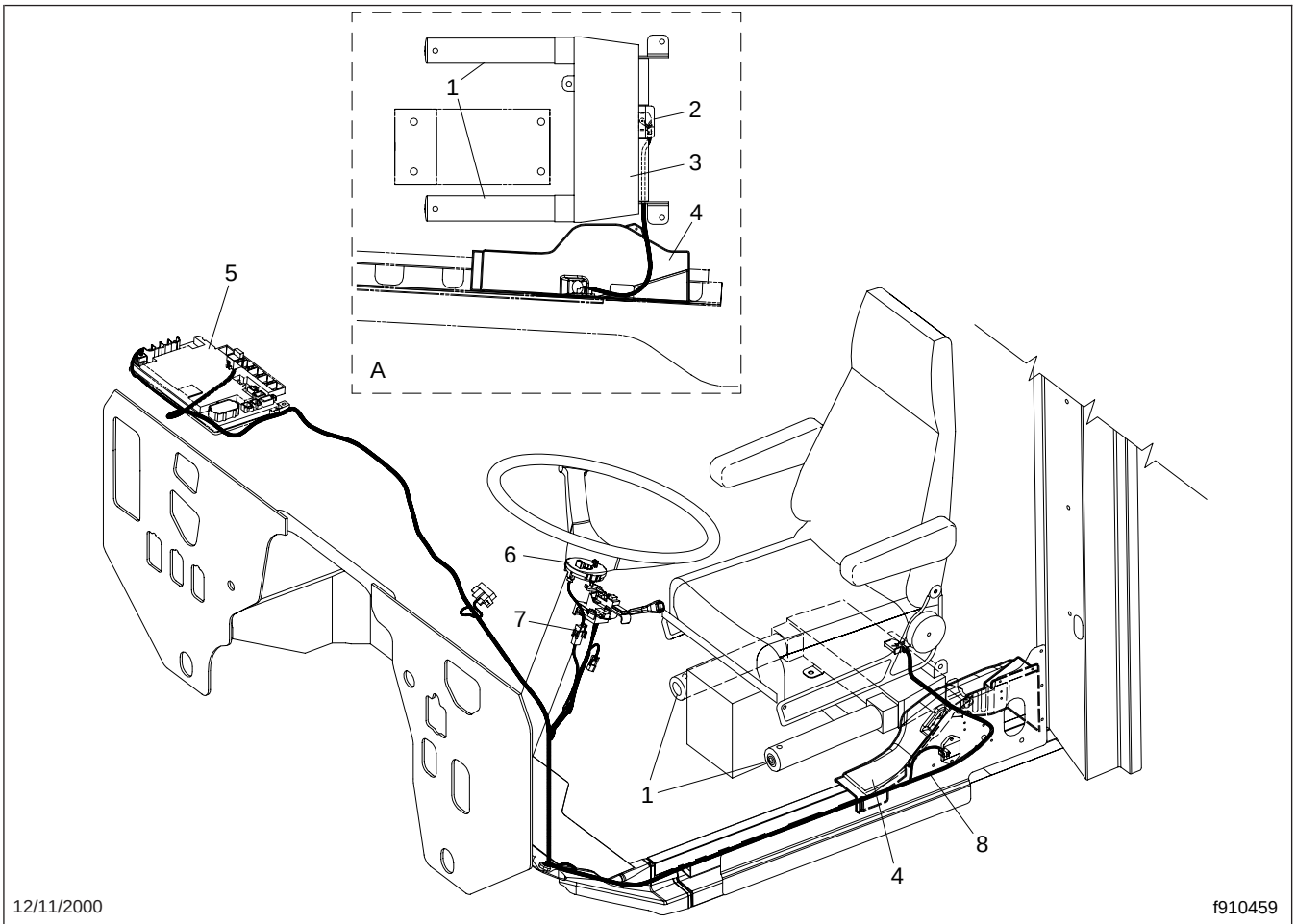
3. Disconnect the DSS connector at the back of the SPACE module. See **Fig. 1**.
4. Remove the fastener cover plugs from the steering wheel lower column cover. See **Fig. 3**.
5. Remove the fasteners and the column cover.
6. Loosen the air bag retainer screws underneath the steering wheel. See **Fig. 4**.

⚠ WARNING

Consider undeployed air bags to be dangerous and capable of deploying at any time. Follow the safety guidelines in this section. Failure to observe the safety guidelines could cause the unintentional deployment of the air bag, which could result in severe injury or death.

7. Carefully lift the air bag from the steering wheel and disconnect the air bag connector (and the horn switch connector if equipped) from the air bag. See **Fig. 5**, **Fig. 6**, and **Fig. 7**.
8. Remove the air bag.
9. Inspect the clockspring and clockspring connector. Replace the clockspring if there is any melting or damage.
10. Connect the electrical wiring from the clockspring (and from the horn switch connector if equipped) to the new air bag module, then position the air bag module on the steering wheel.
11. Tighten the air bag retaining screws at the bottom of the steering wheel.
12. Using the fasteners, attach the steering wheel lower column cover to the dash.
13. Install the fastener plugs.
14. Connect the DSS connector.
15. Connect the batteries.
16. While standing outside the cab and away from the front of the air bag, turn the ignition on. Check to make sure that after the ignition is turned on, the Supplemental Restraint System (SRS) indicator comes on for several seconds and then goes out. Make sure there are no active fault codes. If the SRS indicator remains on or if there are active fault codes, follow the appropriate troubleshooting procedure. The air bag system may need to be deactivated again.

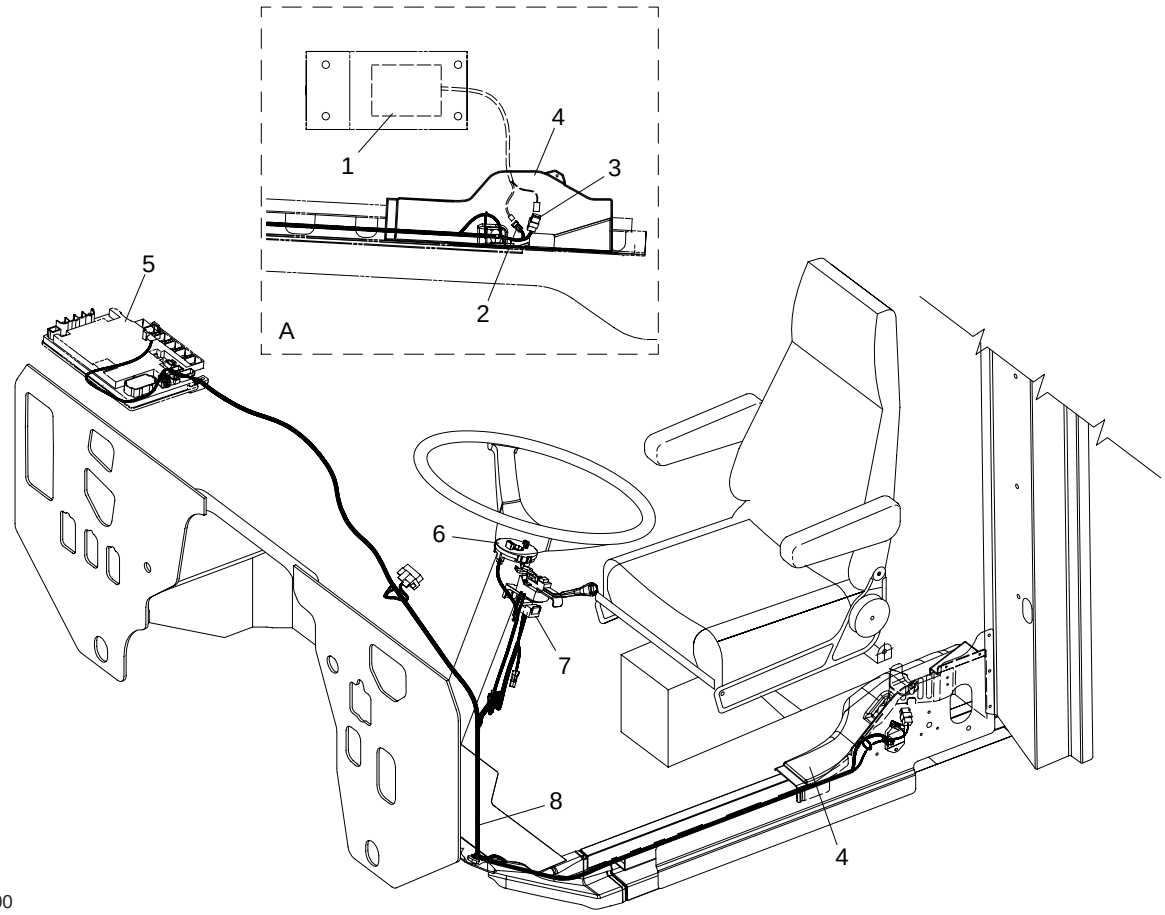
Air Bag Replacement



A. Top view of Air Bag/SPACE System.
1. Gas Cylinder (SPACE system only)
2. DSS (Driver-Side SPACE) Connector
3. Driver-Side SPACE Module
4. B-Pillar Cover
5. Power Distribution Module
6. Clockspring
7. SRS (Supplemental Restraint System) Connector
8. Air Bag Wiring Harness

Fig. 1, Air Bag Harness Routing on Air Bag/SPACE Systems and Air Bag Only Systems Installed Prior to May 12, 2000

17. If the SRS indicator goes out and there are no active fault codes, the system is functioning properly.
18. Remove the chocks from the tires.

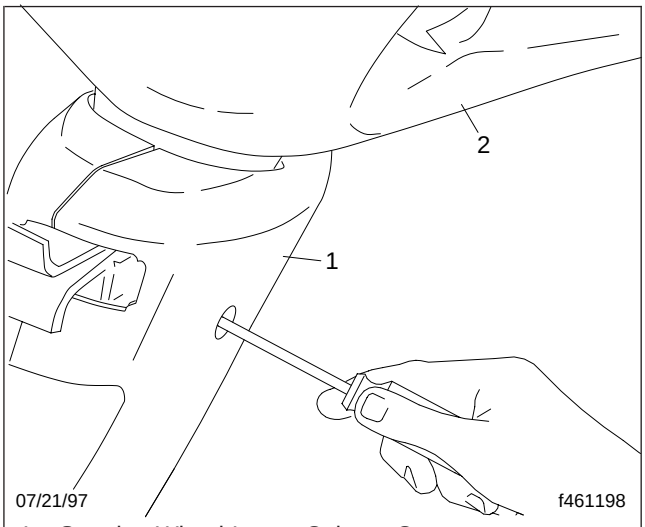


A. Top view of Air Bag Sensor Module.

1. Air Bag Sensor Module
2. AS2 Connector
3. AS1 Connector
4. B-Pillar Cover
5. Power Distribution Module
6. Clockspring
7. SRS1 (Supplemental Restraint System) Connector
8. Air Bag Wiring Harness

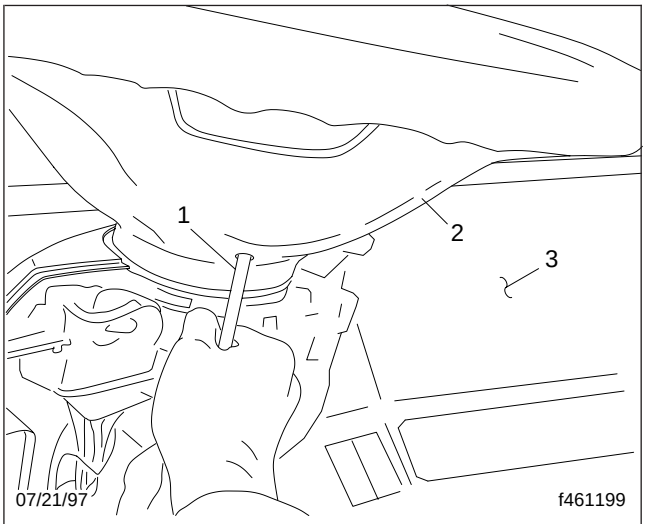
Fig. 2, Air Bag Harness Routing on Air Bag Only Systems Installed on or After May 12, 2000

Air Bag Replacement



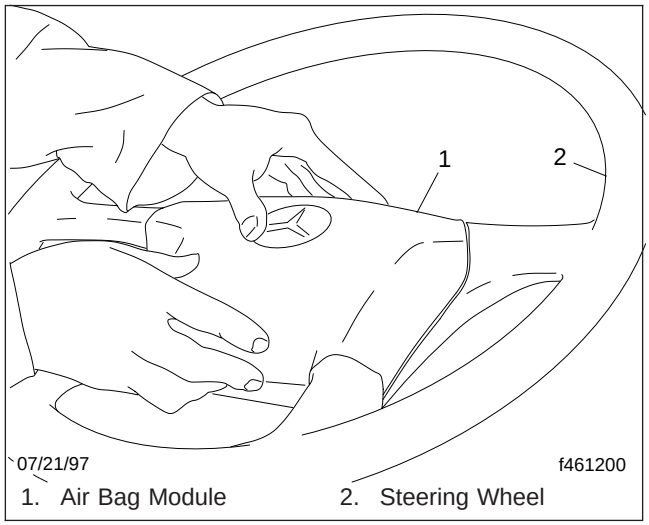
1. Steering Wheel Lower Column Cover
2. Steering Wheel

Fig. 3, Removing the Fastener Cover Plugs



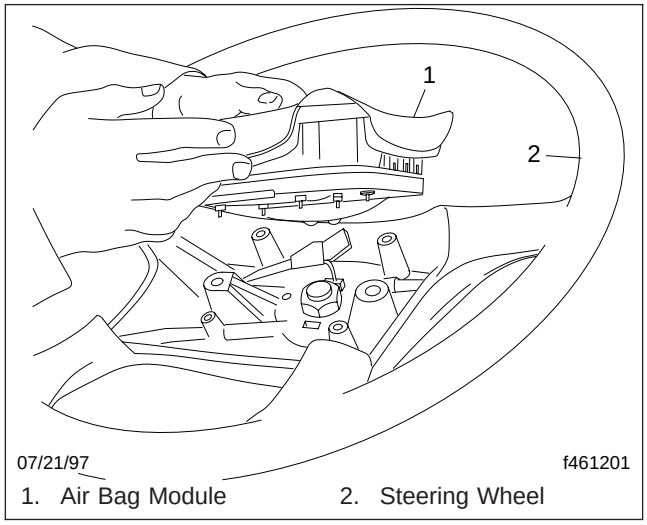
1. Screwdriver
2. Steering Wheel
3. B Dash Panel

Fig. 4, Loosening the Air Bag Retainer Screws



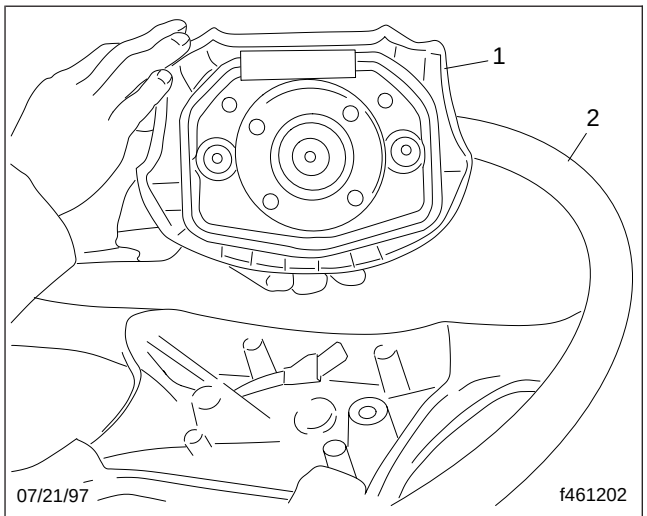
1. Air Bag Module
2. Steering Wheel

Fig. 5, Air Bag Module Installed



1. Air Bag Module
2. Steering Wheel

Fig. 6, Lifting the Air Bag Module



1. Air Bag Module Removed
2. Steering Wheel

Fig. 7, Air Bag Removed

Replacement

WARNING

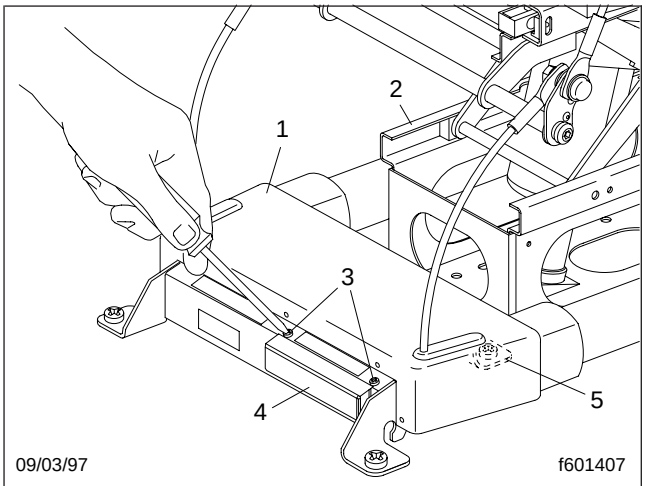
A deployed or damaged SPACE system should be examined before any attempt is made to remove it. Unintentional or improper initiation of a SPACE system deployment could cause severe bodily injury or death.

1. Park the vehicle on a level surface. Shut down the engine. Set the parking brake and chock the rear tires.
2. Disconnect the batteries and wait two minutes before proceeding.

WARNING

Wait two minutes after disconnecting the batteries to allow the internal components to discharge. Failure to allow the components to discharge could cause the air bag to deploy, resulting in severe bodily injury or death.

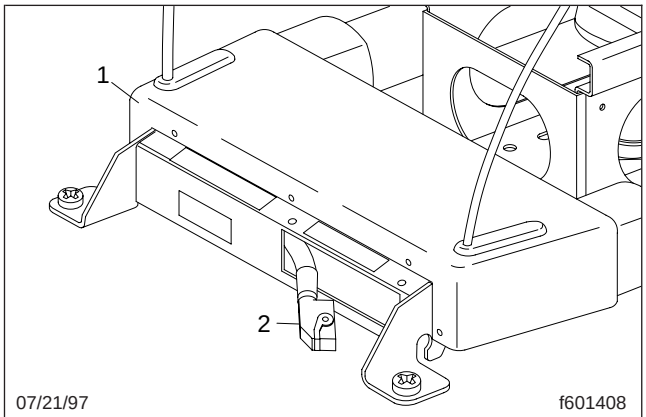
3. Remove the fasteners that attach the connector plate to the SPACE module. See **Fig. 1**.



1. SPACE Module
2. Seat Base
3. Connector Plate Fasteners
4. Connector Plate
5. Sensor Bracket

Fig. 1, Removing the Connector Plate

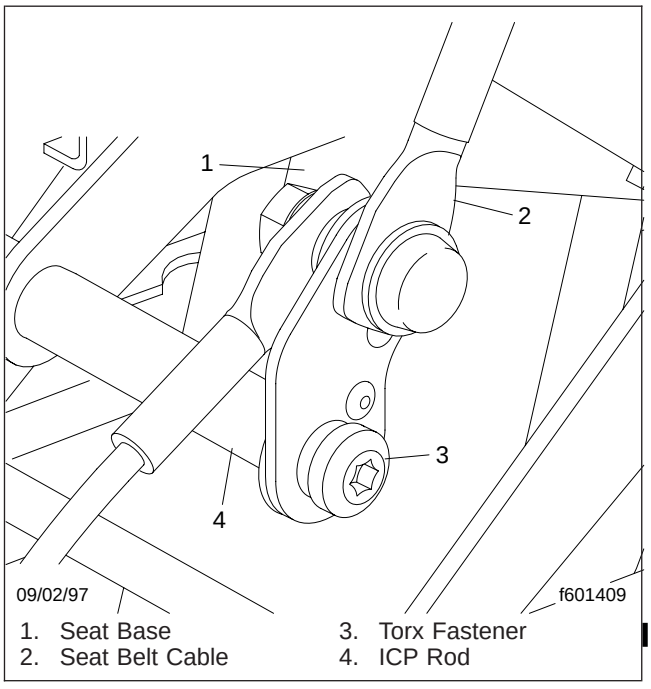
4. Disconnect the connector inside the module. See **Fig. 2**.



1. SPACE Module
2. Module Wiring Connector

Fig. 2, Disconnected Module Wiring

5. Remove the Torx® fasteners that attach the seat belts and SPACE pretensioning cables to the ICP (interconnect point) rod at the rear of the seat. See **Fig. 3**.

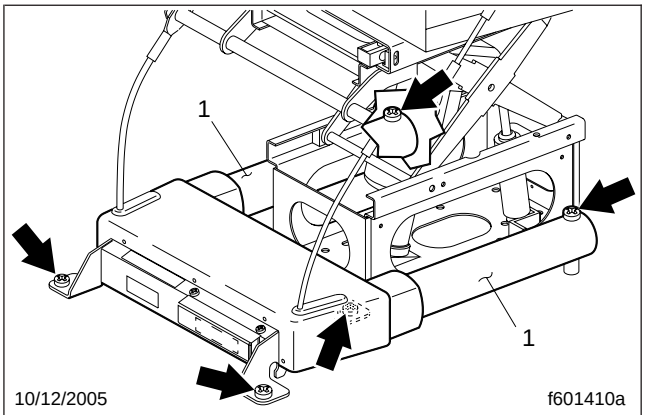


1. Seat Base
2. Seat Belt Cable
3. Torx Fastener
4. ICP Rod

Fig. 3, Torx Fastener at the ICP Rod

SPACE System Replacement

6. Loosen the Torx fasteners that attach the SPACE module to the cab deck and remove the module. See **Fig. 4**. Be careful to avoid damaging the module wiring connector and harness.



Loosen these Torx fasteners.
1. Gas Cylinder

Fig. 4, Attachment of SPACE Module to Cab Deck

NOTE: There are five fasteners for the driver-side module and four fasteners for the passenger-side module. The bolts used to attach the SPACE module to the cab deck are fine-threaded and captured with washers. The bolts will remain on the module. The two bolts mounted to the forward end of the gas cylinders cannot be replaced.

7. Position the new module in place.
8. Attach the module to the cab deck with the Torx fasteners. Tighten the fasteners 35 to 45 lbf·ft (47 to 61 N·m).

IMPORTANT: The bottom flange of the sensor bracket on the bottom of the module must contact the deck metal for the system to properly function. See **Fig. 4**.

9. Attach the pretensioning cables and seat belts to the ICP rod. Tighten the fasteners 25 lbf·ft (34 N·m).
10. Connect the electrical wiring inside the module.
11. Attach the connector plate.
12. Connect the batteries.
13. Dispose of the removed SPACE system components in accordance with all applicable federal, state, and local requirements.
14. Remove the chocks from the tires.

Clockspring Replacement

IMPORTANT: To determine which type of supplemental protection system is installed in the vehicle, look at the module under the driver's seat. The air bag/SPACE system and the air bag only system installed prior to May 12, 2000 have a SPACE module. If the vehicle has a SPACE system, gas cylinders are also located under the driver's seat. See **Fig. 1**. The air bag only system that became available on May 12, 2000 has an air bag sensor module located under the driver's seat. See **Fig. 2**.

NOTE: The following clockspring replacement procedure is for the air bag only system installed prior to May 12, 2000 and the air bag/SPACE system. For information on the air bag only system installed from May 12, 2000, see **Section 46.09** in the *Century Class Trucks Workshop Manual*.

⚠ CAUTION

Do not turn the steering wheel or the steering shaft at any time during this procedure. Doing so may damage the clockspring.

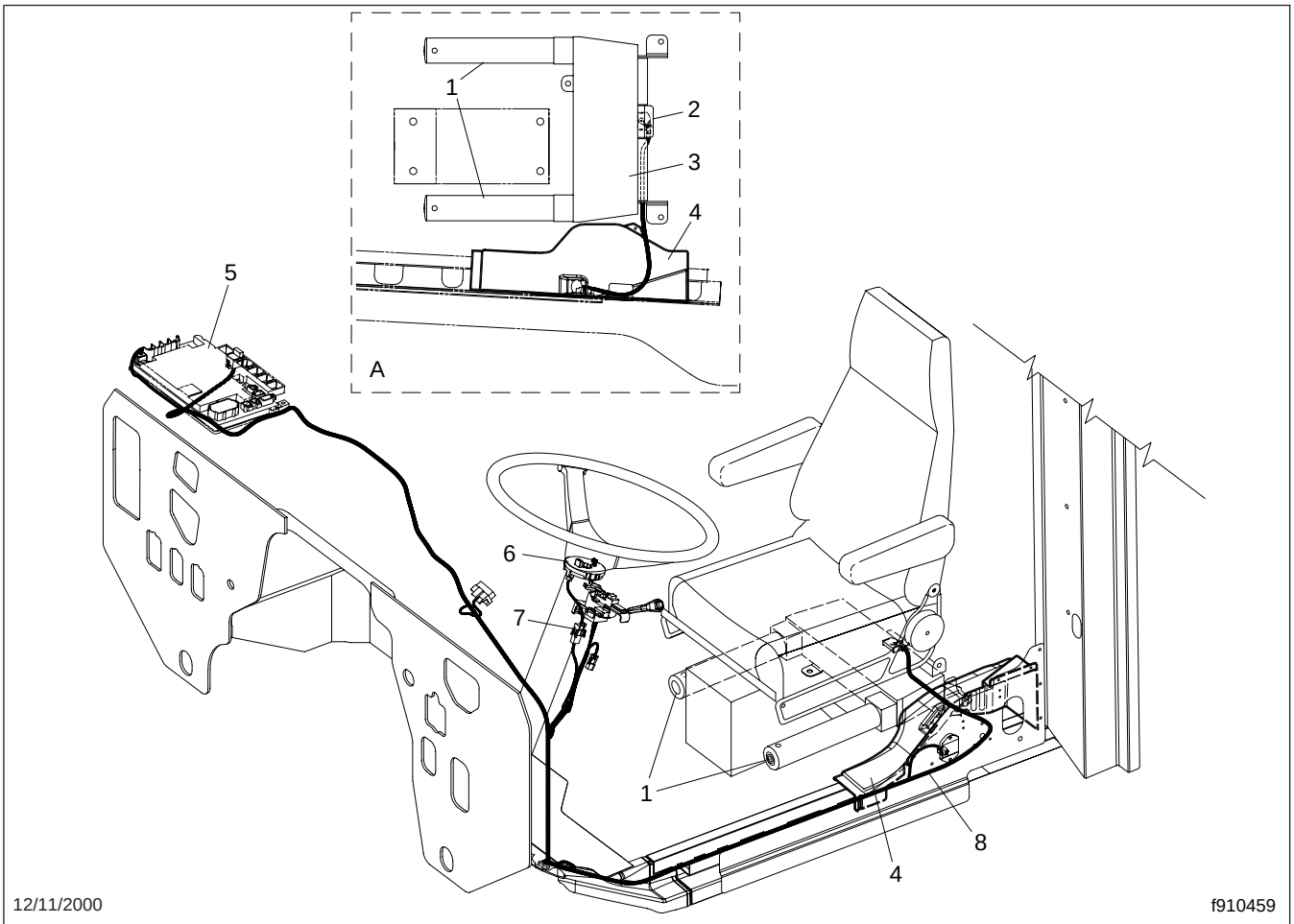
1. Park the vehicle on a level surface with the wheels straight ahead. Turn off the engine, apply the parking brakes, and chock the rear tires.
2. Disconnect the batteries and wait two minutes before proceeding.

⚠ WARNING

Wait two minutes after disconnecting the batteries to allow the internal components to discharge. Failure to allow the components to discharge could cause the air bag to deploy, resulting in severe bodily injury or death.

3. Disconnect the DSS connector. See **Fig. 1**.
4. Remove the air bag. For instructions, see **Section 46.06**, Subject 100 in the *Century Class Trucks Workshop Manual*.
5. Remove the steering wheel. For instructions, see **Section 46.06**, Subject 100 in the *Century Class Trucks Workshop Manual*.
6. Tape the upper and lower portions of the clockspring together to prevent it from turning.
7. Disconnect the connector located under the clockspring mounting plate on top of the steering column.
8. Loosen the screws that attach the clockspring to the clockspring bracket. It is not necessary to remove the screws in order to remove the clockspring.
9. Remove the clockspring.
10. If the steering column shaft has been allowed to rotate independently of the front wheels since the clockspring replacement procedure began, re-center the clockspring.
    - 10.1 While holding the lower portion of the clockspring stationary, rotate the upper portion counterclockwise until resistance is felt. Stop rotation as soon as some resistance is felt or the clockspring may become damaged.
    - 10.2 While holding the lower portion of the clockspring stationary, rotate the upper portion clockwise three full turns.
    - 10.3 Turn the upper portion of the clockspring clockwise until the the mounting holes in the upper portion of the clockspring are aligned with the screws in the lower portion of the clockspring. Tape the upper and lower portions together until the steering wheel is installed.
11. Using screws, attach the clockspring to the clockspring bracket.
12. Reconnect the connector from the clockspring to the air bag wiring harness. If the clockspring is taped together, remove the tape.
13. Install the steering wheel. For instructions, see **Section 46.06**, Subject 100 in the *Century Class Trucks Workshop Manual*.
14. Install the air bag. For instructions, see **Section 46.06**, Subject 100 in the *Century Class Trucks Workshop Manual*.
15. Reconnect the DSS connector.
16. Reconnect the batteries.
17. While standing outside the cab and away from the front of the air bag, turn the ignition on.

Clockspring Replacement

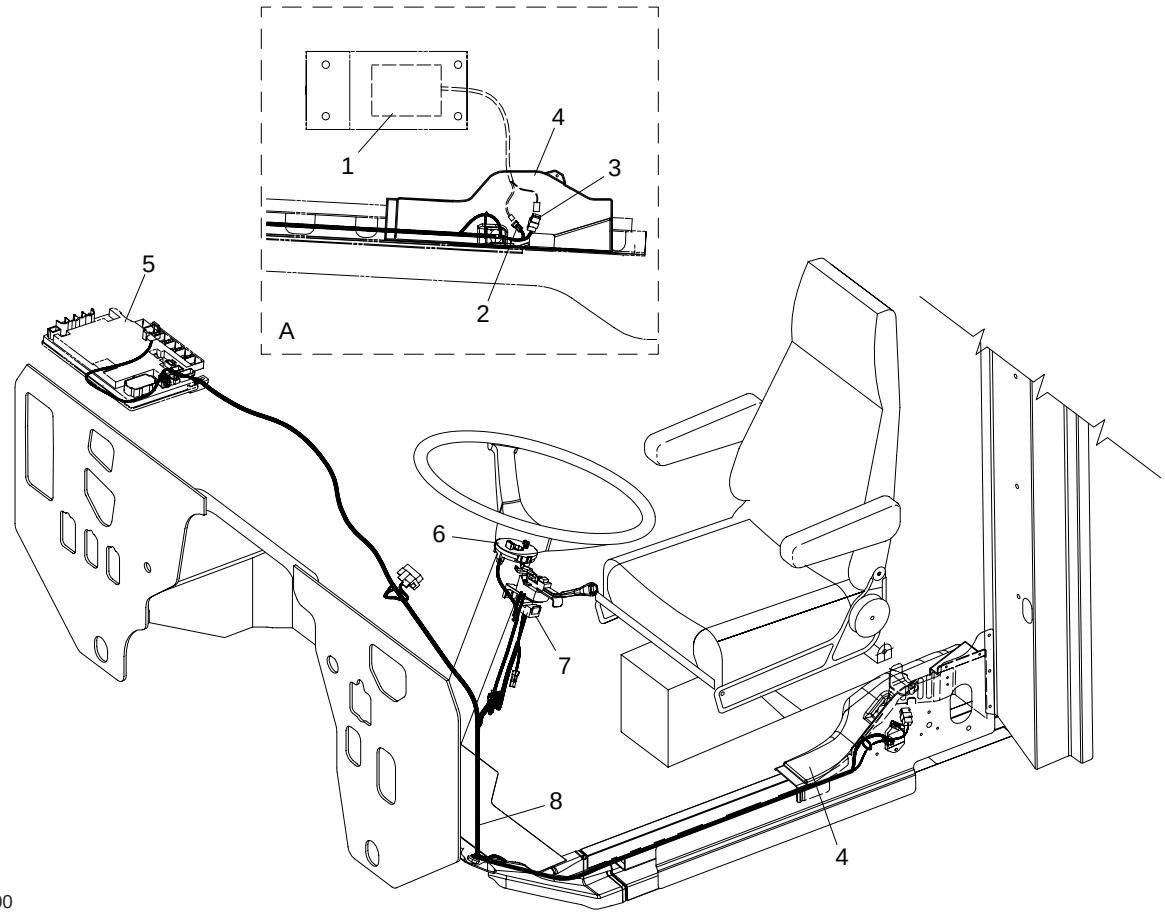


A. Top view of Air Bag/SPACE System
1. Gas Cylinder (SPACE system only)
2. DSS (Driver-Side SPACE) Connector
3. Driver-Side SPACE Module
4. B Pillar Cover
5. Power Distribution Module
6. Clockspring
7. SRS (Supplemental Restraint System) Connector
8. Air Bag Wiring Harness

Fig. 1, Air Bag Harness Routing on Air Bag/SPACE Systems Installed Prior to May 12, 2000

Check to make sure that after the ignition is turned on, the Supplemental Restraint System (SRS) indicator comes on for several seconds and then goes out. Make sure there are no active fault codes. If the SRS indicator remains on or if there are active fault codes, follow the appropriate troubleshooting procedure. The air bag system may need to be deactivated again.

18. If the SRS indicator goes out and there are no active fault codes, the system is functioning properly.
19. Remove the chocks from the tires.



A. Top view of Air Bag Sensor Module.

1. Air Bag Sensor Module
2. AS2 Connector
3. AS1 Connector
4. B Pillar Cover
5. Power Distribution Module
6. Clockspring
7. SRS1 (Supplemental Restraint System) Connector
8. Air Bag Wiring Harness

Fig. 2, Air Bag Harness Routing on Air Bag Only Systems Installed From May 12, 2000

IMPORTANT: There is no difference between an air bag/SPACE system installed on or after May 12, 2000 and an air bag/SPACE system installed prior to May 12, 2000. There is a difference in the air bag only system installed on or after May 12, 2000 and the air bag only system installed prior to May 12, 2000.

Before doing any of the following procedures, determine which type of supplemental protection system is installed in the vehicle. Look at the module under the driver's seat. The air bag/SPACE system and the air bag only system installed prior to May 12, 2000 have a SPACE module. If the vehicle has a SPACE system, gas cylinders are also located under the driver's seat. See **Fig. 1**. The air bag only system that became available on May 12, 2000 has an air bag sensor module located under the driver's seat. See **Fig. 2**.

Deactivating an Air Bag/SPACE System or an Air Bag Only System Installed Prior to May 12, 2000

NOTE: Deactivate the air bag only when directed to do so in the troubleshooting procedure.

1. Turn off the engine, apply the parking brakes, and chock the rear tires.
2. Disconnect the batteries and wait two minutes before proceeding.

⚠ WARNING

Wait two minutes after disconnecting the batteries to allow the internal components to discharge. Failure to allow the components to discharge could cause the air bag to deploy, resulting in severe bodily injury or death.

NOTE: Make sure the ignition is off when the DSS (Driver-Side SPACE) connector is disconnected or reconnected.

3. Disconnect the DSS connector and the PSS (Passenger-Side SPACE) connector if equipped. See **Fig. 1**.
4. Remove the fastener cover plugs from the steering wheel lower column cover. See **Fig. 3**.
5. Remove the fasteners and the column cover.
6. Loosen the air bag retainer screws underneath the steering wheel. See **Fig. 4**.

⚠ WARNING

Consider undeployed air bags to be dangerous and capable of deploying at any time. Follow the safety guidelines in this section. Failure to observe the safety guidelines could cause the unintentional deployment of the air bag, which could result in severe injury or death.

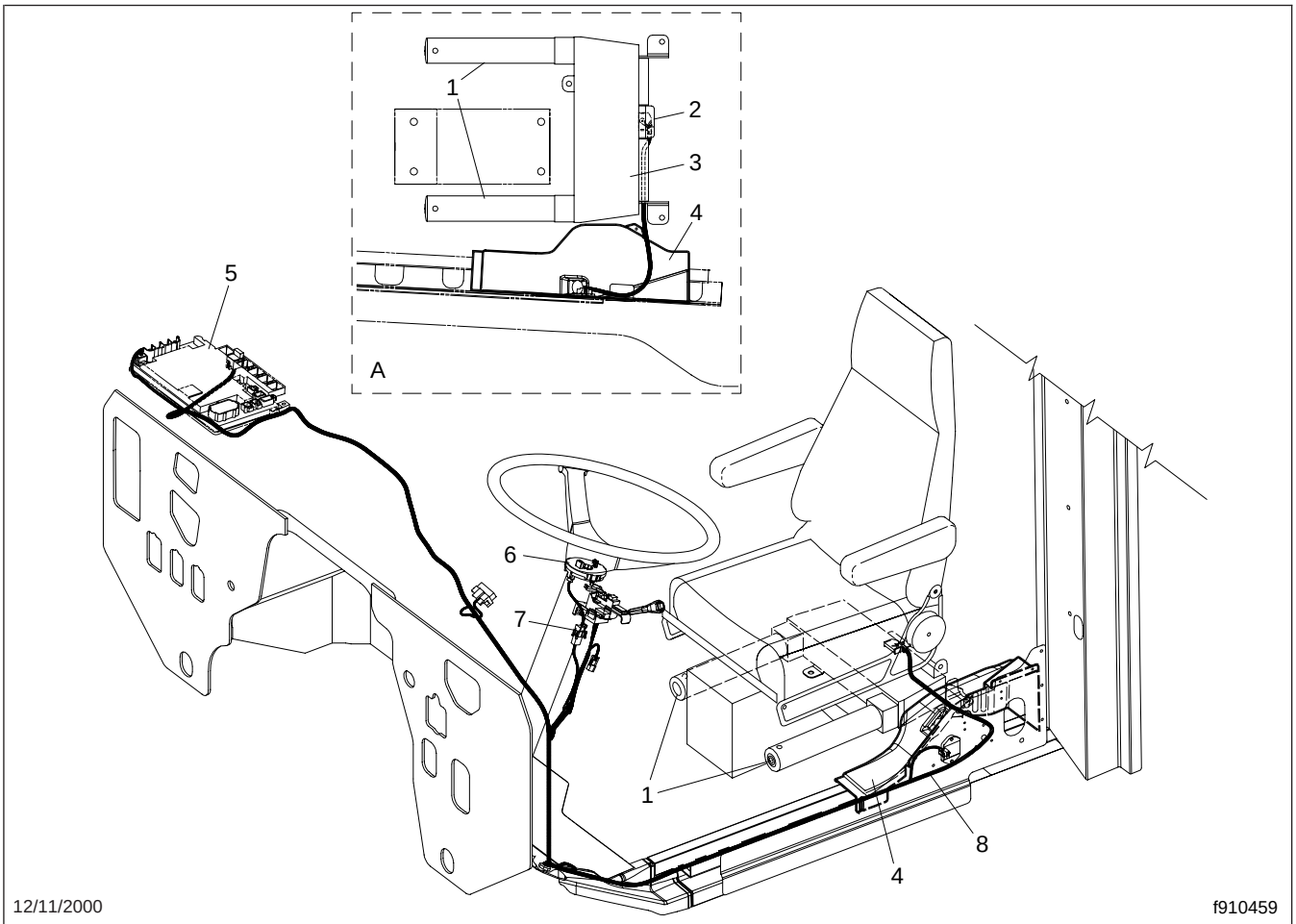
7. Carefully lift the air bag from the steering wheel and disconnect the air bag connector (and the horn switch connector if equipped) from the air bag. See **Fig. 5**, **Fig. 6**, and **Fig. 7**.
8. Remove the air bag.
9. Reconnect the DSS connector.
10. Reconnect the batteries.
11. Remove the chocks from the tires.

Reactivating an Air Bag/SPACE System or an Air Bag Only System Installed Prior to May 12, 2000

NOTE: Reactivate the air bag only when directed to do so in the troubleshooting procedure.

1. Turn off the engine, apply the parking brakes, and chock the rear tires.
2. Make sure that the connectors in the air bag system are connected, except for the air bag connector, the DSS connector, and the PSS connector if equipped.
3. Disconnect the batteries and wait two minutes before proceeding.

Deactivating and Reactivating Procedures



A. Top view of Air Bag/SPACE System.
1. Gas Cylinder (SPACE system only)
2. DSS (Driver-Side SPACE) Connector
3. Driver-Side SPACE Module
4. B-Pillar Cover
5. Power Distribution Module
6. Clockspring
7. SRS (Supplemental Restraint System) Connector
8. Air Bag Wiring Harness

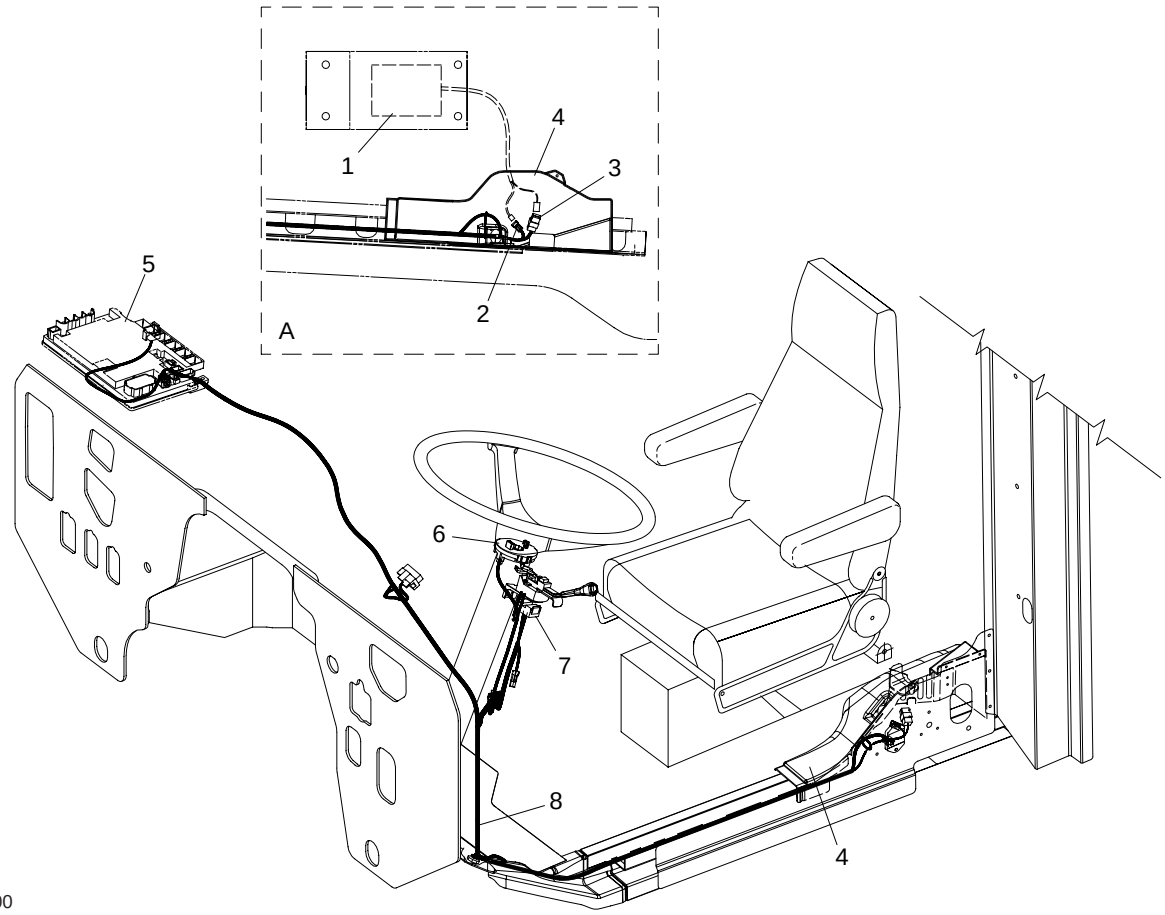
Fig. 1, Air Bag Harness Routing on Air Bag/SPACE Systems and Air Bag Only Systems Installed Prior to May 12, 2000

⚠ WARNING

Wait two minutes after disconnecting the batteries to allow the internal components to discharge. Failure to allow the components to discharge could cause the air bag to deploy, resulting in severe bodily injury or death.

4. Connect the electrical wiring from the clockspring (and from the horn switch connector if equipped) to the new air bag module, then position the air bag module on the steering wheel.
5. Tighten the air bag retaining screws at the bottom of the steering wheel.
6. Using the fasteners, attach the steering wheel lower column cover to the dash.
7. Install the fastener plugs.

NOTE: Make sure the ignition is off when the DSS connector is reconnected.



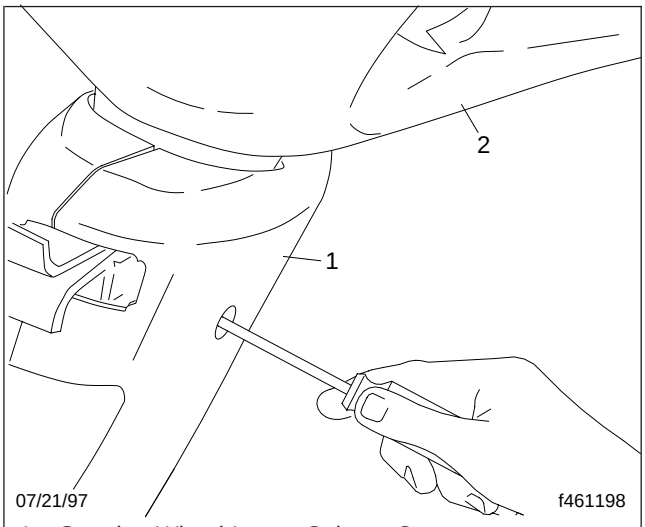
A. Top view of Air Bag Sensor Module.
1. Air Bag Sensor Module
2. AS2 Connector
3. AS1 Connector
4. B-Pillar Cover
5. Power Distribution Module
6. Clockspring
7. SRS1 (Supplemental Restraint System) Connector
8. Air Bag Wiring Harness

Fig. 2, Air Bag Harness Routing on Air Bag Only Systems Installed on or After May 12, 2000

8. Reconnect the DSS connector and the PSS connector if equipped. See **Fig. 1**.
9. Reconnect the batteries.
10. Check for fault codes and for the proper operation of the Supplemental Restraint System (SRS).
    - 10.1 While standing outside the cab and away from the front of the air bag, turn the ignition on.
    - 10.2 Check for active fault codes. If any are active, deactivate and correct them. If there are no active faults, go to the next step.
    - 10.3 Clear the historic faults using Service-Link®.

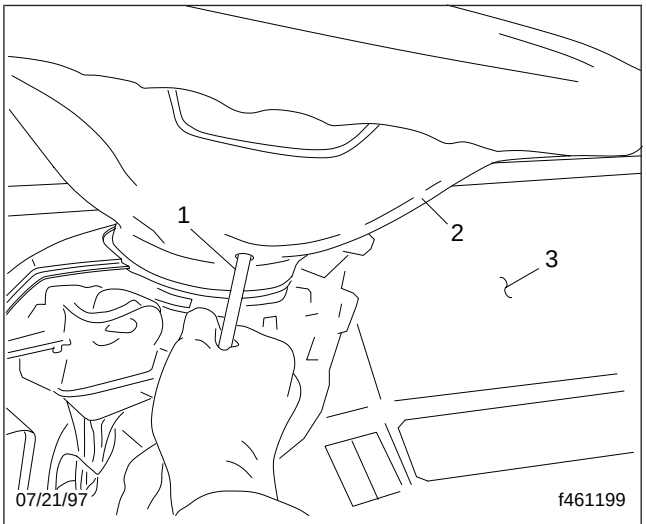
NOTE: If any faults are active, you must clear the historic codes or the SRS indicator will stay on.

Deactivating and Reactivating Procedures



1. Steering Wheel Lower Column Cover
2. Steering Wheel

Fig. 3, Removing the Fastener Cover Plugs

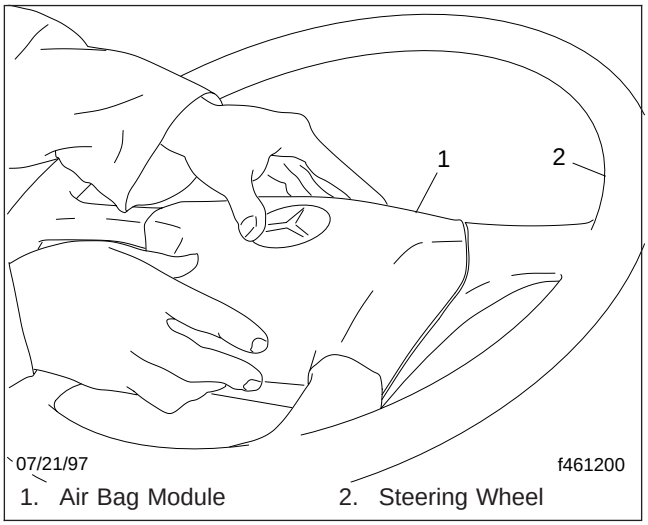


1. Screwdriver
2. Steering Wheel
3. B Dash Panel

Fig. 4, Loosening the Air Bag Retainer Screws

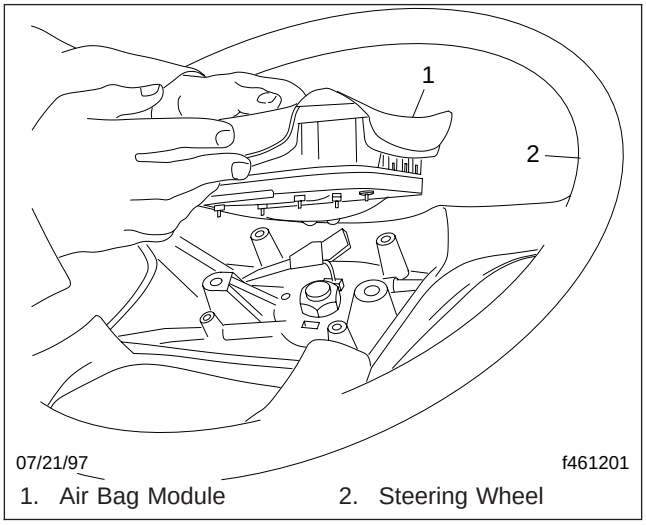
10.4 Check to make sure that the SRS indicator comes on for several seconds after the ignition is turned on, and then goes out.

10.5 If the SRS indicator remains on, or if there are active fault codes, follow the appropriate troubleshooting procedure. The air bag system may need to be deactivated again.



1. Air Bag Module
2. Steering Wheel

Fig. 5, Air Bag Module Installed

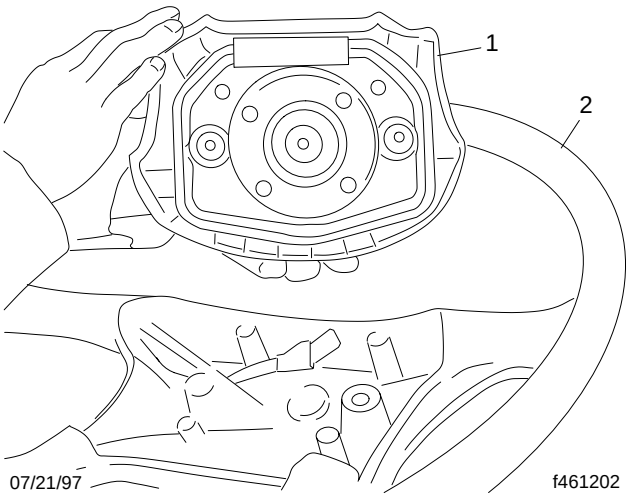


1. Air Bag Module
2. Steering Wheel

Fig. 6, Lifting the Air Bag Module

11. If the SRS indicator goes out and there are no active fault codes, the system is functioning properly.

12. Remove the chocks from the tires.



1. Air Bag Module Removed
2. Steering Wheel

Fig. 7, Air Bag Removed

Deactivating an Air Bag Only System Installed on or After May 12, 2000

NOTE: Deactivate the air bag only when directed to do so in the troubleshooting procedure.

1. Turn off the engine, apply the parking brakes, and chock the rear tires.
2. Disconnect the batteries and wait two minutes before proceeding.

⚠ WARNING

Wait two minutes after disconnecting the batteries to allow the internal components to discharge. Failure to allow the components to discharge could cause the air bag to deploy, resulting in severe bodily injury or death.

3. Disconnect the AS2 connector. See **Fig. 2**.
4. Remove the fastener cover plugs from the steering wheel lower column cover. See **Fig. 3**.
5. Remove the fasteners and the column cover.
6. Loosen the air bag retainer screws underneath the steering wheel. See **Fig. 4**.

⚠ WARNING

Consider undeployed air bags to be dangerous and capable of deploying at any time. Follow the safety guidelines in this section. Failure to observe the safety guidelines could cause the unintentional deployment of the air bag, which could result in severe injury or death.

7. Carefully lift the air bag from the steering wheel and disconnect the air bag connector (and the horn switch connector if equipped) from the air bag. See **Fig. 5**, **Fig. 6**, and **Fig. 7**.
8. Remove the air bag.
9. Reconnect the AS2 connector.
10. Reconnect the batteries.
11. Remove the chocks from the tires.

Reactivating an Air Bag Only System Installed on or After May 12, 2000

NOTE: Reactivate the air bag only when directed to do so in the troubleshooting procedure.

1. Turn off the engine, apply the parking brakes, and chock the rear tires.
2. Make sure that the connectors in the air bag system are connected, except for the air bag connector and the AS2 connector.
3. Disconnect the batteries and wait two minutes before proceeding.

⚠ WARNING

Wait two minutes after disconnecting the batteries to allow the internal components to discharge. Failure to allow the components to discharge could cause the air bag to deploy, resulting in severe bodily injury or death.

4. Connect the electrical wiring from the clockspring (and from the horn switch connector if equipped) to the new air bag module, then position the air bag module on the steering wheel.

Deactivating and Reactivating Procedures

5. Tighten the air bag retaining screws at the bottom of the steering wheel.
6. Using the fasteners, attach the steering wheel lower column cover to the dash.
7. Install the fastener plugs.
8. Connect the AS2 connector. See **Fig. 2**.
9. Reconnect the batteries.
10. Check for fault codes and for the proper operation of the Supplemental Restraint System (SRS).
    - 10.1 While standing outside the cab and away from the front of the air bag, turn the ignition on.
    - 10.2 Check for active fault codes. If any are active, deactivate and correct them. If there are no active faults, go to the next step.
    - 10.3 Clear the historic faults using Service-Link®.

    NOTE: If any faults are active, you must clear the historic codes or the SRS indicator will stay on.

    - 10.4 Check to make sure that the SRS indicator comes on for several seconds after the ignition is turned on, and then goes out.
    - 10.5 If the SRS indicator remains on, or if there are active fault codes, follow the appropriate troubleshooting procedure. The air bag system may need to be deactivated again.
11. If the SRS indicator goes out and there are no active fault codes, the system is functioning properly.
12. Remove the chocks from the tires.

Air Bag Disposal Procedure

⚠ WARNING

Air bags are designed to work in specific vehicle makes and models. Air bag modules and components can not be adapted, reused, or installed in any vehicle other than the vehicle they are designed and manufactured for. Any attempt to adapt, reuse, or install an air bag module or component in any other vehicle can result in death or severe injury to vehicle occupants in the event of an accident.

IMPORTANT: The storage, transportation, disposal, or recycling of air bag modules or components must be performed in accordance with all applicable federal, state, and local regulations including, but not limited to, those governing building and fire codes, environmental protection, occupational health and safety, and transportation.

NOTE: If a vehicle is going to be scrapped and the air bag or SPACE system has not been deployed, contact your District Service Manager for instructions on how to proceed.

1. Remove the inflator from a deployed air bag module. Send the inflator to a recycler for reclamation of the steel and aluminum components.
2. Separate the air bag from the recyclable steel and aluminum components.
3. The plastic materials may be recycled or disposed of in common trash.

Replacement

1. Turn off the engine, apply the parking brakes, and chock the rear tires.

⚠ WARNING

Before removing the mounting capscrews from the sensor module, be sure to disconnect the batteries and disconnect the wiring from the sensor module. Failure to follow these precautions may result in the air bag being unintentionally deployed, which could cause severe bodily injury or death.

2. Disconnect the batteries and wait two minutes before proceeding.

⚠ WARNING

Wait two minutes after disconnecting the batteries to allow the internal components to discharge. Failure to allow the components to discharge could cause the air bag to deploy, resulting in severe bodily injury or death.

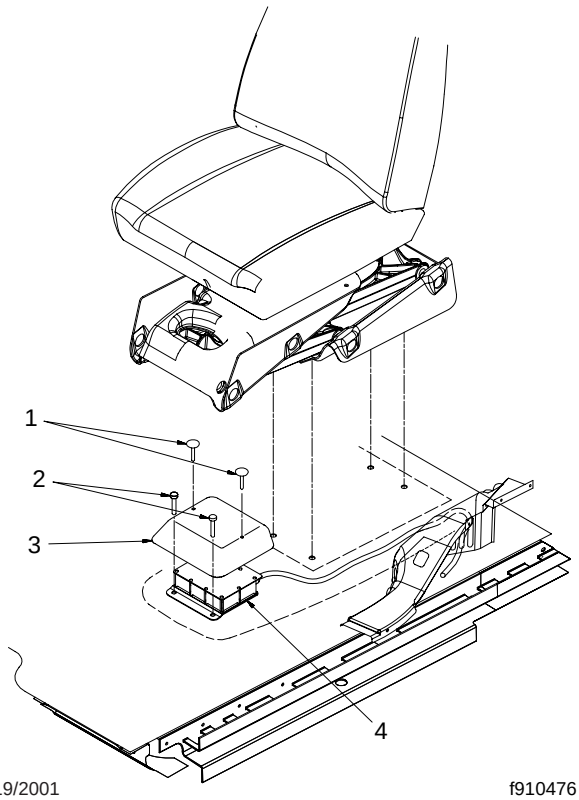
3. Raise the seat to its maximum position. If the seat is equipped with a seat shroud, lift the shroud to access the air bag sensor module.
4. Remove the plastic retainers that attach the sensor module cover to the sensor module and remove the cover. See **Fig. 1** or **Fig. 2**.
5. Disconnect the wiring from the sensor module at the AS2 connector under the B pillar cover.
6. Remove the sensor module.
   - On vehicles with an EzyRider seat, remove the capscrews that attach the sensor module to the cab floor. See **Fig. 1**.
   - On vehicles with a nonproprietary seat, remove the capscrews that attach both the sensor module and the seat to the cab floor. The front mounting capscrews for the seat may need to be loosened to remove the sensor module. See **Fig. 2**.
7. Install the new sensor module.
   - On vehicles with an EzyRider seat, use two capscrews to attach the sensor module to the cab floor. Torque the capscrews 25 to 29 lbf·ft (34 to 39 N·m).
   - On vehicles with a nonproprietary seat, use two capscrews to attach both the sensor module and the seat to the cab floor. If the front mounting capscrews for the seat were loosened, tighten the capscrews. Torque the capscrews 35 to 40 lbf·ft (47 to 54 N·m).

⚠ WARNING

Before attaching the wiring to the sensor module and before connecting the batteries, be sure to attach and tighten the mounting capscrews to the sensor module. Failure to follow these precautions may result in the air bag being unintentionally deployed, which could cause personal injury or property damage.

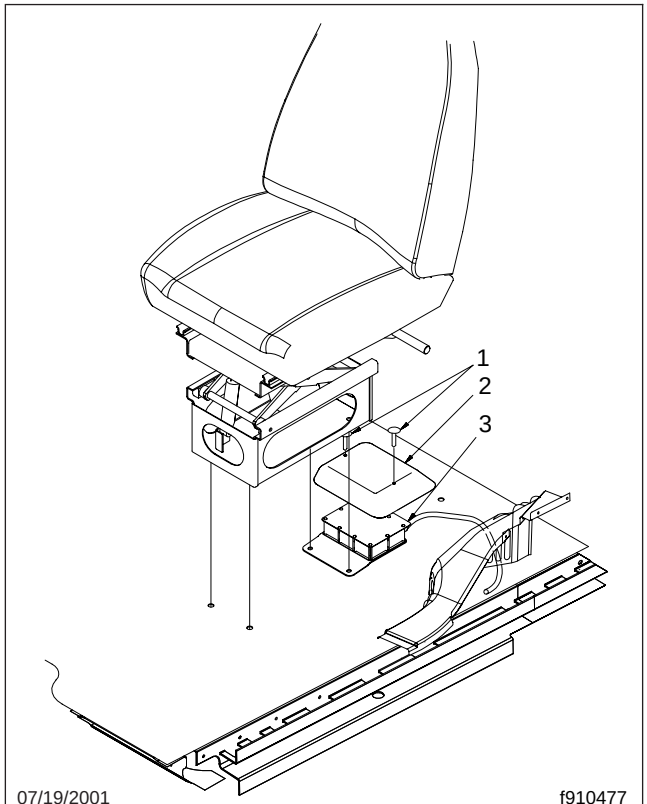
8. Attach the wiring to the sensor module.
9. Using two plastic retainers, attach the sensor module cover to the sensor module.
10. Lower the seat. If the seat is equipped with a seat shroud, lower the shroud around the base of the seat.
11. Connect the batteries and remove the chocks from the tires.

Air Bag Sensor Module Replacement



1. Sensor Module Cover Plastic Retainer
2. Sensor Module Capscrew
3. Sensor Module Cover
4. Sensor Module

Fig. 1, EzyRider Seat With Air Bag Sensor Module



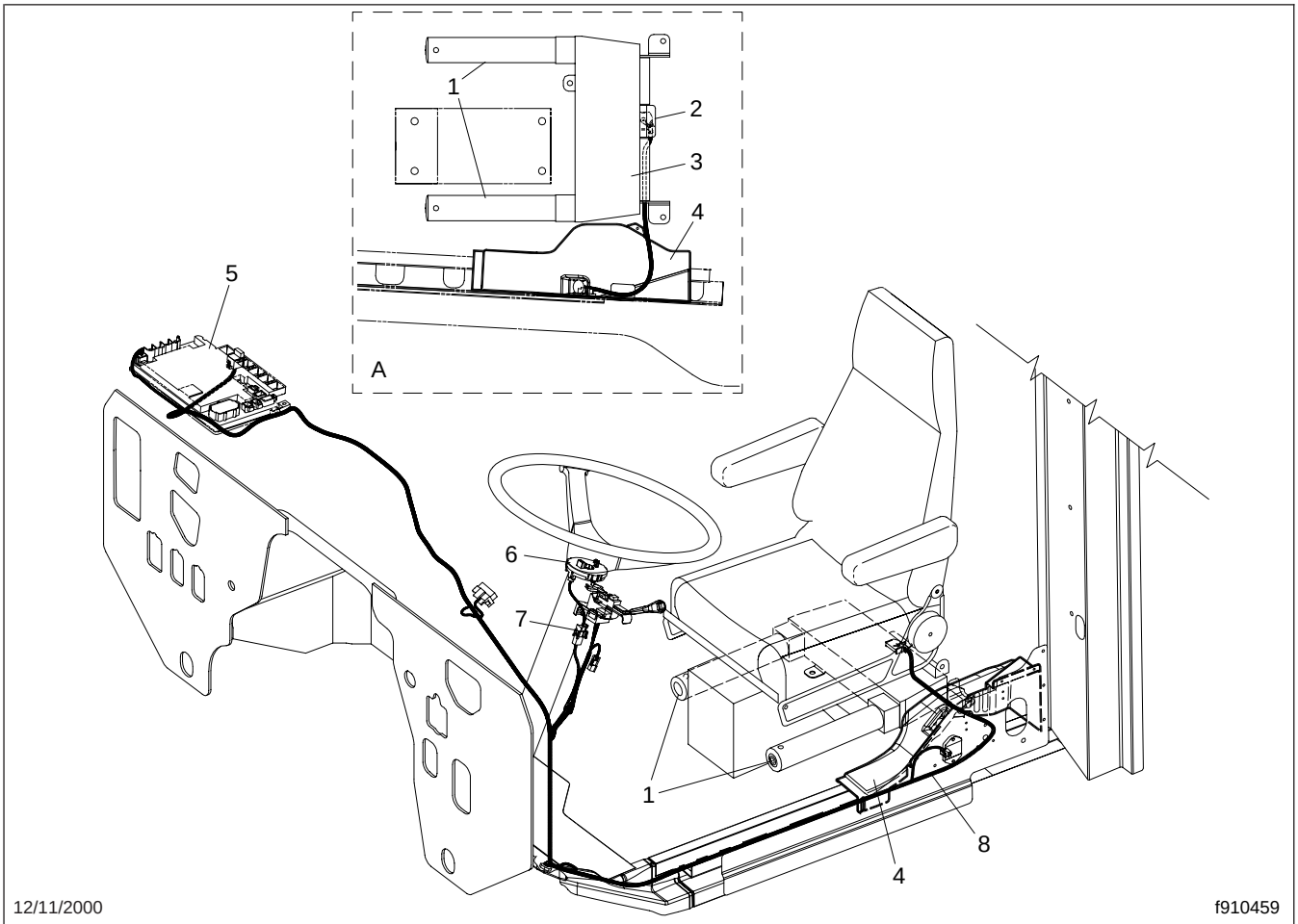
1. Sensor Module Cover Plastic Retainer
2. Sensor Module Cover
3. Sensor Module

Fig. 2, Nonproprietary Seat With Air Bag Sensor Module

Troubleshooting

IMPORTANT: There is no difference between an air bag/SPACE system installed on or after May 12, 2000 and an air bag/SPACE system installed prior to May 12, 2000. There is a difference in the air bag only system installed on or after May 12, 2000 and the air bag only system installed prior to May 12, 2000.

To determine which type of supplemental protection system is installed in the vehicle, look at the module under the driver's seat. The air bag/SPACE system and the air bag only system installed prior to May 12, 2000 have a SPACE module. If the vehicle has a SPACE system, gas cylinders are also located under the driver's seat; see **Fig. 1**. The air bag only system that became available on May 12, 2000 has an air bag sensor module located under the driver's seat; see **Fig. 2**.

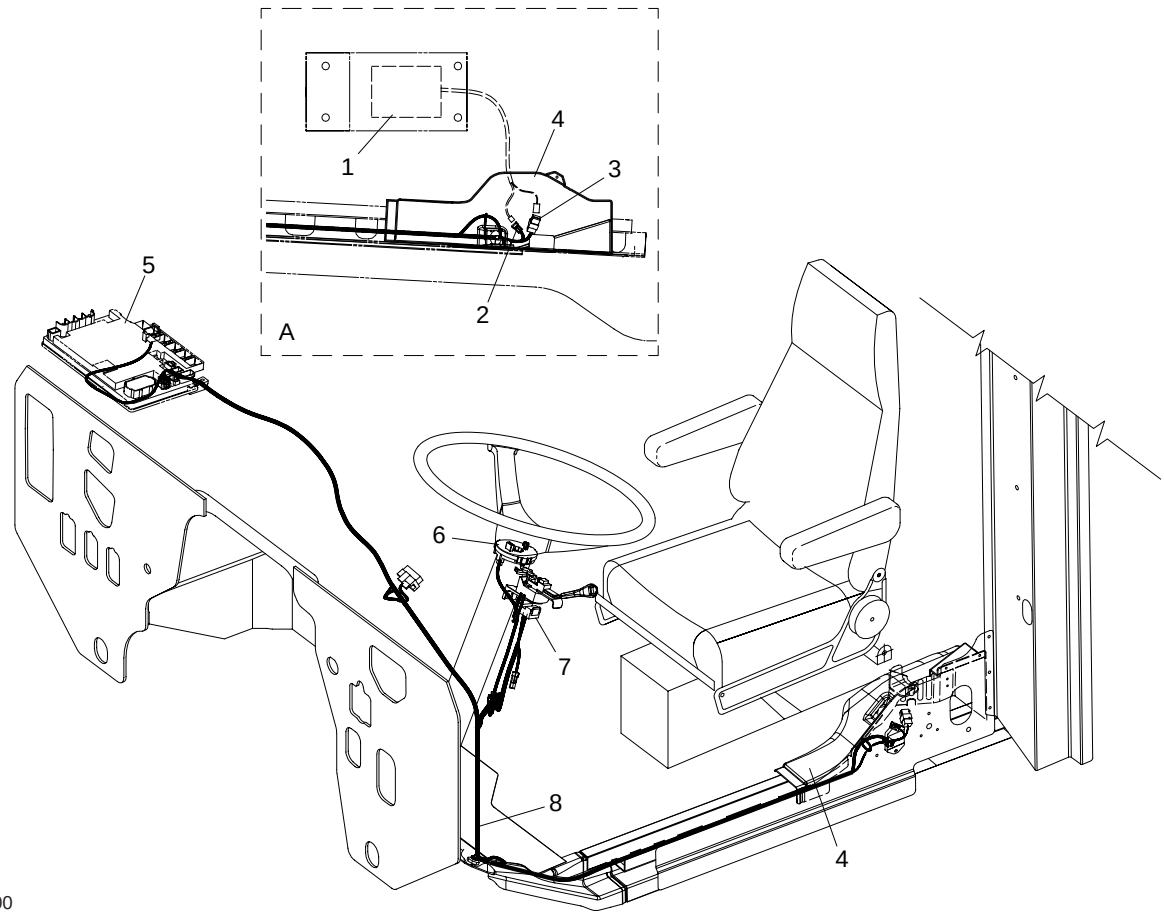


A. Top view of Air Bag/SPACE System.

1. Gas Cylinder (SPACE system only)
2. DSS (Driver-Side SPACE) Connector
3. Driver-Side SPACE Module
4. B-Pillar Cover
5. Power Distribution Module
6. Clockspring
7. SRS (Supplemental Restraint System) Connector
8. Air Bag Wiring Harness

Fig. 1, Air Bag Harness Routing on Air Bag/SPACE Systems and Air Bag Only Systems Installed Prior to May 12, 2000

Troubleshooting



A. Top view of Air Bag Sensor Module.

1. Air Bag Sensor Module
2. AS2 Connector
3. AS1 Connector
4. B-Pillar Cover
5. Power Distribution Module
6. Clockspring
7. SRS1 (Supplemental Restraint System) Connector
8. Air Bag Wiring Harness

Fig. 2, Air Bag Harness Routing on Air Bag Only Systems Installed on or After May 12, 2000

Troubleshooting the Air Bag/ SPACE System or the Air Bag Only System Installed Prior to May 12, 2000

⚠ WARNING

When directed to activate or deactivate, connect or disconnect, assemble or disassemble any part of the system in a troubleshooting procedure, refer to the appropriate procedures and warnings in Subject 140, and the safety guidelines in Subject 100. Consider undeployed air bags to be dangerous and capable of deploying at any time. Failure to observe the proper procedures and safety guidelines could cause the unintentional deployment of the air bag, which could result in severe injury or death.

IMPORTANT: The clockspring has one green wire and one violet wire. The green-wire circuit has a capacitor in series inside the air bag connector. The wires going into the air bag connec-

tor appear to line up directly with the pins of the connector. However, the wires are routed internally to the opposite pins. Be sure to make note of the pin numbers when troubleshooting the clockspring.

NOTE: On vehicles with driver-side SPACE, the system cannot be fully deactivated and still allow for diagnostics. Consider the driver-side SPACE to be live any time the DSS connector is connected.

See **Specifications 400** for the air bag/SPACE system wiring diagrams.

Troubleshooting the Air Bag Only System Installed on or After May 12, 2000

⚠ WARNING

When directed to activate or deactivate, connect or disconnect, assemble or disassemble any part of the system in a troubleshooting procedure, refer to the appropriate procedures and warnings in Subject 140, and the safety guidelines in Subject 100. Consider undeployed air bags to be dangerous and capable of deploying at any time. Failure to observe the proper procedures and safety guidelines could cause the unintentional deployment of the air bag, which could result in severe injury or death.

IMPORTANT: The clockspring has one green wire and one violet wire. The green-wire circuit has a capacitor in series inside the air bag connector. The wires going into the air bag connector appear to line up directly with the pins of the connector. However, the wires are routed internally to the opposite pins. Be sure to make note of the pin numbers when troubleshooting the clockspring.

See **Specifications 400** for the air bag only system wiring diagram.

Troubleshooting Charts

NOTE: If the fault codes were active previously, you must clear the historic codes, or the SRS lamp will stay on.

For the air bag/SPACE system or the air bag only system installed prior to May 12, 2000, see **Table 1** for the fault codes, fault code descriptions, and the figure numbers of the corresponding troubleshooting charts.

For the air bag only system installed on or after May 12, 2000, see **Table 2** for the fault codes, fault code descriptions, and the figure numbers of the corresponding troubleshooting charts.

Troubleshooting Charts for the Air Bag/SPACE System or the Air Bag Only System Installed Prior to May 12, 2000

Fault Code	Fault Code Description	Figure Number
232-001-03	driver-side air bag short to power	**Fig. 3**
232-001-04	driver-side air bag short to ground	**Fig. 4**
232-001-05	driver-side air bag open circuit	**Fig. 5**, **Fig. 6**, and **Fig. 7**
232-001-06	driver-side air bag loop wiring shorted	**Fig. 8**
232-003-03	driver-side SPACE firing circuit short to power	**Fig. 9**
232-003-04	driver-side SPACE firing circuit short to ground	**Fig. 9**
232-003-05	driver-side SPACE firing circuit open circuit	**Fig. 9**
232-003-06	driver-side SPACE firing circuit short	**Fig. 9**
232-004-03	passenger-side SPACE firing circuit short to power	**Fig. 10**
232-004-04	passenger-side SPACE firing circuit short to ground	**Fig. 11**
232-004-05	passenger-side SPACE firing circuit open circuit	**Fig. 12**
232-004-06	passenger-side SPACE firing circuit shorted	**Fig. 13**

Troubleshooting

Troubleshooting Charts for the Air Bag/SPACE System or the Air Bag Only System Installed Prior to May 12, 2000		
Fault Code	**Fault Code Description**	**Figure Number**
232-005-03	SRS warning lamp short to power	**Fig. 14**
232-005-04	SRS warning lamp short to ground	**Fig. 15**
No Fault Code	SRS indicator is not working	**Fig. 16**
No Fault Code	SRS indicator stays on and/or a connection to the vehicle through the J1587 diagnostic connector is not possible	**Fig. 17**
232-240-14	frontal collision detected*	No Figure Air bag deployed during frontal collision; replace the airbag sensor module and deployed components.
232-253-02	SRS module calibration memory checksum error (internal error)*	No Figure The SRS module has an internal memory error and must be replaced.
232-254-07	SPACE module is not communicating with the J1587 datalink or it has lost power—the roll call fault code will only display on the ICU, not on ServiceLink	**Fig. 18**
232-254-12	SRS module bad intelligent device (internal error)*	No Figure The SRS module has an internal memory error and must be replaced.

* This fault cannot be cleared from memory.

Table 1, Troubleshooting Charts for the Air Bag/SPACE System or the Air Bag Only System Installed Prior to May 12, 2000

Troubleshooting Charts for the Air Bag Only System Installed on or After May 12, 2000		
Fault Code	**Fault Code Description**	**Figure Number**
232-001-03	air bag loop wiring short to power	**Fig. 19**
232-001-04	air bag loop wiring short to ground	**Fig. 20**
232-001-05	air bag loop wiring open circuit	**Fig. 21** and **Fig. 22**
232-001-06	air bag loop wiring shorted	**Fig. 23**
232-003	air bag sensor loops improperly terminated	**Fig. 24**
232-004	air bag sensor loops improperly terminated	**Fig. 24**
232-005-03	SRS warning lamp short to power	**Fig. 14**
232-005-04	SRS warning lamp short to ground	**Fig. 15**
No Fault Code	SRS indicator is not working	**Fig. 25**
No Fault Code	SRS indicator stays on and/or a connection to the vehicle through the J1587 diagnostic connector is not possible	**Fig. 26**

Troubleshooting Charts for the Air Bag Only System Installed on or After May 12, 2000		
Fault Code	**Fault Code Description**	**Figure Number**
232-240-14	frontal collision detected*	No Figure Air bag deployed during frontal collision; replace the airbag sensor module and deployed components.
232-253-02	SRS module calibration memory checksum error (internal error)*	No Figure The SRS module has an internal memory error and must be replaced.
232-254-07	SPACE module is not communicating with the J1587 datalink or it has lost power—the roll call fault code will only display on the ICU, not on ServiceLink	**Fig. 27**
232-254-12	SRS module bad intelligent device (internal error)*	No Figure The SRS module has an internal memory error and must be replaced.

* This fault cannot be cleared from memory.

Table 2, Troubleshooting Charts for the Air Bag Only System Installed on or After May 12, 2000

Troubleshooting

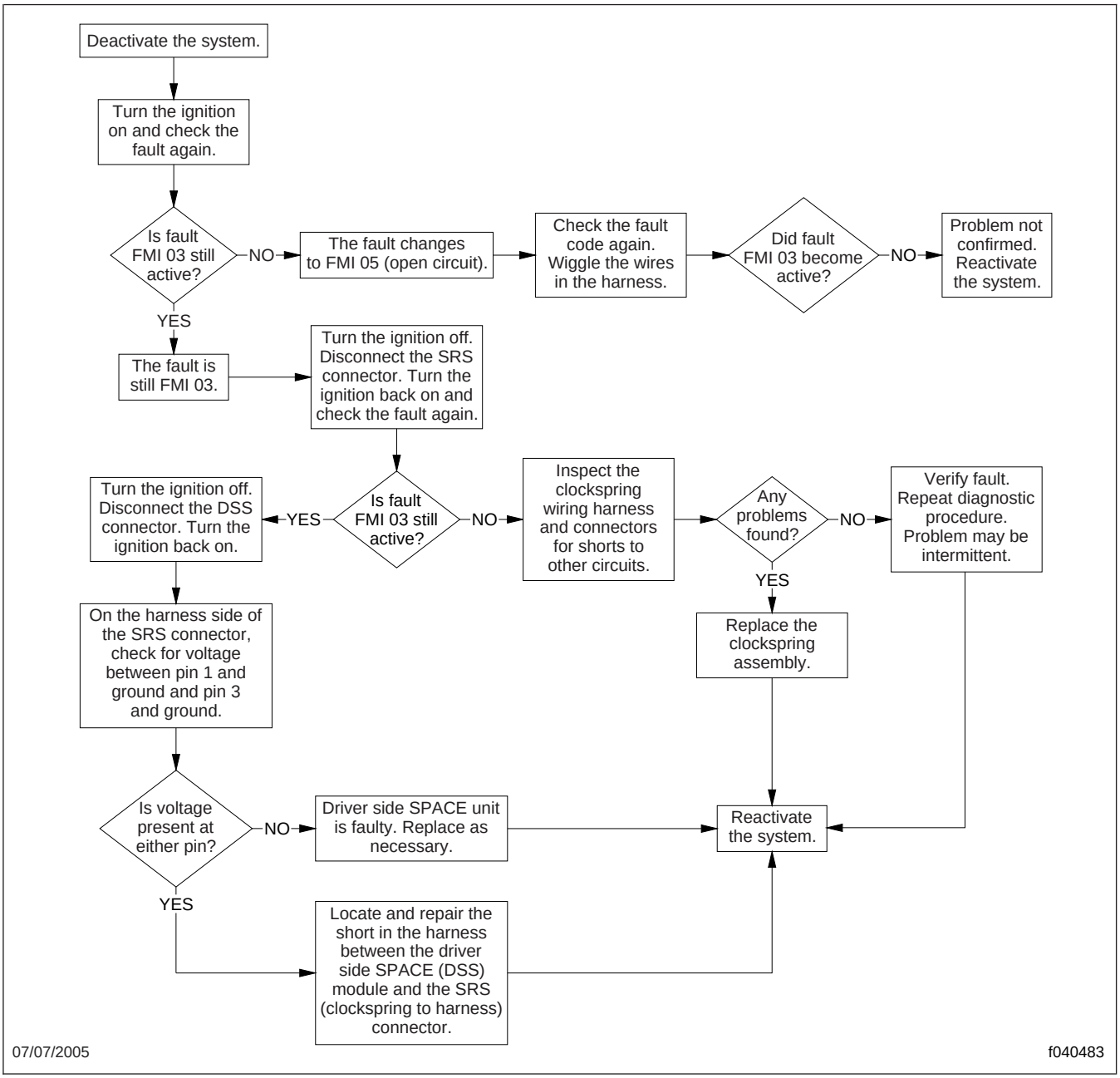


Fig. 3, Fault Code 232-001-03, Driver-Side Air Bag Short to Power

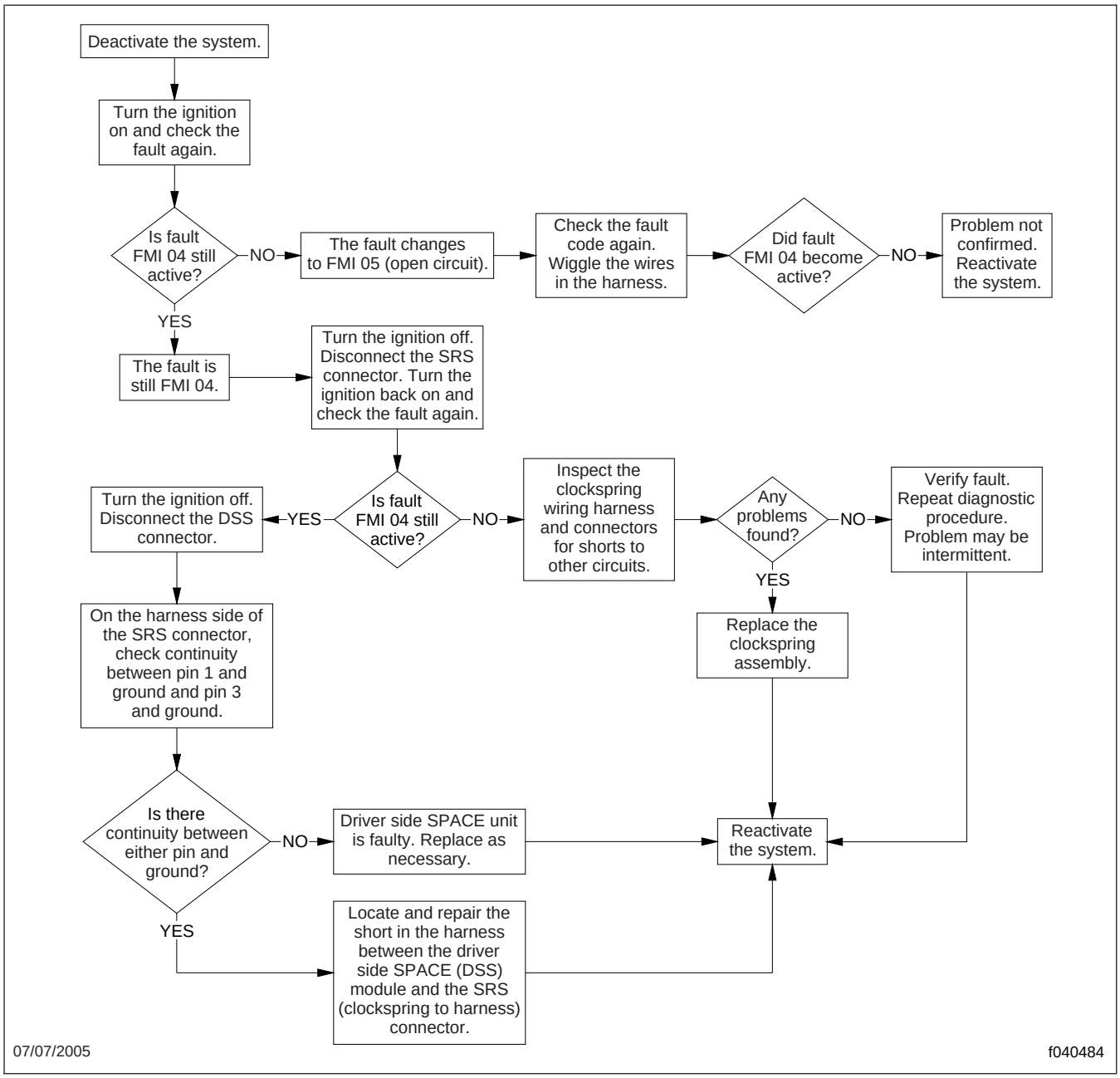


Fig. 4, Fault Code 232-001-04, Driver-Side Air Bag Short to Ground

Troubleshooting

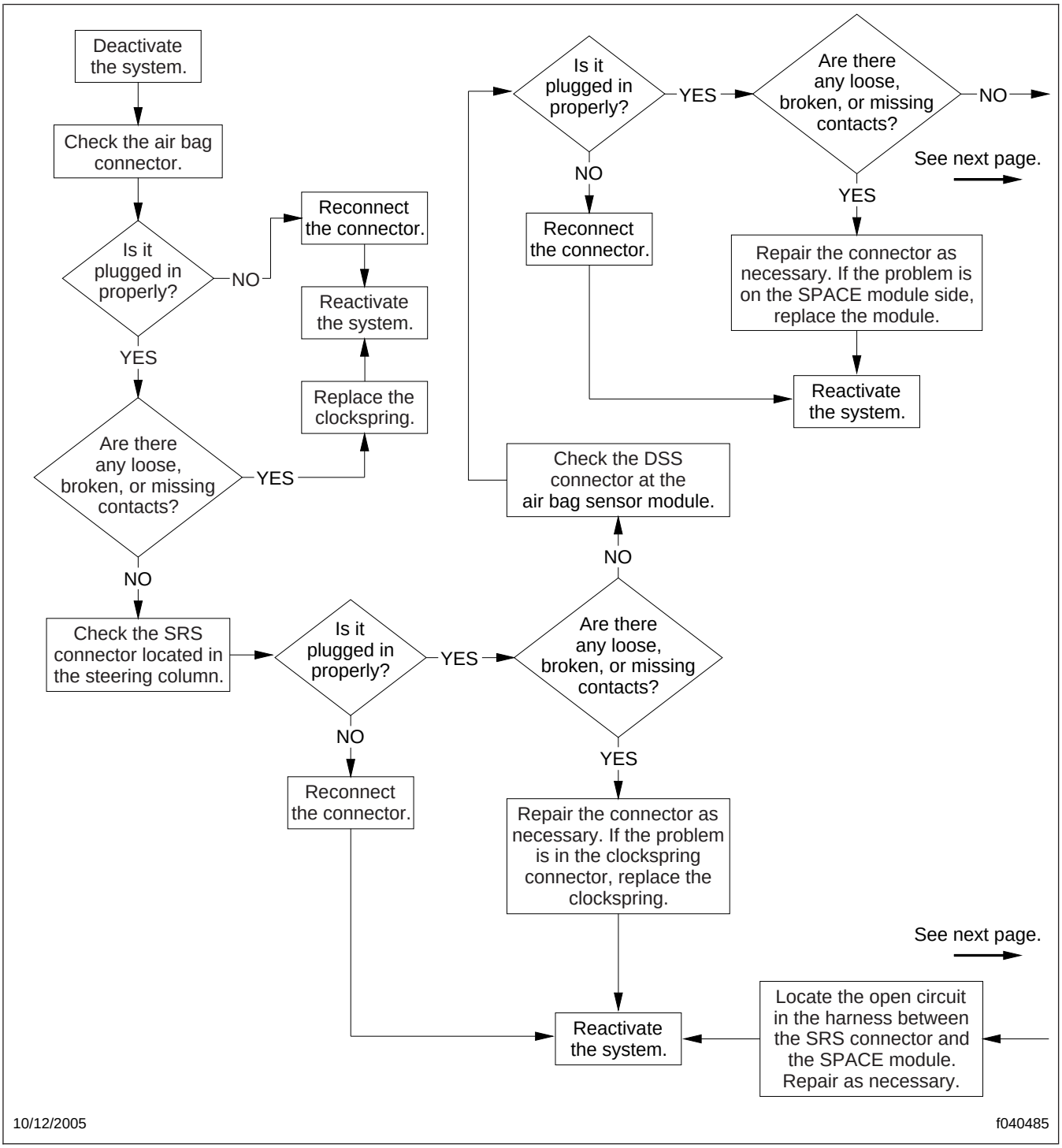


Fig. 5, Fault Code 232-001-05, Driver-Side Air Bag Open Circuit, Part 1

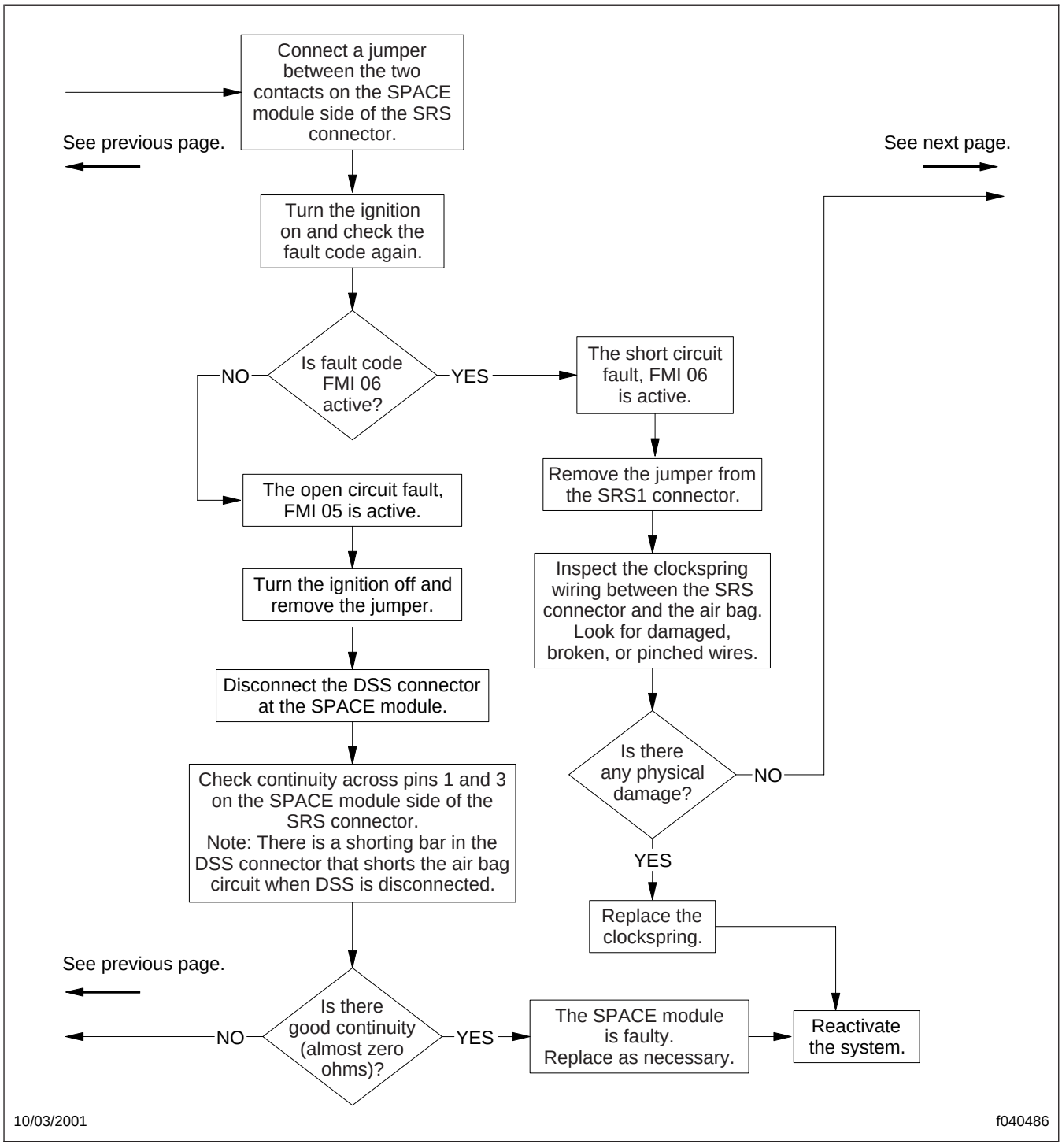


Fig. 6, Fault Code 232-001-05, Driver-Side Air Bag Open Circuit, Part 2

Troubleshooting

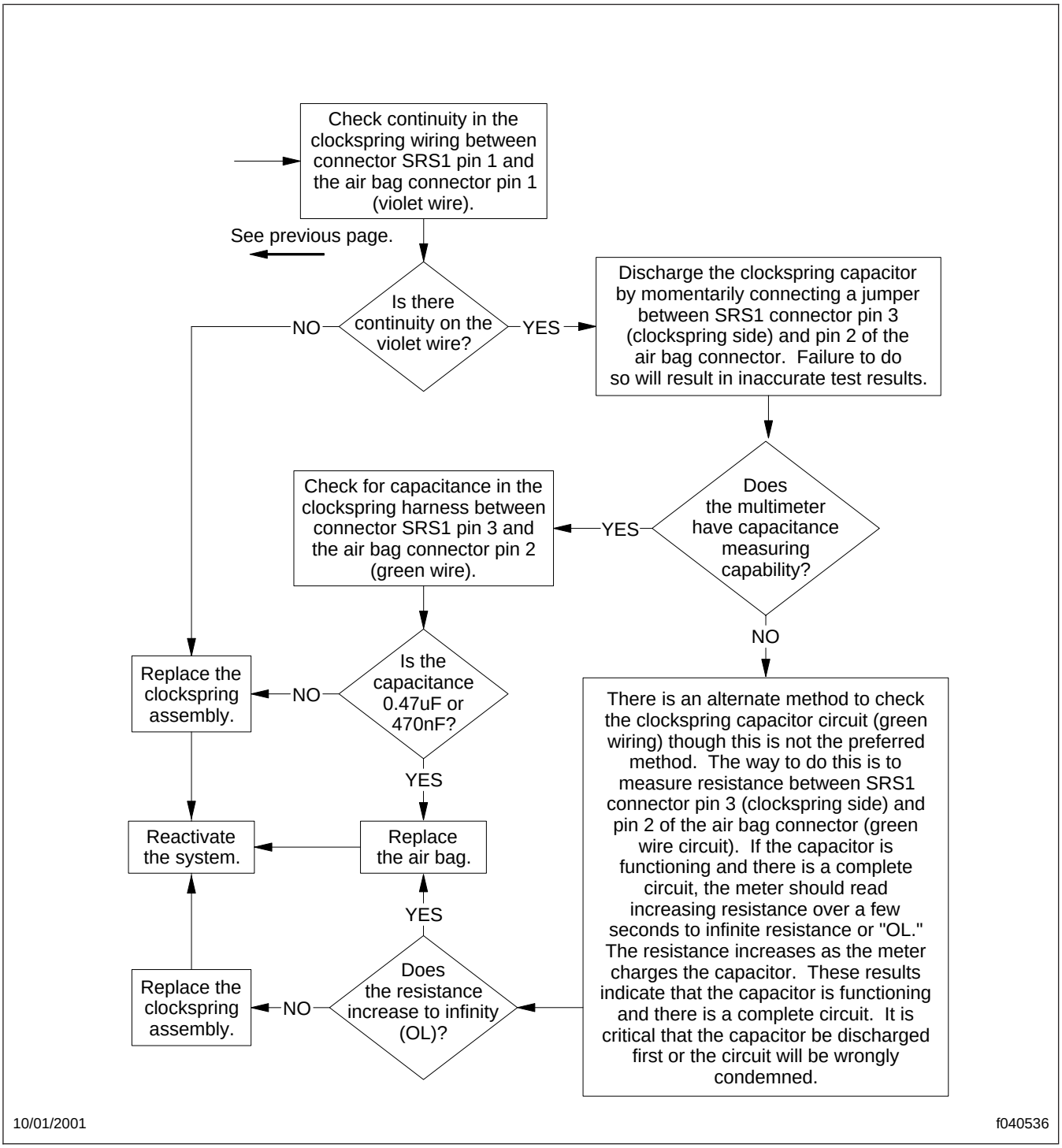


Fig. 7, Fault Code 232-001-05, Driver-Side Air Bag Open Circuit, Part 3

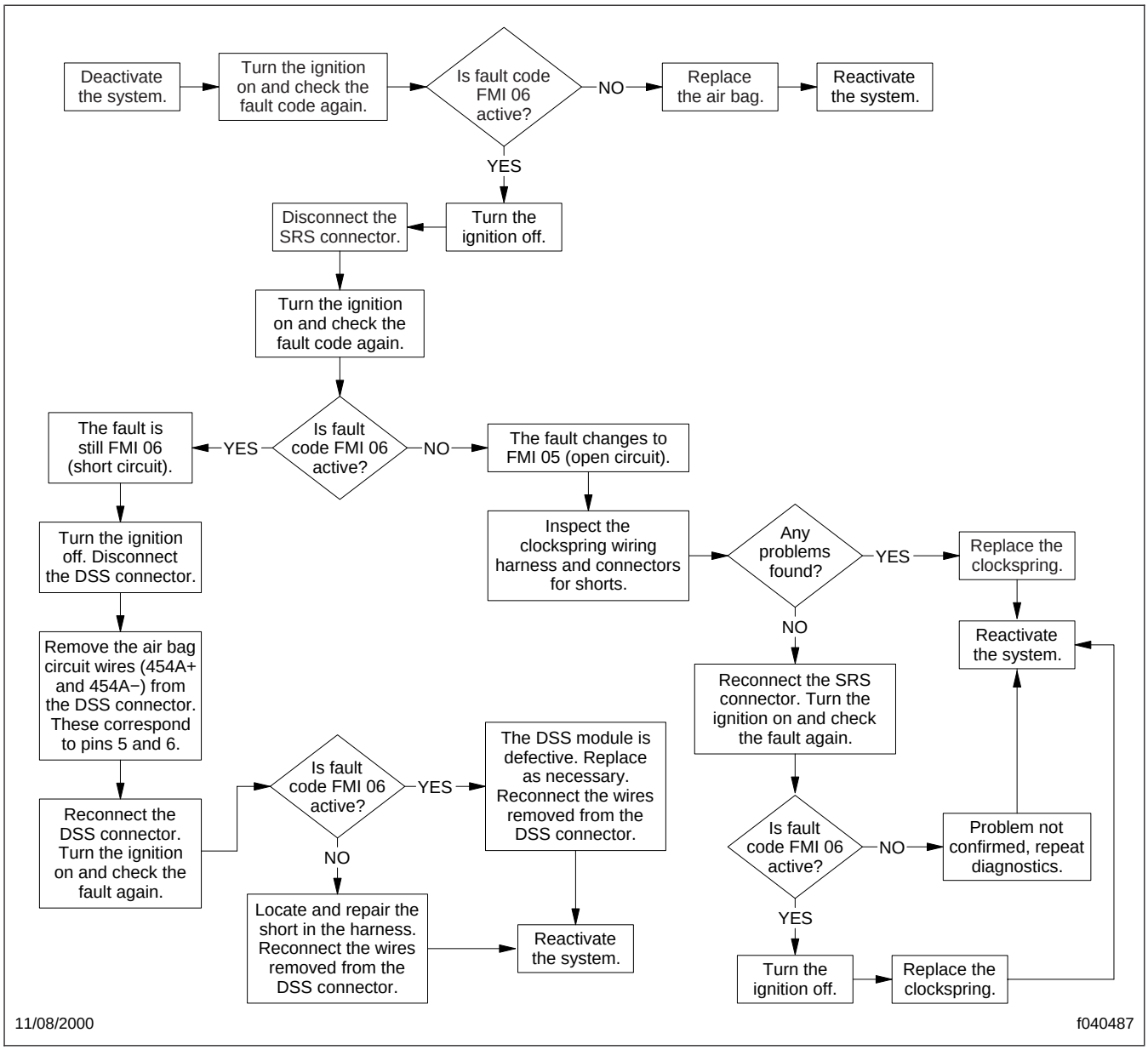


Fig. 8, Fault Code 232-001-06, Driver-Side Air Bag Loop Wiring Shorted

Troubleshooting

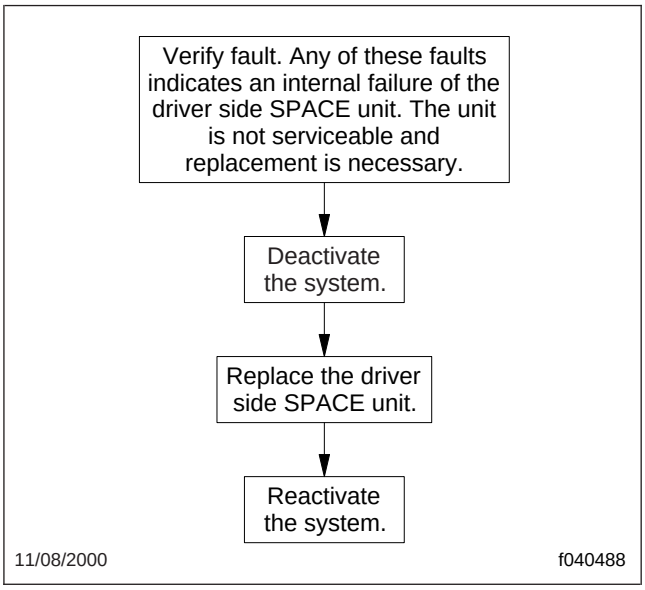


Fig. 9, Fault Codes 232-003-03, Short to Power, 232-003-04, Short to Ground, 232-003-05, Open Circuit, and 232-003-06, Short

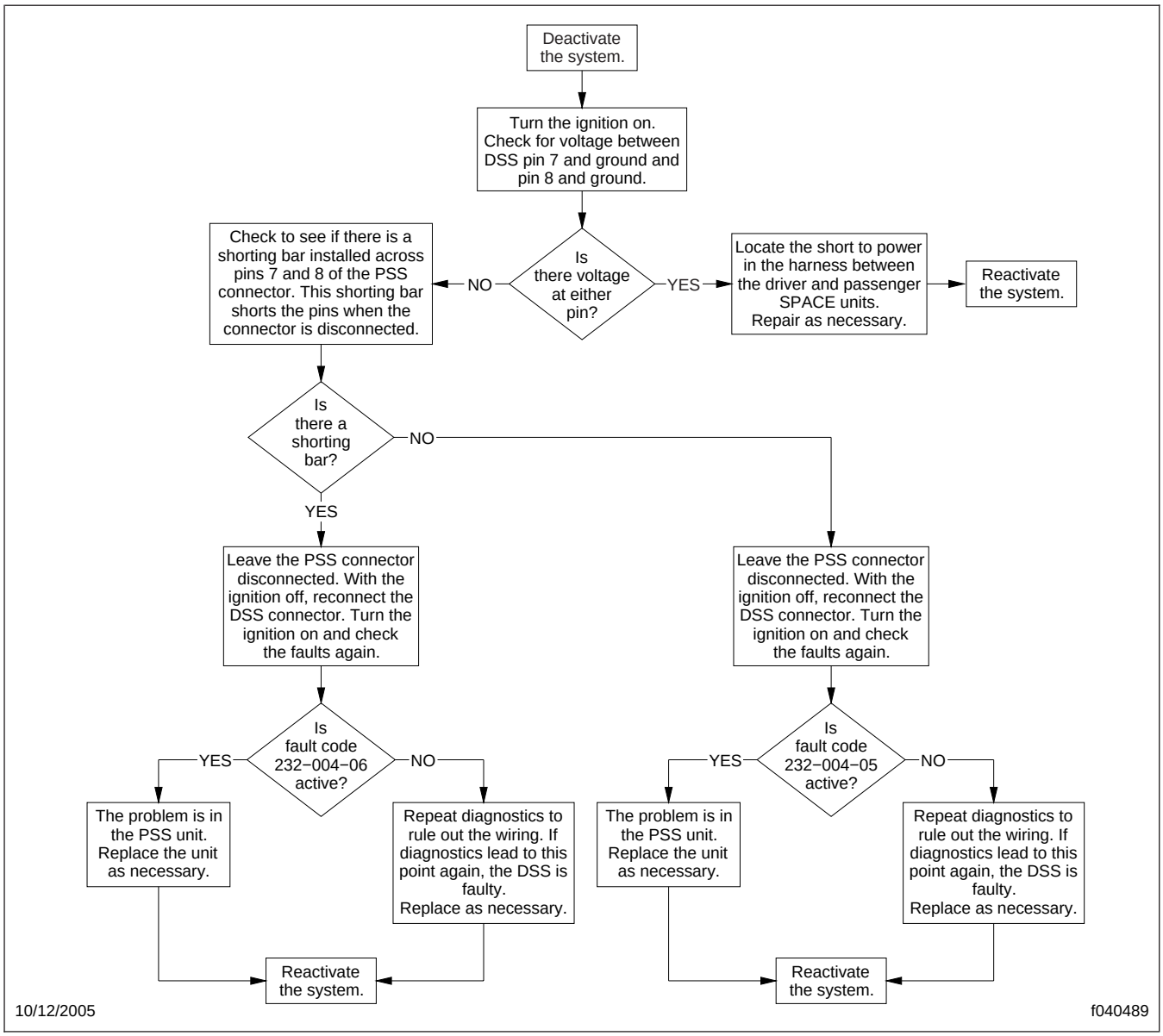


Fig. 10, Fault Code 232-004-03, Passenger-Side SPACE Firing Circuit Short to Power

Troubleshooting

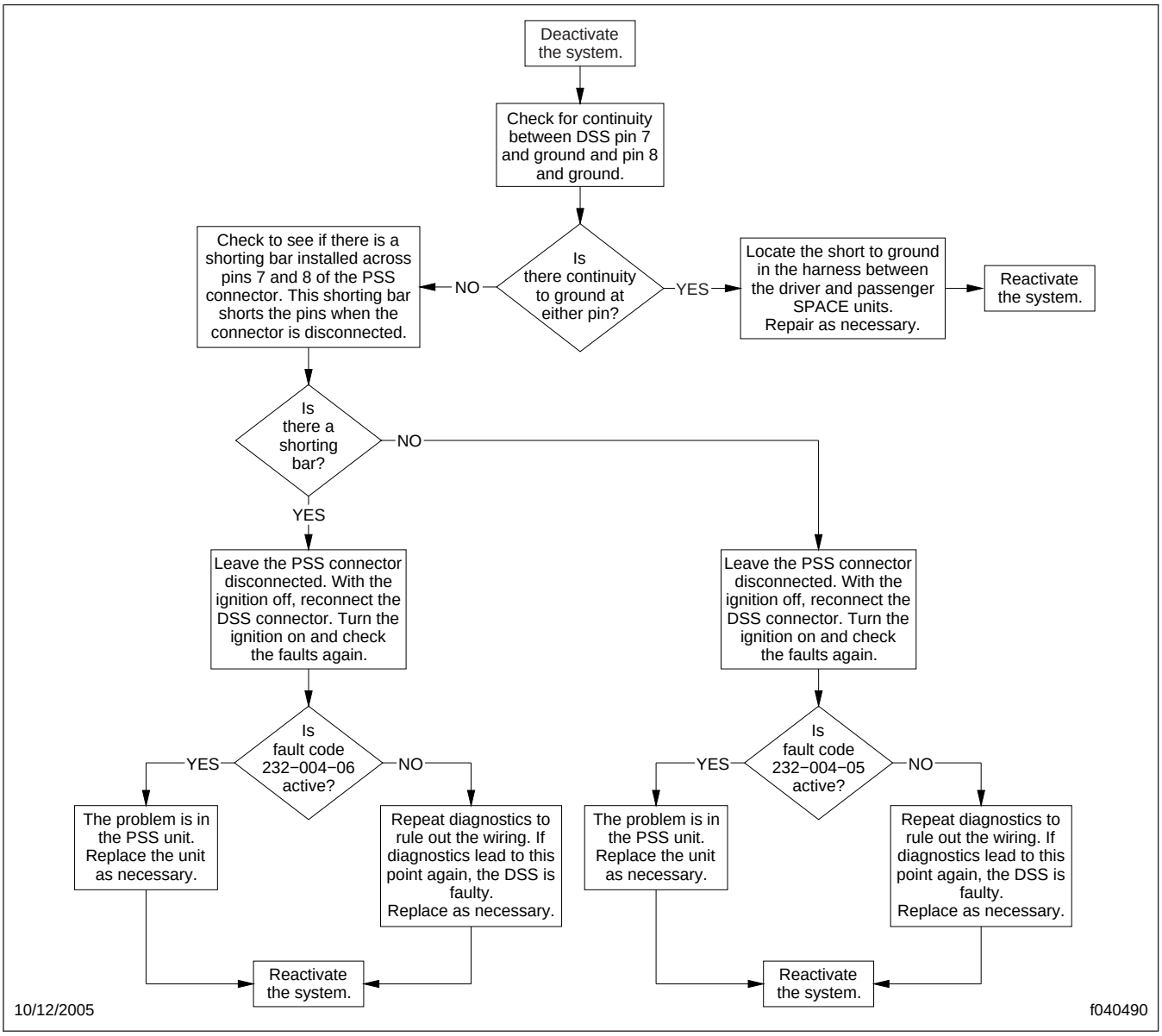


Fig. 11, Fault Code 232-004-04, Passenger-Side SPACE Firing Circuit Short to Ground

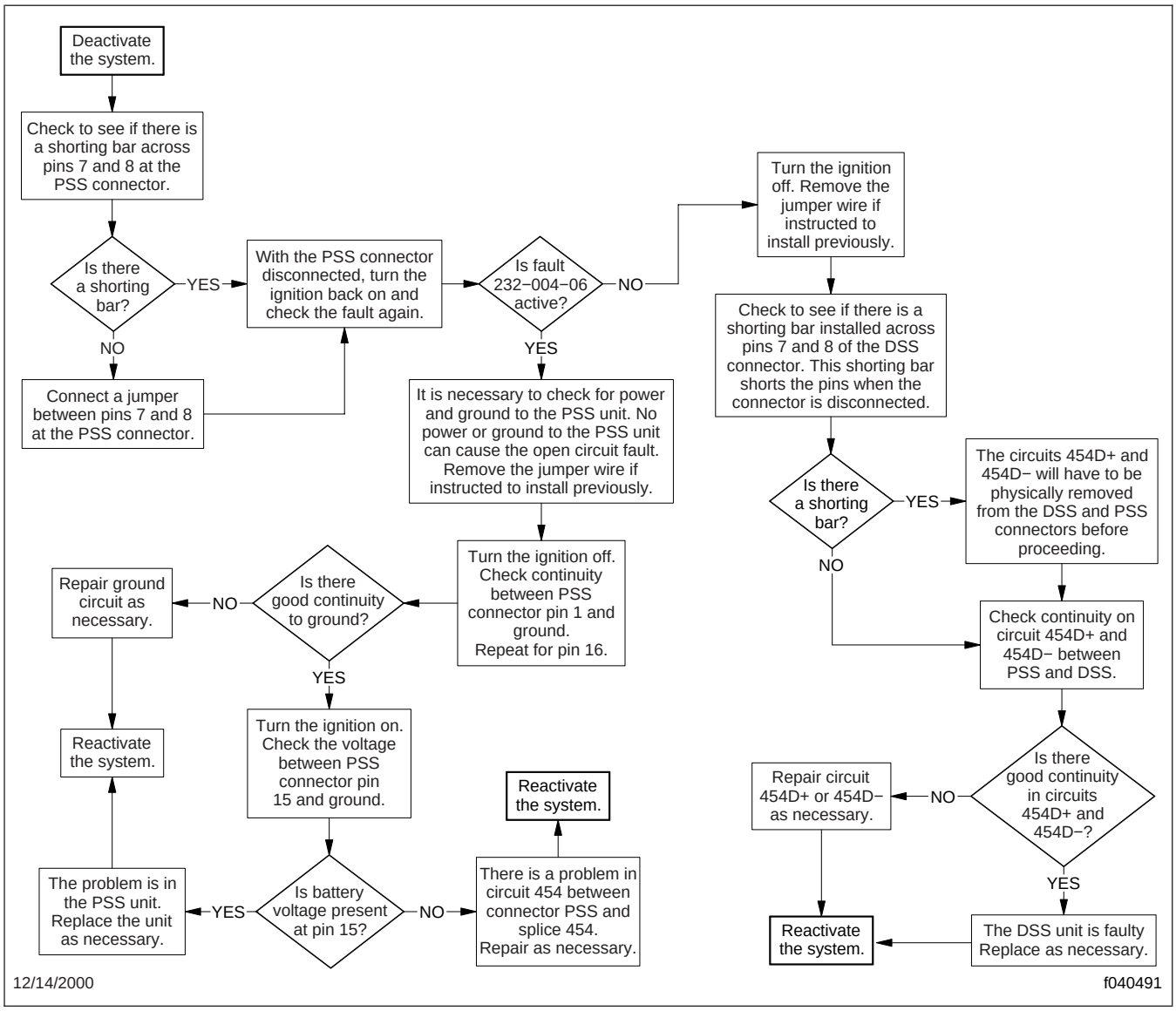


Fig. 12, Fault Code 232-004-05, Passenger-Side SPACE Firing Circuit Open Circuit

Troubleshooting

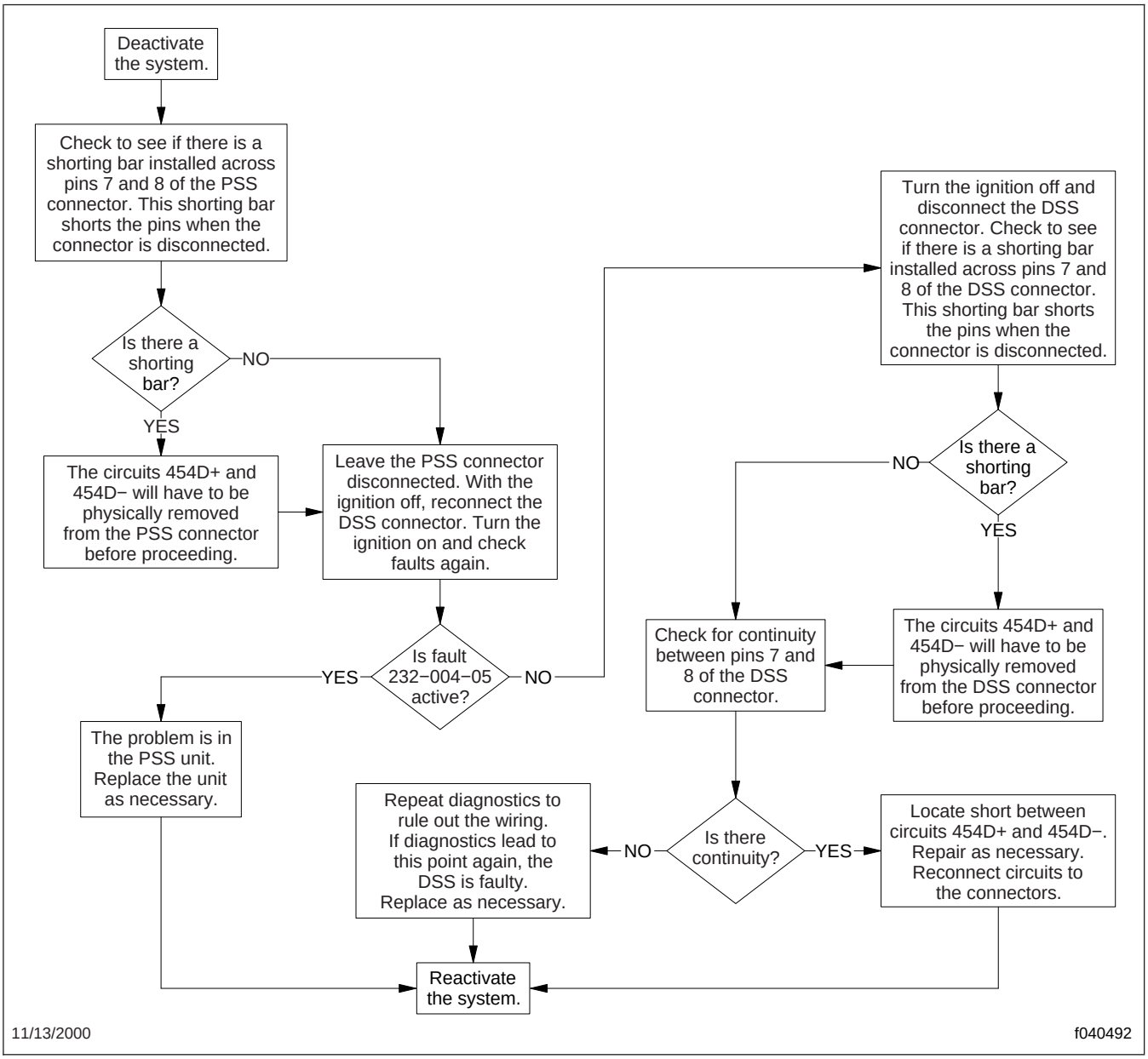


Fig. 13, Fault Code 232-004-06, Passenger-Side SPACE Firing Circuit Shorted

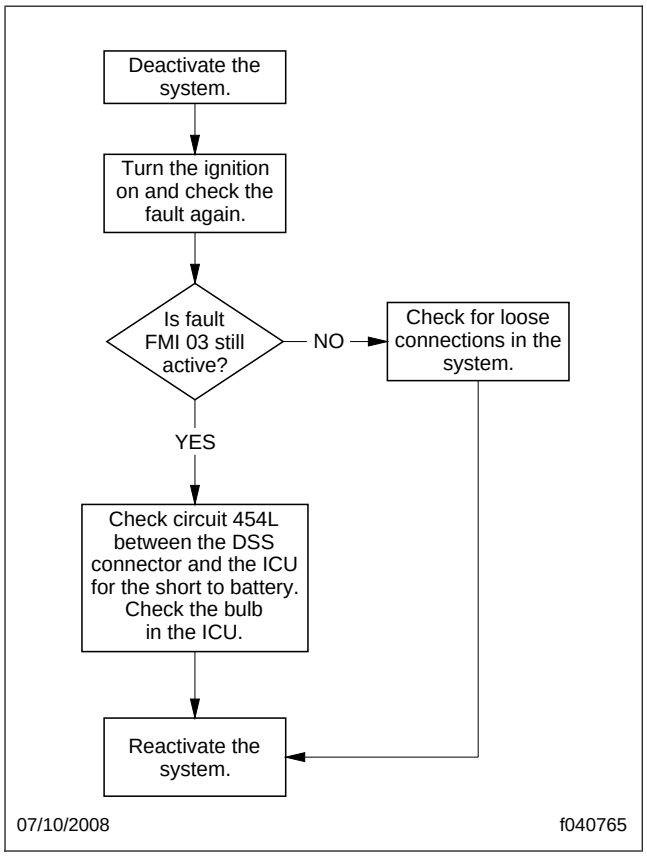


Fig. 14, Fault Code 232-005-03, SRS Warning Lamp—Shorted to Power

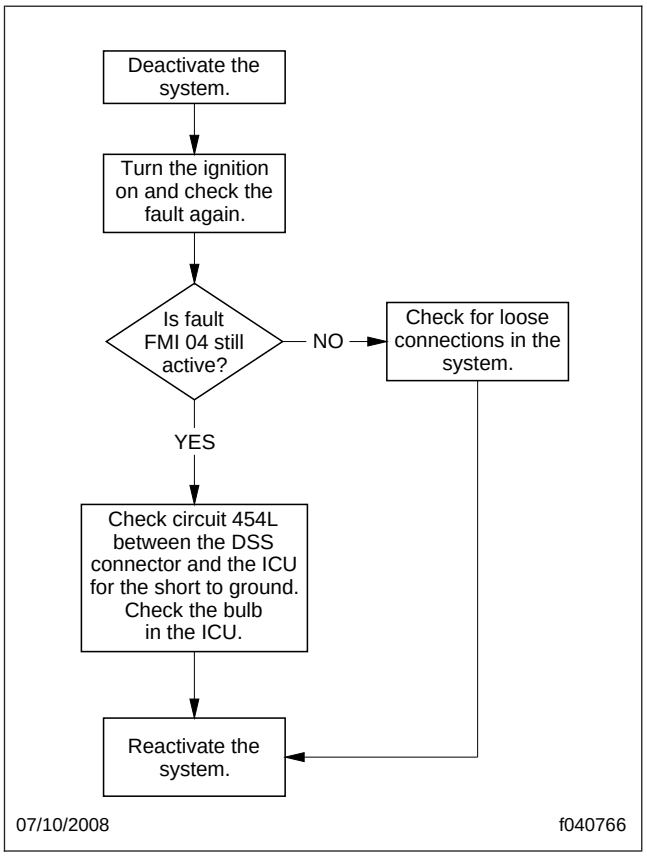


Fig. 15, Fault Code 232-005-04, SRS Warning Lamp—Shorted to Ground

Troubleshooting

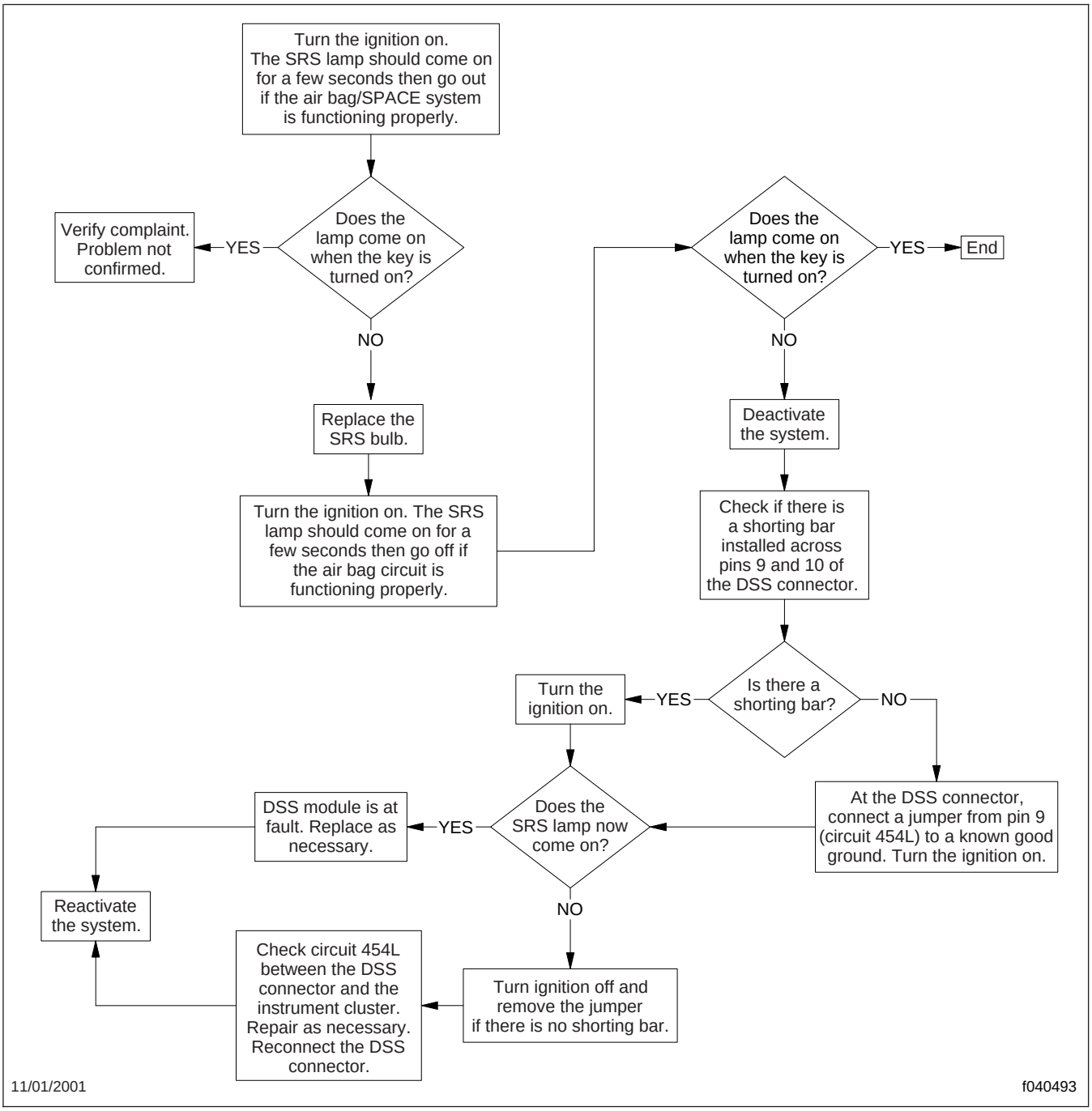


Fig. 16, No Fault Code, the SRS Indicator is Not Working

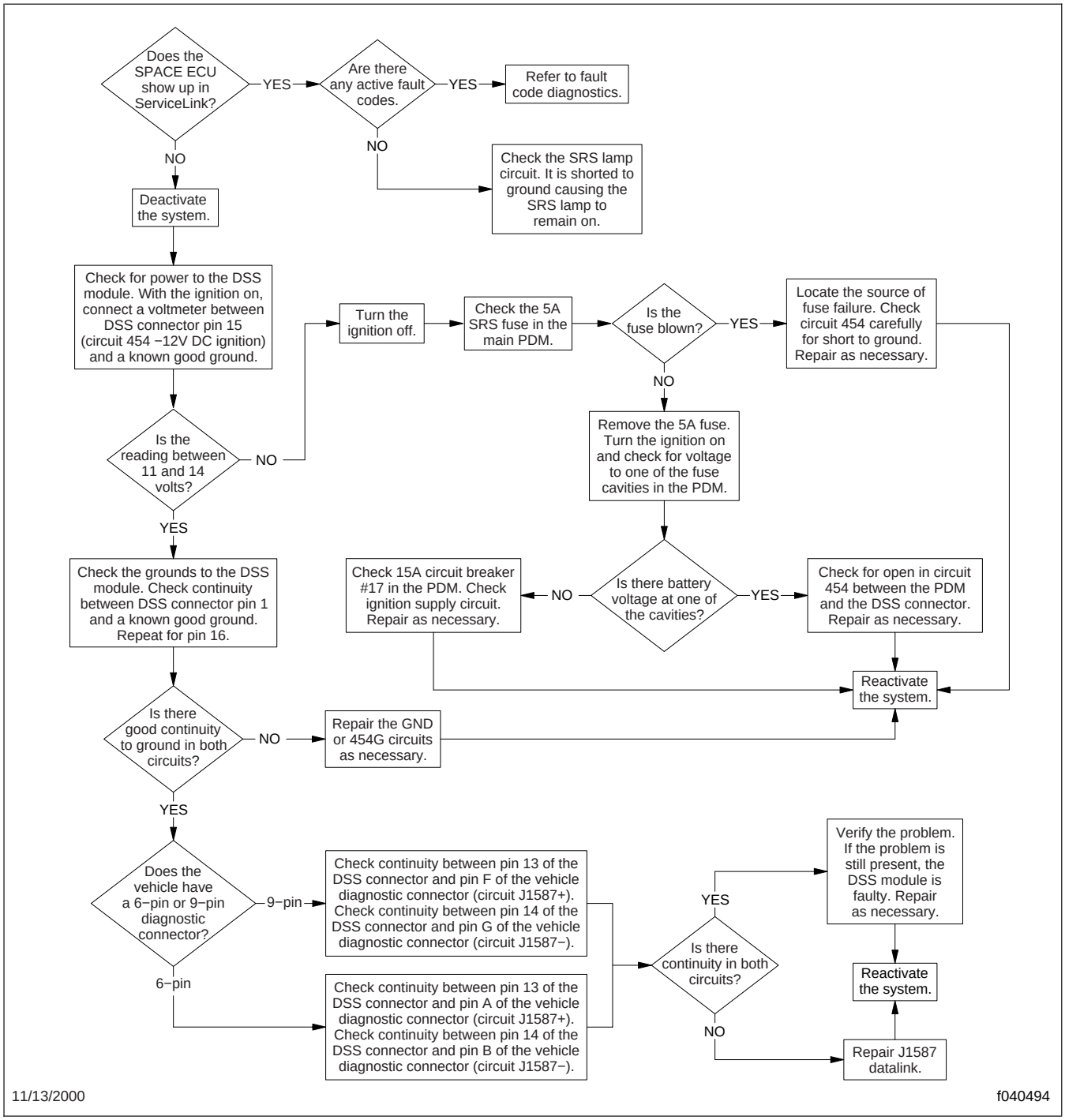


Fig. 17, The SRS Indicator Stays On and/or a Connection to the Vehicle Through the J1587 Diagnostic Connector is Not Possible

Troubleshooting

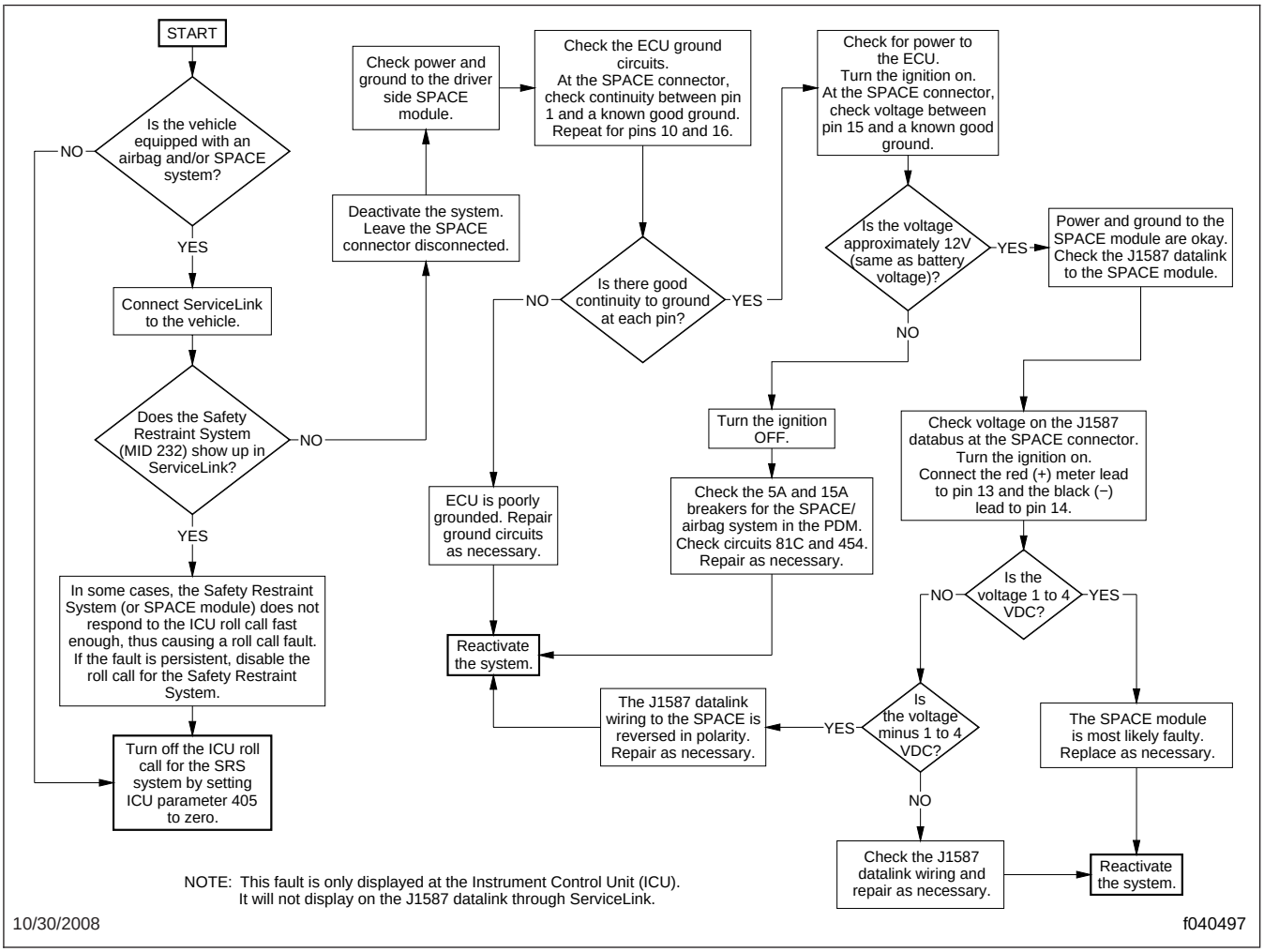


Fig. 18, Fault Code 232-254-07, the SPACE Module is Not Communicating With the J1587 Datalink or It Has Lost Power

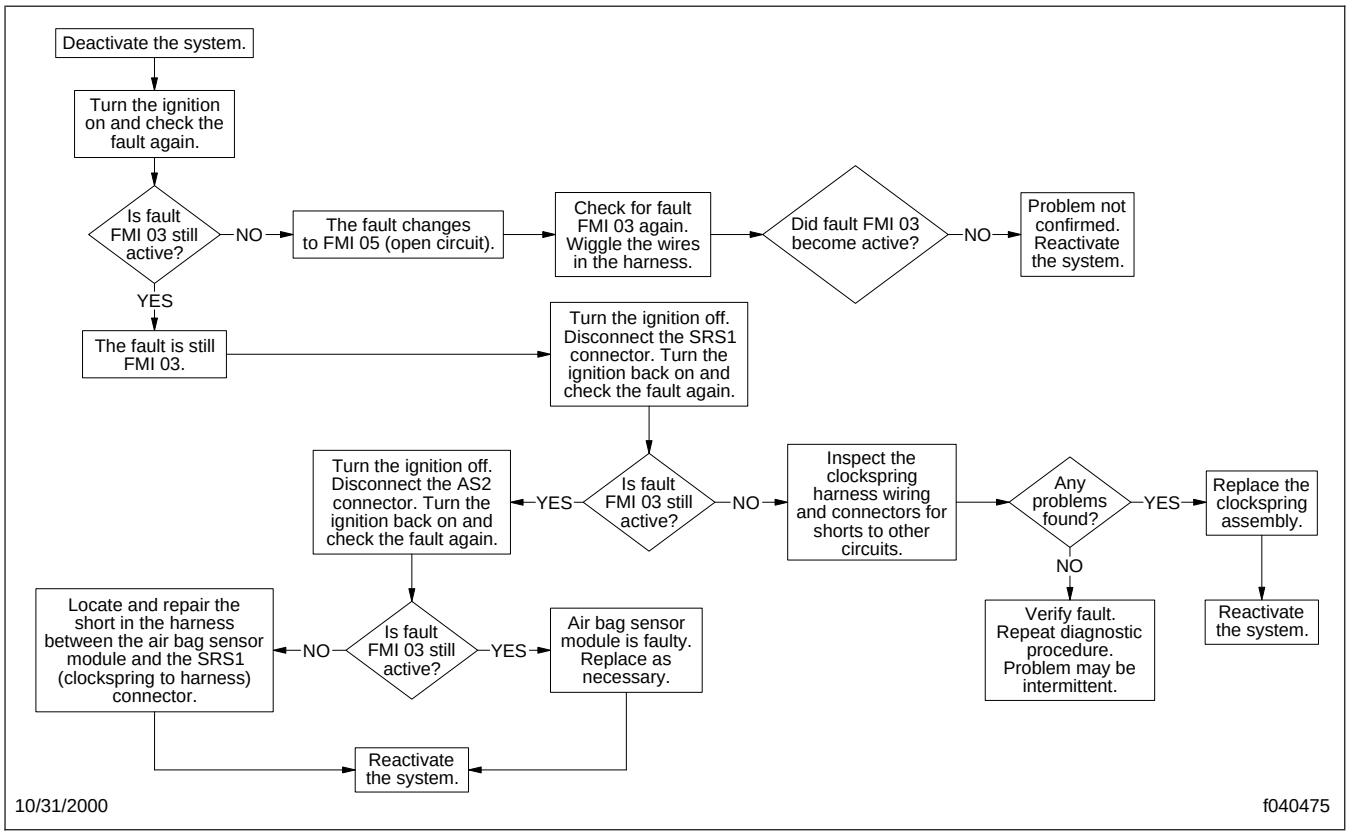


Fig. 19, Fault Code 232-001-03, Air Bag Loop Wiring Short to Power

Troubleshooting

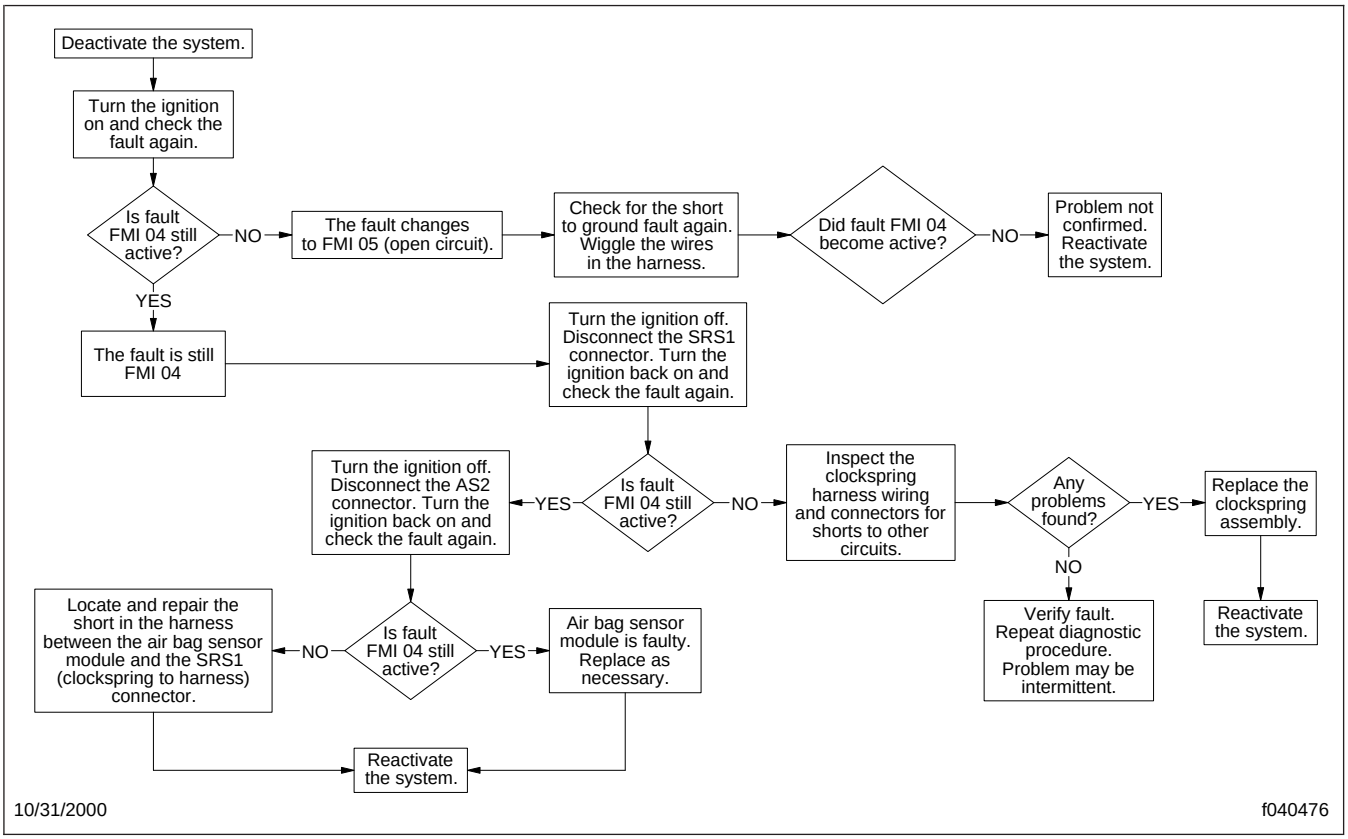


Fig. 20, Fault Code 232-001-04, Air Bag Loop Wiring Short to Ground

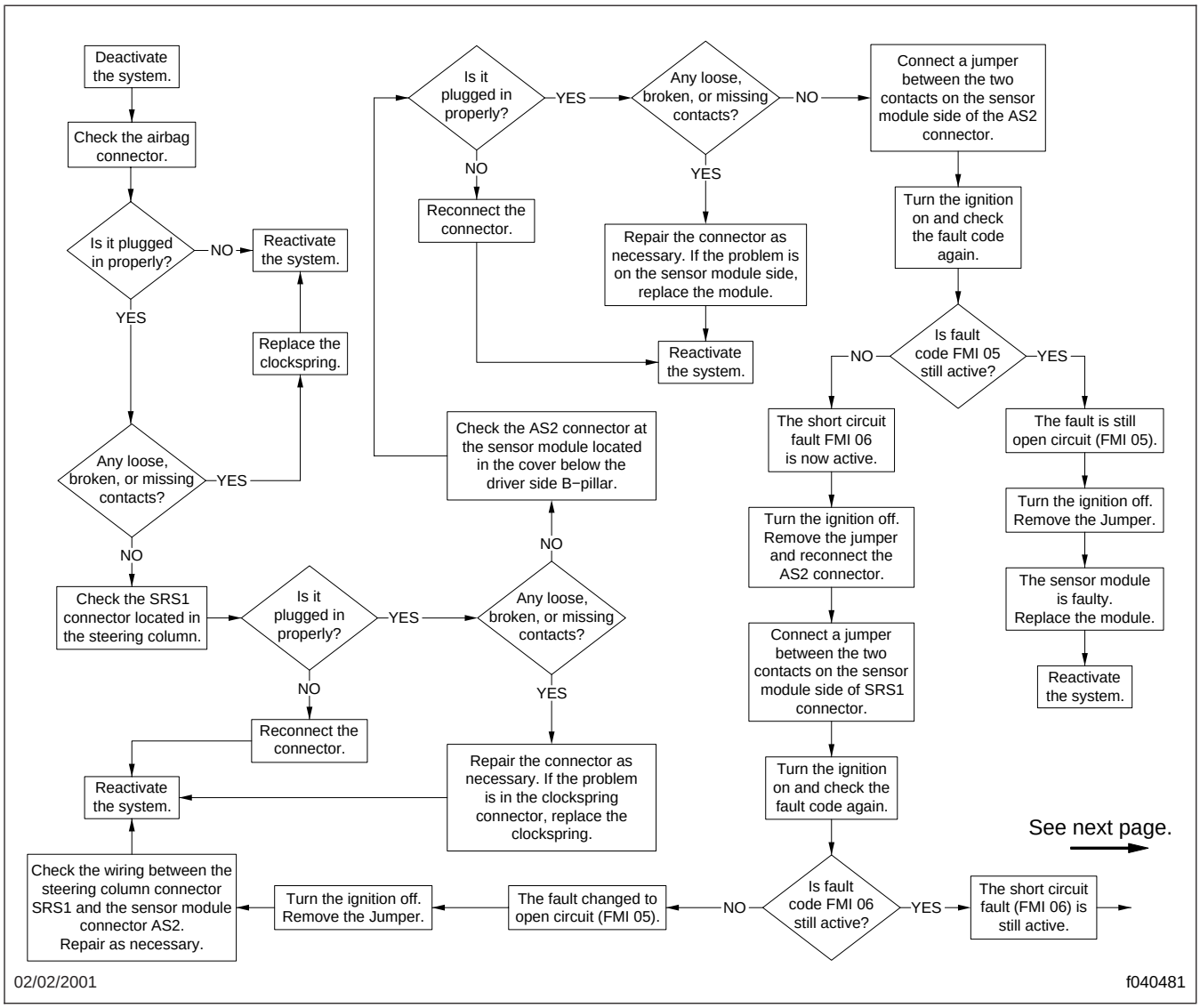


Fig. 21, Fault Code 232-001-05, Air Bag Loop Wiring Open Circuit, Part 1

Troubleshooting

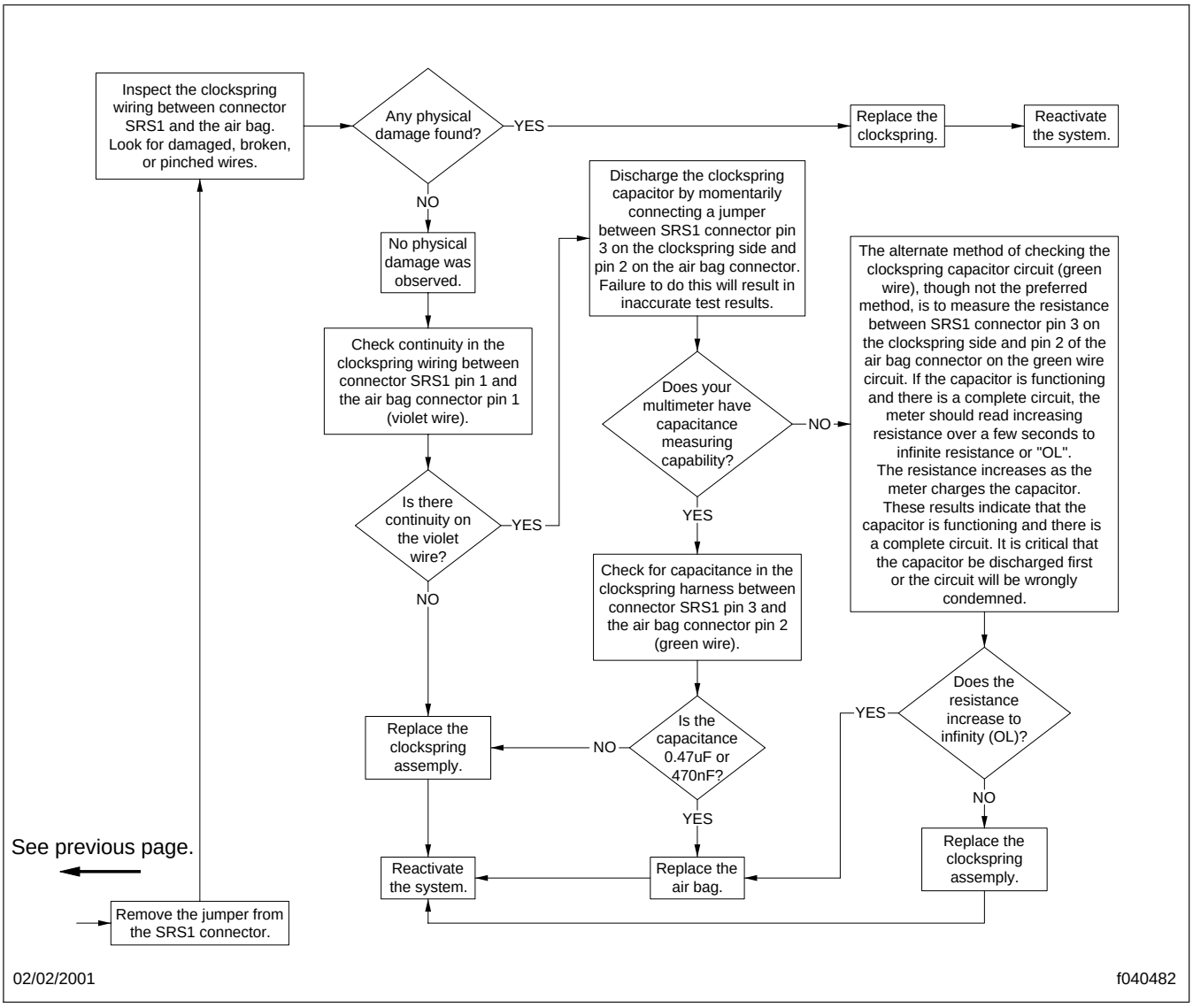


Fig. 22, Fault Code 232-001-05, Air Bag Loop Wiring Open Circuit, Part 2

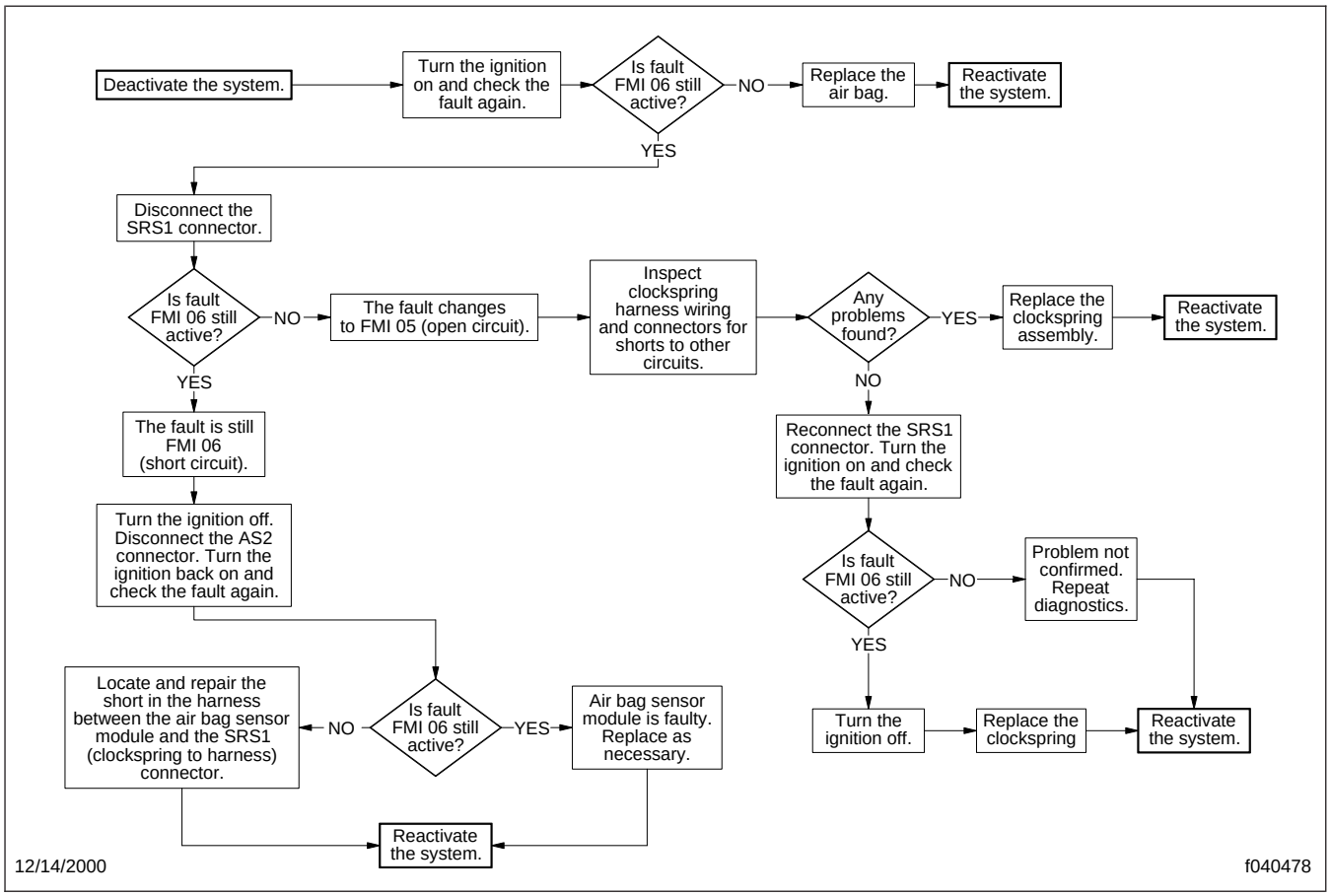


Fig. 23, Fault Code 232-001-06, Air Bag Loop Wiring Shorted

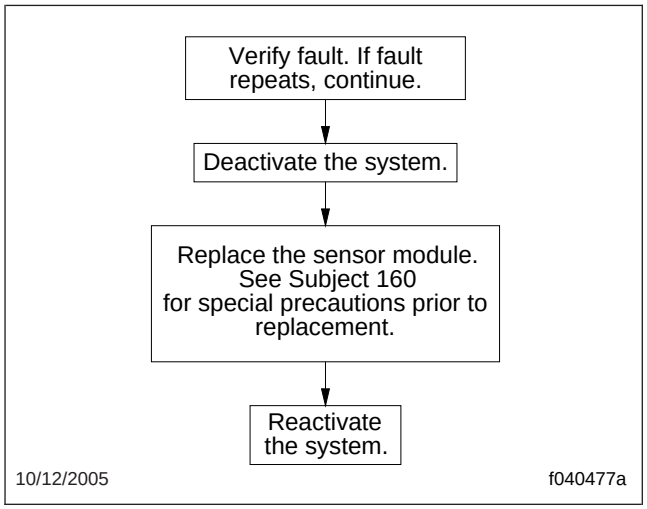


Fig. 24, Fault Codes 232-003 or 232-004, Air Bag Sensor Loops Improperly Terminated

Troubleshooting

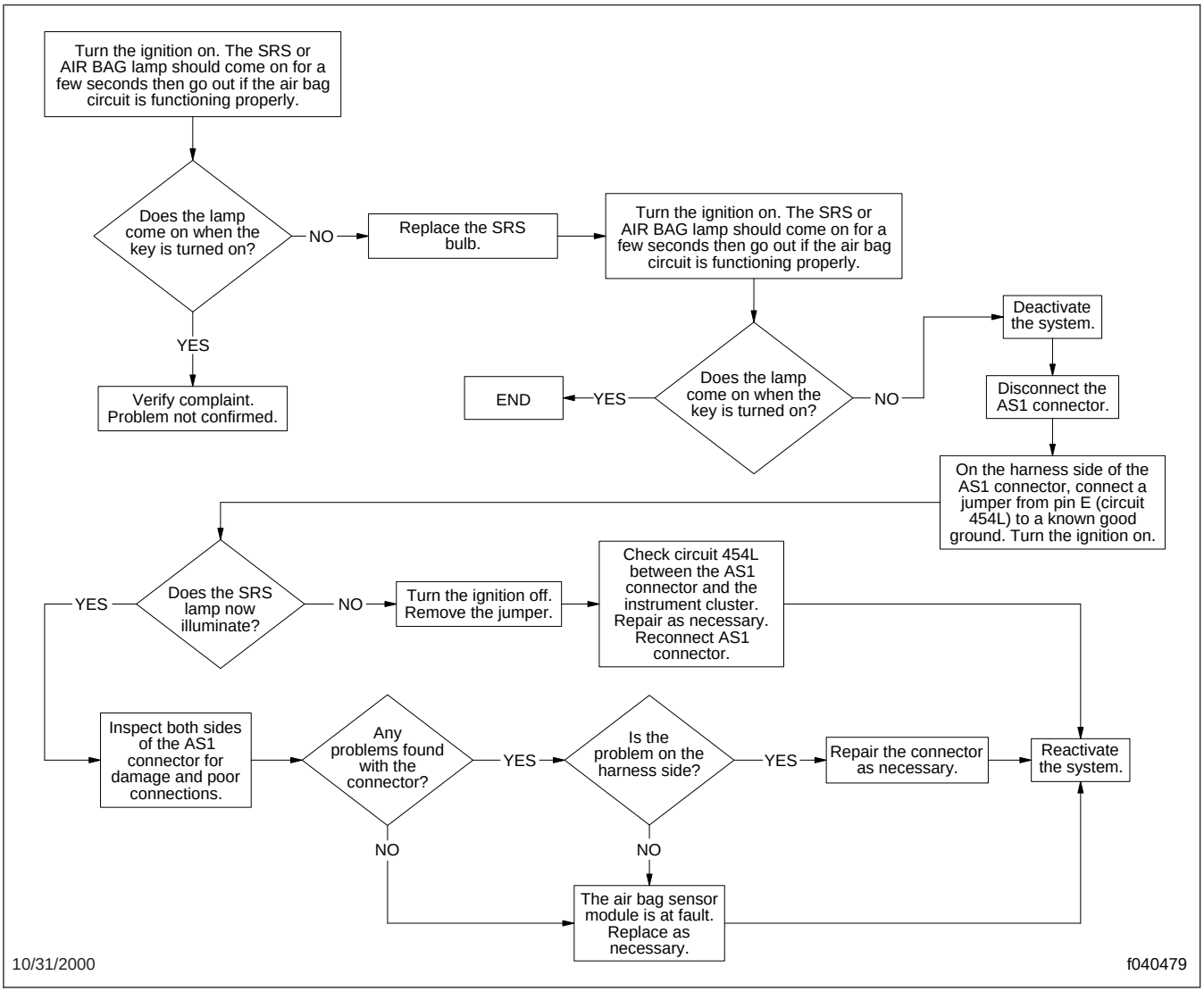


Fig. 25, No Fault Code, the SRS Indicator is Not Working

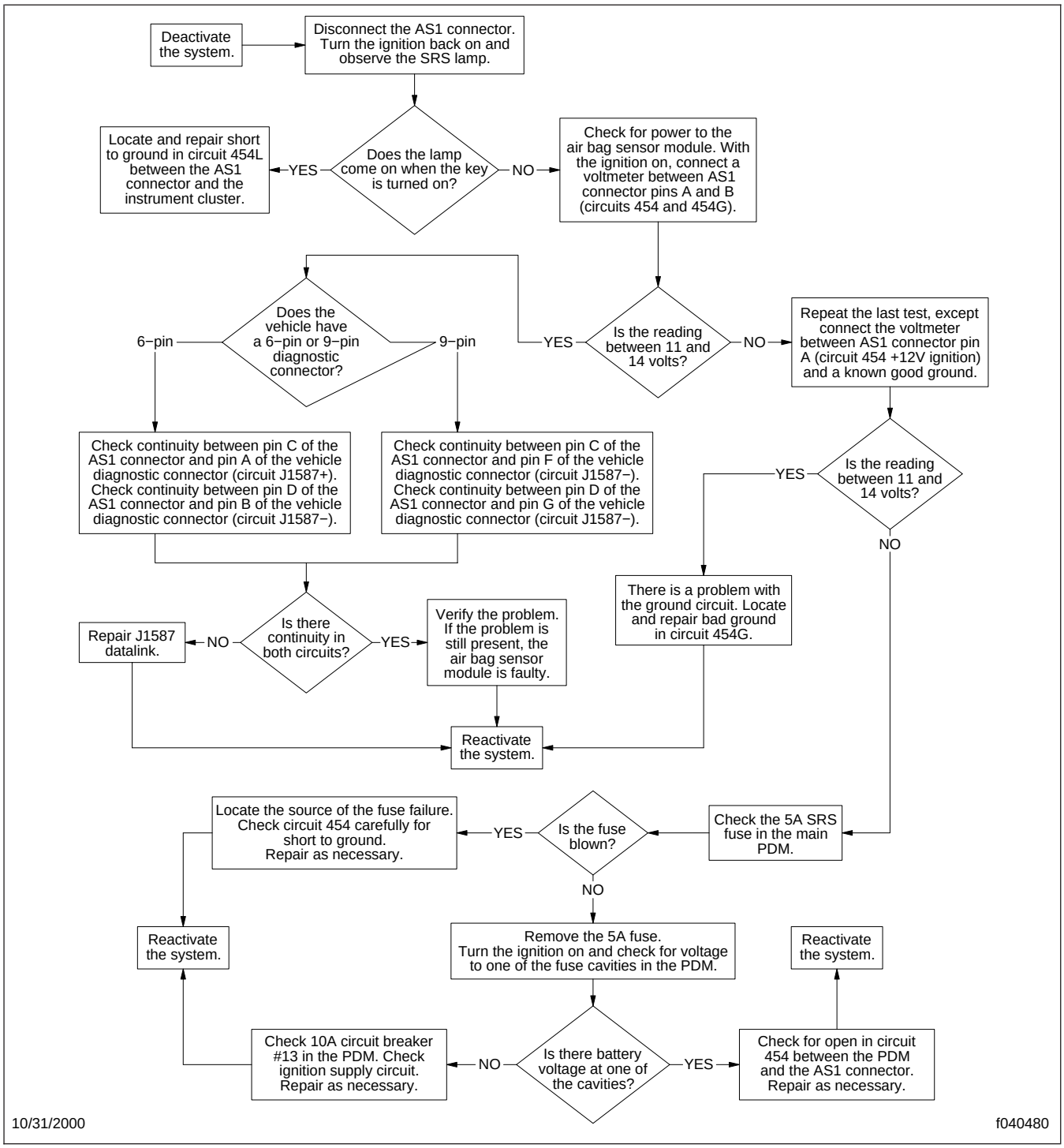


Fig. 26, The SRS Indicator Stays On and/or a Connection to the Vehicle Through the J1587 Diagnostic Connector is Not Possible

Troubleshooting

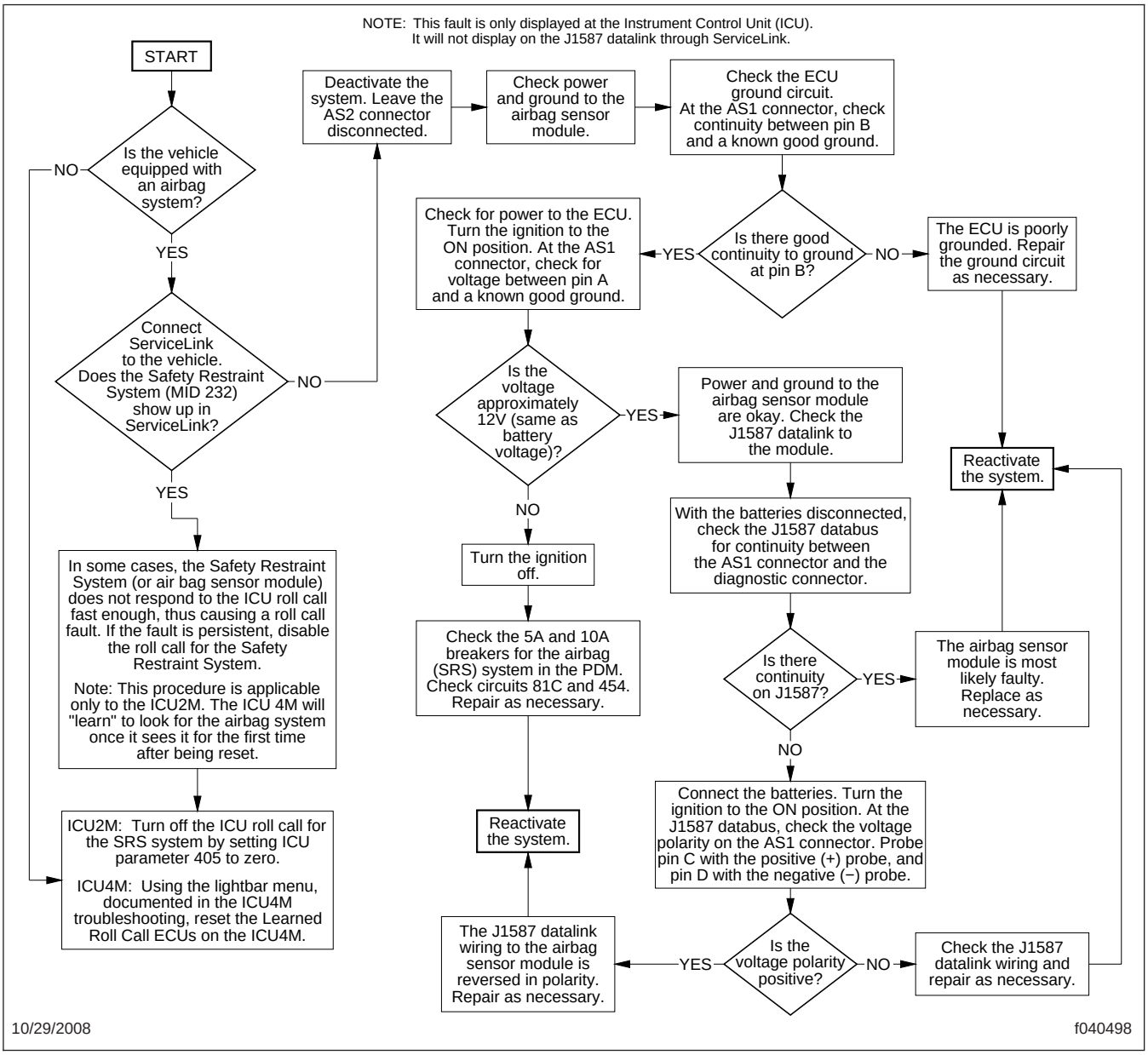


Fig. 27, Fault Code 232-254-07, the SPACE Module is Not Communicating With the J1587 Datalink or It Has Lost Power

See **Fig. 1** for the driver-side air bag/SPACE system wiring diagram.

See **Fig. 2** for the driver and passenger air bag/SPACE system wiring diagram.

See **Fig. 3** for the air bag only system wiring diagram.

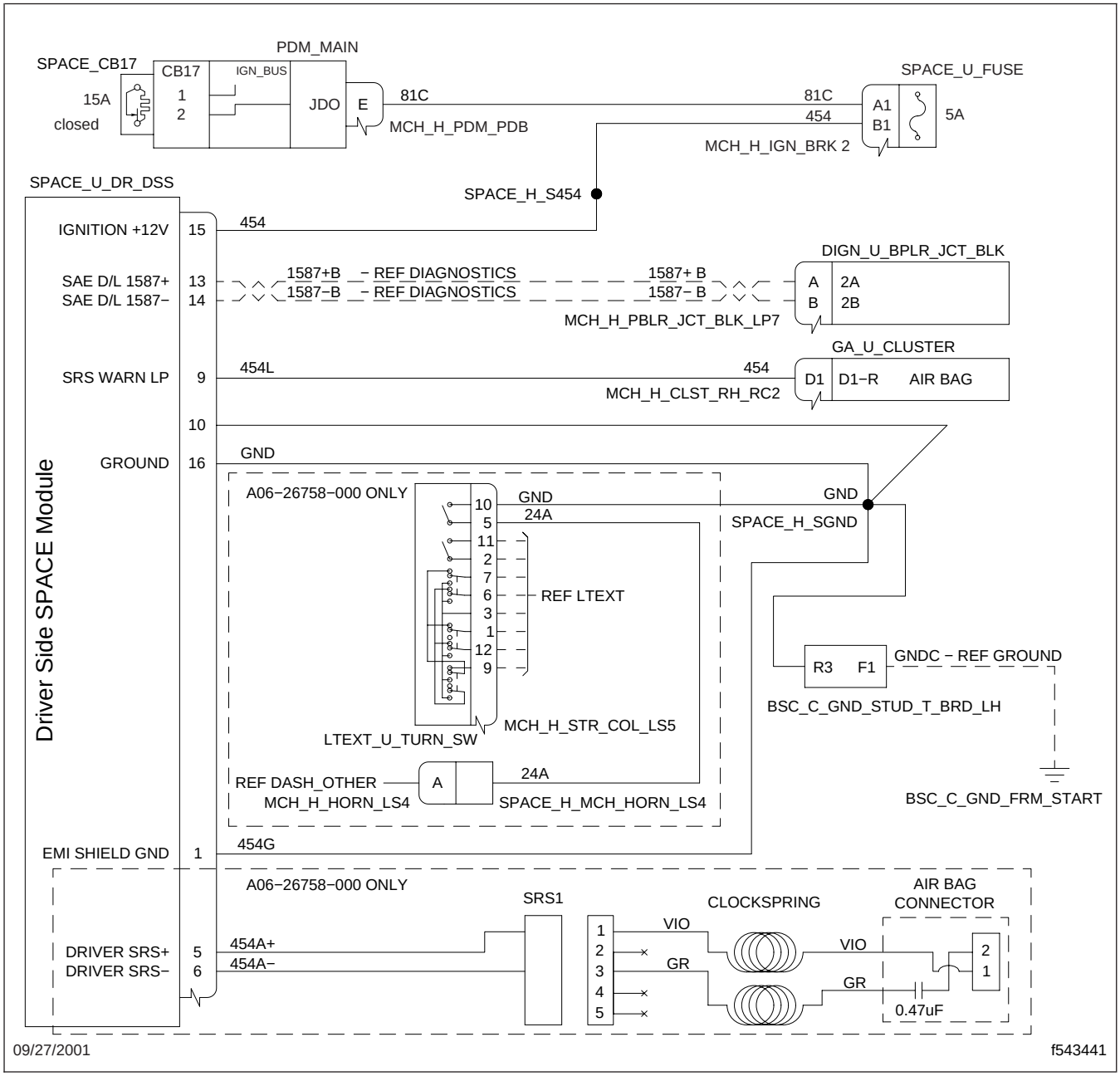


Fig. 1, Driver-Side Air Bag/SPACE System Wiring Diagram

Specifications

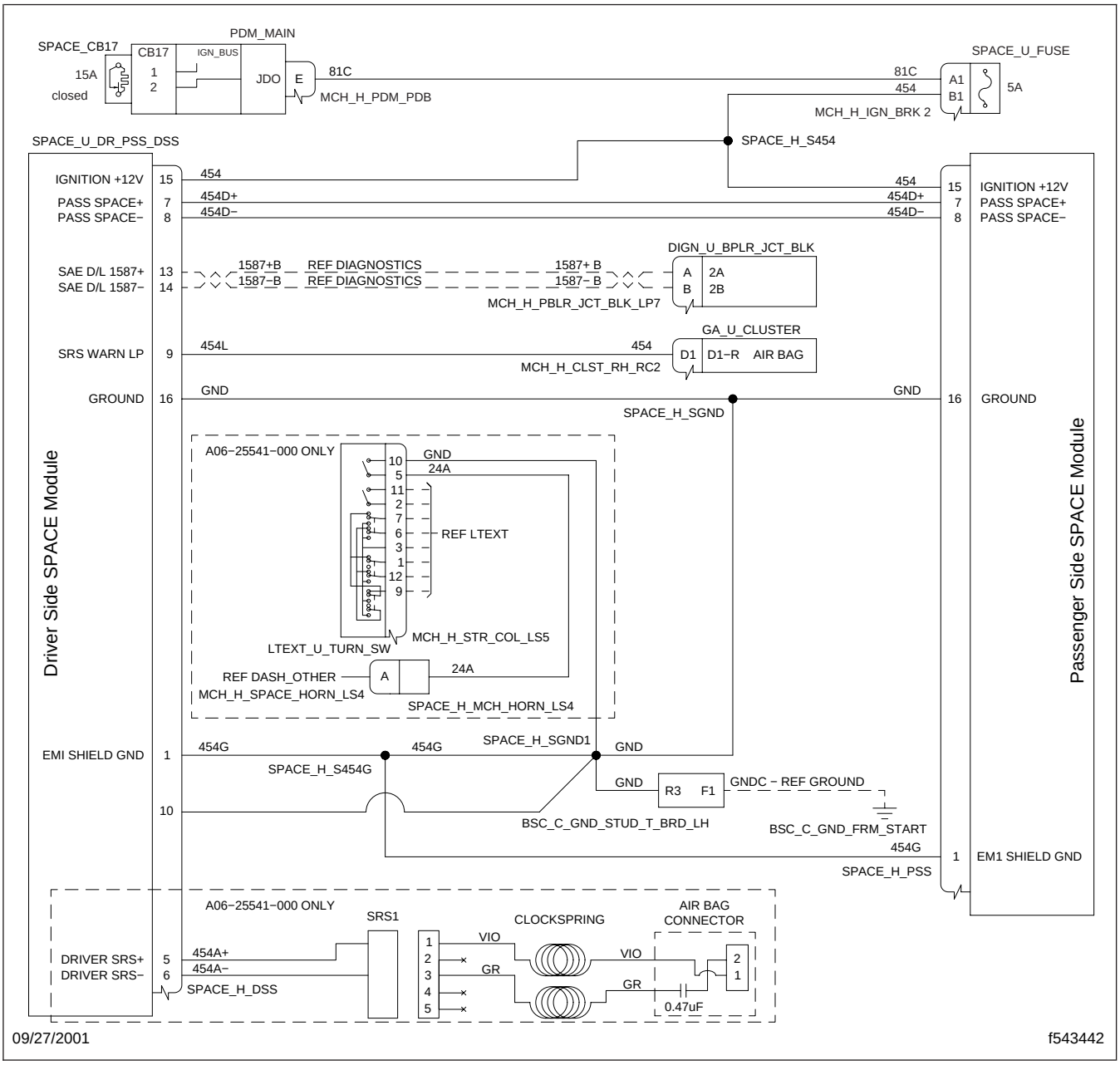


Fig. 2, Driver and Passenger Air Bag/SPACE System Wiring Diagram

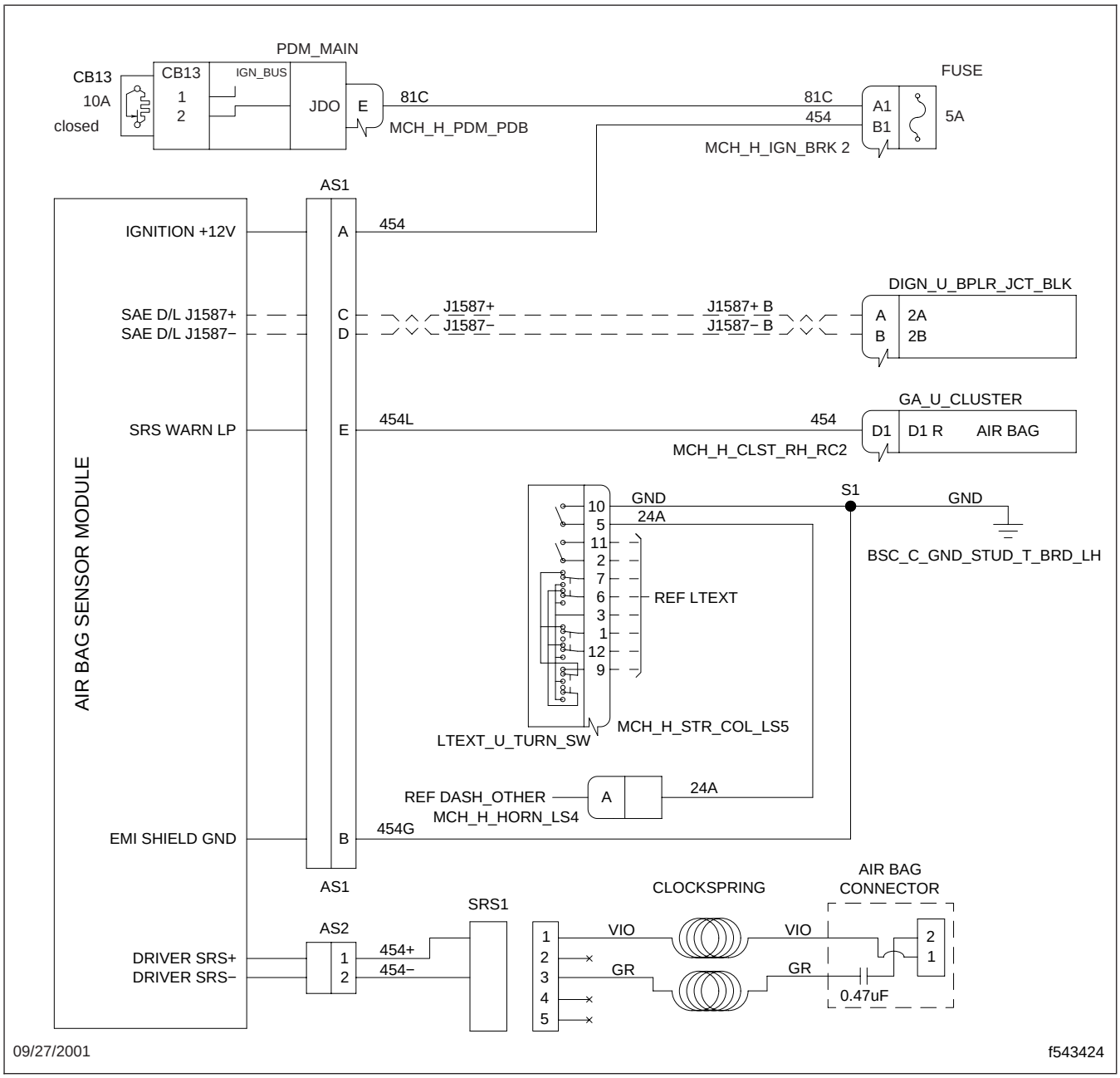
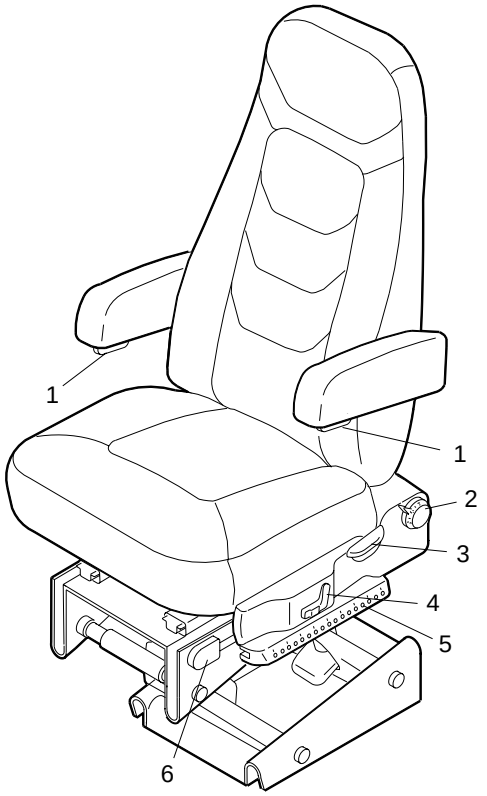


Fig. 3, Air Bag Only System Wiring Diagram for Vehicles Installed on or After May 12, 2000

General Information

EzyRider seats (see **Fig. 1**) offer adjustment features for height, fore and aft positioning, back cushion tilt, lumbar support, and seat cushion tilt. The air suspension and height-adjustment features are provided by an air spring that receives air pressure from the vehicle air system; pressure in the air spring is controlled by a set of switches attached to the seat frame. Each seat is equipped with a shock absorber to dampen unwanted up-and-down motion of the seat. An isolator reduces the amount of road shock by isolating the occupant from the motion of the vehicle. A lockout feature is used whenever the isolator is not desired.



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1. Armrest Adjustment Knob
2. Back Cushion Tilt Position Indicator
3. Back Cushion Tilt Lever
4. Height Adjustment and Lumbar Support Lever
5. Fore/Aft Seat Position Indicator
6. Isolator and Fore/Aft Seat Adjustment Lever

Fig. 1

For a complete description of, and operating instructions for, all seat adjustment features, refer to the vehicle driver's manual.

Removal

1. Park the vehicle on a level surface, apply the parking brake, shut down the engine, and chock the front and rear tires.
2. Press the seat ride-height rocker switch until the seat is adjusted to its maximum height.
3. If so equipped, remove the seat suspension skirt. It is attached to the seat with 11 upholstery fasteners.
4. Cut a wooden block to the length required to support the seat at its maximum height, and place the block between the air suspension seat base and the rear crosstube of the lower arm.
5. Drain the vehicle air reservoirs. Then press the seat-height adjustment switch until all the air is exhausted from the air spring.
6. Remove the seat heel guard. See **Fig. 1**.

   6.1 Remove the two T20 Torx® capscrews that attach the heel guard to the cab deck.

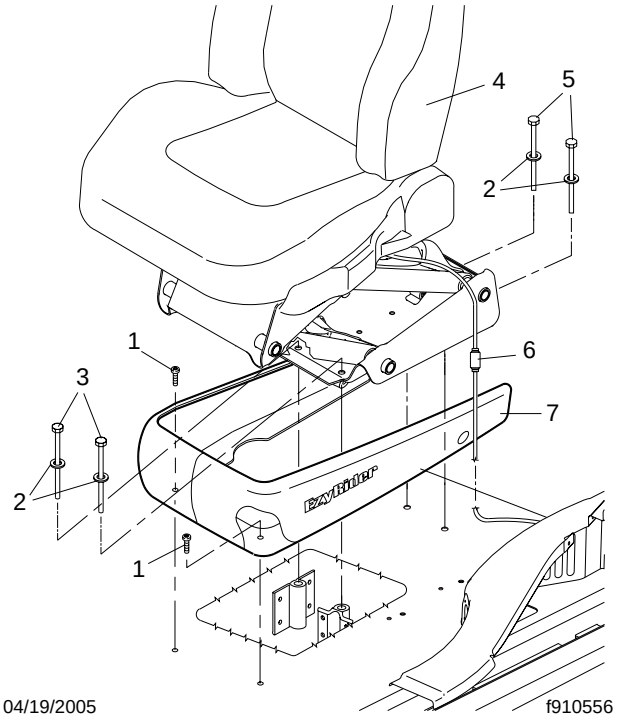
   NOTE: On Argosy models, the passenger-side heel guard is cut off, and supported by a bracket on the inboard side. Remove the two screws that hold the bracket to the cab deck.

   6.2 Loosen the four T50 Torx capscrews that attach the seat to the cab deck.

   6.3 Slide the heel guard, first backward to unseat the locating bosses from the holes in the seat base, then forward to unseat the bottom flange from under the outer edges of the seat base. Remove the heel guard.
7. Disconnect the air valve air-supply hose at the quick-connect union behind the seat.
8. Remove the capscrews that attach the seat-belt straps and tether straps, if so equipped, to the intermediate-connecting-point threaded rod.

NOTE: On day cab models it may be necessary to detach the seat from the cab deck before removing the seat-belt strap.

9. Remove the four Torx capscrews and the washers that attach the seat to the cab deck. Remove the seat from the cab.



1. Torx Capscrew, T20
2. Washer
3. Torx Capscrew, Long T50 (qty. 2)
4. Seat
5. Torx Capscrew, Short T50 (qty. 2)
6. Air Supply Quick-Connect Union
7. Heel Guard

Fig. 1, EzyRider Seat Installation

Installation

1. Place the seat on the cab deck. Insert the four T50 Torx capscrews through the washers and the seat base, using the longer ones in the front, as shown in **Fig. 1**. Do not tighten the capscrews until the heel guard is installed.

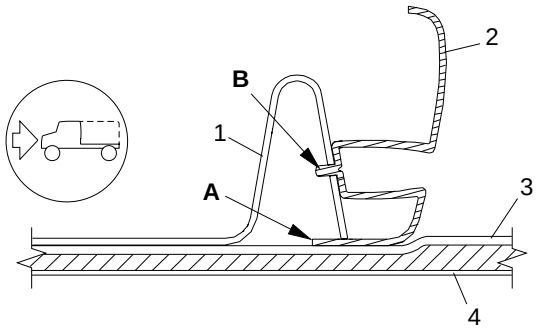
NOTE: On day cab models it may be necessary to first attach the seat-belt strap.

2. Attach the brackets of the seat-belt straps and tether straps to the intermediate-connecting-point threaded rod. Tighten the capscrews 35 to 45 lbf·ft (47 to 61 N·m).
3. Connect the air valve air-supply hose by pressing the pneumatic tubing into the quick-connect union behind the seat.

Seat Removal and Installation

4. Install the seat heel guard.

   4.1 Place the heel guard around the seat base, first sliding it backward to seat the bottom flange under the outer edge of the seat base on both sides, then forward to seat the locating bosses in the holes in the seat base. See **Fig. 2**.



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A. Slide the bottom flange of the heel guard under the outer edge of the seat base.
B. Insert the heel guard locating bosses into the holes on the seat base.

1. Seat Base
2. Heel Guard
3. Floor Covering
4. Cab Deck

Fig. 2, Installing the Heel Guard

   4.2 Tighten the four T50 Torx capscrews that attach the seat to the cab deck 25 to 29 lbf·ft (34 to 39 N·m).

   4.3 Attach the front of the heel guard to the cab deck with the two T20 Torx capscrews.

   NOTE: On Argosy models, the passenger-side heel guard is cut off, and supported by a bracket on the inboard side. Attach the bracket to the cab deck with the two screws.

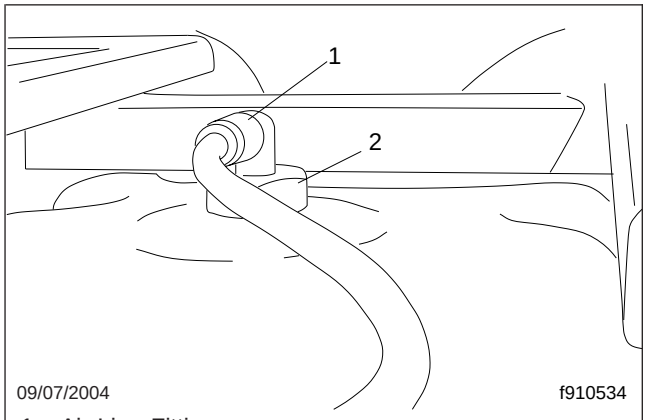
5. Start the engine and allow the air reservoirs to fill. Press the seat ride-height rocker switch until the seat is adjusted to its maximum height, then remove the wooden block that supports the seat suspension.
6. Install the seat suspension skirt.
7. Remove the chocks from the tires.

Air Spring Replacement

1. Park the vehicle, apply the parking brakes, shut down the engine, and chock the front and rear tires.
2. Inflate the seat suspension to the maximum height.
3. Pull the slide lever, and slide the seat to the forward position.
4. Lift the suspension skirt up and out of the way.
5. Cut a wooden block to the length required to support the seat at its maximum height, and place the block between the air suspension seat base and the rear crosstube of the lower arm.

NOTE: The seat must be secured with a block when replacing the air spring.

6. Drain the vehicle air reservoirs. Then push in on the bottom of the seat ride-height rocker switch until all air is exhausted from the air spring.
7. Remove the air line from the air spring. See **Fig. 1**.



1. Air Line Fitting
2. Spring Plate Mounting Nut

Fig. 1, Air Line and Fitting

8. Remove the air fitting from the top of the air spring.
9. Remove the nut that secures the air spring to the spring plate.
10. Use a 9/16-inch socket wrench to remove the lower air spring bolt.
11. Remove the air spring.
12. Install the new air spring.
13. Install the spring plate mounting nut and torque 130 lbf·in (1470 N·cm).
14. Install the air fitting and tighten securely. Make sure that the fitting is oriented forward.
15. Cut 1/4 inch (6 mm) off of the air line using a hose cutter.
16. Insert the air line into the air fitting.
17. Apply Loctite™ 454 to the bottom six threads of the mounting bolt. See **Fig. 2**.

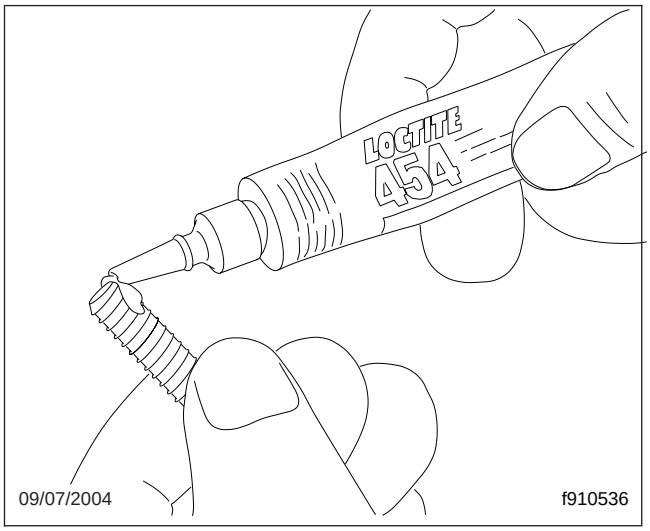


Fig. 2, Apply Loctite to the Bottom Six Threads

18. Install the bolt through the bottom casting of the seat to the air spring and tighten the bolt 45 lbf·in (510 N·cm).
19. Inflate the suspension.
20. Remove the block.
21. Remove the chocks from the tires.

General Information

Freightliner Trucks currently applies DuPont® single-stage Imron® 5000 or two-stage (base coat and clear coat) Imron 6000 high-solids polyurethane enamel on the vehicle cab at the factory.

Black Standard Urethane or Imron 5000 is used on the vehicle chassis. The chassis includes the frame, spoke spider, running gear, and any components attached to the frame. Aluminum fuel tanks are not painted.

To meet the federal air quality regulations imposed by the EPA and local jurisdictions, these products contain lower levels of volatile organic compounds (VOCs) than earlier types (916Y, Centari®, and Imron), and are formulated free of lead and chrome.

The procedures in this section are for use with DuPont products. Unless otherwise noted, all products are manufactured by E. I. du Pont de Nemours and Company, Inc. Obtain approval from a Freightliner Regional Office for use of topcoats produced by other manufacturers.

Color-Matching

The recommended aftermarket paints for color-matching factory-applied paint are as follows:

- Cab—use Imron 5000 or Imron 6000
- Chassis—use only Imron 5000

To ensure proper gloss, durability, and color-matching of the enamel, use only Imron 5000 on panels that were previously painted with Imron 5000, and use only Imron 6000 on panels painted with Imron 6000.

To determine the correct paint number for color-matching any original finish on a vehicle, refer to the paint specification on the vehicle specification decal. Refer to the vehicle driver's manual for the location of this decal.

NOTE: The high-solids Standard Urethane applied to the chassis at the factory is sold to original equipment manufacturers (OEMs) only, and is not available for aftermarket sale. Use Imron 5000, N0001 Black, for repainting.

General Guidelines

This section provides instructions for preparing large panels or the entire cab for topcoating with DuPont® products. For spot repairs or touch-ups, see **Subject 120**.

Before topcoating, the surface must be thoroughly cleaned and sanded. Any bare areas must also be conditioned and primed.

1. Preparation materials specified for one type of surface should not be used for any other type of surface.
2. Limit intermediate coatings, such as primers, to the brand and type specified by the finish-coat manufacturer.

⚠ CAUTION

Only experienced, qualified persons using proper equipment should attempt repainting or touch-up painting. Incorrect application of chemicals or paint could damage the surface or impair the finish.

Preparation for Prime Coat

Use the cleaners and conditioners specified in each step to prepare the surface for priming. See **Specifications, 400** for a summary of the products used in this procedure.

⚠ WARNING

Do not use solvent-based cleaners on large areas of plastic or fiberglass, such as the hood or air fairing. Wiping down these large areas may cause a buildup of static electricity. The resulting spark could cause a flash fire, which could result in personal injury or property damage.

Cab and Hood Preparation

1. Wash and dry the entire vehicle with a mild detergent.

⚠ WARNING

Solvents are flammable. Keep them away from heat, sparks, and open flame. Keep the container closed. Use only with adequate ventilation. Avoid breathing the vapor, or headache, nausea, and impaired reaction time and coordination may result.

2. Wipe all surfaces to be painted with a clean cloth soaked with solvent or cleaner. Remove all traces of wax, polish, grease, and silicones.
   - Metal—use DuPont Prep-Sol 3919 S.
   - Plastic—use DuPont Plastic Prep 2319 S.
   - Fiberglass—use DuPont Prep-N-Solv.

   2.1 Work on small areas at a time, wetting the surface liberally.

   2.2 Quickly wipe the surface with a clean cloth before the solvent or cleaner has a chance to dry. Change cloths frequently.
3. Feather the edge of all repaired areas, chipped surfaces, and scratches.

   3.1 Cut down the edges of broken spots with no. 220 sandpaper.

   3.2 Feather the edges by hand, using a sanding block with no. 400 sandpaper.
4. Sand the entire area to be painted. Using a sanding block and no. 400 sandpaper, remove the gloss to improve adhesion of the primer.
5. Using a clean cloth soaked with cleaner, remove any sanding dust.
   - Metal or plastic—use DuPont 3939 S lacquer and enamel cleaner.
   - Fiberglass—use a solution of one part water and one part isopropyl alcohol (IPA).
6. Treat bare metal and rusted areas.
   - Steel—use DuPont 5717 S metal conditioner.
   - Aluminum—use DuPont 225 S aluminum cleaner.

   6.1 Mix one part of the cleaner with two parts of water in a plastic bucket.

6.2 Apply the cleaner with a cloth or sponge. If corrosion is present, work the surface with a stiff plastic brush or 3M Scotch-Brite® pad. Do not use any pads containing iron.

6.3 While the metal is still wet, wipe thoroughly with a clean, dry cloth. Allow the surface to dry before applying a conversion coating.

7. Apply a conversion coating to all bare metal.
   - Steel—use DuPont 5718 S metal conversion coating.
   - Zinc casings or galvanized surfaces (iron or steel)—use DuPont 5718 S metal conversion coating.
   - Aluminum—use DuPont 226 S aluminum conversion coating.

   7.1 Pour the conversion coating into a plastic container (do not dilute). Using a 3M Scotch-Brite or similar non-iron abrasive pad, apply the conversion coating to the metal surface. Work only as much area as can be coated and rinsed before the solution dries.

   7.2 Leave the coating on the surface for 2 to 5 minutes. Then, rinse off the solution with cold water, or mop with a sponge or cloth rinsed frequently in clean water.

   If the metal surface dries before rinsing, reapply the conversion coating, then repeat the previous substep.

   7.3 Wipe the surface dry with a clean cloth, or air dry.

8. With paper and tape, mask all areas that are not to be painted.

Air Fairing Kit Preparation

Before installing a new air fairing, prepare the surface for topcoating.

1. Wash the air fairing with a mild detergent. Dry with a clean, absorbent, lint-free cloth or paper towels.
2. Using a clean cloth soaked with DuPont Prep-N-Solv®, wipe the entire surface to remove any trace of grease or oil.
3. Scuff-sand the air fairing with no. 320 grit sandpaper.
4. Wipe the air fairing with a clean cloth soaked in a solution of one part water and one part isopropyl alcohol. Allow 10 to 15 minutes for the air fairing to dry.
5. With tape and paper, mask all areas that are not to be painted.

Prime Coat

Prime all bare and feathered areas before topcoating. The specified primers can be used on any surface.

1. Clean all cracks and surfaces with dry compressed air.
2. Using a tack cloth, wipe all surfaces to be painted.

⚠ WARNING

Wear a positive-pressure, supplied-air, vapor and particulate respirator, approved by NIOSH or MSHA (TC-19C) when mixing or spraying primer, and until the work area has been exhausted of all vapor and spray mist. Breathing paint fumes can cause serious personal injury.

3. Prime all bare metal and feathered areas with DuPont primer.
   - Steel and aluminum—use Corlar 824 S epoxy primer.
   - Fiberglass—use Corlar 825 S epoxy primer.

   3.1 Stir the primer thoroughly.

   3.2 Mix two parts Corlar epoxy primer with one part DuPont 826 S activator.

   3.3 Reduce three parts of this mixture with one part DuPont 3602 S lacquer thinner (viscosity reading is 18 to 22 seconds in a no. 2 Zahn cup). Stir thoroughly.

   3.4 Wait 1 to 2 hours from time of mixing before using. This provides time for complete chemical induction.

   3.5 Set the air pressure at the spray gun at 45 psi (310 kPa). For pressure feed systems,

set the fluid delivery at 12 to 16 ounces (350 to 470 mL) per minute.

3.6 Hold the spray gun about 10 to 12 inches (25 to 30 cm) from the surface.

3.7 Spray one full wet coat to give a dry film thickness of 0.7 to 1.0 mil (18 to 25 µm).

3.8 Clean the equipment immediately after use with DuPont 3602 S lacquer thinner.

3.9 Air dry 2 hours or force dry 20 minutes.

4. Wet sand the primer with no. 400 grit or finer sandpaper. Feather the edge into the surrounding area.

5. Dry the surface. Using a clean cloth soaked with cleaner, remove any sanding dust.
   - Metal or plastic—use DuPont 3939 S lacquer and enamel cleaner.
   - Fiberglass—use solution of 1 part water and 1 part isopropyl alcohol (IPA).

NOTE: See **Subject 110** for topcoating instructions.

General Guidelines

This section provides instructions for applying a topcoat of DuPont® enamel to full panels or the entire cab. For spot repairs or touch-ups, see **Subject 120**.

⚠ CAUTION

Only experienced, qualified persons using proper equipment should attempt repainting or touch-up painting. Incorrect application of chemicals or paint could damage the surface or impair the finish.

Do not mix additives with the finish coats unless they are specified by the finish-coat manufacturer. See **Specifications, 400** for a summary of the products used in this procedure.

Before applying any topcoat:

1. Prepare the surface for topcoating. See **Subject 100** for instructions.
2. Clean all cracks and surfaces with dry compressed air.
3. Using a tack cloth, wipe all surfaces to be painted.

After topcoating, remove the masking as follows:

- After normal air drying—remove all masking when the surface is reasonably dry.
- After forced drying—remove the masking immediately after the finish has been baked.
- After two-toning—remove the masking used for the first coat as soon as it has set up, usually in about 35 to 40 minutes. Follow the same procedure for the second color.

Imron 5000 Topcoating

Imron 5000 is a single-stage, low VOC, high-solids polyurethane enamel. It provides a durable, high-gloss surface with good chemical resistance. It requires the addition of an activator.

⚠ WARNING

Wear a positive-pressure, supplied-air, vapor and particulate respirator approved by NIOSH or MSHA (TC-19C), while spraying Imron 5000, and until the work area has been exhausted of all vapor and spray mist. Breathing paint vapor or spray mist can cause personal injury.

Mixing

1. Stir the Imron 5000 enamel thoroughly.
2. Mix three parts Imron 5000 enamel with one part of DuPont 193 S or 194 S activator. No further reduction is necessary for application.

NOTE: The pot life of the mixture is about 2 to 4 hours at 70°F (21°C), unless an accelerator is added.

3. If faster curing time is desired, add DuPont 389 S fast-dry accelerator. Add up to 2 ounces (60 mL) to 1 gallon (3.8 L) of mixed material.
4. Mix thoroughly and strain.

NOTE: The viscosity of the mixture is about 9 to 20 seconds in a no. 3 Zahn cup, depending on the color. Adding reducer could affect the color match on some metallics.

Application

1. Set the air pressure at the spray gun to 60 to 65 psi (410 to 450 kPa). For pressure feed systems, set the fluid delivery at 12 to 16 ounces (350 to 470 mL) per minute.
2. Apply the topcoating.
   - 2.1 Hold the spray gun about 10 to 12 inches (25 to 30 cm) from the surface.
   - 2.2 Using a cross-coat technique, spray one medium-wet coat in a north-to-south direction
   - 2.3 Allow 5 to 10 minutes drying time between each application. Do not sand.
   - 2.4 Apply a second medium-wet coat in an east-to-west direction.
   - 2.5 A third medium-wet coat may be needed for good coverage of some colors.
3. To air dry, allow 2 to 4 hours with accelerator 389 S, and 6 to 8 hours without the accelerator.

   To force dry, wait 15 minutes following the application of the final coat, then dry for 30 minutes at 140 to 180°F (60 to 82°C).

4. To prevent tape marking, remove all masking tape and paper immediately after the final coat is applied. Avoid contacting the freshly painted surface with masking paper.
5. Clean the equipment immediately after use with DuPont 3602 S lacquer thinner or 8685 S reducer.

Recoating or Decorating

Two-toning, striping, or lettering may be applied in 4 to 6 hours if DuPont 389 S accelerator is used. Wait 10 to 12 hours if no accelerator is used.

Decals may be applied in 12 to 16 hours if 389 S accelerator is used. Wait 24 hours if no accelerator is used.

For topcoats cured over 72 hours, scuff-sand with no. 400 grit sandpaper and wipe with a clean tack cloth before recoating, striping, lettering, or applying decals.

Imron 6000 Topcoating

Imron 6000 is a two-stage, high-solids polyurethane enamel. It provides good cover with one cross-coat of the base color followed by one coat of Imron 6000 clear coat. Both the base color and clear coat require the addition of an activator.

⚠ WARNING

Wear a positive-pressure, supplied-air, vapor and particulate respirator approved by NIOSH or MSHA (TC-19C), while spraying Imron 6000, and until the work area has been exhausted of all vapor and spray mist. Breathing paint vapor or spray mist can cause personal injury.

Mixing

1. Stir the Imron 6000 base color thoroughly.
2. Mix three parts Imron 6000 base color with one part DuPont 193 S or 194 S activator. No further reduction is necessary for application.

NOTE: The pot life of the mixture is about 2 to 4 hours at 70°F (21°C), unless an accelerator is added.

3. If faster curing time is desired, add DuPont 389 S fast-dry accelerator. Add up to 2 ounces (60 mL) to 1 gallon (3.8 L) of mixed material.
4. Mix thoroughly and strain.

NOTE: For solids, the viscosity of the mixture is about 20 seconds in a DuPont M-222 (M-50) cup; for metallics, it is about 18 seconds.

Application

1. Set the air pressure at the spray gun to 60 to 65 psi (410 to 450 kPa). For pressure feed systems, set the fluid delivery at 12 to 16 ounces (350 to 470 mL) per minute.
2. Apply the topcoating.
   - 2.1 Hold the spray gun about 10 to 12 inches (25 to 30 cm) from the surface.
   - 2.2 Apply one cross-coat of the Imron 6000 base color.
   - 2.3 Flash 10 minutes minimum. Do not sand.
   - 2.4 Mix three parts DuPont 3440 S or 3480 S clear with one part DuPont 193 S or 194 S activator.
   - 2.5 Apply one coat of the activated DuPont 3440 S or 3480 S clear.
3. To air dry, allow 2 to 4 hours if DuPont 389 S accelerator is used, and 6 to 8 hours if no accelerator is used.

   To force dry, wait 15 minutes following the application of the clear coat, then dry for 30 minutes at 140 to 180°F (60 to 82°C).
4. To prevent tape marking, remove all masking tape and paper immediately after the final coat is applied. Avoid contacting the freshly painted surface with masking paper.
5. Clean the equipment immediately after use with DuPont 3602 S lacquer thinner or 8685 S reducer.

Recoating or Decorating

Two-toning, striping, and lettering may be applied in 4 to 6 hours if DuPont 389 S accelerator is used. Wait 10 to 12 hours if no accelerator is used.

Decals may be applied in 12 to 16 hours if 389 S accelerator is used. Wait 24 hours if no accelerator is used.

For topcoats cured over 72 hours, scuff-sand with no. 400 grit sandpaper and wipe with a clean tack cloth before recoating, striping, lettering, or applying decals.

General Guidelines

This section provides instructions for making spot repairs or touch-ups with DuPont® enamels. Buffing may correct minor imperfections; more serious repairs require surface preparation before a topcoating can be applied. For striping, lettering, or decal application after the repair is complete, see **Subject 110**.

1. Preparation materials specified for one type of surface should not be used for any other type of surface. See **Specifications, 400** for a summary of the materials used in this section.
2. Limit intermediate coatings, such as primers, to the brand and type specified by the finish-coat manufacturer.
3. Do not mix additives with the finish coats unless they are specified by the finish-coat manufacturer.

⚠ CAUTION

Only experienced, qualified persons using proper equipment should attempt repainting or touch-up painting. Incorrect application of chemicals or paint could damage the surface or impair the finish.

Buffing Minor Imperfections

1. Clean the area carefully with a mild detergent and rinse.
2. Remove imperfections using ultra-fine or micro-fine sandpaper (1500 or 2000 grit) and water. Rinse the area with clean water, then dry.
3. Buff the area.
   - 3.1 Use a clean foam pad at low speed (about 1600 rpm) with one of the following products:
     - DuPont 1500 S
     - Meguiar's No. 2
     - 3M Finesset Two 5928
   - 3.2 Using medium pressure, buff slowly in an overlapping pattern until the imperfection has been eliminated. Repeat as necessary.
   - 3.3 Rinse the area with clean water, then dry.
4. Polish the area.
   - 4.1 Apply one of the following products with a clean pad (3M Waffle Pad):
     - DuPont 3000 S
     - Meguiar's No. 9
     - 3M 5996
   - 4.2 Using medium pressure, work small areas using an even, overlapping pattern until the gloss is restored. As the polish dries and the gloss appears, ease the pressure on the polishing pad. Repeat as necessary.

Preparing for Topcoating

1. Wash the entire panel with mild detergent. Dry with a clean, lint-free cloth.

⚠ WARNING

Solvents are flammable. Keep them away from heat, sparks, and open flame. Keep the container closed. Use only with adequate ventilation. Avoid breathing the vapor, or headache, nausea, and impaired reaction time and coordination may result.

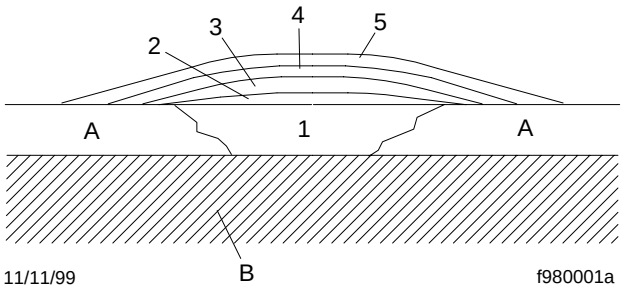
2. Clean the area to be repaired with DuPont 3939 S solvent and quickly wipe the surface with a clean, lint-free cloth before the solvent dries. Remove all traces of wax, polish, grease, and silicones.
3. Sand or grind all dents and scratches.
4. Wet sand and the area being repaired with no. 320 grit or finer sandpaper, or a 3M Scotch-Brite® or similar non-iron abrasive pad. Feather the edge.
5. Remove the sanding dust. Use the same solvent and wipe-on, wipe-off method used earlier to clean the area.
6. Mask all areas that will not be painted.
7. Clean all cracks and surfaces with dry compressed air.
8. Using a tack cloth, wipe all surfaces to be painted.

Spot Repair

WARNING

Wear a positive-pressure, supplied-air, vapor and particulate respirator, approved by NIOSH or MSHA (TC-19C) when mixing or spraying primer, and until the work area has been exhausted of all vapor and spray mist. Breathing paint fumes can cause serious personal injury.

9. Prime all bare metal and feathered areas with DuPont primer. See **Fig. 1**.
   - Steel and aluminum—use Corlar 824 S epoxy primer.
   - Fiberglass—use Corlar 825 S epoxy primer.



NOTE: Scale exaggerated for clarity. The number of layers depends on the specific application.

A. Existing Paint
B. Panel Material (substrate)
1. Primer
2. First Color Topcoat
3. Second Color Topcoat
4. Third Color Topcoat
5. Clear Coat

Fig. 1, Spot Repair Cross-Section

9.1 Stir primer thoroughly.

9.2 Mix two parts Corlar epoxy primer with one part DuPont 826 S activator.

9.3 Reduce three parts of this mixture with one part DuPont 3602 S lacquer thinner (viscosity reading is 18 to 22 seconds in a no. 2 Zahn cup). Stir thoroughly.

9.4 Wait 1 to 2 hours from time of mixing before using. This provides time for complete chemical induction.

9.5 Set the air pressure at the spray gun to 45 psi (310 kPa). For pressure feed systems, set the fluid delivery at 12 to 16 ounces (350 to 470 mL) per minute.

9.6 Hold the spray gun about 10 to 12 inches (25 to 30 cm) from the surface.

9.7 Spray one wet coat to give a dry film thickness of 0.7 to 1.0 mil (18 to 25 µm).

9.8 Clean the equipment immediately after use with DuPont 3602 S lacquer thinner.

9.9 Air dry 2 to 4 hours or force dry 20 minutes.

10. Wet sand the primer with no. 400 grit or finer sandpaper. Feather the edge into the surrounding area.

11. If the original paint was Imron 6000, hand-rub the area around the spot repair with a medium grade compound to ensure a seamless finish.

12. Remove the sanding dust. Use the same solvent and wipe-on, wipe-off method used earlier to clean the area.

13. Wipe the repair area with a tack cloth.

14. If the finish is old, apply one coat of DuPont 222 S adhesion promoter over the entire repair area.

14.1 Set the air pressure to 35 psi (240 kPa) at the spray gun.

14.2 Flash for 5 to 10 minutes at 70°F (21°C) before topcoating.

Topcoating a Spot Repair

WARNING

Wear a positive-pressure, supplied-air, vapor and particulate respirator approved by NIOSH or MSHA (TC-19C), while spraying topcoating, and until the work area has been exhausted of all vapor and spray mist. Breathing topcoating vapor or spray mist can cause personal injury.

Imron 5000 Topcoating

1. Mix the Imron 5000 polyurethane enamel.

1.1 Stir the Imron 5000 enamel thoroughly.

1.2 Mix three parts Imron 5000 base color with one part DuPont 193 S or 194 S activator. No further reduction is necessary for application.

1.3 Mix thoroughly and strain.

2. Set the air pressure at the spray gun at 60 to 65 psi (410 to 450 kPa). For pressure feed systems, set the fluid delivery at 12 to 16 ounces (350 to 470 mL) per minute.

3. For metallic topcoats only, apply one coat of DuPont 500 S urethane clear.

3.1 Mix eight parts of 500 S urethane with one part 193 activator.

3.2 Reduce the activated 500 S urethane mixture 50 percent with 8685 S reducer.

3.3 Apply a medium-wet coat of the reduced 500 S urethane over the entire repair area, and well beyond where the color will be applied.

3.4 Flash 3 minutes before applying the Imron 5000 topcoat.

4. Apply the solid color or metallic topcoating.

4.1 Hold the spray gun about 10 to 12 inches (25 to 30 cm) from the surface.

4.2 Spray one medium-wet coat over the primed area.

4.3 Flash 5 to 10 minutes.

4.4 Apply a second medium-wet coat. Extend the spray area slightly to taper the edge and avoid a visible ring.

4.5 A third medium-wet coat may be needed for good coverage of some colors. Allow each coat to flash before applying the next coat.

NOTE: A mist coat of five parts of color to three parts of 8022 S is recommended when applying metallics. Hold the gun about 18 inches (45 cm) from the surface.

5. Blend the repair area into the OEM finish.

5.1 Lower the air pressure to 15 to 20 psi (100 to 140 kPa) at the spray gun.

5.2 Empty the spray cup and refill it with DuPont 8022 S reducer or a blend of 8022 S and 8093 S.

5.3 Carefully blend the edge of the repair with even coats to melt in the overspray.

5.4 Spray one or two medium coats of the reducer over the entire area.

5.5 If a haze appears around the edge after the reducer has dried, lightly rub the edge with DuPont 1500 S one-step polish.

6. To air dry, allow 2 to 4 hours if DuPont 389 S accelerator is used, and 6 to 8 hours if no accelerator is used.

To force dry, wait 15 minutes following the application of the final coat, then dry for 30 minutes at 140 to 180°F (60 to 82°C).

7. To prevent tape marking, remove all masking tape and paper immediately after the final coat is applied. Avoid contacting the freshly painted surface with masking paper.

8. Clean the equipment immediately after use with DuPont 3602 S lacquer thinner or 8685 S reducer.

Imron 6000 Topcoating

1. Mix the Imron 6000 polyurethane enamel.

1.1 Stir the Imron 6000 base color thoroughly.

1.2 Mix three parts Imron 6000 base color with one part DuPont 193 S or 194 S activator. No further reduction is necessary for application.

1.3 Mix thoroughly and strain.

2. Set the air pressure at the spray gun at 60 to 65 psi (410 to 450 kPa). For pressure feed systems, set the fluid delivery at 12 to 16 ounces (350 to 470 mL) per minute.

3. Apply the topcoating.

3.1 Hold the spray gun about 10 to 12 inches (25 to 30 cm) from the surface.

3.2 Apply one cross-coat of the Imron 6000 base color over the primed area. No flash time is required before applying a clear coat.

Spot Repair

3.3 Flash 10 minutes minimum. Do not sand.

3.4 Mix three parts DuPont 3440 S or 3480 S clear with one part DuPont 193 S or 194 S activator.

NOTE: For best results, apply the clear coat over the entire panel. If a blend of the repair area is attempted, apply the clear coat only over the repair area, overspraying the edge slightly.

3.5 Apply one coat of the activated DuPont 3440 S or 3480 S clear.

4. Blend the 3440 S or 3480 S clear into the surrounding topcoat.

   4.1 Set the air pressure to 25 psi (170 kPa) at the spray gun.

   4.2 Apply one coat of 3401 S blending clear over the repair area only to the overspray edge.

   4.3 Flash 2 minutes. Repeat if necessary.

5. To air dry, allow 2 to 4 hours if DuPont 389 S accelerator is used, and 6 to 8 hours if no accelerator is used.

   To force dry, wait 15 minutes following the application of the final coat, then dry for 30 minutes at 140 to 180°F (60 to 82°C).

6. To prevent tape marking, remove all masking tape and paper immediately after the final coat is applied. Avoid contacting the freshly painted surface with masking paper.

7. Clean the equipment immediately after use with DuPont 3602 S lacquer thinner or 8685 S reducer.

General Information

If corrosion appears around the rivets on an aluminum cab, the rivets must be replaced as part of the surface corrosion repair.

Use only the DuPont products specified in each step. See **Specifications, 400** for a summary of the products used in this procedure.

⚠ CAUTION

Only experienced, qualified persons using proper equipment should attempt repainting or touch-up painting. Incorrect application of chemicals or paint could damage the surface or impair the finish.

⚠ WARNING

Wear a positive-pressure, supplied-air, vapor and particulate respirator, approved by NIOSH or MSHA (TC-19C) when mixing or spraying primer or topcoat, and until the work area has been exhausted of all vapor and spray mist. Breathing paint vapor or spray mist can cause personal injury.

Surface Preparation

1. Wash and dry the cab with a mild detergent.
2. Wipe all areas to be repaired with a clean cloth soaked with DuPont Prep-Sol 3919 S.
   - 2.1 Work on small areas at a time, wetting the surface liberally.
   - 2.2 Quickly wipe the surface with a clean cloth before the solvent has a chance to dry. Change cloths frequently.
   - 2.3 Remove all traces of wax, polish, oil, grease, and silicones.
3. Using a no. 11 tool bit (0.191-inch/4.85-mm diameter), drill out the rivet heads in the corroded area. Remove the rivets.
4. Sand the corroded areas.
   - 4.1 Using no. 220 to 320 grit sandpaper, sand the corroded or otherwise exposed areas on the aluminum skin (substrate).
   - 4.2 Feather the edges by hand or with an oscillating sander (DA).
5. Sand the entire area to be painted. Using a sanding block and no. 400 sandpaper, remove the gloss to improve adhesion of the primer and topcoat.
6. Using a clean cloth soaked with DuPont 3939 S lacquer and enamel cleaner, remove any sanding dust.
7. Install new 3/16-inch-diameter rivets in the clean, drilled holes.

IMPORTANT: Make sure both the bare metal and new rivets are treated with metal conditioner.

8. Treat all bare metal and new rivets with metal conditioner.
   - 8.1 Mix one part of DuPont 225 S aluminum cleaner with two parts of water in a plastic container. Do not use a metal container.
   - 8.2 Apply the cleaner with a cloth or sponge. Work the surface with a stiff plastic brush or 3M Scotch-Brite® pad. Do not use any pads containing iron.
   - 8.3 While the metal is still wet, wipe thoroughly with a clean, dry cloth. Allow the surface to dry before applying the conversion coating.
9. Apply a conversion coating to all bare metal.
   - 9.1 Pour DuPont 226 S aluminum conversion coating into a plastic container. *Do not dilute.* Using a 3M Scotch-Brite or similar non-iron abrasive pad, apply the conversion coating to all bare metal surfaces.

     Work only as much area as can be coated and rinsed before the solution dries.
   - 9.2 Leave the coating on the surface for 2 to 5 minutes. Then, rinse off the solution with cold water, or mop with a sponge or cloth rinsed frequently in clean water.

     If the metal surface dries before rinsing, reapply the conversion coating, leave it on for 2 to 5 minutes, then rinse thoroughly.
   - 9.3 Wipe the surface dry with a clean cloth, or air dry.

10. With paper and tape, mask all areas that are not to be painted. Prime immediately.

Prime Coat

1. Clean all cracks and surfaces with dry compressed air.
2. Using a tack cloth, wipe all surfaces to be painted.
3. Prime all bare metal and feathered areas with DuPont Corlar® 824 S epoxy primer.
   - 3.1 Stir Corlar 824 S primer thoroughly.
   - 3.2 Mix two parts Corlar 824 S primer with one part DuPont 826 S activator.
   - 3.3 Reduce three parts of this mixture with one part DuPont 3602 S lacquer thinner (viscosity reading is 18 to 22 seconds in a no. 2 Zahn cup). Stir thoroughly.
   - 3.4 Wait 1 to 2 hours from time of mixing before using, to provide time for complete chemical induction.
   - 3.5 Spray one full wet coat to give a dry film thickness of 0.7 to 1.0 mil (18 to 25 µm).
   - 3.6 Clean equipment immediately after use with DuPont 3602 S lacquer thinner.
   - 3.7 Air dry 2 to 4 hours or force dry 20 minutes.

Topcoat

Imron 5000® is a single-stage, low VOC, high-solids polyurethane enamel. It provides a durable, high-gloss surface with good chemical resistance. It requires the addition of an activator.

Mixing

1. Stir the enamel thoroughly.
2. Mix three parts Imron 5000 enamel with one part of DuPont 193 S or 194 S activator. No further reduction is necessary for application.

NOTE: The pot life is about 2 to 4 hours at 70°F (21°C), unless an accelerator is added.

3. If faster curing time is desired, add DuPont 389 S fast-dry accelerator. Add up to 2 ounces (60 mL) to 1 gallon (3.8 L) of activated material.
4. Mix thoroughly and strain.

NOTE: The viscosity of the mixture is about 9 to 15 seconds in a no. 3 Zahn cup, depending on the color. Adding reducer could affect the color match on some metallics.

Application

1. Set the air pressure at the spray gun at 50 to 60 psi (345 to 414 kPa) for solid colors, and 65 psi (448 kPa) for metallics. For pressure feed systems, set the fluid delivery at 12 to 16 ounces (355 to 473 mL) per minute. See **Specifications, 400**.
2. Apply the topcoating.
   - 2.1 Hold the spray gun about 8 inches (20 cm) from the surface.
   - 2.2 Spray one medium-wet coat over the primed area.
   - 2.3 Allow 5 to 10 minutes drying time between each application.
   - 2.4 Apply a second medium-wet coat. Extend the second coat beyond the edge of the first coat to provide the correct taper and avoid a visible ring.
   - 2.5 A third medium-wet coat may be needed for good coverage of some colors.
3. To air dry, allow 2 to 4 hours if DuPont 389 S accelerator is used, and 6 to 8 hours if no accelerator is used.

   To force dry, wait 15 minutes following the application of the final topcoat, then dry for 30 minutes at 140 to 180°F (60 to 82°C).
4. To prevent tape marking, remove all masking tape and paper immediately after the final coat is applied. Avoid contacting the freshly painted surface with masking paper.
5. Clean the equipment immediately after use with DuPont 3602 S lacquer thinner or 8685 S reducer.

Recoating or Decorating

Two-toning, striping, or lettering may be applied in 4 to 6 hours if DuPont 389 S accelerator is used. Wait 10 to 12 hours if no accelerator is used.

Decals may be applied in 12 to 16 hours if DuPont 389 S accelerator is used. Wait 24 hours if no accelerator is used.

For topcoats cured over 72 hours, scuff-sand with no. 400 grit sandpaper and wipe with a clean tack cloth before recoating, striping, lettering, or applying decals.

Equipment Application Parameters

Equipment Application Parameters		
Parameter	**English Units**	**Metric Units**
Atomizing Air		
Primer	45 psi	310 kPa
Enamel	60–65 psi	410–450 kPa
Fluid Delivery	12–16 oz/min	350–470 mL/min
Booth Temperature	75°F	23°C
Spray Gun Distance	10–12 in	25–30 cm

DuPont Surface Preparation Materials

Step	**Surface Preparation Materials**			
	Steel	**Aluminum**	**Plastic**	**Fiberglass**
Wash and dry	Mild detergent (such as diswashing detergent)			
Wipe with cleaner	Prep-Sol 3919 S	Prep-Sol 3919 S	Plastic Prep 2319 S	Prep-N-Solv
Sand and feather	220 grit, then 400 grit			320 grit
Remove sanding dust	3939 S lacquer and enamel cleaner			Mix: - 1 part water - 1 part isopropyl alcohol
Treat bare metal	5717 S metal conditioner	225 S aluminum cleaner	—	—
Apply conversion coating to bare metal	5718 S metal conversion coating	226 S aluminum conversion coating	—	—
Apply sealer primer	Mix: - 2 parts Corlar 824 S primer with 1 part DuPont 826 S activator - reduce 3 parts of mixture with 1 part DuPont 3602 S lacquer thinner		Mix: - 2 parts Corlar 825 S primer with 1 part DuPont 826 S activator - reduce 3 parts of mixture with 1 part DuPont 3602 S lacquer thinner	

DuPont Topcoating Materials

Step	**Topcoating Materials**	
	Imron 6000	**Imron 5000**
Mix enamel	Mix: - 3 parts Imron 6000 - 1 part 193 S or 194 S activator	Mix: - 3 parts Imron 5000 - 1 part 193 S or 194 S activator
Add accelerator (optional)	389 S accelerator (up to 2 oz/gal of activated enamel)	
Mix clear coat	Mix: - 3 parts 3440 S or 3480 S clear - 1 part 193 S or 194 S activator	—

Specifications

Step	Topcoating Materials	
	Imron 6000	Imron 5000
Pressure at gun	60–65 psi (414–448 kPa)	60 psi (414 kPa)
Equipment cleanup	3939 S lacquer and enamel cleaner or 8685 S reducer	

DuPont Spot Repair Materials

Step	Spot Repair Materials	
	Imron 6000	Imron 5000
Cleaning	3939 S lacquer and enamel cleaner	
Sanding	320 grit or finer	
Sealer primer	Mix: - 2 parts Corlar 824 S primer with 1 part DuPont 826 S activator - reduce 3 parts of mixture with 1 part DuPont 3602 S lacquer thinner	
Compound	Medium grade compound	—
Adhesion promoter	222 S adhesion promoter	
Topcoat	1 coat Imron 6000: - 3 parts base color - 1 part 193 S or 194 S activator	2 coats Imron 5000: - 3 parts enamel - 1 part 193 S or 194 S activator
Topcoat viscosity	Solids: 20 sec; Metallics: 18 sec (#2 Zahn cup)	9–20 sec (#3 Zahn cup)
Clear coat	Mix: - 3 parts 3440 S or 3480 S clear - 1 part 193 S or 194 S activator	—
Accelerator (optional)	389 S accelerator	
Blending clear	1 coat 3401 S blending clear	
Equipment cleanup	3939 S lacquer and enamel cleaner or 8685 S reducer	

General Description

PPG Delta® DUHS base-coat and DCU2070 clear-coat paint is used on the vehicle cab. To meet the federal air quality regulations imposed by the EPA and local jurisdictions, these products contain low amounts of solvent and are formulated to be free of lead and chrome.

The procedures in this section are for use with PPG products. Unless otherwise noted, all products are manufactured by PPG. Obtain approval from Daimler Trucks North America LLC for use of topcoats produced by other manufacturers.

Color Matching

PPG Delta® high solids polyurethane is the recommended aftermarket PPG paint. For repairs, use PPG Delta DFHS paint for color-matching the chassis and PPG Delta DUHS base coat with DCU2070 clear coat paint for color-matching the cab.

To determine the correct paint number for color-matching of any original finish on a vehicle, refer to the paint specification on the vehicle specification decal. See **Fig. 1**. Refer to the vehicle operator's manual for the location of this decal.

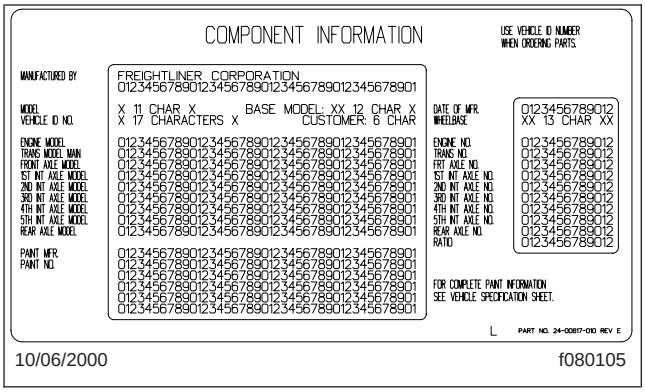


Fig. 1, Vehicle Specification Decal

General Guidelines

1. Preparation materials specified for one type of surface should not be used for any other type of surface.
2. Limit intermediate coatings, such as sealers, to the brand and type specified by the finish coat manufacturer.
3. Do not mix additives with the finish coats, unless the finish coat manufacturer specifies them.

IMPORTANT: Only experienced, qualified persons, using proper equipment, should attempt repainting and touch-up painting.

Preparation for Topcoating

1. Wash and dry the entire surface to be painted.
2. Using a clean cloth soaked with PPG DX436 Wax and Grease Remover, remove all traces of wax, polish, grease, and silicones, as follows:
   - 2.1 Work on small areas at a time, wetting the surface liberally.
   - 2.2 Change cloths frequently.
   - 2.3 Wipe off the surface with a clean cloth before the PPG DX436 wax and grease remover has a chance to dry.
3. Feather-edge all repaired areas, chipped surfaces, and scratches, as follows:
   - 3.1 Cut down the edges of broken spots with 220-grit sandpaper.
   - 3.2 Feather the edges by hand, using a sanding block with 400-grit sandpaper.
4. Sand the entire area to be repainted. Use a sanding block and 400-grit sandpaper to remove the gloss and to improve adhesion of the primer.
5. Using a clean cloth soaked with PPG DX436 wax and grease remover, remove any sanding dust from the area to be painted. Remove all traces of wax, polish, grease, dust, and silicones, as follows:
   - 5.1 Work on small areas at a time, wetting the surface liberally.
   - 5.2 Change cloths frequently.
   - 5.3 Wipe off the surface with a clean cloth before the PPG DX436 wax and grease remover has a chance to dry.
6. Treat bare metal and corroded areas. For aluminum, use PPG DX533 Aluminum Cleaner; for all other metals, use PPG DX579 Metal Cleaner.
   - 6.1 For aluminum, mix one part of PPG DX533 Aluminum Cleaner with three parts of water in a plastic bucket.

     For all other metals, mix one part of the PPG DX579 Metal Cleaner with two parts of water in a plastic bucket.
   - 6.2 All corroded areas must be abraded until the area is free of rust or corrosion. Use 80-grit followed by 220-grit sandpaper to abrade the area.
   - 6.3 Spray cleaner on the surface and allow it to react for 2 to 3 minutes.
   - 6.4 Rinse off the cleaner with fresh water and dry thoroughly with a clean, lint free, dry cloth.

Preparing for Topcoating

IMPORTANT: Carbon steel must be primed immediately after abrading and cleaning. Aluminum must be primed within 4 to 8 hours of abrading and cleaning.

7. With paper and tape, mask all areas that are not to be painted, then prime immediately.

Primers for the Cab

PPG has several compatible primers to use when repainting or repairing. The recommended primers are:

- DP-LF — A chrome- and lead-free epoxy primer with excellent corrosion resistance.
- DPU217 — A chrome-free polyurethane primer that can be applied as low as 2.1 lb./gal VOC with excellent adhesion and corrosion resistance properties.
- DEP351 — A 3.5 VOC chrome- and lead-free epoxy primer with excellent adhesion and corrosion resistance properties.
- DPHS-52 — A non-isocyanate, chrome- and lead-free, corrosion resistant, sandable primer with excellent adhesion and filling properties.

DP-LF Primer

NOTE: Refer to PPG Product Information Bulletin P-196 for additional information.

IMPORTANT: Wear a positive-pressure, supplied-air, vapor and particulate respirator, approved by NIOSH or MSHA (TC-19C), when mixing or spraying primer, and until the work area has been exhausted of all vapor and spray mist.

1. Stir the DP-LF Primer thoroughly. Then, mix two parts of DP-LP with one part of DP 401LF.
2. Stir thoroughly and allow a 30-minute induction time to obtain maximum performance.
3. Apply two light-to-medium wet coats to achieve a 1.0 mil minimum to 2.0 mil maximum dry film thickness (DFT).
4. Allow 15 minutes flash time between coats.
5. Allow a drying time of 1 hour at 70°F (21°C) before topcoating.
6. Clean all cracks and surfaces with dry compressed air.
7. Using a tack cloth, wipe all surfaces to be painted.

DPU217 Primer

NOTE: Refer to PPG Product Information Bulletin FL304 for additional information.

IMPORTANT: Wear a positive-pressure, supplied-air, vapor and particulate respirator, approved by NIOSH or MSHA (TC-19C), when mixing or spraying primer, and until the work area has been exhausted of all vapor and spray mist.

NOTE: This mixture has a VOC of 2.8 lb/gal. To spray at 2.1 lb/gal do not add the DRS reducer.

1. Stir the DPU217 primer thoroughly.
2. Mix five parts of DPU217 with one part of DPU218.
3. Add 6 fluid ounces (177 mL) of DX39/DX53 per ready-to-spray gallon (3.8 L).
4. Add one part of DRS reducers.

NOTE: When adding DRS reducers in the 2.8 VOC blend, for best results, the DRS solvents must be added last, after the addition of the DX39/DX53.

5. Apply one to two coats.
6. Allow 10 to 15 minutes flash time between coats.
7. Allow a drying time of 60 minutes at 70°F (21°C) before topcoating.

NOTE: After four days, DPU217 must be sanded before additional primer or topcoat can be applied.

8. Clean all cracks and surfaces with dry compressed air.
9. Using a tack cloth, wipe all surfaces to be painted.

DEP351 Primer

NOTE: Refer to PPG Product Information Bulletin FL305 for additional information.

IMPORTANT: Wear a positive-pressure, supplied-air, vapor and particulate respirator, approved by NIOSH or MSHA (TC-19C), when mixing or spraying primer, and until the work area has been exhausted of all vapor and spray mist.

1. Stir the DEP351 Primer thoroughly. Then, mix two parts of DEP351 with one part of DEP352.

   The addition of 10 to 20 percent Acetone or DES1570 Exempt Solvent Blend should be used for sealer application.
2. Apply one to two coats.
3. Allow 5 minutes flash time between coats.
4. Allow a drying time of 60 minutes at 70°F (21°C) before topcoating.
5. Clean all cracks and surfaces with dry compressed air.
6. Using a tack cloth, wipe all surfaces to be painted.

DPHS52 Primer

NOTE: Refer to PPG Product Information Bulletin FL301 for additional information.

IMPORTANT: Wear a positive-pressure, supplied-air, vapor and particulate respirator, approved by NIOSH or MSHA (TC-19C), when mixing or spraying primer, and until the work area has been exhausted of all vapor and spray mist.

1. Stir the DPHS52 Primer thoroughly. Then, mix two parts of DPHS52 with one part of DPHS521 and mix thoroughly.
2. Apply two to three wet coats to achieve a 2.0 mil minimum to 3.0 mil maximum DFT.
3. Allow 10 minutes flash time between coats.

NOTE: A minimum of 2.0 mil DFT after sanding must be maintained to ensure proper adhesion and corrosion protection.

4. Allow a drying time of 45 minutes at 70°F (21°C) before topcoating.

   Or, if sanding before topcoating, allow a drying time of 3 to 4 hours, then DA sand with 320- to 360-grit dry sandpaper, followed with a finish DA sanding using 1500-grit or finer paper.
5. Clean all cracks and surfaces with dry compressed air.
6. Using a tack cloth, wipe all surfaces to be painted.

Delta® DFHS High Solids Polyurethane

NOTE: Refer to PPG Product Information Bulletin P-FL504 for additional information.

IMPORTANT: Wear a positive-pressure, supplied-air, vapor and particulate respirator approved by NIOSH or MSHA (TC-19C), while mixing and spraying, and until the work area has been exhausted of all vapor and spray mist.

Mixing

1. Stir Delta DFHS Single Stage thoroughly.
2. Mix four parts Delta DFHS Single Stage with one part DFH535/DFH536.
3. Add six fluid ounces (177 ml) DX39 per ready-to-spray (RTS) gal.

NOTE: May substitute with DX53 or DX49, but pot life, dry times, and recoat ability may be affected.

4. Mix thoroughly and strain.

Spraying

1. For High Velocity, Low Pressure (HVLP) systems, the air pressure at the air cap should be set at 10 psi (69 kPa).

   For conventional spray guns, set the air pressure to 45 to 60 psi (310 to 414 kPa) at the gun.

   The fluid tip size for conventional HVLP guns should be 1.3 to 1.7 mm.

   The fluid tip size for pressure-feed HVLP guns should be 1.0 to 1.4 mm.
2. Apply two coats, or until hiding is achieved. Flash time between coats is 5 to 10 minutes at 70°F (21°C).
3. Dry times: See **Table 1** for air dry times. See **Table 2** for force dry times.

Delta® DUHS Basecoat

NOTE: Refer to PPG Product Information Bulletin P-FL507 for additional information.

IMPORTANT: Wear a positive-pressure, supplied-air, vapor and particulate respirator approved by NIOSH or MSHA (TC-19C), while mixing and spraying, and until the work area has been exhausted of all vapor and spray mist.

Air Dry Time - at 70°F (21°C) with DFH535	
Using DX39	12 hours
Using DX53	16 hours
Using DX49	5 hours

Table 1, Air Dry Times

Force Dry with DX53 only.	
Flash	10 minutes
@ 120°F (49°C)	30 minutes
@ 180°F (82°C)	15 minutes

Table 2, Force Dry Times

Mixing

NOTE: One-quarter part DHSX Converter is the minimum quantity and one part is the maximum quantity of converter to add to DUHS Basecoat. Increasing the level of DHSX will speed dry time, but will shorten pot time, especially in warm and humid conditions.

1. Stir Delta DUHS Basecoat thoroughly.
2. Mix two parts of Delta DUHS Basecoat with one-quarter to one part of DHSX Converter.
3. Add one part DDH526.
4. Mix thoroughly and strain.

Spraying

1. For High Velocity, Low Pressure (HVLP) systems, the air pressure at the air cap should be set at 10 psi (69kPa).

   For conventional spray guns, set the air pressure to 45 to 60 psi (310 to 414 kPa) at the gun.

   The fluid tip size should be 1.3 to 1.7 mm for conventional HVLP guns and 1.0 to 1.4 mm for pressure feed HVLP guns.
2. Apply two coats of the basecoat, or until hiding is achieved. Minimum film build for each coat

should be 1.5 mils wet and no more then 2.0 mil wet. Flash time between coats is 5 to 10 minutes at 70°F (21°C).

3. Dry time to clearcoat is 10 to 15 minutes minimum and up to 72 hours maximum at 70°F (21°C). After 72 hours the DUHS basecoat must be sanded and additional color applied before clearcoating.
4. Allow a drying time of 60 minutes at 70°F (21°C) before topcoating.

Delta® Urethane Clear DCU2070

NOTE: Refer to PPG Product Information Bulletin FL600 for additional information.

IMPORTANT: Wear a positive-pressure, supplied-air, vapor and particulate respirator approved by NIOSH or MSHA (TC-19C), while mixing and spraying, and until the work area has been exhausted of all vapor and spray mist.

Mixing

1. Mix four parts of DCU2070 with one part of DRS Reducer.
2. Add two parts DCX2071/DCX2072.
3. Add four fluid ounces (118mL) of DX39/DX54 per RTS gallon (3.8 L) of mixed material.
4. Mix thoroughly and strain.

Spraying

1. For HVLP systems, the air pressure at the air cap should be set at 10 psi (69 kPa).

   For conventional spray guns, set the air pressure to 55 to 60 psi (379 to 414 kPa) at the gun.

   The fluid tip size should be 1.0 to 1.4 mm for pressure feed HVLP and 1.3 to 1.5 mm for conventional feed HVLP.
2. Apply two coats allowing 10 to 15 minutes between coats.
3. For dry times at 70°F (21°C), See **Table 3**. Force dry time is 30 minutes at 140°F (60°C).

Dry Times		
DCU2070	**With DCX2071**	**With DCX2072**
With DX39	3 hours	1 to 2 hours
With DX53	4 to 5 hours	2 hours

Table 3, Dry Times

4. Buffing may begin 4 to 6 hours after the unit is air dried, or immediately after cool off, if force dried.

NOTE: If polishing is required, use DCX2071 Polish within 24 hours.

Buffing

Refer to PPG Product Information Bulletin PD768 for polishing and compounding.

General Guidelines

These are instructions for making spot repairs or touch-ups with PPG Delfleet® Evolution urethane topcoat single stage or basecoat/clearcoat.

Buffing may correct minor imperfections; more serious repairs require surface preparation before a topcoating can be applied.

1. Preparation materials specified for one type of surface should not be used for any other type of surface.
2. Limit intermediate coatings, such as primers, to the brand and type specified by the paint manufacturer.
3. Do not use any products or additives that are not specifically recommended by the paint manufacturer in published literature.
4. Substrate and ambient temperature should be above 65°F (18°C) for optimum performance.

Buffing Minor Imperfections

1. Clean the area carefully with a mild detergent, then rinse.
2. Remove imperfections using ultra-fine or micro-fine sandpaper (1500- or 2000-grit) and water.
3. Rinse the area with clean water, then dry.
4. Buff the area, using a clean foam pad at low speed (about 1600 rpm) with one of the following products:
   - Meguiar's No. 2 Fine-Cut Cleaner
   - 3M Finesse-it II 05928

   Using medium pressure, buff slowly in an overlapping pattern until the imperfection has been eliminated. Repeat as necessary.
5. Rinse the area with clean water, then dry.
6. Polish the area with a clean pad, such as a 3M Waffle Pad, using either of the following products:
   - Meguiar's No. 9 Swirl Remover
   - 3M Perfect-It 05996

   Using medium pressure, work small areas using an even, overlapping pattern until the gloss is restored. As the polish dries and the gloss appears, ease the pressure on the polishing pad. Repeat as necessary

Preparing for Topcoating

1. Wash the entire panel in mild detergent, containing no lanolin or additives. Before the solution dries, rinse with fresh water. Dry with a clean, lint-free cloth.
2. Cover areas around the repair area to prevent damage to surrounding objects from solvent overspray or drips.

⚠ WARNING

Solvents are flammable. Keep the container closed. Use only with adequate ventilation. Keep solvents away from heat, sparks, and open flame. Breathing the vapor can cause headache, nausea, impaired reaction time, and impaired coordination.

3. Clean the area to be repaired with PPG D436/DX437/DX438 Substrate Cleaner. Choose the product depending on local regulations and degree of contamination. Quickly wipe the surface with a clean, lint-free cloth before the substrate cleaner dries.

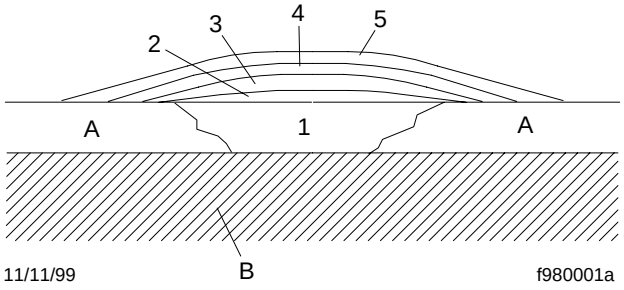
   Remove all traces of substrate contamination such as wax, polish, grease, diesel exhaust residue, and silicones. Do not allow substrate cleaners to air dry on the repair area.
4. Sand or grind all dents and scratches.
5. DA sand the area being repaired with 320- or 400-grit, or finer sandpaper, or a 3M Scotch-Brite® pad. Feather the edge.
6. Remove sanding dust using the method detailed in step 3 above.
7. Mask all areas not to be painted.
8. Clean all cracks and surfaces with dry compressed air.
9. Use a tack cloth to wipe all surfaces to be painted.

Spot Repair

WARNING

Wear a positive-pressure, supplied-air, vapor and particulate respirator, approved by NIOSH or MSHA (TC-19C) when mixing or spraying paint products, and until the work area has been exhausted of all vapor and spray mist. Breathing paint fumes can cause serious personal injury.

10. Prime all bare metal and feathered areas with PPG primer. Use F3995 primer for fiberglass, steel, and aluminum. See **Fig. 1**.



NOTE: The number of paint layers depends on the specific use.

A. Existing Paint
B. Panel Material (Substrate)
1. Primer
2. First Color Topcoat
3. Second Color Topcoat
4. Third Color Topcoat
5. Clearcoat

Fig. 1, Spot Repair Cross Section, Scale Exaggerated for Clarity.

10.1 Stir or shake primer thoroughly.

10.2 Mix three parts F3995 epoxy primer with one part F3996 activator and one-half part F–series reducer.

10.3 Set the air pressure at the spray gun to 55 psi (380 kPa). For pressure feed systems, set the fluid delivery at 12 to 16 ounces (350 to 470 ml) per minute.

10.4 Spray one wet coat to yield a minimum dry film thickness of 0.7 mils (18µm).

10.5 Clean equipment immediately after use with PPG Gun Cleaning Solvent.

10.6 Air dry 1 hour or force dry 20 minutes at 120 to130°F (49 to 55°C).

11. If the original paint was a basecoat/clearcoat, hand rub the area around the spot repair with a medium grade compound to ensure a seamless finish. Use Scotch–Brite® 7448 or 2000-grit wet or dry sandpaper.

12. Remove the sanding dust. Use the same cleaner and wipe on, wipe off method used earlier to clean the area.

13. Wipe the repair area with a tack cloth.

Topcoating a Spot Repair

Delfleet® Evolution Single Stage Topcoating

1. Mix the Delfleet® Evolution Single Stage (FDGH) polyurethane enamel.

1.1 Stir the Delfleet® Evolution Single Stage (FDGH) polyurethane enamel thoroughly.

1.2 Mix three parts Delfleet® Evolution color (FDGH) with one part F3260 activator to 6 ounces additive F34XX per RTS gallon (44 ml per liter), to an optional 10 percent F33XX reducer. The pot life is 2 to 3 hours at 70°F (22°C). See **Table 1**.

Speed Rating	F34XX Additives	F33XX Reducers
Fast Dry	F3400	F3320
Medium Dry	F3405	F3330
Slow Dry	F3410	F3340
Extra Slow Dry	—	F3350

Table 1, PPG Additives and Reducers

1.3 Mix thoroughly and strain.

NOTE: the viscosity of the mixture should be at 25 to 35 seconds in a No. 2 Zahn cup. Check the designated shelf life if using a product from a previously opened container.

2. Set the air pressure at 50 to 60 psi (345 to 415 kPa). For pressure feed systems, set the fluid delivery at 12 to 16 ounces (350 to 470 ml) per minute. The fluid tip should be 1.3 to 1.5 mm.

3. Apply the solid or metallic color topcoat.

3.1 Spray one medium-wet coat over the primed area.

3.2 Flash 10 to 15 minutes.

3.3 Apply a second medium-wet coat. Extend the spray area slightly to taper the edge and avoid a visible ring.

4. FDGH dry film thickness must be a minimum of 1.5 mils (38µm).
5. To air dry, allow overnight cure at 65°F (19°C) minimum.
6. To force dry, flash 5 to 10 minutes, then cure 40 minutes at 140°F (60°C) metal temperature.
7. If taping, allow 3 hours at 68°F (20°C). To prevent tape marking, remove all masking tape and paper immediately after the final coat is applied.
8. If decals are to be applied, let the paint cure at 70°F (21°C) for 3 days prior to putting them on.
9. Clean the equipment immediately after use with PPG Gun Cleaning Solvent.

Delfleet Evolution Basecoat/ Clearcoat Topcoating

1. **Option 1:** Mix the Delfleet Evolution Basecoat (FBCH) polyurethane enamel.

1.1 Stir/shake the Delfleet Evolution Basecoat (FBCH) thoroughly.

1.2 Mix three parts FBCH basecoat color with one part F3260 activator to one-half part F3440 converter. Pot life is 1 to 2 hours at 70°F (21°C) and 50 percent relative humidity.

1.3 Mix thoroughly and strain.

1.4 The viscosity of the mixture is 20 to 25 seconds in a No. 2 Zahn cup, depending on the color.

2. **Option 2:** Mix the Delfleet Evolution Basecoat-Fast (FBCS) polyurethane enamel.

2.1 Stir or shake the Delfleet Evolution Basecoat-Fast (FBCS) color thoroughly.

2.2 Mix three parts FBCS basecoat color with one part F3200. Ten percent F33XX Reducer is optional for this application. Pot life is 1 hour at 70°F (21°C) and 50 percent relative humidity.

2.3 Mix thoroughly and strain.

2.4 The viscosity of the mixture is 20 to 30 seconds in a No. 2 Zahn cup, depending on the color.

3. Set the air pressure at 50 to 60 psi (345 to 415 kPa). For pressure feed systems, set the fluid delivery at 12 to 16 ounces (350 to 470 ml) per minute. The fluid tip should be 1.3 to 1.5 mm.
4. Apply the basecoat (FBCH or FBCS): Apply one or two coats of FBCH or FBCS basecoat color over the primed area until full hiding is achieved. Allow 5 to 10 minutes between coats.
5. If blending the repair area into the OEM finish, see instructions at the end of the top coat instructions.
6. Allow 30 minutes flash, prior to applying clearcoat.
7. If clearcoat is not applied within 8 hours, FBCH/ FBCS basecoat color must be sanded and recoated.
8. Mix the Delfleet Evolution High Build Clear

8.1 Mix three parts Delfleet Evolution Clearcoat F3905 with one part F3240 activator to one-half part reducer (F33XX) to 2 ounces accelerator per RTS gallon (16 ml per liter). Pot life is 1 hour to 1.5 hours at 70°F (21°C) and 50 percent relative humidity. See **Table 2**.

PPG Thinners	
Fast	F3320
Medium	F3330
Slow	F3340
Extra Slow	F3350

Table 2, F33XX Thinner Selection

8.2 Mix thoroughly and strain.

8.3 The viscosity of the mixture is 32 seconds in a No. 2 Zahn cup.

9. Set the clearcoat air pressure at the spray gun at 45 to 55 psi (310 to 380 kPa). For pressure feed

systems, set the fluid delivery at 12 to 16 ounces (350 to 470 ml) per minute. Use a 1.3 to 1.5 mm fluid tip.

10. Apply 2 coats of F3905 clearcoat with a 10 to 15 minute flash time between coats to reach 2.0 mils (50 µm) minimum dry film thickness.

NOTE: For best results, apply the clearcoat over the entire panel.

11. To blend the clearcoat:

    11.1 Apply one coat of the activated Delfleet Evolution F3905 Clearcoat.

    11.2 Mix one part DX840 to one part ready-to-spray F3905 clearcoat and apply this mixture to the blend edge. Additional DX840 may be added if a second coat to extend the blend edge is necessary or desired.

    11.3 Moving the gun from the outside in, mist a light coat onto the edge of the repair to melt in the dry overspray.

    11.4 To air dry, allow overnight cure at 65°F (18°C).

    11.5 If taping, allow 6 hours at 68°F (20°C). To prevent tape marking, remove all masking tape and paper immediately after the final coat is applied.

    11.6 To force dry, flash off up to 5 minutes, then dry for 40 minutes at 150°F (65°C).

    11.7 If sanding or polishing are desired, allow the finish to sit 16 hours if air dried, and 4 to 8 hours after bake cool-down before polishing.

    11.8 Clean the equipment immediately after use with PPG Gun Cleaning Solvent.

Solid Color Blends in FBCH/FBCS/FDGH

1. Prepare the repair area as outlined above.
2. Spray color to full hiding in two or three coats, allowing specified flash time between coats.
3. Once hiding is achieved, pour out the remaining ready-to-spray (RTS) color from the gun.
4. Add several ounces of DX840 to the gun that still contains residual RTS color and lightly blend the outside edge.

NOTE: It is very important to add DX840 to the gun that still contains some residual RTS color. This keeps the outside edge from breaking or de-wetting.

5. For FBCH or FBCS repair jobs, apply clearcoat following a 30 minute flash time, or a similar force-dry.

Blending Metallic Colors in FDGH and Blending Metallic/Pearl Colors in FBCH/FBCS

NOTE: Spot repairs in high-solid colors often show a dark ring or halo around their edges. Spraying a wet bed helps prevent the ring or halo when repairing high-solid colors.

On very light colors, it may be necessary to spray the wet bed completely to the edge of the panel but not over the repair area, to prevent the halo effect.

1. Follow the steps outlined above to prepare the area for applying the wet bed.
2. Prior to applying the wet bed, the area that is to receive the wet bed should be scuffed with a gray scuff pad and cleaned with an appropriate substrate cleaner.
3. Mix F3905. Reduce the RTS F3905 1:1 by volume with DX840 and spray a wet bed on the outside of the spot.

    3.1 Spray one medium-wet coat to establish the wet bed. Keep the wet bed 4 to 6 inches outside the repair spot.

    3.2 Apply the color system mixed as detailed in previous headings, but do not add DX840 in this step. Spray from the repair spot into the wet bed, while the wet bed is still wet.

    NOTE: Do not apply DX840 to the edge of the color in this application. Doing so causes a halo effect.

3.3 For basecoat repairs, allow the color to become tack-free before applying the final overall color. The overall clear (F3905) is not reduced with DX840. DX840 can be used to melt in the edges of the clearcoat, once this step is complete.